technopolis group

March 2026

International Evaluation of Scientific Institutions Activity

Panel Report: Natural Science

Professor Krikor Ozanyan (chair), Professor Frank Behrendt, Professor Jeanine Duistermaat, Professor Anders Forsman, Professor Francisca Kemper, Professor Willy Verstraete

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Table of Contents

Figures

Abbreviations

A&A – Astronomy & Astrophysics (scientific journal)
ALMA – Atacama Large Millimeter/submillimeter Array (international observatory)
ApJ – Astrophysical Journal
ARC – Average Relative Citations
ASTRON – Netherlands Institute for Radio Astronomy
ATAWEY – French company adopting one of VIRAC's patents
CETAF – Consortium of European Taxonomic Facilities
CSIC – Consejo Superior de Investigaciones Científicas
DU – Daugavpils University
DUNS – Daugavpils University Natural Sciences
eDNA – Environmental DNA
ERC – European Research Council
ERIC – European Research Infrastructure Consortium
ESA – European Space Agency
ESO – European Southern Observatory
EVN – European VLBI Network
FIT – Faculty of Information Technologies (VUAS)
FWCI – Field-Weighted Citation Impact
FRB – Fast Radio Burst
GBIF – Global Biodiversity Information Facility
GIS – Geographic Information System
HPC – High-Performance Computing
ICT – Information and Communication Technologies
Ilgas – DU Study and Research Centre "Ilgas"
IP – Intellectual Property
IUCN – International Union for Conservation of Nature
JAXA – Japan Aerospace Exploration Agency
LOFAR – Low-Frequency Array (radio telescope network)
LOFAR2.0 – Upgraded second-generation LOFAR network
MHD – Magnetohydrodynamics
MNRAS – Monthly Notices of the Royal Astronomical Society
MoD – Ministry of Defence
NASA – National Aeronautics and Space Administration
NACEE – Network of Aquaculture Centres in Central and Eastern Europe
REBUS – DU Centre for Research and Business Support
RT-16 / RT-32 – 16-m and 32-m Irbene radio telescopes
RTU – Riga Technical University
SKAO / SKA – Square Kilometre Array Observatory

SSC – Swedish Space Corporation
STEM – Science, Technology, Engineering, Mathematics
UL – University of Latvia
VIRAC – Ventspils International Radio Astronomy Centre
VLBI – Very-Long-Baseline Interferometry
VUAS – Ventspils University of Applied Sciences

Introduction

International Evaluation of Scientific Institutions Activity analysed the research performance and international competitiveness, considering also the socio-economic impact and development potential of the units. Results of the evaluation can serve as input in policy making and will enable the units to improve their performance based on the recommendations.

The Natural Science Expert Group evaluated six units:

- Faculty of Science and Technology - University of Latvia
- Ventspils University of Applied Sciences/ Field of Natural sciences
- Daugavpils University Research programme "Natural Sciences"
- Latvian Institute of Aquatic Ecology, agency of Daugavpils University
- Latvian State Institute of Wood Chemistry
- Institute of Solid State Physics, University of Latvia

The Expert Group evaluated the units using the following criteria:

- Quality of the research
- Impact on the scientific discipline
- Economic impact
- Social impact
- Research environment and infrastructure
- Development potential

The evaluation of each unit involved a documentary review and the Expert Group's visit to the units. The final evaluation of each unit is a collective view of the Expert Group.

The analysis of each unit by the Expert Group is presented in the following sections.

Institution reports

N_1 Faculty of Science and Technology - University of Latvia

1.1.1. The unit

The Faculty of Science and Technology (FST) at the University of Latvia (UL) is a research entity established in 2024 through the merger of three faculties and nine research institutes and centres. The mission of FST is to become an internationally recognised centre of scientific excellence, innovation, and societal impact, by advancing four strategic priorities: research excellence, diversification of funding sources, supporting innovation and knowledge exchange, empowering talent development, and strengthening global research networks.

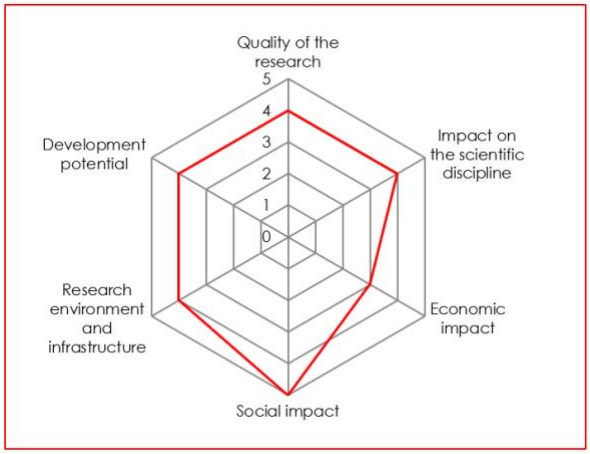
Research at FST is organised around several main fields, including computer and information sciences, physical sciences, material sciences and engineering, mathematics, earth and environmental sciences and educational sciences supporting STEM education in Latvia. FST engages in both fundamental and applied research, with a slight emphasis on applied research. FST fosters interdisciplinary collaboration across various domains, such as biophotonics, biomaterials, and environmental modelling. It maintains partnerships with industry and international research networks, and its research outputs are disseminated through peer-reviewed journals, conferences, and the development of computer programmes and algorithms. FST has established a dedicated position for innovation and established a prototyping laboratory to enhance its research and commercialisation activities.

1.1.2. Expert Group evaluation

The figure below presents the scores assigned by the Expert Group to the unit.

Figure 1 Faculty of Science and Technology - University of Latvia– Scores

Criteria	Scores
Quality of the research	4
Impact on the scientific discipline	4
Economic impact	3
Social impact	5
Research environment and infrastructure	4
Development potential	4
OVERALL SCORE	**4**



Overall score:
Score 4: very good

The Faculty of Science and Technology at the University of Latvia demonstrates strong performance across research, international collaboration, and societal impact. Research quality is very good, with several areas—such as Computer and Information Science, Physics, and Material Sciences—achieving outstanding results, including publications in high-impact journals such as Nature, Nature Technology, Nature Human Behaviour and Nature Communications, and notable technological developments. FST has significantly improved its research visibility, increasing the share of Q1 publications from 39% to 57%, and actively

participates in major international projects, including Horizon Europe consortia. While ERC funding remains elusive, FST secured approximately 60% of its 2024 funding from competitive project sources including national funds, EU structural funds, EU Framework Programme and other international funding, reflecting research excellence, strong international recognition and scientific impact.

FST's contribution to society and education is exceptional, with active involvement in national policy development, STEM outreach, and advancements in health, environmental monitoring, and quantum technologies. Economic impact is good, supported by an active Intellectual Property office, patent applications, and spin-off companies although collaborations with large companies remain limited due to structural challenges in Latvia. The research environment is modern and collaborative, strengthened by a recent merger and new facilities that provide state-of-the-art infrastructure. Strategic planning and open management foster interdisciplinary projects, though a comprehensive strategy for interdisciplinarity and industrial engagement is still needed. Doctoral education has improved with a new programme offering partial funding and greater autonomy for PhD candidates, complemented by initiatives for early-career researchers and international mobility.

Overall, FST shows high potential for growth, with clear plans to address weaknesses such as international leadership capacity and intersectoral collaboration. These achievements, combined with targeted improvements, reflect very good performance with room for further development in strategic areas.

Quality of Research
Score 4: very good

The research quality at the Faculty of Science and Technology, University of Latvia, is very good, with several areas demonstrating outstanding performance. Notably, Computer and Information Science, Physics, Material Sciences, and Earth and Environmental Sciences stand out for their publications in high-impact Q1 journals. The Expert Group also commends the faculty's technological developments, which are of an exceptionally high standard. Examples include the creation of top-tier MHD liquid metal pumps and satellite laser ranging systems, enabling them to participate in global consortia such as ITER and ESA. In addition, the faculty has developed numerous software packages.

However, the Expert Group observes a weak role for the Department of Mathematics within the faculty. Despite strong technological components and significant data-generating facilities, the contribution of applied mathematics and statistics appears limited. Based on the Faculty's description of the research fields and achievements, the emphasis appears to be on applying existing methodologies rather than generating substantial new research contributions in applied mathematics and statistics.
Overall, the faculty has shown progress in research visibility: the share of Q1 publications increased from 39% (2013–2018) to 57% (2019–2024). The average citation and the average of relative citations (ARC) are 8.8 and 1.01, respectively, which are very good results for a large and heterogeneous entity. The proportion of highly cited publications is also very good, namely 10.9. During the assessment period, the faculty delivered 87 computer programmes and algorithms, many of which are used outside the institution, including several open-source packages available via github, e.g. MACPLAS or via collaborative software, e.g. exciting (https:/exciting-code.org)

The Expert Group was also impressed by the faculty's ability to secure funding: approximately 60% of its funding comes from competitive national or EU programmes. However, the faculty was unsuccessful in obtaining ERC funding during this period.

The recent merger of various units into one faculty and the move to a new building have fostered collaboration between research groups. There is an ongoing collaboration between

Computer Science and Physics on applications of quantum computing theory, which resulted in a paper in Nature Communications. The faculty won 3 out of 13 interdisciplinary research grants offered by the University of Latvia. These initiatives are expected to generate significant outputs in the coming years. Investing in mathematics may accelerate this even further.

Impact on scientific discipline:
Score 4: very good

The Expert Group finds that the faculty is very well embedded internationally. It maintains strong collaborations with renowned institutes and universities in the Baltic region, across Europe (including CERN), and globally (e.g., in the US and Japan). These partnerships have led to joint publications in high-impact journals (e.g. Nature) and new collaborative projects funded by the EU.

The work of the faculty is well cited, as was indicated in the previous section.

The faculty's participation in 21 Horizon Europe projects, with coordination of 14 consortia, namely MSCA, Marie Curie Fellowships and QuantERA ERANet, demonstrates its potential for leadership roles in international research initiatives. In addition, FST is active in international networks such as JIVE-ERIC and engages in joint PhD projects with institutions in countries such as the Netherlands and Japan.

FST also contributes to the organisation of high-profile international conferences, for example, TQC2021 on quantum computing. Its staff members are editors of journals indexed in Scopus, namely Magnetohydrodynamics and the Baltic Journal of Modern Computing, and serve on editorial boards of 13 other Scopus-indexed journals.

Economic impact
Score 3: good

The economic impact of FST is good. The Expert Group was impressed by the large number of initiatives and collaborations with industry, particularly in information technologies, as well as in microelectronics and educational developments. However, these collaborations are primarily focused on student projects and service activities, rather than large-scale research partnerships. Industry contributions to research funding remain limited (2% during the assessment period). The Expert Group notes that this low percentage is largely due to the absence of major industrial players in FST's research domains within Latvia. Currently, FST does not show initiatives to build more and bigger relationships with industry in Latvia and abroad.

FST benefits from an active and visible Intellectual Property (IP) office, which plays a key role in stimulating commercialisation of novel ideas. It provides support for patent applications and assists researchers in launching spin-offs. During the assessment period, 37 patent applications were filed, and three spin-offs were created, all in the field of diagnostics.

In terms of human capital, FST delivered 651 master's and 83 doctoral graduates. Despite a general decline in student numbers due to demographic changes, FST has successfully maintained stable enrolment in its programmes. Furthermore, it has strengthened its research profile by repatriating five Principal Investigators and appointing three ERA Chairs, thereby increasing opportunities for collaboration with industry.

Social impact
Score 5: Outstanding

The Expert Group considers the social impact of FST to be outstanding.

Faculty scientists make significant contributions to Latvian society and globally through their research in diverse fields, including:

- Geology – development of novel magnetic field sensing technologies for navigation
- Environmental Sciences – research on microplastics and environmental monitoring
- Physics – asteroid observation programmes: near Earth encounter forecasts
- Quantum Technology – applications relevant to national defence
- Health – advances in medical diagnostics

Beyond research with direct societal impact, faculty members actively advise on national policies and legislation. In addition, researchers are in high demand to serve as advisors to the Parliament, Ministries of Defence, Science and Education, and Environmental Protection, and Regional Development, and various national councils, and contribute to National Development Plans and Strategies.

FST also plays a key role in STEM education and outreach. By providing teacher training, curriculum development, and teaching materials for schools, FST is an important driver of the education of new generations in Latvia. Members of the Department of Educational Science actively promote STEM through school visits, participation in STEM schools, and the organisation of national and international science Olympiads.

Finally, FST demonstrates a strong commitment to science communication and public engagement, as evidenced by its participation in science festivals, appearances in national media, and active presence on social platforms.

Research environment and infrastructure
Score 4: very good

The Faculty of Science and Technology is young, established in 2024, and has developed a well-structured research organisation. Departments operate with a high degree of autonomy, while the FST board maintains regular communication through meetings with department heads and general staff assemblies. To ensure continuous improvement, a staff satisfaction survey and an external audit of the operating model are planned. Staff members also have clear channels to discuss issues beyond their line managers when necessary. The Expert Group was impressed by the well organised and chaired discussion session with scientists across FST. The impression is that the management structure is open and flat., so there are few hierarchical levels and it is fairly easy to access management.

Strategic and financial planning is good. FST relies for a large part on competitive funding and actively supports researchers in grant writing and proposal preparation. Investments in interdisciplinary research and advanced technologies enhance FST's attractiveness as a partner in large consortia. However, there does not seem to be an overall strategy to increase interdisciplinary research even further.

FST has worked on a new HR framework, improving career pathways and increasing the number of tenured positions, which will be in place in 2027. Currently, staff have temporary positions and are appointed on projects. FST offers financial and institutional support to researchers during gaps between funded projects, ensuring continuity of their work. An improved Doctoral programme is already in place, offering candidates a 50% paid position.

This arrangement ensures that students have ownership of their project for at least half of the time and allows them to choose their supervisors. Additionally, having two supervisors is becoming increasingly common. Early Career researchers can apply for post-doc positions, including international visits. These programmes should enable FST to increase the number of young scientists in the near future. All staff undergo performance evaluations and receive performance-based remuneration. Training in transferable skills for early-career scientists is in place. An active IP office, visible and approachable, assists with intellectual property management and commercialisation.

The research themes' orientation is strong, with targeted investments in areas of excellence. FST strategically attracts international scientists through repatriation programmes to boost visibility in key research domains. Interdisciplinary projects and joint PhD programmes also help strengthen weaker departments.

The research infrastructure is excellent. The new buildings provide a modern and collaborative environment, complemented by state-of-the-art laboratories and technologies. The merger of departments has facilitated shared access to facilities, such as organised HPC resources, and improved collaboration. A research information system is in place to track outputs at both departmental and individual levels. Support for grant proposals and IP issues is in place. Support for international visitors and scientists seems to be very good.

FST demonstrates a strong commitment to Open Science. During the evaluation period, 55% of publications were open access. Dedicated data stewards provide advice and training on research data management and promote FAIR principles. Additionally, FST actively supports public engagement, participating in initiatives such as the Horizon Europe project ROSiE, which develops guidelines for Citizen Science.

Development potential
Score 4: very good

The Expert Group considers FST's outlook highly promising. Research quality over the past five years has been very good, with several outstanding areas (e.g. Computer and Information Science, Physics, Material Sciences, and Earth and Environmental Sciences). Several groups (e.g. in Quantum Technologies, Geology, Nanotechnology) are internationally well embedded. Given recent developments, further growth in research output is expected. Key drivers include the 2024 merger of units and the new campus, which enables shared facilities and fosters collaboration and participation in collaborative projects and in international networks. Additionally, the open management structure supports an excellent research environment.

The need to acquire ERC funding for further scientific impact is recognised by FST. Early-career researchers are actively supported through CV development and grant-writing assistance to improve competitiveness. These initiatives and their international recruitment programme enable FST to start new research directions. FST has a large impact on the economy in Latvia and on society. However, there is little intersectoral collaboration today, and what exists is mostly restricted to IP and spin-offs. The Expert Group was not able to identify a strategy for collaboration with the large industry.

The vision of the unit seems to focus on internationality, scientific excellence, innovation and scientific impact and less on industrial impact. The Expert Group finds the assessment of the strengths, weaknesses, opportunities and threats of the unit very good and agrees with this analysis. The unit has identified several weaknesses and has already implemented plans to address most of them:

- International Leadership Capacity: While FST successfully attracts international scientists at all levels—from students to professors—there remains limited capacity for leadership roles in international consortia. This is critical, as the Unit's financial sustainability depends on such funding opportunities. To address this, FST invests in early-career researchers by providing grant-writing and project management support. Further plans include tenured positions in strategic areas such as industrial quantum technologies, numerical simulations, AI foundations, and cybersecurity.
- Internationalisation: The number of foreign students and scientists has increased however it is still insufficient. To improve this, FST is developing new interdisciplinary programmes in English, applying for EU funding to attract students and postdoctoral fellows, and planning to recruit senior international staff. Additional measures include leveraging MSCA Cofund programmes and ERASMUS+ to increase mobility and diversity.
- Intersectoral Collaboration: FST has a proactive IP office and mandates industrial projects in bachelor programmes. However, a clear strategy for initiating collaborations with large European companies is not yet in place.
- Uneven Scientific Impact Across Disciplines: FST anticipates that shared facilities will raise the quality of all research groups. It also aims to secure more national funding for PhD students to promote collaboration between strong and weaker research areas. Nonetheless, further efforts could include identifying key interdisciplinary fields—such as data science and applied mathematics—to strengthen integration.
- A high proportion of academic staff is past retirement age: FST supports early career researchers.

Potential to offer doctoral studies

FST has recently established a doctoral school following the new format. Before their enrolment, students write their own research proposals. Requirements for the degree and the performance of the candidates are discussed regularly, and plans are updated. Doctoral students have access to courses in research methodologies and transferable skills, as well as support for international mobility. Supervisory arrangements are flexible, allowing students to have co-supervisors from other institutions, including universities in Japan and the Netherlands.

FST aims to increase international student enrolment, for example, by offering greater flexibility between recruitment and project start dates. The Expert Group observed that doctoral students regularly interact through networking events, fostering peer support throughout different stages of their studies. However, a formal PhD forum or council does not yet appear to be in place, which will be important when the number of doctoral students further increases.

Financially, doctoral students have 50% of their salary guaranteed, while the remaining portion is typically secured through research projects aligned with their topic or fellowships. Here, it might be good to have two supervisors, so the candidate is not overloaded with work that does not support their PhD and the candidate is able to obtain their PhD in 4 years. There is adequate funding for participation in international conferences and research visits, and several students reported plans for extended stays abroad (e.g., in the Netherlands and Japan). FST also invests in supervisor training, and the number of projects involving multiple supervisors is steadily increasing.

Alignment with the Smart Specialisation Strategy

FST actively addresses all RIS3 research priorities through its diverse research portfolio:

- Knowledge-Intensive Bioeconomy – Research on land use, resource evaluation, and environmental planning, contributing to sustainable agriculture and forestry.

- Biomedicine, Medical Technologies, and Biopharmacy – Studies on visual perception and the development of an app for personalised allergy forecasting.
- Photonics, Smart Materials, Technologies, and Engineering Systems – Advanced research in quantum computing materials and related technologies.
- Smart Energy and Mobility – Innovations in building energy efficiency and the design of novel heat exchangers.
- Information and Communication Technologies (ICT) – Cutting-edge work in quantum computing, cryptographic security, and related ICT domains.

Conformity with state scientific and technology development

FST's strategy is fully aligned with national priorities for scientific, technological, educational, and innovation development, as well as the University of Latvia's Development Strategy 2021–2027. This alignment is evident across research excellence, human resources, doctoral education, infrastructure, and internationalisation.

In the area of scientific excellence and industry collaboration, FST has implemented the UL Scientific Excellence and Commercialisation Support Programme, which incentivises Q1 journal publications and partnerships with industry. These measures have resulted in a significant increase in Q1 and Q2 publications in the assessment periods and a rise in industrial collaborations. Furthermore, centralised support for participation in international and local conferences, networking, training, and mobility events has strengthened FST's involvement in international research consortia, enhancing its global visibility and impact.

Human resources development is another key priority. UL is revising its Human Resources Policy, which will soon apply to FST. The updated policy focuses on career progression, job stability, and a balanced distribution of teaching and research responsibilities. It also introduces regular staff evaluations, fostering a research-oriented academic environment that supports long-term staff development and institutional excellence. Moreover, it enables strategic hiring.

A new unified doctoral programme is in place, offering improved conditions for PhD candidates. In addition, the newly launched Tenure Programme aims to recruit and retain top researchers in strategic areas, ensuring that FST remains competitive in attracting high-level talent and sustaining research leadership.

Infrastructure development is maintained through a combination of base funding, competitive grants, and EU structural funds, which guarantee the upkeep and modernisation of research facilities. FST's research activities are aligned with RIS3 priorities, and excellence centres have been established in cutting-edge fields such as photonics and quantum computing, reinforcing FST's commitment to high-impact research and innovation.

Education and internationalisation are also central to FST's mission. FST offers modern, labour-market-aligned curricula in line with the Education Development Guidelines and actively engages in science outreach through school visits and workshops in collaboration with teacher associations. International collaboration is supported by Erasmus+ partnerships with 86 universities across 22 countries, providing mobility opportunities for both students and staff and fostering a truly global academic environment.

Overall, these initiatives demonstrate FST's strong alignment with institutional and national objectives, advancing excellence in research, education, and innovation while ensuring sustainable growth and international competitiveness.

Recommendations

FST demonstrates strong strategic alignment in enhancing research excellence, fostering internationalisation, and creating impact in both the economy and society. Its overall approach reflects a clear commitment to advancing academic quality and societal relevance.

Research excellence and new directions

- FST is encouraged to actively pursue ERC funding opportunities and incorporate targeted measures to do this into its strategic plan. One effective approach could be allocating dedicated research time for early-career researchers, allowing them to concentrate on high-quality projects
- While several policies supporting interdisciplinary work are already in place, an overarching strategy appears to be missing. The recent merger and the availability of new facilities present an excellent opportunity to strengthen interdisciplinary research further. Particular attention could be given to fields where collaboration is most flexible and promising, such as applied mathematics, statistics, and data science. For these fields the approach should be interdisciplinary, i.e. multiple research fields contribute equally yielding publications in several domains including mathematical and statistical journals.
-

Regarding industrial impact

- FST maintains a solid portfolio of collaborations with industry and benefits from an Intellectual Property office that supports scientists in managing innovation and establishing spin-offs. However, a comprehensive strategy for engaging with large companies and industries is still lacking. To overcome the limited presence of such companies in Latvia, FST should make targeted approaches to national and international industry. This could help expand FST's industrial reach and impact and financial situation in the future

Doctoral studies

- The introduction of a new programme has enhanced the position of PhD students. This initiative is expected to increase timely completions of degrees and strengthen their contribution to research excellence. Nevertheless, only 50% of the funding for these positions is secured, leaving students dependent on fellowships and project participation. This dependency may lead to time spent on work unrelated to their doctoral research, which could hinder progress. To ensure that only limited work is spent on unrelated work, FST should consider assigning a mentor or second supervisor to each PhD candidate
- FST should establish a PhD forum where students can discuss challenges and share experiences. This would provide a valuable addition to support PhD students' academic journeys

N_2 Ventspils University of Applied Sciences - Field of Natural sciences

1.1.3. The unit

The Ventspils University of Applied Sciences (VUAS) is represented in this evaluation by the Faculty of Information Technologies (FIT) and the Engineering Research Institute 'Ventspils International Radio Astronomy Centre' (VIRAC). The mission of VUAS is to be a global provider of research in its chosen fields while maintaining a sustainable team of researchers and providing state-of-the-art research infrastructure. The university aims to contribute to the global space industry and collaborate with international networks. It is located in Ventspils, Latvia, and operates a radio telescope site at Irbene, which contributes to its regional presence and research capabilities in astronomy and astrophysics.

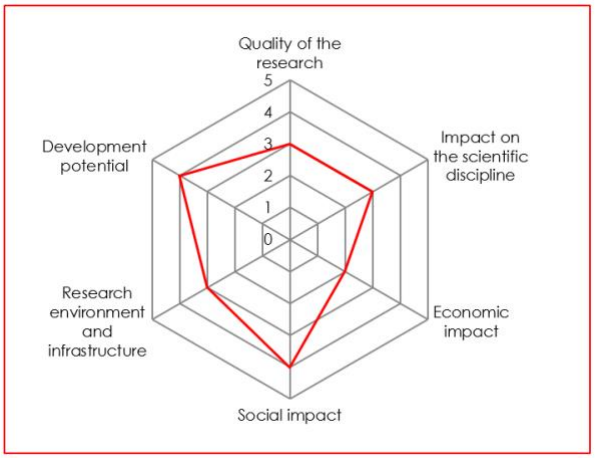
Research at VUAS is focused on the primary fields of physical sciences and computer and information sciences. In VIRAC the research is conducted in three departments: astronomy and astrophysics, electronics and satellite technology, and engineering and technical operations unit. VIRAC has been restructured during the evaluation period, with the department of remote sensing being dissolved, the economics research group being integrated into the VUAS Science and development department, and the High-Performance Computing department being integrated into the Department of Astronomy and Astrophysics. FIT's research topics focus on computer sciences and electronics engineering. Distinctive research themes include studies of interstellar and circumstellar mediums, observational radio astronomy, astrochemistry, machine learning, and interdisciplinary studies combining natural sciences with engineering and computer sciences.

1.1.4. Expert Group evaluation

The figure below presents the scores assigned by the Expert Group to the unit.

Figure 2 Ventspils University of Applied Sciences/ Field of Natural sciences – Scores

Criteria	Scores
Quality of the research	3
Impact on the scientific discipline	3
Economic impact	2
Social impact	4
Research environment and infrastructure	3
Development potential	4
OVERALL SCORE	**3**



Overall score
Score 3: good

The presence of the radio astronomy facility at Irbene is a fortunate accident of history. Formerly in use as military spy antennas by the Soviets, they were stripped and abandoned when Latvia became an independent country. The 32-m and 16-m parabolic radio telescopes (known as RT-32 and RT-16), still remained in good enough shape to be refurbished as radio telescopes. The telescopes form the basis of the VIRAC institute.

The Expert Group found it very difficult to use the same evaluation criteria on the two entities (FIT and VIRAC) comprising this unit. There is a clear difference in research performance between the two. The scores, therefore, are an average and do not properly reflect the situation for either part.

Overall, the quality of the research is good. The scientific output and international collaboration on scientific projects is good, although only a relatively small fraction (~35%) of its publications appear in Q1 journals. The 15 highlighted publications in the self-evaluation report all originate from VIRAC, with not a single contribution by FIT highlighted. The impact on the field of science is good. About 64% of the publications by the unit are done in collaboration with international co-authors, again mostly in the field of astronomy and astrophysics. The citation rates are well below the field averages, typically receiving 60-65% of the number of citations expected based on field averages. The unit also publishes relatively few top 10% cited papers in the field, but there are some positive exceptions with significant impact.

The economic impact is adequate. FIT and VIRAC maintain a good relationship with the municipality, which is financially supporting the researchers and students and both institutes. The unit is a source of technically skilled human resources for the area. Additionally, the unit's high tech collaborations are able to access funding sources not otherwise available to the region. The social impact is very good. As the astronomy community at VIRAC and in Latvia as a whole is small, observing time on the telescope is not fully subscribed and the Ministry of Defence makes good use of the facility and helps fund its upkeep. The unit has increased its outreach activities, with media appearances and public involvement, both at the FIT and VIRAC sides. The Research environment and Infrastructure of the institution are good. Research infrastructure present includes the radio telescopes RT-32 and RT-16, and LOFAR, but also the HPC, various labs and workshops present on site at VIRAC to maintain the telescopes and build instrumentation. An obvious shortcoming is the lack of a PhD degree programme. The development potential of the institution is very good. This is in a large part driven by the opportunities in radio astronomy.

The Expert Group recommends that there should be an evaluation of whether VIRAC can act as an independent national observatory, which would be a (partially government-funded) resource for the Latvian astronomical community as a whole. This would also extend access to VIRAC's international networks, such as the ERICs, to the entire nation. It is worth noting that observing time at the facilities operated by VIRAC (RT-32, RT-16, LOFAR) is already open to any astronomer, within or outside Latvia. Additionally, VIRAC should consider formalising its links to the University of Latvia, which offers the nation's only astrophysics PhD programme. This would not need to affect the connection with Ventspils municipality – after all, the physical location of the site and the motivation to collaborate do not change. Such a reorganisation would enhance the competitiveness of the research infrastructure present at the Irbene site. At the very least, the unit should evaluate whether to enter FIT and VIRAC separately in the national research assessment in the next round.

Quality of Research

Score 3: good

The astronomy research at VUAS is of a strong international standard, while that in the other disciplines (information technology) is merely adequate. The unit publishes 61% of its articles in physical sciences (mostly through VIRAC in astronomy-related journals) and 36% in computer/information sciences. Only 35% of work appears in Q1 journals. As the main astrophysics journals (MNRAS, A&A, ApJ) are Q1, this number should be higher. Instead, the two journals most frequently used for the output in physical sciences are Q4.

The unit shows leadership in the work it presents. Of the 15 key papers listed, 12 are first-authored by unit researchers, two others have VUAS as second author, and one (Nature, 300+ citations) includes VUAS later in authorship. These publications mainly cover astrophysics,

instrumentation, and Earth sciences, with one in chemistry. No publications on information technology or computer science are included among the 15 highlighted publications.

Significant themes within astronomy areas include Fast Radio Bursts, Interstellar Chemistry, Star Formation, and Solar Magnetohydrodynamics. The Irbene 32m and 16m antennas, refurbished in 2014-2019, enable advanced observations and participation in the European VLBI Network. Publications demonstrate the telescopes' importance (e.g., maser monitoring survey and EVN follow-up). Their frequency range (4.5 – 8.8 GHz, to be expanded to 15 GHz) supports studies of complex molecules, complementing theoretical astrochemical modelling work carried out at VIRAC. The LOFAR station (10 – 90 MHz) connects to the LOFAR network, supporting e.g. FRB research. VIRAC also excels in Solar MHD and plasma physics. Despite the small group size, the astronomy output since 2019 (post-refurbishment) is considerable. The group leaders in astrochemistry and solar physics are prolific and internationally recognised.

However, machine learning research at FIT lacks detail and impact, with few papers, low citations, and none mentioned among the 15 highlighted publications.

Interdisciplinary potential (e.g., machine-learning for radio data pipelines) is underused, as FIT focuses on other areas like language processing. This is a missed opportunity. Interdisciplinary work that did come to fruition includes Earth sciences research using astronomical observations to study the magnetosphere. Overall, astronomy research carried out at VIRAC is of an internationally competitive level, although not always published in the highest impact journals, while research in information technology is limited.

Impact on scientific discipline
Score 3: good

The bibliometric data show that the scientific publications from the unit overall have a limited impact. The Average Relative Citations (ARC) and the Field Weighted Citation Impact (FWCI), both measures of scientific impact, are 0.64 and 0.61, well below the average, which by definition is 1. Only 7.1% of the publications published over the 2019-2023 period are among the top 10% cited publications in the field, and the Citation Distribution Index is –22.9, based on the bibliographic analysis, which is at the low end of the usual range. It can thus be concluded that, on average, publications by the FIT/VIRAC unit have below-average impact in the international community. However, some of the publications in astronomy have had a significant impact and are the result of successful research lines on the interstellar and circumstellar medium. MHD studies of the Sun, for instance the work by Kalvans (2021, ApJ 910, 54) and by Nakariakov et al. (2024, Rev. Modern Plasma Phys. 8, 19), are both published in Q1 journals.

About 64% of the publications are done in collaboration with international co-authors, and with the fraction of publications in physical sciences at 61%, the suggestion presents itself that these two groups of publications are mostly the same. Indeed, international collaboration is the norm in astronomical research, and the group at VIRAC has taken advantage of the presence of the former Soviet antenna and successfully reutilised this as an astronomical observatory. The size and the location of the facilities are unique and have been recognised as welcome additions to European VLBI Network, leading to VIRAC's participation in the JIVE ERIC. On the ground, VIRAC has also set up a LOFAR station, and joined the corresponding ERIC, taking advantage of the same unique baseline to be added to an interferometric array. VIRAC is also a partner in the RADIOBLOCKS consortium, which has obtained Horizon funding to enhance the data chain in radio astronomy, from receiver to final output. These international collaborations are essential to the integration of VIRAC into the international community. The participation in the ERICs has indeed yielded several important international publications with VIRAC co-authors. Three of these publications appeared in Nature and Nature Astronomy, in 2022 and in 2023, with the latest one also linked to the Maser Monitoring Organisation. A bilateral collaboration exists with the Ukrainian astronomical community, which operates a

similar type of facility in the western part of Ukraine. In addition to coordinated observations, Ukraine also has supplied three post-docs and visits of guest researcher to VIRAC.

Thus, refurbishing the RT-32 and RT-16 telescopes and equipping them with modern receivers has been an investment that is clearly paying off.

Economic impact
Score 2: adequate

Both FIT and VIRAC have a local impact. Ventspils is only a small town (36.000 inhabitants), and the presence of FIT and VIRAC is a major local economic driving force. FIT bachelor degree graduates enter the local workforce, and thus are an economic factor. Although records are not kept of where the alumni end up working, during the site visit faculty and students suggested that unemployment amongst the graduates is very low: most find employment in local tech/manufacturing companies that have sprung up in the Ventspils area, and the apparent unemployment can be explained almost entirely by the fact that graduates that are not currently employed are in fact enrolled in a master's or PhD programme.

The Ventspils municipality therefore supports the VUAS by investing in human resources. It provides monetary incentives to the researchers at FIT/VIRAC for publishing their results. It also operates a programme for expats to help them set up their life in Ventspils. The municipality considers this to have a good return on investment, in particular as FIT/VIRAC attracts national and international project funding that would otherwise not be available to the area. The value of the support from the municipality over the period evaluated is €1.25m.

FIT/VIRAC also collaborates with small local companies such as SIA Nanocraft, and Testdevlab, (a Latvian software start-up, since acquired by Xorient Group) in obtaining funding from the European Space Agencies for joint projects. For example, the collaboration with SIA Nanocraft resulted in a €100k grant to model flyby scenarios for the Comet Interceptor project, as well as an additional €35k for miscellaneous projects. FIT/VIRAC also works with several international and local private companies (Firefly Aerospace, Spire Global, AAE Space Agency, Thales Alenia Space, and OHB Digital Connect). Investments by the Swedish Space Corporation have been important in building VIRAC's ground infrastructure and enabling it to provide commercial services.

Work in the unit has resulted in spinoff companies (VIRATEC, IrbGS, and Bitlake) and patents (12 over the evaluation period, one of which has been adopted by ATAWEY in France).

However, the economic footprint of FIT/VIRAC remains limited beyond the immediate regional level, as the unit has not yet developed strong or sustained partnerships with larger national industries or multinational corporations. Moreover, the long-term economic contribution is constrained by the small scale of the research teams and the lack of a broader, coordinated national strategy to capitalise on the technological expertise generated at the Irbene site.

Social impact
Score 4: very good

For Latvia's Ministry of Defence (MoD), the telescope and its location are of strategic and geopolitical importance. The nature of this collaboration and the activities carried out cannot be disclosed to the review Expert Group, but 45% of the observatory's income originates from MoD. In return, MoD uses a similar share of the telescope time, mostly with the RT-16 telescope. National security use of the antennas thus provides a major justification for continued operation of the facility.

The RT-32 and RT-16 antennas are both used for Deep Space communications with spacecraft. Their location partly compensates for the loss of access to such facilities in Russia due to the geopolitical situation. VIRAC has monetised their use with the Swedish Space Corporation (SSC) since 2013, as well as the space agencies ESA, NASA and JAXA.

Astronomers affiliated with VIRAC teach courses at the University of Latvia in Riga, to complement existing teaching into a well-rounded astronomy programme. In return, doctoral students from the University of Latvia find their way to VIRAC to do their thesis research projects. VIRAC is the largest astronomy research facility and observatory in Latvia. However, VUAS does not independently offer a doctoral programme in physics and astronomy. Thus, continued collaboration with the University of Latvia is of vital importance for the field of astronomy in Latvia, and should be further formalised.

Following the recommendation from the previous evaluation, the unit has significantly increased its media presence, aiming to enhance the social impact of its research. These media appearances include TV and radio interviews, but projects are also required to include press releases as deliverables. VUAS staff also give public lectures. The self-report also emphasises a FIT-organised STEM club for high-school students, and other activities with schools and their students. VIRAC operates a visitor centre, and offers tours of the – historically relevant – site to visitors. The Expert Group did not have the opportunity to go to the visitor centre, but was told that the visitor centre is in need of an upgrade.

Finally, the FIT/VIRAC unit participates in industry and research-field focused events to enhance its visibility, such as Deep Tech Atelier, Paris Space Week, International Astronautical Congress, Northern-Baltic-8 Forum, SpaceOps, ESA schools, workshops.

Research environment and infrastructure
Score 3: good

The self-evaluation report details the management structure of FIT and VIRAC in the context of VUAS as a whole. Both FIT and VIRAC have their own management structure, headed by the dean and the faculty board for FIT and the director and scientific council for VIRAC. VUAS has its own overarching structure, headed by the rector, with the current rector having a background in Space Physics. This seems adequate, and the Expert Group does not identify strong weaknesses or strengths here.

The unit management structure described above follows the VUAS strategy, detailed in the document "Strategy of Ventspils University of Applied Science for 2021-2027". The vision regarding science can be briefly described as becoming a science-excellence platform conducting education-integrated research that contributes significantly to national development and science internationally. Strategic goals in science call for effectively managing "excellence in science and the transfer of knowledge in the national economy". The natural sciences branch contributes to both these aspects. Major targets are promoting scientific excellence, collaboration, knowledge transfer, and developing research environment and infrastructure. Active strategic research directions related to natural sciences are astronomy, mathematical modelling, spectroscopy, information and computing technologies, signal processing, and supporting developments in software and hardware. With limited baseline funding from the government available, management has correctly identified that it is the large scale projects that enable lasting growth of the research output of the unit, in particular infrastructure projects (telescopes, etc.) and it is coaching its researchers to apply for funding in these areas. This strategic planning strategy appears to be researcher driven, but management has some tools at its disposal to direct this process: prioritisation of promising project applications building on already existing strengths; merit-based remuneration and infrastructure improvements. Given the need to rely mostly on outside funding, the Expert Group finds that the long-term strategic and financial resource planning is adequate. With more generous baseline funding, it would be possible to give more direction to the research performed in the unit.

The introduction states that the goal of the entity is to advance as a global provider of research in its science fields while maintaining and expanding an internationally competitive, balanced, and sustainable team of researchers and engineers and providing state-of-the-art research infrastructure for science and the global space industry. While progress is being made, for instance towards maintaining and providing state-of-the-art research infrastructure (the telescopes), in other areas the unit is still far away from its goals, for instance in maintaining and expanding an internationally competitive and balanced team of researchers. As discussed above, the quality of the research outputs themselves are still quite far from the goals that have been set. This aspect is still quite weak.

The refurbished RT-32 and RT-16 radio telescopes, equipped with L, S, C, and X band receivers, as well as the LOFAR site are world-class astronomical research facilities. A cryogenic workshop has been setup to build further receivers for the telescopes in house, rather than buying them already completed, and further well-equipped laboratories provide additional essential components. VIRAC has access to a pool of about 15 technicians and mechanical engineers for the maintenance of the facilities. Because of these facilities, VIRAC is part of the JIVE and LOFAR ERICs, and the RADIOBLOCKS Horizon Europe project.

In addition, all FIT/VIRAC researchers have access to state-of-the-art high performance computing (HPC) facilities, a computer vision and machine learning lab, and other specialised classrooms, that were visited during the site tour. Researchers in FIT have a heavy teaching load as VUAS is predominantly a teaching university, leaving limited time to pursue their research interests. Researchers in VIRAC provide teaching at the University of Latvia, but this appears to be on a voluntary basis and not a requirement from VUAS. While Bachelor students from FIT do small research projects, they do not provide a substantial contribution to the research done at FIT/VIRAC as a whole. Master's and PhD students at VIRAC are typically enrolled at the University of Latvia or Riga Technical University. Because of the gap in the age profile of staff at VIRAC, some of them take on leading roles in the observatory, even before defending their PhD.

The unit scores very well for its research environment, mainly because of the presence of international-quality telescopes on site. There is still room for growth in the operation and equipment of these facilities, as well as the staffing to ensure their optimal use.

The main Q1 journals in astronomy, including ApJ, MNRAS, A&A, offer open access to their entire collection. Article processing charges are covered mainly from the budgets of the respective projects, or from the university's institutional funding. No information is given for publication in non-astronomy journals, e.g. for results in information technology coming out of FIT. The unit is rather weak in encouraging and ensuring publication in high quality open access journals.

Development potential
Score 4: very good

VIRAC has potential to become a strong international player. The telescope itself is of world-class quality and provides a valuable extension to the European VLBI Network (EVN), operated by JIV-ERIC. Its geographical location provides a unique baseline of astrophysical importance to the interferometry array.

The site also hosts a LOFAR station, built by VIRAC using funds acquired by them. LOFAR is a low frequency array centred on ASTRON in the Netherlands, for which Ventspils also provides a unique baseline enabling key science. At the moment, however, the LOFAR array is being upgraded into LOFAR2.0, for which the local station needs a technical upgrade (about €220k), followed by a €100K annual membership fee, to be paid by the Latvian government on behalf of the entire Latvian astronomical community. Participation in LOFAR2.0 would provide access to a state of the art facility, and connect Latvian radio astronomers with the top researchers in the global field. LOFAR, and its successor LOFAR2.0 are stepping stones for potential truly paradigm-shifting and trail-blazing facilities such as the Square Kilometre Array Observatory

(SKAO), currently under construction in South Africa and Australia. When completed, the SKAO will be by far the largest and most expensive astronomical observatory ever built, and it comes with a unique set of challenges, in particular in relation to data processing and data science, to which Latvia can contribute through VIRAC. SKAO is governed as a treaty organisation, headquartered in Manchester, UK. Participation in a treaty organisation like SKAO or the European Southern Observatory (ESO), which co-operates ALMA, is beneficial for the member states through bidding for contracts with the treaty organisation. This has the potential to benefit Latvian research institutes and high-tech industry, and provides a good return on investment. The member states will also have a seat on the council of such organisations, regardless of the size of the member state, and it is thus well known that participation in such research-oriented treaty organisations disproportionally benefits the smaller member states.

The technical laboratories at VIRAC are currently building, upgrading and maintaining astronomical instrumentation for the RT -32 and RT-16. The L, S, C and C band receivers are currently operational on RT-32, with the S, C, and X band corresponding receivers on RT-16, for local interferometric observations, with a 600-m baseline. Future receivers, currently under development include the Ka band, and an upgrade of the X band receiver.

VIRAC is also a member of the RADIOBLOCKS consortium, a Horizon Europe research infrastructure programme geared towards the data generation and processing in radio observatories, from observation to final product.

With the technical expertise related to the refurbishing, maintenance (RT-32 and RT-16) and building (LOFAR) of telescopes, and the experience in operations, data acquisition and processing, VIRAC is interested in exploring participation in existing (ALMA) and future (AtLAST) radio observatories, as well as the afore-mentioned SKAO. New and continued participation in international telescope projects further consolidates access to and participation in the broader European and worldwide astronomical community, and will be a driving force to further develop Latvian (radio) astronomy.

The attraction of international staff is challenging, in part due to the remote location of the site. A counter example is senior researcher Valery Nakariakov who has a joint appointment between VIRAC and the University of Warwick. He has recently (in June 2025) won an ERC advanced grant, for the second time in his career. Although he will officially hold this grant in Warwick, it will affect research activities at VIRAC as well.

There are some challenges that are holding back the growth of the research institute:

First, VUAS does not have a degree programme in physics, and does not independently offer PhD degrees at all, in any discipline. It does offer PhD studies in economics and business and l language and literature studies jointly with other higher education institutions. A joint PhD programme with three other European universities is currently being established, in the field of "International Socio-technical Systems Engineering". It is not clear whether this programme would support PhDs in physics, although "astronomical aspects" are included. Thus, VUAS is missing the actual user base required for VIRAC to operate competitively, and graduate students are recruited from the University of Latvia and other universities.

Second, VIRAC is listed as an engineering research facility, and while advanced engineering certainly takes place in connection with VIRAC, it is rather an astronomical research facility, which is supported by engineering activities, related to the operation and development of the facility for astronomical research purposes. Ultimately, astronomical questions drive research at VIRAC.

Next, VUAS is a small university focused on teaching and lacks a tradition of doing faculty research. Newly recruited faculty members are encouraged to undertake research however, but so far the one new recruit the Expert Group interacted with, working in computer science, has not shown an interest in doing a research project related to astronomical data science.

Further, the size of the astronomical research staff at VIRAC is limited, and telescope time is undersubscribed. Fortunately, there is strong demand from the Ministry of Defence for about one third of the total telescope time, against payment. There are also other non-astronomical applications, such as the Deep Space network enabling communication with spacecraft. The funds raised by providing these services are used for telescope maintenance and management of the institute in general.

Finally, the staff age profile is problematic. There are many young researchers under the age of 40, but the age range 40-50 is almost completely missing. This is leading to the strange situation that some of the staff members with important roles in the observatory are formally still PhD students or degree candidates.

The combination between FIT and VIRAC poses additional challenges in staffing the two departments. FIT attracts mainly local students for its undergraduate degrees, in line with VUAS' regional mission. Because of its highly specialised research topic, VIRAC has to cast its net wider, and is finding it difficult to attract students and staff to the institute, especially from abroad, due to its remote location. Students and staff have offices in the town of Ventspils, and, depending on their job description, work at the observatory only part of the time.

Potential to offer doctoral studies

VIRAC is the prime location for PhD research in astronomy in Latvia. It has top-level observational facilities, and is a member of key international infrastructures and networks, giving access to top international researchers. It also has leading researchers in theoretical astrophysics and other non-radio astronomy fields amongst its staff, and could increase its contribution to doctoral education if it were given national rather than regional status in the research and higher education system.

However, the main drawback for doing PhD research at VIRAC is that VUAS, is not a PhD granting institution, and it also does not have a study direction in physics and astronomy. A recent attempt to set up a joint PhD programme with the University of Latvia, Riga Technical University and the University of Tartu (Estonia) failed because of the remoteness of the Ventspils location. A current application to set up a joint PhD programme entitled "International Socio-technical Systems Engineering" with universities in Latvia, Portugal and Austria is under evaluation. If successful, this programme may improve the situation somewhat, but it still does not offer the physics and astronomy PhD degrees required to drive a world-class astronomical observatory, although the programme includes “astronomical aspects”.

Currently, most PhD students pursuing a degree in astronomy at VIRAC are enrolled at the University of Latvia or the Riga Technical University, effectively treating VIRAC as an independent research institute or a national observatory. This means that graduate student support is typically offered through these universities, and differ from student to student. Students also have different requirements for graduation, depending on the university where they are enrolled. The students are typically offered employment contracts by VIRAC however, so are listed among the staff.

Alignment with the Smart Specialisation Strategy

Alignment with the Smart Specialisation Strategy within FIT/VIRAC lies in two of the RIS3 areas: "Photonics and smart materials, technologies and engineering systems" and "Information and communication technologies (ICT)", with VIRAC contributing to both areas, and FIT mainly contributing to the second area. The technology developed in VIRAC offer solutions in radio astronomy, satellite communications, and sensor systems, radio-frequency interference, and all related aspects, ensuring know-how and competitiveness in science, engineering and international space industry ("Photonics and smart materials, technologies and engineering systems"). In the area of "Information and communication technologies (ICT)", the expertise in

data processing and computing at VIRAC, as well as the machine learning research at FIT are highly relevant. FIT and VIRAC train competent staff in both areas that are entering the Latvian workforce, and there is also information exchange and spinoff into industry in these areas.

Conformity with state scientific and technology development

FIT/VIRAC conforms with all five objectives and priorities of the *Science, Technology Development and Innovation Guidelines 2021-2027*, where the Expert Group, once again wants to highlight specifically the effort towards the second bullet (research excellence competitive positioning in Europe), for which the radio observatory has already proven to be a great asset to forge these international collaborations. The unit also does well on the other points, given its size, which immediately makes clear its weakness: the relative lack of senior scientists in its institute demographic. Additionally, the internationalisation of work done at the institute, is on the one hand of high level, through the participation in international projects (JIVE, LOFAR, RADIOBLOCKS), and the connection with the international space industry (Deep Space Network), but on the other hand is lacking, due to limited exchange at the human resource level. The unit employs very few international researchers.

The unit also does well in conforming to the priorities and objectives of the *National Industry Policy Guidelines 2021-2027*, as is already highlighted in the economic impact above. FIT delivers a steady flow of trained graduates that find employment locally and more widely. VIRAC collaborates with the global Space industry, and furthermore, the activities at the observatory drive high tech engineering collaboration with local and international partners.

Recommendations

- Increase the fraction of publications in Q1 journals. Especially, authors publishing in astronomy should aim for Q1 journals, conforming to the norm in that field.
- The Expert Group recommends that there should be an evaluation of whether VIRAC can act as an independent national observatory, which would be a (partially government-funded) resource for the Latvian astronomical community as a whole. Additionally, VIRAC should consider formalising its links to the University of Latvia, which offers the nation's only astrophysics PhD programme. Such a reorganisation would enhance the competitiveness of the research infrastructure present at the Irbene site.
- Aided by the analysis provided in this report, the unit should devise a strategy for synergy and collaboration between FIT and VIRAC, defining, growing and exploiting common goals and objectives. At present, there is insufficient synergy between the two parts. VIRAC is a research facility in the natural sciences, while FIT gravitates towards providing education and training in the field of engineering. The scientific output of FIT is limited and generally not relevant to the research performed at VIRAC. Members of the VIRAC staff who are teaching do so at FIT and the University of Latvia, and astronomy PhD students are also enrolled elsewhere.
- The Expert Group recommends that the participation in LOFAR2.0 is formalised. This requires an upgrade of the LOFAR facility to meet the standards of LOFAR2.0, for which the unit should apply for funding, and the ERIC membership fee for which the government ultimately would be responsible, on behalf of the entire Latvian astronomical community.
- As VIRAC is a prime research facility in astrophysics, the Expert Group recommends the unit to ensure that it will offer a full astrophysics PhD, either through the new EU PhD programme being set up, or through the formalisation of a joint PhD programme specifically in the field of astrophysics between VIRAC and the University of Latvia. Participation of Riga Technical University can also be considered, especially to allow for PhDs in astrophysical instrumentation.
- At the moment some key positions within the observatory are held by degree candidates. One or more senior astrophysicists (mid-career or up) should be recruited to provide additional leadership to VIRAC, and increase the ability of VIRAC to apply for ERC grants,

for which you need to be a PhD holder. Senior hires will also enhance the international visibility of the institute.

- VIRAC should use its already existing international connections, through the ERICs and otherwise, to apply for various forms of European funding. Parts of this funding should be used towards a visitor programme, for eminent radio astronomers to spend weeks or months at VIRAC, teaching and working with local staff and students. For example, several bilateral arrangements exists, and the Expert Group recognises that VIRAC has already successfully applied for an exchange programme with CSIC, Spain, and encourages the unit to build on this success.
- Because of its limited staff size, and limited resources, VIRAC should further align its research programme with the available infrastructure, related to radio astronomy. This means that further reduction of non-aligned research lines should be considered, while actively promoting research areas (including theoretical astrophysics) with demonstrable links to radio astronomy. This can probably be achieved by natural demographic evolution of the institute, and by assuring that new hires occur in the areas aligned to the radio astronomy mission of the observatory.
- An upgrade of the visitor centre at VIRAC to modernise it and increase the educational and outreach value is desirable. Because of tourism in the area, there is a high level of interest in the site, and this is clearly an opportunity to educate the population about science in general and astronomy in particular. This may ultimately also have a positive effect on student numbers in STEM, which we have been hearing about at all natural sciences institutes that have been visited. Given the possible effect on STEM student numbers, involvement of the University of Latvia should be explored in improving the visitor centre at Irbene, and/or setting up an astronomy-themed VIRAC/University of Latvia visitor centre in Riga. Funding to improve and enhance a visitor centre may be available from the local government and national government through channels other than those used to support scientific research.

N_3 Daugavpils University Research programme "Natural Sciences"

1.1.5. The unit

The Daugavpils University (DU) is a research university. Its research programme in natural sciences was established in 2001. The vision of the programme is to be a centre of excellence at the Baltic level, providing an ecosystem for knowledge and technology transfer. The unit aims to be active within the scientific community both regionally and globally, focusing on high-quality scientific outcomes and building an ecosystem for knowledge transfer to the public sector, enterprises, and other research institutions. The university collaborates with stakeholders including state institutions, municipalities, businesses, and other scientific institutions. It plays a significant role in the regional scientific landscape, particularly in the fields of biosystematics, biodiversity, and environmental sciences.

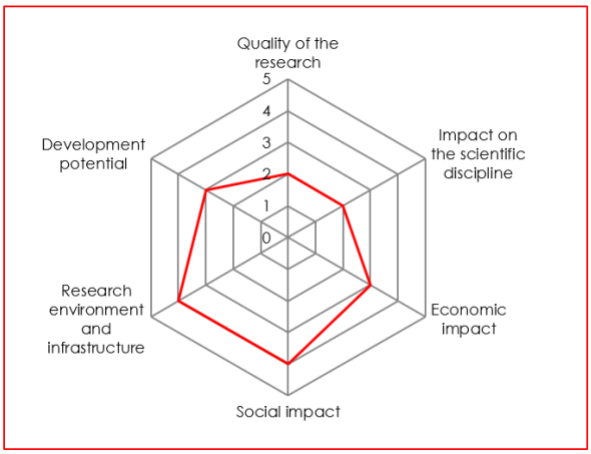
Research in the field of biology covers several main areas, including biosystematics, biodiversity, coleopterology, behaviour ecology, parasitology, hydro-ecology, and botany. The university emphasises interdisciplinary research, integrating biology with chemistry, physics, and mathematics. These interdisciplinary fields cover nano-biotechnologies, biosensorics, digital holography, synthesis and research into fluorescent compounds, and nonorganic chemistry. The university's research contributes to both basic and applied science. It has a significant involvement in nature conservation and biodiversity protection projects, aligning with national and international conservation efforts.

1.1.6. Expert Group evaluation

The figure below presents the scores assigned by the Expert Group to the unit.

Figure 3 Daugavpils University Research programme "Natural Sciences"– Scores

Criteria	Scores
Quality of the research	2
Impact on the scientific discipline	2
Economic impact	3
Social impact	4
Research environment and infrastructure	4
Development potential	3
OVERALL SCORE	**3**



Overall score
Score 3: good

The overall score (good) reflects that the Daugavpils University research programme "Natural Sciences" (henceforth DUNS) is a strong national player, performing fundamental, applied, and interdisciplinary research. DUNS provides education, expertise, and advice frequently sought by national ministries and agencies as well as international partners. Collaboration and communication with stakeholders and the general public are ambitious and well developed. Interactions with the private sector are at a level that is expected of recognised academic

institutions, and the research is important for the economy. The research, expertise, education, collaboration, science communication, policy development, and outreach activities directed towards diverse target groups and stakeholders stand out and are likely to have a substantial impact on society and regional development, particularly in the areas of biodiversity protection, conservation planning, environmental monitoring, and public education. Together, this translates into good economic impact and very good social impact. The overall visibility and impact of the research on the global scientific community is adequate but limited, although the institution has good international recognition in certain areas of biology and provides valuable resources for researchers in specialised disciplines such as taxonomy, systematics, and biodiversity of some taxonomic groups. The quality of the research, as evidenced by bibliometric statistics and acquisition of competitive funding, is below average by national and international comparison. In terms of dissemination, the publication strategy seems to prioritise quantity over quality. However, the combination of a very good research environment, excellent infrastructure, good availability of support services, a well-developed long-term strategy for goal-oriented research, and a clear vision contributes to a good potential to strengthen its position and impact, and to become a strong international player. A modified publication strategy, aiming to increase submissions to top-tier journals, may induce a self-reinforcing loop whereby the strife for excellence, improved quality, and contributions in prestigious journals will increase visibility, competitiveness, participation in international collaborative projects, interactions with the international scientific community at large, and external funding.

Quality of Research

Score 2: adequate

The quality of the research performance is adequate. DUNS is a strong national player in certain areas, conducting both fundamental and applied research, with a focus on 'green' biology and environmental sciences (e.g., biosystematics, coleopterology, botany, hydro-ecology), aiming to develop and strengthen multi-/interdisciplinary cooperation with chemistry, physics, and mathematics. The Expert Group finds it discomforting that the self-assessment does not clearly describe the latter three disciplines, nor the development of interdisciplinary research. There were also no representatives of these three disciplines present during the site visit interviews with staff members, making it difficult to assess research in these areas.

Performance in terms of number of papers published in Web of Science (WoS) or Scopus journals is adequate and shows a positive trend. Most contributions are directly related to traditional Biological Sciences (e.g., zoology, entomology, ecology and biodiversity), but contributions from engineering, biochemistry, genetics and molecular biology, physics and astronomy, mathematics, and chemistry have increased, according to the self-assessment. However, although publication output is good in terms of quantity, the Expert Group thinks there is reason for concern when it comes to quality. Only a low proportion of the papers are published in top journals (<20% in Q1), citation impact is weak both by national and international standards, and the disciplinary diversity of authors is relatively low. That 4 of the 9 selected full-text publications during the evaluation period were published in 'predatory' journals (MDPI) also does not provide testimony of scientific excellence and raises the question whether the publication strategy would benefit from being revised.

The number of doctoral theses defended during the evaluation period is good and has increased compared with the previous period. However, the Expert Group notes that several doctorate students exceed the expected time-to-degree and is concerned that the expectation to publish one paper per year, together with encouraging doctoral students to publish in 'inhouse' journals (e.g., Acta Biologica Universitatis Daugavpiliensis and Baltic Journal of Coleopterology) does not necessarily benefit quality, international impact, or future career development. The relatively low number of post-doctoral researchers and incoming researchers may suggest that early-career researchers do not regard DUNS as an attractive or competitive environment.

DUNS holds significant biological collections and provides specialist expertise, thereby strengthening its international and national research relevance and positioning in systematics and biodiversity research.

The environment has attracted some EU-projects (e.g., Horizon 2020, LIFE, Interreg, and BiodivRestore) during the evaluation period, although seemingly not as coordinators. Competitive external funding acquisition relative to base funding is relatively weak and - contrary to what is stated in the self-assessment – has declined substantially between 2019 and 2024 in both absolute amounts and relative to base funding.

According to the self-assessment, the strategy is to cooperate, develop research directions that complement existing niches, and avoid competition. Due to an evidence gap regarding comparative quantitative performance measures in the self-assessment the Expert Group is prevented from evaluating the performance of research at DUNS relative to its leading scientific competitors.

Impact on scientific discipline

Score 2: adequate

The impact of DUNS research on the field of science is adequate. The researchers are involved in major international biodiversity and biosystematics oriented scientific networks (e.g., GBIF, CETAF, Baltic CERN, NACEE, various museums, IUCN), enabling the integration of Latvian biodiversity research into European and global programmes. Participation in externally (EU) funded projects, albeit not as coordinators, contributes to strengthening international impact. The expertise of researchers at DUNS is sought by national authorities and international partners. Although DUNS is a relatively strong national research player in certain areas (e.g., biodiversity and nature conservation), the overall international impact, recognition, and visibility appear modest and relatively narrow. Although scientific output is adequate, the published work attracts limited attention. There is a low proportion of highly-cited papers by national and international standards, and a low field-weighted citation index of 0.58, compared with the global average of 1.0. and relatively few invited plenary talks and conference contributions. The Expert Group acknowledges that the significant collections (World Beetle Collection, DAU Herbarium) and databases managed by the institution provide important services to national and international research on taxonomy, systematics, ecology, parasitology, and biodiversity, particularly within the landscape surrounding the Baltic Sea.

Economic Impact

Score 3: good

The economic impact is good. The Expert Group recognises that DUNS has mainly orientated its research activities towards the understanding, management, conservation of biodiversity, and sustainable utilisation of ecosystems. In so doing, the unit contributes to economic development primarily through knowledge transfer, ecosystem-related services, and specialised expertise that supports sustainable use of natural resources. As such, part of the research is of relevance for the public sector, including government institutions, municipalities, and large enterprises via the provisioning of expert evaluations, environmental impact assessments, policy development, and training of human capital. Given DUNS' thematic specialisation, the level of direct interactions with economy and the private sector is relatively limited. Physics has more interaction with the private sector, because of its industrial relevance. Collaborations with stakeholders indirectly support the bioeconomy by improving ecosystem services, water-resource management, and biodiversity-based tourism. The Expert Group acknowledges that the recent establishment of centre REBUS in 2024, aiming to strengthen partnership with businesses in the Latgale region and to foster knowledge transfer and commercialisation, and participation in the EU/World Bank "Catching-up Regions Initiative" (CuRI), aiming to improve business environments in Latvia's border regions is commendable. DUNS also contributes to workforce and skills development by training students in STEM fields,

thereby supporting labour-market competitiveness, economic impact, and regional development. The Expert Group acknowledges that the 11 societal stakeholder and industry representatives that were present during the site visit meeting with stakeholders unanimously testified to the significant importance of the interactions and collaborations with the institute.

Social impact

Score 4: very good

The social impact of DUNS is very good. The Expert Group recognises that the scientific, educational, collaboration, science communication, policy development, and outreach activities directed towards diverse target groups and stakeholders likely have a substantial impact on society, particularly in the areas of biodiversity protection, conservation planning, environmental monitoring, and public education. Researchers at DUNS participate in various projects (e.g., protected insect species list, OPTAIN HORIZON, BETTER LIFE, REBUS) and commit as experts and advisors in international and national bodies, networks, and non-academic organisations concerned with nature conservation, biodiversity protection, and management planning (e.g., IUCN, GBIF, Nature Conservation Agency, Nature Protection Department at Ministry of Environmental Protection and Regional Development, Latvia's State Forests), of ultimate relevance for public health. DUNS provides guidance and analytical support for regional environmental planning, contributing to sustainable land- and water-resource management. This contributes to improving societal resilience and quality of life, illustrating high national relevance. DUNS provides teacher training, school outreach, citizen-science activities, and STEM promotion activities, thereby promoting environmental awareness and scientific culture in society. Researchers at DUNS are involved in the dissemination of research findings to the public via different popular activities, events, and communication channels. It also contributes to science literacy and public understanding of the significance of science and the promotion of higher education. Continued strengthening of communication interfaces and participatory research initiatives will further expand DUNS's societal footprint.

Research environment and infrastructure

Score 4: very good

The environment and infrastructure for conducting research at DUNS is very good. The Scientific Council (or Research Council – both are mentioned in the self-assessment) of the institute is responsible for the management of research and the achievement of the KPIs relevant to Natural Sciences. As of recently (2022), the research environment is built on the strategic specialisation area 'Natural Sciences' with a strong core of biology and environmental sciences complemented with other disciplines (chemistry, physics and mathematics) providing interdisciplinary cooperation and support, according to the self-assessment. The formation of the new plant nano-biotechnology research direction appears to be a successful outcome of the multidisciplinary approach, alongside with behavioural neuroscience and pollinator biology. DUNS has implemented significant infrastructure modernisation projects aimed at improving educational and research opportunities. However, there is an evidence gap in the self-assessment regarding whether and how organisation, management, decision making, and financial incitements have been designed to foster interdisciplinary collaboration. The goal orientation focuses on being recognised and active within the scientific community in the Baltics and globally; high-quality scientific outcomes and long-term collaborations; and knowledge transfer. DUNS benefits from new spacious facilities and well-equipped modern laboratories, also by international standards, allowing for advanced educational and research activities in diverse areas are available at The Laboratory Campus in the centre of Daugavpils. Investments through European Regional Development Fund programmes have strengthened facilities in molecular biology, microscopy, flow cytometry, aquaculture systems, and environmental genomics, supporting both basic and applied research needs. The Expert Group notes that laboratory safety issues pose a challenge in need of future attention. Infrastructure for field biodiversity research, limnology, forestry, and significant insect (beetle) collections are available at the Study and Research Centre 'Ilgas', and Herbarium Universitatis

Daugavpiliensis offers equipment for experiments and premises for the huge plant collection. Adequate digital and data-management capacities, including access to research databases (e.g., Scopus, WoS, Science Direct), GIS platforms, biodiversity databases, and cloud storage solutions are available. Together, this offers distinct advantages for biodiversity and ecological studies.

The Expert Group notes that although the self-assessment lists several main interaction channels, the mobility, level of international exchange, and recruitment to the DUNS environment of doctoral students, specialists, and visiting researchers are relatively low, and are likely to be limiting the development of high-quality research. The Expert Group is concerned that funding for infrastructure has declined during the evaluation period, alongside with total funding, and by that the number of technicians and research assistants required for maintenance of laboratories and equipment has dropped and appear to be in short supply. The Expert Group recognises that the institute's strategy for the development of scientific personnel for the 2022-2028 period includes measures and priorities to remedy these issues, but questions whether this will be sufficient. The Expert Group notes that, except for a statement in the SWOT analysis of the self-evaluation report that 'The scientific workload of staff is not balanced', there is an evidence gap in the self-assessment regarding staff teaching and training workload, and the ratio of students involved in research. The Expert Group notes that researchers at DUNS adhere to all three Open Science pillars via membership and participation in the OpenEU alliance, CETAF, GBIF, plutoF, NACEE databases, and involvement in citizen science activities for co-creation of knowledge in collaboration with stakeholders.

Development potential

Score 3: good

The developmental potential of DUNS is good. The capacity to participate in international competition seems excellent, particularly in the sense that the necessary infrastructure, resources, and strategic vision appear to be in place. The relatively low proportion of publications in prestigious and high-quality journals and limited international visibility and impact, according to bibliometric statistics, together with the declining acquisition of external competitive funding during the past evaluation period leaves opportunity for increased aspiration and improvement. This can probably be realised in part by a modified publication strategy and increased international mobility and collaboration and may facilitate future involvement in promising international projects and networks.

Looking back, the Expert Group notes that some but not all positive outcomes listed as results of the measures implemented in response to the recommendations put forward in the previous (2019) separate evaluations of the research programmes "Mathematics, Physics and Chemistry" and "Biology" are supported by the information in the self-assessment, leaving room for continued development and improvement.

Looking ahead, the Expert Group acknowledges that DUNS has decided (2022) on a strategy and identified priorities to strengthen research capacity, foster interdisciplinary collaboration, and increase international competitiveness, with the specific long-term goals to enhance research excellence, promote innovation, and ensure sustainable infrastructure development. The research strategy lists several well-developed specific objectives to fulfil these goals.

The establishment of the REBUS centre reflects an intention to deepen collaboration with industry and regional stakeholders, creating a platform for applied research, innovation partnerships, and technology transfer. The doctoral school model, internal support schemes for early-career researchers, including internal grants and English Program, measures to incentivise high-quality outputs, and quantitative criteria for selecting scientific personnel indicate a proactive approach to talent development and long-term capacity building. DUNS demonstrates potential and ability to develop new research directions. Examples include newly initiated research on pollination ecology, species distribution models using GIS-based approaches, as well as more novel lines of investigation related to neurotransmitters and

behaviours, new interdisciplinary research on plant nanobiotechnology, and materials characterisation. Measures to strengthen communication and better integrate representatives from different scientific disciplines in governance, strategy-building, and decision-making may improve the institute's developmental capacity.

The Expert Group observes that research in 'green' biology (including environmental and biodiversity monitoring) is changing rapidly due to the development of new tools (e.g., sequencing techniques, eDNA, barcoding, and meta-barcoding). Integrating such methods with traditional approaches would promote future visibility and impact of the Institute. Artificial intelligence (AI) plays an increasingly important role in research. While this brings with it several opportunities for the collection, compilation, and analyses of data, as well for the reporting and dissemination of results, it also comes with potential pitfalls. The Expert Group notes that these issues were not mentioned in the SWOT analysis. The Expert Group agrees with the SWOT analysis in the self-assessment that there is an urgent need to reverse the negative trend of external funding, declining academic staff/human resources including the number of professors and docents, and fewer MSc students, as the current situation poses a constraint on developmental potential. The institute faces structural challenges, including demographic pressures and competition for qualified researchers. The Expert Group notes that the self-assessment of research quality, impact, and international standing does not align well with the bibliometric statistics at hand. The Expert Group agrees that the institute may benefit from an increased demand for research and scientific expertise on biodiversity in the wake of climate change, and from opportunities for EU-based funding and cooperation.

Potential to offer doctoral studies

DUNS offers three Doctoral study programmes: Biology; Mathematics; and Solid State Physics; but the latter two are not clearly described in the self-assessment. The ability to support doctoral studies in biology is facilitated by physical infrastructure, including very good laboratory facilities, specialist equipment in molecular and ecological sciences, and the Ilgas research and field facility, which provides unique opportunities for field-based studies and long-term ecological research. According to the self-assessment, there is an ambition to integrate in the doctoral training the multi- interdisciplinary cooperation and approach that is emphasised in the overall research strategy. Social and educational support was recently (since 2024) strengthened by the establishment of the Doctoral School in Biology, accredited in two languages. It is a platform for the development of research competences, international cooperation, networking, and scientific communication directed at doctoral students, doctoral degree applicants, post-docs, and other staff. It provides academic support, mentoring, supervision, and research infrastructure. The students also have access to exchange and mobility programmes (e.g., Erasmus).

In terms of size, 12 doctoral theses were defended in the period 2013-2018, compared with 20 during the period 2019-2024. It is not stated in the self-assessment whether these numbers represent Biology alone or are summed across the three programmes. There are also mixed messages in the self-assessment regarding the number of doctoral students. The Expert Group is concerned by the relatively high proportion of doctorate students exceeding the expected time-to-degree. The Expert Group questions why doctoral students are expected to publish one paper per year, as there is a risk that a publication strategy that prioritises quantity and speed over quality will become permanent and jeopardise their future career development. Demographic constraints and competitive recruitment conditions remain challenges, particularly regarding attracting international candidates. The Expert Group is concerned that the seemingly low number of students, combined with relatively limited mobility and international exchange, declining external funding, low ambition regarding research quality, and modest international visibility does not provide a particularly attractive, strong, intellectually stimulating, and creative training environment for doctoral students, postdocs, and early career researchers. The Expert Group is also concerned that the declining number of MSc students will limit the future recruitment of doctoral students and young researchers. The

Expert Group acknowledges that the doctoral students interviewed during the site visit stated that they were very pleased with the training environment, despite that their conditions and financial situations varied considerably.

Alignment with the Smart Specialisation Strategy

DUNS demonstrates a clear and credible alignment with Latvia's Smart Specialisation Strategy (RIS3) areas. Regarding *knowledge-intensive bioeconomy*, DUNS contributes via inter-disciplinary projects, biosystematics, ecosystem services, nature-based innovation using knowledge of natural processes and structures and applying them in policy development and implementation *and monitoring of the development of sustaina*ble environmental protection (forestry and agriculture). Regarding *smart materials, advanced technologies, engineering systems,* DUNS provides research in nanotechnology and materials characterisation. The institute contributes to implementation of green-transition priorities through participation in EU and national research programmes that address ecosystem restoration, climate resilience, genetic resource protection, and biodiversity monitoring, and by providing science-based input to public authorities and protected-area management. Engagement with regional development initiatives and the establishment of the REBUS research-industry collaboration platform further reinforce innovation capacity. The concrete contribution to the overall objective of supporting economic transformation through innovation, added value, productivity, and resource efficiency is difficult to assess based on the self-assessment. While scientific and policy contributions are strong, continued expansion of collaboration with private-sector bioeconomy partners and applied biotechnology stakeholders would enhance RIS3-aligned innovation potential.

Conformity with state scientific and technology development

DUNS has a proven track record of national natural sciences applied and basic research, particularly in the fields of biodiversity and conservation, biosystematics, and environmental sciences. The institution is working towards attracting new students and promoting the career development of doctoral students and young researchers, it supports human-capital development through initiatives in STEM education and teacher training, and it also participates in the ERASMUS-LS Open European University programme for strengthening higher education. DUNS is well integrated in regional and international networks, contributing to policy frameworks, and the overall research community, with the mindset to develop complementary expertise rather than compete with other institutes in Latvia and neighbouring countries in the Baltic Region. DUNS provides scientific expertise to ministries, municipalities, and national environmental agencies. It provides a solid foundation for Latvia's compliance with EU directives on biodiversity, habitats, and water management, while also aligning with national priorities for climate and ecosystem protection. DUNS contributes to the objectives of national science, technology, and innovation development policy via participation in EU projects (e.g., Life for species, ERA-NET, and Horizon Europe) and implementation of conservation policies (e.g., Natura 2000, protected species lists) aligning with the European Green Deal objectives, by advisory board membership, and the recent (2024) establishment of Research and Business Centre (REBUS). Although DUNS plays a pivotal role in the realm of evidence-based environmental policymaking and sustainable-development implementation, the Expert Group is of the opinion that there is potential to contribute more to strengthening science and innovation, research excellence, and the translation of research into societal impact, including improving collaboration with industry.

Recommendations

To enhance performance over the next six years, the Expert Group advises DUNS to:

- Develop a more selective publication strategy. This should prioritise Q1 journals and internationally reputable outlets. This will enhance visibility, citation impact, and research quality.
- Strengthen interdisciplinarity by formalising collaborative structures between biology, chemistry, physics, and mathematics. It is also essential to ensure cross-disciplinary participation and inclusion in governance, strategy setting and decision-making. A more efficient use of complementary areas of expertise may generate synergy effects.
- Increase its efforts to attract competitive external funding, especially from Horizon Europe and other EU framework programmes. It also needs to develop internal support for proposal preparation and project coordination.
- Enhance international collaboration through targeted mobility schemes, visiting scholar programmes, and active participation in leading international consortia.
- Strengthen doctoral training by revising publication expectations, improving supervision practices, developing mentoring, reducing time-to-degree, expanding mobility opportunities, and improving career development opportunities for doctoral students.
- Increase staffing in technical support roles. This will ensure the long-term sustainability of laboratory operations and research infrastructure.
- Develop well-structured policies on recruitment, tenure, and succession planning. This is the only way to address the challenges posed by demographic changes while also ensuring the continued maintenance of research capacity.
- Strengthen the translation of research into innovation. This can be achieved by expanding collaboration with bioeconomy partners, SMEs, and applied biotechnology sectors.
- Support the establishment of spin-offs and commercialisation pathways. This can be achieved by enhancing IP management capacities and offering entrepreneurship training.
- Enhance the monitoring and evaluation of interdisciplinary activities, research outputs and infrastructure use. This must be done in a way that ensures alignment with strategic objectives.
- Address workload imbalances and clarify expectations for research, teaching and service to ensure a sustainable and competitive work environment.
- Expand science communication activities, citizen science programmes, and public engagement initiatives to further strengthen societal impact.
- Integrate modern molecular tools (e.g., eDNA, barcoding, and meta-barcoding) with traditional approaches in environmental and biodiversity monitoring. This will enhance efficiency, visibility, and impact.
- Develop and implement a strategy to make efficient use of artificial intelligence (AI) tools in the collection, compilation, and analysis of data, as well as for the reporting and dissemination of results. This should also be integrated in doctoral training.

N_4 Latvian Institute of Aquatic Ecology, agency of Daugavpils University

1.1.7. The unit

The Latvian Institute of Aquatic Ecology (LHEI) is a scientific institute in Riga that has been affiliated to Daugavpils University, focusing on both fundamental and applied research. LHEI aims to become a centre of excellence in the Baltic Sea region, promoting sustainable blue bioeconomy. The institute aligns its research with broader environmental strategies and collaborates with Latvian and European entities to enhance the effectiveness of aquatic ecosystem restoration. LHEI aims to contribute to regional and international scientific communities through its research outputs and collaborations.

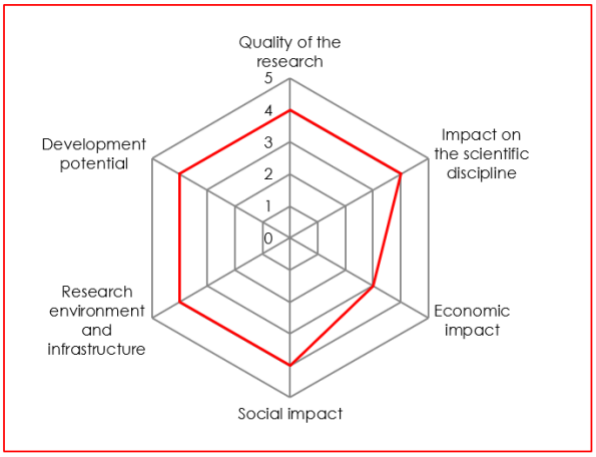
Research at LHEI is organised around research themes including marine ecosystem functioning, ecosystem approaches in maritime spatial planning, pollutant effects in aquatic environments, biological effects of pollutants, and non-indigenous species. In addition to research, it contributes to policymaking and environmental quality assessments. The institute emphasises interdisciplinary research, integrating academic and applied studies. LHEI collaborates with universities and other research entities to foster capacity building and attract talent through student involvement and international partnerships. Its research is primarily funded by the Latvian state and European funds, with a focus on developing infrastructure and human resources.

1.1.8. Expert Group evaluation

The figure below presents the scores assigned by the Expert Group to the unit.

Figure 4 Latvian Institute of Aquatic Ecology, agency of Daugavpils University – Scores

Criteria	Scores
Quality of the research	4
Impact on the scientific discipline	4
Economic impact	3
Social impact	4
Research environment and infrastructure	4
Development potential	4
OVERALL SCORE	**4**



Overall score
Score 4: very good

The LHEI was evaluated as a strong international player, with an overall assessment of very good. This reflects the very high quality of its research activities, outputs and impacts in the domain of aquatic and marine ecology. LHEI focuses on interdisciplinarity, seeking the boundaries of fields such as conventional marine ecosystem science requiring in-depth exploratory work and combines that with more applied work, including dealing with a variety of actual threats such as microplastics and other pollutants. A key aspect of its current work is taking a leading role in assessing the functioning of the marine ecosystems via novel measurements, parameters, and indexes such as heavy metals analyses and acoustic current meters. These tools are very much at the forefront of what society needs in order to be better

able to govern complex ecological entities. In terms of impact on the scientific discipline of marine ecology, LHEI has been very influential with respect to spatial planning, nutrient abatement by macro-algae, and microplastics. The LHEI institute could enlarge its staff by about 20%, based on income generated by commercial service contracts. These services are apparently provided via study contracts on ecological topics, which safeguards the policy of the institute to focus primarily on science and foster its independence. In view of its reliance on highly competitive funding, it is imperative that the institute set up a strategic long-term plan on how to become more resilient to changes in funding while further pursuing its role in scientific excellence and safeguarding marine ecosystem cultural heritage. That should include a plan for more adequate laboratory infrastructure. LHEI's potential in doctoral education is under-exploited, and it should prepare a transparent overview of its relationships with universities and other R&D institutions in the field of marine ecology to clarify and publicise how potential PhD candidates can obtain their doctorates at the institute.

Quality of Research

Score 4: very good

The quality of research at LHEI is very good both in terms of the quality of its publications and the efficiency with which they are produced. The institute is nationally leading and internationally competitive in applied and fundamental research in aquatic ecology and Baltic Sea marine ecosystems. LHEI has produced 64 publications in the period 2019-2024 – a significant increase compared to the previous evaluation period. Some 72% of the publications are in Q1 and 20% in Q2 scientific journals. For a team of about 40 people, this is quite efficient and supports LHEI's international reputation in aquatic ecology. It is noteworthy that this high scientific quality has been achieved mainly based on competitive funding.

LHEI's strategy emphasises interdisciplinarity, seeking the boundaries of fields such as conventional marine ecosystem science (e.g., documentation of non-indigenous species), requiring in-depth exploratory work and the necessity to deal with current threats such as microplastics and other pollutants, which is more applied. The most relevant current aspect is LHEI's work to generate adequate assessments of how marine ecosystems function using novel indexes. These indexes are at the forefront of what society demands from science, to enable better governance of marine ecosystems. The institute demonstrates a leading position in its field, for example, through the study by Armoskaite et al. (2020), which established an ecosystem service assessment tool. This work shows that LHEI is able to identify and respond to key priorities within its domain, while effectively bringing together diverse groups of scientists to develop shared, operational approaches to ecosystem evaluation and management.

Impact on scientific discipline

Score 4: very good

The impact of the research at LHEI on science is very good. The institute is involved in several formal and informal networks to interact with the international scientific community (e.g., HELCOM, ICES, SUBMARINER, Baltic Earth). The research publications during the evaluation period have very good citation impact (field-weighted citation impact 1.17), high average citations (11.6), and a very high proportion of highly-cited papers (15.2% of LHEI's papers were among the 10% of most-cited papers in their field), by both national and international standards. LHEI is working at the forefront of the assessment of marine ecosystem functions and the services these systems provide. A second area, demonstrating LHEI's leadership and international connections, is its prominent role in maritime spatial planning, for example in the BONUS BASMATI project. A third area where LHEI plays a leading role is in using tools that can clean up lakes by cleverly implementing the removal of nutrients using macro-algal cultivation (Eroldogan et al. 2023). The strong and strategic engagement of the institution in the detection, characterisation and determination of the spread and the dynamics of microplastic pollution in Latvian and Icelandic sea and lake waters is also noteworthy. Not only academic

publications and reports, but also more general awareness has been generated via various channels, including Nature News (https:/www.nature.com/articles/d41586-024-00535-5). These influential developments in aquatic ecology are reflected in a substantial set of publications in which the scientists of the LHEI take leading positions. Given that the scientific discipline is evolving rapidly, it is essential that LHEI critically explores the future evolution of these four areas of impact. For example, if the line of microplastics should lose its attractiveness, alternative lines of research must be available. This will allow LHEI to acquire sufficient expertise in time to gain dominance on the international scene. AI is rapidly being adopted in many if not most fields of science. It will be important for LHEI to use artificial intelligence in the study and management of marine ecosystems order to remain competitive as the field advances and to exploit the opportunities it provides for more effective analysis and discovery. AI makes it possible to overview large amounts of research data and improve the management of marine ecosystems. However, this needs to be underpinned by meaningful and financially sustainable targets. To be successful, this means that LHEI researchers should continue to enjoy the academic freedom to pursue priorities it itself determines in the field of marine ecology.

Economic impact
Score 3: good

While the economic impact of LHEI is good, it has deliberately chosen not to focus on direct industrial connections such as intensive aquaculture but to work for the good governance of natural resources, particularly open marine waters. LHEI is determined to commit to new practices, such as fish-producing aquaculture, despite the availability of alternative avenues, such as the use of mussels for the dual purpose of water improvement and fertiliser or animal feed.

The institute hosted an international conference 'Mission Arena' bringing together over 200 actors dealing with blue growth, social justice, conservation, and marine planning from 5 north European countries, emphasising sustainability and traditional coastal communities. This is most valuable for the overall social and cultural status of these countries.

Notwithstanding, its strong stand on basic science and the ecological aspects of the marine ecosystem, LHEI collaborates with two small Swedish firms. TRUST ALUM aims to mitigate eutrophication in the Baltic region; BioFloat focuses on enhancing green infrastructure and thus enhancing the biodiversity and health of habitats influenced by human activities.

The institute could increase its staff by about 20% – a substantial amount for this basic science orientated group – by exploiting potential income from commercial service contracts. These opportunities should be sought in study contracts on ecological topics, and not in routine measurements or straightforward practical advises. That would safeguard the policy of the institute to focus primarily on science, and foster LHEI's independence from powerful industrial players.

In view of the apparently positive experiences with the two mentioned SME's, LHEI should further explore in a broader international context to what extend small and medium sized firms, that have knowledge which can have economic value for the marine ecosystem functioning without infringing on the principles of sustainability, could profit from collaboration with the institute, and vice versa. To achieve this, a clear set of guidelines needs to be developed for such collaborations and broadly disseminated in the community of marine industrial entrepreneurs and marine policymakers. LHEI can increase its economic impact without compromising its focus on sustainability by collaborating with more institutes that share its focus on sustainability rather than intensive aquaculture. In that way, it can promote 'green activities and technologies', based on the results of its scientific research.

Since a large proportion of threats appear to come from the flow of runoff waters into the brackish coastal areas of the Baltic Sea, the institute could step up its capacity of detecting

and identifying in an early stage the responsible pollution source, and by doing so decrease the economic burdens that the respective receiving marine waters experience.

Social impact
Score 4: very good

The social impact of LHEI is very good. The institute addresses the preservation of the cultural heritage of the Baltic region, which has direct links with the sea and the aquatic ecosystems in the region, as a prime duty. The COOL BLUE Baltic initiative for the restoration of marine ecosystems and the advancement of regenerative aquaculture (in the non-industrial sense) are therefore of central importance for the Baltic area. The number of science communication activities has risen substantially in the last years to reach a remarkable 73 events in the 2024. Given that the institute employs about 40 people, this testifies to its commitment to societal impact. LHEI contributes to the Kolba exhibition, the European Research night in Riga, and to the Liepaja sea festival where the aspects of marine science are brought to life. There are also activities organised at schools and citizen science events (see Plastic Pirates) contributing to increase public interest and awareness of the importance of science. The institute communicates a great deal about the relevance of the research topics at LHEI, for instance in relation to the national regulations about invasive species, via social media channels such as Facebook, Instagram, LinkedIn, Twitter, and YouTube. The website of the institute is attractive and convincingly illustrates the topic of data collection via the institute's various marine monitoring stations. LHEI scientists play leading roles in the SEADITO network, focusing on social-ecological analysis and models for digital twin systems for oceans. There is engagement with stakeholders by means of publications which explain what sustainability means in everyday life, for example by involving stakeholders in Latvian marine spatial planning processes. Public debate is stimulated via newspaper articles and seminars. It is important and courageous that efforts are made to explain to the taxpayers that the breakdown of a variety of ecosystem functions and services will come at a cost to everyone.

Altogether, there is remarkable outreach to society but the aspect of 'you can come and work with us' – for instance as a student (internship or doctoral work) or as a small and medium enterprise – is not presented in an appealing way. Opportunities to cooperate with the LHEI on scientific and societal topics could be advertised more widely.

Research environment and infrastructure
Score 4: very good

The physical infrastructure of the LHEI is appropriate to an institute of its size. Although the available laboratory space and equipment are limited, they are clearly very well used, given the scientific output. However, there is scope for the institute to grow and deliver more scientific and societal value. In that case, the limited size of the laboratory facilities and the need for state-of-the-art instrumentation could constrain LHEI's ability to perform efficient work at the forefront of science in the future. There would be major benefits from having a larger investment . At present, infrastructure funding is of the order of €0.6-1.0m over 5 years. There is a need for an infrastructure funding line that provides a substantial and sustained increase beyond the present level. The current facilities should be improved in the future for an institute such as LHEI which produces top-level international R&D that needs to attract students and collaborators on the national and international arenas.

In view of LHEI's strong dependence on highly competitive EU Horizon funding, it is imperative that the institute sets up a strategic long-term plan that is resilient to reductions in the budget-lines for EU research, while strengthening its role in terms of scientific excellence and cultural heritage. The attempt to acquire some 20% of the budget from commercial cooperation is fine and can gradually be extended, albeit with care to maintain the independence of research.

LHEI has a strong management commitment to orient and boost its research. The institute stands for constant building of excellence, both in terms of output (see Publications, above) and the competence of the staff. A central factor here is that researchers are allocated a maximum of freedom to operate and have adequate mobility opportunities so that they at regular intervals can benchmark and boost their own work and ideas in a broader context.

LHEI has concluded the first phase of the open-access database LATMARE and strongly encourages its collaborators to pursue various dissemination openings, like the European Marine Observation and Data Network (EMODnet) platform. Although the staff is small, there is an atmosphere of fair and do-able workload, and there appear to be sufficient time and opportunities to think forward to develop new strategies and potential.

Development potential
Score 4: very good

The developmental potential of LHEI is very good. LHEI has developed a clear future vision. It stands for sustainable blue economy, and the maintenance of the marine ecosystem related cultural heritage in the Baltic Sea area. The approach is multi-faceted. This includes not only technical aspects (aimed at reducing pollution and developing new technologies such as cultivation of reeds and macro-algal systems), but also socio-economic themes (arming rural municipalities and authorities with legislative information and suggestions for adequate business development). The key denominator here is 'Knowledge Intense Bio-Economy'. That Flow Cytometry technology will be started up is in line with the need to gather and interpret large amounts of data. In that context, LHEI must soon decide how to deal with the opportunities that come with tools related to molecular biology. Next Generation Sequencing, eDNA, and metabarcoding, and the data these approaches generate, enable detection and quantification of the multitude of organisms in the marine environment in a very precise way. LHEI has at present no investment or standing expertise in these areas. However, the scientific staff has increased in numbers and competence, and is relatively young, which should make it possible to work in these areas.

While the trend in LHEI's external funding is strong and positive, the institute also faces two important threats, namely, demographic trends and the low overall level of base funding. To continue the current development of the institute, it is crucial to attract human capital from outside the Baltic region and to assure more income via services delivered to organisations (national and also worldwide) which operate and promote according to the principles of sustainable blue economy. At present, LHEI has no earmarked instrument to deal with economic development. It should urgently try to remediate this blind spot, for instance by setting up collaboration with a faculty or institute with expertise in macro-economics, or by means of joint doctoral programmes in which the financial side of marine sustainability issues are explored.

LHEI listed in its self-assessment a modest set of local scientific entities to be compared with. Notwithstanding current limitations of finance and infrastructure, the many international collaborations listed and its high-quality output status, entitle the institute to aim to be compared (taking scale into account) with well-known international institutes such as Ifremer in France.

Potential to offer doctoral studies

LHEI does not have its own established doctoral programme. Being an agency of Daugavpils University, it can find inspiration and support at its university partner institution, but these exchanges are not strong at present. It is therefore essential that the LHEI increases the opportunities for doctoral candidates to collaborate with it, via a transparent platform for

recruiting PhD students. Formalising with which universities and faculties LHEI can have co-promotorships for PhDs would be helpful. Opportunities to have two universities together with the institute providing a joint doctoral degree should also be explored.

Overall, the output of scholars of the institute is low (16 bachelors, 18 masters, and 4 PHDs in the period 2019-2024), but this is explained by the small numbers of staff available to supervise them. However, four post-doctoral grants have been received, which will generate extra opportunities to strengthen the training component of LHEI.

At the level of the PhD students, action is needed to provide opportunities to develop confidence and career planning, so that they dare to think and act internationally and to plan not only tactically but also strategically. The impression was that current PhD candidates feel and act like employees rather than as young talents with the ability and agency to explore new areas and find new knowledge in the domain of marine ecosystem assessment and the related blue bioeconomy.

Alignment with the Smart Specialisation Strategy

LHEI's work tends most directly to impact ecosystems and government responsibilities such as regulation. Its effect on the economic and social goals of RIS3 tend to be more indirect. LHEI is well aligned with the objectives of Latvia's Smart Specialisation Strategy, especially in relation to the priority on "Knowledge-Intensive Bioeconomy". It has helped the Investment and Development Agency of Latvia (LIAA) link international businesses to entrepreneurs in the Latvian blue economy, and supported development of innovative solutions to reduce human impact on the marine ecosystem as part of Mission Oceans – Latvia.

LHEI plays important roles in marine spatial planning, which affects blue economy opportunities such as offshore wind, the cultivation of macroalgae, and aquaculture, but also the planning of protected marine areas. LHEI thus helps support balanced and sustainable development of the marine economy.

LHEI also contributes to building Latvian capacity in terms of young researchers – not only those who stay in the higher education and research sector, but also those who eventually obtain government or private-sector jobs. As indicated above, it contributes to scientific excellence and has significant wider socioeconomic impact.

Conformity with state scientific and technology development

The LHEI is a very visible and highly reputable player in the field of marine science and addresses important objectives and priorities in the national science technology and innovation guidelines.

- It targets 'excellence building', in terms of interdisciplinary marine science and technology
- It contributes to the growth of human resources by training researchers able to work in both the public and private sectors, especially in the blue economy and the growing bioeconomy
- In maintains a Latvian presence in these fields within European and other international research communities, learning from and contributing to international research
- It contributes to both national and EU regulation, supporting national and European sustainable innovation
- It maintains and develops the national research infrastructure in its fields

Recommendations

To enhance LHEI's performance over the next six years, the Expert Group recommends:

- At the level of basic science, the LHEI should pursue its current path focused on assessment of the functioning of the marine ecosystems via novel tools, parameters, and indexes. The institute should continue its activities to communicate between scientists and policy makers and aim to become an international leader in this domain. Through its scientific expertise, it should help governments and authorities to better comprehend and govern various aspects of the Blue Economy.
- The concept of implementing artificial intelligence in the discipline of marine ecosystem study and management is valuable but needs to be underpinned by meaningful targets such as the open-access database LATMARE and explored in terms of attracting financial support from governmental and private sources.
- To deal more convincingly with the economic aspects, LHEI should embark on collaborations with experts in macro-economics and various aspects of technology transfer towards private industries interested in dealing with the sustainable use of marine resources.
- Explore in a broader international context the extent to which LHEI and small and medium sized firms with knowledge of economic value for the sustainable functioning of the marine ecosystem, could profit from collaboration to support sustainable economic development, and follow up such opportunities if appropriate
- Future-proof the laboratories and equipment, and invest in developing and extending the laboratory space. A key decision is – depending on decisions about LHEI's strategy – whether to invest in molecular biology tools and assessment matrices.
- Develop a plan for LHEI's role in doctoral and postdoctoral training. This should provide a transparent overview of LHEI's relationships with universities and other R&D institutions in the field of marine ecology and map the possible routes for candidates to obtain a PhD at the institute
- Ensure that the website of the institution not only provides information but clearly 'invites' people to join as researchers, project partners, or experts at the institute.

N_5 Latvian State Institute of Wood Chemistry

1.1.9. The unit

The Latvian State Institute of Wood Chemistry (LSIWC) is a research institute established in 1946. The institute's mission is to develop competitive materials and products from wood and other biomass using environmentally friendly technologies. Its vision is to be a Baltic centre of excellence in the bioeconomy, promoting biorefinery and sustainable building materials to reduce fossil resource use and contribute to Europe's zero-emission goals. LSIWC aims to align with broader strategies such as the European Green Deal and Latvia's Smart Specialisation Strategy, contributing to sustainable resource utilisation and circular economy principles. The institute is based in Riga and consists of six laboratories, each specialising in different aspects of biomass component research, including wood degradation, bioengineering, polymers, cellulose, biorefinery, and lignin chemistry.

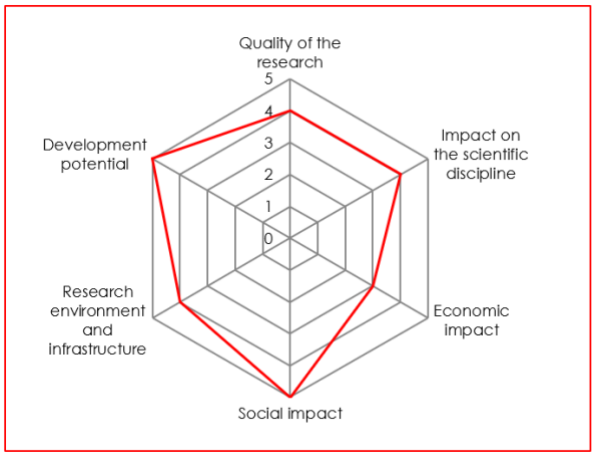
Research at LSIWC is organised around three main areas: wood materials with enhanced properties, biorefining technologies, and green chemistry and biotechnologies. The institute emphasises applied research and industry collaboration, contributing to sustainable forestry, waste valorisation, and wood preservation technologies. LSIWC fosters interdisciplinary collaboration across fields such as chemistry, material science, engineering, biology, physics, and environmental science. It actively participates in national and international projects, collaborating with industry leaders to scale biopolymer technologies for commercial adoption.

1.1.10. Expert Group evaluation

The figure below presents the scores assigned by the Expert Group to the unit.

Figure 5 Latvian State Institute of Wood Chemistry – Scores

Criteria	Scores
Quality of the research	4
Impact on the scientific discipline	4
Economic impact	3
Social impact	5
Research environment and infrastructure	4
Development potential	5
OVERALL SCORE	**4**



Overall score
Score 4: very good

The overall score of very good reflects a research unit that performs at a high level in several key areas, contributes meaningfully to national priorities, and demonstrates substantial potential for further development. LSIWC's research agenda addresses key challenges related to the sustainable utilisation of wood and lignocellulosic resources, the development of bio-based materials and products, and the advancement of resource-efficient chemical processes. Its work is aligned with national and European policy frameworks, particularly those supporting the bioeconomy, circular economy, sustainable materials, and the substitution of

fossil-based resources with renewable alternatives. Through this alignment, the unit contributes to long-term sustainability objectives while maintaining a strong scientific and technological focus.

The unit is a trusted provider of scientific evidence and analytical tools for government agencies and public authorities such as ministries and regulators. These contributions demonstrate strong societal relevance and underpin the unit's highest score: social impact. The unit's role at multiple levels is well established, and its interactions with ministries, regional administrations, and municipalities are strong.

The unit's research quality is solid, with clear scientific competence and productivity. However, the distribution of outputs across groups is uneven. Research teams should publish more in the international journals seen by researchers in the field as the leading ones, and actively participate in cross-border consortia. They should not focus primarily on applied or commissioned projects, as this can limit scientific innovation and academic visibility. The unit has a strong scientific impact overall, but this impact is not yet uniform across all research groups.

The infrastructure is good enough for core operations. Some of the six research laboratories are well equipped, while others require modernisation. The unit's self-assessment report lists the key items of equipment needed, in the context of a strategic equipment investment plan for the period 2025-2030, primarily using ERDF funds but also money from the Institute's basic funding and project income. Access to well-maintained analytical equipment, specialised laboratory facilities for wood and lignocellulosic materials, and accumulated experimental data supports the research environment. There have been significant recent investments in the Pilot-scale Hangar and the Liquid Chromatography Centre. However, administrative support for project management and research coordination is insufficient to fully support competitive proposal development and large-scale collaboration.

The unit has a modest but meaningful economic impact. LSIWC collaborates with industry and provides services that are directly relevant to economic sectors such as forestry, wood processing, and the bio-based materials industry. However, the depth of these partnerships is limited, and commercialisation pathways are not yet fully developed.

The unit's development potential is excellent. LSIWC must invest strategically in people, infrastructure, coordination and publication planning to enhance its national and international visibility. A clearer internal structure and a more proactive pursuit of competitive international funding are essential to consolidate its strengths and raise its academic profile. LSIWC is unequivocally a very good research unit with strong societal contributions and the capacity for notable future growth.

Quality of Research

Score 4: very good

The quality of research conducted at LSIWC is indisputably very good. This is a unit that is technically competent, thematically relevant, and significantly engaged in scientific development. The research portfolio covers both fundamental and applied aspects of wood chemistry, reflecting its dual role in advancing scientific understanding and addressing industry-relevant challenges. This positioning is well aligned with national research and innovation priorities and provides a sound basis for internationally visible research.

LSIWC's research is based on laboratory-centred chemical analysis and materials characterisation, complemented by experimental studies on the modification and conversion of wood and lignocellulosic materials. The unit's strengths lie in the integration of analytical chemistry, reaction studies, and structure–property investigations, allowing it to link chemical

composition and processing conditions with material performance. Experimental laboratory data provide the empirical foundation for process understanding and, where appropriate, for modelling of chemical reaction pathways and material behaviour. These approaches support the evaluation of wood-based materials and processes under different application-relevant conditions and contribute to the development of scientifically sound and industrially relevant solutions.

Overall, the bibliometric indicators clearly support a positive assessment of research quality. The unit produces a mixture of academic publications, technical reports and analytical outputs. The pattern of publication activity varies among groups. Some researchers publish regularly in reputable international journals with the polymer, biorefinery and lignin laboratories providing most of the sample papers listed in the self-assessment report. Others focus predominantly on applied or commissioned work, resulting in fewer peer-reviewed outputs. The self-assessment recognises this discrepancy and states that time pressures related to applied projects can limit capacity for academic publishing. The expert group recognises these constraints but emphasises the importance of balancing applied work with fundamental research and scientific dissemination.

Between 2019 and 2024, with the unit produced 333 academic publications that were indexed in WoS and Scopus. The compound annual growth rate was approximately 5-6%, indicating a steady increase in output. The field-normalised impact indicators (ARC and FWCI) are clearly above average (around 1.1, compared with the world average of 1.0), and the average citation rate per paper is comparatively high, placing the unit among the stronger Latvian performers in the natural sciences. Close to half of the papers are published in Q1 journals, which is a very good result in the national context. The proportion of highly cited papers (top 10%) is marginally higher than expected. The disciplinary diversity indicators suggest a reasonably broad scientific reach. The bibliometric profile demonstrates a strong publication record that is competitive on the global stage. It is recommended that the unit continue to focus on publishing in leading international journals and expanding high-quality international collaborations to further enhance its research standing.

The unit's thematic breadth is undoubtedly advantageous for societal impact, but it also leads to fragmentation in research quality. Different teams operate with varying levels of methodological depth, international engagement and publication ambition. A more unified research strategy is needed. This should include strategic prioritisation of themes and improved internal coordination. This will enhance the consistency of research performance. Provision of deliberate support for high-impact publications, including writing workshops, mentoring, and internal peer review is needed. This will help elevate the overall research quality.

The unit's engagement in externally funded research projects is promising, though some groups do better than others. Several groups participate in ERDF and Horizon research projects, Marie_Skłodowska - Curie Actions, regional cross-border programmes, and nationally funded projects. These collaborations expose researchers to international methodologies and help strengthen the unit's academic visibility. Expanding this participation further – especially in competitive EU funding programmes – is the key to supporting scientific advancement and enhancing publication output.

LSIWC's research is undeniably high-quality, relevant on an international level, and methodologically sound. It is clearly aligned with national priorities. The unit is well placed to boost its research performance thanks to strengthened internal coordination and increased emphasis on academic publishing.

Impact on scientific discipline
Score 4: very good

The impact of LSIWC on its scientific disciplines is indisputably very good, reflecting a growing presence in wood chemistry, lignocellulosic materials science, chemical processing of bio-based materials, and structure–property relationships of wood-derived systems. The unit's contributions are derived from scientific publications, participation in collaborative research networks, methodological developments in experimental and analytical approaches, and the provision of high-quality laboratory-generated datasets that support scientific inquiry.

LSIWC researchers actively participate in international projects and networks, giving them access to shared data, modelling platforms, and collaborative research programmes. These partnerships drive methodological innovation and strengthen the unit's position within European wood chemistry and bio-based materials research.

Several groups have developed important niche expertise, such as advanced analytical characterisation of lignocellulosic materials, chemical modification of wood polymers, or process development for bio-based materials. This allows them to contribute meaningfully to international research initiatives.

The unit's involvement in European regional projects and international scientific collaborations clearly reflects its disciplinary impact. Researchers contribute to conference presentations, joint publications, and international working groups addressing material performance optimisation, sustainable utilisation of wood resources, and quality assessment of wood-based materials. These engagements undoubtedly boost the unit's visibility and underscore a dedication to scientific collaboration.

The unit's methodological contributions, including the integration of experimental data with analytical and modelling approaches in wood and lignocellulosic chemistry, contribute to disciplinary development. LSIWC combines chemical characterisation techniques, structure–property analysis, and process-oriented investigations to advance understanding of wood-based materials and their modification and utilisation. Through this work, the unit has established itself as a relevant national contributor to wood chemistry and bio-based materials research, applying advanced analytical tools to material systems of importance for both science and industry.

Leadership roles in international consortia are limited. While some researchers coordinate specific work packages or methodological tasks, the unit has not yet consistently taken on responsibilities for leading entire research consortia or directing major international projects. Increasing leadership ambition in this area would further enhance disciplinary impact.

The unit also contributes to scientific and technical assessment frameworks[1] at national and EU levels. Its involvement in developing material-related indicators, contributing to standardisation and regulatory consultations, and supporting assessment activities related to wood and wood-based materials represents a key interface between scientific research and policy application. While these contributions may not always be reflected in traditional academic metrics, they

[1] Notably Horizon 2020, Horizon Europe, ERA-NET, ESA, European Maritime, Fisheries and Aquaculture Fund (EMFAF) - Measure "Innovation, pilot projects, cooperation with science, and knowledge transfer in aquaculture"

reinforce the unit's relevance and visibility in applied wood chemistry and bio-based materials research.

LSIWC's scientific impact is solid and growing. It has the potential to be enhanced further through increased scientific leadership, strengthened publication strategies and more consistent participation in competitive international research initiatives.

Economic impact
Score 3: good

LSIWC has a good economic impact, making significant but still developing contributions to economically relevant sectors such as forestry, wood processing, and the bio-based materials industry. The unit's applied expertise is highly valued by external partners, and its analytical services play a vital role in informing operational decision making in several areas of the economy. The depth and breadth of economic engagement are limited compared with the unit's societal contributions.

The unit provides practical tools and assessments that support economic actors, particularly in the forestry, wood-processing, and bio-based materials sectors. These include analytical and modelling tools for assessing material properties and process performance, applied chemical analyses that support product development and quality control, and technical evaluations that inform process optimisation and material selection. These outputs contribute to improved resource efficiency, product performance, and regulatory compliance, thereby generating tangible economic benefits for industrial partners.

The amount of direct collaboration with companies is modest. The unit works with enterprises in the forestry, wood-processing, and bio-based materials sectors, but these partnerships are often short-term and project-specific. The unit has not yet developed a robust portfolio of strategic industrial partnerships or a systematic engagement with broader innovation ecosystems, such as long-term industry alliances, joint development platforms, or sustained technology-transfer mechanisms.

The unit identifies a range of industrial collaborators, and reports that approximately 14% of its budget during the reporting period originated from private or industrial sources, including contracts with state-owned enterprises. While this indicates engagement with applied research, a closer examination of the financial data, supported by the on-site visit, suggests that genuine private-sector involvement remains limited. The listed collaborations include public or state-owned entities.

This assessment is supported by the financial breakdown in Section 7.3 of the self-evaluation report ("Commercialisation of the research"), where more than half of the reported income (approximately EUR 2 million) derives from ERDF-funded contracts, which cannot be considered industrial funding in a strict sense. Of the remaining amount (around EUR 1.6 million), substantial shares again stem from public or semi-public partners, including Latvian State Forests and Riga Technical University. Although Section 5.1 ("Collaborations/Enterprises") reports somewhat higher figures for industrial collaboration, these discrepancies are likely due to differing definitions across sections. Overall, genuinely private industry funding appears to account for roughly 7–8% of the unit's total budget, with the number of active industrial partners being around ten.

Claims of approximately 200 industry projects during 2019–2024 are not fully substantiated by the financial evidence presented and may reflect a broad interpretation that includes industry participation in publicly funded or EU-level consortia rather than direct bilateral collaborations. The pilot-scale hangar represents a valuable infrastructure asset with future economic potential; however, it is currently under-utilised by industrial partners and does not yet contribute substantially to the unit's income stream. Taken together, the unit demonstrates

relevant applied activities and engagement with public and semi-public stakeholders, but the depth and scale of direct private-sector collaboration remain moderate.

Commercialisation pathways need to be developed. There is little evidence of sustained intellectual property generation, licensing, or spin-off creation. The self-assessment clearly identifies structural barriers, including a lack of institutional incentives and administrative obstacles for intellectual property development, that are contributing to these limitations.

The overall economic impact is nonetheless significant. LSIWC has the expertise to be at the forefront of emerging economic sectors related to bio-based materials, wood-based products, and sustainable chemical processing of lignocellulosic resources. With stronger institutional support for innovation, clearer commercialisation pathways, and improved outreach to industry, the unit could substantially expand its economic footprint, particularly within the forestry, wood-processing, and bioeconomy value chains.

Social impact
Score 5: outstanding

LSIWC's social impact is excellent, representing one of the strongest dimensions of the unit's performance. The institute plays an important role in supporting Latvia's transition towards a sustainable bio-based economy. It contributes directly to standards development, regulatory processes, and evidence-based policy formulation related to wood and wood-based materials, product safety, material performance, and the sustainable use of renewable resources. Through these activities, the unit supports public authorities, industry stakeholders, and society more broadly in addressing sustainability objectives linked to material use, resource efficiency, and the substitution of fossil-based products.

The unit's analytical expertise, testing capabilities, and applied research outputs are used by public authorities and sectoral stakeholders to support standards development, regulatory compliance, and evidence-based decision-making related to wood and wood-based materials. These contributions include chemical characterisation data, material performance assessments, and evaluations of processing methods relevant to safety, durability, and sustainability requirements. The availability of such scientifically sound analyses, combined with the unit's expertise in wood chemistry, enables authorities and stakeholders to make informed decisions concerning material standards, product regulation, and the sustainable use of renewable resources.

LSIWC acts as a trusted advisor to relevant ministries, regulatory bodies, and sectoral authorities. Its contributions are substantial and include expert input to policy processes, reports for national programmes, methodological support for material standards and regulatory assessments, and active participation in working groups related to the bioeconomy, circular economy, and sustainable use of wood-based materials. The unit's involvement in public consultations and expert panels strengthens Latvia's capacity for evidence-based policymaking in areas related to materials regulation, product safety, and the sustainable transition towards renewable, bio-based resources.

LSIWC's public outreach is strong LSIWC researchers actively participate in educational events, public workshops, and communication initiatives. These activities are aimed at raising awareness of wood-based materials, sustainable material use, and the role of the bio-based economy in resource-efficient and circular value chains. Several staff members engage in outreach activities and collaborate with schools, vocational institutions, and community organisations. These efforts enhance public understanding of renewable materials, material sustainability, and responsible resource use, and promote informed and sustainable practices at the community level.

LSIWC has a definitive social impact. It contributes directly to Latvia's transition towards a sustainable bio-based economy and responsible use of renewable materials.

Research environment and infrastructure
Score 4: very good

LSIWC is a very good place to conduct research. The researchers are highly motivated and have access to important experimental data, and the laboratories support key analytical and materials-characterisation tasks. The unit benefits from accumulated experimental datasets, reference material collections, and long-term laboratory-generated data related to wood and lignocellulosic materials. These generate high-quality data that support both research and applied activities. These datasets constitute valuable internal assets that contribute significantly to the unit's research environment.

LSIWC operates state-of-the-art laboratories for chemical analysis, materials characterisation, and experimental research on wood and lignocellulosic materials. These facilities support both applied and scientific work. As indicated above, some laboratories are well equipped with modern instrumentation, while others require upgrading to meet contemporary research needs. The self-assessment report provides a list of the key equipment needed and refers to a strategic plan for investing on it during the period 2025-2030. The infrastructure is limited by uneven equipment distribution, the absence of a unified long-term infrastructure strategy, and insufficient administrative support for project management and technical maintenance. Investment decisions have largely been reactive rather than strategic, resulting in disparities in laboratory capacity and equipment availability. Strengthening long-term infrastructure planning is therefore essential to addressing these gaps and improving overall operational efficiency.

The research environment would also benefit from improved internal coordination. Thematic fragmentation and variable collaboration between research groups reduce opportunities for methodological integration, shared use of infrastructure, and joint project development. Stronger cooperation across research groups and the establishment of cross-group working structures would help to consolidate expertise, enhance coherence, and foster innovation within the institute.

Overall, LSIWC provides a solid research environment that supports high-quality work. Some 53% of scientific publications are published in open access, and the Institute aims to raise this proportion to 80% by 2030. However, targeted improvements in strategic planning, administrative support, and infrastructure investment are required to fully realise the unit's potential.

Development potential
Score 5: outstanding

LSIWC's development potential is excellent. It reflects strong thematic alignment with national priorities, a motivated research staff, and emerging international engagement. The unit operates in areas of growing importance, including the development of bio-based materials, sustainable utilisation of wood and lignocellulosic resources, and resource-efficient chemical processing. These domains are central to Latvia's bioeconomy and circular economy strategies and are expected to receive increasing policy attention and research funding in the coming years.

The unit's ability to integrate experimental work, analytical characterisation, and process-oriented modelling is a key strength. These competencies are in high demand in national and European research programmes such as Horizon 2020, Horizon Europe and ERA-NET frameworks

listed in section 7.2 of the self-assessment report. focused on bio-based materials and sustainable industrial processes. The unit's scientific trajectory and visibility would be significantly strengthened by expanding participation in competitive international funding schemes, particularly within EU research frameworks.

The unit's ambitions for developing doctoral training, mentoring systems, and early-career opportunities indicate strong forward momentum. The implementation of structured supervision processes and targeted career development support would help build a sustainable pipeline of future researchers and strengthen long-term capacity.

Leadership is aware of the unit's strengths and weaknesses, and the unit is prepared to modernise its strategy, consolidate research themes, and improve its internal organisation. LSIWC is well positioned to increase its scientific and societal relevance through enhanced administrative support, improved infrastructure planning, and a clearer strategic direction.

Potential to offer doctoral studies

LSIWC does not have the authority to award PhD degrees. The institute has the fundamental capacity to contribute to doctoral studies, but improvements are required to support a fully competitive training. There is supervisory expertise, but it is unevenly distributed across groups. The unit's applied orientation and strong connections with industry and regulatory stakeholders provide valuable opportunities for doctoral research, particularly in wood chemistry, bio-based materials development, chemical processing of lignocellulosic resources, and materials characterisation.

Supervision processes must be more structured, and doctoral students must have greater access to modern laboratory facilities and mentoring support. The doctoral environment must be strengthened by enhancing career development measures, training workshops, and methodological courses. It is vital to ensure stable funding and supervisory continuity to attract high-quality doctoral candidates and maintain research momentum.

LSIWC has promising potential for contribution to doctoral training.

Alignment with the Smart Specialisation Strategy

LSIWC's research aligns strongly with Latvia's Smart Specialisation Strategy (S3), particularly in the areas of knowledge-intensive bioeconomy, bio-based materials, and resource-efficient processing of wood and lignocellulosic resources. The unit's applied projects and analytical capabilities contribute directly to the S3 objective of fostering innovation in wood-based industries and sustainable material value chains. To further reinforce this alignment, the unit should strengthen its thematic focus and articulate a clearer institutional strategy that consolidates its core competencies and strategic priorities.

Conformity with state scientific and technology development

LSIWC's work is closely aligned with national scientific and technological priorities, particularly those related to the development of the bioeconomy, sustainable utilisation of wood and lignocellulosic resources, and the advancement of bio-based materials and processes. The unit's long-standing collaborations with ministries, regulatory bodies, and sectoral stakeholders provide direct support to national policy development and implementation in areas such as materials regulation, product standards, and sustainable industrial innovation. It is important that participation in international research programmes is increased further to ensure continued alignment with broader European and global scientific priorities.

Recommendations

The Expert Group recommends the following actions:

- Strengthen incentives for high-quality publications and leading authorship roles
- Expand participation in competitive EU research programmes and develop structured proposal-support mechanisms
- Implement a long-term infrastructure plan to address laboratory upgrading and resource disparities
- Enhance administrative support for project development, management, and reporting
- Promote cross-group collaboration and thematic consolidation across research groups
- Improve doctoral supervision structures, mentoring, and career development opportunities
- Develop clear innovation and commercialisation pathways, including incentives for IP creation and applied technology development
- Increase the number and seniority of leadership roles LSIWC takes in international research consortia
- Formalise stakeholder engagement strategies to sustain high societal impact

N_6 Institute of Solid State Physics, University of Latvia

The unit

The Institute of Solid State Physics, University of Latvia (ISSP) is an independent research institution focused on materials science and cross-disciplinary topics. Its vision is to create a dynamic environment for addressing global societal and technological challenges, thereby enhancing the role of Latvian and European science globally. The institute collaborates with national and international stakeholders, contributing to Latvia's research and innovation strategies.

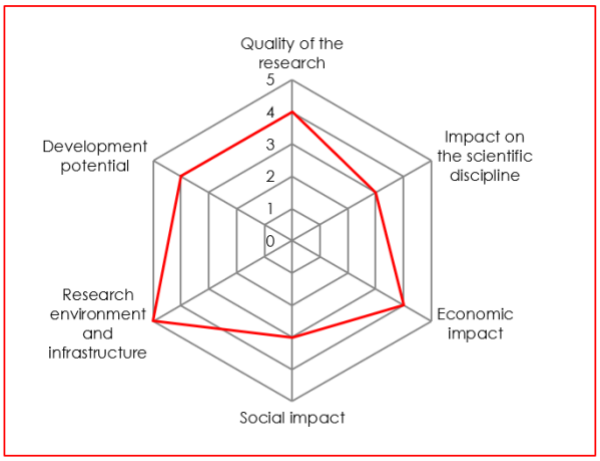
ISSP organises its research around three main areas: materials for photonic devices, advanced materials for energy, and microfluidics and biomedical technologies. The institute emphasises multidisciplinarity and interdisciplinarity, integrating knowledge from various fields to address complex challenges. It conducts both basic and applied research, ensuring a balanced approach to scientific advancements and practical applications. ISSP collaborates with international partners to enhance its research capacity and impact.

Expert Group evaluation

The figure below presents the scores assigned by the Expert Group to the unit.

Figure 6 Institute of Solid State Physics, University of Latvia – Scores

Criteria	Scores
Quality of the research	4
Impact on the scientific discipline	3
Economic impact	4
Social impact	3
Research environment and infrastructure	5
Development potential	4
OVERALL SCORE	**4**



Overall score

Score: 4 – very good

Research quality at ISSP overall is very good, with the status of a national leader, and a premier research institution in the Baltics, in the area of solid-state physics. In the reporting period this high standing has been retained through a range of accomplishments: fine-tuning the interdisciplinary research enabled by ISSP's expertise in condensed matter physics, development of human and infrastructure resources, as well as targeting impact outside the academic community.

The overall quality of research is very good, and the Institute is a strong international player. Quality has improved with increasing international involvement in publications and funding. The nominated most important research outputs are of high quality and are produced under most rigorous standards of publication.

ISSP's impact on the scientific discipline is good and is in compliance with national and European research strategies. International co-authorship has improved significantly and the income from internationally competitive funding is around a third of the total budget. Firming up of the spread in research effort has the potential to allow ISSP to assume a leading position in niche areas on a European scale. The overall citation rate, however, remains a challenge.

The economic impact is very good, as ISSP is a sought-after R&D Partner by non-academics as part of a network of non-academic collaborations. This is evidenced by licensed products and a number of spin-offs and work with the Latvian government. Improved direct industrial funding remains a continuing target.

Societal impact is good. ISSP research is important for society and the interactions with the public sector and the public in general are at a level that would be expected of recognised academic institutions. This is evidenced by socially significant local activity, presence in national media, promotion of higher education, and engagement with national public institutions and government. A well-maintained website will secure continuing visibility and interaction with various social groups and national agenda.

Research environment and infrastructure are excellent. Scaled to size, the institution's organisation, strategy and infrastructure are internationally comparable to the best in the discipline. ISSP can attract the highest quality international researchers, having a strong research team, a very strong equipment infrastructure and healthy management of resources. The SWOT analysis is realistic and helpful. This allows issues such as the timely completion of PhD work and gender balance to be maintained in the future at the necessary standard.

Development potential is very good. ISSP is able to establish itself as a recognised and respected player in the international scientific community within solid-state physics and its interdisciplinary reach. It is credible to expect that over a 5 -10 year horizon, ISSP will attain the level of scientific quality and influence required for high-profile international collaboration projects and networks. This target should be based on a realistic SWOT and criticality analysis, a good level of strategic and operational planning and constructive contributions by the International Advisory Board.

Quality of Research

Score 4: very good

ISSP has built upon its established status as centre of excellence in solid-state physics. Institute researchers have well defined areas of interest and benefit from adequate organisation of activities and infrastructure. The number of scientific papers published yearly has increased from 109 in 2019 to 182 in 2024, apparently without compromising quality, as the percentage published in Q1 and Q2 journals is 88% (by self-assessment). More than half of these (47.7% of total by Scopus bibliometrics), are in Q1 journals, which is roughly on par with other similar-scale national players assessed by this Expert Group. Raising the Q1 share further is imperative, to demonstrate originality and rigour. One full monograph and four book chapters are reported as further evidence of a notable publication effort.

Some 70% of the published papers have been produced in international co-authorship, reflecting the international contacts, networking and engagement of ISSP. International benchmarking with peers is in place. However, ISSP would benefit from benchmarking against top-level players in the EU (e.g. the Max-Planck Institute for Solid-State Research). This will help, and may reveal ways to work towards European leadership in niche topics. ISSP has the potential, in suitable partnerships, quickly to embrace trending areas in the European and global research landscape.

Despite its size, ISSP does not currently host ERC Synergy grants, which are hallmarks of research excellence and boost the prestige of the individual researcher and institution. It became clear during the site visit that there has been past success and there is a pending application, but it is important for this to be a permanent item on ISSP's list of operational and strategic targets.

Scrutiny of the self-nominated sample (just above 1% of the total publications number) of Q1 research outputs in each of the three strategic research areas, suggests that all of these are in highly respected publication outlets, with no overlapping authorships. However, there is a certain imbalance in this sample. Materials for Photonic Devices (MPD) is represented by a Letter (albeit in one of the most prestigious short-length high-immediacy outlets) and a paper in one of the top-tier journals in all areas of interest for ISSP; Advanced Materials for Energy (AME) is represented by 6 papers in top journals with citations per document (CPD) above 10; Microfluidics and Biomedical Technologies (MBT) is represented by a single paper in a journal with a considerably lower CPD. Given the deficit of highly cited papers, this sample could be taken as a starting point a) to enhance the overall percentage of papers in such outlets and b) to grow the weight of AME and most importantly MBT in this aspect. Synergy among the three areas also needs to be considered to improve efficiency and visibly strengthen overall performance.

Impact on scientific discipline
Score 3: good

International collaboration is crucial for ISSP to increase the number of highly cited papers and its overall scientific impact. Since 2017, ISSP has been EU-funded as a trans-Baltic hub for Advanced Materials and Technology Transfer. This has boosted research performance, resulting in regional prominence, in full compliance with RIS3.

ISSP lists eight substantial international institutions in Northern Europe, Italy, France and Germany, with which it has partnerships involving varying amounts of funding and numbers of publications. Multiple prizes and awards, mostly local, indicate substantial impact on Latvian science and applied science and this should be enhanced by achievements recognised in the Baltic and the European research landscapes. More of ISSP's senior researchers need to hold editorship of journals and there should be better spread across strategic areas. SSP is gaining attention for its organisation of international research events, but these are spread across a large range of topics and should be more focused, aiming at expansion of specialised conferences in the EU. Examples of successful hosting include the Baltic region FM&NT in 2020 and 2024, as well as the European-based LUMDETR, started in Riga in 1991 where ISSP was co-organiser of the 12th conference in 2024, together with the University of Latvia.

By the end of the self-assessment period, ten international projects under Horizon 2020 and Horizon Europe worth €7.58m were funded, which when added to other internationally funded projects yielded a total of €11.77m, which is more than one third of the total funding received by ISSP. Undoubtedly, this has contributed to the observed increase the international co-authorship of publications, with the effect likely to be sustained for some years to come.

The CAMART^2 project (half-funded by EC at the level of €15.3m) is particularly notable as it transforms ISSP to a significantly stronger centre of excellence, in substantial collaboration with Swedish partners. The strategic research areas of ISSP map reasonably well onto the specialisation grid of CAMART^2 (aligned with Latvian RIS3 and EC-defined Key Enabling Technologies), but more straightforward correspondence in grouping themes and terminology would bring more clarity and purpose, as well as encourage ISSP to pursue research themes that are internationally strategic.

An obvious area for improvement is the comparatively low field-weighted citation index (0.83, compared with the world average of 1.0), which has gone up only marginally since 2019, and the correspondingly low percentage of highly cited papers (10-percentile). This impacts unfavourably on the perceived significance of ISSP publications. ISSP has already recognised the need to increase citations, and this needs to be strongly prioritised in the coming years. In-depth analysis of these metrics across the three main themes, and possibly down to individual paper level, in ISSP could suggest winning approaches based on prioritisation, building of publishing skills and competence, timely re-orientation of resources, and so on.

Building upon the good level of international connections, given the size and specialisation of ISSP, it would be essential to strive towards a recognised internationally leading role in at least one niche area within ISSP's strategic foci.

Economic impact
Score 4: very good

ISSP continues to benefit from Materize - a single point of access to expertise and equipment, screening all research activities on annual basis and further evaluating all ideas which might have commercial potential - thus positioning ISSP for notable economic impact. In the self-assessment ISSP has submitted a full quota (16) list of non-academic collaborations, of which 14 are national and international companies of varying sizes. This, together with the 15 Latvian and 8 EU registered patents, is evidence for a good resonance with industrial pull. Two examples stand out: Cellbox Labs, which appears to be a purely ISSP spin-off and the first licensing of a product - the TESS detector - developed in ISSP and manufactured in Germany. The commercial product is featured in the official catalogue of Thorlabs, a premier global supplier of photonic instrumentation. The substantial list of companies with interest in the ISSP research, corroborated by the notable increase in co-authored publications with industry, however, contrast with the low level of direct industrial funding (2% of total ISSP funding). The share of direct industrial funding should be a target for improvement.

It is notable that ISSP has worked with the Ministry of Economics on ecosystem development and market research, however, it is unclear whether the Ministry has solicited contributions mostly as recognition of the expertise of individuals or of ISSP as an institution.

Social impact
Score 3: good

ISSP drives an array of socially significant local activity, some involving national and international science popularisation events: Deep Science hackathons and Solar Cup competitions, TV shows (Smart Technology, Money Speaks), European Researchers' Night, participation in the University of Latvia Science Café, which are all well publicised on ISSP's website. ISSP appears to consider these successful activities as 'citizen Science', which is quite a wide interpretation of the concept. It would be important to recognise that citizen science is properly a form of scientific research where the public participates in data collection and analysis, to help professional scientists. A straightforward route would be through relevant parts of the ROSiE Knowledge Hub.

In promotion of higher education, ISSP works closely with the University of Latvia and Riga Technical University, on research-informed master's and doctoral curricula in materials science and photonics. Improved social impact management is achieved through the ISSP Foundation, established in 2020, with the ambition of international reach, however this still needs to be evidenced. ISSP engages with national public institutions and government (Ministry of Economy, Investment and Development Agency, Office of the Prime Minister) to forge science-related policies.

Research in ISSP is relevant to national security, as well as public health, but it is unclear whether the social impact of this goes beyond direct research and dual use of technology and methods, i.e. whether there is involvement undertaken at societal level.

ISSP actively uses its own web site as well as various sites associated with collaborative EU projects for dissemination. The extensive "News" menu on the institutional website provides free access to video recordings and text concerning their research agenda since 2021. It may be helpful to structure these into e.g. sub menus, to help the wider public identify material according to their age, level of education, etc. It is also important to keep web pages up to date, for improved credibility and impact.

Research environment and infrastructure
Score 5: outstanding

While ISSP is associated with the University of Latvia, its independent status is prominent and helps in forging constructive relationships with other Latvian higher educational institutions such as the Riga Technical University. ISSP does not have degree-awarding power itself but actively contributes to the University of Latvia's teaching and administration of degree programmes in Physics. ISSP has defined its own strategy for 2016-2026 in a separate document, superseded by its current version for 2025-2030. The research team appears well-motivated and enthusiastic, balancing the interests and needs across the whole range of researcher roles. The specialist infrastructure (research capabilities and equipment) is strong and very well documented, with clear access procedures in place. ISSP deserves strong commendation for the management of its services offering online detailed technical description for 56 items of research equipment. This positions ISSP favourably in attracting national and international players and is on par with the best examples in EU and beyond. The main ISSP facility is the 650 sq.m. clean room, which has been in operation for the whole of the reporting period. The current overall functioning and load on the clean room appears sustainable and there is reasonable space for possible expansion. Areas/volumes of ISO Class 5 and below are organised within small footprints, making it possible to manage them without unnecessarily costly maintenance schedules. ISSP maintains an Infrastructure Development and Investment Plan which is revised yearly. Almost all the investment for the ERDF €15m project (upgrade with 62 new tools) took place during the reporting period.

Student numbers have risen in the reporting period. The Expert Group's face-to-face meeting with student representatives gave the impression of a well-motivated and adequately supported community. PhD students at different stages of their project were positive regarding timely completion, which gives reassurance that the substantial delays incurred (less than half of the theses on projects finished in 2018-2023 have been defended or scheduled for defence by mid-2025) have already been overcome. Of the 8 projects finished in 2024, 2 theses finished in 2024 have already been defended and the other 6 are set to complete by 2026, thus clearing the backlog.

There do not seem to be problems with funding of APCs for open access publication, but it may be beneficial for all researchers for ISSP to run discussions on options for open access and how they are exercised by leading publishers.

Hiring of new researchers in the last 3 years appears gender-balanced, but this is probably strongly influenced by the younger age brackets. In time, this will affect the balance on a more senior level, but currently it appears that just 2 of the 12 Heads of Laboratory are female. A faster result may be obtained by positive action, as defined in EU directives and practice.

ISSP has an established and long standing International Advisory Board. Its evaluation reports for 2011 and 2018 are public. The Institute publishes its Annual Reports, and the Ethics Policy was published its in 2020. It is commendable that ISSP embraces good practice in corporate branding.

In the research environment and infrastructure, apparent strengths are:

- Active in international and national networks; functioning International Advisory Board; "Research Programme 2030" roadmap aligned with RIS3 and EU
- Growing portfolio of national and international projects
- Growth in research output with improving publication quality and visibility
- Well maintained and accessible research infrastructure
- Environment supportive of young researchers and students, innovation and knowledge transfer, utilisation of Materize ecosystem

Apparent weaknesses are:

- Financial unpredictability, negatively affecting recruitment and infrastructure development, due to the current budget share of competitively secured funding
- Uneven efficiency across laboratories demanding periodic adjustment of goals, ambitions and internal interactions, which can be disruptive
- Workforce age and gender profiles need further improvement.

Development potential
Score 4: very good

On the 5 to10 years horizon, ISSP is facing substantial external uncertainties, some of which have already been addressed and mitigated, to an extent. The Institute is experienced in participating in international competitions, which together provide about a third of its funding and its success rate has the potential to rise. It is capable of recruiting and retaining high-quality well-established researchers, as well as promising students, but it would be important to run (and act upon) critical mass analysis of the spread of resources (human and infrastructural) at carefully-chosen intervals. This would also help to increase the scientific and societal impact, which will become increasingly demanding in the coming period. Innovation development appears high on priorities (Materize) and is likely to bring more tangible results in the future, raising the economic impact European HE twinning projects are also used to this effect. The age profile of researchers has significantly shifted to younger age, mostly due to a new system of managing students as employees.

The Institute's SWOT analysis is realistic and conducive to reflection, as is the detailed response to the recommendations from the previous evaluation period, provided in the current self-assessment. The current strategic plan covers the period up to 2030. It would be essential to continue working with the International Advisory Board or similar structure. Maintaining a dynamic body of diverse external experts will be essential in moulding the shape and contents of the Institute's yearly reports and strategic correctives, encouraging the rising hot topics and phasing out the declining ones.

Potential to offer doctoral studies

ISSP does not have degree-awarding power, but institute researchers engage with teaching programmes in the University of Latvia and collaborate with Riga Technical University. The Faculty of Physics and Mathematics in the University of Latvia has offered a doctoral sub-programme in solid state physics, along with a more applied sub-programme in materials physics, focusing on materials and their applications. This does not seem to imply that ISSP's lack of the right independently to award doctoral degrees is problematic. Based on the site visit, the community of 7-10 PhD students in the last three years is lively and engaged . Numbers have increased since the start of the reporting period, and they appear to have benefited from the change in the status of PhD candidates from being students to being employees of the university. This change appears to be well received by students, who are cognisant of the compromise between the need to support themselves and to have adequate time for research. In this context, while there are no doubts regarding the quality of research supervision, infrastructure and procedural expertise that the Institute can offer, it is not straightforward to judge whether ISSP should offer doctoral studies of its own, as it would incur/duplicate substantial additional administration.

Alignment with the Smart Specialisation Strategy

ISSP's research specialisation is actively aligned with all the RIS3 domains. Each area is exemplified below with a single significant result.

- Knowledge-Intensive Bioeconomy – elements contributing to circular economy (LACISE, with Switzerland)
- Biomedicine, Medical Technologies, and Biopharmacy – organ-on-a-chip (Cellbox Labs)
- Photonics, Smart Materials, Technologies, and Engineering Systems – fast IR detector (Thorlabs)
- Smart Energy and Mobility – photochromic and thermochromic films for smart windows (GroGlass)
- Information and Communication Technologies – advanced models of new materials in energy and catalysis

The self-assessment report implies that ISSP is fully capable of adjusting its research agenda according to the dynamics of European and global research developments, as well as governmental policies.

Conformity with state scientific and technology development

ISSP aligns very well with the Latvian Science, Technology Development, and Innovation Guidelines 2021–2027, contributing actively to the transition of Latvia towards the knowledge-based economy. The Institute continues to internationalise its networks and is working to improve its competitive positioning in Europe, notably by being active in international collaborations, particularly within the EU Framework Programme, ISSP's human resources appear stretched across ambitious research programmes, but its researchers are equipped and organised well enough to achieve their operational and strategic goals. Collaboration with industry is at a very good level too and has generated commercial products. In the current funding climate, it would nonetheless be essential to grow substantially the share of direct industrial funding from national and international industry.

Recommendations

The Expert Group recommends that ISSP should:

- Improve synergies among the three strategic research areas, to increase the opportunities for cross-disciplinary research, improve the efficiency of resource use, strengthen performance, and increase visibility
- Strengthen research performance by assessing and managing critical mass across the strategic areas, as well as in the individual research laboratories.
- More clearly map the three strategic research areas and activities in the 12 research laboratories onto Latvian RIS3 objectives and EU Key Enabling Technologies, to increase the transparency of the institute's abilities and make it a more attractive partner for other researchers, industry and policymakers
- Identify and strengthen at least one niche area targeted within the capabilities of ISSP, where it is realistic to achieve recognised top-level leadership at the EU level and possibly beyond
- Benchmark itself against players at the top level in the EU (e.g. the Max-Planck Institute for Solid-State Research). This will help the ISSP identify and address areas where quality gaps exist
- Improve analysis and management of research quality to increase substantially the field-weighted citation rate and percentage of highly-cited papers. Available actions include greater use of internal and external pre-submission article reviews, mentorship by the more successful authors in house, and the use of external training courses specifically aiming to increase the quality of publications
- Enhance ISSP's representation – especially, but not only, by more senior people – on editorial boards and organisation committees of international research events at EU and

global levels, as well as peer panels of research funders. Seek more memberships of prestigious learned societies with global outreach. These measures will not only increase the institute's visibility but also support quality by increasing colleagues' understanding of research assessment criteria and processes

- Work more closely with industry – especially larger firms in Latvia and abroad – to increase industrial funding substantially beyond the current 2% of total ISSP funding.
- Launch an internal group to review concepts in 'citizen science' and expand practices to include the involvement of citizens in research, in line with some of the opportunities presented by ROSiE.
- Having cleared the backlog in PhD student completion, ensure future adherence to the established standards for timely submission of theses and their defence
- Take further steps to manage age profile, succession and gender balance at all levels in the institute, ensuring equality and sustainability.

Summary of findings across the set of unit evaluations

The units evaluated

The Natural Sciences Expert Group assessed six rather diverse units. The University of Latvia's (UL) Faculty of Science and Technology and its Institute of Solid State Physics are parts of Latvia's largest comprehensive research university in Riga, together accounting for two thirds of the employment in scope to this Expert Group. In contrast, the two other universities in scope are essentially small, regional universities of applied sciences. Such universities' social role tends to be more focused on teaching than in national research universities, and research is often more applied and focused on regional economic and social impact. Ventspils University of Applied Sciences benefits from its internal VIRAC radio astronomy institute. Daugavpils University formally has the Latvian Institute of Aquatic Ecology as its 'agency', but in practice the institute is a long way away in Riga and interacts little with Daugavpils. The Latvian Institute of Aquatic Ecology functions both as a government laboratory, providing data and information for regulation and policy, and also does more fundamental research. The other unit in scope – the Latvian State Institute of Wood Chemistry – is also a free-standing research institute, which is more industrially orientated towards understanding opportunities to use wood in the economy.

The general level of quality of research

The two regional university units were judged overall to be 'strong national players with some international recognition' (3), while the large units from UL and the two- free-standing research institutes were 'strong international players' (4). The scores for research quality were similar to the overall scores. Generally, it would be expected that the research quality and scientific impact scores would be similar to the overall scores, but Daugavpils scored much better on most of the other criteria (especially societal impact), supporting their regional roles, and thus merited an overall score of '3'.

In most cases, the Expert Group felt that the scientific impact was not quite as good as the quality would justify, so it made suggestions for how to improve the impact.

The 'social impact' scores were very strong, notably when compared with the economic impact scores. It appears this is because social impact is easier for active researchers to organise, and society itself tends to be interested. Economic impact relies not only on what the research organisation does but how receptive industry is to various kinds of partnership. Companies' absorptive capacity matters. Many smaller firms have only limited ability to make use of new knowledge unless it is packaged up in turnkey equipment or standardised processes. Latvia does not have many large firms, and often those that exist are foreign-owned and can more easily get their new knowledge from headquarters than from Latvian research.

The rather high 'research environment' scores can be attributed partly to physical investments, partly to the effects of system-wide policies such as the reform of doctoral training and the new employment status of doctoral candidates, and partly to improvements in organisation, responding to recommendations from the 2019-2020 assessment. This is an important success, removing important obstacles to future performance. Development potential is therefore also broadly good.

The fact that there are a few scores of '5' among these criteria is especially impressive. At the same time, it should be noted that '4' – like the other scores – corresponds to a quite wide range of performance. Several steps can be needed to move up to the level of global leadership.

Key strengths

The quality of natural sciences research in Latvia is clearly on an upward trajectory. However, the natural sciences are vast and the numbers of institutions and researchers in Latvia who can address them are small, and predominantly have teaching obligations across a wide range of sub-disciplines in addition to research duties. The result is a fragmented pattern of high quality in some places where a critical mass of research can be assembled, but also many areas where there is more moderate quality, or there is no research at all. UL's Faculty of Science and Technology shows that research quality can be produced in a (for Latvia) large university, while the institutes of Aquatic Ecology, Institute of Solid State Physics and Institute of Wood Chemistry show the power of focused effort in comparatively narrow areas. The implication for a small country is that high research quality needs specialisation.

The Expert Group mostly allocated similar scores for research quality and scientific impact, but generally also offered suggestions for increasing impact. Building such impact is not only an intellectual but also a social process, involving elements such as a publication strategy focused on journals read by the leaders in the field, internationalisation through research visits, seeking membership – and especially leadership roles – in international research networks and consortia, as well as international joint authorships. These increase the size of the potential audience for research results, and also trigger feedback and learning that can help increase research quality further.

Doctoral training has become more attractive and efficient. The doctoral reforms of the last few years have had clear effects in improving the quality of training and building critical mass by creating doctoral schools as well as joint doctoral programmes across institutions. The effects are visible via reductions in completion times towards international norms and reduced precarity for doctoral candidates. However, it remains hard to recruit doctoral candidates outside the large institutions.

Evaluated units' research generally has a good fit with both smart specialisation goals and the national scientific strategy.

Examples of high points observed by the Expert Group include:

- **University of Latvia Faculty of Science and Technology** – leading aspects include Computer and Information Science, Physics, Material Sciences, Earth and Environmental Sciences, and the cooperation between Physics and Computer Science on quantum computing theory applications
- **Ventspils University of Applied Sciences** – astronomy at VIRAC is internationally recognised and is well integrated into global research networks
- **Daugavpils University** – high points include maintaining significant collections, notably the World Beetle Collection and the DAU Herbarium, as well as databases that provide important services to national and international research on taxonomy, systematics, ecology, parasitology, and biodiversity, particularly within the landscape surrounding the Baltic Sea
- **The Latvian Institute of Aquatic Ecology** – working at the forefront of the assessment of marine ecosystem functions and the services these systems provide, maritime spatial planning, using tools that can clean up lakes by removing excess nutrients using macro-algal cultivation. Work on detection, characterisation and monitoring of microplastic pollution in Latvian and Icelandic sea and lake waters is also noteworthy
- **Latvian State Institute of Wood Chemistry** – integration of analytical chemistry, reaction studies, and structure–property investigations, allowing it to link chemical composition and processing conditions with material performance
- **University of Latvia, Institute of Soid State Physics** – fine-tuning the interdisciplinary research enabled by ISSP's expertise in condensed matter physics, development of human and infrastructure resources, as well as targeting impact outside the academic community

Main weaknesses

As indicated in the previous section, small scale and its corollary of fragmentation is an important weakness across the natural sciences in Latvia. The needed response is for individual institutions to move from the generalities of most university strategies – which traditionally aim for excellent education, research and knowledge transfer to society, without filling in the details – to setting specific priorities among alternative research themes.

Much of the national effort in natural sciences is in applied research, partly in combination with more fundamental work. Such research benefits from interaction with strong knowledge users, both to identify and to solve relevant and interesting problems. The small Latvian economy, with a limited number of large and technological capable firms, is a weaknesses for research. The needed response is not only to continue contributing to economic development at regional and national levels but also to seek relationships with knowledge users abroad – both bilaterally and through international networks such as those created by the EU Framework Programme. Technology transfer and outreach mechanisms are weak or new across the natural science units. US-style technology transfer offices (TTOs), which have high running costs and need a strong flow of patentable knowledge to be viable, are even less likely to be economic in the Latvian context than they are in most places. Focus on industrial liaison or extension is likely to provide better economic and social impact.

Physical research infrastructure varies from 'good' to 'outstanding' across the evaluated units. While the largest units have started to tackle the 'soft' aspects of the research environment, such as mentoring, career development processes, publication and proposal support, this was a gap in several cases.

Conclusions

The overall performance of the units in the natural sciences has improved, driven by implementation of recommendations from the 2019-20 assessment, continued capacity-building supported by structural funds, national reform of university classification and doctoral education, and the efforts of the units and institutions themselves. This is important, partly for developing the research system in Latvia and partly because in the highly competitive world of research, the bar is always rising.

In summary, this assessment finds that the UL unit and the three evaluated institutes are 'strong international players'. This is a broad category, but these units are winning their place in European and world science, building broad foundations from which they can take on more leading positions in project and research communities. The two universities of applied science – Ventspils and Daugavpils – play their partly regional roles well and have strong social impact. By and large they lack the scale and concentration of research resources in individual areas of research that are possible in the other four units. The factor that disrupts this pattern is the VIRAC radio telescope centre, which on the one hand increases the research quality and impact of VUAS while on the other hand being geographically distant from its most natural domestic research partners among the UL astronomers.

The evidence from this assessment suggests five areas where there are opportunities for improvement. Individual unit recommendations are contained in the unit reports.

- Developing more focused research strategies
- Becoming more deeply embedded in international R&D communities
- Striving further for excellence
- Reinforcing 'soft' aspects of the research environment
- Strengthening economic impact

Recommendations

Based on the analysis above, the Expert Group makes the following recommendations at the level of the natural science units as a group. They are not surprising, and some units are more advanced in some of these respects while others are less so.

The natural science units should **develop and implement more focused research strategies** to support specialisation in areas where they can build critical mass and differentiate themselves in competition. This requires a strong bottom-up effort by those who define the research directions and do the work, but also coordination from the centre to maintain critical mass, support the creation of synergies (for example, through shared infrastructure and cross-disciplinarity) and connect the strategy to human and investment resource plans. In applied fields where there are larger knowledge-using organisations in industry and society, it can additionally be useful to maintain strategic relationships with them, both to identify interesting research questions and to help generate external funding.

The natural science units should **explicitly plan to join and work within international R&D networks, and monitor their progress in this respect**. It is traditionally accepted that science is a global, rather than a national, enterprise. To contribute to, as well as to learn from, the international community requires membership of the relevant networks. In research, these include scientific societies and academies, journal editorships, conference committees, funder peer review panels, networks around infrastructures, and international joint authorships. In R&D, such networks extend to academic-industrial consortia, competence centres, international standardisation bodies and lobbies. The EU Framework Programme is especially important in Europe, where funding tends to go to more or less established networks, which themselves can be hard to enter. Insiders in these networks generally have better information about needs, trends and opportunities than those outside. Gaining entry involves action at home – such as international recruitment, hosting research visitors and conferences – as well as working internationally.

They should systematically **strive for research excellence by targeting specific achievements**.

- Explicitly target ERC grants, not only because they are prestigious and well-funded but also because winning them largely depends on setting up training and mentorship in research design, management and proposal-writing, thus building wider capacity for excellence
- Develop specific publications strategies, targeting lists of respected journals that are prestigious but also within reach, with the aim of being read and cited by the relevant research community. Producing large numbers of papers that are never cited brings no benefit for science or for their authors. As with seeking ERC grants, training and mentorship in publication are helpful in building capacity
- Identify and monitor unit performance against a small number of 'benchmark' institutions whose performance it would like to emulate

The natural science units should **prioritise activities that improve 'soft' aspects of the research environment**. These include the ERC and publication support mentioned above, and extend to career development support, learning how to do as well as receive mentorship, and making the research environment friendly to women and foreigners.

While the units' societal impact was very good or outstanding, their economic impact was not quite so good. This is partly due to Latvia's industrial structure, but the units can (with some appropriate variation depending on their intended role) nonetheless more systematically **link applied research to economic needs**.

- Strategically target a limited number of large, technologically capable firms (outside as well as inside Latvia) who could act as R&D partners over longer periods
- Ensure they engage as fully as possible with smart specialisation plans and the state science and technology strategy in areas relevant to their research agendas, to help link applied research to the demand side

- Focus their third mission activities towards industrial liaison, extension and support to relevant SMEs
- Limit any ambition to establish unit-level, US-style technology transfer offices, which require a sophisticated technical and financial context to survive, and which rarely generate economic rewards to the university. Such ambitions could be more relevant at the national level.