TALLINN UNIVERSITY OF TECHNOLOGY

RESEARCH AND DEVELOPMENT

2020

TAL TECH

TALLINN UNIVERSITY OF TECHNOLOGY

TALLINN UNIVERSITY OF TECHNOLOGY

FOUNDED IN 1918, UNIVERSITY STATUS IN 1936

Rector:	Professor TIIT LAND
e-mail:	tiit.land@taltech.ee
Vice-Rector for research:	Professor MAARJA KRUUSMAA
e-mail:	maarja.kruusmaa@taltech.ee

MAIN FIGURES 2020

(as of Dec. 31, 2020)

1028 Academic staff — Incl. **147** professors, **498** researchers

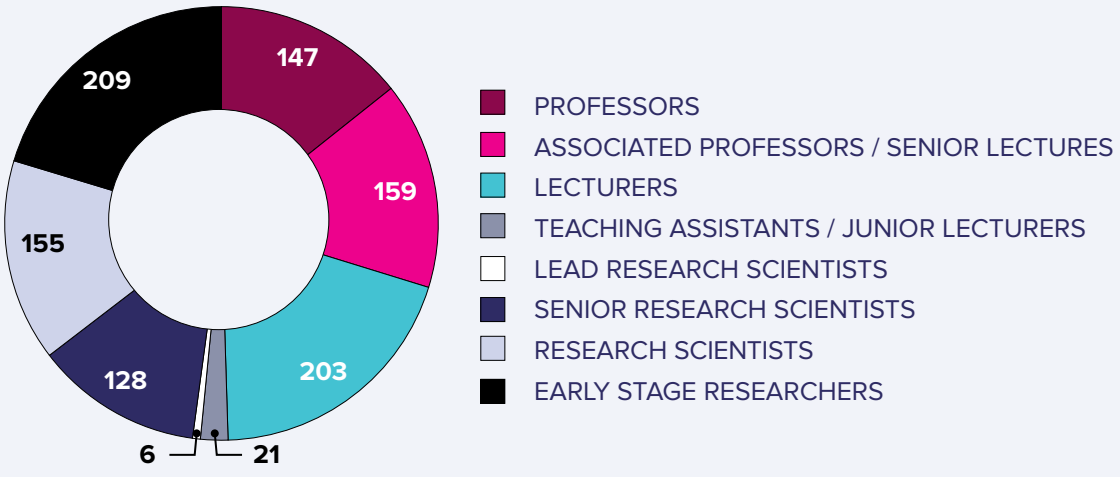
525 Doctoral students — **55** Defended doctoral dissertations

1154 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

SCHOOLS

- **SCHOOL OF ENGINEERING**
- **SCHOOL OF INFORMATION TECHNOLOGIES**
- **SCHOOL OF SCIENCE**
- **SCHOOL OF BUSINESS AND GOVERNANCE**
- **ESTONIAN MARITIME ACADEMY**



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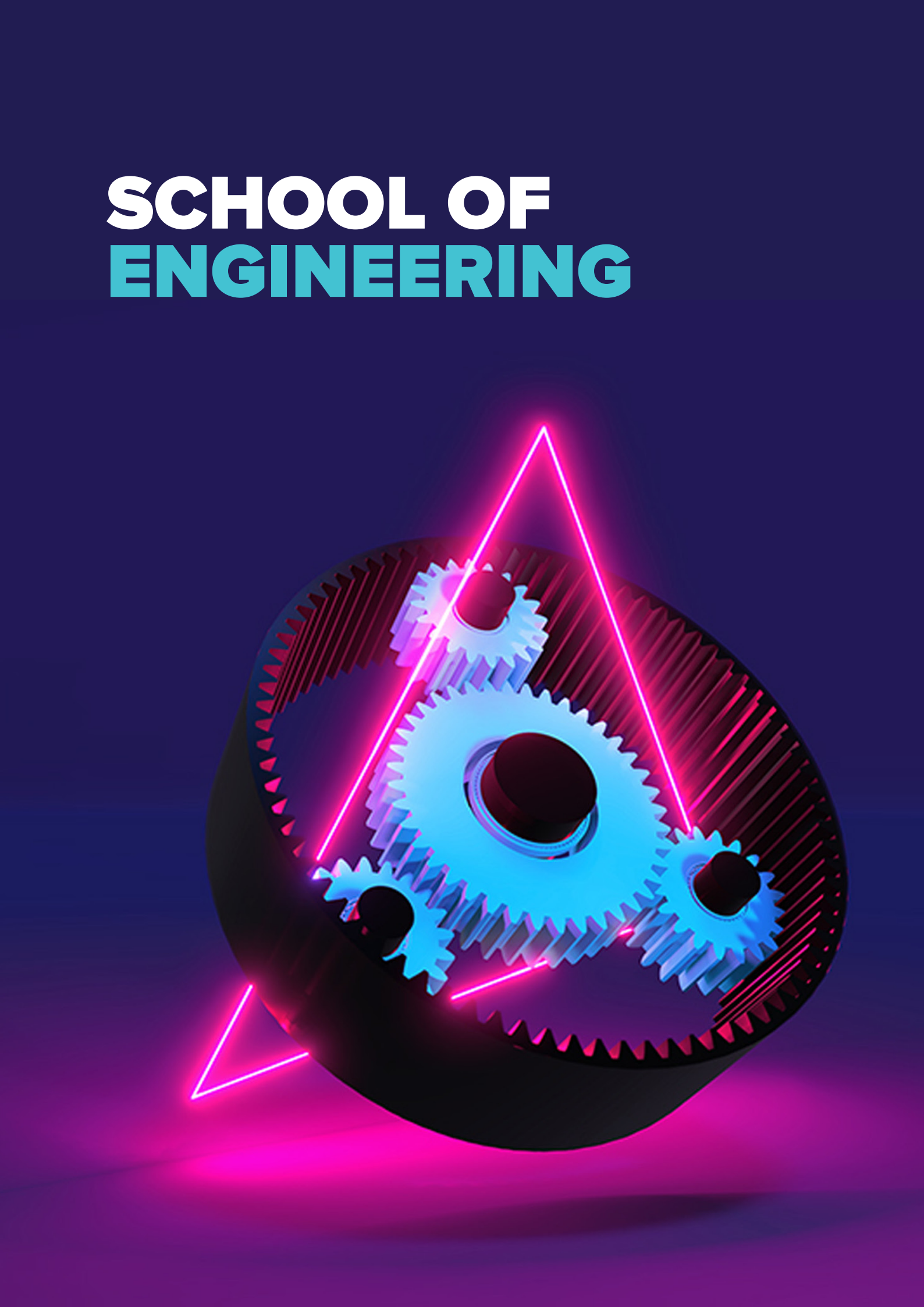
SCHOOL OF ENGINEERING



SCHOOL OF ENGINEERING

Dean: Professor FJODOR SERGEJEV

e-mail: fjodor.sergejev@taltech.ee

Vice-Dean for Research: Professor ARGO ROSIN

e-mail: argo.rosin@taltech.ee

MAIN FIGURES 2020

(as of Dec. 31, 2020)

349 Academic staff — Incl. **52** professors, **161** researchers

173 Doctoral students — **16** Defended doctoral dissertations

459 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

DEPARTMENTS, COLLEGES

DEPARTMENT OF CIVIL ENGINEERING AND ARCHITECTURE
Director: Professor JAREK KURNITSKI, jarek.kurnitski@taltech.ee

DEPARTMENT OF ELECTRICAL POWER ENGINEERING AND MECHATRONICS
Director: Professor IVO PALU, ivo.palu@taltech.ee

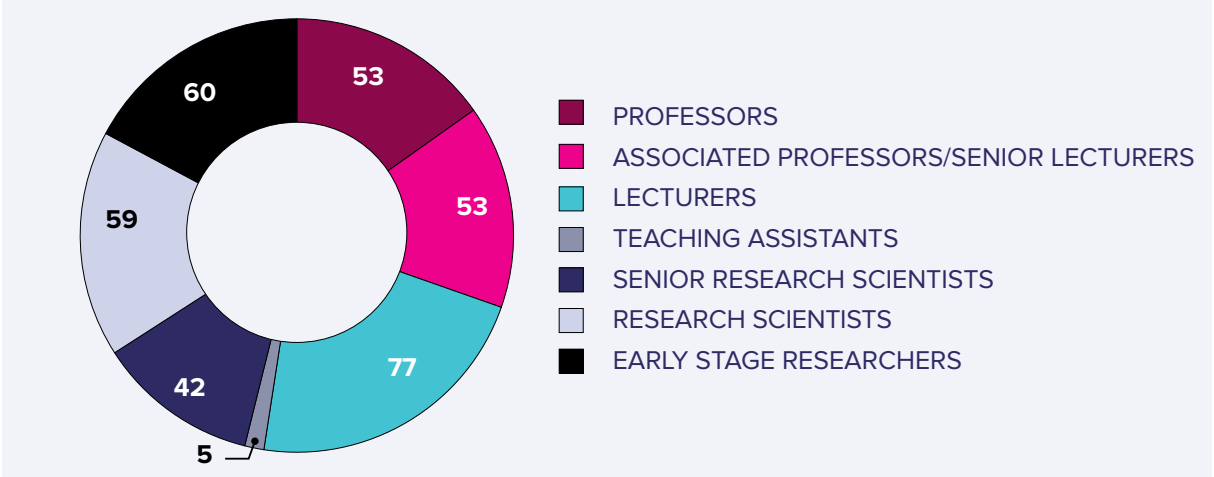
DEPARTMENT OF ENERGY TECHNOLOGY
Director: Professor ANDRES SIIRDE, andres.siirde@taltech.ee

DEPARTMENT OF MATERIALS AND ENVIRONMENTAL TECHNOLOGY
Director: Professor MALLE KRUNKS, malle.krunks@taltech.ee

DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING
Director: Professor KRISTO KARJUST, kristo.karjust@taltech.ee

TARTU COLLEGE
Director: Professor LEMBIT NEI, lembit.nei@taltech.ee

VIRUMAA COLLEGE
Director: MARE ROOSILEHT, mare.roosileht@taltech.ee



DEPRATMENT OF CIVIL ENGINEERING AND ARCHITECTURE

Direktor: JAREK KURNITSKI,
jarek.kurnitski@taltech.ee,
+372 620 2406

MAIN FIGURES 2020

(as of Dec. 31, 2020)

99 Academic staff — Incl. **13** professors, **29** researchers

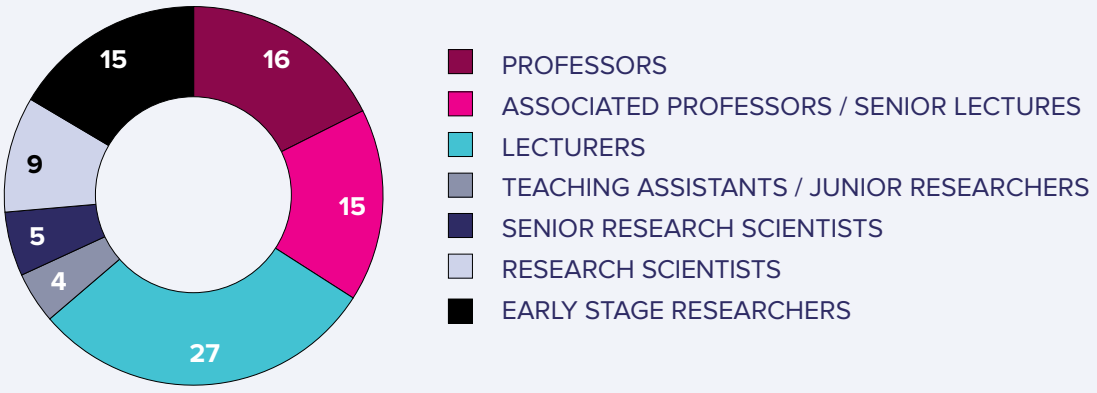
56 Doctoral students — **6** Defended doctoral dissertations

91 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 7 RESEARCH GROUPS:

- **ARCHITECTURE AND URBAN STUDIES.**
  Head: Professor KIMMO SAKARI LYLYKANGAS, kimmo.lylykangas@taltech.ee
- **BUILDING LIFECYCLE RESEARCH GROUP.**
  Head: Professor IRENE LILL, irene.lill@taltech.ee
- **NEARLY ZERO ENERGY BUILDINGS RESEARCH GROUP.**
  Head: Professor JAREK KURNITSKI, jarek.kurnitski@taltech.ee
- **ROAD ENGINEERING AND GEODESY RESEARCH GROUP.**
  Head: Professor ARTU ELLMANN, artu.ellmann@taltech.ee
- **STRUCTURAL AND FLUIDS MECHANICS RESEARCH GROUP.**
  Head: Professor ALEKSANDER KLAUSON, aleksander.klauson@taltech.ee
- **STRUCTURAL ENGINEERING RESEARCH GROUP.**
  Head: Associated Professor IVAR TALVIK, ivar.talvik@taltech.ee
- **WATER AND ENVIRONMENTAL ENGINEERING RESEARCH GROUP.**
  Head: Professor KARIN PACHEL, karin.pachel@taltech.ee



ACADEMY OF ARCHITECTURE AND URBAN STUDIES

Head of the research group: Professor KIMMO SAKARI LYLYKANGAS, kimmo.lylykangas@taltech.ee

Members: Jenni Vilhelmiina Partanen, Jaan Kuusemets, Luca Mora, Anu Juurak, Raoul Kurvits, Epi Tohvri, Sergei Letunovitš, Ignar Fjuk, Üllar Ambos, Kristi Grišakov, Harri Annuka, Ioannis Lykouras, Aurika Nõmm, Irina Raud, Tiina Tuulik, Emil Urbel, Külli Meister

Postdocs: Veronika Valk-Siska, Francesco de Luca

Doctoral students: Martin Allik, Abel Sepulveda Luque, Hanna Vikberg, Nasim Eslamirad, Mahdi Rasoulinezhad

TOPICS AND COMPETENCES

KEYWORDS: history of architecture, urban design, urbanism, planning, building performance, daylighting, sustainability, Smart City, Future City, landscape architecture

The research work of the Academy comprises the practical and analytical cycle of architectural design and urban planning, integrating different fields of engineering and humanities, incl. social spheres related to the functioning of the society, real estate management, etc.

The research team has top expertise in the following fields:

- Sustainable performance of built environment (De Luca, Lylykangas, Vikberg, Sepulveda Luque), for example greenhouse gas quantification, daylighting and energy-efficiency;
- History of architecture (Epi Tohvri);
- Research by design (Valk-Siska);
- New methods and practices in planning and landscape architecture (Grišakov, Tuulik);
- Building Physics, Building Performance, Eco-Efficient Façade system Design, Double Skin Façade systems (DSFs), Building LCA (Life Cycle Assessment), LCC (Life Cycle Cost), LCEA (Life Cycle Energy Assessment), Smart Building Design, Smart Urban and Cities, and Sustainable Architecture in respect of saving energy resources and environment. Application of Machine Learning method in building and urban optimization (Eslamirad);
- Simulation-based design (Sepulveda Luque);
- Urban modelling and data analytics (Partanen);
- Smart cities (Mora).

SELECTED PROJECTS

LEAAV20128 "*Quantitative Greenhouse Gas Impact Assessment Method for Spatial Planning Policy*"

AR20013EA "*GreenTwins*"

LEP18058 "*Model technical solutions for Haljala nearly zero energy school building*".

SELECTED ARTICLES

Alkadri, M. F.; De Luca, F.; Turrin, M.; Sariyildiz, S. (2020). An Integrated Approach to Subtractive Solar envelopes based on Attribute Information of Point Cloud Data. Renewable and Sustainable Energy Reviews, 123, 109742–19.

Partanen, J. (2020). Guiding Urban Self-Organization: Combining Rule-Based and Case-Based Planning. Environment and Planning B: Urban Analytics and City Science, 47 (2), 304–320.

Alkadri, M. F.; De Luca, F.; Turrin, M.; Sariyildiz, S. (2020). Understanding Computational Method of Solar Envelopes Based on Design Parameters, Tools, and Case Studies: A Review. Energies, 2020 (13), 3302–24.

BUILDING LIFECYCLE RESEARCH GROUP

Head of the research group: Professor IRENE LILL, irene.lill@taltech.ee

Members: Roode Liias, Raido Puust, Lembi-Merike Raado, Emlyn David Qivitoq Witt, Tiina Nuuter, Tiina Hain, Virgo Sulakatko, Erki Soekov, Tanel Tuisk

Postdoctoral researcher: Ieva Ubarte

Doctoral students: Eneli Liisma, Viktorija Prilenska, Margarita Ratšinski, Theophilus Oluwarotimi Olatunde Olowa, Kaleem Ullah

TOPICS AND COMPETENCES

KEYWORDS: Keywords: multiple criteria management strategies; building information modelling (BIM); construction economics; construction management; building life cycle; technical conditions of housing; disaster resilience of built environment; construction regulations, normative materials, standards; utilization of oil shale ash in the production of building materials; energy saving materials for the renovation of buildings

The research group approaches the building lifecycle as a whole, integrating the construction process and its outcomes with management strategies, technologies, building materials, economics and facilities management.

Research involves the following studies:

- Main characteristics of binders or binder constituents based on oil shale ashes from electrostatic precipitator systems;
- Basics of new utilization processes for oil shale combustion solid wastes;
- Low strength backfilling concrete based on the residues of oil shale processing;
- Frost resistance of various concretes and comparison of their test methods;
- Building properties of chemically treated timber;
- Durability characteristics (vapour and water migration) of facade systems, thermal insulation and external facade coverings.

The Research and Testing Laboratory of Building Materials has certified testing personnel, standards, methods and equipment for the evaluation of conformity for various building products: cement, mortar, grout and concrete products and products from natural and artefact stones and insulation materials.

SELECTED PROJECTS

- LEP17099, "*Digital Model of Building Lifecycle*" (2018–2022)
- LMIN18069, "*Developing a unified construction classification system*" (2018–2020)
- VERT19009, "*REbuildinG AfteR Displacement*" (2018–2021)

- VERT19053, "*New MINDSET for high-quality European BAUKULTUR: bridging DIGITAL and CRAFT*" (2019–2022)
- VERT20002, "*Building Resilience in Tropical Agroecosystems*" (BRITAE) (2020–2023)

SELECTED ARTICLES

Ullah, K.; Raitviir, C.; Lill, I.; Witt, E. (2020). BIM adoption in the AEC/FM industry – The case for issuing building permits. International Journal of Strategic Property Management. DOI: 10.3846/ijspm.2020.13676.

Olowa, T.; Witt, E.; Lill, I. (2020). Conceptualising building information modelling for construction education. Journal of Civil Engineering and Management, 26 (6), 551–563. DOI: 10.3846/jcem.2020.12918.

Chellappa, V.; Salve, U. R.; Li, R. Y. M.; Liias, R. (2020). A knowledge-based approach for enhancing fall prevention in the construction industry. Journal of Statistics and Management Systems, 23 (2), 373–378. DOI: 10.1080/09720510.2020.1736320.

NEARLY ZERO ENERGY BUILDINGS NZEB RESEARCH GROUP

Head of the research group: Professor JAREK KURNITSKI, jarek.kurnitski@taltech.ee

Members: Targo Kalamees, Hendrik Voll, Martin Thalfeldt, Endrik Arumägi, Kalle Kuusk, Dmitri Loginov, Peeter Parre, Marko Ründva, Simo Ilomets, Peep Pihelo, Kristina Volkova, Martin Talvik, Priit Rannik, Liina Kotkas, Laura Kadaru, Peeter Linnas

Postdoctoral Researcher: Andrea Ferrantelli

Doctoral students: Helena Kuivjõgi, Jevgeni Fadejev, Alo Mikola, Ülar Palmiste, Anti Hamburg, Kaspar Tennokese, Paul Klõseiko, Tuule Mall Kull, Villu Kukk, Johanna Liblik, Jaanus Hallik, Karl Villem Võsa, Martin Kiil, Kristo Kalbe, Meril Tamm, Lauri Lihtmaa, Qidi Jijang

TOPICS AND COMPETENCES

KEYWORDS: building physics, HVAC, building service systems, indoor climate, IAQ, radon, energy performance of buildings.

The main research topics have been focused on technical solutions and system integration for NZEB most urgently needed in Estonia, but also on NZEB development in Europe and worldwide. In addition to solutions for new buildings, the group has been extensively working on renovation and development of an energy calculation methodology.

The research group has the NZEB technological research facility – a full-scale test building, climate chambers for controlled laboratory experiments, and heating and ventilation laboratories.

The group has contributed to the preparation of European NZEB technical definitions and system boundaries especially through the REHVA NZEB Task Force, has participated in the development of the 2nd generation EPBD standards in CEN TC371, TC156 and TC228 standardization committees, the preparation of the European COVID-19 ventilation guidance the REHVA COVID-19 Task Force, has contributed to the preparation of the Estonian energy action plan ENMAK 2030+ and the Long-term Renovation Strategy 2020–2050, and Estonian NZEB requirements and the development of an energy calculation methodology.

Some examples of the research topics and outcomes:

- Measurement of heat emission efficiency and development of a simulation methodology for EN EN15306-2;
- Development of occupancy and internal heat gain schedules for prEN16798-1 and ISO 17772-1;
- Modeling of geothermal energy piles and ground source heat pump in a whole building simulation environment for heating and free cooling purposes;
- Development of overheating prevention solutions and a temperature simulation based compliance assessment methodology for residential buildings;
- Development and validation of a simplified energy performance compliance assessment method for Estonian regulation based on the specific heat loss correlation;
- Quantification of economic benefits and job creation through renovation of apartment buildings;
- Scenario analyses for energy savings and investment needs within the framework of the Estonian energy action plan ENMAK 2030+;

- Preparation of European nZEB technical definitions and system – REHVA nZEB definition 2013, within the REHVA nZEB task force and cooperation with CEN;
- Preparation of the Estonian regulation on minimum energy performance requirements, calculation methodology and the energy performance certificate, including the acts of MKM m63 2012 and 2018, MKM m58 2012 and 2019 and MKM m36 2012 and 2019;
- Development of a completely new Estonian regulation for the indoor climate and ventilation requirements since 2015, expected to be published in 2021.
- Development of European REHVA COVID-19 guidance "How to operate HVAC and other building service systems to prevent the spread of the coronavirus (SARS-CoV-2) disease (COVID-19) in workplaces 2020"
- Preparation of the Estonian Long-term Renovation Strategy 2020–2050
- Development of European REHVA COVID-19 ventilation guidance, Estonian COVID-19 ventilation regulation and guidance for ventilation systems operation and improvements.

SELECTED PROJECTS

- COVSG38 "*Development of ventilation solutions for reduction of respiratory infections and sizing principles for SARS-CoV-2 virus*"
- VIR20049 "*Transnational Cooperation for Serial Energy Refurbishment in Baltic Sea Region*"
- VNF20025 "*Knowledge sharing on NZEB buildings in the Nordic-Baltic region*"

ROAD ENGINEERING AND GEODESY RESEARCH GROUP

Head of the research group: Professor ARTU ELLMANN, artu.ellmann@taltech.ee

Members: : Juhan Idnurm, Andrus Aavik, Ain Kendra, Luule Kaal, Inna Romandi, Arto Lille, Harri Rõuk, Nelli Ustinova, Tiit Metsvahi, Kalev Julge; mitteakadeemilised (Teede ja liikluse teadus- ja katselaborist): Sven Sillamäe, Hardo Pajus, Kristjan Lill, Urmo Pappel, Matiko Arde, Kait Värat, Rainis Eksi, Julia Kutsõn, Virko Pirrus

Doctoral students: Sander Sein, Kristjan Lill, Karli Kontson, Sander Varbla, Vahidreza Jahanmard, Majid Mostafavi

TOPICS AND COMPETENCES

KEYWORDS: roads, bridges, geodesy, geoinformatics

The main research topics of the Road Engineering and Geodesy research group are as follows:

- Implementation of the new research results concerning filtration properties of soils and their test methods;
- Research on stabilized pavement layers;
- Development of methodology for elastic pavement design
- Research on the road construction materials (bitumen, fillers, asphalt mixes, etc.)
- Analysis of increase in traffic and its impact, traffic safety (road safety auditing and inspection, road network impact analysis, safety analysis, etc.)
- Development of the calculation method for steel tube bridges based on the interaction between arc and soil
- Development of bridge managing systems and life cycle calculation for bridges
- Specification of the load bearing capacity for Soviet era standard reinforced concrete bridges according loadings based on Eurocode
- Geoid modelling research with emphasis on the Nordic-Baltic region
- Continued participation in an Estonian Research Infrastructures Roadmap project Estonian Environmental Observatory, which is a network of experimental sampling stations for environmental research – a system of uniform geographically and climatically integrated field laboratories and automatic stations that is supported by a geomatics and geoinformatics science laboratory;
- Development of geodetic infrastructure (e.g. establishment/validation of gravity databases, geoid modelling computations, mean sea surface modelling, studies of shipborne GNSS to evaluate geoid models at sea) for finalizing hydrographic surveys in the Baltic Sea;
- Development of technological solutions for combining different spatial data acquisition sensors in a mobile platform and corresponding data processing;
- Geodetic SAR for Baltic Height System Unification and studies for marine processes;
- Assessment of existing structures based on visual inspections, non-destructive testing or analytical models. Analysis of optimal intervention and inspection planning;
- Load testing of several bridges with heavy vehicles, validation of calculation models (resistance and structural models) and performance analysis of bridge network;
- Carrying out visual inspections, non-destructive testing, condition and intervention analysis of bridges.

SELECTED ARTICLES

Lill, K.; Khan, A. N.; Kontson, K.; Hesp, Simon A. M. (2020). Comparison of performance-based specification properties for asphalt binders sourced from around the world. Construction and Building Materials, 261, #120552.

Varbla, S.; Puust, R.; Ellmann, A. (2020). Accuracy assessment of RTK-GNSS equipped UAV conducted as-built surveys for construction site modelling. Survey Review.

Gruber, T.; Ågren, J.; Angermann, D.; Ellmann, A.; Engfeldt, A.; Gisinger, C.; Jaworski, L.; Marila, S.; Nastula, J.; Nilfouroushan, F.; Oikonomidou, X.; Poutanen, M.; Saari, T.; Schlaak, M.; Świątek, A.; Varbla, S.; Zdunek, R. (2020). Geodetic SAR for height system unification and sea level research – observation concept and preliminary results in the Baltic Sea. Remote Sensing, 12 (22), #3747.

STRUCTURAL AND FLUIDS MECHANICS RESEARCH GROUP

Head of the research group: Professor ALEKSANDER KLAUSON, aleksander.klauson@taltech.ee

Members: Ivar Annus, Andres Braunbrück, Janek Laanearu, Madis Ratassepp, Hendrik Naar, Andrus Räämet, Kristjan Tabri, Anatoli Vassiljev, Aleksander Kartušinski, Medhat Hussainov, Peeter Tikerpe, Murel Truu

Doctoral students: Lauri Hass, Saeed Hosseinzadeh, Mikk-Markus Imala, Katrin Kaur, Nils Kändler, Muhammad Saladin Prawirasasra, Carlos Omar Rasgado Moreno, Janet Roosimägi

TOPICS AND COMPETENCES

KEYWORDS: urban water systems, including drinking water, drainage and sewage systems, hydrodynamics, pipe flow, climate change mitigation, urban planning; anthropogenic underwater noise, monitoring and analysis of ambient underwater sound; nondestructive testing, modeling ultrasound propagation in various materials; fluid structure interaction of deformable structures; ultimate limit strength of marine structures; analysis and simulation of maritime accidents; simulation and assessment of ships seakeeping performance

The research team works in four research fields:

1. Modelling, planning, management and risk analysis of urban water systems.

The research is focused on optimization, planning, development, management, risk assessment and mitigation of hydraulic systems (e.g. urban drainage systems, water distribution networks). The research focuses on implementation and improvement of digital twins of the systems in order to decrease the pluvial flooding risks in urban areas. New algorithms have been developed to enable automatic calibration of the simulation models and to apply these for decentralized model based control. The development of a holistic urban planning tool has been completed. It enables analyzing of the impacts of climate change, new developments and technical solutions for managing flooding risks in urban areas. The research of drinking water systems focuses on the impact of old rough pipes on the flow dynamics and water quality modelling.

2. Underwater acoustics research.

The underwater acoustics research focuses on the contribution of anthropogenic noise to ambient noise according to MSRD requirements. To achieve this goal, the correlation of natural underwater noise with wind speed was studied. A new methodology has been developed to separate the wind-dependent signal portion in the frequency bands of interest.

3. Research on ship and marine structures.

The research on ship and marine structures focuses on the analysis of the behavior of marine structures under ultimate and accidental loads; on the analysis of the seakeeping performance of midsize fast ships and on the analysis interaction between fluid and deformable metallic structures. The studies are mainly based on experimental and numerical modeling.

SELECTED PROJECTS:

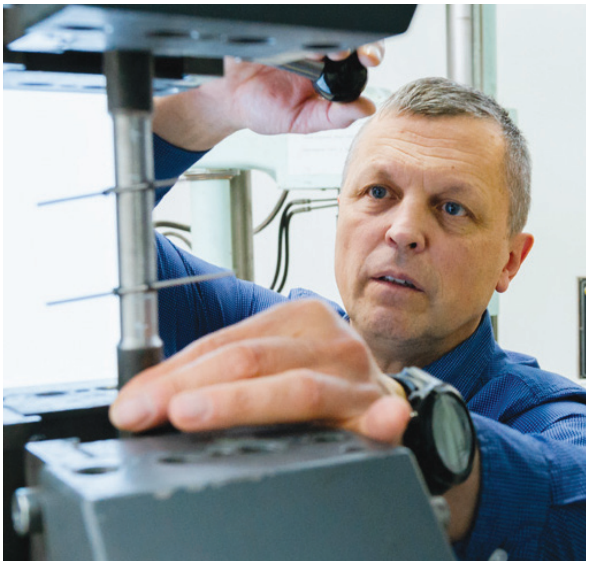
- PRG667 *Decentralized real-time control platform for urban drainage systems in climate proof smart cities* (DEPART) (2020–2024)
- VIR20031 *Testing new storm water treatment solutions for reduction of hazardous substances and toxins inflows into the Baltic Sea* (2020–2022)
- VIR18049 *Protecting Baltic Sea from untreated wastewater spillages during flood events in urban areas* (2019–2022)

SELECTED ARTICLES

Annus, I.; Vassiljev, A.; Kändler, N.; Kaur, K. (2020). Determination of the corresponding roughness height in a WDS model containing old rough pipes. Journal of Water Supply Research and Technology –AQUA, 69 (3), 201–209.

Kändler, N.; Annus, I.; Vassiljev, A.; Puust, R. (2020). Real time controlled sustainable urban drainage systems in dense urban areas. Journal of Water Supply Research and Technology – AQUA, 69 (3), 238–247.

Kaur, K.; Vassiljev, A.; Annus, I.; Kändler, N.; Roosimägi, J. (2020). Numerical investigation of the impact of irregular pipe wall build-up on velocity in the water distribution system. Journal of Water Supply Research and Technology – AQUA, 69 (7), 647–655.



STRUCTURAL ENGINEERING RESEARCH GROUP

Head of the research group: Associate Professor IVAR TALVIK, ivar.talvik@taltech.ee

Members: Alar Just, Ahti Lääne, Aldur Parts, Johannes Pello, Kristo Paalandi, Priit Luhakooder, Mattia Tiso

Doctoral students: Johanna Liblik, Eero Tuhkanen, Katrin Nele Mäger

TOPICS AND COMPETENCES

KEYWORDS: structural engineering, fire resistance, Eurocode, cross-laminated timber, glulam timber

The studies of the group are related to the analysis of various building structures and foundations.

Current research is focused on timber and steel structures at ambient and elevated temperatures. Design methods are developed regarding the effect of the charring layer on resistance of timber elements in fire. Interaction of timber structures with different insulation materials and claddings is also studied. The European test method for determining the fire resistance of adhesives used in engineered wood structures is under development. The research results have direct connection with the revision process of Eurocode 5.

Other topics of research cover connections and stiffness properties of cross laminated timber elements and behaviour of steel elements and connections in fire.

The members of the group provide their expertise in industrial research and development projects of the construction sector.

The research group cooperates with other technical universities and research institutes (ETH, RISE, TUM) MPA Stuttgart.

SELECTED ARTICLES

Kervalishvili, A.; Talvik, I. (2020). Reliability based design method for buckling of steel columns in fire. Journal of Structural Fire Engineering, vol 11, pp 167–187.

Liblik, J.; Küppers, J.; Maaten, B.; Just, A. (2020). Fire protection provided by clay and lime plasters. Wood Material Science and Engineering. DOI: 10.1080/17480272.2020.1714726.

Mäger, K. N.; Tiso, M.; Just, A. (2020). Fire Design Model for Timber Frame Assemblies with Rectangular and I-Shaped Members. In: Wood & Fire Safety (268–274). Springer.

WATER AND ENVIRONMENTAL ENGINEERING

Head of the research group: Professor KARIN PACHEL, karin.pachel@taltech.ee

Members: Arvo Iital, Enn Loigu, Alvina Reihan, Viktoria Voronova, Kristjan Piirimäe, Erki Lember, Argo Kuusik, Olev Sokk, Jaak Jaaku, Eve Pehka, Maret Merisaar

Doctoral students: Marija Klõga, Kati Roosalu, Yaroslav Kobets, Pavlo Lyshtva

TOPICS AND COMPETENCES

KEYWORDS: water quality, water resources, climate changes, hydrology, pollution load, water supply, sewerage, water monitoring, nutrients, wastewater, stormwater, sewage, sludge, waste

This is an interdisciplinary research group, where engineers, hydrologists, water chemists and other specialists from both water and environmental engineering participate. Research is developed in the following directions:

- Sustainable management of water resources and water quality. Hydrological studies of rivers from engineering viewpoint. Climate change and its impact on the quantity and quality of water. Floods and draughts.
- Studies on pressures having impact on water quality. Regularities in water quality formation in both natural conditions as well as under various anthropogenic impacts.
- Studies in the field of riverine pollution loads. Water protection measures. Innovative methods of water monitoring (automatic systems for water monitoring). Studies on diffuse pollution and mitigation thereof.
- Urban water supply (domestic water) and sewage systems (sewerage, wastewater, stormwater), including pipelines outside buildings, internal pipelines in buildings, treatment facilities, engineering solutions and technologies, studies for improving design and construction. Pharmaceutical residues and heavy metals in municipal wastewater and sludge, as well as elaboration of relevant treatment technologies.
- Waste management. Waste utilisation. Treatment technologies for landfill leachate water, engineering solutions. Investigation of the possibilities of production of biogas from biodegradable waste and by-products of the processing industry.

For scientific and experimental research, the group uses its own internationally accredited water quality laboratory.

SELECTED PROJECTS

- VFP19048 "*Developing and Implementing Sustainability-Based Solutions for Bio-Based Plastic Production and Use to Preserve Land and Sea Environmental Quality in Europe*" Horizon2020.

- VEU19017 "*Development of an integrated water management and its modern tools in Estonia – strategic choices for future*".
- VIR20028 "*Development of Daily Allowable Maximum Loads of pollutants and fostering agreements between stakeholders in pilot catchment areas on effective measures to decrease nutrient load to the Gulf of nutrient load to the Gulf of Riga*".

SELECTED ARTICLES

Smol, M.; Preisner, M.; Bianchini, A.; Rossi, J.; Hermann, L.; Schaaf, T.; Kruopienė, J.; Pamakštys, K.; Klavins, M.; Ozola-Davidane, R.; Kalnina, D.; Strade, E.; Voronova, V.; Pachel, K.; Yang, X.; Steenari, B.-M.; Svanström, M. (2020). Strategies for Sustainable and Circular Management of Phosphorus in the Baltic Sea Region: The Holistic Approach of the InPhos Project. Sustainability, 12 (6), 2567.

Kõrgmaa, V., Laht, M., Rebane, R., Lember, E., Pachel, K., Kriipsalu, M., Tenno, T., Iital, A. (2020). Removal of Hazardous Substances in Municipal Wastewater Treatment Plants. Water Science & Technology, 81 (9).

DEPARTMENT OF ELECTRICAL POWER ENGINEERING AND MECHATRONICS

Director: Professor IVO PALU,
ivo.palu@taltech.ee,
+372 620 3752

MAIN FIGURES 2020

(as of Dec. 31, 2020)

58 Academic staff — Incl. 9 professors, 36 researchers

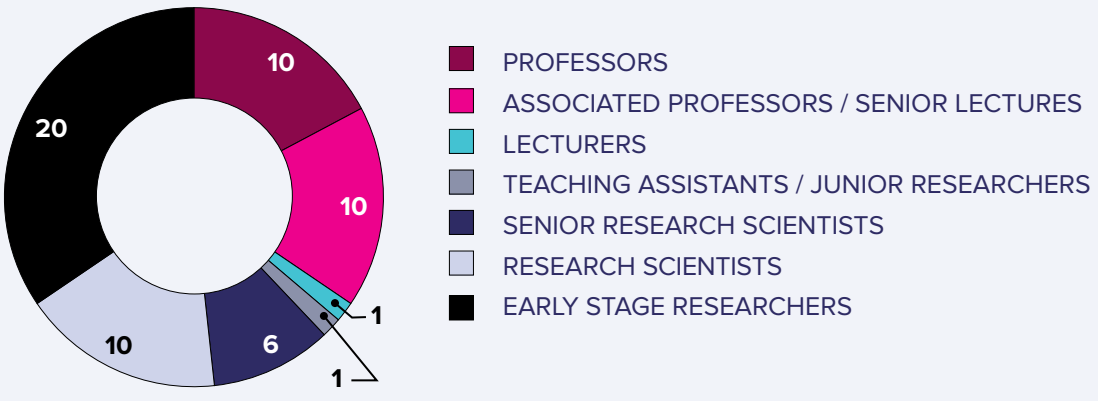
43 Doctoral students — 1 Defended doctoral dissertations

163 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 7 RESEARCH GROUPS:

- **ELECTRICAL MACHINES.**
  Head: Professor ANTS KALLASTE, ants.kallaste@taltech.ee
- **ENERGY ECONOMICS.**
  Head: Professor IVO PALU, ivo.palu@taltech.ee
- **FUNDAMENTALS OF ELECTRICAL ENGINEERING.**
  Head: Professor LAURI KÜTT, lauri.kutt@taltech.ee
- **MECHATRONICS AND AUTONOMOUS SYSTEMS CENTRE.**
  Head: Professor ANTON RASSÕLKIN, anton.rassolkin@taltech.ee
- **MICROGRIDS AND METROLOGY.**
  Head: Professor ARGO ROSIN, argo.rosin@taltech.ee
- **POWER ELECTRONICS.**
  Head: Researcher-Professor DMITRI VINNIKOV, dmitri.vinnikov@taltech.ee
- **POWER SYSTEMS.**
  Head: Associated Professor JAKO KILTER, jako.kilter@taltech.ee



ELECTRICAL MACHINES RESEARCH GROUP

Head of the research group: Professor ANTS KALLASTE, ants.kallaste@taltech.ee

Members: Anouar Belahcen, Toomas Vaimann, Payam Shams Ghahfarokhi

Doctoral students: Bilal Asad, Hans Tiismus, Hadi Ashraf Raja, Ekaterina Andriushchenko, Karolina Kudelina

TOPICS AND COMPETENCES

KEYWORDS: electrical machines, generators, electrical drives, fault diagnostics, condition monitoring, artificial intelligence

The Electrical Machines Research Group is mainly involved in analysis, design, testing, development etc. of electrical machines, including wind generators. Additionally, the research group deals with electrical machine diagnostics, developing of permanent magnet materials for the use in electrical machines, novel methodologies for design and optimization of electrical machines and drives.

The main research topics of the last years have been the investigation of additive manufacturing possibilities of electrical machines and the development of this technology. Active research is going on in the field of intelligent methods for electrical machines and drive systems condition monitoring and diagnostics, involving Artificial Intelligence methods, possibilities provided by Internet of Things and Industry 4.0 technologies.

The group is actively involved in scientific partnership with other universities and R&D institutions. Services, such as consultations, trainings, expert assessment, etc., are provided for industrial partners.

SELECTED PROJECTS

- PSG137 "*Additive Manufacturing of Electrical Machines*".
- Lep19042 "*Changing the transport characteristics of the TEP70 locomotive*".

SELECTED PUBLICATIONS

Asad, B.; Vaimann, T.; Belahcen, A.; Kallaste, A.; Rassõlkin, A.; Naveed Iqbal, M. (2020). The Cluster Computation-Based Hybrid FEM–Analytical Model of Induction Motor for Fault Diagnostics. Applied Sciences. DOI: 10.3390/app10217572.

Asad, B.; Vaimann, T.; Belahcen, A.; Rassõlkin, A.; Kallaste, A. Naveed Iqbal, M. (2020). Modified Winding Function-based Model of Squirrel Cage Induction Motor for Fault Diagnostics. IET Electric Power Applications, 1–13.

Tiismus, H.; Kallaste, A.; Belahcen, A.; Vaimann, T.; Rassõlkin, A.; Lukichev, D. (2020). Hysteresis Measurements and Numerical Losses Segregation of Additively Manufactured Silicon Steel for 3D Printing Electrical Machines. Applied Sciences, 10 (18), #6515.

Sathyan, S.; Aydin, U.; Lehikoinen, A.; Belahcen, A.; Vaimann, T.; Kataja, J. (2019). Influence of magnetic forces and magnetostriction on the vibration behavior of an induction motor. International Journal of Applied Electromagnetics and Mechanics, 59 (3), 825–834.10.3233/JAE-171045. Case Studies in Thermal Engineering, 12, 381–389.

ENERGY ECONOMICS RESEARCH GROUP

Head of the research group: Professor IVO PALU, ivo.palu@taltech.ee

Members: Fushuan Wen, Heiki Tammoja, Victor Astapov, Jelena Šuvalova, Paul Taklaja, Hardi Koduvere, Hannes Agabus

Doctoral students: Karl Kull, Sambeet Mishra, Ivar Kiitam, Lauri Ulm, Cletus John Crasta, Aron Kuhi-Thalfeldt, Elina Rebecka Rikkas

TOPICS AND COMPETENCES

KEYWORDS: green energy economy, technology applicability and investment profitability analyses, economic and technical modelling of power system and electricity market, high voltage, insulators, partial discharges.

The research team specializes in energy systems by looking and taking into account the different components and challenges that the energy market consists of in today's society. By conducting various analysis, the team is able to create order and gain insight into the complex field of energy forecasting.

In everyday practice, the team has vast resources of information on the Estonian energy system and by implementing it with modelling software like Balmorel, LEAP, EnergyPro and TIMES, it is possible to make breakthroughs and define conclusions on the economic aspects and the future of the energy system.

The energy economics research team is able to create complicated models, which take into account possible future technologies and trends in order to help assess the economic aspect of new power plants and their competitiveness in tomorrow's market.

The research team has raised its international competence in the fields of technology applicability and real investment profitability analysis.

An additional area of research is the digitalization of the energy sector, where the focus is on leveraging climate finance/green investments and modernizing the electricity market design with products and services based on new technologies.

The High Voltage research laboratory activities are focused on the studies of the high voltage insulation and applications associated with the high voltages and strong electrical fields. Most research is related to the insulators and insulation used in power lines, both overhead and cable lines are studied. Another scope of research is the effects of high loading, nonlinear loads and power quality to high voltage equipment (transformers, cable power lines etc.).

SELECTED PUBLICATIONS

Shafiq, M.; Kiitam, I.; Kauhaniemi, K.; Taklaja, P.; Kütt, L.; Palu, I. (2020). Performance Comparison of PD Data Acquisition Techniques for Condition Monitoring of Medium Voltage Cables. Energies, 13 (16), #4272.

Mishra, S.; Oren, E.; Bordin, C.; Wen, F.; Palu, I. (2020). Features Extraction of Wind Ramp Events from a Virtual Wind Park. Energy Reports, 237–249.

Weijia Liu, Fushuan Wen, Zhaoyang Dong, Ivo Palu. Development of robust participation strategies for an aggregator of electric vehicles in multiple types of electricity markets. Energy Conversion and Economics (IET, Wiley), Vol.1, No.2, 2020, pp.104–123.

RESEARCH GROUP OF FUNDAMENTALS OF ELECTRICAL ENGINEERING

Head of the research group: Professor LAURI KÜTT, lauri.kutt@taltech.ee

Members: Aleksander Kilk, Martin Jaanus, Toomas Vinnal, Tarmo Rosman, Heigo Mõlder, Marek Jarkovoi, Martin Parker

Doctoral students: Muhammad Naveed Iqbal, Noman Shabbir, Kamran Daniel

TOPICS AND COMPETENCES

KEYWORDS: electromagnetic compatibility, electric power quality, electromagentic research, electrical engineering, circuit analysis, thermo-electric generators

The main research activities are related to electric power supply quality (voltage quality, including voltage level and voltage waveform parameters, their influences and optimization; alternating voltage/current measurements and measurement data processing; investigation for influence of the voltage quality on the operation of devices and systems, etc.) and electromagnetic compatibility (EMC) (mutual electromagnetic influence of devices and systems, electromagnetic emission and immunity; wideband EM-field measurement and evaluation; influence of EM-noise on the operation of devices and systems, etc.).

In the field of electric power quality, challenges arise from the upcoming EU energy regulations, laying down requirements that can be achieved through higher amount of power electric converters related to small-power generation units including photovoltaic panels, small-power wind and other renewable producers. In order to achieve this, an investigation has to be carried out for the limits and capabilities of a public distribution network for operation without inadvertent violations of the voltage quality. The topics are closely related to both the fields of power quality (requirements to voltage quality and overload avoidance) and of EMC (requirements for devices and/or enforcement of the network against voltage degradation).

In the topics of EMC the research is targeted at conditions on how to combine different technologies in the same power supply grid (for example, power line communication and devices in the network), how to guarantee the compliance of specific electric and electronic products to the EU EMC and low voltage directives. The research group has equipment in the EMC laboratory, which also provides capabilities to test the products prior to their market release. The EMC laboratory can also provide services to the innovative electric and electronic industry, supporting faster development and market entry of their products.

SELECTED PUBLICATIONS

Iqbal, M. N.; Kütt, L.; Asad, B.; Vaimann, T.; Rassõlkin, A.; Demidova, G. (2020). Time Dependency of Current Harmonics for Switch-Mode Power Supplies. Applied Sciences, 10 (21), #7806.10.3390/app10217806.

Shabbir, N.; Kütt, L.; Jawad, M.; Iqbal, M. N.; Ghahfaroki, P. S. (2020). Forecasting of Energy Consumption and Production Using Recurrent Neural Networks. Advances in Electrical and Electronic Engineering, 18 (3), 190–197. DOI: 10.15598/aeee.v18i3.3597.

MECHATRONICS AND AUTONOMOUS SYSTEMS CENTRE

Head of the research group: Professor ANTON RASSÕLKIN, anton.rassolkin@taltech.ee

Members: Trieu Minh Vu (until 31.08.2020), Mart Tamre, Andres Kiitam, Tiia Tammaru, Leo Teder, Dmitry Shvarts, Robert Hudjakov, Märt Juurma, Ali Zahavi, Georg Haud

Doctoral students: Kristjan Pütsep, Hamidreza Heidari, Viktor Rjabtšikov, Dhanushka Chamara Liyanage, Even Sekhri, Saleh Ragheb Saleh Alsaleh

TOPICS AND COMPETENCES

KEYWORDS: design and control of mechatronic systems, machine vision applications, propulsion drive, Digital Twins , UGV and UAV simulations

The research activities of the Mechatronics and Autonomous Systems Centre are focused on the further development of mechatronics and autonomous systems. Modern vehicles (including various electric vehicles, e.g. electric cars, unmanned land and aircraft) also require energy efficiency optimization. To achieve this goal, the research team is working on the development of a number of test platforms and digital twins. In order to prolong the working life of vehicles and reduce the risk of failure, the possibilities of combining real and virtual sensors with artificial intelligence are being explored.

Prof. Mart Tamre is focused on the development of robotics and automation hardware and software based on the AI and the development of smart user interfaces as well as the development of sensor and especially machine vision applications. The main attention is on AI and especially on Depp Learning and hyper- and multispectral machine vision applications and the respective application and simulation software development and their implementation at practical industrial robotics social robotics and UGV and UAV systems. The focus is also on the development of hardware-in-the-loop simulation and test systems.

The research group is also active in Quality Engineering activities led by Prof. Emer and researcher Andres Kiitam together with researcher Tiia Tammaru.

SELECTED PUBLICATIONS

Rassõlkin, A.; Belahcen, A.; Kallaste, A.; Vaimann, T.: Lukichev, D. V.; Orlova, S.; Heidari, H.; Asad, B.; Pando Acedo, J. (2020). Life cycle analysis of electrical motor-drive system based on electrical machine type. Proceedings of the Estonian Academy of Sciences, 69 (2), 162–177.

Heidari, H.; Rassolkin, A.; Holakooie, M. H.; Vaimann, T; Kallaste, A; Belahcen, A; Lukichev, D. V. (2020). A Parallel Estimation System of Stator Resistance and Rotor Speed for Active Disturbance Rejection Control of Six-Phase Induction Motor. Energies, 13 (5).

Orosz, T.; Rassõlkin, A.; Kallaste, A.; Arsénio, P.; Pánek, D.; Kaska; J.; Karban, P. (2020). Robust Design Optimization and Emerging Technologies for Electrical Machines: Challenges and Open Problems. Applied Sciences, 10 (19), #6653.

MICROGRIDS AND METROLOGY

Head of the research group: Professor ARGO ROSIN, argo.rosin@taltech.ee

Members: Helmuth Biechl (Hochschule Kempten, Germany), Tarmo Korõtko, Arvo Oorn, Taavi Möller

Postdoctoral researcher: Roya Ahmadiahangar

Doctoral students: Tobias Häring, Vahur Maask, Andreas Christian Armstorfer, Jorge Luis Helguero Cruz, Toivo Varjas, Freddy Plaum, Nauman Beg

TOPICS AND COMPETENCES

KEYWORDS: microgrids, artificial intelligence, automation systems, energy flexibility, energy storages, electrical lighting

The studies of the research group are focused on

(1) optimization of microgrids power supply systems;

(2) AI based power flow control and energy storages;

(3) research of electrical lighting and development of measurement science.

Social influence: higher energy/cost efficiency, reliability, and flexibility of power supply automation and lighting systems; improvement of measurement methods and development of integrated diagnostic solutions for industry.

SELECTED RESEARCH PROJECTS:

- *Proof of Concept of an Integrated Monitoring and Diagnostics Solution For Predictive Maintenance of Expansion Joints* (LEP18101);
- *Lighting the Baltic Sea Region – Cities accelerate the deployment of sustainable and smart urban lighting solutions* (VIR19013);
- *Optimization of power flow control in Zero energy and resource efficient smart buildings and districts* (TAR16012);
- VFP19031 (H2020) "*FINEST TWINS: Establishment of Smart City Center of Excellence*"

SELECTED PUBLICATIONS

Rosin, A.; AhmadiAhangar, R.; Azizi, E.; Sahoo, S.; Vinnikov, D.; Blaabjerg, F.; Dragicevic, T.; Bolouki, S. (2020). Clustering-based Penalty Signal Design for Flexibility Utilization. IEEE Access, 1–11.

Ahmadiahangar, R.; Shabbir, N.; Rosin, A.; Kütt, L.; Palu, I.; Fushuan, W. (2020). Flexibility Enhancement for a Power System through Machine-learning based Electricity Demand Prediction. Electric Power Construction, 41 (S1), 38–44.

Ahmadiahangar, R.; Rosin, A.; Palu, I.; Azizi, A. (2020). Demand-side Flexibility in Smart Grid. Springer. Part of the SpringerBriefs in Applied Sciences and Technology book series (BRIEFS-APPLSCIENCES).

POWER ELECTRONICS GROUP

Head of the research group: Researcher-Professor DMITRI VINNIKOV, dmitri.vinnikov@taltech.ee

Members: Indrek Roasto, Tanel Jalakas, Andrii Chub, Andrei Blinov, Oleksandr Husev, Elizaveta Liivik, Roman Kosenko

Postdoctoral researcher: Hamed Mashinchi Maheri, Naser Vosoughi Kurdkandi

Doctoral students: Oleksandr Korkh, Denys Zinchenko, Oleksandr Matiushkin, Mahdiyyeh Najafzadeh, Abualkasim Ahmed Ali Bakeer, Vadim Sidorov, Saeed Rahimpour

TOPICS AND COMPETENCES

KEYWORDS: power converters for renewables, energy systempower converters for renewables, energy systems for near-zero energy buildings, power converters for energy storages, reliability of power electronic systems

Research in the group is focused on the development and experimental validation of advanced power electronic converters for such demanding applications as renewable energy systems, rolling stock, automotive and telecom. The key research directions include synthesis of new converter topologies, development of special control and protection algorithms, implementation of advanced components and materials, and elaboration of design guidelines for enhancing the efficiency, power density and reliability of the on-market power electronic systems.

Since 2010 the Power Electronic Group is a member of ECPE - European Center for Power Electronics e.V., which is an industry-driven research network promoting education, innovation, science, research and technology transfer in the area of Power Electronics in Europe. Moreover, the group is a part of ZEBE – Estonian Centre of Excellence for zero energy and resource efficient smart buildings and districts. The core activities in ZEBE are related to the advancing of the residential DC microgrid technology and acceleration of the transition towards highly energy-efficient and decarbonized buildings. In 2020 the group members participated in more than 10 different national and international R&D projects, from which the following can be highlighted:

- LEP18046 "*Proof of Concept of Energy Efficient Universal Autonomous Surface Vessel* (15.05.2018–30.04.2020)", Indrek Roasto
- PSG206 "*DC-DC Converters with Ultra-Wide Regulation Range and Post-Fault Operation Capability* (1.01.2019–31.12.2022)", Andrii Chub
- VE19058 "*High-efficient EV charger based on 3-level unfolder and current-fed isolated DC-DC converters* (1.05.2019–31.12.2020)", Andrii Blinov

SELECTED PUBLICATIONS

Chub, D. Vinnikov, R. Kosenko, E. Liivik and I. Galkin, "Bidirectional DC–DC Converter for Modular Residential Battery Energy Storage Systems," in IEEE Transactions on Industrial Electronics, vol. 67, no. 3, pp. 1944–1955, March 2020.

D. Vinnikov, A. Chub, D. Zinchenko, V. Sidorov, M. Malinowski and S. Bayhan, "Topology-Morphing Photovoltaic Microconverter With Wide MPPT Voltage Window and Post-Fault Operation Capability," in IEEE Access, vol. 8, pp. 153941-153955, 2020.

O. Husev, C. Roncero-Clemente, E. Makovenko, S. P. Pimentel, D. Vinnikov and J. Martins, "Optimization and Implementation of the Proportional-Resonant Controller for Grid-Connected Inverter With Significant Computation Delay," in IEEE Transactions on Industrial Electronics, vol. 67, no. 2, pp. 1201–1211, Feb. 2020.

POWER SYSTEMS RESEARCH GROUP

Head of the research group: Associate Professor JAKO KILTER, jako.kilter@taltech.ee

Members: Ülo Treufeldt, Mati Meldorf, Kaur Tuttelberg, Tanel Sarnet, Uku Salumäe

Doctoral students: Doctoral students: Mari Löper, Madis Leinakse, Marko Tealane, Tarmo Trummal, Alexander Mazikas, Henri Manninen, Guido Andreesen, Nathalia De Morais Dias Campos

TOPICS AND COMPETENCES

KEYWORDS: power system analysis, wide area measurementsHVDC and FACTS control, wind power connections, power quality, load modelling

Research activities in the group are focused on the development of control and protection algorithms and applications, and performing system analysis considering the challenges in modern and future power systems.

Key research areas: power system real-time control protection and analysis based on wide-area information with respect to HVDC and FACTS control, wind power integration, power quality and load modelling. Emphasis is on modern power systems where the level of generation through converters is increasing and consequently the level of system inertia is decreasing.

Other research activities: the development and assessment of power quality mitigation methods in transmission and distribution systems considering the availability of modern compensation devices and wide-area information.

Cooperation with companies is focused on carrying out multiple and important R&D activities related to power system planning and control challenges, e.g. system black start capability, optimal system control in future power systems, static and dynamic characteristics of the Estonian power system and reactive power planning in the Estonian power system.

Main research outcomes:

- Development of
  - new methods and applications for power system, inertia and short-circuit power estimation for the use of wide-area measurements for power system analysis and control.
  - novel methods for power quality monitoring and assessment in transmission networks.
  - principles for modelling and analysis of Estonian power system black-start restoration process
  - Electrical Power Engineering master's level study programme and its enhancement in the field of ICT.
- Development and application of complex optimization methods for thermal power plants.
- Analysis of the operation of Estonian HVDC connections considering various future scenarios.
- Analysis and development of the power system wide-area protection concept in the scope of Estonian power system protection principles.

SELECTED PUBLICATIONS

Leinakse, M., Kilter, J. (2021) Exponential to ZIP and ZIP to exponential load model conversion: Methods and error. IET Generation, Transmission & Distribution.

Ramlal, C., Manninen, H., Singh, A., Rocke, S., Kilter, J., Landsberg, M. (2020). Toward Automated Utility Pole Condition Monitoring: A Deep Learning Approach. The 2020 IEEE PES Innovative Smart Grid Technologies Europe (ISGT-Europe), The Hague, Netherlands, 25–28 October 2020.

DEPARTMENT OF ENERGY TECHNOLOGY

Director: Professor ANDRES SIIRDE,
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+372 620 3902

MAIN FIGURES 2020

(as of Dec. 31, 2020)

21 Academic staff — Incl. 3 professors, 13 researchers

9 Doctoral students

19 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN THREE RESEARCH GROUPS:

- **CHEMICAL ENGINEERING RESEARCH AND DEVELOPMENT CENTER.**
  Head: Senior Researcher OLIVER JÄRVIK, oliver.jarvik@taltech.ee
- **RESEARCH GROUP OF SUSTAINABLE ENERGY AND FUELS.**
  Head: Professor ALAR KONIST, alar.konist@taltech.ee
- **SMART DISTRICT HEATING SYSTEMS AND INTEGRATED ASSESSMENT ANALYSIS OF GREENHOUSE GASES EMISSIONS.**
  Head: Senior Researcher ANNA VOLKOVA, anna.volkova@taltech.ee

CHEMICAL ENGINEERING RESEARCH AND DEVELOPMENT CENTER

Head of the research group: Senior Researcher OLIVER JÄRVIK, oliver.jarvik@taltech.ee

Members: Zachariah Steven Baird

Doctoral students: Parsa Mozaffari, Sepehr Mozaffari

TOPICS AND COMPETENCES

KEYWORDS: thermodynamic properties, multicomponent mixtures, vapor pressure, correlations, pyrolysis, machine learning

The research group carries out studies of thermodynamic properties of organic compounds and pyrolysis oils (shale oil and bio-oil) with the focus on vapor pressure measurements.

Research on the thermal behavior of solids and liquids and on the parameters (molar mass distribution, density, refractive index, rheological properties) and thermal stability of various mixtures of organic substances (oils, resins, polymers) is also underway. The group's activities are closely intertwined with the work of the Sustainable Energy and Fuels Research Group.

The group's recent research activities are related to the following topics:

- Measurements of vapor pressures of shale oil fractions;
- Measurement of vapor pressures of phenolic compounds;
- Modelling of vapor pressures of mixtures;
- Studies of co-pyrolysis

SELECTED ARTICLES

Mozaffari, P.; Baird, Z. S.; Listak, M.; Oja, V. (2020). Vapor pressures of narrow gasoline fractions from Kukersite shale oil. Oil Shale, https://doi.org/10.3176/oil.2020.4.03

Mozaffari, P.; Järvik, O.; Baird, Z. S. (2020). Vapor Pressures of Phenolic Compounds Found in Pyrolysis Oil. Journal of Chemical & Engineering Data, 65 (11), 5559–5566.

Baird, Z. S.; Uusi-Kyyny, P.; Witos, J.; Rantamäki, A. H.; Sixta, H.; Wiedmer, S. K.; Alopaeus, V. (2020). Vapor–Liquid Equilibrium of Ionic Liquid 7-Methyl-1,5,7-triazabicyclo [4.4.0]dec-5-enium Acetate and Its Mixtures with Water. Journal of Chemical & Engineering Data.

RESEARCH GROUP OF SUSTAINABLE ENERGY AND FUELS

Head of the research group: Professor ALAR KONIST, alar.konist@taltech.ee

Members: Tõnu Pihu, Oliver Järvik, Dmitri Nešumajev, Birgit Maaten, Heidi Lees, Zachariah Steven Baird

Postdoctoral Researcher: Päärn Paiste

Doctoral students: Heliis Pikkor, Mari Sulg, Alejandro Lyons Cerón, Mais Hanna Suleiman Baqain

TOPICS AND COMPETENCES

KEYWORDS: fuels, combustion, pyrolysis, gasification, ash, activation energies, CO_2 emissions, CCS and CCU (incl. Oxyfuel)

Moving toward zero carbon emissions is an ultimate goal for energy technology. The group intends to tackle the problem by studying the possibilities of oxy-fuel co-combustion of oil shale (OS) and biomass in circulating fluidized bed (CFB) boiler. Further, utilization of the remaining Ca-rich ash as a bed material for binding CO_2 (also SO_x and NO_x) in fluidized bed combustion of biomass for achieving negative carbon emissions in biomass combustion will be studied. Lab-scale up to semi- industrial scale experiments will be carried out to investigate the combustion process parameters to achieve this.

In addition, the group deals with better characterization of fly ash, in order to enable more effective use of the ash that is formed under oxyfuel combustion conditions. The "organic and in-organic" (carbon) portion of the ash is the key to success in many new utilization schemes.

A broad-based scientific investigation of the form, sorptive properties and behaviour of the inorganic/organic material in ash samples is carried out in order to help identify new commercial opportunities.

The accredited laboratory group provides accredited sample analyses for various customers.

SELECTED PROJECTS

- PSG266, *Effects of activation conditions on preparation of porous carbon from oil shale* (2019–2022)
- RITA1/02-20, *Climate change mitigation with CCS and CCU technologies* (2019–2021)
- LEP17084, *Fundamental Research studies on thermochemical conversion of local biomass in Utilitas Tallinn powerplant* (2017–2020)
- LEIEE20004 "*Fundamental Research studies on Oil Shale Technologies at Enefit Energiatootmise AS*" (2020)

SELECTED ARTICLES

Lees, H.; Järvik, O.; Konist, A.; Siirde, A.; Maaten, B. (2020). Computational results of the ecotoxic analysis of fly and bottom ash from oil shale power plants and shale oil production facilities. Chemical Engineering Transactions, 81, 967–972.

Pikkor, H.; Maaten, B.; Baird, Z. S.; Järvik, O.; Konist, A.; Lees, H. (2020). Surface Area of Oil Shale and its Solid Pyrolysis Products Depending on the Particle Size. Chemical Engineering Transactions, 81, 961–966.

Konist, A.; Neshumayev, D.; Baird, Z. S.; Anthony, E. J.; Maasikmets, M.; Järvik, O. (2020). Mineral and Heavy Metal Composition of Oil Shale Ash from Oxyfuel Combustion. ACS Omega, 5, 32498–32506.

SMART DISTRICT HEATING SYSTEMS AND INTEGRATED ASSESSMENT ANALYSIS OF GREENHOUSE GASES EMISSIONS

Head of the research group: Senior Researcher ANNA VOLKOVA, anna.volkova@taltech.ee

Members: Andres, Siirde, Eduard Latõšov, Igor Krupenski, Vladislav Mašatin, Jūlija Gušča, Henrik Pieper

Doctoral student: Kertu Lepiksaar

TOPICS AND COMPETENCES

KEYWORDS: 4th generation district heating, low temperature district heating, primary energy factors, CO_2 emissions, thermal energy storage, CHP

The group deals with: (1) the development of new technical solutions for the transition of district heating (DH) systems towards an intelligent, highly efficient and regenerative energy supply concept and (2) integrated assessment analysis of greenhouse gas emissions.

The group's recent research activities are connected with the analysis of:

- The heat supply option of a low temperature district heating network from the return line of a well-established high temperature district heating system.
- The impact of return temperature reduction on a high temperature district heating system.
- Planning of Estonian district heating regions.

- Existing large-scale DH system transition towards 4th generation DH.
- Low temperature DH networks.
- Integration of large heat pumps into DH systems.
- The mobile app NutiSoojus for promotion of sustainable district heating.
- The impact of parallel consumption on district heating.
- Calculation of primary energy factors for district heating and cooling.

SELECTED PROJECTS

- LEIEV20064 "*Heat pump potential in the Baltic States*" (2020–2021)
- LEIEV20114 "*A comprehensive toolbox for integrating low-temperature sub-networks in existing district heating networks*" (2020–2022).

SELECTED ARTICLES

Volkova, A.; Krupenski, I.; Ledvanov, A.; Hlebnikov, A.; Lepiksaar, K.; Latõšov, E.; Mašatin, V. (2020). Energy cascade connection of a low-temperature district heating network to the return line of a high-temperature district heating network. Energy, 198, https://doi.org/10.1016/j.energy.2020.117304

Volkova, A.; Latõšov E.; Lepiksaar K.; Siirde A. (2020). Planning of district heating regions in Estonia. International Journal of Sustainable Energy Planning and Management, Vol.25, 2020 https://doi.org/10.5278/ijsepm.3490

Volkova, A.; Pieper, H.; Krupenski, I.; Ledvanov, A.; Latõšov, E.; Siirde, A. (2019). Small low-temperature district heating network development prospects. Energy, 714–722.

DEPARTMENT OF MATERIALS AND ENVIRONMENTAL TECHNOLOGY

Director: Professor MALLE KRUNKS,
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+372 620 3363

MAIN FIGURES 2020

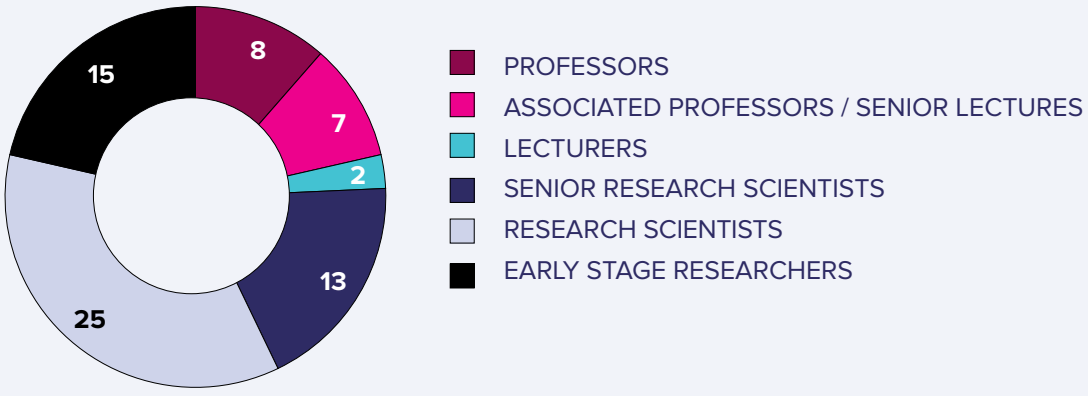
(as of Dec. 31, 2020)

70	Academic staff	Incl. 8 professors, 53 researchers	
27	Doctoral students	3	Defended doctoral dissertations
69	Scientific publications*		

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 8 RESEARCH GROUPS:

- **LABORATORY OF BIOFUNCTIONAL MATERIALS.**
  Head: Senior Research Scientist VITALI SÕRITSKI, vitali.syritski@taltech.ee
- **LABORATORY OF CHEMICAL THIN FILM TECHNOLOGIES.**
  Head: Professor ILONA OJA ACIK, ilona.oja@taltech.ee
- **LABORATORY OF ENVIRONMENTAL TECHNOLOGY..**
  Head: Professor SERGEI PREIS, sergei.preis@taltech.ee
- **LABORATORY OF INORGANIC MATERIALS.**
  Head: Professor ANDRES TRIKKEL, andres.trikkel@taltech.ee
- **LABORATORY OF OPTOELECTRONIC MATERIALS PHYSICS.**
  Head: Professor MAARJA GROSSBERG, maarja.grossberg@taltech.ee
- **LABORATORY OF PHOTOVOLTAIC MATERIALS RESEARCH.**
  Head: Senior Research Scientist MARIT KAUK-KUUSIK, marit.kauk-kuusik@taltech.ee
- **LABORATORY OF POLYMERS AND TEXTILE TECHNOLOGY.**
  Head: Professor ANDRES KRUMME, andres.krumme@taltech.ee
- **LABORATORY OF WOOD TECHNOLOGY.**
  Head: Professor JAAN KERS, jaan.kers@taltech.ee



LABORATORY OF BIOFUNCTIONAL MATERIALS

Head of the Laboratory: Senior Research Scientist VITALI SÕRITSKI, vitali.syritski@taltech.ee

Members: : Andres Öpik, Jekaterina Reut, Roman Borozнjak, Akinrinade George Ayankojo, Mariia Antipchik, Anna Kidakova

Doctoral student: Abdul Raziq

TOPICS AND COMPETENCES

KEYWORDS: Molecularly Imprinted Polymers, synthetic receptors, sensors, medical diagnostics, PoCT, environmental monitoring, COVID-19 express test

The group develops smart biosensing functional materials to propose solutions with considerable potential impact on essential areas of human life such as environmental protection, medical diagnostics and cure. By employing the molecular imprinting technology, the group designs and synthesizes polymeric materials capable of selective capturing of small (traces of different antibiotics) and biomacromolecules (proteins e.g. antibodies and neurotrophic factors). The main benefits of these materials, so called Molecularly Imprinted Polymers (MIP), are related to their synthetic nature, i.e. excellent chemical and thermal stability associated with reproducible, cost-effective fabrication.

MIPs can be easily integrated with a variety of sensor platforms allowing label-free detection of a target analyte with high sensitivity and selectivity offering thus solutions for design of multianalyte chemosensors at low cost. The promising practical applications of such sensors could be found in clinical diagnostics, where MIP-based sensors could be implemented in devices for point-of-care testing (PoCT). It is expected that PoCT market segment will continue to grow at a rapid rate and thus will have immense importance in the healthcare systems both in Estonia and worldwide. MIPs could be also attractive materials for cost effective fabrication of chemosensors for real-time monitoring of hazardous pollutants in aquatic environment as an alternative to traditional costly and lengthy chromatography-based methods.

Currently the group is developing a prototype sensing system allowing express detection of the new coronavirus (SAR-CoV-2). The system is portable and can be employed e.g. at primary health care centers and hospitals for preliminary screening of patients.

SELECTED PROJECTS

- PRG307 *Molecularly imprinted polymers as sensing materials for medical diagnostics and environmental monitoring* (2019–2023)
- COVSG34, *Target grants aimed at solving the problems caused by the SARS-CoV-2 virus* (2019–2023)

SELECTED ARTICLES

Kidakova, A.; Borozнjak, R.; Reut, J.; Öpik, A.; Saarma, M.; Syritski, V. (2020). Molecularly imprinted polymer-based SAW sensor for label-free detection of cerebral dopamine neurotrophic factor protein. Sensors and Actuators B Chemical, 308, 127708.

Ayankojo, A. G.; Reut, J.; Opik, A.; Syritski, V. (2020). Sulfamethizole-imprinted polymer on screen-printed electrodes: Towards the design of a portable environmental sensor. Sensors and Actuators B Chemical, 320, #128600.

Ayankojo, A. G.; Reut, J.; Ciocan, V.; Öpik, A.; Syritski, V. (2020). Molecularly imprinted polymer-based sensor for electrochemical detection of erythromycin. Talanta.

LABORATORY OF CHEMICAL THIN FILM TECHNOLOGIES

Head of the research group: Professor ILONA OJA ACIK, ilona.oja@taltech.ee

Members: Malle Krunks, Tatjana Dedova, Atanas Katerski, Erki Kärber, Merike Kriisa, Nicolae Spalatu, Arvo Mere

Doctoral students: Jako Siim Eensalu, Ibrahim Dündar, Abayomi Oluwabi Titilope, Jekaterina Spiridonova, Zengjun Chen, Robert Krautmann, Nimish Juneja

TOPICS AND COMPETENCES

KEYWORDS: solar cells, photocatalytic coatings, thin film transistors

The main research topic of the Laboratory of Thin Film Chemical Technologies is the development of multifunctional metal oxide and chalcogenide thin films and nanostructures by chemical technologies and vacuum based technologies. The setup for the technologies is simple, inexpensive and easily transferrable to industrial scale.

The key competences of the research group are:

- Development of nanostructured, semi-transparent solar cells for smart renewable energy solutions in future buildings.
- Development of thin films for electronic devices, gas sensors and self-cleaning coatings.
- Development of thin films and nanostructured materials for clean and healthy environment, including antibacterial coatings and materials for air and water purification.

MAIN RESULTS:

- TiO_2 thin films are effective to degrade volatile organic carbons such as acetone, acetaldehyde and heptane in air and inactivate bacteria, and are thus applicable in indoor air cleaning devices.
- Low temperature deposition route for ZrO_x thin films enabling application in flexible and wearable electronics.
- The growth of Sb_2Se_3 thin films was controlled by the window layer post-deposition treatment and solar cell efficiency of 5.3% was achieved.

SELECTED PROJECTS

- TAR16016, *Advanced materials and high-technology devices for energy recuperation systems* (2015–2023)
- VFP20035, *ERA chair of emerging next-generation photovoltaics* (2020–2026)
- PRG627, *Antimony chalcogenide thin films for next-generation semi-transparent solar cells applicable in electricity producing windows* (2020–2024)

SELECTED ARTICLES

A.T. Oluwabi, A. Katerski, E. Carlos, R. Branquinho, A. Mere, M. Krunks, E. Fortunato, L. Pereira, I. Oja Acik, (2020). Application of ultrasonic sprayed zirconium oxide dielectric in zinc tin oxide-based thin film transistor. Journal of Materials Chemistry C, 11.

J. Spiridonova, A. Mere, M. Krunks, M. Rosenberg, A. Kahru, M. Danilson, M. Krichevskaya, I. Oja Acik, (2020). Enhanced Visible and Ultraviolet Light-Induced Gas-Phase Photocatalytic Activity of TiO2 Thin Films Modified by Increased Amount of Acetylacetone in Precursor Solution for Spray Pyrolysis. Catalysts, 10 (9), #1011.

LABORATORY OF ENVIRONMENTAL TECHNOLOGY

Head of the Laboratory: Professor SERGEI PREIS, sergei.preis@taltech.ee

Members: Marina Trapido, Niina Dulova, Marina Kritševskaja, Juri Bolobajev, Eneliis Kattel

Postdoctoral researcher: Vladimir Derevshchikov

Doctoral students: Maarja Kask, Balpreet Kaur, Liina Onga, Priit Tikker, Dmitri Nikitin

TOPICS AND COMPETENCES

KEYWORDS: environmental technology, water and wastewater treatment, pollutants, indoor air purification, advanced oxidation processes, pulsed corona discharge plasma technology

The laboratory has long-term experience in water, air and soil treatment technologies, with the main emphasis on the implementation of the Advanced Oxidation Processes (AOPs). The latter encompasses several oxidative technologies commonly recruiting highly powerful oxidants. Such technologies include ozonation and its catalytic modification, Fenton and Fenton-like reagents, photolytic and photocatalytic processes, oxidation with peroxy-compounds, ultrasonication, and pulsed electric discharge plasma treatment.

The processes under study have great potential for the removal of persistent and micro-contaminants from water/wastewater, contaminated soils and exhaust gases. Treatment of air with pulsed corona electrical discharge plasma as a high energy efficiency purification process is used to destroy microorganisms, including viruses, and to decompose volatile organic compounds. These green technologies are being applied to the sustainable use of resources in the circular economy. The laboratory personnel participate in an international project addressing one of the current challenges for drinking water supply such as the abatement of natural radioactivity.

SELECTED PROJECT:

- PRG776, *Innovative energy-efficient abatement of aqueous and airborne hazardous pollutants combining pulsed corona discharge plasma with catalysis/photocatalysis* (2020–2021)

SELECTED ARTICLES

Kask, M.; Bolobajev, J.; Krichevskaya, M. (2020). Gas-phase photocatalytic degradation of acetone and toluene, and their mixture in the presence of ozone in continuous multi-section reactor as possible air post-treatment for exhaust from pulsed corona discharge. Chemical Engineering Journal, 399, 125815.

Balpreet Kaur; Dulova, N. (2020). UV-assisted chemical oxidation of antihypertensive losartan in water. Journal of Environmental Management, 261, 110170.

Onga, L.; Kornev, I.; Preis, S. (2020). Oxidation of reactive azo-dyes with pulsed corona discharge: surface reaction enhancement. Journal of Electrostatics, 103, 103420.

LABORATORY OF INORGANIC MATERIALS

Head of the Laboratory: Professor ANDRES TRIKKEL, andres.trikkel@taltech.ee

Members: Tiit Kaljuvee, Rein Kuusik, Kaia Tõnsuaadu, Mai Uibu, Siim Link, Marve Einard, Can Rüstü Yörük

Postdoctoral Researcher: Kadriann Tamm (until February 2020)

Doctoral students: Hakan Berber (defended PhD degree in April 2020), Ana Jurkeviciute, Mustafa Cem Usta, Gizem Hacialioglu

TOPICS AND COMPETENCES

KEYWORDS: oil shale ash, precipitated calcium carbonate, CCUS, phosphorite, graptolite-argillite, thermal analysis

The research of the laboratory in the current period is focused on the processing of wastes related to oil shale - the reuse of oil shale ash and the abatement of greenhouse gas emissions with the aim to expand the basic chemical and technological knowledge of the related processes. The research directions are related to mineral carbonation, obtaining of precipitated calcium carbonate and other carbonate materials, apatite chemistry, development of new processing technologies for Estonian phosphorite and accompanying graptolite-argillite, oxy-fuel combustion of oil shale and other thermal processes to achieve feasible, environmentally friendly, optimized applications both experimentally and through mathematical modeling.

SELECTED PROJECTS

- IUT33-19, *Fundamentals of multicomponent mineral-organic systems: Chemistry, modeling and sustainable processing* (2015–2020)
- VA17086, *FLy Ash to valuable MinErals – FLAME* (2017–2020)
- VFP17114EK, *CLEAN clinKER production by Calcium looping process, CLEANKER* (2017–2021)

SELECTED PUBLICATIONS

Berber, H.; Tamm, K.; Leinus, M-L.; Kuusik, R.; Tõnsuaadu, K.; Paaver, P.; Uibu, M. (2020). Accelerated carbonation technology granulation of industrial waste: Effects of mixture composition on product properties. Waste, Management & Research: The Journal for a Sustainable Circular Economy, 38 (2), 142–155.

Yörük, C. R.; Uibu, M.; Usta, M. C.; T.; Trikkel, A. (2020). CO2 mineralization by burnt oil shale and cement bypass dust: effect of operating temperature and pre-treatment. Journal of Thermal Analysis and Calorimetry.

Usta, Mustafa Cem; Yörük, Can Rüstü; Hain, Tiina; Paaver, Peeter; Snellings, Ruben; Rozov, Eduard; Gregor, Andre; Kuusik, Rein; Trikkel, Andres; Uibu, Mai (2020). Evaluation of New Applications of Oil Shale Ashes in Building Materials. Minerals, 10 (9), 765.

LABORATORY OF OPTOELECTRONIC MATERIALS PHYSICS

Head of the Laboratory: Professor MAARJA GROSSBERG, maarja.grossberg@taltech.ee

Members: Jüri Krustok, Olga Volobujeva, Valdek Mikli, Sergei Bereznev, Dieter Meissner, Mati Danilson, Taavi Raadik, Peter Robert Walke

Post-doctoral researcher: Souhaib Oueslati

Doctoral students: Reelika Kaupmees, Aleksei Penezko, Akram Abdalla Mohammed Ibrahim, Mehmet Ender Uslu, Elizaveta Shmagina

TOPICS AND COMPETENCES

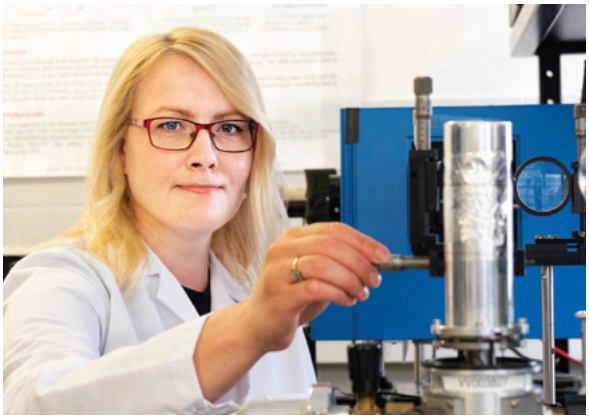
KEYWORDS: 2D materials, optoelectronic properties of materials, solar cells, conductive oxides, defect physics

The Laboratory focuses on the synthesis and studies of fundamental physical properties of semiconductors for optoelectronic applications such as solar cells, lasers, diodes, sensors, etc. Physical deposition techniques are used for the materials synthesis. The research infrastructure enables exploration of the band structure, crystal and defect structure, phase and elemental composition, morphology, electrical and optical properties of the materials and devices.

Current research is focused on the fundamental studies of different novel absorber materials for solar cells, for example $Cu_2ZnSn(S,Se)_4$, $Cu_2Sb(S,Se)_3$, $Cu(In,Ga)Se_2$, Sb_2Se_3, etc., and two-dimensional materials such as WS_2, $MoSe_2$ etc. The latter have versatile applications in addition to photovoltaics, namely photonics, sensors, etc. In addition to the inorganic semiconductor based structures, hybrid structures combining the advantages of inorganic and organic semiconductors are being developed and studied.

Some of the important research results from 2020:

- In collaboration with a research group from the University of Duisburg, the high-temperature degradation of next generation optoelectronic material, WS2 monolayers, was studied by photoluminescence and atomic force microscopy. We demonstrated that the center of the WS2 monolayer flake starts to undergo irreversible degradation at a temperature of 573 K in an inert environment. Changes in the monolayer properties taking place at lower temperatures were found to be reversible. This is an important finding for the application of these materials in optoelectronics.
- We investigated the adhesion properties of SWCNT thin films with commonly used substrates such as glass (SiO_2), indium tin oxide (ITO), crystalline silicon (C–Si), amorphous silicon (a-Si:H), zirconium oxide (ZrO_2), platinum (Pt), polydimethylsiloxane (PDMS), and SWCNTs for self-adhesion using atomic force microscopy. We found that the SWCNT thin films have stronger adhesion in an inert atmosphere and it can be further improved by a fluorination process.



SELECTED PROJECTS

- TAR16016 (TK141), *Advanced materials and high-technology devices for sustainable energetics, sensorics and nanoelectronics* (2015–2023)
- LEKEE20041, *Improving reliability of photovoltaic modules by investigating the long-term environmental impacts on polymeric encapsulants* (2020–2022)
- VFP20034, *Disruptive kesterites-based thin film technologies customised for challenging architectural and active urban furniture applications* (2020–2024)

SELECTED ARTICLES

R. Kaupmees, P. Walke, L. Madauß, A. Maas, E. Pollmann, M. Schleberger, M. Grossberg, J. Krustok. The effect of elevated temperatures on excitonic emission and degradation processes of WS2 monolayers. Phys. Chem. Chem. Phys. 22 (2020) 22609.

M. Rajanna, P.; Luchkin, S.; Larionov, K. V.; Grebenko, A.; Popov, Z. I.; Sorokin, P. B.; Danilson, M.; Bereznev, S.; Lund, P. D.; Nasibulin, A. G. (2020). Adhesion of Single-Walled Carbon Nanotube Thin Films with Different Materials. The Journal of Physical Chemistry Letters, 504.

S. Oueslati, M. Kauk-Kuusik, C. Neubauer, V. Mikli, D. Meissner, G. Brammertz, B. Vermang, J. Krustok, M. Grossberg. Study of (AgxCu1−x)2ZnSn(S,Se)4 monograins synthesized by molten salt method for solar cell applications. Solar Energy 198 (2020) 586.

LABORATORY OF PHOTOVOLTAIC MATERIALS RESEARCH

Head of the Laboratory: Senior Research Scientist MARIT KAUK-KUUSIK, marit.kauk-kuusik@taltech.ee

Members: Mare Altosaar, Kristi Timmo, Maris Pilvet, Jelena Maricheva, Katri Muska, Tiit Varema, Jaan Raudoja

Doctoral students: Xiofeng Li, Fairouz Ghisani, Xenia Filippova

TOPICS AND COMPETENCES

KEYWORDS: monograin layer solar cell, absorber material, synthesis of semiconductor materials

The main field of research of the Laboratory of Photovoltaic Materials Research is the synthesis and the design of the properties of semiconductor powders as absorber materials for next-generation evironmentally friendly inorganic building integrated photovoltaics. This is a unique concept that is protected by several patents. The developed materials are complex semiconductor compounds, but they contain mainly earth abundant and low cost chemical elements, providing environmentally friendly solutions with versatile applications.

In 2020, the research was focused on the following:

- A continuous $Cu_2CdGe(SxSe_{1-x})_4$ solid solution series of microcrystalline powders have been synthesized by the molten salt method for different photovoltaic applications. Introducing 20% of sulfur into the $Cu_2CdGeSe_4$ improved the PCE of the monograin layer solar cells about 12%.
- Synthesis process parameters for new multinary compounds in the systems FeS_{2-S}, $Cu_{12}Sb_4S_{13-}CdI_2$ ja $Cu_{10}Cd_2Sb_4S_{13-}CdI_2$ by monograin powder technology were developed. The results showed the potential of theses absorbers to achieve optoelectronic properties suitable for PV applications.
- A technique for simultaneous electrodeposition of Sb_2O_3 coupled with Sb_2S_3 was developed for photocatalytic applications. It was shown that L-cysteine can be used as both complexing agent and sulphur source. Deposited films showed photocatalytic activity with methyl orange photocatalytic degradation up to 40%.

SELECTED PROJECTS

- TAR16016 (TK141), *Advanced materials and high-technology devices for sustainable energetics, sensorics and nanoelectronics* (2015–2023)
- AR17092, *Center of nanomaterials research and technologies (NAMUR+)* (2017–2021)

- VFP20034, *Disruptive kesterites-based thin film technologies customised for challenging architectural and active urban furniture applications* (2020–2024)

SELECTED ARTICLES

Li, X.; Pilvet, M.; Timmo, K.; Grossberg, M.; Mikli, V.; Kauk-Kuusik, M. (2020). The effect of S/Se ratio on the properties of Cu2CdGe(SxSe1−x)4 microcrystalline powders for photovoltaic applications. Solar Energy, 209, 646–652

Li, X.; Pilvet, M.; Timmo, K.; Grossberg, M.; Danilson, M.; Mikli, V.; Kauk-Kuusik, M. (2020). Effect of absorber surface modification on the optoelectronic properties of Cu2CdGeSe4 solar cells. Thin Solid Films, 697, 137822.

Ghisani, F.; Timmo, K.; Altosaar, M.; Raudoja, J.; Mikli, V.; Pilvet, M.; Kauk-Kuusik, M.; Grossberg, M. (2020). Synthesis and characterization of tetrahedrite Cu10Cd2Sb4S13 monograin material for photovoltaic application. Materials Science in Semiconductor Processing, 110, 104973.

LABORATORY OF POLYMERS AND TEXTILE TECHNOLOGY

Head of the Laboratory: Professor ANDRES KRUMME, andres.krumme@taltech.ee

Members: Elvira Tarasova, Viktoria Gudkova, Natalja Savest, Illia Krasnou, Tiia Plamus, Kersti Merimaa, Mihkel Viirsalu

Doctoral students: Siret Malmberg, Nele Mandre, Merit Rikko

TOPICS AND COMPETENCES

KEYWORDS: polymers, biopolymers, derivatives of cellulose, polymer technology, polymeric composites, textile, electrospinning, nanofibres, conductive polymers, supercapacitors, filtering materials

The main focus of research of the laboratory is valorization of environmental resources and development of new energy storage methods for energy efficient environments. The goal is to find sustainable alternatives for fossil resources based polymeric materials by more efficient utilisation of biopolymers and recycled materials in commodity products and in specific fields.

Thermoplastc derivatives of cellulose are developed in the laboratory by novel synthesis methods and resucable dissolution environments. The derivatives can replace commodity plastics in the field of packaging and also in several specific applications such as energy storage and filtering of fine particles.

The laboratory is developing durable and flexible supercapacitors by electrospinning technology for demanding areas, such as space industry. Nanofibrous composites, containing modified biopolymers, conductive polymers, several allotropes of carbon and ionic liquids are used for this.

Filtering materials containing antiviral components are developed by the electrospinning method. The novel materials can prolong the useful lifetime of filtering masks and turn them carbon neutral.

The hi-tech field of electrospinning is not the only technology available in the laboratory. The laboratory has pilot production capacity in the most of important fields of polymer technology, including compounding, extrusion and injection moulding. Composites of thermoplastic or thermosetting polymers with inorganic or bio-based fillers are developed for efficient utilisation of secondary resources in circular economy.

SELECTED PROJECT

- RESTA10, *Chemical valorization of cellulose in environment of ionic liquids* (2020–2023)

SELECTED ARTICLE

Malmberg, S.; Arulepp, M.; Savest, N.; Tarasova, E.; Vassiljeva, V.; Krasnou, I.; Käärik, M.; Mikli, V.; Krumme, A. (2020). *Directly electrospun electrodes for electrical double-layer capacitors from carbide-derived carbon*. *Journal of Electrostatics, 103, 103396.*

LABORATORY OF WOOD TECHNOLOGY

Head of the Laboratory: Professor JAAN KERS, jaan.kers@taltech.ee

Members: Triinu Poltimäe, Heikko Kallakas, Karmo Kiiman, Anti Rohumaa, Silvi Treial, Margus Kangur

Doctoral students: Percy Festus Alao

TOPICS AND COMPETENCES

KEYWORDS: veneer, plywood, wood-polymer composites, wood and natural fibre composites, furnituure

The Laboratory of Wood Technology investigates the birch veneer surface properties, quality, and bonding quality. Another main research area is wood and natural fiber polymer composites, where we investigate how birch veneer residues can be used in the wood-plastic composites. We develope novel thermoplastic cellulose materials for further commodity applications. We also investigate how industrial hemp can be used to make building materials and insulation materials. One of our research topics is also cross-laminated timber (CLT) panels, which are used for building houses. The impact of moisture content and temperature on crack formation in CLT panels is investigated in the TalTech zero-energy building.

SELECTED PROJECT

- RITA1/01-18-15, *Maximising added value and efficient use of raw materials in bioeconomy and its sectors in Estonia* (2018–2021).
- PRG820, *Wood-bio-based adhesive systems design for enhancing the materials performance in sustainable veneer-based products from underutilized wood species* (2020–2021)
- RESTA10, *Chemical valorization of cellulose in environment of ionic liquids* (2020–2023)

SELECTED ARTICLES

Kallakas, H.; Rohumaa, A.; Vahermets, H.; Kers, J. (2020). Effect of Different Hardwood Species and Lay-Up Schemes on the Mechanical Properties of Plywood. Forests, #649.

Alao, P.; Visnapuu, K.; Kallakas, H.; Poltimäe, T.; Kers, J. (2020). Natural Weathering of Bio-Based Façade Materials. Forests, #642.

Kukk, V.; Kers, J.; Kalamees, T. (2020). Field measurements and simulation of an massive wood panel envelope with ETICS. Wood Material Science and Engineering, 1–8.

DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING

Director: Professor
KRISTO KARJUST,
kristo.karjust@taltech.ee

MAIN FIGURES 2020

(as of Dec. 31, 2020)

53 Academic staff — Incl. 14 professors, 26 researchers

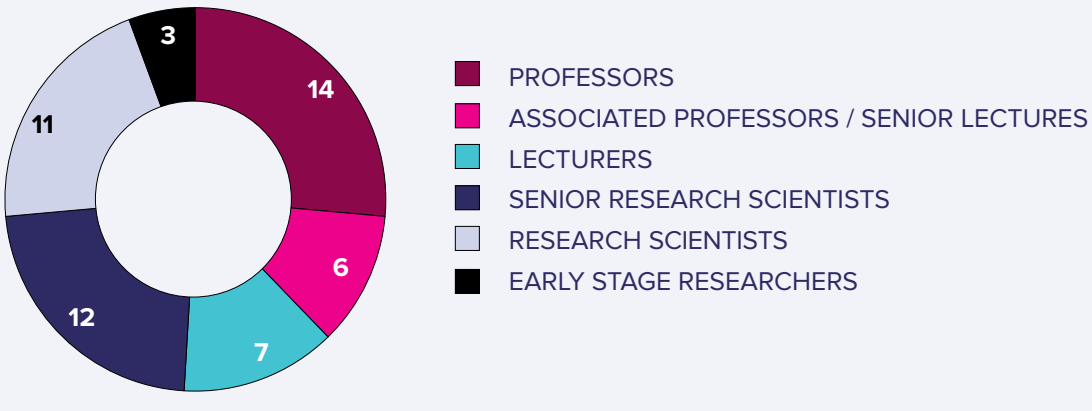
38 Doctoral students — 6 Defended doctoral dissertations

115 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 8 RESEARCH GROUPS:

- **ADVANCED POWDER TECHNOLOGY.**
  Head: Professor PRASHANTH KONDA GOKULDOSS, prashanth.konda@taltech.ee
- **ADVANCED STRUCTURES AND PRODUCTS.**
  Head: Professor JÜRI MAJAK, juri.majak@taltech.ee
- **AUTOMATED PRODUCTION SYSTEMS AND REAL-TIME MONITORING AND AI MODELS RESEARCH GROUP.**
  Head: Professor KRISTO KARJUST, kristo.karjust@taltech.ee
- **AUTONOMOUS VEHICLES RESEARCH GROUP.**
  Head: Professor RAIVO SELL, raivo.sell@taltech.ee
- **INNOVATIVE SYSTEMS FOR INDUSTRIAL APPLICATIONS.**
  Head: Professor IRINA HUSSAINOVA, irina.hussainova@taltech.ee
- **LOGISTICS AND TRANSPORT.**
  Head: Professor DAGO ANTOV, dago.antov@taltech.ee
- **SMART INDUSTRY.**
  Head: Professor TAUNO OTTO, tauno.otto@taltech.ee
- **WEAR RESISTANT COMPOSITES AND COATINGS.**
  Head: Professor JAKOB KÜBARSEPP, jakob.kubarsepp@taltech.ee



ADVANCED POWDER TECHNOLOGY

Head of the research group: Professor PRASHANTH KONDA GOKULDOSS, prashanth.konda@taltech.ee

Members: Lauri Kollo, Ramin Rahmani

Doctoral students: Javad Karimi, Navid Alinejadian

Visiting doctoral students: Salini Singh, Lanka Dinesh, Jayashree Narayanan, Jagadeesh Baskaran

TOPICS AND COMPETENCES

KEYWORDS: additive manufacturing, powder metallurgy, solidification, meta-stable materials, amorphous alloys, high entropy alloys, high temperature materials, light metals, biomaterials and mechanical properties

The research topics of the group are:

(1) Alloy design for additive manufacturing;

(2) Pre-mature failure in additively manufactured materials;

(3) Powder metallurgy of high entropy alloys for extreme environments;

(4) Processing of functional materials by additive manufacturing.

SELECTED PROJECT

- MOBERC15, "*Alloy design for Additive Manufacturing*" (2018–2020)

SELECTED ARTICLES

Singh, N.; Hameed, P.; Ummethala, R.; Manivasagam, G.; Prashanth, K. G.; Eckert, J. (2020). Selective laser manufacturing of Ti-based alloys and composites: impact of process parameters, application trends, and future prospects. Materials Today Advances, 8, #100097.

Wang, Z.; Xie, M.; Li, Y.; Zhang, W.; Yang, C.; Kollo, L.; Eckert, J.; Prashanth, K. G. (2020). Premature failure of an additively manufactured material. NPG Asia Materials, 12 (1).

Ummethala, R.; Karamched, P. S.; Rathinavelu, S.; Singh, N.; Aggarwal, A.; Sun, K.; Ivanov, E.; Kollo, L.; Okulov, I.; Eckert, J.; Prashanth, K. G. (2020). Selective laser melting of high-strength, low-modulus Ti–35Nb–7Zr–5Ta alloy. Materialia, 14, #100941.

ADVANCED STRUCTURES AND PRODUCTS

Head of the research group: Professor JÜRI MAJAK, juri.majak@taltech.ee

Members: Martin Pärn, Martin Eerme, Jüri Lavrentjev, Meelis Pohlak, Fabio Auriemma, Hans Rämmal, Maarjus Kirs, Tarmo Velsker, Ruth Helene Melioranski, Janno Nõu

Postdoctoral researcher: Mustafa Arda

Doctoral students: Madis Mikola, Pavel Tšukrejev, Tiina Mäe, Ramachandran Karunanidhi, Marvar Mehrparvar, Margus Villau

TOPICS AND COMPETENCES

KEYWORDS: structural analysis and design optimization, artificial intelligence, acoustics, numerical methods

The research group has long time experience in the area of structural analysis and design optimization, also design of production processes. One of the main topics in recent years is implementation of artificial intelligence (AI) tools and methods in modelling and design optimization (EA, GA, ACO, PSO). Another topical field of research is development of hybrid algorithms (ANN+EA) and combining multiple AI tools. One subtopic is development and adaption of new numerical methods with focus on Haar wavelet based dicretization methods.

The research team has a long experience in wave propagation research in channels and more generally in a limited space. Various test methods for sound field decomposition have been developed. The developed applications can be used for experimental determination of acoustic properties of different materials and products, as well as for the collection of energy (noise) in the acoustic field and are converted into a useful type of energy.

SELECTED PROJECTS

- TAR16012, "*Zero energy and resource efficient smart buildings and districts*" (2015–2023).
- VIR19004, *Innovation Framework for Challenge Oriented Intelligent Manufacturing* (INforM) (2019–2021)
- MOBJD704, *Development of numerical methods for analysis of advanced composite and nanostructures* (2021–2022), Postdoctoral researcher grant, Mustafa Arda

SELECTED ARTICLES

Majak, J.; Shvartsman, B.; Ratas, M.; Bassir, D.; Pohlak, M.; Karjust, K.; Eerme, M. (2020). Higher-order Haar wavelet method for vibration analysis of nanobeams. Materials Today Communications, 25, #101290. DOI: 10.1016/j.mtcomm.2020.101290.

Tsukrejev, P.; Kruuser, K.; Gorbachev, G.; Karjust, K.; Majak, J. (2020). Real-Time Monitoring of Solar Modules Manufacturing. International Journal of Engineering Research in Africa, 51, 9–13. DOI: 10.4028/www.scientific.net/JERA.51.9.

Auriemma, F.; Giulio, E. Di; Napolitano, M.; Dragonetti, R. (2020). Porous Cores in Small Thermoacoustic Devices for Building Applications. Energies, 13 (11), #2941. DOI: 10.3390/en13112941.

AUTOMATED PRODUCTION SYSTEMS AND REAL-TIME MONITORING AND AI MODELS RESEARCH GROUP

Head of the research group: Professor KRISTO KARJUST, kristo.karjust@taltech.ee

Members: Jüri Riives, Priit Põdra, Martinš Šarkans, Kashif Mahmood, Aigar Hermaste, Margus Müür, Tõnis Raamets, Allan Aari, Riho Uusjärv

Doctoral students: Pavel Tšukrejev, Kaarel Kruuser, Heiko Pikner

TOPICS AND COMPETENCES

KEYWORDS: manufacturing execution system (MES), production monitoring, production optimisation, real time information, wireless sensor network, predictive maintenance, artificial intelligent in production

The main objective of the research is to study and develop a Production Monitoring System (PMS) with predictive functionality that operates in near real time, focusing on SMEs. The main activities of the research are: (a) development of the PMS concept; (b) system prototyping; (c) development of model predictive control.

The advanced Production Monitoring and Prediction System detects, measures and monitors the variables, events and situations which affect the performance and reliability of manufacturing systems and processes. Efficient, real-time feed of information for production control and monitoring includes data acquisition about the state of equipment, production orders, flow of materials, quality of products, process data and other necessary data which are used for making proper and optimised decisions regarding manufacturing planning, improved use of available resources, planning of equipment maintenance, etc.

SELECTED PROJECTS

- VIR19004 "*Innovation Framework for Challenge Oriented Intelligent Manufacturing (INforM)*"
- KIK19019, *Developing of textile waste shredding technology and innovative materials to adding value to textile waste and support the circular economy* (2019–2021)
- LEMEE20129, *Development of repair and maintenance information management system of Enefit Energiatootmine AS* (2020–2021)
- LEMEE20093, *Applied research of Lotus Timber's self-adapting production management tool* (2020–2021)

SELECTED ARTICLES

Tsukrejev, P.; Kruuser, K.; Gorbachev, G.; Karjust, K.; Majak, J. (2020). Real-Time Monitoring of Solar Modules Manufacturing. International Journal of Engineering Research in Africa, 51, 9–13.

Majak, J.; Shvartsman, B.; Ratas, M.; Bassir, D.; Pohlak, M.; Karjust, K.; Eerme, M. (2020). Higher-order Haar wavelet method for vibration analysis of nanobeams. Materials Today Communications, 25, #101290.

Kangru, T.; Riives, J.; Otto, T.; Kuts, V.; Moor, M. (2020). Optimisation of decision-making process in industrial robot selection. Journal of Machine Engineering, 20 (1), 70–81.

AUTONOMOUS VEHICLES RESEARCH GROUP

Head of the research group: Professor RAIVO SELL, raivo.sell@taltech.ee

Members: Andres Petritšenko, Martinš Šarkans, Margus Müür, Vladimir Kuts, Kaimo Sonk, Andres Udal

Doctoral students: Ehsan Malayjerdi, Heiko Pikner, Mohsen Malayjerdi, Krister Kalda, Junyi Gu, Andrew James Roberts, Andrus Pedai

TOPICS AND COMPETENCES

KEYWORDS: self-driving vehicles, robotics, artificial intelligence, autonomous systems, smart city

The research group is working on the development and research on complex autonomous systems, including localization, navigation, mission planning, sensorics, artificial intelligence, electro-mechanics, control, simulation and machine vision.

The topics are applied to a full range of autonomous systems, in particular to self-driving vehicles, mobile robots, industrial logistics robots and drones.

SELECTED PROJECTS

- VFP19031, FINEST TWINS: *Establishment of Smart City Center of Excellence* (2019–2026)
- VFP20052, *City-level Cyber-Secure Multimodal Transport Ecosystem* (2020–2023)
- LEP19064, *Future Automated Bus Urban Level Operation System* (2019–2020)

SELECTED ARTICLES

Sell, Raivo; Leier, Mairo; Rassõlkin, Anton; Ernits, Juhan-Peep (2020). Autonomous Last Mile Shuttle ISEAUTO for Education and Research. International Journal of Artificial Intelligence and Machine Learning, 10 (1), 18–30. DOI: 10.4018/IJAIML.2020010102.

Wang, R.; Sell, R.; Rassõlkin, A.; Otto, T.; Malayjerdi, E. (2020). Intelligent Functions Development on Autonomous Electric Vehicle Platform. Journal of Machine Engineering, 20 (2), 114–125. DOI: 10.36897/jme/117787.

Razdan, R.; Sell, R.; Tino, C.; Schmidt, B.; Akbas, M.; Cherian, J.; Boer, N. (2020). Unsettled Topics Concerning Autonomous Public Transportation Systems. SAE Technical Paper Series.

INNOVATIVE SYSTEMS FOR INDUSTRIAL APPLICATIONS

Head of the research group: Professor IRINA HUSSAINOVA, irina.hussainova@taltech.ee

Members: Maksim Antonov, Roman Ivanov, Sofiya Aydinyan, Dmitri Goljandin, Mart Viljus, Fjodor Sergejev, Rocío Rojas Hernandez, Tatevik Minasyan, Nikhil Kumar Kamboj, Rainer Traksmaa, Hans Vallner, Heinar Vagiström

Postdoctoral researcher: Rocío Rojas Hernandez

Doctoral students: Ali Saffar Shamshirgar, Mansure Rezapourian, Rahul Kumar

TOPICS AND COMPETENCES

KEYWORDS: ceramics; composites; multifunctional structures; bio-inspired materials; tribology; recycling; high temperature materials; chemical vapour deposition; self-propagating high temperature synthesis; microstructural analysis; mechanical testing; additive manufacturing; spark plasma sintering

The research is broadly subdivided into three main interconnected and highly interdisciplinary directions focused on (a) hierarchically structured bio-inspired multi-functional composites including but not limited to electroconductive ceramics, functionally graded and anisotropic ceramic-based composites, mesoporous ceramics, nanofibers, graphene added bulks, ceramic membranes; (b) tribology and high-temperature damage-tolerant composites for tribo-applications, and (c) selective laser melting and powders for SLM/S of ceramic – metal composites and AM of complex-shaped ceramic-matrix composites.

The team has several inventions keeping research at a high international level. The most influential are (i) a self-aligned fibrous scaffold for highly anisotropic cell cultures; (ii) a method for producing nanofibers composites by combustion techniques and products comprising thereof; (iii) fibrous ceramic networks and preparation thereof by selective laser melting; and (iv) ceramic complex structures by SLS.

SELECTED PROJECTS

- PRG643 "*Bio-replicating Engineering Structures for Tribo-applications (BEST)*" (2020–2024)
- PSG220 "*Additive manufacturing of super-strong and lightweight ceramics for next generation high temperature compounds*" (2019–2023)
- PSG466 "*Enhanced and wavelength-tunable luminescence in nanostructured phosphor films*" (EWALUNFILMs) (2020–2023)
- MOBERA18 "*Self-lubrication systems for high-temperature tribo-applications*" (2019–2021)

SELECTED ARTICLES:

Gasik, M.; Ivanov, R.; Kazantseva, J.; Bilotsky, Y.; Hussainova, I. (2020). Biomechanical Features of Graphene-Augmented Inorganic Nanofibrous Scaffolds and Their Physical Interaction with Viruses. Materials, 14 (1), 164.

Rojas-Hernandez, Rocio E., Rubio-Marcos, F.; Gorni, G.; Marini, C.; Danilson, M.; Pascual, L.; Uhida Ichikawa, R.; Hussainova, I.; Fernandez, J.F. (2020). Enhancing NIR Emission in ZnAl2O4:Nd,Ce Nanofibers by Energy Transfer from Ce to Nd: a Promising Biomarker Material with a Low Cytotoxicity. Materials Chemistry C, 2020.

Minasyan, T., Aydinyan, S., Toyserkani, E., Hussainova, I. (2020). Parametric Study on In Situ Laser Powder Bed Fusion of Mo(Si1−x,Alx)2. Materials, 2020, 13, 4849.

RESEARCH GROUP OF LOGISTICS AND TRANSPORT

Head of the research group: Professor DAGO ANTOV, dago.antov@taltech.ee

Members: Jüri Lavrentjev, Kati Kõrbe Kaare, Hans Rämmal, Ott Koppel, Eduard Ševtšenko, Jelizaveta Janno, Anton Pashkevich

Doctoral students: Kristjan Kuhi, Imre Antso, Juri Ess, Allan Nõmmik, Kaur Sarv, Raul Markus, Erko Vallbaum

TOPICS AND COMPETENCES

KEYWORDS: logistics, mobility and transport planning, supply chain planning

The research group focuses on the following research directions:

- Eco-friendly vehicles.
  Contact: Jüri Lavrentjev, *juri.lavrentjev@taltech.ee*

  The research aims at reducing the environmental impact of vehicles. The main research object is vehicle-generated noise produced by both an individual vehicle and traffic flow. The design of an individual vehicle explores the possibilities for creating and deploying new and more effective noise absorbing materials. In the applied research, the focus is also on new types of liquid fuel, their technical and economic problems.
- Mobility engineering and traffic planning.
  Contact: Dago Antov, *dago.antov@taltech.ee*

  Transport, mobility and traffic related studies are aimed to find the possibilities of safe, seamless and sustainable mobility, the study of the interlinkages between urban logistics and transport and space use.

  Besides the aforementioned, the keywords include sustainable mobility and sustainable transport, including public transport in the city, region, country and internationally, traffic forecasting, transport studies, mobility schemes, transport network analysis and transport system planning, road safety and surveillance.
- Logistics.
  Contact: Kati Kõrbe Kaare, *kati.korbe@taltech.ee*

  The research relates to smart logistics, freight security, transport pricing and network performance measurement.
- Supply chain engineering.
  Contact: Eduard Shevchenko, *eduard.sevtsenko@taltech.ee*

  The studies are related to value chain analysis, supply chain collaboration, sustainable supply chain and demand forecasting.

SELECTED PROJECTS

- AR17119 "*Infotechnological Mobility Observatory*" (2017–2022)
- VIR17131, "*Using ferry real time information to optimise intermodal transport chains in the Baltic Sea Region*" (2017–2020)
- VFP19031, *FINEST TWINS: Establishment of Smart City Center of Excellence* (2019–2026)

SELECTED PUBLICATIONS

Nõmmik, A.; Antov, D. (2020). European Regional Airport: Factors Influencing Efficiency. Transport and Telecommunication Journal, 21 (3), 211–220.

Janno, J.; Koppel, O. (2020). Occupational Qualification Standard for Truck Drivers as a Risk Management Tool in Road Transportation of Dangerous Goods. ICL2020 Proceedings: 23st International Conference on Interactive Collaborative Learning (ICL2020). Ed. T. Rüütmann. Springer International Publishing AG. (Advances in Intelligent Systems and Computing).

Uukkivi, R.; Koppel, O. (2020). Assessment of the economic regulation of network industries: oil shale value chain in Estonia. Oil Shale, 37 (2), 158–176.

SMART INDUSTRY

Head of the research group: Professor TAUNO OTTO, tauno.otto@taltech.ee

Members: Jüri Riives, Lauri Kollo, Meelis Pohlak , Eduard Ševtšenko, Tatjana Karaulova, Fjodor Sergejev, Toivo Tähemaa, Martinš Sarkans, Yevhen Bondarenko, Margus Müür, Aigar Hermaste

Doctoral students: Tavo Kangru (defended PhD degree in Jan. 2021), Kristo Vaher, Madis Moor, Simone Lucca Pizzagalli, Geithy Sepp

TOPICS AND COMPETENCES

KEYWORDS: smart manufacturing, industry 4.0, digital twins, digital manufacturing

The research of the group is focused on development of the concept of smart manufacturing and digital twins (DT).

THE LATEST RESULTS:

The simulation environment in virtual reality based on the principles of Industry 4.0 has been developed. By exploiting the digital twin's concept, a new communication method has been developed where industrial robot control programming does not depend on human presence. Dual-way synchronisation based on the example of the industrial robotic cell enables management and control of the factory from the simulation in real-time. The corresponding application works from different smart platforms and new robot systems and also self-driving robotic vehicles, can be managed via a digital twin.

A robotic workplace design solution (methodology) was developed using the possibilities of artificial intelligence and based on multi-criteria decision possibilities, which take into account the company's production needs and ensures successful output from the planned production system. The developed methodology is built on different decision algorithms and is recursive between steps. The decision-making methods mainly used are a weighted sum method, different analytical hierarchical decision-making methods, and decision models based on artificial neural networks. These listed methods have been integrated into a knowledge-based system, the raw data are collected from implemented robot-based production cells, experimental tests or based on simulations.

SELECTED PROJECTS

- VERT18066, "*Transforming Educational Programmes For Future Industry 4.0 Capabilities*" (2018–2021)
- VERT18042, *Virtual Learning Factory Toolkit* (2018–2021)
- VFP21010 "*Accelerating deployment and matureness of DIHs for the benefit of Digitisation of European SMEs*" (2021–2023)

SELECTED ARTICLES

Kangru, T.; Riives, J.; Otto, T.; Kuts, V.; Moor, M. (2020). Optimisation of decision-making process in industrial robot selection. Journal of Machine Engineering, 20 (1), 70–81.

Kuts, V.; Cherezova, N.; Sarkans, M.; Otto, T. (2020). Digital Twin: industrial robot kinematic model integration to the virtual reality environment. Journal of Machine Engineering, 20 (2), 53–64.

Vaher, K.; Otto, T.; Riives, J. (2020). Positioning error correction of autonomously movable robot arm. Journal of Machine Engineering, 20 (6), 152–160.

WEAR RESISTANT COMPOSITES AND COATINGS

Head of the research group: Professor JAKOB KÜBARSEPP, jakob.kubarsepp@taltech.ee

Members: Kristjan Juhani, Marek Tarraste, Mart Viljus, Lauri Kollo, Maksim Antonov, Dmitri Goljandin, Märt Kolnes, Fjodor Sergejev, Andrei Surženkov, Priit Kulu, Vitali Podgurski, Mart Saarna, Andrei Bogatov, Rainer Traksmaa, Hans Vallner, Heinar Vagiström

Doctoral students: Mart Kolnes, Dmytro Tkachivskyi, Alamgir Shaikh, Vahur Leinberg

TOPICS AND COMPETENCES

KEYWORDS: ceramic-based composite, cemented carbide, cermet, ceramic-matrix composite, coating, composite hardfacing, wear resistance, corrosion resistance

The R&D activities of the research group have been focused mainly on the following research topics and related industrial applications: (a) Co- and Ni-free WC-based cemented carbides with alternative (considering critical materials supply, environmental safety and healthcare aspects) Fe-based metallic binders; (b) W-free, TiC- and Ti(C,N)-based cermets with alternative Fe-based binders; (c) ceramic-matrix composites based on refractory compounds of Ti; (d) Fe-based composite hardfacings; (e) diamond-based thin coatings.

THE LATEST RESULTS

- industrial technology for production of Co- and Ni-free WC-FeMn and TiC-FeCrMn ceramic-metal composites;
- industrial technology for production of TiN- and TiCN-based ceramic-matrix composites;
- advancement of high-temperature performance of diamond coatings for a wide range of application conditions;
- advanced technology for deposition of hardfacings with novel Cr_3C_2-Ni and TiC-NiMo reinforcement.

SELECTED PROJECTS

- PUT1369 "*Adaptation mechanisms of diamond films in dry sliding wear*" (2017–2020).
- PRG665, *Composites "ceramics – Fe alloy" for a wide range of application conditions* (2020–2020)
- LEMEV20091, *Coloured ceramic matrix composites for watch and jevelry applications: development of materials and related manufacturing technologies* (2020–2021)

SELECTED ARTICLES

Jakob Kübarsepp, Kristjan Juhani (2020). Cermets with Fe-alloy binders :A review. International Journal of Refractory Metals & Hard Materials, 92 105290.

Tkachivskyi, D., Juhani, K., Surženkov, A., Kulu, P., Tesar, T., Mušalek,, R., Lukac, F., Antoš, J., Vostrak, M., Antonov, M.,Goljandin, D. (2020). HVOF sprayed Fe-based wear-resistant coatings with carbide reinforcement, synthesized in situ and by mechanically activated synthesis. Coatings 10(11).

TARTU COLLEGE

Director: Professor LEMBIT NEI,
lembit.nei@taltech.ee,
+372 620 4802

MAIN FIGURES 2020

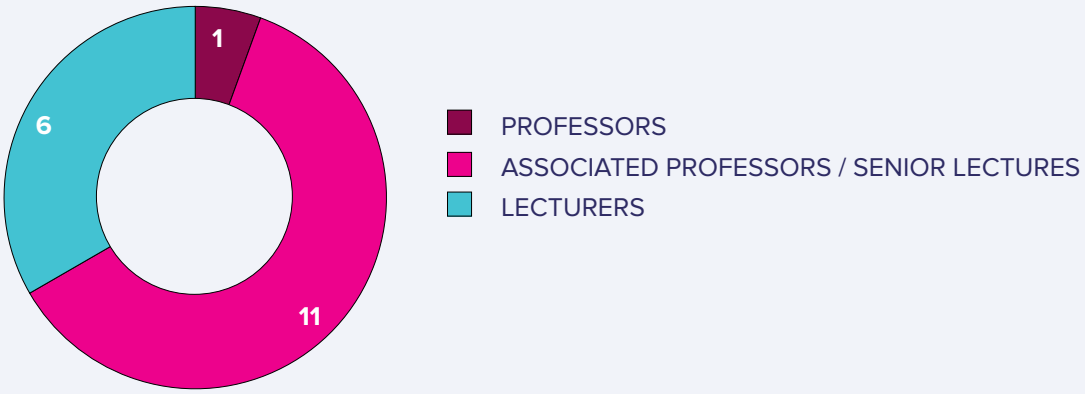
(as of Dec. 31, 2020)

19	Academic staff	Incl. **1**	professor
1	Doctoral students	1	Defended doctoral dissertation
13	Scientific publications*		

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN TWO RESEARCH GROUPS:

- **BUILT ENVIRONMENT RESEARCH GROUP.**
  Head: Associate Professor AIME RUUS, aime.ruus@taltech.ee
- **RESEARCH GROUP OF ENVIRONMENTAL TECHNOLOGIES.**
  Head: Associate Professor ANNELY KUU, annely.kuu@taltech.ee



BUILT ENVIRONMENT RESEARCH GROUP

Head of the research group: Associate Professor AIME RUUS, aime.ruus@taltech.ee

Members: Zenia Kotval, Mihkel Kiviste, Merik Meriste, Ernst Tungel, Nele Nutt, Helle Hallik, Ago Rootsi, Jiri Tintera, Sven Oras, Jane Raamets, Taisi Kadarik, Karin Muoni, Sirle Salmistu

Doctoral students: Lehar Leetsaar, Minea Kaplinski-Sauk, Ardo Kubjas

TOPICS AND COMPETENCES

KEYWORDS: brownfields, shrinking cities, urban planning, history of wooden architecture, recycled aggregate concrete, (natural) building materials, indoor climate

The research topics of the team are: (1) built environment, urban and regional planning; (2) community development, economic revitalization, reuse and restoration, urban and rural settlement assessment; (3) heritage conservation in urban planning and historical landscapes and parks; (4) revitalization of brownfields; (5) examination of historical buildings; (6) construction materials, indoor climate, aspects of building physics and energy efficiency; (7) possibilities to produce recycled aggregate concrete, (8) cyber-physical systems for buildings and urban and regional planning.

These issues are topical in the field of urban planning and help to solve problems with the implementation of cyber-physics systems in construction, industry and other fields of life.

SELECTED PROJECT

- VEU19008, "*CA17136 – INDoor AIR POLLution NETwork*" (2018–2022).
- LEP19082, *Termbase of spatial planning* (2019–2021).
- LETAE20061, *Valuable settlement structures in Valga municipality: determining milieu areas and the conditions for their use and protection* (2020–2021).

SELECTED PUBLICATIONS

Nutt, N.; Kubjas, A. (2020). Moisture Buffer Value of Composite Material Made of Clay-Sand Plaster and Wastepaper. Journal of Sustainable Architecture and Civil Engineering, 27 (2), 108–115.

Nutt, N.; Kubjas, A. (2020). The model of trees for the restoration of historical manor parks in Estonia. Landscape Architecture and Art, 17 (17), 22–29.

Nutt, N.; Kubjas, A., Nei, L. (2020). Adding waste paper to clay plaster to raise its ability to buffer moisture. Proceedings of the Estonian Academy of Sciences, 69 (3), 179–185.

RESEARCH GROUP OF ENVIRONMENTAL TECHNOLOGIES

Head of the research group: Associate Professor ANNELY KUU, annely.kuu@taltech.ee

Members: Lembit Nei, Mari Ivask, Tiit Lepasaar, Kai Kalda, Egge Haiba, Nele Nutt, Sirle Salmistu, Tiina Niine, Kärt Kanger, Aija Kosk, Rinaldo Rüütli, Laura Lokko

Doctoral students: Jane Raamets (defended doctoral theses in Dec. 2020)

TOPICS AND COMPETENCES

KEYWORDS: environmental technology, industrial ecology; environmental technology, ecosystem services, environmental microbiology and -chemistry, circular economy, industrial ecology

The main competences of the group are:

- The studies of energy and material flow, LCA, efficiency in using resources.
- Development and implementation of waste recycling technologies (drug residues in sewage sludge and their degradation efficiency).
- Development of methodologies for assessing the status of the environment. In assessing the status of the environment, soil microbiological parameters and the parameters of soil invertebrates are used as bioindicators.

SELECTED PROJECTS

- VEU19008 "*CA17136 – INDoor AIR POLLution NETwork*" (2018–2022).
- KIK20033, *Optimisation of sewage sludge composting technology with aim of more efficient degradation of pharmaceutical residues* (2020–2021).
- SEA2LAND, Fishery and aquaculture by-products for healthier soils (2021–2024), Tartu College is the subcontracting partner.

SELECTED PUBLICATIONS

Eklund, J.; Nei, L. (2020). Richard Compton: Thought Leader, Educator and Bon Viveur. Journal of Electroanalytical Chemistry, 872 (Article 114279), 1–3.

Nutt, N.; Kubjas, A., Nei, L. (2020). Adding waste paper to clay plaster to raise its ability to buffer moisture. Proceedings of the Estonian Academy of Sciences, 69 (3), 179–185.

Nutt, N.; Kubjas, A.; Nei, L.; Ruus, A. (2020). The Effects of Natural Paints on the Moisture Buffering Ability of Paper Plaster. Latvian Journal of Physics and Technical Sciences, 57 (5), 51–60.

VIRUMAA COLLEGE

Director: MARE ROOSILEHT,
mare.roosleht@taltech.ee,
+372 336 3922

MAIN FIGURES 2020

(as of Dec. 31, 2020)

37 Academic staff — Incl. 1 professor, 3 researchers

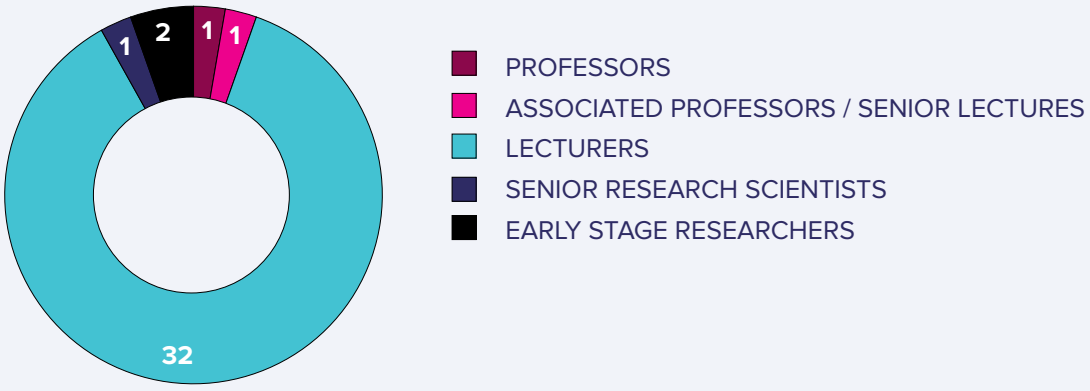
1 Doctoral students

10 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN TWO RESEARCH GROUP:

- **LABORATORY OF FUELS TECHNOLOGY AT OIL SHALE COMPETENCE CENTER.**
  Head: OLGA PIHL, olga.pihl@taltech.ee
- **APPLIED CHEMISTRY RESEARCH GROUP (LAUNCHED IN 2019).**
  Head: Professor ALLAN NIIDU, allan.niidu@taltech.ee



LABORATORY OF FUELS TECHNOLOGY

Head of the laboratory: OLGA PIHL, olga.pihl@taltech.ee

Members: Hella Riisalu, Larissa Kruglenkova, Viktoria Petrova, Dmitri Suštšik, Maria Tšepelevitš, Jelena Upan, Julia Kravetskaja, Olga Suštšik

Doctoral student: Mihhail Fomitšov

TOPICS AND COMPETENCES

KEYWORDS: pyrolysis, hydrogenation, semi-coking, co-processing, distillation, solid and liquid fuels, waste fuels, water and gas analysis, standardization

The Laboratory of Fuels Technology at Oil Shale Competence Center (OSCC) offers both direct research and analysis services in accredited areas.

The laboratory's competencies include:

- Thermal processing of materials containing organic substances (including waste) and the analysis of the obtained products. Particular attention is paid to the co-processing of different materials with oil shale.
- Determination of the content of chemical elements (carbon, hydrogen, nitrogen, sulfur, oxygen, phosphor, chlorine, fluorine, metals) in different materials.
- Determination of the component composition of gas and liquid samples using chromatographic and mass spectrometry methods.
- Determination of the distribution of the particle size in crushed or grinded materials up to the level of common sieve analysis and the finest distribution with laser diffraction method from 10 nanometers.
- Determination of the fuel quality according to the standards.
- Offering tailor-made solutions in cooperation with companies.

There is a modern equipment park including a There is a modern equipment park including a pyrolysis reactor, a high pressure reactor, a rectification column, a retort, mass spectrometer, a thermogravimetric analyzer device for studying the thermal processes of different materials and analyzing the equipment for determining the properties of fuels for all of these areas of research and development.

OSCC provides services in the area of protecting the intellectual property in the region. OSCC is involved in promoting the standardization of oil shale by organizing and implementing activities

through the corresponding technical committee EVS/TK 57 "The processing of Oil Shale and oil shale products".

SELECTED ARTICLES

Aints, P. Paris, M. Laan, K. Piip, H. Riisalu, I. Tufail (2018). Determination of Heating Value of Estonian Oil Shale by Laser-Induced Breakdown Spectroscopy. Journal of Spectroscopy, 2018, 4605925.

Aints, M.; Paris, P.; Tufail, I.; Jõgi, I.; Aosaar, H.; Riisalu, H.; Laan, M. (2018). Determination of the calorific value and moisture content of crushed oil shale by LIBS. Oil Shale, 35 (4), 339–355.

APPLIED CHEMISTRY RESEARCH GROUP

Head of the research group: Professor ALLAN NIIDU, allan.niidu@taltech.ee

Members: Moonika Ferschel

Doctoral students: Bijan Barghi

TOPICS AND COMPETENCES

KEYWORDS: metal-organic framework, CO_2 adsorption and utilization (CCSU), heterogeneous catalysis, adsorption, nanomaterials, liquid separation, oil shale as raw material for chemical industry, mechanochemistry

The research group's competencies include:

- Co-valorization of CO_2 and oil shale into catalysts and adsorbents for chemical industry.
- Application of said catalysts to oxidation of organic sulfur and relevant adsorbents to adsorb sulfurous compounds form liquid hydrocarbon streams.
- Extracting added value from mining waste and process waters via selective removal of required metals.

In cooperation with the Industrial Chemistry group, research into oxidative valorization of kerogen is conducted.

SELECTED PROJECTS:

- LEVEE20069, *Applied research in reduction of sulfur containing compounds in shale oil products* (2020–2022)
- F19044, *Valuing oil shale (products) and expanding the field of activity of the Oil Shale Competence Centre* (2020–2023)
- F20057, *Waste carbon utilisation development strategy with industrial symbiosis pilot* (2020–2022)

RECENT ARTICLES

Pihl, O.; Niidu, A.; Merkulova, N.; Fomitsov, M.; Siirde, A.; Tshepelevitsh, M. (2019). Gas-chromatographic determination of sulfur compounds in the gasoline fractions of shale oil and oil obtained from used tires. Oil Shale, 36 (2), 188–196.

Hernández, J. G.; Halasz, I.; Crawford, D. E.; Krupicka, M.; Baláž, M.; André, V.; Vella-Zarb, L.; Niidu, A.; García, F.; Maini, L.; Colacino, E. (2020). European Research in Focus: Mechanochemistry for Sustainable Industry (COST Action MechSustInd). Justus Liebig's Annalen der Chemie, 2020, 8–9.

Niidu, A. (2019). Phenols to pores to adsorption: a potential route towards new methods for extracting value from shale oil side stream. Oil Shale, 39 (2S), 128–141.

SCHOOL OF INFORMATION TECHNOLOGIES

SCHOOL OF INFORMATION TECHNOLOGIES

Dean: Professor GERT JERVAN

e-mail: gert.jervan@taltech.ee

Vice-Dean for Research: Professor MAIE BACHMANN

e-mail: maie.bachmann@taltech.ee

MAIN FIGURES 2020

(as of Dec. 31, 2020)

245 Academic staff — Incl. 33 professors, 150 researchers

116 Doctoral students — 14 Defended doctoral dissertations

270 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

DEPARTMENTS

DEPARTMENT OF COMPUTER SYSTEMS

Director: Associate Professor MARGUS KRUUS, margus.kruus@taltech.ee

DEPARTMENT OF SOFTWARE SCIENCE

Director: Associated Professor MARKO KÄÄRAMEES, marko.kaaramees@taltech.ee

DEPARTMENT OF HEALTH TECHNOLOGIES

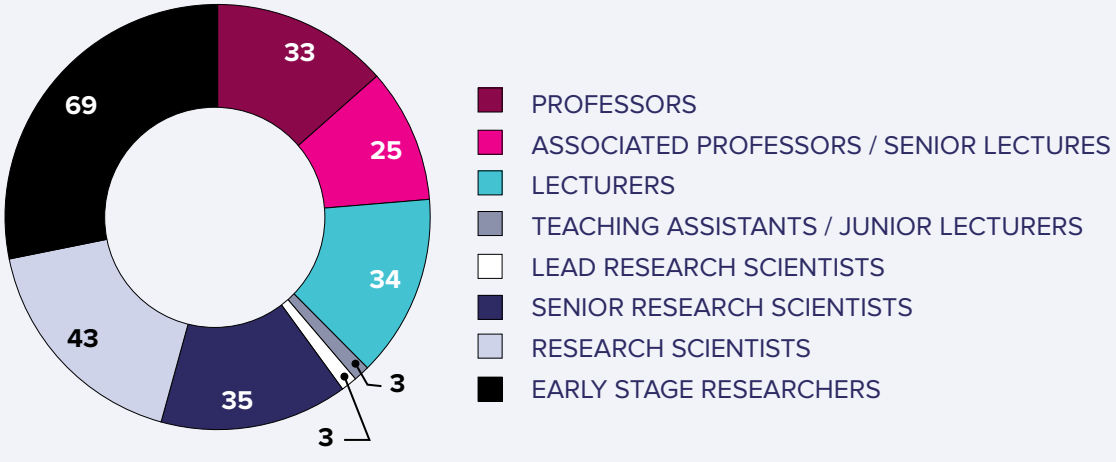
Director: Professor KALJU MEIGAS, kalju.meigas@taltech.ee

THOMAS JOHANN SEEBECK DEPARTMENT OF ELECTRONICS

Director: LAUR LEMENDIK, laur.lemendik@taltech.ee

IT COLLEGE

Director: Associated Professor KALLE TAMMEMÄE, kalle.tammemae@taltech.ee



DEPARTMENT OF COMPUTER SYSTEMS

Direktor: Associated Professor
MARGUS KRUUS,
margus.kruus@taltech.ee,
+372 620 2250

MAIN FIGURES 2020

(as of Dec. 31, 2020)

63 Academic staff — Incl. 9 professors, 42 researchers

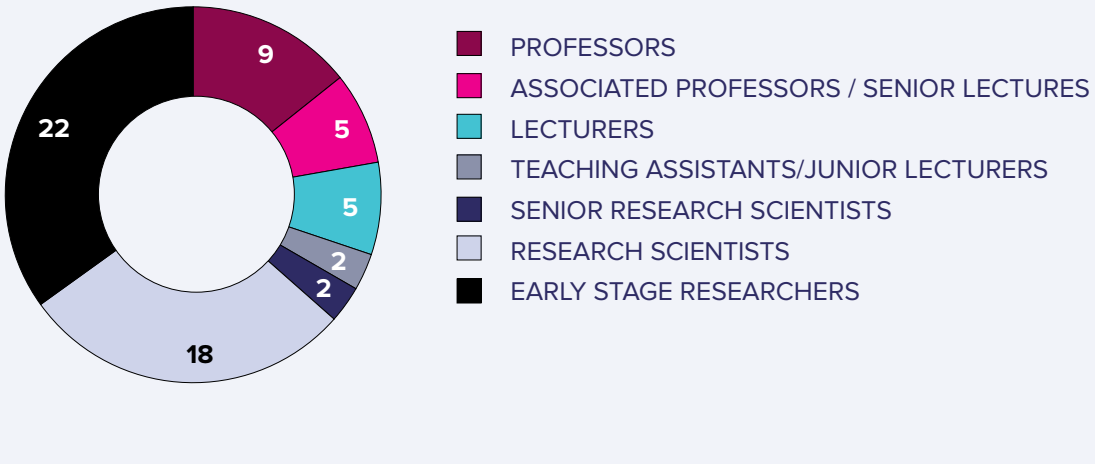
31 Doctoral students — 2 Defended doctoral dissertations

79 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 6 RESEARCH CENTRES:

- **CENTRE OF DEPENDABLE COMPUTING SYSTEMS DESIGN.**
  Head: Professor JAAN RAIK, jaan.raik@taltech.ee
- **CENTRE FOR BIOROBOTICS.**
  Head: Professor MAARJA KRUUSMAA, maarja.kruusmaa@taltech.ee
- **CENTRE FOR INTELLIGENT SYSTEMS.**
  Head: Professor EDUARD PETLENKOV, eduard.petlenkov@taltech.ee
- **CENTRE FOR HARDWARE SECURITY.**
  Head: Professor SAMUEL NASCIMENTO PAGLIARINI, samuel.pagliarini@taltech.ee
- **SMART HARDWARE RESEARCH CENTRE (SHARC).**
  Head: Senior Researcher ARTUR JUTMAN, artur.jutman@taltech.ee
- **EMBEDDED AI RESEARCH LAB.**
  Head: Researcher MAIRO LEIER, mairo.leier@taltech.ee



CENTRE FOR DEPENDABLE COMPUTING SYSTEMS

Head of the centre: Professor JAAN RAIK, jaan.raik@taltech.ee

Members: Peeter Ellervee, Maksim Jenihhin, Gert Jervan, Raimund-Johannes Ubar, Thomas Hollstein, Masoud Daneshtalab, Aleksander Sudnitsõn, Kalle Tammemäe, Tara Ghasempouri, Behrad Niazmand, Lembit Jürimägi

Doctoral students: Karl Janson, Madis Kerner, Xinhui Lai, Adeboye Stephen Oyeniran, Lauri Vihman, Ameer Shalabi, Hardi Selg, Mohammad Hasan Ahmadilivani

TOPICS AND COMPETENCES

KEYWORDS: nanoelectronics design, reliability, security, verification and test; multi-/many-core systems

The research in the Centre for Dependable Computing Systems covers a wide range of topics in the areas of design, reliability, security, verification and testing of nanoelectronic systems (including multi-/many-core systems):

- Study of aging and rejuvenation in nanometer technologies (cooperation with TU Delft, Politecnico di Torino and PUCRS, Brazil).
- Hardware security (cooperation: Airbus, Frankfurt UAS, TU Delft, Intrinsic-ID, Riscure);
- Embedded artificial intelligence architectures (Mälardalen University);
- Cross-layer resilience in sensor networks (cooperation: Testonica Lab OÜ);
- Verification (assertion mining) (cooperation: EPFL/Lausanne, TU Hamburg, DLR, University of California Irvine);
- Diagnostic test generation and microprocessor testing (cooperation: Politecnico di Torino);
- Multi-aspect verification of computing systems (cooperation: iROC Technologies);
- Optimisation of fault injection campaigns (cooperation: Cadence).

The centre has been the initiator of several pan-European actions. Currently it coordinates the Horizon2020 Marie Skłodowska Curie ITN RESCUE project and is contributing to a newly launched Horizon2020 Twinning Action SAFEST. We are also partners in the national ICT centre of research excellence EXCITE.

SELECTED PROJECTS

- VFP17093, "*RESCUE ETN – Interdependent Challenges of Reliability, Security and Quality in Nanoelectronic Systems Design*" (2017–2021)
- TAR16013, "*Estonian Centre of Excellence in ICT Research*" (2016–2023)

- VFP20015, *Secure and Assured Hardware: Facilitating ESTonia's Digital Society* (2021–2023)

SELECTED PUBLICATIONS

Kerner, M.; Tammemäe, K.; Raik, J.; Hollstein, T. (2021). Triple Fixed-Point MAC Unit for Deep Learning. Design Automation and Test in Europe Conference (DATE). IEEE.

Jürimägi, L.; Ubar, R.; Jenihhin, M.; Raik, J. (2020). Calculation of Probabilistic Testability Measures for Digital Circuits with Structurally Synthesized BDDs. Microprocessors and Microsystems, 77, 1–12.

Oyeniran, A. S.; Ubar, R.; Jenihhin, M.; Raik, J. (2020). High-Level Implementation-Independent Functional Software-Based Self-Test for RISC Processors. Journal of Electronic Testing 36, 87–103.

CENTRE FOR BIOROBOTICS

Head of the centre: Professor MAARJA KRUUSMAA, maarja.kruusmaa@taltech.ee

Postdoctoral researchers: Juri Gavšin, Margit Egerer, Asko Ristolainen, Gert Toming, Jeffrey A. Tuhtan, Laura Piho

Doctoral students: Christian Meurer, Roza Gkliva, Mohamed Walid Remmas, Cecilia Monoli, Simon Pierre Godon, Lizaveta Miasayedava, Ali Hassan Khan, Michail Panteris, Konstantin Bilozor, Jürgen Soom

Non-academic members: Jaan Rebane, Andres Ernits, Kilian Ochs

TOPICS AND COMPETENCES

KEYWORDS: underwater robotics, underwater sensing, environmental monitoring

The Centre for Biorobotics focuses on underwater technologies, more specifically on underwater robotics inspired by biological principles, underwater sensing and underwater sensor networks.

Our core competences are:

- Underwater robotics
- Robot locomotion in multi-fluid environments
- Underwater sensing
- Experimental fluid mechanics
- Sensor networks for environmental monitoring

Most important projects (past 3 years):

- VFP15016, H2020 "*LakHsMI (Sensors for Large Scale Hydrodynamic Imaging*", 2015–2019)
- TAR16013 (TK148), "*Estonian Centre for Excellence in IT* (EXCITE, 2016–2023)"
- VFP16051, *H2020 FitHydro (Fish Friendly Hydropower Technologies, 2016–2020)*
- ETAG17107, *FLAG-ERA RoboCom++ (Rethinking Robot Companions of the Future, 2017–2020)*
- VFP18044, *H2020 RISE ECOBOTICS. SEA (Bioinspired Technologies for Sustainable Marine Ecosystem, 2019–2022)*

SELECTED ARTICLES:

Meurer, C.; Fuentes-Perez, J. F.; Schwarzwalder, K.; Ludvigsen, M.; Sorensen, A. J.; Kruusmaa, M.a (2020). 2D Estimation of Velocity Relative to Water and Tidal Currents Based on Differential Pressure for Autonomous Underwater Vehicles. IEEE Robotics and Automation Letters, 5 (2), 3444–3451.

Simha, A.; Gkliva, R.; Kotta, Ü.; Kruusmaa, M. (2020). A flapped paddle-fin for improving underwater propulsive efficiency of oscillatory actuation. IEEE Robotics and Automation Letters, 5 (2), 3176–3181.

Monea, M. C.; Loehr, D. K.; Meyer, C.; Preyl, V.; Xiao, J.; Steinmetz, H.; Schoenberger, H.; Drenkova-Tuhtan, A. (2020). Comparing the leaching behavior of phosphorus, aluminum and iron from post-precipitated tertiary sludge and anaerobically digested sewage sludge aiming at phosphorus recovery. Journal of Cleaner Production, 247, #119129.

For more information please visit *www.biorobotics.taltech.ee*

CENTRE FOR INTELLIGENT SYSTEMS

Head of the centre: Professor EDUARD PETLENKOV, eduard.petlenkov@taltech.ee

Members: Kristina Vassiljeva, Aleksei Tepljakov, Kadri Umbleja, Ahmet Köse, Vitali Vansovitš

Doctoral students: Andrei Maalberg, Maksimilian Tarasevich, Saleh Ragheb Saleh Alsaleh, Abiodun Emmanuel Onile, Olutosin Ajibola Ademola, Hossein Alimohammadi, Vjatšeslav Škiparev

TOPICS AND COMPETENCES

KEYWORDS: control, modelling of dynamic systems, computational intelligence, machine learning, adaptive and self-learning systems, extended reality, digital twins.

The Centre consists of two laboratories: *Control Systems Research Laboratory* and *Virtual and Augmented Reality Laboratory*.

The core competences of the Centre for Intelligent Systems are:

- Modelling, control, and analysis of complex nonlinear dynamic systems;
- Computational Intelligence based algorithms: Artificial Neural Networks, Genetic Algorithms, Fuzzy Logic, etc.;

- Self-learning and adaptation methods in control systems;
- Fractional-order modelling and control;
- Distributed control systems;
- Data analysis;
- Development of research software;
- Virtual and Augmented Reality applications;
- Digital twins.

The research group focuses on development and implementation of novel efficient control techniques for Industry 4.0 applications based on the combination of classical industrial controllers with computational intelligence methods and knowledge based reasoning.

SELECTED PROJECTS

- PRG658, *Intelligent Control Systems for Industry 4.0* (2020–2024)
- VERT20001, *University Business Cooperation for Promoting Virtual, Augmented and Mixed Reality Applications within Small and Medium-sized Manufacturing Companies* (2020–2022)
- LIAEE2017, *Energy flexilibilty service pilot project – Stage 2* (2020–2023)
- LEP19101, *Automated machine learning and rule-based methods for fault detection of air handling units to increase their efficiency* (2019–2020)

Homepage: *http://is-centre.eu/*.

CENTRE FOR HARDWARE SECURITY

Head of the centre: Professor SAMUEL NASCIMENTO PAGLIARINI, samuel.pagliarini@taltech.ee

Postdoctoral researchers: Mahdieh Grailoo, Levent Aksoy

Doctoral students: Antonio Felipe Costa de Almeida, Maliik Imran, Tiago Diadami Perez, Zain Ul Abideen, Mohammad Eslami

TOPICS AND COMPETENCES

KEYWORDS: hardware security, trustworthy integrated circuits, ASICs, cryptohardware, circuit obfuscation

The Centre for Hardware Security conducts research in all applied aspects of hardware security: the aim is to validate security techniques in real silicon. The Centre's research on integrated circuit (IC) design, electronic design automation (EDA), and cryptographic hardware enables trustworthy IC-based systems to be built. Threats such as hardware Trojans, reverse engineering, circuit (de)obfuscation, IP piracy, IC overbuilding, side-channel attacks, etc., are addressed through an array of technical countermeasures.

Core competences:

- Design of Application Specific Integrated Circuits
- Circuit obfuscation by design partitioning and locking

- Trustworthy electronic design automation tooling (from RTL to layout)
- Countermeasures to reverse engineering, side channel attacks, and piracy
- Crypto hardware

Key achievements in 2020:

- *H2020 Twinning project SAFEST* (coordinator: professor Pagliarini)
- Fabrication of two integrated circuits designed by students of the Centre
- Achieved "first silicon success" for our first ever fabricated integrated circuit
- Best paper nomination at HOST 2020
- Closing keynote talk at ICR2020
- Organization of a special session on Hardware Security at the 25th IEEE European Test Symposium (ETS 2020)
- Submission of a US/EU patent on circuit obfuscation (pending review)

SELECTED ARTICLES

Pagliarini, Samuel N.; Bhuin, Sudipta; Isgenc, Mehmet Meric; Biswas, Ayan Kumar; Pileggi, Larry (2020). A Probabilistic Synapse With Strained MTJs for Spiking Neural Networks. IEEE Transactions on Neural Networks and Learning Systems, 31 (4), 1113–1123.

Pagliarini, Samuel; Sweeney, Joseph; Mai, Ken; Blanton, Shawn; Mitra, Subhasish; Pileggi, Larry (2020). Split-Chip Design to prevent IP Reverse Engineering. IEEE Design and Test, 1–1.

Isgenc, Mehmet Meric; Martins, Mayler G. A.; Zackriya, V. Mohammed; Pagliarini, Samuel N.; Pileggi, Larry (2020). Logic IP for Low-Cost IC Design in Advanced CMOS Nodes. IEEE Transactions on Very Large Scale Integration (VLSI) Systems, 28 (2), 585–595.

SMART HARDWARE RESEARCH CENTRE (SHARC)

Head of the centre: Senior Researcher ARTUR JUTMAN, artur.jutman@taltech.ee

Members: Sergei Devadze, Anton Tšertov, Igor Aleksejev, Dmitri Mihhailov, Sergei Odintsov, Konstantin Shibin

TOPICS AND COMPETENCES

KEYWORDS: system health awareness, self-healing and adaptation to damage, predictive maintenance, embedded systems, embedded software, test and diagnostics, DFT, FDIR

Research focus: cutting-edge industrial-grade approaches for self-health awareness, fault tolerance and quality assurance through the entire product life cycle of microelectronic systems.

Development focus: professional design of embedded systems from hardware to software.

The core competences of the group are:

- Designing with FPGA SoCs (Zynq, CycloneV SoC and others)
- Designing with soft-processors from Xilinx (Microblaze) and Intel (NIOS II)
- VHDL and Verilog hardware design languages
- Xilinx Vivado, Altera/Intel Quartus, Lattice Diamond, ModelSim, QuestaSim
- High-speed design with multi-gigabit transceivers

- Implementation of high-speed serial interfaces such as PCIe, SATA, USB3.0
- Memory controllers: DDR2, DDR3, DDR4; Buses: AXI, Avalon, AXI-Lite
- Bare-metal applications, bootloaders, Linux drivers and Userspace applications
- Petalinux, Yocto, FreeRTOS and embedded SDKs, ELDK
- Instrumentation for test and troubleshooting
  - ChipScope, SignalTAP II, Reveal Analyzer, Quick Instruments
  - JTAG/Boundary Scan IEEE Std. 1149.1, IEEE Std. 1149.6, IEEE Std. 1687

Key achievements in R&D:

- TRL-4 demonstrator of fitness and fault management technology for microprocessors making them self-health-aware, hence helping space electronics to maintain its fitness under the pressure of cosmic radiation and to withstand a higher dose.
- TRL-6 embedded instrumentation technology for marginal defect detection and their impact measurement in high-speed electronics.
- Full stack design (hardware, drivers, software), test and delivery of processing, communication and test equipment for large accelerators: CERN and ESS/ERIC.

In 2020, the research group participated in the following R&D projects:

- Development contracts for the European Spallation Source – ESS
  - Implementation of an EtherCAT slave board and its software support
  - Implementation of FPGA IOC FMC Carrier Card and respective software
- PRG780, *Preparing the CMS experiment for high luminosity operations through trigger improvements* (2020–2024)
- VFP17095, *TEchnology TRAnsfer via Multinational Application eXperiments* (2017–2021)

EMBEDDED AI RESEARCH LABORATORY

Head of the laboratory: Researcher MAIRO LEIER, mairo.leier@taltech.ee

Members: Uljana Reinsalu, Priit Ruberg, Jürgen Soom, Karl Janson, Olutosin Ajibola Ademola

TOPICS AND COMPETENCES

KEYWORDS: embedded machine learning, edge computing, embedded systems design, signal processing

The Embedded AI Research Lab focuses on developing and optimizing machine learning solutions in the embedded systems. The laboratory collaborates internationally with research teams and companies from the maritime, smart city, autonomous vehicles and industrial automation sectors. Focus is on maritime and mobility solutions.

CORE COMPETENCIES

- embedded hardware design and prototyping,
- machine learning model optimization for embedded hardware,
- hardware accelerators for edge computing,
- image and video processing on edge devices.

SELECTED PROJECTS

- LEP19006, "*Smart cardeck*" (2019–2020)
- LIAEE20135, *Sensor solution development for Kinema industrial doors* (2020–2021)
- VA20069, *Green RORO shipping through digital innovation* (2020–2024)

More information: *https://iot.ttu.ee*

DEPARTMENT OF SOFTWARE SCIENCE

Director: MARKO KÄÄRAMEES,
marko.kaaramees@taltech.ee

MAIN FIGURES 2020

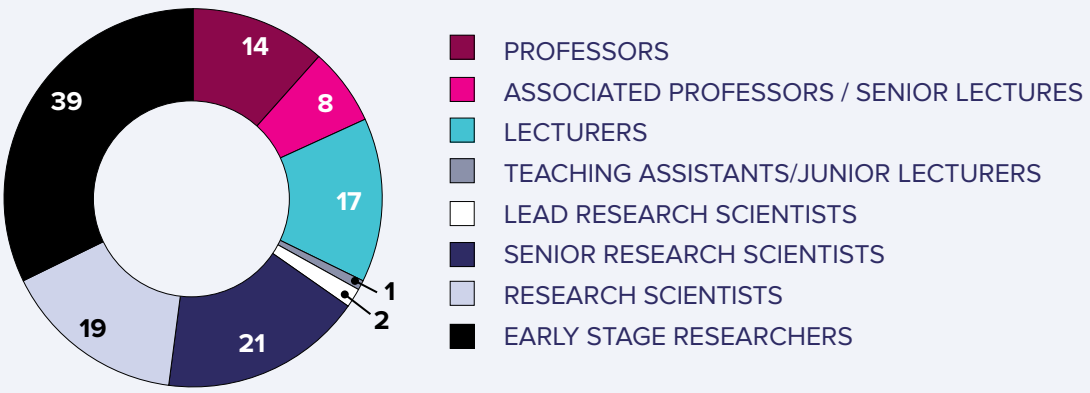
(as of Dec. 31, 2020)

121	Academic staff	Incl. 14	professors
		81	researchers
55	Doctoral students	8	Defended doctoral dissertations
136	Scientific publications*		

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 11 RESEARCH UNITS:

- **APPLIED ARTIFICIAL INTELLIGENCE.**
  Head: VAHUR KOTKAS, vahur.kotkas@taltech.ee
- **BUSINESS INFORMATION TECHNOLOGY GROUP.**
  Head: Associated Professor GUNNAR PIHO, gunnar.piho@taltech.ee
- **CENTRE FOR DIGITAL FORENSICS AND CYBER SECURITY.**
  Head: Professor RAIN OTTIS, rain.ottis@taltech.ee
- **DATA SCIENCE.**
  Head: Professor SADOK BEN YAHIA, sadok.ben@taltech.ee
- **HIGH-ASSURANCE SOFTWARE LABORATORY.**
  Head: Lead Research Scientist TARMO UUSTALU, tarmo.uustalu@taltech.ee
- **INFORMATION SYSTEMS GROUP.**
  Head: Professor DIRK DRAHEIM, dirk.draheim@taltech.ee
- **LABORATORY FOR COMPOSITIONAL SYSTEMS AND METHODS.**
  Head: Professor PAWEL SABOCINSKI, pawel.sobocinski@taltech.ee
- **LABORATORY OF LANGUAGE TECHNOLOGY.**
  Head: Senior Researcher TANEL ALUMÄE, tanel.alumae@taltech.ee
- **LABORATORY OF PROACTIVE TECHNOLOGIES.**
  Head: Researcher JAANUS KAUGERAND, jaanus.kaugerand@taltech.ee
- **NEXT GEN DIGITAL STATE RESEARCH GROUP.**
  Head: Associated Professor INGRID PAPPEL, ingrid.pappel@taltech.ee
- **NONLINEAR CONTROL SYSTEMS GROUP.**
  Head: Lead Research Scientist ÜLLE KOTTA, ulle.kotta@taltech.ee



APPLIED ARTIFICIAL INTELLIGENCE

Head of the research group: Development Officer VAHUR KOTKAS, vahur.kotkas@taltech.ee

Members: Tanel Tammet, Hele-Mai Haav, Mait Harf, Irina Astrova, Riina Maigre, Ago Luberg, Margarita Spitšakova, Kristiina Kindel, Rauni LillemetsKarl Ivory Pappel, Hannes Tarn, Sven Veskioja, Julia Kalašnikova, Marta Olvet

Doctoral students: Martin Verrev, Priit Järv

TOPICS AND COMPETENCES

KEYWORDS: machine learning, automated commonsense reasoning, ontology based reasoning, AI methods in spatial data analysis, recommender systems, logic-based software systems

The Applied AI Group conducts research in application of AI methods in various fields and systems. We investigate applicability of machine learning, ontology based reasoning, automated theorem provers, knowledge discovery and other AI methods for solving digitalisation problems of different industrial and governmental stakeholders.

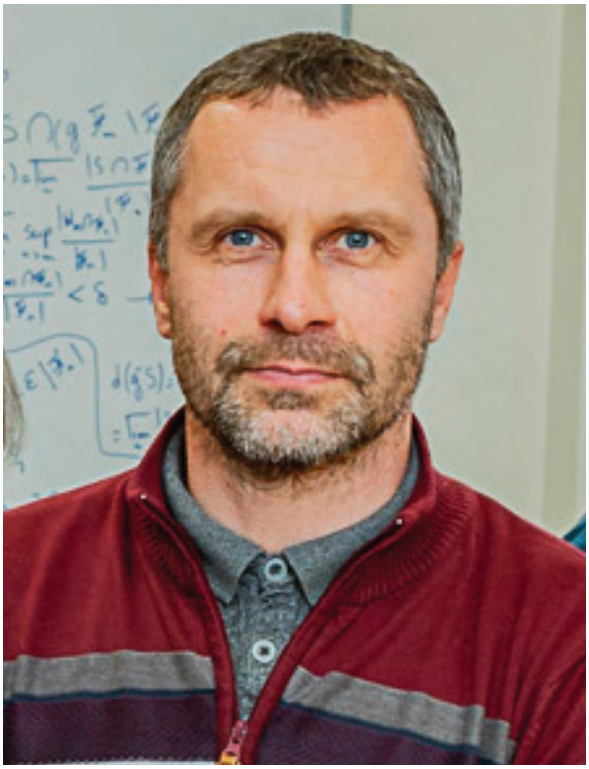
Our previous research has been concentrated on building software development methods and tools (e.g. CoCoViLa) with AI components, basically with program synthesis and ontology based knowledge representation components.

During a number of decades several software tools that facilitate AI techniques have been developed by the group. The following is a list of tools that are still in use or under development:

- CoCoViLa – a visual model-based software development environment – http://cocovila.github.io/
- WhiteDB – a lightweight NoSQL database library – http://whitedb.org/
- GKC – a discussion tool on large knowledge bases – https://github.com/tammet/gkc

Currently we work on topics such as application of AI methods in spatial data analysis, using machine learning for risk management in e-commerce and for public service delivery. The corresponding projects are listed below:

- Applied research for creating a cost-effective interchangeable 3D spatial data infrastructure with survey-grade accuracy
- Applied research for e-commerce EU VAT and duty declaration (as from 2021) digitalisation
- Machine learning and AI powered public service delivery



SELECTED PUBLICATIONS:

Luberg, A.; Pindis, J.; Tammet, T. (2020). Sights, titles and tags: mining a worldwide photo database for sightseeing. Proceedings of 10th International Conference on Web Intelligence, Mining and Semantics (WIMS 2020) & 5th International Conference on Real-time Intelligent Systems (RTIS 2020), 149–158. (ICPS).

Draheim, D.; Tammet, T. (2020). From sensors to Dempster-Shafer theory and back: the axiom of ambiguous sensor correctness and its applications. Database and Expert Systems Applications: 31st International Conference, DEXA 2020, Proceedings, Part I (3–19). Cham: Springer. (Lecture Notes in Computer Science; 12391).

Astrova, I. (2020). How the Anti-TrustRank algorithm can help to protect the reputation of financial institutions. Research Challenges in Information Science: 14th International Conference, RCIS 2020, Proceedings. Cham: Springer, 503–508. (Lecture Notes in Business Information Processing; 385).

BUSINESS INFORMATION TECHNOLOGY GROUP

Head of the research group: Associated Professor GUNNAR PIHO, gunnar.piho@taltech.ee

Members: Viljam Puusep, Tõnn Talpsepp, Kristiina Hiie, Liisa Jõgiste, Inna Švartsman, Tarvo Treier, Jekaterina Tšukrejeva, Karl-Erik Karu

Doctoral students: Kristina Murtazin, Oleg Shvets

TOPICS AND COMPETENCES

KEYWORDS: professional applications, dependable, interoperable and evolutionarily changeable enterprise applications, business software, future professionals, professional education

The research of the Business Information Technology Group is focused on a theory and practice of dependable, interoperable and evolutionarily changeable enterprise applications and on the education of a future specialists in the field.

SELECTED PROJECTS

- LEP18020, *Clinical pilot projects of personalised medicine in the precise prevention of breast cancer and cardiovascular diseases* (2018–2020).
- VERT20061, *EuroTeQ Engineering University* (2020–2023).

SELECTED ARTICLES

Murtazin, K.; Shvets, O.; Piho, G. (2020). Curriculum for business information technology studies at BSc and MSc levels – observations from a long-term educational endeavour. Proceedings of the 2020 IEEE Global Engineering Education Conference (EDUCON): 27–30 April, 2020, Porto, Portugal. Ed. Cardoso, Alberto; Alves, Gustavo R.; Restivo, Teresa. New York, NY: IEEE, 409–418.

Shvets, O.; Murtazin, K.; Piho, G. (2020). Providing feedback for students in e-learning systems: a literature review, based on IEEE Explore Digital Library. Proceedings of the 2020 IEEE Global Engineering Education Conference (EDUCON): 27–30 April, 2020, Porto, Portugal. New York, NY: IEEE, 284–289.

Shvets, O.; Murtazin, K.; Piho, G. (2020). Creation of software platform for distance use of lab equipment and data in Virumaa College at Tallinn University of Technology. 2020 43rd International Convention on Information, Communication and Electronic Technology (MIPRO): September 28 – October 2, Opatija, Croatia, Proceedings. Ed. Koricic, Marko; Skala, Karolj; Car, Zeljka; et al. Rijeka, Croatia: MIPRO/IEEE, 1591–1595.

CENTRE FOR DIGITAL FORENSICS AND CYBER SECURITY

Head of the centre: Professor RAIN OTTIS, rain.ottis@taltech.ee

Members: Olaf Manuel Maennel, Ahto Buldas, Hayretdin Bahsi, Stefan Sütterlin, Matthew Sorell, Adrian Venables, Risto Vaarandi, Birgy Lorenz, Eneken Tikk, Mika Juha Kerttunen, Anna-Maria Osula, Andro Kull, Toomas Lepik, Kristine Hovhannisyan

Doctoral students: Dan Heering, Alejandro Guerra Manzanares, Kaie Maennel, Sten Mäses, Jaan Priisalu, Tiia Sõmer, Pavel Tšikul, Ahto Truu, Erwin Orye, Mauno Pihelgas

TOPICS AND COMPETENCES

KEYWORDS: cyber defense; digital expertise, cryptography

TalTech Centre for Digital Forensics and Cyber Security works towards raising Estonian cyber security competence and capacity through education, research and development. The research team includes experts from various scientific disciplines, including computer science, law and psychology. Such a team can take on complex cyber security issues that require an interdisciplinary approach.

The main research directions of the Centre are: Critical Information Infrastructure Protection (focus on eGovernance and transportation sectors), cryptography, network monitoring, digital forensics, education research, and cyber security strategy and policy.

SELECTED ARTICLES

Buldas, A.; Gadyatskaya, O.; Lenin, A.; Mauw, S.; Trujillo-Rasua, R. (2020). Attribute Evaluation on Attack Trees with Incomplete Information. *Computers & Security, 88, 101630, 1–17.*

Guerra-Manzanares, A.; Medina-Galindo, J.; Bahsi, H.; Nõmm, S. (2020). MedBIoT: Generation of an IoT Botnet Dataset in a Medium-sized IoT Network. *Proceedings of the 6th International Conference on Information Systems Security and Privacy, ICISSP, Volume 1 : February 25–27, 2020, La Valletta, Malta. La Valletta: SciTePress, 207–218.*

Maennel, K. (2020). Learning analytics perspective: evidencing learning from digital datasets in cybersecurity exercises. *Proceedings 5th IEEE European Symposium on Security and Privacy Workshops EUROS&PW 2020 : 7–11 September 2020, VIrtual Event. Los Alamitos, Calif.: IEEE, 27–36.*

DATA SCIENCE

Head of the research group: Professor SADOK BEN YAHIA, sadok.ben@taltech.ee

Members: Jaak Henno, Deniss Kumlander, Innar Liiv, Ahti Lohk, Ants Torim, Grete Lind, Leo Võhandu

Post-doctoral researcher: Imen Ben Sassi

Doctoral students: Martin Rebane, Chahinez Ounoughi, Ashiq Ahmed, Markko Liutkevicius, Siim Salin, Fabiano Spiga, Nzamba Bignoumba, Kyrylo Medianovskyi, Anton Vedešin

TOPICS AND COMPETENCES

KEYWORDS: data science, combinatorial optimisation, smart cities

The Data Science Group carries out research activities towards extracting value from information standing at the crossroads of some of the priority areas, e.g.

- Cyber security: intrusion / outlier detection.
- Digital transformation of the society; healthcare information systems (adverse events in hospitals, mining of patient trajectory).
- Smart-environment: Internet of Things (IoT), intelligent transportation system, smart city, smart home.

The main competences of the research group are:

- Data mining.
- Big data analytics.
- Data seriation /visualization.
- Ontology alignment/merging.
- Random data modelling.

SELECTED ARTICLES

Abidi, B.; Ben Yahia, S.; Perera, C. (2020). Hybrid microaggregation for privacy preserving data mining. Journal of Ambient Intelligence and Humanized Computing, 11 (1), 23–38.

Vedeshin, A.; Dogru, J. M. U.; Liiv, I.; Ben Yahia, S.; Draheim, D. (2020). A secure data infrastructure for personal manufacturing based on a novel key-less, byte-less encryption method. IEEE Access, 8, 40039–40056.

Allani, S.; Yeferny, T.; Chbeir, R.; Ben Yahia, S. (2020). Towards a smarter directional data aggregation in VANETs. World Wide Web, 23 (4), 2303–2322.

Hammami, H.; Obaidat, M. S.; Ben Yahia, S. (2020). An efficient authentication and key agreement scheme for secure smart grid communication services. International Journal of Communication Systems, 33 (15), e4558, 1–13.

HIGH-ASSURANCE SOFTWARE LABORATORY

Head of the laboratory: Lead Research Scientist TARMO UUSTALU, tarmo.uustalu@taltech.ee

Members: Jüri Vain, Juhan-Peep Ernits, Marko Kääramees, Sven Nõmm, Hellis Tamm, Leonidas Tsiopoulos, Maksym Bortin, Niccolò Veltri, Denis Firsov, Gert Kanter, Evelin Halling, Hendrik Maarand

Postdoctoral researchers: Niels Voorneveld, Stephan A. Spahn

Doctoral student: Elli Valla

TOPICS AND COMPETENCES

KEYWORDS: functional and dependently-typed programming, software verification and testing, formalized programming theory

The group conducts research into theories, methods and tools for developing high-assurance software, specializing on both proofs (certified software) and testing.

THE LATEST RESEARCH RESULTS

Residual monad-comonad interaction laws were shown to correspond to certain operations on algebras and coalgebras. From this correspondence, several relationships between interaction laws and stateful and continuation-based runners were derived.

Novel concepts of flexibly graded monad and algebraic were introduced together with their basic theory. Flexibly graded operations facilitate more precise quantification of computational effects that ordinary (rigidly) graded operations.

A time semantics of fUML (the Foundational UML Subset) activity diagrams (ADs) was introduced and time activity diagrams with observable labels were defined in order to support the relativised time input-output conformance (rtioco) relation for executable UML ADs.

A sentence writing test was developed for diagnosing Parkinson's disease that operates on a set of interpretable quantitative features.

SELECTED ARTICLES

A. Buldas, D. Firsov, R. Laanoja, H. Lakk, D. Firsov, A. Buldas, A. Truu, R. Laanoja. (2020). Verified security of BLT signature scheme. CPP '20 : Proceedings of the 9th ACM SIGPLAN International Conference on Certified Programs and Proofs : January 20–21, 2020, New Orleans, LA, US. Ed. Blanchette, Jasmin; Hriţcu, Cătălin. New York, NY: ACM, 244–257.

S. Katsumata, E. Rivas, T. Uustalu. (2020). Interaction laws of monads and comonads. LICS '20 : Proceedings of the 35th Annual ACM/IEEE Symposium on Logic in Computer Science, July 8–11, 2020, Saarbrücken, Germany. New York: ACM Press, 604–618.

A. Netšunaev, S. Nõmm, A. Toomela, K. Medijainen, P. Taba. 2020). Sentence writing test for Parkinson disease modeling: comparing predictive ability of classifiers. Intelligent Information and Database Systems : 12th Asian Conference, ACIIDS 2020, Phuket, Thailand, March 23–26, 2020, Proceedings, Part I. Ed. Nguyen, Ngoc Thanh; Jearanaitanakij, Kietikul; Selamat, Ali; Trawinski, Bogdan; Chittayasothorn, Suphamit. Cham: Springer, 345–357. (Lecture Notes in Artificial Intelligence; 12033).

INFORMATION SYSTEMS GROUP

Head of the research group: Professor DIRK DRAHEIM, dirk.draheim@taltech.ee

Members: Jaak Tepandi, Tõnn Talpsepp, Erki Eessaar, Ingrid Pappel, Gunnar Piho, Enn Õunapuu, Regina Erlenheim, Kristiina Hiie, Liisa Jõgiste, Kristina Murtazin, Viljam Puusep, Karl Ivory Pappel

Doctoral students: Rahul Sharma, Suran Shweta, Valentyna Tsap, Sidra Azmat Butt, Minakshi Kaushik, Markko Liutkevicius, Silvia Lips, Keegan David Braun McBride, Vishwajeet Pattanaik, Sijo Arakkal Peious

TOPICS AND COMPETENCES

KEYWORDS: information systems, e-government, e-governance, e-health, data science, system architecture, system design, databases, large-scale systems

The LSS group conducts research in large- and ultra-large-scale IT systems. The group investigates the architecture, design, realization and management of IT system landscapes, high-volume data-intensive systems, high-volume workflow-intensive systems, massively resource-intensive systems, highly distributed systems. In particular, LSS group investigates the next generation of digital government technologies and digital government ecosystems. Together with the partners from industry, academia and the public sector the group strives for excellent solutions for non-standard, mission-critical IT system problems.

SELECTED ARTICLES

Draheim, Dirk; Tammet, Tanel (2020). From sensors to Dempster-Shafer theory and back: the axiom of ambiguous sensor correctness and its applications. Database and Expert Systems Applications: 31st International Conference, DEXA 2020. Proceedings, Part I (3–19). Cham: Springer. (Lecture Notes in Computer Science; 12391).

Bharosa, Nitesh; Lips, Silvia; Draheim, Dirk (2020). Making e-government work: Learning from the Netherlands and Estonia. Electronic Participation : 12th IFIP WG 8.5 International Conference, ePart 2020. Proceedings. Cham: Springer, 41–53. (Lecture Notes in Computer Science; 12220).

Vedeshin, Anton; Dogru, John Mehmet Ulgar; Liiv, Innar; Ben Yahia, Sadok; Draheim, Dirk (2020). A secure data infrastructure for personal manufacturing based on a novel key-less, byte-less encryption method. IEEE Access, 8, 40039–40056.

Rasheed, Jawad; Jamil, Akhtar; Hameed, Alaa Ali; Aftab, Usman; Aftab, Javaria; Shah, Syed Attique; Draheim, Dirk (2020). A survey on artificial intelligence approaches in supporting frontline workers and decision makers for the COVID-19 pandemic. Chaos, Solitons & Fractals, 141, 110337, 1–17.

LABORATORY FOR COMPOSITIONAL SYSTEMS AND METHODS

Head of the laboratory: Professor PAWEŁ MARIA SOBOCIŃSKI, pawel.sobocinski@taltech.ee

Post-doctoral researchers: Edward Barish Morehouse, Fosco Loregian

Doctoral students: Elena Di Lavore, Nathan Josep Haydon, Chad Mitchell Nester, Mario Román Garcia, Amar Hadzihasanovic, Matthew David Earnshaw, Diana-Maria Kessler

TOPICS AND COMPETENCES

KEYWORDS: compositionality, open games, open systems, applied category theory, programming languages, diagrammatic reasoning, string diagrams, logic in computer science, relational methods

The group's goal is to study compositional techniques in the context of models of computation. Compositionality means that syntactic descriptions for (open) systems are designed to be compatible with their semantics. While the examples motivating the research come from a broad section of scientific disciplines (logic, control theory, formal language theory, control theory, business processes, game theory, economics, machine learning), we have identified common principles for reasoning about open systems, guided by category theory. These include a semantic universe based on relations rather than functions, and the use of the diagrammatic syntax of string diagrams. String diagrams provide an intuitive calculus for computations via diagrammatic reasoning, and fine-grained control over resources, which is important for faithful descriptions of open systems.

The group's big questions/challenges are:

- to design a next generation of programming/specification languages that will be more suited for compositional (and therefore, more trustworthy and reliable) descriptions of systems,
- to use compositionality to improve the analysis of systems, including the design of new techniques and algorithms, and
- to design and implement tools for working with string diagrams, fast-tracking the passage from theory to practice.

SELECTED ARTICLES

Behr, N.; Sobocinski, P. (2020). Rule algebras for adhesive categories. Logical Methods in Computer Science, 16 (3), 2:1–2:38.

Bonchi, F.; Piedeleu, R.; Sobociński, P.; Zanasi, F. (2020). Contextual equivalence for signal flow graphs. Foundations of Software Science and Computation Structures: 23rd International Conference, FOSSACS 2020. Proceedings. Ed. Goubault-Larrecq, J.; König, B.a. Cham: Springer, 77–96. (Lecture Notes in Computer Science; 12077).

Haydon, N.; Sobociński, P. (2020). Compositional diagrammatic first-order logic. Diagrammatic Representation and Inference : 11th International Conference, Diagrams 2020. Proceedings. Ed. Pietarinen, A.-V.; Chapman, P.; Bosveld-de Smet, L.; Giardino, V.; Corter, J.; Linker, S. Cham: Springer, 402–418. (Lecture Notes in Artificial Intelligence; 12169).

LABORATORY OF LANGUAGE TECHNOLOGY

Head of the laboratory: Senior Researcher TANEL ALUMÄE, tanel.alumae@taltech.ee

Members: Einar Meister, Lya Meister, Jörgen Valk

Doctoral student: Asad Ullah, Joonas Kalda

TOPICS AND COMPETENCES

KEYWORDS: speech technology, phonetics, speech corpora

The Language Technology Laboratory focuses on the following topics:

- Speech recognition
- Speaker, spoken language and accent identification
- Speech corpora
- Phonetics (Estonian language prosody and vocal system, L2 speech)
- Various sub-topics of natural language processing

One of the important activities is the creation of speech technology applications targeted at society as a whole. This includes applications of end-user speech recognition as well as the key integration components that are easy to integrate. Although the focus is on speech recognition in Estonian, most of the software created in the laboratory is not specific to Estonian. The laboratory is a solid open source free software supporter.

SELECTED ARTICLES

Łańcucki, A.; Chorowski, J.; Sanchez, G.; Marxer, R.; Chen, N.; Dolfing, H.; Khurana, S.; Alumäe, T.; Laurent, A. (2020). Robust training of vector quantized bottleneck models. 2020 International Joint Conference on Neural Networks (IJCNN): [Glasgow, Scotland, UK, 19–24 July, 2020], Proceedings. Piscataway, NJ: IEEE, [1–7].

Paats, A.; Alumäe, T.; Meister, E.; Fridolin, I. (2018). Retrospective analysis of clinical performance of an Estonian speech recognition system for radiology: effects of different acoustic and language models. Journal of Digital Imaging, 31 (5), 615–621.

Alumäe, T. (2018). Training speaker recognition models with recording-level labels. 2018 IEEE Workshop on Spoken Language Technology, SLT 2018: Proceedings, December 18–21, 2018, Athens, Greece.

LABORATORY OF PROACTIVE TECHNOLOGIES

Head of the laboratory: Researcher JAANUS KAUGERAND, jaanus.kaugerand@taltech.ee

Members: Leo Mõtus, Kalev Rannat, Hannes Keernik, Taivo Kangilaski, Andri Riid, Raul Savimaa, Andres Udal, Tõnu Näks, Sergei Astapov, Ermo Täks

Doctoral students: Johannes Ehala, Rene Pihlak, Konstantin Bilozor, Lizaveta Miasayedeva

TOPICS AND COMPETENCES

KEYWORDS: cyber-physical-systems, spontaneous sensor networks, fog calculation, supranational comprehensive situational awareness, deep learning

The laboratory focuses on the theoretical and practical study of networked systems built from stationary and/or mobile software-intensive (proactive) components. Typical components are pervasive computing systems. The research is partitioned into three threads: (1) modeling and verification of situation-aware interaction-centered computation; (2) methods and technologies for acquiring situational information; (3) methods for processing and interpretation of situational information for (proactive) decision making. The long-term goal of the laboratory is the ability to detect and partially control the emergent behaviour in pervasive computing systems. In addition, ProLab performs research on classification, semantic segmentation and object detection using convolutional neural networks. The methodology has been applied to photographic images, point cloud collections and sound recordings.

SELECTED PROJECTS

- LEP19022 "*Applied Research for creating a cost-effective interchangeable 3D spatial data infrastructure with survey-grade accuracy*" (2019–2020)
- AR20013, *Smart City Center of Excellence* (2020–2023)
- AR17119, *Infotechnological Mobility Observatory* (2017–2022)

SELECTED ARTICLES

Riid, Andri; Manna, Davide Liberato; Astapov, Sergei (2020). Image-Based Pavement Type Classification with Convolutional Neural Networks. INES 2020 : IEEE 24th International Conference on Intelligent Engineering Systems, Proceedings, July 8-10, 2020, Reykjavík, Iceland. IEEE, 55–60. DOI: 10.1109/INES49302.2020.9147199.

Lõuk, Roland; Riid, Andri; Pihlak, René; Tepljakov, Aleksei (2020). Pavement defect segmentation in orthoframes with a pipeline of three convolutional neural networks. Algorithms, 13 (8), 198, 1–27. DOI: 10.3390/a13080198.

Mõtus L., K.Taveter, V. Dieves (2019). Speculations on Collaboration of Models. CogSIMA 2019 Conference, Poster, Poster, DOI: 10.1109/COGSIMA.2019.8724167, Conference: 2019 IEEE Conference on Cognitive and Computational Aspects of Situation Management (CogSIMA).

NEXT GEN DIGITAL STATE RESEARCH GROUP

Head of the research group: Associated Professor INGRID PAPPEL, ingrid.pappel@taltech.ee

Members: Alexander Norta, Regina Sirendi

Doctoral students: Richard Michael Dreyling III, Teona Gelashvili, Eric Blake Jackson

TOPICS AND COMPETENCES

KEYWORDS: public sector digital transformation, development of public services, data exchange platforms and automation lines

The Next Gen Digital State (NGDS) research group addresses the technological complexities of how governments can satisfy the current and future needs of their citizens. We focus on digital government ecosystems by investigating technologies that support digital transformation, innovation and implementation.

Our research group collaborates with Estonian and international public sector agencies, ministries, and departments for developing next generation government technology through cutting edge research topics focused on artificial intelligence architecture, requirements engineering, data analytics, and understanding the socio-economic effects of technological implementation. We strive to be on the forefront of public sector innovation research.

More information: *https://egov.ee/nextgen-group/*

SELECTED PROJECTS

- LEP19059, *Tender for e-commerce EU VAT and duty declaration (as from 2021) digitalization applied research* (2019–2020)
- VIR19028, *Supporting Smart Specialization Approach in Silver Economy for Increasing Regional Innovation Capacity and Sustainable Growth* (2018–2021)

SELECTED ARTICLES

Pappel, Ingrid; Tsap, Valentyna; Draheim, Dirk (2021). The e-LocGov Model for Introducing e-Governance into Local Governments: an Estonian Case Study. IEEE Transactions on Emerging Topics in Computing.

Mærøe, Anders Røsten; Norta, Alexander; Tsap, Valentyna; Pappel, Ingrid (2021). Increasing Citizen Participation in e-Participatory Budgeting Processes. Journal of Information Technology & Politics, 18, 1–23.

NONLINEAR CONTROL SYSTEMS GROUP

Head of the research group: Lead Research Scientist ÜLLE KOTTA, ulle.kotta@taltech.ee

Members: Arvo Kaldmäe, Vadim Kaparin, Juri Belikov

Postdoctoral researcher: Ashutosh Simha

Doctoral students: Christian Meurer, Vjatšeslav Škiparev, Tuuli Uudeberg, Abiodun Emmanuel Onile

TOPICS AND COMPETENCES

KEYWORDS: non-linear control systems, algebraic methods, autonomous vehicles, power systems

The group is a leading Estonian research unit in automatic control, focusing on nonlinear control systems, including also hybrid and time-delay systems. The group has made a significant contribution to the development of constructive algebraic methods and the associated symbolic software package NLControl, which supports research, teaching and applications.

A universal algebraic methodology has been developed that simplifies the study of very different problems for nonlinear control systems from unified perspective. The main idea is to construct sequences of subspaces (or submodules) of differential 1-forms that provide a lot of information about the structural properties of the system. For instance, an event-based resource-aware control method based on the concept of differential flatness has been developed.

Although the group is developing predominantly application-independent general methods, the applicability of which depends rather on the dynamic properties of mathematical models, we have recently focused on some carefully selected applications, some of which are addressed within the joint topics of the *Estonian Centre for Excellence in Science (EXCITE)*, our group is part of.

These include control of autonomous underwater vehicles and ionic polymer-metal composite actuators. Within the last few years, special attention has been paid to the study of practical problems arising in the limits of renewable energy integration, and determineing the possible limitations of distributed energy storage devices in low inertia power systems utilizing methods from optimal control theory.

MAIN RESULTS

- The solution for the realization problem of nonlinear time-delay systems was found. Realization in special forms that help to handle different control problems was also addressed.
- In order to obtain higher efficiency in underwater robot control, the asymmetry concept was used. In particular, design of control law for orientation control, based on asymmetric actuation signals, was found and implemented, and the new design of a fin was suggested to obtain higher efficiency in force generation.
- The problem of malicious attacks detection and identification for cyber-physical systems was solved in the fully distributed and decentralized manner.
- A novel control approach was proposed for optimal control of energy storage systems under limited information and uncertainty conditions.

Homepage:
https://cc.ioc.ee/dokuwiki/doku.php?id=en:start

SELECTED ARTICLES:

Aabloo, A.; Belikov, J.; Kaparin, V.; Kotta, Ü. (2020). Challenges and perspectives in control of ionic polymer-metal composite (IPMC) actuators: A survey. IEEE Access, 8, 121059–121073.

Simha, A.; Gkliva, R.; Kotta, Ü.; Kruusmaa, M. (2020). A flapped paddle-fin for improving underwater propulsive efficiency of oscillatory actuation. IEEE Robotics and Automation Letters, 5 (2), 3176–3181.

Kaldmäe, A.; Kawano, Y.; Kotta, Ü. (2020). Realizations in feedforward forms of nonlinear input-output equations with time-delays. International Journal of Robust and Nonlinear Control, 30 (17), 7560–7573.

DEPARTMENT OF HEALTH TECHNOLOGIES

Director: Professor KALJU MEIGAS,
kalju.meigas@taltech.ee,
+372 620 2204

MAIN FIGURES 2020

(as of Dec. 31, 2020)

26 Academic staff — Incl. 6 professors, 15 researchers

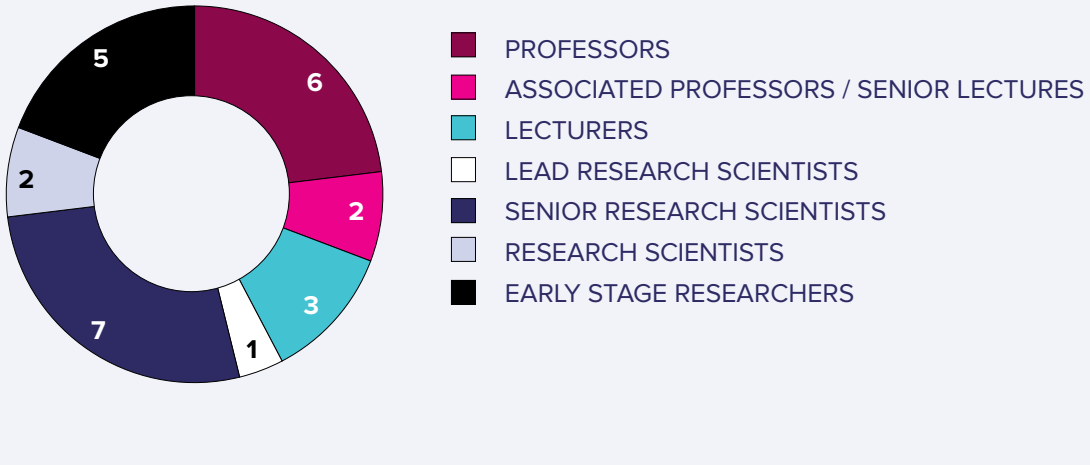
11 Doctoral students — 4 Defended doctoral dissertations

27 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 5 RESEARCH GROUPS:

- **BRAIN BIOELECTRICAL SIGNALS.**
  Head of the research group: Professor MAIE BACHMANN, maie.bachmann@taltech.ee
- **eHEALTH APPLICATIONS AND SERVICES.**
  Head of the research group: Professor PEETER ROSS, Peeter.Ross@taltech.ee
- **RESEARCH GROUP ON DIAGNOSTICS AND TREATMENT TECHNOLOGIES OF HYPERTENSION AND ATHEROSCLEROSIS.**
  Head of the research group: Professor MARGUS VIIGIMAA, margus.viigima@taltech.ee
- **RESEARCH GROUP OF e-NMR.**
  Head of the research group: Lead Researh Scientist AGO SAMOSON, ago.samoson@taltech.ee
- **SENSOR TECHNOLOGIES IN BIOMEDICAL ENGINEERING (SensorTechBME).**
  Head of the research group: Professor IVO FRIDOLIN, ivo.fridolin@taltech.ee



BRAIN BIOELECTRICAL SIGNALS RESEARCH GROUP

Head of the research group: Professor MAIE BACHMANN, maie.bachmann@taltech.ee

Members: Hiie Hinrikus, Jaanus Lass

Doctoral students: Laura Päeske, Toomas Põld, Tuuli Uudeberg

TOPICS AND COMPETENCES

KEYWORDS: signal processing, electroencephalography, brain disorders

The research group is experienced in the interdisciplinary area of information technology and brain physiology. The studies are aimed to detect and interpret the features in the brain electroencephalography (EEG) signal characteristic for mental disorder, occupational and/or environmental stressors comprising the advanced methods of signal analysis and the knowledge about brain neuronal activity. An original Spectral Asymmetry Index (SASI) has been developed and proved as a promising method in various applications.

RECENT RESULTS

- By applying EEG-based objective measures it is feasible to indicate early symptoms of depression;
- Decreased small-world organization of a brain network is compensated with increased alpha connectivity;
- Long-term temporal variability of SASI for a person is much lower than inter-individual variability, supporting the possibility of using SASI for evaluation of depression symptoms for an individual.

SELECTED PROJECTS

- TAR16013 (EXCITE) (TK148) "*Estonian Centre of Excellence in ICT Research*" (2016–2023);
- COST Action CA19127 Cognitive decline in Nephro-Neurology: European Cooperative Target (2020–2024)
- COST Action CA18106 The neural architecture of consciousness (2019–2023).

SELECTED ARTICLES

Päeske, L.; Hinrikus, H.; Lass, J.; Raik, J.; Bachmann, M. (2020). Negative Correlation Between Functional Connectivity and Small-Worldness in the Alpha Frequency Band of a Healthy Brain. Frontiers in Physiology, 11 (910). DOI: 10.3389/fphys.2020.00910.

Uudeberg, T.; Päeske, L.; Põld, T.; Lass, J.; Hinrikus, H.; Bachmann, M. (2020). Long-Term Stability of EEG Spectral Asymmetry Index – Preliminary Study. In: XV Mediterranean Conference on Medical and Biological Engineering and Computing – MEDICON 2019 (276–281). Springer. (IFMBE Proceedings; 76). DOI: 10.1007/978-3-030-31635-8_33.

eHEALTH APPLICATIONS AND SERVICES RESEARCH GROUP

Head of the research group: Professor PEETER ROSS, peeter.ross@taltech.ee

Members: Madis Tiik, Katrin Gross-Paju, Riina Hallik, Priit Kruus, Hany Gergis Moawad Mina, Kerli Metsla, Mall Maasik, Maarja Kuslapuu, Helen Staak

Doctoral students: Janek Metsallik, Markus Bertl, Kristian Juha Ismo Kankainen, Olga Vovk, Toomas Klementi, Riin Ehin

TOPICS AND COMPETENCES

KEYWORDS: digital health, eHealth, change management in health care

The core competencies of the research group are the development of IT solutions related to digitalization of health care (e-health) and research of the interoperability factors necessary for their implementation. The factors to be studied include strategies, standards, IT architecture, data statuses and databases used for large (national or regional) e-health systems. In 2020, the research team's more specific activities were related to the medical and health care digital data quality, architecture and models, evaluation and use of digital health technologies and the development of a framework for reimbursement of digital health solutions. The studies were also related to the development and research of IT solutions related to personal medicine.

Main research activities of the eMed Lab in 2020: conducting research in areas of clinical decision support systems, evaluation of digital health technologies, user behavior concerning web-based health and medical data access, and components and factors for digitizing healthcare.

The group cooperates with Kyoto University and Keio University from Japan, with several Finnish R&D institutions, with the University of Applied Sciences in Flensburg and many others. Two of the Centre's employees are World Bank consultants in the field of eHealth. There is also close co-operation with Estonian start-ups in the field of e-health, as well as with the leading hospitals – East Tallinn Central Hospital, North Estonia Medical Center, and Health Insurance Fund, TEHIK, Genome Center and several IT companies.

SELECTED PROJECTS:

- VIR17121, *BaltCityPrevention – Baltic Cities tackle lifestyle related diseases – Development of an innovative model for prevention interventions targeting public health authorities in the Baltic Sea Region* (2017–2020)
- LEP18020 (RITA1/01-42-07), "*Clinical pilot projects of personalised medicine in the precise prevention of breast cancer and cardiovascular diseases*" (2018–2020)
- LMIN18098, "*Joint Action supporting the eHealth Network*" (2018–2020)
- VA18055, International Foundation for Integrated Care (IFIC) project "*Supporting Integrated Service Provision Reform in Estonia*" (2018–2020)

RESEARCH GROUP ON DIAGNOSTICS AND TREATMENT TECHNOLOGIES OF HYPERTENSION AND ATHEROSCLEROSIS

Head of the research group: Professor MARGUS VIIGIMAA, margus.viigima@taltech.ee

Members: Kalju Meigas, Sergei Nazarenko, Kristjan Pilt

Doctoral students: Sandra Einstein, Juhan Reimand, Grete Talviste

TOPICS AND COMPETENCES

KEYWORDS: hypertension, atherosclerosis, technologies, diagnosis, treatment

Competency

- Research and development of novel technologies in cardiovascular medicine
- Development of cardiovascular medical engineering
- Clinical application of novel technologies in the field of cardiovascular medicine
- Early atherosclerosis and development of novel technologies and devices
- Hemodynamics of resistant hypertension and development of novel methods in guiding of drug treatment
- Cardiovascular risk assessment (including polygenic risk score) and management
- Diagnosis and treatment of familial hypercholesterolemia.

SELECTED ARTICLES

Nilsson P.M., Viigimaa M., Giwercman A., Cifkova R. (2020). Hypertension and Reproduction. Curr Hypertens Rep. 2020 Mar 13;22(4):29.

Viigimaa M. et al. (2020). Update of the position paper on arterial hypertension and erectile dysfunction. J Hypertens. 2020 Jul;38(7): 1220–1234.

Lotman E.M., Viigimaa M. Digital Health in Cardiology: The Estonian Perspective. Cardiology. 2020;145(1):21–26.

Zemtsovskaja G, Pilt K, Samarin A, Abina J, Meigas K, Viigimaa M. (2020). Construction of gender-specific regression models for aortic length estimation based on computed tomography images. Health and Technology 2020; 10 (3), 679–687.

RESEARCH GROUP OF e-NMR

Head of the research group: Lead Researh Scientist AGO SAMOSON, ago.samoson@taltech.ee

Members: Tiina Titma, Kalju Vanatalu, Andres Oss, Meelis Rohtmäe, Andres Reinhold

TOPICS AND COMPETENCES

KEYWORDS: micromechanics, radioengineering, technical ceramics, CAD, Alzheimer, NMR, MAS, metabolomics

NMR is a remarkably universal analytical method since essential spin interactions can be reliably calculated. The spectra allow in principle a 3D reproduction of the entire spin system and associated atoms/molecules, even a dynamics of it, given sufficient resolution and sensitivity.

The group develops NMR sensors-probeheads, notably to use the most sensitive nuclei-hydrogens, in locally viscous and solid environment.

The most critical feature is rapid sample spinning. We were the first to reach rates beyond 120 kHz, getting presently over 150 kHz, which facilitates a practical inverse detection in solid state NMR. The immediate sensitivity increase is two orders of magnitude. The technology is applied in contemporary priority areas: biomedical research and development of F-ion batteries as a safer and more potent alternative for Li-based energy storage. The related key competences comprise CAD/CAM design, RF circuit modelling, technical ceramics processing and micromachining.

In 2020 the group worked on development of NMR technologies and inhibition of fibril formation, related to preventing Alzheimer disease..

SELECTED PUBLICATIONS

Schledorn, M.; Malar, A. A.; Torosyan, A.; Penzel, S.; Klose, D.; Oss, A.; Org, M.-L.; Wang, S.; Lecoq, L.; Cadalbert, R.; Samoson, A.; Bockmann, A.; Meier, B. H. (2020). Protein NMR Spectroscopy at 150 kHz Magic-Angle Spinning Continues To Improve Resolution and Mass Sensitivity. ChemBioChem, 21 (17), 2540–2548.

Paula, C.; Wisser, D.; Rangus, M.; Schwieger, W.; Hovestadt, M.; Kriesten, M.; Vanatalu, K.; Oss, A.; Org, M.-L.; Samoson, A.; Hartmann, M. (2020). Phase Transformations in Porous Materials Studied by In Situ Solid-State NMR Spectroscopy and In Situ X-ray Diffraction. The Journal of Physical Chemistry C, 124 (35), 19136–19145.

Shin, M.-J.; Veskioja, T.; Titma, T.; Samoson, A. (2020). Kemeny-Snell Distance in Nuclear Magnetic Resonance Metabolomics. Applied Magnetic Resonance, 51 (12), 1637–1645.

SENSOR TECHNOLOGIES IN BIOMEDICAL ENGINEERING (SensorTechBME) RESEARCH GROUP

Head of the research group: Professor IVO FRIDOLIN, ivo.fridolin@taltech.ee

Members: Jürgen Arund, Jana Holmar, Merike Luman, Kristjan Pilt, Risto Tanner, Nils Fredrik Arne Uhlin, Moonika Viigimäe, Sigrid Kalle, Deniss Karai, Rain Kattai

Doctoral Students: Ardo Allik, Andrus Paats, Joosep Paats

TOPICS AND COMPETENCES

KEYWORDS: sensors, algorithms, sensor fusion, biofluid optics, uremic toxins, dialysis, on-line monitoring, spectrophotometry, spectrofluorimetry, signal processing, smart workwear, physical activity monitoring, energy consumption, fatigue monitoring, automatic speech recognition, speech-to-text applications

The main research field of the SensorTechBME team is to develop flexible and novel sensor technologies and algorithms in biomedical engineering applications:

- To estimate dialysis adequacy and quality securing end stage renal disease (ESRD) patients' care quality. The research is exploring spectrophotometrical and spectrofluorimetrical characteristics-signatures of the biofluids and performing various signal processing and analysis on those signals.
- To develop beyond the state-of-the-art applications incorporated into a smart wearable multi-sensor fusion system for generating valuable data about the workers' location, locomotion, physical activity, energy consumption and physiological status;
- For speech-to-text usage in healthcare and industry.

Professor Fridolin is a member of the international European Uremic Toxin Work Group (EUTox WG).

MAIN RESULTS

- A novel on-line multicomponent miniaturized optical sensor for monitoring removal of uremic toxins in the spent dialysate during hemodialysis was designed and validated in the European multicenter clinical study.
- A new method and device were developed for real-time physical fatigue estimation based on physiological signals and parameters.

ONGOING PROJECTS:

- TAR16013 (TK148) "*Estonian Centre of Excellence in ICT Research*" (EXCITE, 2016–2023)
- 767572 "*On-line Dialysis Sensor Phase2 (OLDIAS2)*" (2017–2019)
- "Further development and piloting of smart suit Ragnarok2.0 using Protex AS and AS Tallinna Sadam as test-fields", one partner Dept. of Healthcare Tech, CBE. Enterprise Estonia via Estonian Smart Electronics Cluster ESTRONICS (TalTech PI I. Fridolin)

SELECTED PUBLICATIONS:

Allik, A.; Pilt, K.; Karai, D.; Fridolin, I.; Leier, M.; Jervan, G. (2019). Optimization of Physical Activity Recognition for Real-Time Wearable Systems: Effect of Window Length, Sampling Frequency and Number of Features. Applied Sciences, 9 (22).

Lauri, K.; Arund, J.; Holmar, J.; Tanner, R.; Kalle, S.; Luman, M. and Fridolin, I. (2020). Removal of Urea, β2-Microglobulin, and Indoxyl Sulfate Assessed by Absorbance and Fluorescence in the Spent Dialysate During Hemodialysis. ASAIO Journal, Vol. 66, No. 6, pp 698–705.

Paats, J., Adoberg, A.; Arund, J.; Dhondt, A.; Fernström, A.; Fridolin, I.; Glorieux, G.; Leis, L.; Luman, M.; Gonzalez-Parra, E.; Perez-Gomez, V.M.; Pilt, K.; Sanchez-Ospina, D.; Segelmark, M.; Uhlin, F. and Arduan Ortiz, A. (2020). Serum Levels and Removal by Haemodialysis and Haemodiafiltration of Tryptophan-Derived Uremic Toxins in ESKD Patients. International Journal of Molecular Sciences 21(4): 1522.

THOMAS JOHANN SEEBECK DEPARTMENT OF ELECTRONICS

Director: LAUR LEMENDIK,
laur.lemendik@taltech.ee,
+372 620 2151

MAIN FIGURES 2020

(as of Dec. 31, 2020)

21 Academic staff — Incl. 4 professors, 12 researchers

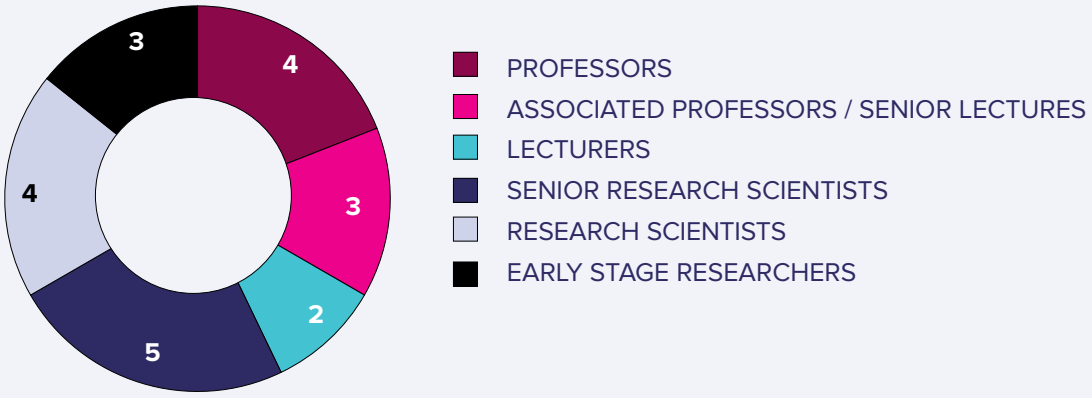
19 Doctoral students

61 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN THREE RESEARCH GROUPS:

- **RESEARCH LABORATORY FOR COGNITRONICS.**
  Head of the laboratory and research group: Professor YANNICK LE MOULLEC, yannick.lemoullec@taltech.ee
- **MEASUREMENT ELECTRONICS RESEARCH GROUP.**
  Head of the research group: Professor OLEV MÄRTENS, olev.martens@taltech.ee
- **COMMUNICATION SYSTEMS RESEARCH GROUP.**
  Head of the research group: Professor MUHAMMAD MAHTAB ALAM, muhammad.alam@taltech.ee



RESEARCH LABORATORY FOR COGNITRONICS

Head of the laboratory and research group: Professor YANNICK LE MOULLEC, yannick.lemoullec@taltech.ee

Members: Toomas Rang (until August 2020), Muhammad Mahtab Alam, Ants Koel, Tamas Pardy (until August 2020)

Doctoral students: Kaiser Pärnamets, Sikandar Muhammad Zulqarnain Khan, Rauno Jõemaa, Udayan Sunil Patankar, Haroon Rashid, Mehadi Hasan Ziko, Fariha Afrin, Kanwal Ashraf, Abdul Mujeeb

TOPICS AND COMPETENCES

KEYWORDS: energy-efficient IoT platforms, Lab-on-Chip; semiconductor electronics, smart multiscale surfaces

The research group develops methods and techniques for miniaturized actuators and sensor technologies; resource-constrained implementation of wireless connectivity technologies; transition methods for exploitation and implementation of sensors in data processing and artificial intelligence for decision-making and actuation.

The research group has accomplished the following results in 2020:

- Three events were held:
  - Low Power Wide Area Networks Technologies for Internet of Things Symposium,
  - Baltic Electronics Conference (BEC) 2020,
  - EAI BodyNets 2020.

MAJOR RESEARCH PROJECTS

- PUT1435, *Heterojunctions based on Wide Bandgap Semiconductor Materials* (2017–2020);
- Interreg BSR "*LUCIA: Lighting the Baltic Sea Region*" (2019–2021);
- PRG620, *CogniFlow-Cyte: Cognitronic Lab-on-a-Chip System for Highly-Automated Flow Cytometry* (2020–2024)

SELECTED PUBLICATIONS

Rashid, H. M.; Koel, A.; Rang, T.; Ziko, M. H. (2020). Simulation of Benzene and Hydrogen-Sulfide Gas Detector based on Single-Walled Carbon Nanotube over Intrinsic 4H-SiC Substrate. Micromachines, 11, 453–465.

Saboor, A.; Ahmad, R.; Ahmed, W.; Kiani, A. K.; Alam, M. M.; Kuusik, A.; Le Moullec, Y. (2020). Dynamic Slot Allocation using Non Overlapping Backoff Algorithm in IEEE 802.15.6 WBAN. IEEE Sensors Journal, 10862–10875.

Khan, S. Z.; Kakar, R.; Alam, M. M.; Le Moullec, Y.; Pervaiz, H. (2020). A Green IoT Node incorporating Transient Computing, Approximate Computing and Energy/Data Prediction. Proceedings of IEEE Consumer Communications & Networking Conference 2020 (CCNC 2020).

MEASUREMENT ELECTRONICS RESEARCH GROUP

Head of the research group: Professor OLEV MÄRTENS, olev.martens@taltech.ee

Members: Paul Annus, Mart Min, Jaan Ojarand, Andrei Krivošei, Raul Land, Marek Rist, Margus Metshein

Doctoral students: Robin Benjamin Ehrminger, Hip Kõiv, Ksenija Pesti, Eiko Priidel

TOPICS AND COMPETENCES

KEYWORDS: impedance spectroscopy, impedance tomography, eddy current, real-time, measurement, instrumentation

The group performs R&D of electrical impedance spectroscopy measurement solutions. This covers the developing and investigation of related instrumentation, signals and signal processing for several applications (including test and diagnostics e.g. in bio-, healthcare, medical and microfluidics areas, for metal, electronics and other industries).

The research group has accomplished the following results in 2020:

- IEEE I2MTC 2020 International Instrumentation & Measurement Technology Conference Best Paper Award for: Metshein, M.; Annus, P.; Land, R.; Rist, M.; Min, M.; Märtens, O. (2020). Correlation between electrical bioimpedance and pressure waveform in radial artery and in mechanical pulsating pipe system. Proceedings of the IEEE Instrumentation and Measurement Technology Conference (I2MTC2020): 2020 IEEE International Instrumentation & Measurement Technology Conference (I2MTC2020), 2020, Dubrovnik, Croatia, 25–28 May. Dubrovnik, Croatia: IEEE Operations Center, 1–6.
- Based on the results of the research, the following impedance-measurement related patents were granted and several applications were submitted:
  - R.Land et al, "Method and device for broadband analysis of systems and substances", US10698023 (granted 30.06.2020);
  - J.Ojarand et al, "Microfluidic method and device", EE201900007 (granted 15.12.2020);
  - J.Ojarand et al, "Microfluidic method and device", US202025681 (applied).

MAJOR RESEARCH PROJECTS

- MOBERA20, Chist-ERA Project: *JEDAI Event Driven Artificial Intelligence Hardware for Biomedical Sensors* (2019–2022);
- EAG34, *Non-invasive sensor of central aortic blood pressure waveform* (2020–2020).

SELECTED PUBLICATIONS

Ehrminger, R.; Kopanchuk, S.; Kivirand, K.; Romann, T.; Rinken, T.; Min, M.; Rinken, A. (2020). Characterizing the biofunctionalization of gold surface with total internal reflection fluorescence (TIRF) microscopy. Proceedings of the Estonian Academy of Sciences, 69 (1), 27–34.

Priidel, E.; Annus, P.; Krivošei, A.; Rist, M.; Land, R.; Min, M.; Märtens, O. (2020). Methods for detection of bioimpedance variations in resource constrained environments. Sensors, 20 (5).

COMMUNICATION SYSTEMS RESEARCH GROUP

Head of the research group: Professor MUHAMMAD MAHTAB ALAM, muhammad.alam@taltech.ee

Members: Toomas Ruuben, Alar Kuusik, Julia Berdnikova, Ivo Müürsepp, Eerik Lossmann, Priit Roosipuu

Postdoctoral researchers: Osama Mohamed Mostafa Elgarhy, Dadmehr Rahbari

Doctoral students: Ali Masood, Rida Khan, Collins Burton Mwakwata, Taavi Laadung, Marika Kulmar, Harish Kumar Singh

TOPICS AND COMPETENCES

KEYWORDS: radio resource and interference management, device to device communications, low-power communication technologies for healthcare, 5G and Beyond, NB-IoT, BAN

The group performs R&D of interference control in wireless communication: techniques and algorithms for enabling 5G new radio, but also development of 5G testbed including support to realize massive machine type communication enhanced mobile broadband services and ultra-reliable and low latency communication services and digitalization of society (i.e., smart healthcare, smart city, industrial automation 4.0), development of vertical applications and services including connectivity, mobility, end-user community.

The research group has accomplished the following results in 2020:

- In ETSI SmartBAN TR 103 711 "Work Item Title: Smart Body Area Network (SmartBAN); "Applying SmartBAN MAC (TS 103 325) for various use cases"

In 2020, the research activities were conducted in the framework of the following projects:

- PRG424, *Closed-loop communication system to support highly responsive neuromuscular assistive stimulation* (2019–2023);
- VNT18039, "*NATO-Science for Peace and Security project Public Safety Communication in the Context of Terrorist Attacks*" (2018–2021);
- VFP20045, *5th Generation connected and automated mobility cross-border EU trials* (2020–2023).

SELECTED PUBLICATIONS

Malik, H.; Alam, M. M.; Pervaiz, H.; Le Moullec, Y.; Al-Dulaimi, A.; Pärand, S.; Reggiani, L. (2019). Radio Resource Management in NB-IoT Systems: Empowered by Interference Prediction and Flexible Duplexing. IEEE Network. vol. 34, no. 1, pp. 144-151, January/February 2020

Khan, R.; Alam, M. M.; Guizani, M. (2020). A Flexible Enhanced Throughput and Reduced Overhead (FETRO) MAC Protocol for ETSI SmartBAN. IEEE Transactions on Mobile Computing.

SCHOOL OF SCIENCE

SCHOOL OF SCIENCE

Dean: Professor ANDRUS SALUPERE

e-mail: andrus.salupere@taltech.ee

Vice-Dean for Research: Professor RIINA AAV

e-mail: riina.aav@taltech.ee

MAIN FIGURES 2020

(as of Dec. 31, 2020)

205 Academic staff — Incl. 26 professors, 131 researchers

116 Doctoral students — 14 Defended doctoral dissertations

233 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

DEPARTMENTS

DEPARTMENT OF CHEMISTRY AND BIOTECHNOLOGY

Director: Professor IVAR JÄRVING, ivar.jarving@taltech.ee

DEPARTMENT OF CYBERNETICS

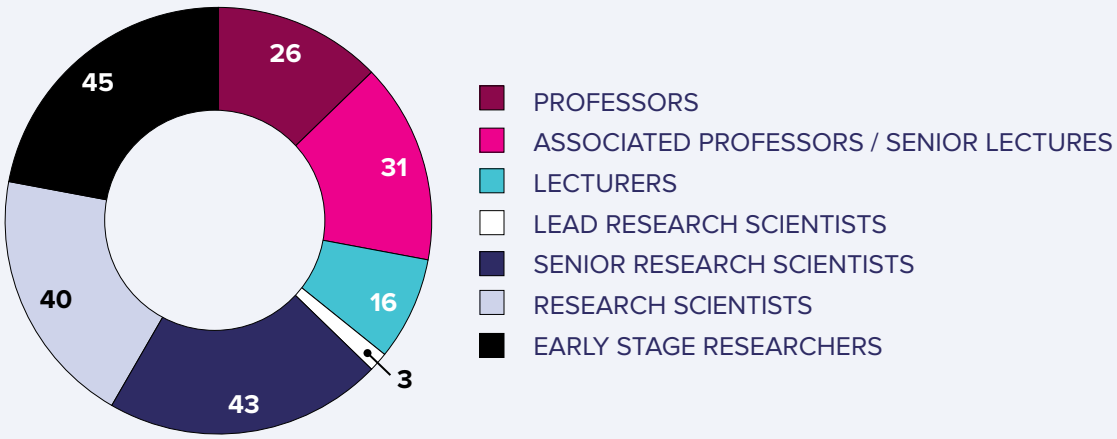
Director: Professor JAAN JANNO, jaan.janno@taltech.ee

DEPARTMENT OF GEOLOGY

Director: Professor MICHAEL WILLIAM HITCH, michael.hitch@taltech.ee

DEPARTMENT OF MARINE SYSTEMS

Director: Senior Researcher RIVO UIBOUPIN, rivo.uiboupin@taltech.ee



DEPARTMENT OF CHEMISTRY AND BIOTECHNOLOGY

Director: Professor IVAR JÄRVING,
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MAIN FIGURES 2020

(as of Dec. 31, 2020)

90 Academic staff — Incl. 10 professors, 57 researchers

80 Doctoral students — 9 Defended doctoral dissertations

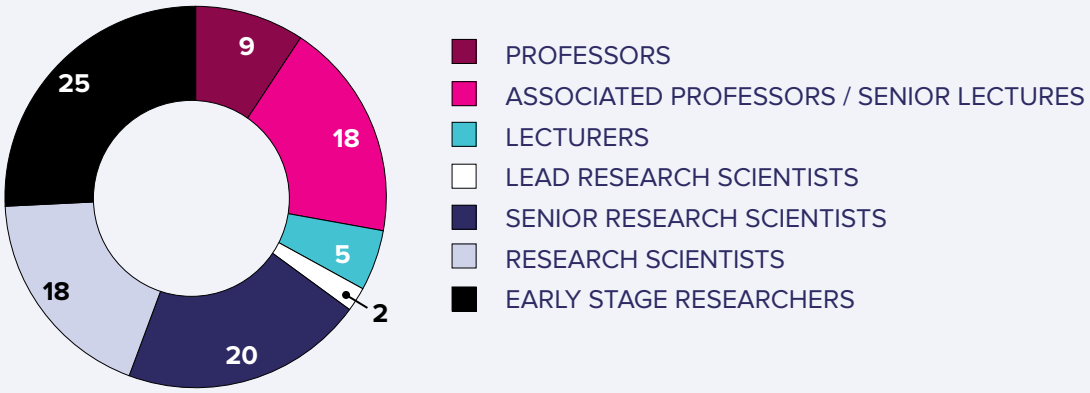
65 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN THE FOLLOWING RESEARCH GROUPS:

- **ADVANCING ANALYTICAL AND COMPUTATIONAL CHEMISTRY METHODS FOR REGULATORY DECISIONS.**
  Head: Senior Research Scientist MERIKE VAHER, merike.vaher@taltech.ee
- **APOPTOSIS OF NEURONS.**
  Head: Associated Professor URMAS ARUMÄE, urmas.arumae@taltech.ee
- **ASYMMETRIC SYNTHESIS.**
  Head: Professor MARGUS LOPP, margus.lopp@taltech.ee
- **BIOCHEMISTRY OF LIPIDS AND LIPOPROTEINS.**
  Head: Lead Research Scientist AIVAR LÕOKENE, aivar.lookene@taltech.ee
- **BIOINFORMATICS.**
  Head: Professor OLLI-PEKKA SMOLANDER, olli-pekka.smolander@taltech.ee
- **BIOMEDICINE.**
  Head: Senior Researcher PIRJO SPUUL, pirjo.spuul@taltech.ee
- **COGNITRONIC LAB-ON-A-CHIP RESEARCH GROUP.**
  Head: Senior Researcher TOOMAS RANG, toomas.rang@taltech.ee
- **COMPUTATIONAL CHEMISTRY.**
  Head: Professor TOOMAS TAMM, toomas.tamm@taltech.ee
- **FOOD SCIENCE AND TECHNOLOGY.**
  Head: Professor TOOMAS PAALME, toomas.paalme@taltech.ee
- **GENETIC AND MOLECULAR ASPECTS OF PLANT-MICROBE INTERACTIONS.**
  Head: Senior Research Scientist KADRI JÄRVE, kadri.jarve@taltech.ee
- **IMMUNOBIOLOGY OF LEUKOCYTE ACTIVATION.**
  Head: Associated Professor SIRJE RÜÜTEL-BOUDINOT, sirje.boudinot@taltech.ee
- **INTERACTIONS BETWEEN PLANT VIRUSES AND THEIR HOSTS.**
  Head: Senior Research Scientist ALLAN OLSPERT, allan.olspert@taltech.ee
- **METALLOPROTEOMICS.**
  Head: Professor PEEP PALUMAA, peep.palumaa@taltech.ee
- **MICROFLUIDICS.**
  Head: Professor OTT SCHELER, ott.scheler@taltech.ee
- **MOLECULAR NEUROBIOLOGY.**
  Head: Professor TÕNIS TIMMUSK, tonis.timmusk@taltech.ee
- **MOLECULAR TECHNOLOGY.**
  Head: Senior Research Scientist PAVEL STARKOV, pavel.starkov@taltech.ee
- **OIL SHALE CHEMISTRY.**
  Head: Professor MARGUS LOPP, margus.lopp@taltech.ee

- **PLANT-MICROBE INTERACTIONS.**
  Head: Senior Researcher MARIA CECILIA SARMIENTO GUERIN, cecilia.sarmiento@taltech.ee
- **REPLICATION RESEARCH GROUP.**
  Head: Senior Researcher Tatiana Moiseeva, tatiana.moiseeva@taltech.ee
- **RESEARCH GROUP FOR THE STUDY OF LIGNIN BIODEGRADATION.**
  Head: Senior Research Scientist TIIT LUKK, tiit.lukk@taltech.ee
- **RESEARCH GROUP OF CATALYSIS.**
  Head: Professor TÕNIS KANGER, tonis.kanger@taltech.ee
- **RESEARCH GROUP OF REPRODUCTIVE BIOLOGY.**
  Head: Associated Professor AGNE VELTHUT-MEIKAS, agne.velthut@taltech.ee
- **SUPRAMOLECULAR CHEMISTRY RESEARCH GROUP.**
  Head: Professor RIINA AAV, riina.aav@taltech.ee
- **SUSTAINABLE CHEMISTRY AND ENGINEERING.**
  Head: Senior Researcher YEVGEN KARPICHEV, yevgen.karpichev@taltech.ee



ADVANCING ANALYTICAL AND COMPUTATIONAL CHEMISTRY METHODS FOR REGULATORY DECISIONS

Head of the Research Group: Senior Research Scientist MERIKE VAHER, merike.vaher@taltech.ee

Members: Mihkel Kaljurand, Maria Kuhtinskaja, Maria Kulp, Mihkel Koel, Jekaterina Mazina, Piret Saar-Reismaa, Kristiina Leiman

Postdoctoral researcher: Martin Ruzicka

Doctoral students: Tiina Aid (Kontson), Piia Jõul, Dawit Firemichael Bebizuh (visiting doctoral student from Addis-Ababa University, Etiopia)

TOPICS AND COMPETENCES

KEYWORDS: separation methods, capillary electrophoresis, miniaturization, phytochemicals, antioxidativity, biomass, ionic liquids, deep eutectic solvents, banned chemicals

The members of the group have competence in development of analytical methods and procedures and use of these in analysis of different compounds and mixtures in complicated matrices. The group has good specialists in separation methods: gas and liquid chromatography and especially in capillary electrophoresis where they use a wide variety of detectors: electrical, optical and mass spectrometrical. The group has also competence and means for supercritical extraction for a wide range of extraction parameters. The group has provided recognised results on development of porous materials – aerogels and these have been taken into use as adsorbents in analytical separation and catalysts in electrochemistry and water purification.

The aim of the present research is development and application of a variety of analytical methodologies (primarily capillary electrophoresis) for analysis of different classes of compounds (banned chemicals, drugs, polyphenols, fermentable sugars) in complex matrixes such as environmental samples, body fluids, biomass and herbal extracts. The results obtained will be used to develop an expert system using quantitative structure-activity relationship (QSAR).

Miniaturization of capillary electrophoresis apparatus is an important feature, which provides an opportunity to perform on-site analyzes.

Most important part of the research was connected to the development and evaluation of an automatic portable capillary electrophoresis instrument, prototype II of Narcotester (DrugHunter). The CE system was coupled to UVC fluorescence detector providing 225–255 nm exitation wavelenght range for the determination of the abuse of illegal drugs in oral fluid in situ. This portable Narcotester was employed for determination of natively fluorescensing drugs, such as cocaine, cocaethylene, seven amphetamines, fentanyl, LSD, tetrahydrocannabinol and

cannabidiol. Based on this portable apparatus, several electrophoretic methodologies were developed, validated and successfully utilized for the determination of illegal abuse of drugs during music festivals in Estonia and Latvia.

SELECTED PUBLICATIONS:

P. Saar-Reismaa, C-A. Brilla, K. Leiman, M. Kaljurand, M. Vaher, M. Kulp, J. Mazina-Šinkar (2020). Use of a newly-developed analyser to detect drugs of abuse in oral fluid: a case study. Talanta, 211

P. Saar-Reismaa, A. Tretjakova, J. Mazina-Šinkar, M. Vaher, M. Kaljurand, M. Kulp (2019). Rapid and Sensitive Capillary Electrophoresis Method for the Analysis of Ecstasy in an Oral Fluid, Talanta, 197, 390–396.

J. Bolobajev, M. Kask, K. Kreek, M. Kulp, M. Koel, A. Goi (2019). Metal-doped organic aerogels for photocatalytic degradation of trimethoprim. Chemical Engineering Journal, 357, 120–128.

APOPTOSIS OF NEURONS

Head of the Research Group: Associate Professor URMAS ARUMÄE, urmas.arumae@taltech.ee

Member: Jaan Palgi

Doctoral student: Valentina Božok

TOPICS AND COMPETENCES

KEYWORDS: apoptosis, neurotrophic factors, neurons

Our group studies the mechanisms of apoptosis and survival, as well as the control of these processes by neurotrophic factors, on the neurons, but also other cells. Our main research topic, in collaboration with the Institute of Biotechnology, University of Helsinki, is the mechanism of action of neurotrophic factors MANF and CDNF. These factors have neurorestorative activity in the animal models of Parkinson's disease, as they repair the neurological damages and restore the lost motility in the experimental animals, being thus currently the best candidates for the treatment of Parkinson's disease. The mechanism of action of these factors is, however, poorly understood. We described earlier a CXXC motif of MANF that is functionally critical for its anti-apoptotic activity, as mutation of this motif inactivates MANF protein functionally. We have also shown that the CXXC tetrapeptide has anti-apoptotic activity of its own. In 2020 we focused on the role of CXXC motif in the development of Drosophila, using the fly lines where this motif is mutated.

Another research topic concerns the neonatal sympathetic neurons that are in the developmental stage of programmed cell death and require a neurotrophic factor NGF to survive. From our earlier microarray study we have selected several genes of interest whose expression changes during the development of these neurons. We focused on the role of these genes in the apoptotic program as well as its repression by neurotrophic factors in the neurons. To that end, we are able to culture several types of primary neurons (sympathetic, sensory, cortical, hippocampal etc.), but also the cell lines (Jurkat, HEK, HeLa etc.). On these cells we perform apoptotic and survival assays, inducing apoptosis and blocking it by several ways, and estimating the amount of survived / dead cells. We are able to manipulate the primary neurons experimentally, overexpressing or silencing the genes of interest via lentiviral vectors. We can study the cultures using a variety of microscopic, biochemical as well as molecular biological techniques.

MAIN RECENT RESULTS:

- We have found a functional motif in the molecule of neurotrophic factor MANF that is responsible for its anti-apoptotic activity, and described its mechanism of action (Mätlik et al, Cell Death Dis31;6:e2032; Bozok et al, Front Cell Dev Biol. 2018;6:106).

SELECTED ARTICLES:

Božok, V.; Palgi, J.; Yu, L.; Arumäe, U. (2018). Antioxidative CXXC Peptide Motif From Mesencephalic Astrocyte-Derived Neurotrophic Factor Antagonizes Programmed Cell Death. Frontiers in Cell and Developmental Biology. 04 September 2018.

ASYMMETRIC SYNTHESIS

Head of the Research Group: Professor MARGUS LOPP, margus.lopp@taltech.ee

Members: Anne Paju, Marek Kõllo, Aleksander-Mati Müürisepp

Doctoral students: Anni Larin, Eleana Lopušanskaja

TOPICS AND COMPETENCES

KEYWORDS: asymmetric chemical analysis and catalysis, synthesis of bioactive and nature compounds

The research is closely related to the topic of the Center of Excellence in Molecular Cell Technology (CEMCE).

The research is mainly focused on the following topics:

- *Selective alkylation of phenols*. In order to extend the limits of electrophilic C-alkylation and to find ways for chemo-, regio- and stereo-selective reactions of phenolates, alkylation of Li phenolates with active halides in water solution was studied. It was found that unsubstituted phenol reveals moderate reactivity with unsatisfactory o/p and C/O-alkylation selectivity yielding o-alkylated product in 46% yield. Substituted phenols have different activity and regioselectivity, depending on the substituents and their bulkiness. Selectivity was increased by carrying out the reaction in toluene, generating the Li-phenolates with n-BuLi. In the case of tri-substituted phenols dearomatization occurs leading to enones. The reaction is catalysed by ethers and alcohols.
- *Selective alkylation of naphthols*. It was found that naphthols undergo selective reaction with alkyl halides in toluene, yielding ortho-C-alkylation product. The reaction results in chiral substituted naphthalenones. These substances are a useful starting material for the synthesis of various natural products and bioactive compounds. The obtained results are a good basis for further development of the asymmetric alkylation method to obtain enantiomeric substituted naphthalenones.
- *Synthesis of 9,11-secosterols*. The 9,11 diol precursors for secosterols were synthesized from natural sterols, using biotransformation by genetically modified whole cells, followed by chemical oxidation of the obtained 9,11 diols. The developed method provides a simple and convenient access to secosterol skeleton only in two steps under mild reaction conditions. The method is environmentally friendly.

- *New advances of cyclopropane chemistry*. A review of publications of the last 30 years on enantioselective reactions of chiral Ti-cyclopropane reagents was published. It reflexed the achievements of the researchers turning the attention on reaction mechanisms, on theoretical breakthroughs and on unsolved problems.

SELECTED PUBLICATION

Zubrytski, D. M.; Elek, G. Z.; Lopp, M.; Kananovich, D. G. (2020). *Generation of Mixed Anhydrides via Oxidative Fragmentation of Tertiary Cyclopropanols with Phenyliodine(III) Dicarboxylates*. *Molecules, 26 (1)*

BIOCHEMISTRY OF LIPIDS AND LIPOPROTEINS

Head of the Research Group: Lead Research Scientist AIVAR LÕOKENE, aivar.lookene@taltech.ee

Members: Ly Villo, Ivar Järving, Nigulas Samel, Helike Lõhelaid, Priit Eek, Kaia Kukk, Mart Reimund, Tarvi Teder

Doctoral student: Robert Risti

TOPICS AND COMPETENCES

KEYWORDS: mechanisms of lipid and lipoprotein metabolism regulation, biomolecular interactions, lipases, lipid analysis

Lipids have shown to play many dynamic roles The main topic of the research group is related to the identification of fundamental aspects of lipid and lipoprotein metabolism. The main focus of the study is on the mechanisms of regulation of lipases and lipoxygenases. We have competence and experience in the study of the structure and properties of proteins, in the analysis of biomolecular interactions, in enzymology and in the analysis of lipids. In our research we use mass spectrometry, chromatography, calorimetry, surface plasmon resonance and technologies based on fluorescence measurements.

The research is supported by IUT19-9 "*Structural and regulatory aspects of lipid and lipoprotein metabolism*".

SELECTED ARTICLES

Rump, A.; Risti, R.; Kristal M.-L.; Reut, J.; Syritski, V.; Lõokene, A., Rüütel Boudinot, S. (2021). Dual ELISA using SARS-CoV-2 N protein produced in E. coli and CHO cells reveals epitope masking by N-glycosylation. Biochemical and Biophysical Research Communications, 534, 457–460.

Villo, Ly; Risti, Robert; Reimund, Mart; Kukk, Kaia; Samel, Nigulas; Lõokene, Aivar (2020). Calorimetric approach for comparison of Angiopoietin-like protein 4 with other pancreatic lipase inhibitors. Biochimica et Biophysica Acta (BBA) – Molecular and Cell Biology of Lipids, 1865 (2), UNSP 158553.

Bhadoria, R.; Ping, K.; Lohk, C.; Järving, I.; Starkov, P. (2020). A phenotypic approach to probing cellular outcomes using heterobivalent constructs. Chemical Communications, 4216–4219.

BIOINFORMATICS GROUP

Head of the Research Group: Professor OLLI-PEKKA SMOLANDER, olli-pekka.smolander@taltech.ee

Members

Post-doctoral Researcher: Maria Bouvy-Liivrand

Doctoral student: Immanuel Sanka, Airi Rump

TOPICS AND COMPETENCES

KEYWORDS: bioinformatics, computational biology, genomics, transcriptomics, data integration

Bioinformatics and computational methods in biology allow analysis of large scale data and modeling of biological phenomena by combining the biosciences, statistics, applied mathematics, physics and computer science. By using these methods, it is possible to discover new knowledge on how the biological systems function at different levels, ranging from single genes and cells to whole organisms and their interactions.

The group's research has wide applications in biotechnology and biomedicine, particularly in plant and microbial biotechnology and disease genomics.

The group is currently leading research efforts in the following topics:

- Computational genomics and data integration in the life sciences at genome scale (TalTech development program 2016–2022)
- *Identification of genomic factors affecting wood formation with a genomics approach* (PSG318).

SELECTED PUBLICATIONS

Rooda, I.; Hasan, M. M.; Roos, K.; Viil, J.; Andronowska, A.; Smolander, O. P.; Jaakma, Ü.; Salumets, A.; Fazeli, A.; Velthut-Meikas, A. (2020). Cellular, extracellular and extracellular vesicular miRNA profiles of pre-ovulatory follicles indicate signaling disturbances in polycystic ovaries. International Journal of Molecular Sciences, 21 (24), 1–23.

Scheler, O.; Makuch, K.; Debski, P. R; Horka, M.; Ruszczak, A.; Pacocha, N.; Sozański, K.; Smolander, O.-P.; Postek, W.; Garstecki, P. (2020). Droplet-based digital antibiotic susceptibility screen reveals single-cell clonal heteroresistance in an isogenic bacterial population. Scientific Reports, 10 (1), 3282–3282.

Alonso-Serra, J.; Shi, X.; Peaucelle, A.; Rastas, P.; Bourdon, M.; Immanen, J.; Takahashi, J.; Koivula, H.; Eswaran, G.; Muranen, S.; Help, H.; Smolander, O.-P.; Su, C.; Safronov, O.; Gerber, L.; Salojarvi, J.; Hagqvist, R.; Mahonen, A. P.; Helariutta, Y.; Nieminen, K. (2020). ELIMAKI Locus Is Required for Vertical Proprioceptive Response in Birch Trees. Current Biology, 30 (4), 589–599.

Teppo, J.; Vaikkinen, A.; Stratoulias, V.; Mätlik, K.; Anttila, J. E; Smolander, O.-P.; Pöhö, P.; Harvey, B. K; Kostiainen, R.; Airavaara, M. (2020). Molecular profile of the rat peri-infarct region four days after stroke: Study with MANF. Experimental Neurology, 113288–113288.

BIOMEDICINE

Head of the Research Group: Senior Researcher PIRJO SPUUL, pirjo.spuul@taltech.ee

Members, doctoral students: Olga Smirnova, Kaisa Roots, Sadia Khalid

TOPICS AND COMPETENCES

KEYWORDS: Helicobacter pylori, invadosomes, liver damage, actin cytoskeleton

The main research topic of the team is *Helicobacter pylori* (HP)-induced liver damages. HP is a gram-negative bacterium that colonizes the human gastric epithelium in about half of the world´s population. HP infection is usually acquired during early childhood and the immune system is not able to clear the bacteria. In Estonia, around 80% of the people are infected. HP has been classified as class-I carcinogen by the World Health Organization as approximately 1% of infected individuals develop gastric adenocarcinoma. Several studies have associated HP infection with the progression of liver cirrhosis and hepatocellular carcinoma. Additionally, coinfection with hepatitis C virus seems to enhance the severity of liver pathology. However, the mechanisms by which HP causes liver damage and promotes carcinogenesis remain largely unknown.

Pathogens have developed a wide repertoire of strategies to exploit host cell functions for their own benefit, leading to the development of severe diseases, including cancer. HP induces the formation of peculiar cellular structures named invadosomes in infected hepatocytes. The goal of our research is to explore the role of invadosomes induced by HP infection in liver damage. Our preliminary results show that different strains, with distinct pathogenic outcomes, induce invadosomes with distinctive features. The specific aim is to identify the virulence factors that govern invadosomes specificities, then to correlate these findings with the subversion of the host cell functions.

The results are expected to increase our understanding of the mechanisms behind bacteria-induced carcinogenesis. Revealing the cellular functions targeted by HP and correlating these findings with the induction of differential invadosomes should help to get new insights into liver diseases. The research explores a novel aspect of HP infection as it has a particular focus on matrix damages and associated alterations of HP-infected hepatocyte micro-environment caused by the newly discovered invadosomes. Targeting the host signal transduction pathways and key players in carcinogenesis is the first step for the development of novel drugs with reduced risks for emergence of drug resistance.

SELECTED PROJECT:

- PUT1130, "*Role of Helicobacter pylori-induced invadosomes in liver damages*" (2020–2021)

- VNF20013 "*Alteration of gut microbiota by Helicobacter pylori leading to the progression of liver diseases. Pilot study*" (2020–2021)

SELECTED ARTICLES:

Alonso F, Spuul P, Decossas M, Egaña I, Curado F, Fremaux I, Daubon T, Génot E. (2020). Regulation of podosome formation in aortic endothelial cells vessels by physiological extracellular cues. European Journal of Cell Biology, 99 (4), 151084.

Alonso F, Spuul P, Genot E. (2020). Podosomes in endothelial cell-microenvironment interactions. Curr Op hematol. 27(3), 197–205.

Chi P.-Y., Spuul P., Tseng F.-G, Genot E., Chou C.-F., Taloni A. (2019). Cell Migration in Microfluidic Devices: Invadosomes Formation in Confined Environments. In: C. A. M. La Porta, S. Zapperi (Ed.). Cell Migrations: Causes and Functions (79–103). Springer. (Advances in Experimental Medicine and Biology; 1146).

Alonso F., Spuul P., Daubon T., Kramer I., Génot E. (2019). Variations on the theme of podosomes: A matter of context. Biochimica et Biophysica Acta – Molecular Cell Research, 1866 (4), 545–553.10.1016/j.bbamcr.2018.12.009

COGNITRONIC LAB-ON-A-CHIP RESEARCH GROUP

Head of the Research Group: Senior Researcher TOOMAS RANG, toomas.rang@taltech.ee

Members: Tamas Pardy, Ott Scheler, Ants Koel, Raul Land, Yannick Le Moullec, Andres Udal

Doctoral students: Fariha Afrin, Rauno Jõemaa, Kaiser Pärnamets, Muhammad Haroon Rashid, Udayan Sunil Patankar, Mehadi Hasan Ziko, Kanwal Ashraf, Nafisat Gyimah

TOPICS AND COMPETENCES

Keywords: Lab-on-Chip; semiconductor electronics; multiscale surfaces; microflow and -pumping; droplet sizing of the liquids in microscale solutions; optical sensors and actuators; collecting, processing and communication of gathered information about patterns of images; random- and approximation calculus; application of low energy consumption in IoT platforms

THE GROUP STARTED ITS ACTIVITIES AT THE BEGINNING OF 2020.

The goal of the R&D activity is to create the proof of concept of and develop the methodology for low-cost, fully portable flow cytometers based on droplet microfluidics, which will not only allow field analysis of bacteria, but will have a single-cell resolution. Furthermore, through cognitive electronics, the system will be easy to use and fully automated from sample input to result output.

SELECTED RESULTS IN 2020:

- A review was performed on electronic actuation technology options and microchannel geometries have been searched. The CFD simulations and droplet generation experiments were conducted in parallel to optimize channel geometries and determine maximum flow rates.
- Using different manufacturing technologies, a novel droplet generator together with the supporting environment was developed using both 3D printing and the PGMS lithography. The research group of Tallinn University of Technology worked together with the researchers from the Department of Electron Devices at the Budapest University of Technology and Economics.
- For the image processing algorithms, the judgement approaches were initiated for ability to detect the patterns of droplets. This action gave the possibility to define the preliminary configuration of a communication channel. Also, the optimal version of the controller's process for signal/image processing was estimated.
- During the experiments the best setup of the exiting source and receptor configuration for optical pattern detection application was searched.
- Using the achieved processing ability, the patterns of droplets with red-blood cells were searched and the information flow formation was predicted. The detection of microbeads and bacteria was checked in the droplet system as well.

SELECTED PROJECT

- PRG620, *CogniFlow-Cyte: Cognitronic Lab-on-a-Chip System for Highly-Automated Flow Cytometry* (2020–2024)

COMPUTATIONAL CHEMISTRY

Head of the Research Group: Professor TOOMAS TAMM, toomas.tamm@taltech.ee

Members: Andre Lomaka, Kaie Laane

Doctoral students: Aleksandra Zahharova, Hanna-Eliisa Luts

TOPICS AND COMPETENCES

KEYWORDS: computational chemistry, density functional theory, force fields, machine learning, cucurbiturils

Research in the Computational Chemistry Research Group is focused on the study of reaction mechanisms and weak (host-guest) interactions utilizing modern electronic structure methods (ab initio, DFT). We have competence in modelling of both organic and organometallic reaction complexes as well as weakly bound systems. We use quantum-chemistry software such as Gaussian, Turbomole and Orca. Besides small in-house computational facilities we have access to the ETAIS research computing infrastructure, a part of which is located on TalTech campus.

Research in recent years has been focused on the development of force field and machine learning based approaches for description of inorganic compounds. A highly accurate model utilizing moment tensor potentials was developed for modeling interactions between water molecules. Efforts towards a polynomial-based machine learning model for organic solvents is underway. In parallel we are studying the possibilities for describing conformations of metal hydroxides and intramolecular interactions.

In a side project we are searching for stable forms of novel nonmetal hydrides with potential applications in the development of systems with high energy content.

RESEARCH GROUP OF FOOD SCIENCE AND TECHNOLOGY

Head of the Research Group: Professor TOOMAS PAALME, toomas.paalme@taltech.ee

Members: Katrin Laos, Anna Traksmaa, Kristel Vene, Ildar Nisamedtinov, Inga Sarand, Tagli Pitsi, Tiina Lõugas, Kaarel Adamberg, Signe Adamberg

Doctoral students: Kristi Kõrge, Julia Rosend, Anastassia Taivosalo, Evelin Kivima, Lachinkhanim Huseynli, Luhila Õnnela, Berg Hidde, Madis Jaagura, Tiina Klesment, Grete Raba, Anna Angerjas

TOPICS AND COMPETENCES

KEYWORDS: food, nutrition, food microbes, food technology, food physics, fermentation, food analysis, gut microbiota, culture technologies

The objectives of the research are: (1) to promote the healthy eating of the population through research, development, education and to increase the availability of tastier-healthier foods and beverages; (2) to increase the availability of better tasting and health promoting foods and beverages; (3) to analyze the food processing chain starting from raw food and ending with digestion in human gut; (4) to maintain the core research methods and experts in the field to support the food producers in development and problem-solving issues.

For research and development a wide set of comprehensive experimental methods of food research is used. Sensory methods, incl. SPME-GC/MS-olfactometry, are used for quantitative flavor analysis and category appraisal. Biological (incl. DNA) methods are used in the studies of microbial consortia in food, industry, human GIT and other food systems. Novel cultivation methods (incl. change-stat) are used for culture characterization and optimization of microbial production. Modern methods of instrumental analysis, incl. HPLC, GC, UPLC-MS(/MS), are used for food and process characterization. To improve quantification, internal standards, incl. isotope labeling, are applied. Changes in food microstructure are measured by light- and polarization microscopy, fluidity by viscometer and mechanical properties with texture analyzer. Food systems are analyzed by using statistical and modelling methods.

MAIN RESEARCH ITEMS:

- Impact of human nutrition on gut microbiota, metabolism and health.
- Nutrient's circulation in food systems.
- Food sensory and instrumental analysis.
- Peptides as a source of amino acids in fermentation.
- Microbial consortia in food.
- Food quality and structure.

SELECTED ARTICLES:

Adamberg, K.; Jaagura, M.; Aaspõllu, A.; Nurk, E.; Adamberg, S. (2020). The composition of faecal microbiota is related to the amount and variety of dietary fibres. International Journal of Food Sciences and Nutrition.

Rosend, J.; Kaleda, A.; Kuldjärv, R.; Arju, G.; Nisamedtinov, I. (2020). The effect of apple juice clarification and concentration on cider fermentation and properties of the final product. Foods, 9, 1401. DOI: 10.3390/foods9101401.

Berg, G.; Rybakova, D.; Fischer, D.; Cernava, T.; Champomier-Vergès, M.-C.; Charles, T.; Chen, X.; Cocolin, L.; Eversole, K.; Herrero-Corra, G.; Kazou, M.; Kinke, L.; Lange, L.; Lima, N.; Loy, A.; Macklin, J. A.; Maguin, E.; Mauchline, T.; McClure, R.; Mitte, B. .Sarand, I.; ... Schloter, M. (2020). Microbiome definition re-visited: old concepts and new challenges. Microbiome, 8, 103.

Friedenthal, M.; Eha, K.; Kaleda, A.; Part, N.; Laos, K. (2020) Instability of low-moisture carrageenans as affected by water vapor sorption at moderate storage temperatures. SN Applied Sciences, 2 (2), no 243.

GENETIC AND MOLECULAR ASPECTS OF PLANT-MICROBE INTERACTIONS

Head of the Research Group: Senior Researcher KADRI JÄRVE, kadri.jarve@taltech.ee

Members: Irena Jakobson, Hilma Peusha, Galina Sokolova

TOPICS AND COMPETENCES

KEYWORDS: genotyping, pre-breeding

We study resistance to fungal diseases in spring and winter wheat. In a multi-annual project we are finalising identification of a novel gene for resistance to powdery mildew in a spring wheat line carrying introgressions from *Triticum militinae*. A line carrying *Triticum militinae* introgression is now being tested as a new spring wheat variety.

In 2020, we have generated several spring and winter wheat lines showing improved agronomic traits (yield, earliness, resistance to several fungal diseases).

SELECTED PROJECT

- RP14037, *Collection and Conservation of Plant Genetic Resources in 2014–2020* (2014–2020)

SELECTED PUBLICATION

Runno-Paurson, E.; Tähtjärv, T.; Tõnismann, K.; Peusha, H.; Tsahkna, A.; Jakobson, I.; Kotkas, K.; Järve, K.; Koppel, M. (2019). Foliar resistance to the late blight pathogen Phytophthora infestans (Mont.) de Bary in a backcross of potato (Solanum tuberosum L.) cultivar Ando. Acta Agriculturæ Scandinavica, Section B – Soil & Plant Science, 69, 7, 631–640.

IMMUNOBIOLOGY OF LEUKOCYTE ACTIVATION

Head of the Research Group: Associated Professor SIRJE RÜÜTEL BOUDINOT, sirje.ruutel@taltech.ee

Members: Viiu Paalme, Mai-Ly Kristal

Doctoral students: Airi Rump, Kadri Orro

TOPICS AND COMPETENCES

KEYWORDS: immune regulation, leukocyte activation, RGS16, P2X4, P2X7, Multiple Sclerosis, melanoma, eosinophils, COVID19

The group focuses on the biology of leukocyte activation and its regulation. The control of leukocyte activation is of paramount importance for health, both at the steady state and during the immune response, to warrant the resilience of the immune system. Dysfunctions of these critical mechanisms lead to auto-inflammatory and auto-immune diseases, and also strongly affect the defense against pathogens.

We have selected two families of regulators of which the immune regulatory functions remain poorly understood, the RGS (Regulator of G protein Signalling; main target RGS16) and the purinergic receptors (P2X main targets p2x4 and p2x7). We studied control mechanisms of leukocyte activation mediated by these genes in the context of two pathologies: multiple sclerosis and melanoma. Using a combination of *in vitro* and *in vivo* (KO mice) models, we performed gain and loss of function experiments to characterize regulatory mechanisms mediated by our genes of interest. We will also determine how modulating P2X4 receptor activity could affect the development of pro- versus anti-inflammatory phenotype of leukocytes (especially in eosinophils) during viral infection and cancer models. We also followed comparative approaches to understand the importance of these genes in the context of the evolution of the immune system.

SELECTED PROJECT

- COVSG34, *Novel diagnostic tools for detection of SARS-CoV-2 infection for clinical and point-of-care use* (2020–2021)

SELECTED PUBLICATIONS:

Rump, A.; Smolander, O.-P.; Rüütel Boudinot, S.; Kanellopoulos, J. M; Boudinot, P. (2020). Evolutionary origin of the P2X7 C-ter region: capture of an ancient ballast domain by a P2X4-like gene in ancient jawed vertebrates. Frontiers in Immunology, 11, 113–113.

Paalme, V.; Rump, A.; Mädo, K.; Teras, M.; Truumees, B.; Aitai, H.; Ratas, K.; Bourge, M.; Chiang, C.-S.; Ghalali, A.; Tordjmann, T.; Teras, J.; Boudinot, P.; Kanellopoulos, J.; Rüütel Boudinot, S. (2019). Human peripheral blood eosinophils express high level of the purinergic receptor P2X4. Frontiers in Immunology (published online 06 September 2019).

Teras, J.; Kroon, H. M.; Thompson, J. F.; Teras, M.; Pata, P.; Mägi, A.; Teras, R. M.; Rüütel Boudinot, S. (2019). First Eastern European Experience of Isolated Limb Infusion for In-Transit Metastatic Melanoma Confined to the Limb: Is it still an Effective Treatment Option in the Modern Era? European Journal of Surgical Oncology.

INTERACTION BETWEEN PLANT VIRUSES AND THEIR HOSTS

Head of the Research Group: Senior Research Scientist ALLAN OLSPERT, allan.olspert@taltech.ee

Member: Kairi Kärblane

TOPICS AND COMPETENCES

KEYWORDS: plant viruses, transcriptional slippage, host-pathogen interactions

The research group is engaged in investigating the interaction between plant viruses and their hosts. The research is focused on positive-strand RNA virus family Potyviridae. These viruses utilize the mechanism of transcriptional slippage for gene expression. Transcriptional slippage produces "edited" RNAs with an additional nucleotide at a specific location in RNA and with different coding capacity. These transcripts are also potentially subjects of alternative RNA decay pathways and are excluded from replication by viral polymerase. There may also be differences in the rates of translation and packaging in comparison to unaltered RNAs. In addition, we aim to further characterize the details of potyvirus replication and to elucidate if host RNA surveillance pathways have a significant role in maintaining the desired level of gene expression resulting from slippage. This will also increase our knowledge about RNA decay mechanisms in plant cells in general, and the potential viral modulators of these pathways.

The research may have an impact beyond agriculture and plant science, as a number of medically important human pathogens such as measles, mumps, and Ebola virus also utilize transcriptional slippage. Therefore, in-depth understanding of viral polymerase slippage, polymerase error rates, frequencies and destinations of modified genomes may improve our understanding of and ability to fight against viral diseases in general.

SELECTED PROJECT:

- PUT 1499, "*Differential routes of RNA sub-populations in virus infections*" (2017–2020)

SELECTED PUBLICATION

Stewart, H.; Olspert, A.; Butt, B. G; Firth, A. E (2019). Propensity of a picornavirus polymerase to slip on potyvirus-derived transcriptional slippage sites. The Journal of general virology, 100, 199–205.

METALLOPROTEOMICS

Head of the Research Group: Professor PEEP PALUMAA, peep.palumaa@taltech.ee

Members: Vello Tõugu, Julia Smirnova, Andra Noormägi, Merlin Sardis

Doctoral students: Kristel Metsla, Ekaterina Kabin, Katarina Laks, Sigrid Kirss, Elina Berntsson

TOPICS AND COMPETENCES

KEYWORDS: biometals, zinc, copper, Alzheimer's disease, Wilson's disease

The Research Group of Metalloproteomics is focused on the following topics: (1) structural and functional studies of metalloproteins participating in homeostasis of biometals: zinc, copper and iron by methods like NMR, ESI MS, ICP MS, fluorescence ja UV-VIS spectroscopy; (2) the role of biometals: zinc, copper and iron on fibrillization as well as on *in vitro* and *in vivo* toxicity of amyloigogenic peptides linked with Alzheimer's disease; (3) design of new metal-chelating ligands and elaboration of metal-chelating therapeutic strategies for Wilsons and Alzheimer's disease.

Professor Palumaa is a member of the European Molecular Biology Organization (EMBO).

The most important achievements of the research group during last years:

- studying the effect of chemical modification of histidines in amyloid peptides on peptide fibrillation and
- determining the Cu (II) affinities of copper proteins in the blood, which allowed the calculation of copper equilibria in the blood.

SELECTED PUBLICATIONS

Friedemann M., Tõugu V., Palumaa P. (2020). Copper(II) partially protects three histidine residues and the N-terminus of amyloid-beta peptide from diethyl pyrocarbonate (DEPC) modification. FEBS Open Bio. 10(6), 1072–1081.

Kirsipuu T, Zadorožnaja A., Smirnova, J., Friedemann M., Plitz T., Tõugu V., Palumaa P. (2020). Copper(II)-.binding equilibria in human blood. Scientific Reports. 2020, 10 (1), #5686.

MICROFLUIDICS GROUP

Head of the Research Group: Professor OTT SCHELER, ott.scheler@taltech.ee

Members: Jelena Gorbatšova, Pille Pata, Toomas Teekivi

Postdoctoral researcher: Simona Bartkova

Doctoral students: Immanuel Sanka

TOPICS AND COMPETENCES

KEYWORDS: microfluidics, droplet microfluidics, digital microfluidics, antibiotic resistance, microbiology, analytics

Microfluidics enables conducting of biological and chemical experiments in very small volumes of fluids. In basic and applied research, the volumes used in experiments usually range from 1 litre to 1 microlitre. Microfluidic devices allow automating, controlling, and performing tests using even smaller volumes. Manufacturing of microfluidic devices is multidisciplinary, including the fields of mechanics, IT, engineering, material science, chemistry, and many others.

We currently pursue research in the following fields:

- "general development of novel microfluidic methods in chemistry and biology (TalTech development program 2016–2022", code 2014–2020.4.01.16-0032),
- *Droplet microfluidic platform for studying aspects of population heterogeneity in bacteria at single cell level* (MOBTP109)
- *Elucidating the heavy metal-induced hetero- and collateral resistance in bacteria to antibiotics at the single-cell genomic, transcriptomic and phenotypic levels* (MOBJD556)

The research group participates in the COST network action CA18113 "Understanding and exploiting the impacts of low pH on microorganisms".

SELECTED PUBLICATIONS

Bartkova, S.; Vendelin, M.; Sanka, I.; Pata, P.; Scheler, O. (2020). Droplet image analysis with user-friendly freeware CellProfiler. Analytical Methods, 12 (17), 2287–2294.

Scheler, O.; Makuch, K.; Debski, P. R; Horka, M.; Ruszczak, A.; Pacocha, N.; Sozański, K.; Smolander, O.-P.; Postek, W.; Garstecki, P. (2020). Droplet-based digital antibiotic susceptibility screen reveals single-cell clonal heteroresistance in an isogenic bacterial population. Scientific Reports, 10 (1), 3282–3282.

Lund, P. A.; De Biase, D.; Liran, O.; Scheler, O.; Mira, N. P.; Cetecioglu, Z.; Fernandez, E. N.; Bover-Cid, S.; Hall, R.; Sauer, M.; O'Byrne, C. (2020). Understanding How Microorganisms Respond to Acid pH Is Central to Their Control and Successful Exploitation. Frontiers in Microbiology, 11, #556140.

MOLECULAR NEUROBIOLOGY RESEARCH GROUP

Head of the Research Group: Professor TÕNIS TIMMUSK, tonis.timmusk@taltech.ee

Members in post-doctoral leave: Kaia Palm, Andres Veske Mari Sepp, Hanna Vihma, Indrek Koppel

Doctoral students: Kaja Nurm, Kati Taal, Jürgen Tuvikene, Laura Tamberg, Helle Sadam, Alex Sirp, Eli-Eelika Esvald, Mariliis Jaago, Annela Avarlaid, Annika Rähni, Anastassia Šubina

TOPICS AND COMPETENCES

KEYWORDS: neurotrophins, BDNF, bHLH transcription factors, TCF4/E2-2, neuronal activity-regulated transcription, Pitt-Hopkins syndrome, schizophrenia, neurodegenerative disorders

Our studies focus on the molecular mechanisms of gene expression, including transcription, mRNA and protein subcellular localization, translation, posttranslational modifications, and signaling, in the nervous system health and disease. The main emphasis of the research is on neurotrophins, their receptors and activity-regulated gene expression. We study specifically (1) molecular mechanisms controlling neural activity-regulated transcription and translation of the neurotrophin BDNF; (2) transcriptional deregulation in Huntington's disease; (3) TrkB signaling, and its cross talk with Notch, Hedgehog and Plexin pathways; (4) the functions of the basic helix-loop-helix transcription factor TCF4 in the nervous system of mammals and Drosophila and its deregulation in Pitt-Hopkins syndrome and schizophrenia; (5) synaptic functions of the dendritically localized Neuralized1 as an ubiquitination ligase and transcriptional regulator.

In 2019 we continued our studies on regulation and functioning of genes associated with nervous system diseases and neuronal plasticity.

SELECTED PROJECTS

- TAR16018, *Centre of Excellence for Genomics and Translational Medicine* (2016–2023).
- VFP18046, *Towards Early Molecular Diagnostics of Schizophrenia* (2017–2020)
- PRG805, *Regulation of activity-dependent gene expression in the nervous system* (2020–2024)

SELECTED PUBLICATIONS 2020

Urb M., Niinep K., Matsalu T., Kipper K., Herodes K., Zharkovsky A., Timmusk T., Anier K., Kalda A. (2020). The role of DNA methyltransferase activity in cocaine withdrawal in the nucleus accumbens of mice. Addict Biol, 25(1):e12720.

Esvald E.E., Tuvikene J., Sirp A., Patil S., Bramham C. R., Timmusk T. (2020). CREB family transcription factors are major mediators of BDNF transcriptional autoregulation in cortical neurons. J. Neurosci, 40, 1405–1426.

Tamberg L., Jaago M., Säälik K., Sirp A., Tuvikene J., Shubina A., Kiir C. S., Nurm K., Sepp M., Timmusk T., Palgi M. (2020). Daughterless, the Drosophila orthologue of TCF4, is required for associative learning and maintenance of the synaptic proteome. Dis Model Mech, 13: dmm042747.

Sirp A., Leite K., Tuvikene J., Nurm K., Sepp M., Timmusk T. (2020). The Fuchs corneal dystrophy associated CTG repeat expansion in the TCF4 gene affects transcription from its alternative promoters. Sci Rep, 10:18424.

MOLECULAR TECHNOLOGY

Head of the Research Group: Senior Research Scientist PAVEL STARKOV, pavel.starkov@taltech.ee

Members/doctoral students: Rohit Bhadoria, Kefeng Ping, Mahboob Alam

TOPICS AND COMPETENCES

KEYWORDS: renewable energy, sustainability, catalysis, materials chemistry, chemical biology

Our group uses knowledge in syntheticc chemistry to molecularly design and test so-termed networked molecules. These are a subset of multifunctional small-molecular-weight compounds that address the notions of chemical as well as biological networks. In particular, we employ 'networked molecules' to

- rationally build up well-organized molecular networks and successfully use them as electrocatalyst materials for various applications, incl. renewable energy and 'ligandless' catalysis;
- disrupt and/or rewire biological networks with a goal of inducing new intracellular interactions and observing synergistic effects.

Such entities in their simplest form are heterobivalent constructs, however, we are looking to install additional moieties that would help extend their multifold performance.

SELECTED ARTICLES

Ping, K.; Braschinsky, A.; Alam, M.; Bhadoria, R.; Mikli, V.; Mere, A.; Aruväli, J.; Vlassov, S.; Kook, M.; Rähn, M.; Sammelselg, V.; Tammeveski, K.; Kongi, N.; Starkov, P. (2020). Fused hybrid linkers for metal-organic frameworks-derived bifunctional oxygen electrocatalysts. ACS Appl. Energy Mater. 2020, 3, 152–157.

Bhadoria, R.; Ping, K.; Lohk, C.; Järving, I.; Starkov, P. (2020). A phenotypic approach to probing cellular outcomes using heterobivalent constructs. Chem. Commun. 4216–4219.

Kazimova, N.; Ping, K.; Alam, M.; Danilson, M.; Merisalu, M.; Aruväli, J.; Käärik, M.; Mikli, V.; Leis, J.; Tammeveski, K.; Starkov, P.; Kongi, N. (2021). Shungite-derived graphene as a carbon support for bifunctional oxygen electrocatalysts. J. Catal. ASAP.

OIL SHALE CHEMISTRY

Head of the Research Group: Professor MARGUS LOPP, margus.lopp@taltech.ee
Members: Jaan Mihkel Uustalu, Kati Muldma, Tiina Aid, Kontson Tiina, Galina Varlamova
Doctoral students: Kristiina Kaldas

TOPICS AND COMPETENCES

KEYWORDS: methods of oxidation of oil shale and kerogen for the conversion of dicarboxylic acid derivatives

The research is carried out in the framework of the project "Technological Platform for Processing Oil Shale Kerogen into Dicarboxylic Acids" (Smart Specialization Program, contract LLKEE20030, KEROX II) in order to develop a continuous-flow process and initial conditions were studied for that perquisites to introduce the technology to practice. KEROX II project develops further the initial technological platform from KEROX I (Smart specialization programme, contract LEP17009, KEROX I, 2017–2019).

Two possible oxidizers were compared: air oxygen in alkali solution and air oxygen in the presence of nitric acid. The results of the alkali process were published in the journal ACS Omega, the effect of additives on the process will be published in Oil Shale journal.

The results to achieve a continuous-flow process revealed the sulphuric acid can be used for pre-treatment of the raw material and as an additive to the oxidation process. The results are presented in Estonian Patent Application.

SELECTED PUBLICATION

Kaldas, K.; Preegel, G.; Muldma, K.; Lopp, M. (2020). Wet Air Oxidation of Oil Shales: Kerogen Dissolution and Dicarboxylic Acid Formation. American Chemical Society, 5, 35, 22021–22030.

PLANT-MICROBE INTERACTIONS

Head of the Research Group: Senior Researcher MARIA CECILIA SARMIENTO GUERIN, cecilia.sarmiento@taltech.ee

Members: Merike Sõmera, Lenne Nigul, Signe Nõu

Postdoctoral student: Liina Jakobson

Doctoral students: Jelena Mõttus (Gerassimenko)

TOPICS AND COMPETENCES

KEYWORDS: agricultural crop diseases, plant viruses, RNA silencing suppressors, CRISPR/Cas9, myosins, bioeconomy in Estonia

We study genetic, molecular and cellular aspects of plant-microbe interactions. We use predominantly different cereals as well as the model plant Arabidopsis thaliana and various tobacco species as experimental host plant species. We identify and characterize, using next-generation sequencing techniques, viruses infecting cereal crops in Estonia and neighbouring countries. We study especially sobemoviruses. In plant molecular biology, our object of research is ABCE proteins and we use CRISPR/Cas9 technology for it.

We participate in the study on the current state and future perspectives of Estonian bioeconomy (ADDVAL-BIOEC project).

In collaboration with the Marine Systems Institute, we determined the biodiversity of plankton in the Baltic Sea, using next-generation sequencing techniques.

Using genetic tools, we studied the wolf population in Estonian mainland (contract with the Environment Agency).

SELECTED PUBLICATIONS

Sõmera, M.; Kvarnheden, A.; Desbiez, C.; Sõmera, M.; Kvarnheden, A.; Desbiez, C.; Blystad, D.-R.; Sooväli, P.; Kundu, J. K.; Gantsovski, M.; Nygren, J.; Lecoq, H.; Verdin, E.; Spetz, C.; Tamisier, L.; Truve, E.; Massart, S. (2020). Sixty years after the first description: genome sequence and biological characterization of European Wheat Striate Mosaic Virus infecting cereal crops. Phytopathology, 110, 68–79.

Sõmera, M.; Fargette, D.; Hebrard, E.; Sarmiento, C. (2020). ICTV Report Consortium. Virus Taxonomy Profile: Solemoviridae. Journal of General Virology (in press).

Mõttus, J.; Maiste, S.; Eek, P.; Truve, E.; Sarmiento, C. (2021). Mutational analysis of Arabidopsis thaliana ABCE2 identifies important motifs for its RNA silencing suppressor function. Plant Biology, 23 (1), 21–31.

REPLICATION RESEARCH GROUP

Head of the Research Group: Senior Researcher TATIANA MOISEEVA, tatiana.moiseeva@taltech.ee

Members/students: Hele Anderspuk, Sigvard Vällo

TOPICS AND COMPETENCES

KEYWORDS: cell biology, molecular biology, DNA replication, DNA damage signaling

The group became operational in the second half of 2020.

DNA replication is an essential process of genome duplication that has to be tightly regulated to ensure that each part of the genome is duplicated once and only once per cell cycle. DNA replication remains one of the main targets of cancer therapies as cancer cells tend to proliferate faster and are generally prone to replication stress. One way to make replication targeting drugs more efficient is to increase the number of replication forks in cancer cells. However, most of the replication initiation research to date has been done using model organisms such as yeast Saccharomyces cerevisiae and Saccharomyces pombe, or Xenopus laevis egg extracts. The human DNA replication system is, as expected, much more complex, and identifying human homologs using data from model systems has proven difficult, resulting in the need to re-evaluate every finding from a model system on a case-by-case basis.

Currently the research is focused on the following topics: (1) the role of DNA polymerase epsilon in replication initiation in human cells;

(2) developing a novel system to study DNA replication initiation in human cells based on proximity labelling; (3) the role and order of kinase activities in replication initiation.

THE GROUP FOR THE STUDY OF LIGNIN BIODEGRADATION

Head of the Research Group: Senior Research Scientist TIIT LUKK, tiit.lukk@taltech.ee

Members: Kairit Zovo, Epp Väli, Eve-Ly Ojangu, Kaia Kukk, Maria Kulp, Mihkel Koel, Urve Kallavus, Kristiina Leiman

Post-doctoral Researcher: Zeba Usmani

Doctoral students: Hegne Pupart, Piia Jõul

TOPICS AND COMPETENCES

KEYWORDS: X-ray crystallography, structural biology, biomass valorization, enzymology, rational design of biocatalysts, biocatalysis

The group is involved in a variety of research and development activities related to the valorization of plant biomass. The direction of research activities that focus on the biological routes to valorization of biomass deal primarily with soil bacteria and their metalloenzymes. In addition to the enzymological characterization of those enzymes, the laboratory uses X-ray crystallography methods to study their structure-function relationships. In the past year, the laboratory expanded the scope of study from actionabacterial metalloenzymes that are required for the modification and degradation of lignin to a broader range of enzymes from extremophilic organisms that are involved in biomass conversion as auxiliary enzymes or as degraders of cellulose/hemicellulose. In the past year, the laboratory also welcomed a new postdoc, Zeba Usmani, who joined the group to study what are the roles of actinobacteria in bioremediation processes and in the evolution of soil chemistry.

The group leader coordinates research efforts of the RESTA11 project, which focuses on the further valorization of bleached chemithermomechanical aspen pulps and secondary woody biomass sources.

In addition to developing fractionation technologies of wood biopolymers, the research group is aiming to find new solutions to the synthesis of wood biopolymer based functional materials (surfactants, aerogels) and ways to enhance enzymatic saccharification of cellulose and hemicellulose.

SELECTED PROJECTS

- MOBTT60, "*The role of actinomycete metalloproteins in lignin depolymerization and soil chemistry*" (2017–2022).
- RESTA11, *Development of chemical and biochemical valorization technologies for bleached chemithermomechanical pulps (BCTMP) and secondary woody biomass sources* (2020–2023).

RESEARCH GROUP OF CATALYSIS

Head of the Research Group: Professor TÕNIS KANGER, tonis.kanger@taltech.ee

Members: Kadri Kriis, Andrus Metsala, Kristin Erkman

Doctoral students: Mikk Kaasik, Mariliis Kimm, Dmitri Trubitsõn, Aleksandra Murre, Estelle Silm, Kaarel Erik Hunt

TOPICS AND COMPETENCES

KEYWORDS: asymmetric synthesis, organocatalysis, catalysis, cascade reactions, halogen-bond catalysis, enzymatic catalysis, oligosaccharides

The main research object of the group is asymmetric organic synthesis. The research includes a total synthesis of bioactive compounds and specific investigations of cascade and catalytic reactions. Studies of asymmetric organocatalytic reactions are of importance. Aminocatalysis based on covalently bound compounds, hydrogen-bond and halogen-bond catalysis based on noncovalent interactions, enzymatic and co-operative catalysis are the main topics. Several reactions under the study are cascade reactions providing several new chemical bonds in one step. It increases atom-efficiency, decreases the number of steps needed and makes the whole process environmentally more benign (the number of work-up steps and amount of solvent is diminished). In the case of metal catalysis widely spread and non-toxic calcium salts are used as a metal source. The synthesis is supported by spectroscopic and crystallographic experiments, chromatography and quantum chemical calculations.

The characteristic feature of the research is the application of the principles of sustainable and green chemistry in asymmetric synthesis. The main tasks of the studies are increase of efficiency and selectivities of reactions by means of catalysis, cascade reactions and by use of less toxic metal catalysts.

SELECTED PUBLICATIONS

Kaasik M., Kanger T. (2020). Supramolecular Halogen Bonds in Asymmetric Catalysis. Front. Chem. 8:599064.

Trubitsõn, D.; Martõnova, J.; Erkman, K.; Metsala, A.; Saame, J.; Kõster, K.; Järving, I.; Leito, I.; Kanger, T. (2020). Enantioselective N-Alkylation of Nitroindoles under Phase-Transfer Catalysis. Synthesis, 52, 1047–1059.

A. Peterson, M. Kaasik, A. Metsala, I. Järving, J. Adamson, T. Kanger (2019). Tunable chiral triazole-based halogen bond donors: assessment of donor strength in solution with nitrogen-containing acceptors. RSC Advances, 2019, 9, 11718–11721.

Kaasik, M.; Metsala, A.; Kaabel, S.; Kriis, K.; Järving, I.; Kanger, T. (2019). Halo-1,2,3-triazolium salts as halogen bond donors for the activation of imines in dihydropyridinone synthesis. J. Org. Chem. 2019, 84, 4294−4303.

RESEARCH GROUP OF REPRODUCTIVE BIOLOGY

Head of the Research Group: Associated Professor AGNE VELTHUT-MEIKAS, agne.velthut@taltech.ee

Members, doctoral students: Ilmatar Rooda, Kristiine Roos

TOPICS AND COMPETENCES

KEYWORDS: reproductive biology, infertility, bioinformatics

Infertility is a worldwide problem with medical, socio-economical as well as psychological aspects. According to the European Society of Human Reproduction and Embryology, medical intervention is sought for by 15% of couples who wish to conceive their biological offspring (www.eshre.eu).

The Research Group of Reproductive Biology is mainly focused on the problems of female infertility and we investigate the biological processes in human ovary. Our main goal is to describe intercellular molecular interactions in the ovary and to find factors that would aid in discriminating between viable and non-viable oocytes. Various genome-wide high-throughput technologies are used in our research: next-generation sequencing, proteomics and data analysis methods in the field of systems biology to mention a few. We collaborate with all infertility clinics in Estonia in order to collect biological samples (ovarian granulosa cells, ovarian biopsies, follicular fluid, and blood samples) from fertile and infertile women.

Our research subjects can be divided into three categories:

a. Research on human ovary and related etiologies of infertility.

b. The effect of environmental chemicals on ovarian function.

c. Research on human endometrium and investigating the molecular disturbances in the embryo implantation process.

We collaborate closely with all infertility clinics in Estonia as well as with the Competence Center on Health Technologies.

SELECTED ARTICLES

Rooda, I.; Hasan, M. M.; Roos, K.; Viil, J.; Andronowska, A.; Smolander, O. P.; Jaakma, Ü.; Salumets, A.; Fazeli, A.; Velthut-Meikas, A. (2020). Cellular, extracellular and extracellular vesicular miRNA profiles of pre-ovulatory follicles indicate signaling disturbances in polycystic ovaries. International Journal of Molecular Sciences, 21 (24), 1–23.

Reshi, Q. U. A.; Viil, J.; Ord, J.; Lattekivi, F.; Godakumara, K.; Hasan, M. M.; Nomm, M.; Jaager, K.; Velthut-Meikas, A.; Jaakma, Ü.; Salumets, A.; Fazeli, A. (2020). Spermatozoa induce transcriptomic alterations in bovine oviductal epithelial cells prior to initial contact. Journal of Cell Communication and Signaling, 14 (4), 439–451.

Hasan, M. M.; Viil, J.; Lattekivi, F.; Ord, J.; Reshi, Q. U. A.; Jaager, K.; Velthut-Meikas, A.; Andronowska, A.; Jaakma, U.; Salumets, A.; Fazeli, A. (2020). Bovine Follicular Fluid and Extracellular Vesicles Derived from Follicular Fluid Alter the Bovine Oviductal Epithelial Cells Transcriptome. International Journal of Molecular Sciences, 21 (15), ARTN 5365.

SUPRAMOLECULAR CHEMISTRY GROUP

Head of the Research Group: Professor RIINA AAV, riina.aav@taltech.ee

Members: Victor Borovkov, Omar Parve, Dzmitry Kananovich, Marina Kudrjašova, Elena Prigorchenko, Karin Valmsen

Post-doctoral Researcher: Ustrnul Lukaš

Doctoral students: Anna Peterson, Tatsiana Dalidovich, Tatsiana Shalima, Nele Konrad, Mari-Liis Ludvig, Jevgenia Martõnova, Marko Šakarašvili, Kristjan Siilak, Jagadeesh Varma Nallaparaju

TOPICS AND COMPETENCES

KEYWORDS: supramolecular chemistry, macrocycles, receptors, host-guest complexes, molecular containers, chirality, nuclear magnetic resonance spectroscopy, single-crystal X-ray diffraction analysis, spectroscopy, UV-vis, FS, CD, VCD, NMR

The supramolecular chemistry research group is interested in the study of chiral molecular containers, constructed from urea monomers. More specifically we are studying their synthesis, molecular and supramolecular structure and their interactions. Supramolecular chemistry unites approaches of analytical, organic and physical chemistry to study matter in a broader way. Molecular containers are able to form host-guest complexes with other molecules and in a special case of inclusion complexes, a small molecule is fully encapsulated by the macrocycle. These complexes are held together by non-covalent interactions. We are mainly interested in macrocycles that belong to the cucurbituril family, the hemicucurbiturils and their complexes and derivatives with optically attractive porphyrins. We explore the potential of new molecular containers in material and environmental science for sensing.

Peterson, A.; Ludvig, M-L.; Martõnova, J.; Kaabel, S.; Kerner, P.; Uudsemaa, M.; Trummal, A.; Fomitšenko, M.; Pehk, T.; Aav, R.; Adamson, J. (2020). New oxacalix[4]arene carboxylate detects viologen in protic media. Supramolecular Chemistry, 32 (5), 313–319.

SELECTED PUBLICATIONS

Dalidovich, T.; Mishra, K. A.; Shalima, T.; Kudrjašova, M.; Kananovich, D. G.; Aav, R. (2020). Mechanochemical Synthesis of Amides with Uronium-Based Coupling Reagents: A Method for Hexa-amidation of Biotin[6]uril. ACS Sustainable Chemistry & Engineering, 8 (41), 15703–15715.

Mishra, K. A.; Adamson, J.; Öeren, M.; Kaabel, S.; Fomitšenko, M.; Aav, R. (2020). Dynamic chiral cyclohexanohemicucurbit[12]uril. Chemical Communications, 56 (93), 14645–14648.

Osadchuk, I.; Borovkov, V.; Aav, R.; Clot, E. (2020). Benchmarking computational methods and influence of guest conformation on chirogenesis in zinc porphyrin complexes. Physical Chemistry Chemical Physics, 22 (19), 11025–11037.

SELECTED PROJECTS

- VFP18059, *INnovative chemIcal sensors for enanTioselective detectIon of chiral pOllutants* (INITIO) (2019–2021), H2020-FETOPEN
- PRG399, *Adaptable supramolecular chirality sensors*, (2019–2023)
- COST CA18112, Mechanochemistry for Sustainable Industry (Estonian MCM: R., period 2018–2022).

RESEARCH GROUP ON SUSTAINABLE CHEMISTRY AND ENGINEERING

Head of the Research Group: Senior Research Scientist YEVGEN KARPICHEV, yevgen.karpichev@taltech.ee

Postdoctoral researcher: Zeba Usmani

Doctoral students: Denys Bondar, visiting doctoral students: Yevheniia Velihina, Oleksandr Trybrat

TOPICS AND COMPETENCES

KEYWORDS: functional surfactants and formulations, chemical decontamination, biodegradability, sustainability

The team develops the good practices in the synthesis and application of the sustainable chemicals and formulations:

- Characterisation of new chemicals, functional surfactants, formulations, and functionalized nanoparticles to explore fundamental properties and application in designing drug-delivery systems.
- Novel green formulations for antidotes, chemical decontamination, antibacterial coating and sanitizers.
- Biodegradation (OECD 301D Closed Bottle Test) study to identify low toxicity / mineralisable transformation products of the: (i) surfactants and ionic liquids bearing natural fragment, (ii) surface-functionalized carbon nanoparticles, (iii) natural deep euthectic solvent mixtures used for extraction of natural bioactive compounds in the process of pomace treatment, and (iv) small molecules of potential importance for pharmaceutical and environmental applications.

KEY PROJECTS

- LMIN18040, *Innovative (pre)POmace Valorization procEss (ImPrOVE)* (2028–2021)
- NATO SPS MYP „DEsigning FIRst Responders Versatile Detection and Decontamination Methods“ (DEFIR)
- COVSG5, *Biodegradable formulations for antiviral coatings and sanitizers (BIOFORM)* (2020–2021)

SELECTED ARTICLES:

M. Suk, A. Haiß, J. Westphal, A. Jordan, A. Kellett, I. V Kapitanov, Y. Karpichev, N. Gathergood, K. Kümmerer (2020). Synthesis, self-assembly, bacterial and fungal toxicity, and preliminary biodegradation studies of a series of L-phenylalanine-derived surface-active ionic liquids. Green Chemistry, 22 (14), 4498–4508.

Z. Usmani, M.i Sharma, P. Gupta, Y. Karpichev, N. Gathergood, R. Bhat, V. K. Gupta (2020). Ionic liquid based pretreatment of lignocellulosic biomass for enhanced bioconversion. Bioresource technology, 304, 123003.

S. Pandya, I. Kapitanov, Z. Usmani, R. Sahu, D. Sinha, N. Gathergood, K. K. Ghosh, Y. Karpichev (2020). An Example of Green Micellar Decon System Based on Inherently Biodegradable IL-derived Amphiphilic Oximes. Journal of Molecular Liquids, 305, 112857

DEPARTMENT OF CYBERNETICS

Director: Professor JAAN JANNO,
jaan.janno@taltech.ee,
+372 620 3052

MAIN FIGURES 2020

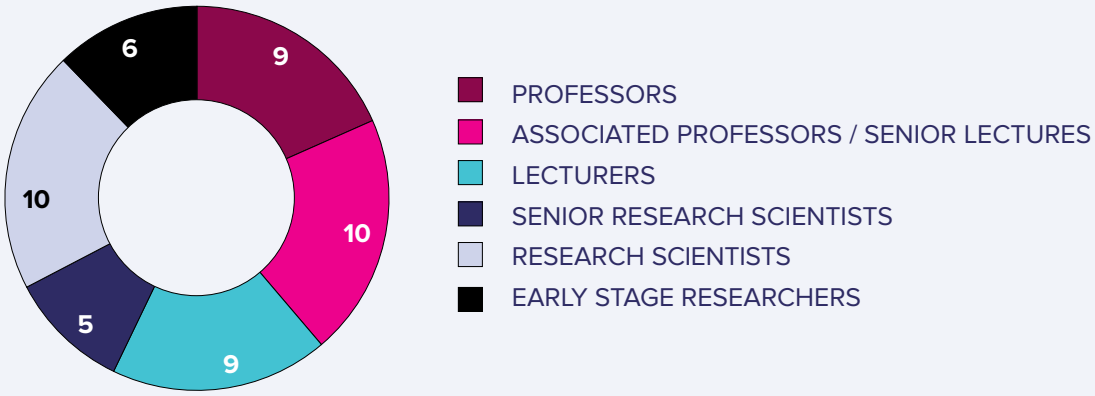
(as of Dec. 31, 2020)

49	Academic staff	Incl. 9 professors, 21 researchers	
15	Doctoral students	3	Defended doctoral dissertations
56	Scientific publications*		

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 8 RESEARCH GROUPS:

- **GROUP AND SEMIGROUP THEORY.**
  Head: Senior Lecturer ALAR LEIBAK, alar.leibak@taltech.ee
- **INVERSE PROBLEMS AND STOCHASTIC METHODS.**
  Head: Professor JAAN JANNO, jaan.janno@taltech.ee
- **MATHEMATICAL ANALYSIS.**
  Head: Senior Research Scientist GERT TAMBERG, gert.tamberg@taltech.ee
- **NONLINEAR WAVE DYNAMICS.**
  Head: Professor ANDRUS SALUPERE, andrus.salupere@taltech.ee
- **RHEOLOGY OF COMPOSITES.**
  Head: Senior Research Scientist HEIKO HERRMANN, heiko.herrmann@taltech.ee
- **SYSTEMS BIOLOGY.**
  Head: Senior Research Scientist MARKO VENDELIN, marko.vendelin@taltech.ee
- **THEORETICAL PHYSICS.**
  Head: Professor JAAN KALDA, jaan.kalda@taltech.ee
- **WAVE ENGINEERING.**
  Head: Professor TARMO SOOMERE, tarmo.soomere@taltech.ee



GROUP AND SEMIGROUP THEORY RESEARCH GROUP

Head of the group: Senior Lecturer ALAR LEIBAK, alar.leibak@taltech.ee

Members of the group: Peeter Puusemp, Piret Puusemp

Doctoral student Märt Umbleja

TOPICS AND COMPETENCES

KEYWORDS: group theory, endomorphism semigroups, applications of algebra in cryptography and mathematical control theory

The research is focused on the study of the connections between groups and their endomorphism semigroups, and the applications of group theory.

The aim is to describe some well-known classes of finite groups by their endomorphism semigroups and to decide whether a group is determined by its endomorphism semigroup in the class of all groups or not. We started to describe all *small groups* that are determined by their endomorphism semigroups. Further, if a group G is not determined by its endomorphism semigroup, then to provide the complete list of nonisomorphic groups having the endomorhism semigroup isomorphic to that of G. As the computational group theory and the software GAP (*http://www.gap-system.org*) are becoming more popular among people working in applied algebra, we started to develop algorithms what are able to decide automatically whether or not a given finite group is determined by its endomorphism semigroup.

MAIN RESULTS:

The distribution of the multi-party Diffie-Hellman common secret keys were studied if the platform group is an arbitrary finite cyclic group. By applying the methods from discrete geometry, we improved the upper bound for the maximal probability of the DH common secret keys.

SELECTED ARTICLE:

Kotta, Ü.; Belikov, J.; Halás, M.; Leibak, A. (2019). Degree of Dieudonné determinant defines the order of nonlinear system. International Journal of Control, 92 (3), 518–527.

INVERSE PROBLEMS AND STOCHASTIC METHODS RESEARCH GROUP

Head of the group: Professor JAAN JANNO, jaan.janno@taltech.ee

Members of the group: Lassi Päivärinta, Margus Pihlak, Kari Kasemets, Emilia Blåsten

Doctoral students: Nataliia Kinash, Sadia Sadique

TOPICS AND COMPETENCES

KEYWORDS: inverse problems, fractional diffusion and wave motion, direct and inverse scattering, nonparametric statistics

The main directions of research are:

- **Inverse problems for equations containing fractional derivatives**. Inverse problems for linear and nonlinear fractional differential equations are studied. The unknowns to be determined are coefficients, source terms and kernels of generalized fractional time derivatives. Such problems occur in modelling of diffusion and mechanical processes in porous, fractal and biological media. The research is focused on both theoretical aspects and elaboration of numerical methods.
- **Direct and inverse scattering in singular and nonlocal media.** Electromagnetic and acoustic direct and inverse scattering in media with singularities or non-local features is studied. Mathematical theory of tripole and more general multipole antennas is developed. This branch is complemented by a development of new signal processing on state-of-the-art computational methods for large-scale inverse problems. Inverse problems to reconstruct in homogeneities of media with non-local properties by means of measurements of scattered acoustic waves at boundaries are investigated.
- **Elaboration of nonparametric statistical methods**. The theory of nonparametric statistical methods is developed and these methods are applied in environmental and building engineering.

RECENT GRANTS:

- PUT568 "*Inverse problems for parabolic differential equations with fractional derivatives*" (2015–2018).
- PUT1093 "*Stochastic methods in inverse problems with special focus on fractional diffusion*" (2016–2019).
- PRG832, *Direct and inverse scattering problem for singular and non-local media* (2020–2024)

SELECTED PUBLICATIONS:

Blasten, E.; Paivarinta, L.; Sadique, S. (2020). Unique Determination of the Shape of a Scattering Screen from a Passive Measurement. Mathematics, 8, 1156.

Janno, J. (2020). Determination of time-dependent sources and parameters of nonlocal diffusion and wave equations from final data. Fractional Calculus and Applied Analysis, 23 (6), 1678–1701.

MATHEMATICAL ANALYSIS RESEARCH GROUP

Head of the group: Senior Research Scientist GERT TAMBERG, gert.tamberg@taltech.ee

Members of the group, PhD students Olga Graf, Olga Meronen

TOPICS AND COMPETENCES

KEYWORDS: sampling operators, approximation theory, signal processing

The main directions of research are as follows:

- Studying the generalized Shannon sampling operators that mean the representations of functions in terms of series, where the expansion coefficients are its samples and expansion functions are translates of certain kernel function. In the case of Kantorovich-type sampling operators we take, instead of point estimates, some local averages as Fejer-type singular integrals.
- Studying applications of the generalized sampling operators in Signal Processing, especially in imaging applications, where the generalized sampling operators are a natural tool for image resampling. We also study applications in HDR imaging. We study the applications of sampling operators in time series analysis and linear prediction.
- Studying representations of the derivatives (also fractional derivatives) with Kantorovich-type sampling operators. We study sampling in fractional Fourier framework.

MAIN RESULTS

- We studied sampling operators for one-bit sampling.
- We applied sampling operators in time series analysis and linear prediction, especially for energy prediction. A hardware realization was proposed.

- We studied Kantorovich-type sampling operators for derivative sampling.

SELECTED ARTICLE:

Ahmed, F.; Kervadec, C.; Le Moullec, Y.; Tamberg, G.; Annus, P. (2019). Autonomous Wireless Sensor Networks: Implementation of Transient Computing and Energy Prediction for Improved Node Performance and Link Quality. The Computer Journal, 62 (6), 820–837.

NONLINEAR WAVE DYNAMICS RESEARCH GROUP

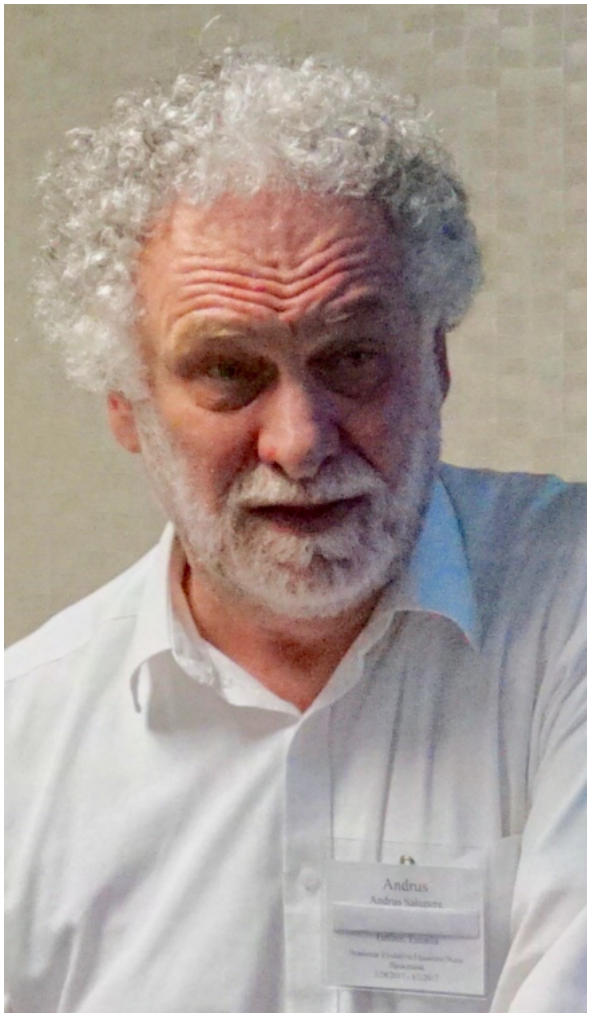
Head of the group: Professor ANDRUS SALUPERE, andrus.salupere@taltech.ee

Members of the group: Arkadi Berezovski, Tanel Peets, Kert Tamm, Dmitri Kartofelev, Martin Lints, Mart Ratas, Jüri Engelbrecht

TOPICS AND COMPETENCES

KEYWORDS: continuum mechanics, theory of internal variables, nondestructive testing of materials, nonlinear waves, solitons, numerical experiments

The activities of the research group are focused on wave propagation in complex media and corresponding applications. On the one hand, this includes direct problems, where the goal is to analyse how waves of different types propagate and interact in materials, the properties of which are known. On the other hand, the aim is to solve inverse problems, in order to determine the properties of materials, existence of defects, residual stresses, etc. by making use of quantities measured from physical experiments.



MAIN RESEARCH DIRECTIONS

- *Theory of continua and internal variables*. The internal structure of materials is described using internal fields. The corresponding mathematical models of wave motion in microstructured solids take into account nonlinear, dispersive and temperature effects and possible multiscale of a microstructure.
- *Solitons and solitary waves*. Boussinesq-type (two-wave) models and KdV-type (one-wave) models, which describe waves in microstructured solids and mechanical waves in biomembranes, are applied. Conditions for formation of solitonic solutions are determined.
- *Numerical analysis of nonlinear wave propagation*. Fourier spectrum related spectral characteristics are applied in order to examine time-space behaviour of complex wave-structures.
- *Nondestructive testing of materials*. Methods for determining of mechanical properties of materials and for detection of defects in laminated objects are developed.

SOME RECENT RESULTS

- In acoustics of musical instruments a theoretical model has been developed for describing the interaction between the string and the obstacle. The model is tested experimentally for string instruments.
- Mathematical models are formulated in order to simulate heat production and corresponding temperature changes, which accompany the propagation of an action potential.
- Activities in the field of non-destructive testing of materials have led to the development of practical applications. This takes place in cooperation with department of Civil engineering and Architecture.

SELECTED PROJECTS

- IUT 33-24, "*Wave propagation in complex media and applications*" (2015–2020).

RHEOLOGY OF COMPOSITES RESEARCH GROUP

Head of the group: Senior Research Scientist HEIKO HERRMANN, heiko.herrmann@taltech.ee

Members of the group: Andres Braunbrück, Dmitri Kartofelev

Doctoral students: Oksana Goidyk, Mark Heinstein

TOPICS AND COMPETENCES

KEYWORDS: mechanics of materials, continuum mechanics, fiber concrete, fiber orientations, computational rheology, image analysis, 3D visualization

The competences of the group have a broad range, from constitutive theory over numerical computer simulations and image analysis to virtual reality visualization of scientific data. The main research topic is concerned with the mechanical properties of composites containing short fibres. The core application is steel fibre reinforced concrete, a construction material, the use of which is gaining momentum in the building industry. The mechanical properties largely depend on the orientation of short fibres, which in turn are influenced by the production process of the structural parts made of fibre concrete. In particular, the flow of the fresh concrete mass, which is mixed with the fibres, determines the fibre orientations. Analysis of fibre orientations in experiment samples is done by x-ray computed tomography, fibre orientations are then extracted from the tomography. The group has developed its own software for this purpose. The production process of concrete parts, in particular the casting, is simulated using computational fluid dynamics (CFD) coupled to an orientation equation. Further, simulations of bending tests and split tests are performed with particle based discrete element simulations. On the theoretical side, the group has developed constitutive models for the influence of the fibre orientations distribution on the mechanical and thermal properties of fibre concrete.

This involves the research on stereoscopic semi-immersive 3D visualization (virtual reality), which is conducted on the self-developed „Kyb3“ system. The main task of the system is the visualization of the computed tomography of fibre concrete and CFD simulations. It is used to visually inspect measurement and simulation results.

SELECTED PROJECT

PUT1146, “*Rheology of short fibre reinforced cementitious composites and influence on fracture behaviour*” (2016–2019)

SYSTEMS BIOLOGY RESEARCH GROUP

Head of the group: Senior Research Scientist MARKO VENDELIN, marko.vendelin@taltech.ee
Members of the group: Rikke Birkedal, Mari Kalda-Kroon, Niina Karro, Martin Laasmaa
Doctoral student: Jelena Branovets

TOPICS AND COMPETENCES

KEYWORDS: heart; biophysics; bioenergetics; electrophysiology; biomechanics; intracellular diffusion; fluorescence microscopy; fluorescence correlation spectroscopy

The Laboratory of Systems Biology was founded in 2007 with the help of the funding from Wellcome Trust. We use interdisciplinary approaches to tackle questions in cardiac physiology. For that, we have formed a team of researchers with backgrounds in biophysics, biology, and applied mathematics/physics. As a result, we are able to approach scientific questions on different scales, from organ to molecular level, using combinations of different experimental and theoretical techniques by focusing on quantitative analysis of the data.

We study diffusion in cardiomyocytes by tracking the movement of fluorescent molecules using extended raster image correlation spectroscopy. Our results suggest that diffusion barriers are arranged in a 3D lattice with relatively small openings. Based on the analysis of autofluorescence response, we demonstrated that mitochondrial outer membrane and cytosolic diffusion barriers reduce the movement of molecules to a similar extent. We study effects of creatine deficiency to establish the role of creatine kinase shuttle in the heart. In 2020 we demonstrated how creatine deficiency leads to intracellular adaptations in terms of alternative energy transfer systems changes and an impact on calcium handling of cardiomyocytes. These studies form a basis for our future line of research on interactions between processes in cardiomyocytes.

We have been active in the development of new techniques and distribute them as open-source tools: deconvolution software for enhancing confocal imaging, symbolic flux analysis for genome-scale metabolic networks, and real-time sarcomere length estimation techniques. This development work has raised interest in companies with an outreach of incorporating our algorithms and software into their products.

ESSENTIAL PROJECTS

- IUT33-7, "*Relationships between microstructure, energy transfer, and performance in heart*".
- European Union Framework Programme Horizon 2020 COST Action CA15203: Mitochondrial mapping: Evolution – Age – Gender – Lifestyle – Environment.
- European Union Framework Programme Horizon 2020 COST Action CA16225: Realising the therapeutic potential of novel cardioprotective therapies.
- Innovative digital platform tailored for AI-assisted discoveries of hidden phenomena in biological function.
- Processing of confocal microscopy images (collaboration with PerkinElmer, USA)

THEORETICAL PHYSICS RESEARCH GROUP

Head of the group: Professor JAAN KALDA, jaan.kalda@taltech.ee

Members of the group: Raavo Josepson, Mihhail Klopov, Mihkel Kree, Tanel Mullari, Vladislav-Veniamin Pustõnski

Postdoctoral researcher: Jesus Alva Samos

Doctoral students: Inderek Mandre, Siim Ainsaar, Mihkel Heidelberg, Stephanie Rendon De La Torre, Iram Tufail, Eero Uustalu, Marek Vilipuu, Ajith Menon

TOPICS AND COMPETENCES

KEYWORDS: turbulence, photovoltaic materials, econphysics, cturbulence, photovoltaic materials, econphysics, complex systems, tools for physics education

The rapidly developing solar cell technology has brought to the forefront the problem about **the properties of inexpensive and efficient photovoltaic materials**. One of our research topics is calculation of the basic physical parameters of new photovoltaic materials (hybrid-perovskite and CZTS) using quantum chemical and density functional theory methods. For material technology applications, it is important to understand the **localized oscillations in solids** and the physical mechanisms of LLM (Linear Localized Modes); we have determined the conditions of excitation of ILM (Intrinsic Localized Modes) in various three-dimensional crystals and compared theory with an experiment.

- **Orbital modelling and planning for satellites**. Within the nanosatellite project "CubeSat", we have developed a solar energy balance model, and predicted the positions of its communication windows.
- **Theoretical analysis and modelling of turbulent mixing**. Our research tools include Fokker-Planck equations for Lagrange stretching statistics, statistical Lagrange dynamics invariants, stochastic matrix products, statistical topography of passive fields, the stochastic baker's map for reducing dimensionality of the problems. In collaboration with the Wave Dynamics Laboratory, we have modelled litter patchiness in marine environment as a result of coupling between the water flow and wind drag. In cooperation with University of Marseille, we have studied mixing in a porous environment, see Phys. Rev. Fluid (2017) 2, 104502 (Altmetrix score 15).

- **Econophysics research**. We have studied scale-free properties of economic networks based on the database of wire transfers of Swedbank – these appear to be multifractal networks, see Eur. Phys. J. B (2017) 90: 234 (Altmetrix score 5).
- **Development physics study materials**. It has mainly focused on methods for solving creative problems, and popularizing physics education. The materials available at *https://www.ioc.ee/~kalda/ipho/* have won great international recognition, with an average download of about 1,000 files per day. TFU initiated the European Physics Olympiad.

WAVE ENGINEERING RESEARCH GROUP

Head of the group: Professor TARMO SOOMERE, tarmo.soomere@taltech.ee

Members: Maris Eelsalu, Nicole Delpeche-Ellmann, Andrea Giudici, Nadezhda Kudryavtseva, Kevin Ellis Parnell, Katri Pindsoo, Bert Viikmäe

Doctoral students: Mojtaba Barzekhar, Mikolaj Jankowski, Rain Männikus, Fatemeh Najafzadeh, Margus Rätsep

Visiting PhD students: Kuanysh Kussembayeva (al-Farabi Kazakh National Univ.), Aigerim Sakhayeva (al-Farabi Kazakh National Univ.), Ilona Šakurova (Klaipeda Univ.)

TOPICS AND COMPETENCES

KEYWORDS: wave dynamics, coastal processes, coastal engineering, wave climatology, coastal management, remote sensing

The laboratory (*wavelab.ioc.ee*) was formed on 01.01.2009 to promote and provide a structure for research in water waves and coastal engineering.

The team focuses on complex and nonlinear phenomena in wave dynamics and coastal engineering, and the applications of mathematical methods in wave studies. The scope of the research involves, but is not limited to, wave theory and applications surface wave modelling, wave climate studies, and wave-driven phenomena in coastal engineering, with application to integrated coastal zone management.

Emerging foci are Lagrangian transport of substances in marine environment, wave and water level extremes, preventive mitigation of marine-induced hazards, and remote sensing methods for studies of both fundamental questions and applied problems such as variations in the properties of waves in small inland seas.

The performed research has established several unexpected properties of internal wave fields in semi-enclosed seas such as the Baltic Sea, the Mediterranean Sea and the Sea of Okhotsk and made it possible to quantify changes in the main properties of surface waves in the Baltic Sea. Studies of the impact of ship wakes in the Venice Lagoon (*Zaggia et al. 2017 PLoS ONE*) caused massive reaction in Venice.

In 2020 we quantified main properties of mean and extreme water levels in Latvian waters, increase rate of extreme water levels for the entire Baltic Sea, spatial distribution of properties of internal motions with periods of 2–12 days in the Baltic Sea, and possibilities for combining remote sensing and geoid model for specification of offshore water level. Interestingly, extreme water levels at the southern coast of the Baltic Sea do not reflect a statistically stationary process. We showed that wave set-up heights usually follow an exponential distribution but they may follow an inverse Gaussian (Wald) distribution in some beaches of the northern coast of Estonia. We developed a method (based on spectrograms) for the identification of sailing parameters of vessels based on measurements of their wakes using pressure sensors, suggested options for climate change planning based on variability in coastal processes in Torres Strait, Australia, generalised the outcome of long-term measurements at Parengarenga Beach (New Zealand), and quantified the transport patterns in Moreton Bay (Austraalia) using the technique of Lagrangian coherent structures.

SELECTED PROJECTS

- IUT33-3, "*Wave dynamics for coastal engineering and management*" (2015–2020).
- MOBTT72, "*Coastal processes and coastal management in a changing climate*" (2018–2022).

DEPARTMENT OF GEOLOGY

Director: Professor
MICHAEL WILLIAM HITCH,
michael.hitch@taltech.ee

MAIN FIGURES 2020

(as of Dec. 31, 2020)

27 Academic staff — Incl. 4 professors, 18 researchers

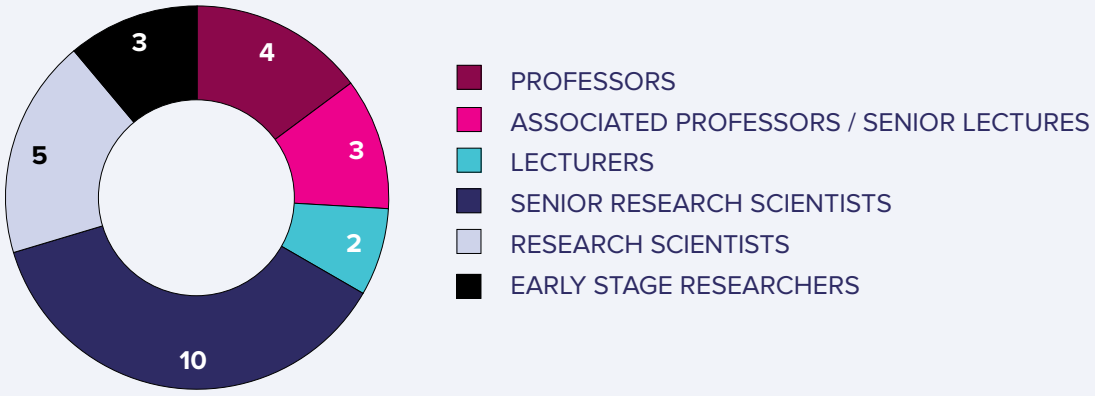
8 Doctoral students — 1 Defended doctoral dissertations

51 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 5 RESEARCH DIVISIONS:

- **BEDROCK GEOLOGY RESEARCH GROUP.**
  Head: Professor OLLE HINTS, olle.hints@taltech.ee
- **ISOTOPE GEOLOGY RESEARCH GROUP.**
  Head: Senior Researcher REIN VAIKMÄE, rein.vaikmae@taltech.ee
- **MINERAL RESOURCES AND APPLIED GEOLOGY RESEARCH GROUP.**
  Head: Researcher RUTT HINTS, rutt.hints@taltech.ee
- **MINING AND MINERAL RESOURCES RESEARCH GROUP.**
  Head: Professor MICHAEL WILLIAM HITCH, michael.hitch@taltech.ee
- **QUATERNARY GEOLOGY RESEARCH GROUP.**
  Head: Professor SIIM VESKI, siim.veski@taltech.ee



BEDROCK GEOLOGY RESEARCH GROUP

Head: Professor OLLE HINTS, olle.hints@taltech.ee

Members: Peep Männik, Ursula Toom, Merlin Liiv, Jaak Nõlvak, Aivo Lepland, Linda Hints

TOPICS AND COMPETENCES

KEYWORDS: Paleozoic geology, paleontology, paleoenvironment, stable isotope geochemistry

Bedrock geology, including paleontology and stratigraphy, have been among the key research areas of the Department of Geology since the 1950s.

The main research topics of the group are related to deciphering Earth's history through the latest Proterozoic and early Paleozoic times, ca 400–600 million years ago. The group is interested in better understanding the interactions between geo- and biosphere processes, in particular, addressing the following:

- paleobiodiversity dynamics and its relationships with climate and environmental changes;
- paleobiology and evolution of various groups of organisms during early Paleozoic;
- global paleobiogeographic patterns and the role of the Baltic faunal province;
- paleoclimate perturbations using multiple proxy indicators (such as conodont apatite);
- changes in carbon, oxygen and sulfur stable isotope composition, reflecting of atmosphere and hydrosphere in deep time.

The group holds leading paleontological competence in Estonia, and for some fossil groups, leading expertise worldwide (notably for conodonts, chitinozoans and scolecodonts). The main applications are related to the high-resolution biostratigraphy of Early Paleozoic sedimentary rocks. Most higher-impact studies are based on material from the Baltoscandian bedrocks, renowned by little alteration and good preservation primary Paleozoic environmental signatures.

The group makes also excessive use of the geological and paleontological collections deposited at the department. These are the largest in Estonia and curated at a high international level.

SELECTED PUBLICATIONS

Ausich, W. I., Wilson, M. A., Toom, U. (2020). Early Silurian recovery of Baltica crinoids following the end-Ordovician extinctions (Llandovery, Estonia). Journal of Paleontology 94, 521–530.

Liang, Y., Hints, O., Tang, P., Cai, C., Goldman, D., Nõlvak, J., Tihelka, E., Pang, K., Bernardo, J., Wang, W. (2020). Fossilized reproductive modes reveal a protistan affinity of Chitinozoa. Geology 48, 1200–1204.

Sorci, A., Cirilli, S., Clayton, G., Corrado, S., Hints, O., Goodhue, R., Schito, A., Spina, A. (2020). Palynomorph optical analyses for thermal maturity assessment of Upper Ordovician (Katian-Hirnantian) rocks from Southern Estonia. Marine and Petroleum Geology 120, 104574.

Toom, U., Vinn, O., Isakar, M., Madison, A., Hints, O., 2020. Small faecal pellets in Ordovician shelly fossils from Estonia, Baltoscandia. Estonian Journal of Earth Sciences 69, 1–19.

Young, S. A., Benayoun, E., Kozik, N. P., Hints, O., Martma, T., Bergström, S. M., Owens, J. D. (2020). Marine redox variability from Baltica during extinction events in the latest Ordovician–early Silurian. Palaeogeography, Palaeoclimatology, Palaeoecology 109792.

ISOTOPE GEOLOGY RESEARCH GROUP

Head: Senior Researcher REIN VAIKMÄE, rein.vaikmae@taltech.ee

Members: Alla Šogenova, Kazbulat Šogenov, Enn Kaup, Jüri Ivask

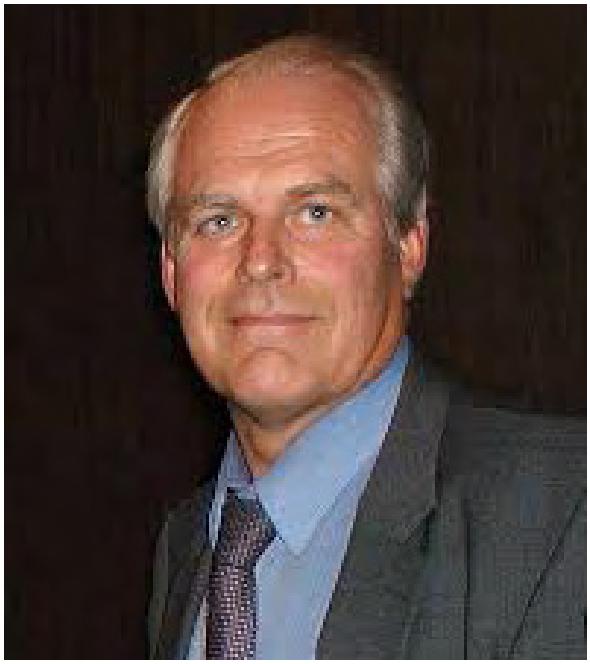
Doctoral student: Joonas Pärn

TOPICS AND COMPETENCES

KEYWORDS: isotope hydrogeology, groundwater, paleoclimatology, polar research, CO_2 and hydrogen storage, Baltic Artesian Basin

The Division of Isotope Geology was formed in The Division of Isotope Geology was formed in the early 1970s with the aim to study the history of Quaternary glaciations and of using isotopic and geochemical indicators in polar ice-cores for the study of global climatic variability and environmental changes back in time. Over the years, the division's main research areas have been expanded to hydrogeology, polar paleoclimatology and environmental change, high-resolution stable isotope Paleozoic chemostratigraphy as well as CO_2 capture and storage.

The division holds a modern research facility with an international client base, incl. two Thermo Fisher Delta V Advantage and DeltaV Plus IRMS, with three sample preparation lines (GasBench II for δ18O and δ13C from carbonate rocks; FlashEA 1112 for δ13C and δ15N analyses from organic matter and TC/EA High Temperature Conversion/Elemental Analyzer), a Picarro L2120-I laser spectrometer for water δ18O ja δ 2H analyses and Thermo Dionex ion chromatograph ICS-1100. Through our international partners, including the IAEA, we have access, if needed, to the unique equipment for water noble gas composition and/or isotope composition analyses.



In 2020, the division's research was carried out on Estonian Research Council project PUTJD920, several international projects (including the IAEA, EU Horizon 2020) and contracted projects:

- PUTJD920, *The geochemical evolution and travel times of agricultural nitrate pollution in groundwater and its influence on the status of groundwater dependent surface water bodies* (2020–2022).
- VA16034, "*Application of long lived Radionuclides for characterizing and dating the groundwaters and brines in the Baltic Artesian Basin*" (2016–2021).
- VFP15013, "*PolarNet-Connecting Science with Society*" (2015–2020).
- LMIN18067, "*Hydrogeological investigation of reasons and the area of distribution of increased content of nitrates and pesticides within the Silurian-Ordovician Pandivere groundwater body in the East-Estonian cachment*" (2018–2020).

SELECTED PUBLICATIONS

Stankevica, K.; Vincevica-Gaile, Z.; Klavins, M.; Kalnina, L.; Stivrins, N.; Grudzinska, I.; Kaup, E. (2020). Accumulation of metals and changes in composition of freshwater lake organic sediments during the Holocene. Chemical Geology, 539, #119502.

Vallner, L., Ivask, J., Marandi, A., Vaikmäe, R., Raidla, V., Raukas, A. (2020). Transient 3D simulation of 18O concentration by codes MODFLOW-2005 and MT3DMS in a regional-scale aquifer system: an example from Estonian Artesian Basin. Estonian Journal of Earth Sciences, 69 (3), 154–174.

Chen, J.; Haldorsen, S.; Vaikmäe, R. (2020). Groundwater and global palaeoclimate signals. Quaternary International, 547, 1–6.

MINERAL RESOURCES AND APPLIED GEOLOGY RESEARCH GROUP

Head: Researcher RUTT HINTS, rutt.hints@taltech.ee

Members: Alvar Soesoo, Tarmo Kiipli, Heidi Elisabet Soosalu, Toivo Kallaste, Kristjan Urtson

Doctoral students: Siim Pajusaar, Sophie Jane Marie-Pascale Huguette Graul

TOPICS AND COMPETENCES

KEYWORDS: mineral resources, geochemistry, mineralogy, black shales, phosphorites

The main study area of the research group is perspective mineral resources of Estonia containing raw material listed as critical by EU. The research issues are related to their genesis, distribution and valorisation. The group's core competencies are related to geochemistry and mineralogy of organic-rich mineral resources, including metalliferous black shales and oil shales. Besides that, several R&D projects focused on various aspects of the geology of sedimentary rocks and ore deposits have been conducted during last few years. The collaborative interdisciplinary research in areas such as valorisation of mineral resources and the recycling of mine wastes is based on group's extensive research experience in areas such as X-ray powder diffraction. From other R&D initiatives, seismic monitoring in the Baltic region is an important separate field of research for the group.

The research group manages the lab of physical methods equipped with analytical instruments for ICP-MS, XRF, and XRD analyses, allowing the complex set of geochemical, mineralogical, and petrological studies to be carried out. The quality of laboratory analyses is assured through participation in the proficiency testing program of the International Association of Geoanalysts. Last year five new in-house reference samples for Estonian phosphorite and black shale samples were developed. Seismic monitoring of the Estonian territory and the surrounding areas was performed during 2020 using data from ten seismic stations.

SELECTED PUBLICATIONS

Kiipli, T.; Hints, R.; Kallaste, T.; Nielsen, A. T.; Pajusaar, S.; Schovsbo, N. H. (2020). Tectono-magmatic division of the Late Ordovician (Sandbian) volcanism at the south-western margin of Baltica using immobile trace elements: Relations to the plate movements in the Iapetus Palaeo-Ocean. Geological Journal, 55 (7), 5155–5165.

Kiipli, E.; Kiipli, T. (2020). Hirnantian sea-level changes in the Baltoscandian Basin, a review. Palaeogeography Palaeoclimatology Palaeoecology, 540, 109524.

Soesoo, Alvar; Vind, Johannes; Hade, Sigrid (2020). Uranium and Thorium Resources of Estonia. Minerals, 10 (9), 1–25.

Saukko, Anna; Ahläng, Christian; Nikkilä, Kaisa; Soesoo, Alvar; Eklund, Olav (2020). Double Power-Law in Leucosome Width Distribution: Implications for Recognizing Melt Movement in Migmatites. Frontiers in Earth Science, 8, 1–14.10.3389/feart.2020.591871.

MINING AND MINERAL RESOURCES RESEARCH GROUP

Head: Professor MICHAEL HITCH, michael.hitch@taltech.ee

Members: Mall Orru, Veiko Karu, Erik Väli, Sander Kanter, Karin Robam

Post-doctoral Researcher: Sanoop Kumar Puthiya Veetil

Doctoral students: Andrus Paat, Nthati Lillian Monei, Tõnu Tomberg

TOPICS AND COMPETENCES

KEYWORDS: mining engineering; circular economy; virtual and augmented reality

The technical competencies of the members of the Mining group include: (1) mining engineering and design; (2) mineral economics; (3) mining environmental impact and remediation; (4) mine waste management; (5) circular economic and social sustainability; (6) quantitative resource evaluation and mining geochemistry.

The infrastructure available to the Mining group includes, a Mining Conditions laboratory, specialised orebody/geological modelling software, and physical and virtual simulation tools (e.g., AR Sandbox, VR Headsets etc.).

The more prominent R&D projects in 2020 were:

- RESTA23, *Quality and properties of Estonian shelly phosphorite as a potential source for phosphorus and rare earth elements and its complex processing technologies* (2020–2023)
- VFP20064, *Sustainable Management in Extractive industries* (2020–2023)
- VA19027 "*MiReBooks. Mixed Reality Handbooks for Mining Education*" (2019–2021)

SELECTED PUBLICATIONS

Veetil, S.P., Hitch, M. (2020). Recent developments and challenges of aqueous mineral carbonation: a review. International Journal of Environmental Science and Technology, 17(10), 4359–4380.

Hitch, M., Lytle, M., Tost, M. (2020). Social licence: power imbalances and levels of consciousness–two case studies. International Journal of Mining, Reclamation and Environment, 34(4), 238–246. DOI: 10.1080/17480930.2018.1530582

Lesser, P., Gugerell, K., Poelzer, G., Hitch, M., Tost, M. (2020). European mining and the social license to operate. Extractive Industries and Society, 787. DOI: 10.1016/j.exis.2020.07.021

QUATERNARY GEOLOGY RESEARCH GROUP

Head: Professor SIIM VESKI, siim.veski@taltech.ee

Members: Tiiu Alliksaar, Atko Heinsalu, Anneli Poska, Triin Reitalu, Jüri Vassiljev, Leeli Amon-Veskimeister, Normunds Stivrinš, Merlin Liiv, Maret Palusalu

Postdoctoral researcher: Olga Lisitsyna

Doctoral students Ansis Blaus, Vladimir Karpin, Anna Lanka, Varvara Bakumenko

TOPICS AND COMPETENCES

KEYWORDS: geoecology, paleoclimate and environment, paleodiversity, Baltic Sea, chronology

The main research aim of the Quaternary group is reconstruction of past ecosystems, vegetation history, climate and environmental change, both natural and manmade, at high temporal resolution during the last 15,000 years through multidisciplinary and multiproxy studies of natural archives such as lake, bog and marine sediments. The group focuses on better understanding the interactions between Quaternary geo- and biosphere processes, in particular, addressing the following:

- Paleoclimate variation using multi-proxy analyses (such as pollen and chironomid based inference models);
- Paleobiodiversity (terrestrial and aquatic), functional and phylogenetic diversity dynamics and relationships with climate and environmental changes;
- Past human impact upon landscapes, waterbodies, vegetation structure and land-cover;
- Postglacial retreat of the ice sheet;
- Shoreline displacement of the Baltic Sea.

The group holds a leading position in Quaternary and palaeoecological studies in the Baltic realm. The main strengths of the group's work are related to the high-resolution paleo-datasets of the geographically and climatically constrained area.

The group hosts several labs of biostratigraphy, dating, geochemistry, granulometry, and takes use of the mass spectrometry lab for stable isotope geochemistry.

SELECTED PROJECTS

- PRG323 "*Tracking the time-lags of species response to environmental change using palaeo-proxy data and modelling*" (TrackLag) (2019–2023)
- LEP19003LG (RITA1/02-60-04) "*Innovative approaches to monitoring and assessing marine environment and nature values in Estonian sea area*" (2019–2021)
- PUT1173 "*Functional and phylogenetic diversity in sedimentary pollen and plant macrofossil data – evaluation of methods and associations with past climate and human impact*" (2016–2020)"
- VA19029 "*Paleoenvironmental changes recorded by Estonian and Polish postglacial sediment*" (2019–2021)"

SELECTED PUBLICATIONS

Blaus, A.; Reitalu, T.; Amon, L.; Vassiljev, J.; Alliksaar, T.; Veski, S. (2020). From bog to fen: palaeoecological reconstruction of the development of a calcareous spring fen on Saaremaa, Estonia. Vegetation History and Archaeobotany, 29, 373–391.

Amon, L.; Blaus, A.; Alliksaar, T.; Heinsalu, A.; Lapshina, E.; Liiv, M.; Reitalu, T.; Vassiljev, J.; Veski, S. (2020). Postglacial flooding and vegetation history on the Ob River terrace, central Western Siberia based on the palaeoecological record from Lake Svetlenkoye. The Holocene, 1–14.

Seidl, R.; Honkaniemi, J.; Aakala, T.; Aleinikov, A.; Angelstam, P.; Bouchard, M.; Boulanger, Y.; Burton, P. J.; De Grandpré, L.; Gauthier, S.; Hansen, W. D.; Jepsen, J. U.; Jõgiste, K.; Kneeshaw, D. D.; Kuuluvainen, T.; Lisitsyna, O.; Makoto, K.; Mori, A. S.; Pureswaran, D. S.; Shorohova, E. ... Senf, C. (2020). Globally consistent climate sensitivity of natural disturbances across boreal and temperate forest ecosystems. Ecography 43(7), 967–978.

DEPARTMENT OF MARINE SYSTEMS

Director: Senior Researcher
RIVO UIBOUPIN,
rivo.uiboupin@taltech.ee

MAIN FIGURES 2020

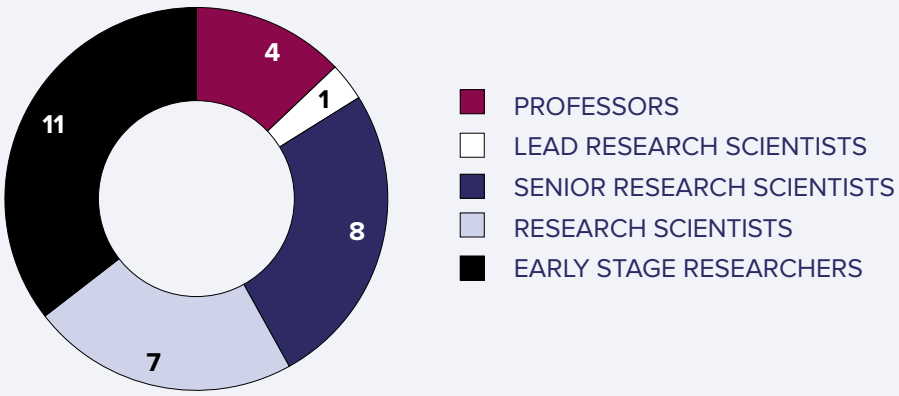
(as of Dec. 31, 2020)

31	Academic staff	Incl. 4 professors, 27 researchers	
14	Doctoral students	1	Defended doctoral dissertations
28	Scientific publications*		

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 2 RESEARCH GROUPS:

- **RESEARCH GROUP ON DYNAMICS OF GRADIENT SYSTEMS.**
  Head: Professor URMAS LIPS, urmas.lips@taltech.ee
- **RESEARCH GROUP ON MODELLING AND REMOTE SENSING OF MARINE DYNAMICS.**
  Head: Professor URMAS RAUDSEPP, urmas.raudsepp@taltech.ee



RESEARCH GROUP ON DYNAMICS OF GRADIENT SYSTEMS

Head of the research group: Professor URMAS LIPS, urmas.lips@taltech.ee

Members: Inga Lips, Ants Erm, Taavi Liblik, Madis-Jaak Lilover, Germo Väli, Ivan Kuprijanov, Kai Künnis-Beres, Peeter Laas, Sirje Sildever, Irina Suhhova, Jaan Laanemets, Villu Kikas, Natalja Buhhalko, Fred Buschmann, Silvie Lainela, Kati Lind, Maarja Lipp, Anne Aan, Enriko Siht

Doctoral students: Natalja Kolesova, Nelli Rünk, Kai Salm, Oliver Samlas, Stella-Theresa Stoicescu, Arun Mishra

TOPICS AND COMPETENCES

KEYWORDS: stratification, hypoxia, submesoscale processes, micro litter, eDNA, innovative observing and analysis methods

The research is focused on multiscale physical processes that influence the biogeochemical cycles of substances and control the transport and mixing in the stratified Baltic Sea, including the hypoxic layer and redoxcline. The main focus is on sub-mesoscale processes, their local and large-scale impact on water and matter exchange between the sub-basins, coastal and open sea and vertically between the water layers that influence the dynamics of the spring bloom, mixotrophic organisms and carbon fluxes. Marine ecology studies focus on pelagic and benthic primary producers, benthic invertebrates, their dynamics and role, and impact of micro-litter and hazardous substances on marine biota. Marine ecology studies focus on pelagic and benthic primary producers, benthic invertebrates, their dynamics and role, and the impact of micro-litter and hazardous substances on marine biota.

METHODS

The main method is field studies using the research vessel Salme and autonomous instruments based on new technologies, including a unique bottom-mounted profiling station and an underwater glider. Numerical modeling is used for process-oriented studies. For the water sample analyses flow-cytometry, spectroscopy, microscopy, and metagenomics are used.

SELECTED PROJECTS

- PRG602, *The role of sub-mesoscale processes in structuring and large-scale dynamics of oceanographic fields* (2020–2024)
- MOBTP160, Phytoplankton response to a changing nutrient regime in the sea: tracing silica adaptation in living resting stages from sediment archives (2020–2022)

SELECTED ARTICLES

Liblik, T.; Väli, G.; Lips, I.; Lilover, M.-J.; Kikas, V.; Laanemets, J. (2020). The winter stratification phenomenon and its consequences in the Gulf of Finland, Baltic Sea. Ocean Science, 16 (6), 1475–1490.

Liblik, T.; Lips, U. (2019). Stratification has strengthened in the Baltic Sea – an analysis of 35 years of observational data. Frontiers in Earth Science, 02 July 2019.

Sildever, S.; Ribeiro, S.; Mertens, K. N.; Andersen, T. J.; Moros, M.; Kuijpers, A. (2019). Reconstructing salinity changes and environmental influence on dinoflagellate cysts in the central Baltic Sea since the late 19th century. Estuarine, coastal and shelf science, 219, 384–394.

RESEARCH GROUP ON MODELLING AND REMOTE SENSING OF MARINE DYNAMICS

Head of the research group: Professor URMAS RAUDSEPP, urmas.raudsepp@taltech.ee

Members: Victor Alari, Irina Didenkulova, Jüri Elken, Tarmo Kõuts, Priidik Lagemaa, Ilja Maljutenko, Sander Rikka, Liis Sipelgas, Rivo Uiboupin, Kaimo Vahter, Svetlana Verjovkina, Alina Lerner

Doctoral students: Ahmed Alkarory Ahmed Abdalazeez, Age Arikas, Laura Siitam, Siim Pärt, Mariliis Kõuts, Mihhail Zujev, Mari-Liis Kasemets, Nikon Vidjajev

TOPICS AND COMPETENCES

KEYWORDS: physical oceanography, atmospheric boundary layer, remote sensing, renewable energy

RESEARCH TOPICS

- Research on cause-response relationships of large-scale circulation patterns and biogeochemical fields in the Baltic Sea;
- Development and operational implementation of marine monitoring methods, which are based on satellite and airborne remote sensing as well as on bio-optical measurements: marine physics, water quality, sea ice, atmospheric processes, etc.;
- Bulk processing and statistical analysis of large remote sensing datasets using machine learning methods for process studies in marine research;

- Development, testing and implementation of real time marine operational measurement systems;
- Development of coupled circulation-wave-ice-atmospheric models for climate and process oriented studies, near real-time marine services and reanalyses;
- Sea and ocean hazards in the coastal zone, including tsunami, rogue waves, extreme storms and storm surges, ship generated waves, internal waves, their dynamics in the coastal zone and impact on coast.

SELECTED PROJECTS

- VA18004, *Copernicus Marine Environment Monitoring Service's at Baltic Monitoring and Forecasting Centre* (2018–2021)
- PUT1378, *Extreme wave events and their impacts in coastal waters* (2017–2020)
- LEP19008LM (RITA1/02-52-04), *Use of remote sensing data for elaboration and development of public services* (2019–2020)
- PSG22, *Interplay between waves and seasonal ice cover: observational and modelling study in the Baltic Sea* (2018–2021)

SELECTED ARTICLES

Björkqvist, J.-V.; Rikka, S.; Alari, V.; Männik, A.; Tuomi, L.; Pettersson, H. (2020). Wave height return periods from combined measurement–model data: A Baltic Sea case study. Natural Hazards and Earth System Sciences Discussions, 3593–3609

Liibusk, A.; Kall, T.; Rikka, S.; Uiboupin, R.; Suursaar, Ü.; Tseng, K.-H. (2020). Validation of Copernicus Sea Level Altimetry Products in the Baltic Sea and Estonian Lakes. Remote Sensing, 12 (24), 4062.

Ytreberg, E.; Eriksson, M.; Maljutenko, I.; Jalkanen, J.-P.; Johansson, L.; Hassellov, I.-M.; Granhaga, L. (2020). Environmental impacts of grey water discharge from ships in the Baltic Sea. Marine Pollution Bulletin, 152, #110891.

SCHOOL OF BUSINESS AND GOVERNANCE

SCHOOL OF BUSINESS AND GOVERNANCE

Dean: Professor ENN LISTRA

e-mail: enn.listra@taltech.ee

Vice-Dean for Research: Professor TIINA RANDMA-LIIV

e-mail: tiina.randma-liiv@ttu.ee

MAIN FIGURES 2020

(as of Dec. 31, 2020)

169 Academic staff Incl. 32 professors 48 researchers

82 Doctoral students 11 Defended doctoral dissertations

163 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

DEPARTMENTS

DEPARTMENT OF BUSINESS ADMINISTRATION

Director: MARI AVARMAA, mari.avarmaa@taltech.ee

DEPARTMENT OF ECONOMICS AND FINANCE

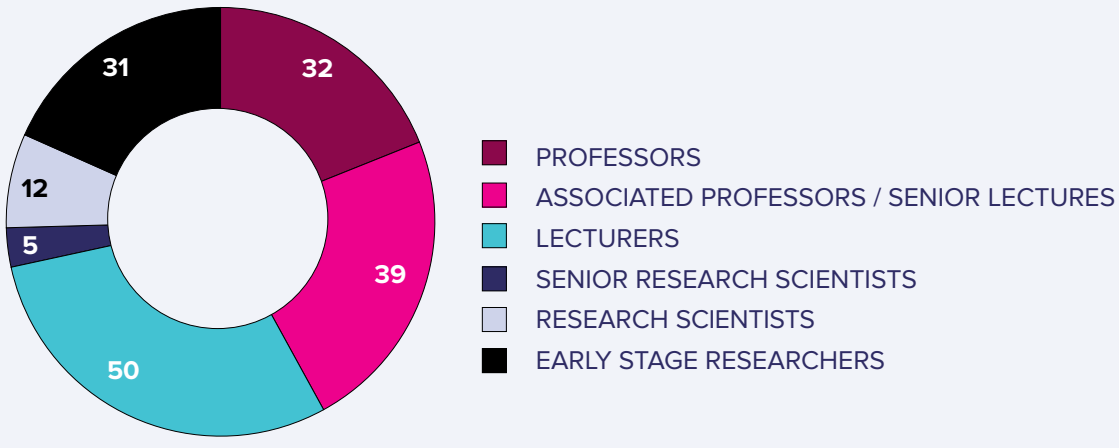
Director: Professor KADRI MÄNNASOO, kadri.mannasoo@taltech.ee

DEPARTMENT OF LAW

Director: Professor TANEL KERIKMÄE, tanel.kerikmae@taltech.ee

RAGNAR NURKSE DEPARTMENT OF INNOVATION AND GOVERNANCE

Director: Professor ERKKI KARO, erkki.karo@taltech.ee



DEPARTMENT OF BUSINESS ADMINISTRATION

Director: MARI AVARMAA,
mari.avarmaa@taltech.ee

MAIN FIGURES 2020

(as of Dec. 31, 2020)

65 Academic staff — Incl. 10 professors, 13 researchers

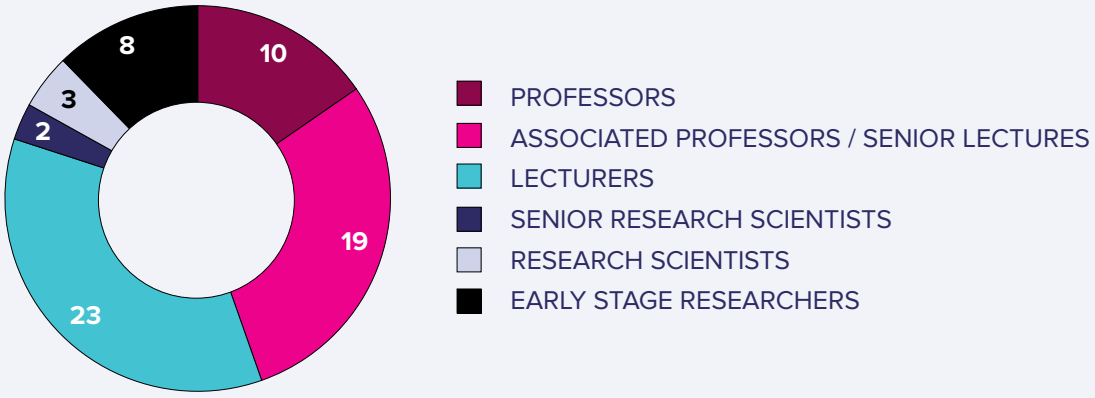
31 Doctoral students — 4 Defended doctoral dissertations

57 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 5 RESEARCH GROUPS:

- **ENTREPRENEURSHIP RESEARCH GROUP.**
  Head: Professor SUSANNE DURST, susanne.durst@taltech.ee
- **ACCOUNTING RESEARCH GROUP.**
  Head: Professor SEFIK ISTEMIHAN DEMIRAG, istemi.demirag@taltech.ee
- **MARKETING RESEARCH GROUP.**
  Head: Professor EDWARD RASHKOV KASABOV, edward.kasabov@taltech.ee
- **ORGANISATION MANAGEMENT RESEARCH GROUP.**
  Head: Professor SUSANNE DURST, susanne.durst@taltech.ee
- **SUSTAINABLE VALUE CHAIN MANAGEMENT RESEARCH GROUP.**
  Head: Professor WOLFGANG GERSTLBERGER, wolfgang.gerstlberger@taltech.ee



ENTREPRENEURSHIP RESEARCH GROUP

Head: Professor SUSANNE DURST, susanne.durst@taltech.ee

Members: Antti Ainamo, Ene Kolbre, Urve Venesaar, Juhan Teder, Juhan Teder, Sirje Ustav, Merli Reidolf, Lasse Torkkeli (Visiting Researcher)

Doctoral students: Marianne Kallaste, Martin Toding, Airi Noppel, Akaki Tartarashvili, Merle Küttim

TOPICS AND COMPETENCES

KEYWORDS: entrepreneurship education, entrepreneurship competencies, entrepreneurial growth, knowledge management, internationalization of entrepreneurial firms, rural entrepreneurship, innovation management, social entrepreneurship, entrepreneurial ecosystem, startups, born globals, university ecosystem

The Entrepreneurship research group brings together academic scholars from diverse backgrounds to investigate how new as well as established entrepreneurial organizations develop and apply their entrepreneurial competencies and organizational knowledge in their quest to exploit present and future business opportunities in a sustainable way.

The purpose of the Entrepreneurship research group is to extend the scientific body of knowledge concerning the broad field of entrepreneurship – in the fields of entrepreneurship education, internationalization of entrepreneurial firm, knowledge management, and innovation management in particular - and to contribute to practice. The group's interest is in investigating how entrepreneurial organizations or individual actors transform their skills and capacities into innovative outputs to contribute to sustainable (business) development.

Given the relevance of entrepreneurship for Estonia, the Baltic region, and the European Union, research efforts regarding entrepreneurship education aim at increasing the employability of graduates in the labour market but also at increasing entrepreneurship and new venture creation, thus developing entrepreneurial mindsets and competencies among broader sections of populations and facilitating and strengthening entrepreneurial ecosystems.

SELECTED ARTICLES

Kalantaridis, C., & Küttim, M. (2020). University Ownership and Information about the Entrepreneurial Opportunity in Commercialisation: A Systematic Review and Realist Synthesis of the Literature. The Journal of Technology Transfer. DOI: 10.1007/s10961-019-09757-6.

Lehtonen, M. J., Ainamo, A., & Harviainen, J. T. (2020). The four faces of creative industries: visualising the game industry ecosystem in Helsinki and Tokyo. Industry and Innovation,27(9), 1062-1087. DOI: 10.1080/13662716.2019.1676704.

Tsvetkova, D., Bengtsson, E., & Durst, S. (2020). Maintaining Sustainable Practices in SMEs: Insights from Sweden. Sustainability, 12, 10242.

Durst, S., Temel, S., & Hinteregger, C. (2020). Influence of network partners on SMEs' innovation activities. Int. J. Business Environment, 11(4), 369–389.

ACCOUNTING RESEARCH GROUP

Head: Professor SEFIK ISTEMIHAN DEMIRAG, istemi.demirag@taltech.ee

Members: Mari Avarmaa, Natalja Gurvitš-Suits, Tarmo Kadak, Paavo Siimann, Vaiva Kiaupaite-Grušniene, Kaidi Kallaste, Dmitri Zdobnõh

Postdoctoal researcher: Anup Kumar Saha

Doctoral students: Xiaosong Zheng, Hla Thel Phyu, Maria Vassiljev

TOPICS AND COMPETENCES

KEYWORDS: accountability, governance, corporate social reporting and sustainability, zero carbon emissions, cash-flow accounting, performance management and public-private partnerships, impacts of Covid-19

The accounting group is active in a number of related research fields, using both quantitative and qualitative research methods and focusing on significant current issues facing our society such as climate change, Covid-19 pandemic, Security of Food Supply Chains, Carbon emissions.

The key research themes the group uses are accountability, governance, sustainability and control, which are in line with the university's research priority areas of Future Governance. The research is multi- and interdisciplinary, and where appropriate the group is developing critical research skills and methods to explore the above research themes.

The group has active and growing links with professional accounting institutions both in Estonia and worldwide and is also actively consulting Estonian government institutions (Ministries of Finance, Defence etc.) on their strategic development and training programmes of their members.

SELECTED PUBLICATIONS

Saha, A.K., Al-Shaer, H., Dixon, R., & Demirag. I. (2020). Determinants of Carbon Emission Disclosures and UN Sustainable Development Goals: The Case of UK Higher Education Institutions. Australian Accounting Review.

Ahmad, S., Connolly, C., & Demirag, I. (2020). Towards an understanding of strategic control at a distance in public service delivery. Accounting, Auditing and Accountability Journal.

Tapver, T., Laidroo, L., & Gurvitš-Suits, N. A. (2020). Banks' CSR reporting – do women have a say? Corporate Governance, 20(4), 639–651.

Gavrilova, V., & Gurvitsh-Suits, N. A. (2020). Contemporary Innovation Challenges – Future of Adoption Artificial Intelligence: Case of Estonia. European Integration Studies, 1(14), 217–225.

MARKETING RESEARCH GROUP

Head: Professor EDWARD RASHKOV KASABOV, edward.kasabov@taltech.ee

Members: Katrin Paadam, Linda Hollebeek, Anu Leppiman, Liis Ojamäe, Oliver Parts, Iivi Riivits-Arkonsuo, René Arvola, Jana Kukk, Kristel Kaljund

Visiting lecturer: Aleksandr Michelson

Doctoral students: Helen Vaikma, Naghmeh Nik Bakhsh, Viktorija Prilenska

TOPICS AND COMPETENCES

KEYWORDS: service marketing, urban studies, rural studies, customer engagement, consumer compliance

Research within the group spans five separate sets of projects, which are closely aligned with novel learning and teaching.

Consumption is a significant topic incorporating consumer behaviour theorisations with a focus on the experience pyramid model, consumer journeys, cosmopolitanism, consumer ethnocentrism, ethical and sustainable consumption. Work on experience service design complements investigations into the digital divide and ageism in marketing. Projects include the Experience Marketing Studies focused on consumption in experience design and holistic customer experiences.

In services and relationship marketing, the investigations focus on customer service-related engagement, digital value co-creation, disciplining and compliance-based interactions between providers and consumers. Empirical and conceptual studies from all four sub-streams of this research area have appeared in top journals in the area, and the Adjunct professor L. Hollebeek leading the area has attracted international recognition and awards, including Clarivate Highly Cited Researcher, SERVSIG Emerging Scholar Award, and Stanford University's Top 2% of Researchers worldwide. Critical examinations of customer-provider relationships and service provision have produced new, state-of-the-art theories complementing research on confusion marketing. The sub-stream of service design is focused around the new dLab initiative, building upon existing and forging new collaborations, including through the collaborative Service Design Conference.

Urban and residential studies support a variety of projects theorising the changing the nature of contemporary urban realities, relationships between spatial processes and social processes. Researchers are currently engaged in integrative analyses of processes in urban residential and public spaces, by applying interdisciplinary perspectives, which adopt sociological, architectural, civil engineering, planning, and business studies sensibilities.

Current work on digital futures of rural areas across the EU complements work on entrepreneurship and entrepreneurial marketing through digitalisation in rural and peripheral locations. This stream builds upon work on regional competitiveness, cluster-based strategy and development, high technology birth and growth, entrepreneurship, regional and rural development.

SELECTED ARTICLES

Hollebeek, L., Kumar, V., & Srivastava, R. (2020). From Customer-, to Actor-, to Stakeholder Engagement: Taking Stock, Conceptualization, and Future Directions. Journal of Service Research.

Khan, I., Hollebeek, L.D., Mobin F., Islam, J., & Riivits-Arkonsuo, I. (2020). Customer experience and commitment in retailing: Does customer age matter? Journal of Retailing and Consumer Services, 57.

Kasabov, E. (2020). Ignored, Silenced, Caricatured, Ridiculed, Patronised, and Hijacked: What Next for a post-Populist, post-Gilded-Age Countryside? Journal of Rural Studies.

Hollebeek L., Smith D., Kasabov E., Hammedi W., Warlow A., & Clark M. (2020). Customer brand engagement during service lockdown. Journal of Services Marketing.

ORGANISATION MANAGEMENT RESEARCH GROUP

Head: Professor SUSANNE DURST, susanne.durst@taltech.ee

Members: Mike Franz Wahl, Marina Järvis, Karin Reinhold, Liina Randmann, Maris Zernand-Vilson, Merle Ojasoo, Aive Pevkur, Virve Siirak, Piia Tint, Tiiu Kamdron, Sigrid Kontus, Tarmo Koppel, Kati Tillemann

Doctoral students: Velli Parts, Marii Haak, Georgi Hrenov, Valeria Kiisk, Karin Kuimet, Mari Kurashvili, Jaana Sepp, Olga Tsenter, Olga Tšernikova, Inese Vilcan, Lidia Davies, Samuel Foli, Yurii Radchenko

TOPICS AND COMPETENCES

KEYWORDS: leadership, well-being, responsible and ethical organizational development, leader-follower relationship, strategic management, knowledge and innovation management, risk management, HRM, change management, occupational health, organizational psychology, occupational safety, digital transformation

The research group is active in a number of research fields related to organisation and management, using different theoretical lenses and research methods. The primary research interests can be grouped under leadership, well-being and responsible, ethical organizational development and sustainability management.

The group uses different theoretical lenses and research methods – bringing together members from diverse backgrounds – to investigate how established and new organizations continuously develop their organizational resources and capabilities to be prepared for present and future business, societal challenges and opportunities in a sustainable way.

The group has access to a number of internationally renowned researchers working on organization and management, occupational safety and related topics and continuously works on the extension of this network.

The purpose of the group is to extend the scientific body of knowledge concerning the related fields of organization and management and to contribute to practice, by presenting opportunities and challenges confronting Estonian organizations and beyond. The overall interest of the group is to investigate how organizations transform their knowledge and access to new digital solutions into innovative outputs to achieve and maintain sustainable business development. The group members have a broad portfolio of expertise gained from working with a variety of national and international private and public organizations. The aim is to take advantage of it and use this expertise to develop it further for the greater good.

SELECTED ARTICLES

Durst and Zieba (2020). Knowledge risks inherent in business sustainability. Journal of Cleaner Production. Volume 251, 1 April 2020, 119670.

Shujahat, M., Wang, M., Ali, M., Bibi, A., Razzaq, S., & Durst, S. (2020). Idiosyncratic job-design practices for cultivating personal knowledge management among knowledge workers in organizations. Journal of Knowledge Management.

Durst, S., Heinze, I., Henschel, T., & Nawaz, N. (2020). Unlearning: a systematic literature review. Int. J. Business and Globalisation, 24(4), 472–495.

Durst, S., & Henschel, T. (2020). Knowledge Risk Management. From Theory to Praxis, Springer, Cham.

SUSTAINABLE VALUE CHAIN MANAGEMENT RESEARCH GROUP

Head: Professor WOLFGANG GERSTLBERGER, wolfgang.gerstlberger@taltech.ee

Members: Gunnar Prause, Üllas Ehrlich, Tarmo Kalvet, Marek Tiits, Jelena Hartšenko, Tarvo Niine, Eunice Omolola Olaniyi, Olha Prokopenko, Tarmo Tuisk

Post-doctoral Researcher: Yassine Bakkar

Doctoral students: Ricardo Ferraz Raats, Vera Gerasimova, Tea Nõmmann, Jana Peterson, Erkki Pärna, Hosein Bagheri, Mihhail Kirejev, Elisabeth Kraut

Visiting doctoral students: Tiina Viin, Robert Philipp, Sina Atari Jabar Zadeh, Erika Müller

TOPICS AND COMPETENCES

KEYWORDS: sustainable business development, operations management, sustainable innovation, environmental economics, green economy, smart supply chain management, organizational learning

Sustainable value chain management deals with tasks and processes aiming at preparing and supporting the implementation of growth opportunities and innovations within the constraints of a firm's strategy. Thus, sustainable value chain management is focused on preparing, planning, implementing and evaluating a continuous stream of potential innovations.

The research group investigates potential growth and innovation opportunities within and between organizations by using interdisciplinary approaches from business, environmental economics, operations and innovation management, engineering, IT, design and social sciences in the context of the European agenda for smart, sustainable and inclusive growth. Consequently, the research group deals with innovations and growth opportunities in the areas of digitalization, smart production and Industry 4.0, Big Data, strategic alliances and networks as well as industrial strategy and competitiveness studies.

The research work usually takes place in the framework of European and/or national projects and in the context of the university-business cooperation.

SELECTED PUBLICATIONS:

Visintainer Lerman, L., Gerstlberger, W., Ferreira Lima, M., & Frank, A. G. (2020). How governments, universities, and companies contribute to renewable energy development? A municipal innovation policy perspective of the triple helix. Energy Research & Social Science, 71, 101854.

Tatar, M., Kalvet, T., & Tiits, M. (2020). Cities4ZERO approach to foresight for fostering smart energy transition on municipal level. Energies, 13(14), 3533.

Olaniyi, E. O., & Prause, G. (2020). Investment Analysis of Waste Heat Recovery System Installations on Ships' Engines. Journal of Marine Science and Engineering, 8(10), 811.

Durst, S., & Gerstlberger, W. (2020). Financing Responsible Small- and Medium-Sized Enterprises: An International Overview of Policies and Support Programmes. Journal of Risk and Financial Management, 14(1), 10.

DEPARTMENT OF ECONOMICS AND FINANCE

Direktor: Professor KADRI MÄNNASOO,
kadri.mannasoo@taltech.ee

MAIN FIGURES 2020

(as of Dec. 31, 2020)

35 Academic staff — Incl. 6 professors, 8 researchers

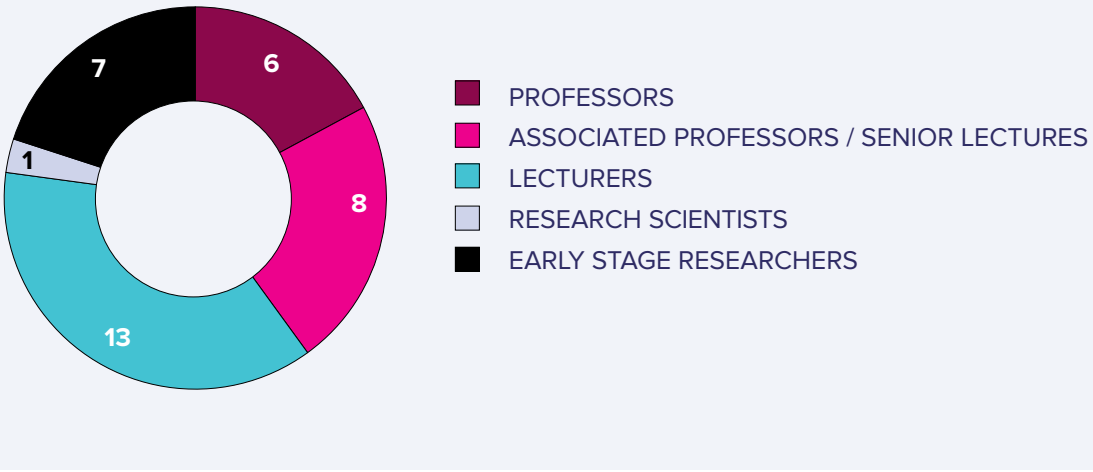
17 Doctoral students — 3 Defended doctoral dissertations

34 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 4 RESEARCH GROUPS:

- **COMPANIES' PRODUCTIVITY, INVESTMENTS AND EXPORT COMPETITIVENESS.**
  Head of the research group: Professor KADRI MÄNNASOO, kadri.mannasoo@taltech.ee
- **ECONOMIC PERFORMANCE: INTEGRATION, GOVERNANCE AND POLICY.**
  Head of the research group: Professor KARSTEN MICHAEL STÆHR, karsten.staehr@taltech.ee
- **FINANCE AND THE REAL ECONOMY: FINANCIAL BEHAVIOUR, MARKETS, AND COMPETITIVENESS.**
  Head of the research group: Associate Professor LAIVI LAIDROO, laivi.laidroo@taltech.ee
- **KNOWLEDGE INTENSITY AND SOCIO-ECONOMIC INCLUSION FOR PROMOTING SUSTAINED DEVELOPMENT.**
  Head of the research group: Professor AARO HAZAK, aaro.hazak@taltech.ee



COMPANIES' PRODUCTIVITY, INVESTMENTS AND EXPORT COMPETITIVENESS

Head of the research group: Professor KADRI MÄNNASOO, kadri.mannasoo@taltech.ee

Members: Juan Carlos Cuestas, Hakan Berber, Simona Ferraro, Jelena Matina, Kirsti Rumma

Post-doctoral Researcher: Rachatar Nilavongse

Doctoral students: Heili Hein, Kaido Kepp, Katriin Ranniku, Svetlana Ridala, Raul Ruubel, Artjom Saia, Helery Tasane, Risto Uuk

TOPICS AND COMPETENCES

KEYWORDS: Keywords: productivity, investments, innovation, research and development, export, digital economy

The line of research pursues micro-level or regional comparative empirical studies. The main research focuses are related to capital and labour productivity, innovation, investments and competitiveness for explaining the economic growth in small, open and export-oriented economies. The aim is to investigate the drivers and obstacles of companies' productivity enhancing investments into adoption of new technologies and production processes, training of employees, R&D and innovation.

The line of investigation seeks for a better understanding on regional convergence issues while integrating the spatial aspects and institutional factors into the research framework. The research aims at new evidence on digital innovation and digital empowerment and on their effect on productivity growth and economic welfare. The research employs advanced econometric techniques and contributes to policy making while providing evidence based quantitative estimations on the impact of macro- and business-environmental factors and companies' decisions and incentives that have an effect on productivity, innovation and export competitiveness.

SELECTED PROJECTS

- LMIN19055, *Evaluation of entrepreneurship and innovation support measures of the 2014–2020 EU cohesion policy funds* (2019–2020).
- VFP16057 (H2020), "*Institutions for Knowledge Intensive Development: Economic and Regulatory Aspects in South-East Asian Transition Economies*" (2017–2020).
- VERT19042, *The Economic and Legal Evaluation of Digital Ecosystems in the EU (ELEDEEU)* (2019–2022).
- VFP20046 (H2020), *Individual Behaviour and Economic Performance: Methodological Challenges and Institutional Context* (IBEP) (2020–2023)

SELECTED ARTICLES

Männasoo, K.; Meriküll, J. (2020). Credit constraints and R&D over the boom and bust: Firm-level evidence from Central and Eastern Europe. Economic Systems, 44 (2), 1–14.

Ridala, S. (2020). Language skills and labour market returns: A meta-regression analysis. Language Problems and Language Planning, vol. 44, no. 2, pp. 200–241.

Faria, J. R.; Cuestas, J. C.; Gil-Alana, L.; Mourelle, E. (2020). Self-employment by gender in the EU: convergence and clusters. Empirica.10.1007/s10663-020-09494-2.

ECONOMIC PERFORMANCE: INTEGRATION, GOVERNANCE AND POLICY

Head of the research group: Professor KARSTEN MICHAEL STÆHR, karsten.staehr@taltech.ee

Members: Tairi Rõõm, Merike Kukk, Natalia Levenko, Signe Rosenberg

Postdoctoral researcher: Rachatar Nilavongse

Doctoral students: Kersti Harkmann, Krista Kollo, Nicolas Reigl, Orsolya Soosaar, Liina Malk, Katri Urke

TOPICS AND COMPETENCES

KEYWORDS: macroeconomics, international integration, international finance, public economics, labour economics, household economics, economic governance

The research group studies contemporary and policy-relevant issues that affect the performance of economies under rapid change. The group seeks to identify key relationships at the macroeconomic and microeconomic levels, to ascertain new policy challenges, and to devise policy measures to improve economic performance. The senior staff members work individually, together with other members of the group or with researchers outside the group. The research is always applied and empirical as well as theoretical. The research typically uses advanced econometric methodologies, large datasets or computer simulation. The senior group members all have doctoral degrees from reputed universities, and they are active researchers who publish regularly in well-ascribed international journals. Their competences are partly complementary as some focus on advanced econometric methodology, some on contemporary economic analysis, and some on policy-oriented studies. The senior group members are among the most productive and cited research economists in Estonia as witnessed by their research output and REPEC/Ideas rankings.

Most of the research group members (Staehr, Kukk, Rõõm, Harkmann, Kollo, Levenko, Malk, Reigl, Soosaar) are affiliated with Eesti Pank and carry out analysis and applied research at this institution.

SELECTED ARTICLES

Bekiros, S.; Nilavongse, R.; Uddin, G. S. (2020). Expectation-driven house prices and debt defaults: the effectiveness of monetary and macroprudential policies. Journal of Financial Stability, 49, 100760.

Kukk, M.; Paulus, A.; Staehr, K. (2020). Cheating in Europe: underreporting of self-employment income in comparative perspective. International Tax and Public Finance, 27 (2), 363–390.

Rosenberg, S. (2020). Conventional and unconventional monetary policies: effects on the Finnish housing market. Baltic Journal of Economics, 20 (2), 170–186.

FINANCE AND THE DIGITAL ECONOMY: FINANCIAL BEHAVIOUR, MARKETS, AND COMPETITIVENESS

Head of the research group: Associate Professor LAIVI LAIDROO, laivi.laidroo@taltech.ee

Members: Karin Jõeveer, Mari Avarmaa, Enn Listra, Kalle Ahi, Kristjan Liivamägi

Doctoral students: Mari-Liis Kukk, Pavlo Illiashenko, Kaido Kepp, Triinu Tapver, Xuejiao An

TOPICS AND COMPETENCES

KEYWORDS: FinTech, financial intermediation, digital economy, financial economics, behavioural finance

The research group seeks to contribute to the international academic literature that deals with contemporary topics in financial economics. Special attention is paid to the emerging topics related to digitalisation in finance (e.g., crowdfunding, ICOs, cryptocurrencies, digital wallets, robo-advisory) as well as to the business models and ecosystems of FinTechs. The research is also linked to the fields of industrial organisation and economic development, innovation, technological change and growth.

Traditional and behavioural finance theories are utilised to investigate topics related to corporate finance, household finance, financial markets, and banking with the aim of enhancing the understanding of the financial behaviour of individuals, firms and financial intermediaries, and the linkages between them (mainly in the European context). Interdisciplinary approach is used to address questions related to business, legal and technological aspects of digitalisation in finance and its economic impact for determining the factors needed for improving the competitiveness and performance of the national economies through the employment of suitable regulative measures.

SELECTED PROJECTS

- BHV1, *Digital Development in Finance* (2018–2020)
- RITA2/103, *Impact assessment of annual report submission timeliness for the Ministry of Finance* (2020–2020)

SELECTED ARTICLES

Laidroo, L.; Avarmaa, M. (2020). The role of location in FinTech formation. Entrepreneurship and Regional Development. , 32(7), 555–572.

Talpsepp, T.; Liivamägi, K.; Vaarmets, T. (2020). Academic abilities, education and performance in the stock market. Journal of Banking & Finance, 117, Article 105848

Illiashenko, P.; Laidroo, L. (2020). National culture and bank risk-taking: Contradictory case of individualism. Research in International Business and Finance, 51, Article 101069.

Tapver, T.; Laidroo, L.; Gurvitš-Suits, N. A. (2020). Banks' CSR reporting – do women have a say? Corporate Governance, 20 (4), 639–651.

KNOWLEDGE INTENSITY AND SOCIO-ECONOMIC INCLUSION FOR PROMOTING SUSTAINED DEVELOPMENT

Head of the research group: Professor AARO HAZAK, aaro.hazak@taltech.ee

Members: Ako Sauga, Marit Rebane, Kirsti Rumma

Doctoral students: Heili Hein, Helery Tasane, Raul Ruubel, Tuba Büsra Özsoy, Artjom Saia, Hakan Berber

Visiting doctoral students: Khaysy Srithilat, Dongbei University of Economics and Finance, China (2019–2020); Munic Boungnarasy, Kobe University, Japan, (2019–2020)

TOPICS AND COMPETENCES

KEYWORDS: Institutions, sustainable economic development, efficiency, wellbeing, human capital, individual behaviour

The research group seeks to investigate various micro and macro level forces and behavioural and institutional incentives, which could speed up the convergence of emerging economies with frontier knowledge based economies and lead to sustained socio-economic development. The group addresses the obstacles in developing knowledge absorptive capacities and overcoming the prevailing regional disparities. The expected results will cast light to the possibly latent or underestimated reasons for development and wellbeing issues and for inefficiencies in human capital use in European (emerging) economies. In particular, human capital endowment, stimuli for capital allocation into intellectual investments, R&D activities, efficient implementation of modern technologies and work regulation/practices are in focus of the studies, particularly in an interdisciplinary context.

SELECTED PROJECTS

- VFP16057 (H2020), "*Institutions for Knowledge Intensive Development: Economic and Regulatory Aspects in South-East Asian Transition Economies*" (2017–2020)
- RITA1/02-20-04, "*Climate change mitigation with CCS and CCU technologies*" (2019–2021)
- VFP20046 (H2020), *Individual Behaviour and Economic Performance: Methodological Challenges and Institutional Context* (IBEP) (2020–2023)

SELECTED ARTICLES

Sõõru, E., Hazak, A., Rebane, M. (2020). Does chronotype restrict the employment options of creative R&D professionals? Biological Rhythm Research, 51(2), 283-293.

Hazak, A., Kerikmäe, T., Pärn-Lee, E. (2020). Efficiency and Bid Rigging in Simultaneous Procurement Auctions under an Oligopoly, International Journal of Procurement Management, 13(2).

Hazak, A., Ruubel, R. and Virkebau, M. (2019). When would creative R&D employees like to work? International Journal of Organizational Analysis, 27(3), 596-612.

DEPARTMENT OF LAW

Director: Professor TANEL KERIKMÄE,
tanel.kerikmae@taltech.ee

MAIN FIGURES 2020

(as of Dec. 31, 2020)

21 Academic staff — Incl. 4 professors, 5 researchers

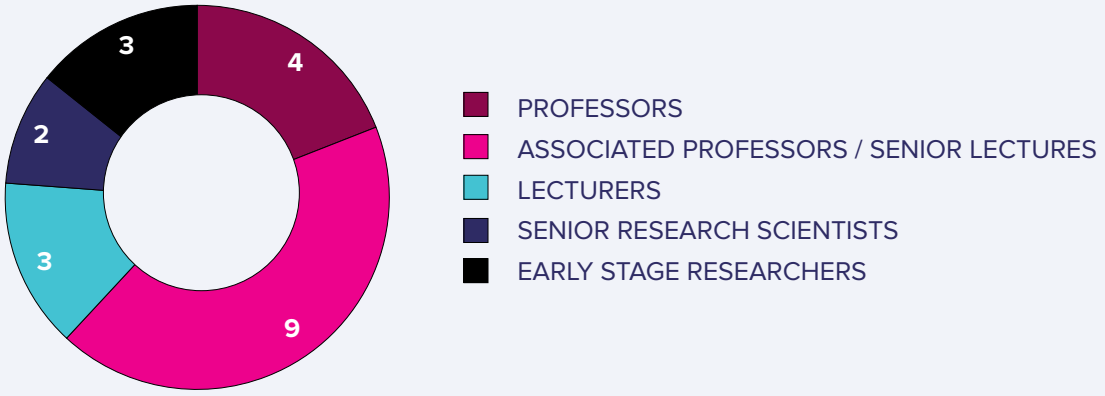
8 Doctoral students

18 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 3 RESEARCH GROUPS:

- **INTERNATIONAL RELATIONS, SECURITY, LAW AND TECHNOLOGY.**
  Head of the research group: Associate Professor HOLGER MÖLDER holger.molder@taltech.ee
- **LEGAL POLICY AND NORMATIVE FRAMEWORK OF EU DIGITAL MARKET AND TECHNOLOGIES AND IT´S APPLICATION IN PARTNER COUNTRIES.**
  Head of the research group: Professor TANEL KERIKMÄE, tanel.kerikmae@taltech.ee
- **PRIVATE LAW.**
  Head of the research group: Professor THOMAS HOFFMANN, thomas.hoffmann@taltech.ee



INTERNATIONAL RELATIONS, SECURITY, LAW AND TECHNOLOGY

Head of the Research Group: Associate Professor HOLGER MÖLDER, holger.molder@taltech.ee

Members: Vlad Alex Vernygora, Evhen Tsybulenko, Abel Polese, Antonius Johannes Hubertus Notermans, David Ramiro Troitino, Peeter Müürsep

TOPICS AND COMPETENCES

KEYWORDS: cyber and information security; international relations and technological challenges; economic security; political economy; international law; European Union; history of science

The research topics are related to international relations, security and technology.

- **International relations:** International conflicts (post-Soviet space, Middle East). Political and societal reforms of the European Union; the future of NATO; international relations in post-truth environment; East-Asia and Pacific region.
- **International security:** Information warfare and strategic communication; cyber threats and counter-activities; culture of fear; strategic narratives; hybrid threats; energy security.
- **Technology:** Information security and digital influence operations; internet and international relations; political and legal aspects of artificial intellect.

Senior lecturer Peeter Müürsepp is active in an independent field of research: history of science, philosophy of science.

SELECTED PROJECTS

- VA19011, "*Youth Opinion and Opportunities for EU Public Diplomacy: Youth Narratives and Perceptions of the EU and EU-Ukraine Relations in Ukraine and the three Baltic States*" (2018–2020).
- MOB7039 "*Mobilitas Pluss. Acitivity nr 7: "ERC (European Research Council) short term study visit" Study visit No MOB7-36*" (12.11.2019–11.08.2020)
- VERT20073 "*Cyber Aware Students for Public Administrations*" (1.12.2020–31.08.2023)"

- VERT17120 "*Digital Single Market as a New Core of European Union Studies*" (1.09.2017–31.08.2020)"

SELECTED ARTICLES

Kasper, A.; Mölder, H. (2020). The EU's Common Security and Defense Policy in Facing New Security Challenges and Its Impact on Cyberdefence. In: Ramiro Troitiño, D.; Kerikmäe, T.; De la Guardia, R. M.; Perez, G. A. (Ed.). The EU in the 21st Century (271–294). Springer. DOI: 10.1007/978-3-030-38399-2_15.

Polese, A.; Seliverstova, O.; Kerikmäe, T.; Cheshkin. (2020). National identity for breakfast: everyday practices, food consumption and the construction of national narratives in the Baltics. Nationalities Papers, 1 (21), 2–21. DOI: 10.1017/nps.2019.131.

Mölder, Holger; Sazonov, Vladimir (2020). Kremlin information campaign in the Baltic states during the COVID-19 pandemic escalation of spring 2020. Modern Management Review, XXV (4), 83–97.

LEGAL POLICY AND NORMATIVE FRAMEWORK OF EU DIGITAL MARKET AND TECHNOLOGIES AND IT'S APPLICATION IN PARTNER COUNTRIES

Head of the research group: Professor TANEL KERIKMÄE, tanel.kerikmae@taltech.ee

Members: Katrin Nyman-Metcalf, Ondrej Hamulak, Archil Chochia

Doctoral students: Olga Shumilo, Kärt Salumaa, Melita Sogomonjan

TOPICS AND COMPETENCES

KEYWORDS: digital market and legal regulation, artificial intelligence and law, law and media, competition law, e-health and law

The research topics are related to law and technology and transfer of knowledge of legal skills.

- **Law and eTechnologies:** e-residency, cryptocurrencies, smart contracts, 3D printing, software agents, digital evidence, artificial intelligence legal policies and modern technologies. Privacy law. Cyber security. Ethics of law and technology. General Data Protection Regulation (GDPR), human rights in European digital era. Rights and duties of digital e-trading.
- **ICT law:** freedom of expression, e-governance, regular legal analysis of media and communications legislations.
- **EU and Private International law:** focusing on the topics related to the Digital Single Market); cross-border private law issues, Law of Obligations/Consumer law, Insolvency Law and IP Law.

SELECTED PROJECTS

- VFP20040, *Mediatized Discourses on Europeanization and Their Representations in Public Perceptions* (2021–2024)
- VFP20030, *Mapping Uncertainties, Challenges and Future Opportunities of Emerging Markets: Informal Barriers, Business Environments and Future Trends in Eastern Europe, The Caucasus and Central Asia* (2020–2024)
- VFP19049, *New Market: an exploration into the changing nature of business environments, informal barriers and emerging markets in the post-Soviet region* (2019–2023)

SELECTED ARTICLES

Nyman-Metcalf, K., kerikmäe, T. (2020). Machines are taking over – are we ready? Law and Artificial Intelligence. Singapore Academy of Law Journal 33, 24–49.

Kerikmäe, T.; Nyman-Metcalf, K. (2020). The rule of law and the protection of fundamental human rights in an era of automation. In: J.-S. Gordon (Ed.). Smart Technologies and Fundamental Rights. Brill.

Hamuľák, O.; Kocharyan, H.; Kerikmäe, T. (2020). The Contemporary Issues of Post-Mortem Personal Data Protection in the EU after GDPR entering into Force. In: Czech Yearbook of Public and Private International Law (225–238). Czech Society of International Law.

PRIVATE LAW

Head of the Research Group: Professor THOMAS HOFFMANN, thomas.hoffmann@taltech.ee

Members: Agnes Kasper, Pawan Dutt, Tatjana Evas-Peeters

Doctoral students: Alexander Antonov, Aleksi Kajander

TOPICS AND COMPETENCES

KEYWORDS: algorithm-based decision-making and liability, blockchain and smart contracts, legal frameworks for Industry 4.0, cyber security and law, consumer law

The main activities of the research group are focused on the following areas:

- contribution to the European Parliament on a civil liability regime for artificial intelligence;

- analyses provided to the European Commission on the gathering of evidence on ways to empower consumers to play an active role in the green transition.

SELECTED PROJECTS

- VEU18012, *Academic Network to perform research services on issues pertaining to Citizenship of the Union rights and related policies* (2018–2020)

SELECTED ARTICLES

Evas, T. (2020). Civil liability regime for artificial intelligence. The European Parliament's committee on Legal Affairs, 1–232.

Hoffmann, T. (2020). The Impact of Digital Autonomous Tools on Private Autonomy. Baltic Yearbook of International Law Online, 18, 18–31.

Kajander, A.; Kasper, A.; Tsybulenko, E. (2020). Making the Cyber Mercenary – Autonomous Weapons Systems and Common Article 1 of the Geneva Conventions. In: Jančárková, T. et al. (Ed.). 12th International Conference on Cyber Conflict. 20/20 Vision: The Next Decade (79–95).

RAGNAR NURKSE DEPARTMENT OF INNOVATION AND GOVERNANCE

Director: ERKKI KARO,
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MAIN FIGURES 2020

(as of Dec. 31, 2020)

38 Academic staff — Incl. 12 professors, 22 researchers

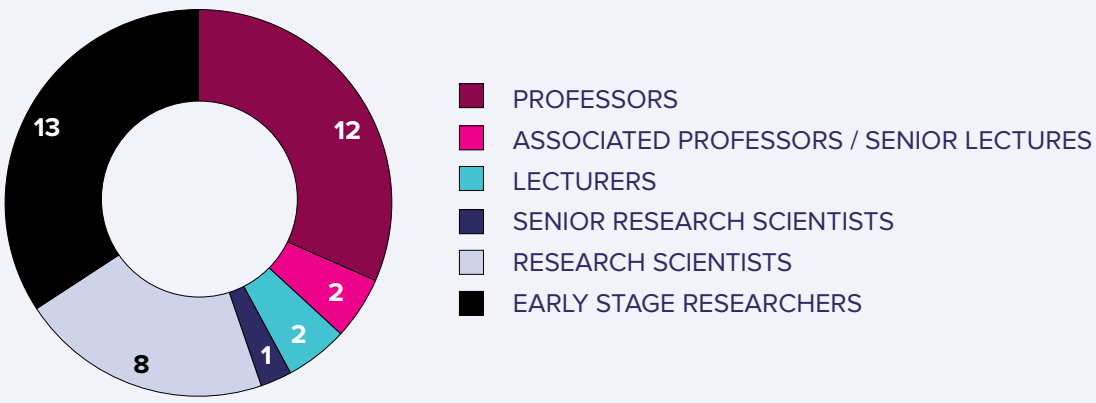
26 Doctoral students — 4 Defended doctoral dissertations

61 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

THE DEPARTMENT CONDUCTS RESEARCH WITHIN 8 RESEARCH GROUPS:

- **BIG DATA IN SOCIAL SCIENCES.**
  Head of the research group: Professor ANU MASSO, anu.masso@taltech.ee
- **e-GOVERNANCE.**
  Head of the research group: Professor ROBERT KRIMMER, robert.krimmer@taltech.ee
- **GOVERNANCE.**
  Head of the research group: Professor WOLFGANG DRECHSLER, wolfgang.drechsler@taltech.ee
- **FISCAL GOVERNANCE.**
  Head of the research group: Professor RINGA RAUDLA, ringa.raudla@taltech.ee
- **PHILOSOPHY OF SCIENCE AND TECHNOLOGY.**
  Head of the research group: Professor AHTI-VEIKKO PIETARINEN, ahti-veikko.pietarinen@taltech.ee
- **PUBLIC MANAGEMENT AND POLICY.**
  Head of the research group: Professor TIINA RANDMA-LIIV, tiina.randma-liiv@taltech.ee
- **PUBLIC SECTOR INNOVATION.**
  Head of the research group: Senior Research Scientist VEIKO LEMBER, veiko.lember@taltech.ee
- **TECHNOLOGY GOVERNANCE AND INNOVATION POLICY.**
  Head of the research group: Professor ERKKI KARO, erkki.karo@taltech.ee



BIG DATA IN SOCIAL SCIENCES

Head of the research group: Professor ANU MASSO, anu.masso@taltech.ee

Post-doctoral researcher: Stefano Calzati

Doctoral students: Colin van Noordt, Mergime Ibrahimi, Sander Salvet, Piia Tammpuu

TOPICS AND COMPETENCES

KEYWORDS: big data and social datafication, social science methods and methodologies, spatial mobility, social transformations.

The research group focuses mainly on basic research in the field of social datafication and related social transformations, combining methodologically computational social sciences and critical data studies. In addition to publishing high-level scientific publications, the research team has been active in transferring knowledge to society, participating in numerous implementation projects. The members of the group participate in the Digital Methods initiative for the teaching and development of social science methods and are actively involved in the creation of the Mobility Data Infrastructure (IMO). Prof. Masso is active in the board of the Estonian Sociological Association and one of the initiators of Thematic Group 10 Digital Sociology at the International Sociological Association.

SELECTED PUBLICATION

Masso, A., & Kasapoglu, T. (2020). Understanding power positions in a new digital landscape: Perceptions of Syrian refugees and data experts on relocation algorithm. Information, Communication & Society, 23(8), 1203–1219.

Misuraca, Gianluca; van Noordt, Colin; Boukli, Anys (2020). The use of AI in public services. Proceedings of the 13th International Conference on Theory and Practice of Electronic Governance: International Conference on Theory and Practice of Electronic Governance, Athens Greece, September 2020. Ed. Yannis Charalabidis, Maria Alexandra Cunha, Demetrios Sarantis. New York, United States: Association for Computing Machinery, 90–99.

e-GOVERNANCE

Head of the research group: Professor ROBERT KRIMMER, robert.krimmer@taltech.ee

Postdoctoral researchers: David Dueans Cid, Nele Leosk

Doctoral students: Iulia Krivonosova, Gregor Wenda, Gerli Aavik, Michael Sachs, Isabel Skierka, Radu Antonio Serra Iova

TOPICS AND COMPETENCES

KEYWORDS: e-governance, e-democracy, Digital Single Market

The e-Governance group focuses on the social science analysis of the most important developments in e-Governance, both for Estonia and globally: the development of user- and citizen-centric e-governments, the transparency and cost-effectiveness of e-voting systems, the use of new modern identity management technologies in the public sector, the use of open data in government.

The group coordinates the largest e-government and public sector innovation project in the EU and H2020, the Once Only Principle, TOOP (*www.toop.eu*), which develops technical architectures and management systems to facilitate automated exchange of data between different government institutions of EU member states and thereby to increase the effectiveness and agility of EU's governments and bring closer to reality the ideal of the European Single Digital Market.

The group members have been active in studying and advising different countries (Estonia, Switzerland, Australia, South Korea, Japan, etc.) on how to build up user-centric e-Governance systems.

SELECTED PROJECTS

- VFP17064 "*The Once Only Principle (TOOP) Project*", (2017–2019), the project is planned to be extended a second time by 6 months until September 2020

SELECTED ARTICLES:

Krimmer, R.; Duenas-Cid, D.; Krivonosova, I. (2020). Debate: safeguarding democracy during pandemics. Social distancing, postal, or internet voting – the good, the bad or the ugly? Public Money & Management.

Krimmer, R.; Duenas-Cid, D.; Krivonosova, J. (2020). New Methodology Calculating Cost-Efficiency of Voting Channels: Is Internet Voting cheaper in Estonian Municipal Elections? Public Money & Management.

GLOBAL GOVERNANCE

Head of the research group: Professor WOLFGANG DRECHSLER, wolfgang.drechsler@taltech.ee

Members: Vasilis Kostakis

Postdoctoral researchers: Christos Giotitsas, Kaire Holts, Matti Ylönen

Doctoral students: Alexandros Pantazis, Alexandros Pazaitis, Christina Priavolou, Pisith San, Shobhit Shakya, Salah Chafik, Lucas Lemos, Nikiforos Tsiouris

TOPICS AND COMPETENCES

KEYWORDS: governance, P2P technologies, commons-based peer production, non-western public administration, global governance, development policy, sustainability

The Governance group of RND deals with basic, as well as policy-focused, academic research focusing on the analysis of governance theories and paradigms in the context of modern socio-technical changes, led especially by the ICT diffusion. The group comprises the ERC Starting Grant 'Cosmolocalism', the only one awarded to an Estonian researcher in 2018, and two large grants, 'Centrinno' and 'Smooth', funded from the EU's Horizon 2020. The 'FinEst Twins: Helsinki and Tallinn as Smart and Sustainable Cities' EU Teaming grant, 2019–26, with €32 million the largest research grant in Estonian history, that commenced in late 2019, emerged from this research group.

Special focus has been on the following topics:

- analysis of global paradigms of governance and comparison of Western and non-Western/Asian paradigms and traditions,
- the impact of technological changes on governance, including the emergence of the concept of smart city and the impact of P2P technologies on production and consumption traditions and governance models, and
- alternative perspectives on sustainability, growth, innovation and their metrics generally.

In all these fields the group is internationally recognized as a trailblazing think tank. This is best exemplified by the fact that both Prof. Drechsler and Prof. Kostakis are Affiliates of Harvard University –at the *David Centre for Russian and Eurasian Studies* and the *Berkman Klein Centre for Internet and Society* respectively – and the former also at *UCL's Institute for Innovation and Public Purpose*, all three usually recognized as the number one institution in their specific field globally.

SELECTED PROJECTS:

- VFP20041, *New Centralities in Industrial Areas as Engines for Innovation and Urban Transformation* (2020–2024)
- VFP20023, *The Political Economy of E-Residency* (2020–2022)

SELECTED ARTICLES

Giotitsas, C.; Nardelli, P. H. J.; Kostakis, V.; Narayanan, A. (2020). From private to public governance: The case for reconfiguring energy systems as a commons. Energy Research & Social Science, 70, #101737.

Drechsler, W. (2020). Good Bureaucracy: Max Weber on the 100th anniversary of his death. UCL IIPP Blog

FISCAL GOVERNANCE

Head of the research group: Professor RINGA RAUDLA, ringa.raudla@taltech.ee

Members/Postdoctoral researchers: Egert Juuse, Aleksandrs Cepilovs

Doctoral students: Johanna Vallistu, Kati Keel, Kerli Onno

TOPICS AND COMPETENCES

KEYWORDS: fiscal governance, public sector financial management, budgeting, financial regulation

The group studies the developments of fiscal governance in Europe with specific focus on the spread of new budgeting principles (participatory budgeting), the impact of fiscal crisis, the evolution of institutional and discursive context. The unique specialization of the group has been to study the impact of fiscal and financial policy bureaucracies (its structure, principles of policy coordination and learning, etc.) on fiscal and financial policies in the Baltic Sea area and EU as a whole. This is a relatively novel theoretical as well as empirical focus since the countries of the region are financially and politically highly interlinked but have also asymmetrical economic relations and politico-administrative differences.

The group is relatively young (Prof. Raudla was elected full professor only in 2014), but it has already gained global recognition for its research work, e.g. Prof. Raudla is in the editorial board of *Governance* (the leading journal on governance and institutional analysis), in addition to seven other international academic journals. She leads the Permanent Working Group on Fiscal Governance and Administration at IIAS (a governance and public administration research society with the widest reach globally). Prof. Raudla is the founding member of the Estonian Youth Academy of Science and she won the 2018 Estonian National Research Award in Social Sciences.

In 2016–2019, Prof. Raudla has been in charge of the research grant "*Developments in the Fiscal Governance of European Countries: Impacts of the Crisis and Future Prospects*", funded by the Estonian Research Council.

The research group participates actively in Jean Monnet Network project VISTA, which deals with the challenges in European integration.

SELECTED ARTICLES

Piatak, Jaclyn S.; Douglas, James W.; Raudla, Ringa (2020). The role perceptions of government professionals: the effects of gender, educational field, and prior job sector. Public Management Review, 22 (10), 1515–1534.

Douglas, J. W.; Raudla, R. (2020). What Is the Remedy for State and Local Fiscal Squeeze During the COVID-19 Recession? More Debt, and That Is Okay. The American Review of Public Administration, 50 (6-7), 584–589

Raudla, R.; Bur, S.; Keel, K. (2020). The Effects of Crises and European-Level Fiscal Governance Reforms on the Budgetary Processes of Member States. JCMS Journal of Common Market Studies, 58 (3), 740–756.

PHILOSOPHY OF SCIENCE AND TECHNOLOGY

Head of the research group: Professor AHTI-VEIKKO PIETARINEN, ahti-veikko.pietarinen@taltech.ee

Member: Amirouche Moktefi

Postdoctoral researcher: Daniele Chiffi

Doctoral students: Jelena Družinina, Marika Proover

TOPICS AND COMPETENCES

KEYWORDS: philosophy of science and technology, abduction, pragmatism, diagrams

The Philosophy of Science and Technology group produces research on human mind and its complexity in the context of science and technology, with emphasis on history and philosophy of science and technology, logic, and in particular, on abduction and fundamental uncertainty in scientific knowledge. It is continuing high-level research and publication activities in its core areas of competence, publishing over 20 articles in top philosophy and humanities journals (*Studies in History and Philosophy of Science; J. Logic, Language and Information; The Review of Symbolic Logic; Synthese; Futures*, etc.) in 2020. The group has also attracted collaboration of a number of international researchers that have expanded the research foci of the group.

The group integrates with the general research focus of Ragnar Nurkse Department and TalTech in analytical and fundamental approaches to cope with fundamental uncertainty that characterises innovation and technological change, and to tackle societal challenges with methods that cope with wicked and game-theoretic problems in group action.

The group developed new diagrammatic logics that are already being caught up and applied e.g. in trustable software development.

SELECTED ARTICLES

Chiffi, D.; Pietarinen, A.-V.; Proover, M. (2020). Anticipation, abduction and the economy of research: The normative stance. Futures, 115, #102471.

Bellucci, F.; Pietarinen, A.-V. (2020). Peirce on the Justification of Abduction. Studies in History and Philosophy of Science Part A, 84, 12–19.

Chiffi, D.; Pietarinen, A.-V. (2020). On the Logical Philosophy of Assertive Graphs. Journal of Logic Language and Information, 29 (4), 375–397.

PUBLIC MANAGEMENT AND POLICY

Head of the research group: Professor TIINA RANDMA-LIIV, tiina.randma-liiv@taltech.ee

Members: Külli Sarapuu, Riin Savi

Doctoral students: Kadi Maria Vooglaid, Mariliis Trei, Steven Nõmmik

TOPICS AND COMPETENCES

KEYWORDS: public sector management, administrative reform, participation, collaboration, small states

Activities within this research group are based on three research grants, which all address reforms in public management, citizen participation in policy-making process and collaboration in public governance. Throughout the research themes, the members of the group explore both the Estonian case as well as global and European comparative perspectives. Most members of the group participate in the Horizon 2020 financed research project TROPICO (*http://tropico-project.eu*) on how new technologies and social innovation affect cooperation and collaboration practices in European public sectors. Prof. Tiina Randma-Liiv is leading a cross-European comparative study on e-participation, whereas the other members of the group contribute to several work packages on collaborative governance. Dr. Külli Sarapuu is leading an Estonian Research Council Grant (PUT1461, *Coordination instruments at the center of government: opportunities and limitations of temporary task forces*) to study novel coordination instruments (task forces, iLabs, etc.) in the center of government. The research group is also actively involved in the international research project on small states, where the group's specific area of responsibility is small state administration (VERT17134, *Navigating the Storm: The Challenges of Small States in Europe*). The group is actively cooperating with Estonian government institutions and nonprofit organizations (e.g. the Government Office, the Ministry of Finance, PRAXIS Center for Policy Studies). The members of the group are participating in different international academic networks and editorial boards. Prof. Randma-Liiv belongs to the editorial boards of 13 academic journals. Dr. Sarapuu co-chairs *EGPA* permanent study group titled 'Governance of Public Sector Organizations' and is a member of *NISPAcee* steering committee – two prominent public administration networks in Europe.

PUBLIC SECTOR INNOVATION

Head of the research group: Senior Research Scientist VEIKO LEMBER, veiko.lember@taltech.ee

Members: Piret Tõnurist, Ralf-Martin Soe

Doctoral students: Laidi Surva, Johanna Vallistu, Steven Nõmmik, Palwasha Ahmadzai, Kerli Onno, Luiza Schuch de Azambuja

TOPICS AND COMPETENCES

KEYWORDS: digital transformation, public sector innovation, public-private partnerships

The research group focuses on the development of the theories of public sector innovation and digital transformation, with rather unique focus on technology driven innovations, e.g. emergence of machine-to-machine coordination in the public policy processes and analysis of the technological capacities of the public sector. Increasingly, the group focuses on understanding and anticipating the societal consequences of technology-driven changes in the public sector (e.g. possibilities for people-centered smart cities). In addition, the group has also produced important contributions to more mainstream PSI topics, i.e. the role of co-production, public procurement of innovation, iLabs and state-owned enterprises as instruments of innovation in the public sector.

SELECTED PROJECTS

- LEP19060 (RITA1/02-82), Estonian Research Agency's RITA project "*Mobile life-style, public service consumption and national registries*" (2019–2021)
- LEP19078MN (RITA1/02-96-12, Estonian Research Agency's RITA project "*Machine learning and AI powered public service delivery*" (2019–2021)
- H2020 projekt *CENTRINNO* (New CENTRalities in INdustrial areas as engines for inNOvation and urban transformation)

SELECTED PUBLICATIONS

Kattel, R.; Lember, V.; Tõnurist, P. (2020). Collaborative Innovation and Human-Machine Networks. Public Management Review, 22 (11), 1652–1673.

Lember, V., Brandsen, T. and Tõnurist, P. (2019). The Potential Impacts of Digital Technologies on Co-Production and Co-Creation. Public Management Review 21(11), 1665–1686.

Lember, V., Kattel, R., Tõnurist, P. (2018). Technological Capacity in the Public Sector: The Case of Estonia. International Review of Administrative Sciences, 84(2), 214–230.

TECHNOLOGY GOVERNANCE AND INNOVATION POLICY

Head of the research group: Professor ERKKI KARO, erkki.karo@taltech.ee

Members: Erik Reinert, Jan Allan Kregel, Carlota Perez, Rainer Kattel, Margit Kirs, Egert Juuse

Doctoral students: Olga Mikheeva, Rauno Mäekivi, Jaanus Müür, Kaija Valdmaa, Teele Tõnisman, Lauma Muižniece

TOPICS AND COMPETENCES

KEYWORDS: innovation, innovation policy, technology governance

The group is the leading centre for science, technology and innovation systems and policies in Estonia.

The basic research of the group centres on the following topics:

- Techno-economic paradigms and the role of the state,
- Future innovation systems and policies,
- Innovation bureaucracies and management of innovation policies

The policy-oriented work of the group covers the following topics:

- Green transition and mission-oriented innovation policies,
- Tackling societal challenges through innovation,
- Drafting and implementing smart specialization strategies and policies in Europe and Estonia,
- Management STI policies and instruments,
- Evaluations of innovation polices and governance systems,
- The impact of Global Value Chains on national innovation systems and policies.

SELECTED PROJECTS

- PRG346, *Reshaping Estonian energy, mobility and telecommunications systems on the verge of the Second Deep Transition* (2019–2023)
- VFP18022, H2020 MC RISE *Catching-Up along the global value chain: business models, determinants and policy implications in the era of the Fourth Industrial Revolution* (2018–2022)
- VIR17124 "*SOHJOA-Baltic Sea Region transition to eco-friendly autonomous last mile public transortation*" (2017–2020)

SELECTED ARTICLES

Kirs, M.; Lember, V.; Karo, E. (2020). Technology Transfer in Economic Periphery: Emerging Patterns and Policy Challenges. Review of Policy Research.

Valdmaa, K.; Pugh, R.; Müür, J. (2020). Challenges with strategic placed-based innovation policy: implementation of smart specialization in Estonia and Wales. European Planning Studies, 1–18. DOI: 10.1080/09654313.2020.1767541.

Saltelli, A., Reinert, E.S. et al (2020) "Five ways to ensure that models serve society: a manifesto." Nature (Comment): 482-484. DOI: 10.1038/d41586-020-01812-9.

ESTONIAN MARITIME ACADEMY

ESTONIAN MARITIME ACADEMY

Director: ROOMET LEIGER
e-mail: roomet.leiger@taltech.ee

Director for Development: MADLI KOPTI
e-mail: madli.kopti@taltech.ee

MAIN FIGURES 2020

(as of Dec. 31, 2020)

59 Academic staff Incl. 3 professors 36 researchers

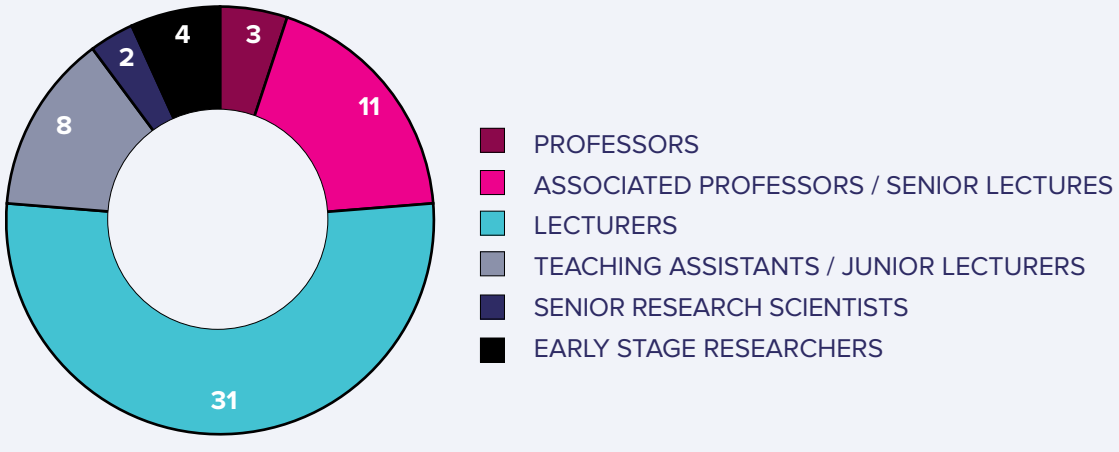
2 Doctoral students

29 Scientific publications*

** Data from the Scopus (as of April 07, 2021)*

EMERA CONDUCTS RESEARCH MAINLY WITHIN ONE RESEARCH GROUP

- **NAVAL ARCHITECTURE AND HYDRODYNAMICS.**
  Head: Professor MIHKEL KÕRGESAAR, mihkel.korgesaar@taltech.ee
- **SMART, SAFE AND GREEN HYDRODYNAMICS RESEARCH GROUP.**
  Head: Assistant Professor ABBAS DASHTIMANESH, abbas.dashtimanesh@taltech.ee
- **BLUE ECONOMY AND AQUATIC RESOURCES RESEARCH GROUP.**
  Head: Senior Researcher LOREIDA TIMBERG, loreida.timberg@taltech.ee



ESTONIAN MARITIME ACADEMY (EMERA)

Head: Director ROOMET LEIGER, roomet.leiger@taltech.ee

Our mission is to be a renowned educator of maritime specialists, contribute to R&D activities and offer services for the maritime sector. Our vision is to become a maritime competence centre, be a reliable partner in R&D projects and contribute to the work of international organisations.

Our focus areas in Estonian Maritime Academy are led by top-specialists in the maritime field:

- **Naval architecture and hydrodynamics** – the growing market of small crafts anticipates the use of novel technologies to make them more environmentally friendly and consume less fuel. The Small Craft Competence Centre (SCC), the main competences of which include computational fluid dynamics analysis of ships and small crafts, hull form design, hull resistance estimations, model testing of small crafts, is contributing to building a recognized small craft cluster in Estonia and supporting research. An important area is the topic of spray rails, for which experimental tests in the pool and software experiments with computational fluid dynamics (CFD) will be continued. The work done at SCC during the last two years has created considerable CFD competence in Estonia. Research is mainly conducted under the leadership of the tenured professor of naval architecture in the Marine Technology and Hydrodynamics research group.

  Two large-scale projects were launched to support research and development in SCC:

  1. *Small Craft Competence Centre – analysis of outer construction elements impact on the performance of a vessel, transition of knowhow and information*
  2. *Development of marine technology and hydrodynamic research infrastructures and services*

- **Marine Technology and digitalisation of shipping** – vast developments in the IT-sector have raised the need for the digitalisation of the shipping sector and optimising the work processes on-board ships and in ports. In 2020 EMERA, together with TalTech Department of Computer Systems and Tallink Group Ltd., completed a project with the goal to develop the concept of a "smart car deck" on passenger ferry Megastar, that enables the automatisation and higher effectiveness of vehicle-related processes.

  In order to introduce complex smart, safe, and clean solutions and increase the performance of marine vehicles Smart, Safe and Green Hydrodynamics research group, led by a tenured professor of marine technology, was established in 2020. The research group will focus on the design, simulation and model testing of various marine vehicles, including autonomous ships.

- **Blue Economy and water resources** – the aim of the Blue Economy research group is to carry out development activities on production technologies and adding value to raw materials in coastal areas and the aquatic environment.

  The Blue Economy research group combines knowledge of:

  - sustainable implementation of the aquatic environment;
  - biology, chemistry and physics of water resources;
  - technological processes in the aquatic environment;
  - the blue economy and the social economy.

- **Maritime transport** – the specialists in EMERA have up-to-date knowledge and practical experience that combined allow us to provide research based services for the maritime sector in order to make maritime transportation and its' digitalisation (e-documents, smart ports) more efficient. To boost the technological advancements and enable growth in research and development in Estonia and internationally a tenure of Maritime Transport has been created.

  In 2020, an assessment of environmental impact and greenhouse gas emissions of the Port of Tallinn was carried out. The aim of the study was to assess the environmental impact of the activities of Port of Tallinn Ltd.(TS) (marine environment, ambient air, energy use, etc.) based on the TS sustainable development goals strategy (achieving climate neutrality, circular economy, energy efficiency), and to develop indicators and target levels.

- **Maritime Cyber Security** – The widespread adoption of IoT technology in the maritime sector has created new opportunities for shipowners to operate ships more safely and economically, while bringing risks that companies have not been exposed to before. To mitigate these risks, the Maritime Cyber Security research group is being set up, focusing on three main topics: maritime communication security, marine technology cyber security and the human aspects of cyber security. Funded by the Horizon 2020 EraChair program, the *MariCybERA* supports bringing outstanding academics and high-level pro-

fessionals to TalTech to develop maritime security expertise in the field. The project will also enable the creation of a maritime cyber security centre at the university.

- **Maritime Safety and Security** – to improve the natural and socio-economic environment it is important to support the achievement of efficiency and sustainability. These fields include the human factor in shipping, ships' workflow, bridgework and resource management, navigational systems, the development of methods for the prevention of marine pollution and response equipment, waterways safety management. To support this focus area a high-tech maritime Simulator Centre that features compatible bridge, maritime communication, engine room, refrigeration training, marine pollution control and other simulators is used.

The possibilities of the Simulator Centre are utilised in the *OIL SPILL* project that focuses on enhancing oil spill response capability in the Baltic Sea region and in the *CoMET project* that aims at making the education of future seafarers more international by enabling cross-border simulator trainings.

NAVAL ARCHITECTURE AND HYDRODYNAMICS

Head: Professor MIHKEL KÕRGESAAR, mihkel.korgesaar@taltech.ee

Members: Kalju Saar, Tarmo Sahk, Henrik Johan Sten Andreasson, Ruttar Teär, Kaarel Koppel, Andrus Sults

Postdoctoral researcher: Zhaolong Yu

Doctoral students: Mikloš Lakatoš, Teguh Putranto, Muhammed Adil Yatkin

TOPICS AND COMPETENCES

KEYWORDS: advanced ship structures, fluid-structure interaction, ship safety, accidental limit states, material modeling

Our research focuses on on the behavior of small crafts, ships, and marine structures in normal and extreme environments. Therefore, we develop advanced computational methods and tools to assess ship structural and operational performance, safety and sustainability both in open-water and Arctic (ice-covered waters) applications. In the field of the hydrodynamics of small crafts and fluid-structure interaction, our research is supported by the experimental testing in our towing tank, where we deepen our understanding regarding ship behavior in different conditions. The goal is to increase energy efficiency and behaviour of small crafts in different operational conditions. On the topic of ship and offshore structures, we focus on the load response and failure mechanisms of materials and welded structures under different loading scenarios, including accidental and ultimate limit states. We create tools tailored for the rapid assessment of large complex structures, which enable optimization early in the conceptual design stage. We use numerical simulations to get insight into theoretical modeling and prevailing assumptions, while experiments provide the supporting validation data. The simplifications enabling computationally efficient calculations are scientifically justified.

In 2020, ETAg funding was received to complete the project to develop novel crashworthy ship structures. The project lasted for 1 year during which the following research was carried out:

- The weaknesses of current methods used for crash analysis were assessed;
- A fracture criterion accounting bending deformations in large structural shell elements was developed;
- Development of fluid structure interaction model applicable for ship crash analysis was started;
- Testing of mechanical properties of materials with an innovative non-contact measuring system was started.

SELECTED ARTICLES:

Kim, S. J.; Kõrgersaar, M.; Ahmadi, N.; Taimuri, G.; Kujala, P.; Hirdaris, S. (2021). The influence of fluid structure interaction modelling on the dynamic response of ships subject to collision and grounding. Marine Structures, 75, #102875

SMART, SAFE AND GREEN HYDRODYNAMICS RESEARCH GROUP

Head: Assistant Professor ABBAS DASHTIMANESH, abbas.dashtimanesh@taltech.ee

Doctoral students: Rasul Niazmand Bilandi, Fatemeh Roshan

TOPICS AND COMPETENCES

Keywords: marine hydrodynamics, fuel efficiency, safety, smartization

The main motivation behind the activities of the research group is the implementation of the principles and strategies declared by regulatory and policy-making bodies (such as IMO, HELCOM, the EU Strategy for the Baltic Sea Region and international agreements on sustainable development) regarding various marine vehicles, especially focusing on high speed crafts. For this purpose, the main research studies of the research group are divided into four fields:

Safety: The main focus is on how the ships'/boats' motions could be reduced. We are also considering the performance of crews and onboard systems under the effects of ships'/boats' motions. Currently we are working on safety improvement of planing hulls by a combination of an active control trim tab and shock mitigation seats.

Emission Reduction: This field focuses on fuel-efficient hull forms, and optimization and zero-emission propulsion systems. The ongoing project, supported by the Interreg Baltic Sea Region programme, focuses on green cruising of small craft where we are working on new hull forms, electric propulsion systems and digital marine control systems to reduce the fuel consumption of high-speed small craft.

Smartization: The focus is on a variety of research problems including smart ship design, unmanned high-speed craft and Digitalized Computational Fluid Dynamics (DCFD) by implementing artificial intelligence, machine learning and genetic algorithm.

Hydrodynamics of Marine Vehicles: Marine hydrodynamics is a part of all the abovementioned research activities. We are working on resistance and propulsion, seakeeping and manoeuvring characteristics of different marine vehicles by considering safety, fuel efficiency and smartization goals. The latest focus is on

seakeeping and manoeuvring of stepped hulls. A large variety of mathematical, numerical and experimental methods are being developed in the research group. Additionally, to address the existing knowledge gap, we are planning to start a series of experimental tests in the towing tank on the behaviour of boats and ships in irregular waves to study the effects of seakeeping on fuel efficiency.

SELECTED PROJECTS:

- VIR20039, *Green Cruising for High-speed Small Craft in The Baltic Sea (2020–2021)*

SELECTED ARTICLES:

Tavakoli, S.; Niazmand B., Rasul; M., S.; De Luca, F.; Dashtimanesh, A. (2020). Dynamic of a planing hull in regular waves: Comparison of experimental, numerical and mathematical methods. Ocean Engineering, 217, 1–24.

BLUE ECONOMY AND AQUATIC RESOURCES RESEARCH GROUP

Head: Senior Researcher LOREIDA TIMBERG, loreida.timberg@taltech.ee

Members: Annmarii Hakkaja, Hele-Riin Kukker

TOPICS AND COMPETENCES

Keywords: aquatic resources innovation, consumers and aquatic products, aquatic resources safety and quality, blue economy and socioeconomics

The research group carries out development activities on production technologies and raw material enhancement in coastal areas and the aquatic environment. The aim of the research is to find opportunities for the sustainable application of the aquatic resources, whereas ecological principles and conditions are taken into account and hazards and risks from human operations are predicted.

In order to valorise aquatic resources, their biological, chemical, and physical properties are analysed, and their functional properties will be described. Technological processes are tested and developed for valorisation of the aquatic recourses. Economical and socioeconomical opportunities of blue economy are analysed and modelled in view of EU strategies, existing legislation and most importantly consumers awareness and expectations.

The Blue Economy and Aquatic Resources research group studies are coherent with public and private sector interests. The public sector is involved in aquatic environment and aquatic resources sustainable development and socioeconomical opportunities development. The private sector is involved in harnessing functional biological, chemical and physical properties of aquatic resources, and innovation of technological processes and economic models.

The research group is currently conducting three studies:

- PRIA19027, *Consumer driven product development of unpopular fish species from costal and inshore fishing* (2019–2021)
- PRIA20029, *Quality of Fish Oil and Fish Meal and Adding Value by Using of Antioxidants* (2020–2022)
- PRIA20030, *Reducing Sodium in Fish Products and Development of Fucus vesiculosus Ingredient* (2020–2022)

SMART CITY CENTER OF EXCELLENCE

SMART CITY CENTER OF EXCELLENCE

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MAIN FIGURES 2020

(as of Dec. 31, 2020)

5 Academic staff Incl. **3** researchers

40 Researchers involved in the activities of the Center from other departments of TalTech and Aalto University

6 Scientific publications*, (with an affiliation model about 40)

** Data from the Scopus (as of April 07, 2021)*

SMART CITY RESEARCH GROUP

Head: Senior Researcher RALF-MARTIN SOE, ralf-martin.soe@taltech.ee

Members: Einari Kisel, Lill Sarv, Henry Patzig, Külle Tärnov

Involved members: 40 TalTech and Aalto University researchers through the H2020 teaming project, who follow a jointly agreed upon Strategic Research and Innovation Agenda led by the Smart City Center of Excellence and also publish under the Smart City Center of Excellence affiliation starting from 1.12.2020.

TOPICS AND COMPETENCES

KEYWORDS: mobility, energy, built environment, governance and data

The research team is one of the leading research centres for smart city in Europe. The group's research focuses on the following research topics:

- Smart city challenges in local governments in five areas (mobility, energy, built environment, governance and data)
- Testing research-based cross-border technologies in local governments
- Smart city development and related visions and strategies

The group's applied development activities help to test various research-based solutions in real-life conditions to make the living environment more human-centered and sustainable. The research group's activities help to analyze and evaluate the current activities of the smart city in urban environments, to better understand the risks and benefits related to the development of the smart city, to identify best practices through extensive agile piloting projects and to disseminate the best solutions in Estonia as well as in the rest of Europe.

The group contributes strongly to the research cooperation between Aalto University and Tallinn University of Technology, and is also actively involving cities across Europe.

The main activities of the research group take place within the framework of two H2020 and one Structural Funds grant. The first H2020 project deals with the establishment of the Smart City Center of Excellence (H2020 team FinEst Twins, Principal Investigator Ralf-Martin Soe) and the second, the Structural Funds grant (Smart City Center of Excellence, Principal Investigator Ralf-Martin Soe) deals with the implementation of research-based smart city pilots in collaboration with cities and local governments. The third grant (CityScape, H2020) deals with cyber security and self-driving vehicles (the person responsible – Henry Patzig).

SELECTED PROJECTS

- VFP19031, *FINEST TWINS: Establishment of Smart City Center of Excellence* (1.12.2019–30.11.2026)
- AR20013, *Smart City Center of Excellence* (2020–2023)

SELECTED PUBLICATIONS

Soe, R.-M. (2020). Innovation Procurement as Key to Cross border ITS Pilots. International Journal of Electronic Governance, 12 (4), 387–403.

Soe, R.-M.; Müür, J. (2020). Mobility Acceptance Factors of an Automated Shuttle Bus Last-Mile Service. Sustainability.

Sarv, L.; Kibus, K.; Soe, R.-M. (2020). Smart city collaboration model. Proceedings of the 13th International Conference on Theory and Practice of Electronic Governance. Association for Computing Machinery (ACM), 674–677.

TALTECH RESEARCH 2020

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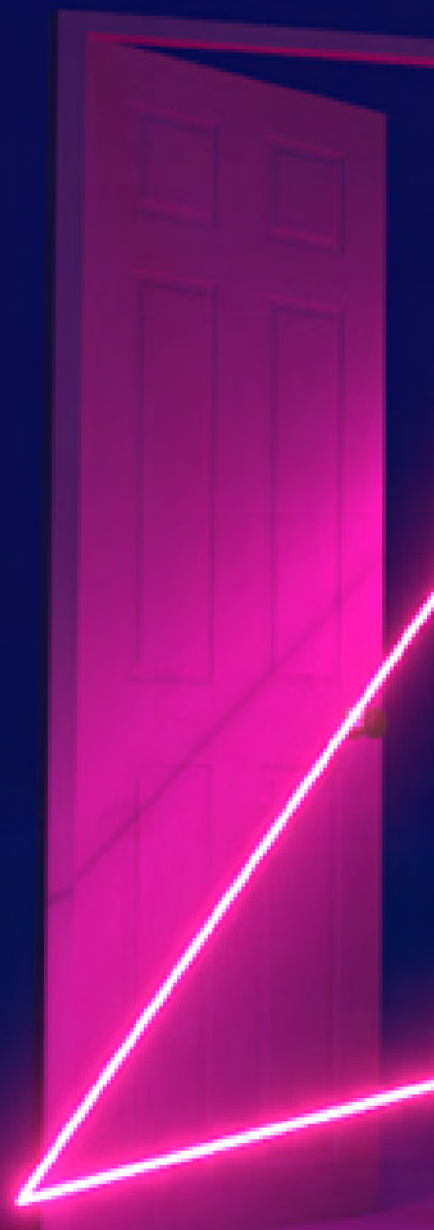
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