



SAFEST

Tallinn University of Technology:
Department of Computer Systems

PROMOTION GUIDE



The SAFEST project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 952252



WELCOME TO THE PROMOTION GUIDE OF THE DEPARTMENT OF COMPUTER SYSTEMS AT THE TALLINN UNIVERSITY OF TECHNOLOGY (TALTECH).

As one of the four departments within the School of Information Technology, this guide presents descriptions of the research groups, infrastructure, innovation activities and international collaboration of the Department of Computer Systems. It has been produced within the framework of the SAFEST project, funded by the European Union's Horizon 2020 Research and Innovation Programme (Grant Agreement No 952252).



SAFEST

[SAFEST.TALTECH.EE](https://safest.taltech.ee)



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FOREWORD

Tallinn University of Technology (TalTech) is the flagship of Estonian engineering and technology education and the only technology university in Estonia. Here, the synergy between different fields (technological, natural, exact, economic and health sciences) is created and new ideas are born. TalTech is becoming one of the leading technology universities in the Baltic Sea region.

As the most international university and the biggest international community in Estonia, TalTech boasts more than 1600 students from over 100 countries and a 13% share of foreign staff members. The emphasis on international cooperation is also a priority for joint curriculum development, student and employee exchange programs and joint research development programs.

Study and teaching is based on internationally recognized research and the graduates are highly rated on the labour market. The University's approximately 73,000 alumni have shaped the economic landscape of present-day Estonia. The TalTech campus is also a home to more than 200 high-tech companies (e.g. Skype).

TalTech is in charge of nurturing the next generation of engineers and advancing engineering culture in Estonia, contributing to the sustainable development of the society and increased national prosperity with its innovative services. Our vision is for an innovative Estonia in a sustainable world.

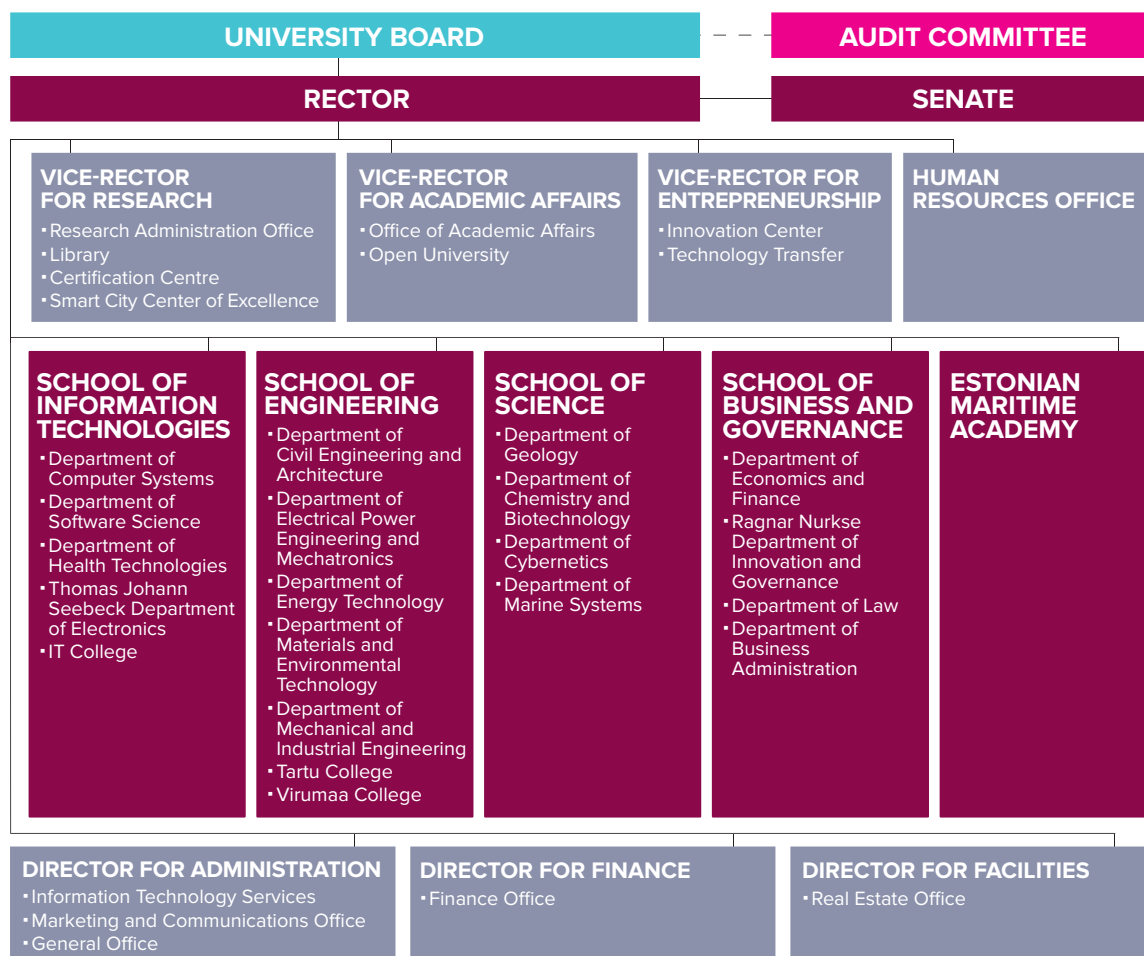


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ABOUT THE UNIVERSITY

Tallinn University of Technology is comprised of four faculties which are sub-divided into specialised departments dedicated to promoting science, technology and innovation. The supportive structure of the institution is also largely credited to co-operation between the university, enterprises and the public sector to significantly contribute to knowledge and academic success of its students.



R&D OBJECTIVES IN STRATEGIC PLAN OF TALLINN UNIVERSITY OF TECHNOLOGY 2025

High quality research is conducted at Tallinn University of Technology, giving rise to applications, teaching and learning as well as research-intensive innovation.

Our research outcomes are published in high quality journals and theses defended at the university are mostly based on said research. We support sustainable, responsible and high-level research groups, which also make a significant contribution to teaching and serving the society. To that end, we shall continue to develop an intra-university financing model, which will mitigate risks for ambitious and entrepreneurial research groups and foster cooperation between research groups on key research fields for the university. We shall increase competition-based funding at the university and provide assistance to research groups applying for funding in key areas for the university.

We shall enhance our career model to support capable, entrepreneurial and result-driven members of our academic community, who contribute to research, teaching and learning as well as serving the society. We support outstanding junior researchers in order to ensure that they can quickly become autonomous and be supported as members of our university community.

Research and education at Tallinn University of Technology are open. Teaching materials and research results are accessible to business partners, secondary school pupils and the public at large.

SCHOOL OF INFORMATION TECHNOLOGIES – MAIN AREAS OF RESEARCH

The structure of the School of Information Technologies is composed of **four departments and one college**:

- Department of Computer Systems
- Department of Software Science
- Department of Health Technologies
- Thomas Johann Seebeck Department of Electronics
- IT College

School of IT **flagship initiatives** are:

- GovAILab
- Digital Health Competence Center
- Secure 5G based Demo Campus
- IoT Competence Center
- Language Technologies Lab
- Centre for Digital Forensics and Cyber Security
- Dependable Software Lab

Due to specialised areas of interest within the many fields and across departments, research is ongoing in dozens of domain-specific topics. A selection of School of IT **focus areas** are given below:

- Security and trust
 - cyber security,
 - trustworthy software,
 - systems safety,
 - secure and reliable hardware systems,
- Digital transformation of the society
 - e-governance technologies,
 - digital health,
 - language technologies,
- Smart environments
 - 5G,
 - IoT,
 - (bio)robotics,
 - intelligent electronic systems.

STUDY PROGRAMMES: SCHOOL OF INFORMATION TECHNOLOGIES (IT)

The School of Information Technologies has a variety of study programmes which are taught in Estonian and in English.

Bachelor's degree programmes (all in Estonian, except for one):

- Hardware Development and Programming
- Informatics
- IT Systems Administration
- IT Systems Development
- Cyber Security Engineering *in English*
- Business Information Technology

Master's degree programmes taught in Estonian:

- Computer Science
- Business Information Technology
- Medical Technology and Physics
- Analysis and Design of Information Systems
- Digital Transformation in Business

Master's degree programmes taught in English:

- Computer and Systems Engineering
- E-Governance Technologies and Services
- Communicative Electronics
- Cyber Security
- Software Engineering
- Health Care Technology

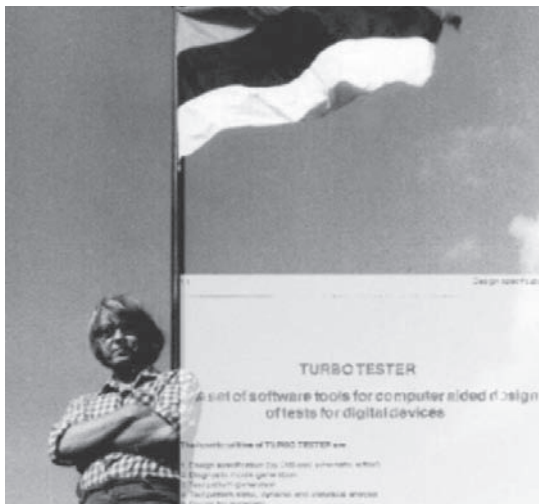
PhD programme is in English:

- Information and Communication Technology

SCHOOL OF IT: DEPARTMENT OF COMPUTER SYSTEMS

Department of Computer Systems (DCS) was established on 1 January 2017 in the course of university's structural reform, but its roots go back to 1966 when TalTech was called Tallinn Polytechnic Institute and DCS's predecessor Department of Information Technics was established soon to be renamed to Department of Electronic Computing. Hence when the university celebrated its centennial in 2018, the DCS passed a 50-year anniversary a few years earlier.

With Estonia regaining its independence in August 1991 (the same night Prof. Raimund Ubar wrote a TurboTester manual in the top left photo) its path to the European started in earnest. Already next year Estonia started to integrate with EU's science community with joint projects (as top right photo illustrates one of the first Tempus projects). Many of the researchers are still active in current EU Twinning projects (like Prof. Jaan Raik in the middle of the bottom photo).



The Department of Computer Systems was established based on

- the Department of Computer Engineering,
- Alpha Control Lab of the Department of Computer Control (<https://a-lab.ee/>), and
- Centre for Biorobotics (<https://www.taltech.ee/en/biorobotics/>).

These days the DCS is one of the 4 departments at the School of Information Technologies.

DEPARTMENT OF COMPUTER SYSTEMS: RESEARCH GROUPS

There are more than twenty research groups in four departments of the School of Information Technology. Six of them are at the Department of Computer Systems:

- Centre for Intelligent Systems
- Centre for Biorobotics
- Smart Hardware Research Centre
- Embedded AI Research Lab
- Centre for Hardware Security
- Centre for Dependable Computing Systems

More information about each of them can be found in the descriptions below.

CENTRE FOR INTELLIGENT SYSTEMS

Centre for Intelligent Systems focuses on control systems, artificial neural networks, fractional-order modelling and control, and virtual reality. The research of the 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. The Centre consists of the Control Systems Laboratory <http://a-lab.ee> and Virtual and Augmented Reality Laboratory <http://recreation.ee>

Its core competencies 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
- Modelling and analysis of complex power systems with high integration of renewable energy sources
- Data analysis
- Development of research software
- Virtual and Augmented Reality applications

Head of the centre:

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<https://is-centre.eu/>

CENTRE FOR BIOROBOTICS

The Centre for Biorobotics focuses on underwater technologies, more specifically on underwater robotics inspired by biological principles, underwater sensing and underwater sensor networks. It invent new ways for moving through water, taking inspiration from animals who have adjusted for life in this environment. They develop sensors inspired by lateral line sensing of fish, methods of data acquisition and analysis and apply them to measure, characterize and classify underwater environments.

Its core competencies are:

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

Head of the centre:

Prof. MAARJA KRUUSMAA

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<https://www.taltech.ee/en/biorobotics-research>

SMART HARDWARE RESEARCH CENTRE

The research focus of the Smart Hardware Research Centre is cutting-edge industrial-grade approaches for self-health awareness, fault tolerance and quality assurance through the entire product life cycle of microelectronic systems. On the other hand, the development work focuses on professional design of embedded systems from hardware to software.

Its core competencies 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)

Head of the centre:

Senior Research Scientist ARTUR JUTMAN

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EMBEDDED AI RESEARCH LAB

The Embedded AI (Artificial Intelligence) Research Lab is an initiative started in 2016 to strength the cooperation between TalTech and private sector companies. Initial focus was to cover different aspects in Internet of Things field. As the industry needs are continuously changing and there have been increasing interest on machine learning competence, the research centre was reorganized to provide better competence in embedded machine learning. The laboratory collaborates internationally with research teams and companies from the maritime, medical, smart city, autonomous vehicles and industrial automation sectors.

Its core competencies are:

- Embedded hardware design and prototyping
- Real-time operating systems
- Machine learning model optimization for embedded hardware
- Communication solutions in embedded systems, sensory solutions

Head of the lab:

Research Scientist MAIRO LEIER

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<https://iot.ttu.ee/>

CENTRE FOR HARDWARE SECURITY

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. The centre was established in late 2019.

Its core competencies are:

- Design of Application Specific Integrated Circuits
- Circuit obfuscation by design partitioning (Split-Chip and Split-Fab)
- Trustworthy electronic design automation tooling (from RTL to layout)
- Countermeasures to reverse engineering, side channel attacks, and piracy
- Crypto hardware

Head of the centre:

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<https://www.taltech.ee/en/centre-for-hardware-security>

CENTRE FOR DEPENDABLE COMPUTING 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 nano-electronic systems (including multi-/many-core systems). The centre is the initiator of several pan-European actions. The centre coordinates the Horizon2020 Marie Skłodowska Curie ITN RESCUE project and is a partner in the national ICT centre of research excellence EXCITE.

Its core competencies are:

- 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)
- Cross-layer resilience (cooperation: Testonica Lab OÜ)
- 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)

Head of the centre:

Prof. Jaan Raik

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(+372) 620 2257

<https://www.taltech.ee/en/centre-dependable-computing-systems>

INFRASTRUCTURE

HARDWARE LABORATORY

The Department of Computer Systems has an already set up laboratory for hardware-related research and teaching. The laboratory is permanently equipped with the following:

- Manson NSP2050 power supply unit
- Intronix LA1034 logic port analyzer
- Four identical working stations that can be used for building up prototypes and/or bench testing of integrated circuits

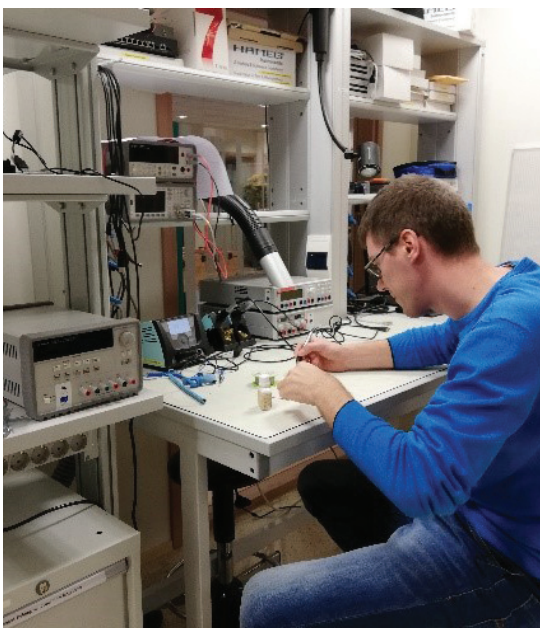
Every working station is equipped with the following instruments:

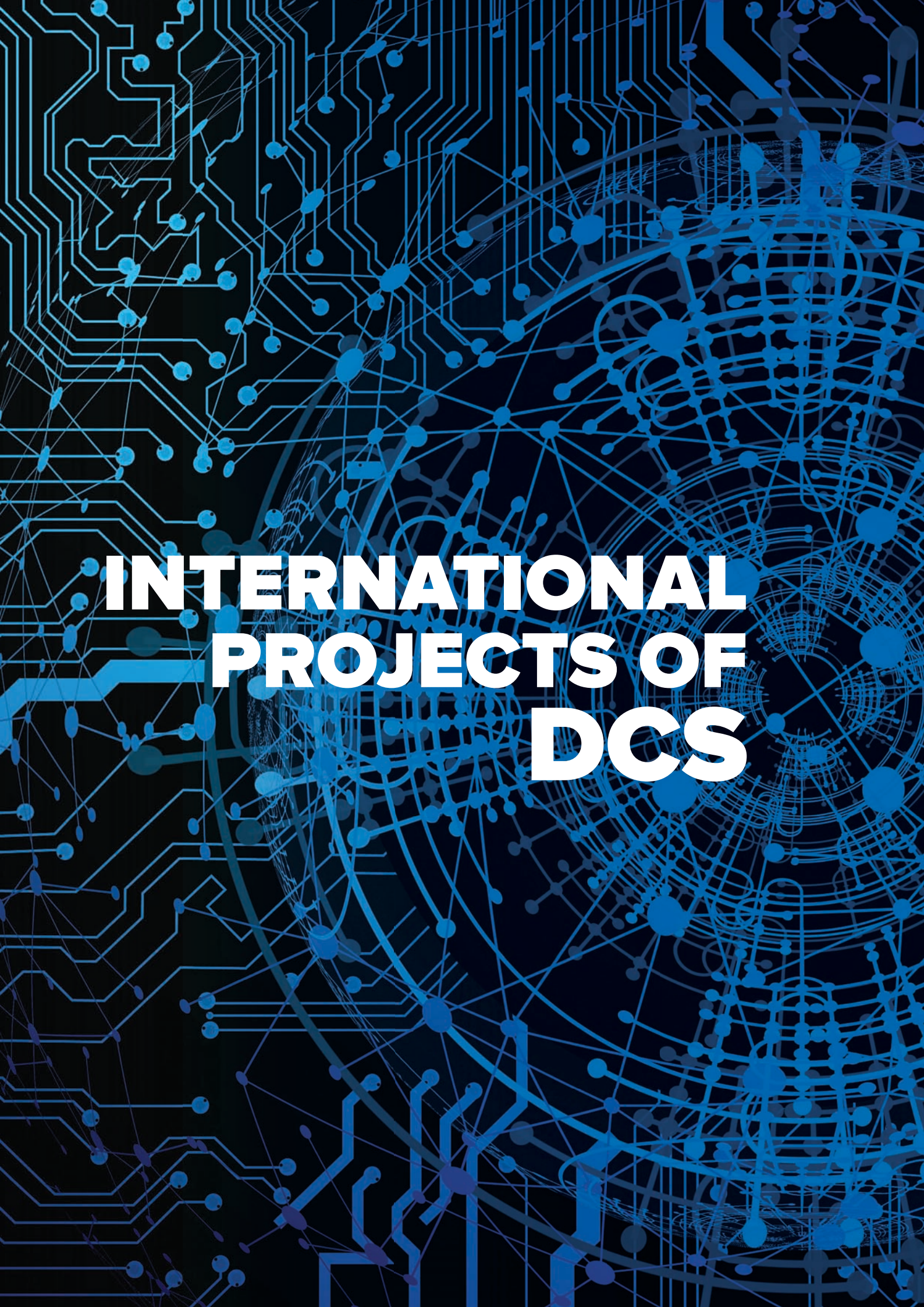
- Hameg – HM8001-2 power supply
- Hameg – HMP2030 power supply
- Weller – Soldering Station WX 2021 with fume extraction hood
- Agilent – MSOX3034A mixed-signal oscilloscope
- Agilent – 34405A digital multimeter
- Agilent – 33522A programmable function generator

Additionally, the following equipment can be flexibly assigned to any working station:

- 2 Hameg – HMP4040 advanced power supply
- 2 Agilent – B2912A Dual-channel SMUs (Source Measurement Unit)
- 1 Rohde & Schwarz – FSH8 portable spectrum analyser
- Rohde & Schwarz – RTO 1024 oscilloscope with differential probes

We also have at our disposal many FPGA prototyping platforms, including an array of Spartan and Zed boards (Xilinx/ARM). Finally, we highlight that TalTech has been a member of EUROCHIP/EUROPRACTICE since 1995, and enjoys access to CAD software from all the major EDA vendors: Mentor, Cadence, and Synopsys.





INTERNATIONAL PROJECTS OF DCS

RESCUE – INTERDEPENDENT CHALLENGES OF RELIABILITY, SECURITY AND QUALITY IN NANOELECTRONIC SYSTEMS DESIGN

2017–2021

Contact: MAKSIM JENIHHIN

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<http://rescue-etn.eu/>

[ETIS](#)

RESCUE action advances scientific competences and establishes an innovative training for *Interdependent Challenges of Reliability, Security and Quality in Nano-electronic Systems Design*. The novel training-through-research platform will **rescue** and enhance design of complex systems at the next generation nanoelectronics technologies by addressing the demanding and mutually dependent aspects of *reliability, security and quality*, as well as corresponding *electronic design automation tools*. It will provide recruited Early-Stage Researchers (ESRs) with innovative training in the involved disciplines and beyond, such that they will not only be able to face today and future challenges in nanoelectronics design but also be innovative, creative, and more importantly – have an entrepreneurial mentality.



SMART4ALL – SELFSUSTAINED CROSS BORDER CUSTOMIZED CYBERPHYSICAL SYSTEM EXPERIMENTS FOR CAPACITY BUILDING AMONG EUROPEAN STAKEHOLDERS

2020–2023

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<https://smart4all-project.eu/>

[ETIS](#)

SMART4ALL builds capacity amongst European stakeholders via the development of selfsustained, cross-border experiments that transfer knowledge and technology between academia and industry. It targets CLEC CPS and the IoT and combines a set of unique characteristics that join together under a common vision different cultures, different policies, different geographical areas and different application domains. SMART4ALL brings a new paradigm for revealing “hidden innovation treasures” from SEE and helping them to find the path to market via new, innovative commercial products.

RIBES – RIVER FLOW REGULATION, FISH BEHAVIOUR AND STATUS

2020–2023

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<https://www.msca-ribes.eu/>

[ETIS](#)

The proposed ETN will train 15 ESRs in the interdisciplinary field of Ecohydraulics to find innovative solutions for freshwater fish protection and river continuity restoration in anthropogenically altered rivers. The 15 ESRs will carry out an innovative and integrated research programme within a multidisciplinary and intersectoral Network, including 8 leading European Universities, consultancy companies, public agencies and hydropower industry, encompassing experts in fish biology, river ecology, environmental fluid mechanics and hydraulic engineering. The 15 ESRs will have access to a number of laboratory and field facilities, modelling techniques, experimental practices and instrumental technologies, to expand current understanding of key fundamental fish bio-mechanical, behavioural and physiological processes, and to promote development of novel tools and management solutions in the area of freshwater fish protection.



ROBOMINERS – RESILIENT BIO-INSPIRED MODULAR ROBOTIC MINERS

2019–2023

Contact: MAARJA KRUUSMAA
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<https://robominers.eu/>

[ETIS](#)

ROBOMINERS will develop a bio-inspired, modular and reconfigurable robot-miner for small and difficult to access deposits. The aim is to create a prototype robot that is capable of mining underground, underwater or above water, and can be delivered in modules to the deposit via a large diameter borehole. In the envisioned ROBOMINERS technology line, mining will take place underground, underwater in a flooded environment.

ECOBOTICS.SEA – BIO-INSPIRED TECHNOLOGIES FOR A SUSTAINABLE MARINE ECOSYSTEM

2019–2022

Contact: MAARJA KRUUSMAA
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<https://ecobotics.isr.uc.pt/>

[ETIS](#)

ECOBOTICS.SEA is a future-oriented 4-year research project with a research-driven human-resources training network in its center. ECOBOTICS.SEA focuses on the research of underwater robotics and biomimetics concepts and technology, targeting problems and needs in the real world that are related to the study of biospheres, species and ecosystems and their preservation.



TETRAMAX – TECHNOLOGY TRANSFER VIA MULTINATIONAL APPLICATION EXPERIMENTS

2017–2021

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<https://www.tetramax.eu/>

[ETIS](#)

TETRAMAX is a new Horizon 2020 innovation action and will provide an implementation of the European Smart Anything Everywhere (SAE) initiative in the domain of customized and low-energy computing for cyber physical systems and the internet of things. The total budget of the TETRAMAX project is 7 M€ and is coordinated by RWTH Aachen University, with 22 partners, covering almost all EU countries. TETRAMAX was launched in Sep 2017 and will run for four years. Department of Computer Systems is one of the partners of the TETRAMAX project.



ROBOCOM++ – RETHINKING ROBOTICS FOR THE ROBOT COMPANION OF THE FUTURE

2017–2020

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<http://robocomplusplus.eu/>

ETIS

The main objective of the RoboCom++ is to lay the foundation for a future global interdisciplinary research programme (e.g., a FET-Flagship project) on a new science-based transformative Robotics, to be launched by the end of the H2020 Programme. RoboCom++ will gather the community and organise the knowledge necessary to rethink the design principles and fabrication technologies of future robots. RoboCom++ will aim at developing the cooperative robots (or Companion Robots) of the year 2030, by fostering a deeply multidisciplinary, transnational and federated effort.

Fractional

CA15225 – FRACTIONAL SYSTEMS

2016–2020

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<http://fractional-systems.eu/>

Fractional-order systems have lately been attracting significant attention and gaining more acceptance as generalization to classical integer-order systems. Mathematical basics of fractional-order calculus were laid nearly 300 years ago and since that it has gained deeply rooted mathematical concepts. Today, it is known that many real dynamic systems cannot be described by a system of simple differential equation or of integer-order system. In practice we can encounter such systems in electronics, signal processing, thermodynamics, biology, medicine, control theory, etc. The Action will favour scientific advancement in above mentioned areas by coordinating activities of academic research groups towards an efficient deployment of fractal theory to industry applications. The cooperation of researchers from different institutions will guarantee wide visibility of Action results.

FITHYDRO – FISHFRIENDLY INNOVATIVE TECHNOLOGIES FOR HYDROPOWER

2016–2020


Contact: MAARJA KRUUSMAA

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<http://www.fithydro.eu/>

[ETIS](#)

FITHydro addresses the decision support in commissioning and operating hydro-power plants (HPP) by use of existing and innovative technologies. It concentrates on mitigation measures and strategies to develop cost-efficient environmental solutions and on strategies to avoid individual fish damage and enhancing population developments. Therefore HPPS all over Europe are involved as test sites. The facilities for upstream and downstream migration are evaluated, different bypass systems including their use as habitats and the influence of sediment on habitat.

The background is a dark blue field filled with intricate, glowing light blue patterns. On the left, there are circuit-like traces and nodes. On the right, a complex network of interconnected nodes and lines is visible, resembling a data mesh or a molecular structure. The overall effect is one of high-tech connectivity and digital complexity.

CONFERENCES ORGANISED BY DCS



BALTIC ELECTRONICS CONFERENCE 2020

DURATION: OCTOBER 6–8, 2020

Website: <https://www.taltech.ee/en/bec2020>

BEC2020, the 17th Biennial Conference on Electronics and Embedded Systems was held in Tallinn, Estonia in October 2020. The aim of the Conference is to promote research and development in the field of electronics and embedded systems, particularly in the Baltic Sea region. The scope of the conference was “Smart technologies and services”, a very wide-ranging multidisciplinary research, development, and application field of rapid growth and expansion.



BALTIC DB&IS 2020

DURATION: JUNE 16-19, 2020

Website: <https://dbis.ttu.ee/>

14th International Baltic Conference on Databases and Information Systems – Baltic DB&IS 2020 – conference on databases and information systems was an international forum, which provided an environment to exchange research findings and ideas for researchers, practitioners and PhD students on the crucial matters on engineering reliable, secure and sustainable information systems with data and data analysis in the central role. The 14th edition of the Baltic DB&IS conference featured original research and application papers on the theory, design, implementation and security of today's IS on a set of themes and issues.



ETS'20

DURATION: MAY 25–29, 2020

Website: <https://ets2020.ttu.ee/>

25th IEEE European Test Symposium – ETS'20 – was Europe's premier forum dedicated to presenting and discussing scientific results, emerging ideas, applications, hot topics and new trends in the area of electronic-based circuits and system testing, reliability, security and validation. In 2020, ETS in Tallinn, Estonia had to be replaced by a virtual event as a result of the worldwide COVID-19 outbreak. The symposium was organized by the [Tallinn University of Technology \(TalTech\)](#), which co-sponsors the event jointly with the [IEEE Council on Electronic Design Automation \(CEDA\)](#).



TESTFORUM 2019

Tue-Wed, November 26th and 27th, 2019

NTF 2019

DURATION: NOVEMBER 26–27, 2020

Website: <http://nordictestforum.org/2019>

The 2-day **Nordic Test Forum 2019 – NTF 2019** was a major event for Test professionals in the Nordic area and Baltic states. Every year the TestForum is attended by key people from the industry's test community as well as by international vendors of test and measurement equipment and solutions. Nordic Test Forum has its main emphasis on issues relevant to production managers, engineers and technicians working in the fields of production, test, inspection and validation of electronics. At Nordic Test Forum events we offer technically relevant presentations on methodology, tools, modules/instruments and available technology. The interaction between users and suppliers within the focus areas is an important asset of the Test Forum, and this balance and interaction is pursued in presentations, panel discussions, and in the planning of the events.

EARLIER EVENTS

2019

23.–25.10.2019	The 16th EuroVR International Conference – EuroVR 2019 (in cooperation with Department of Mechanical and Industrial Engineering)
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2018

30.–31.10.2018	IEEE Nordic Circuits and Systems Conference – NorCAS 2018
08.–10.10.2018	16th Biennial Baltic Electronic Conference – BEC2018 (in cooperation with Thomas Johann Seebecki Department of Electronics)
20.–22.06.2018	8th Biannual European – Latin American Summer School on Design, Test and Reliability – BELAS 2018

2017

25.–26.05.2017	RESCUE 2017 – Workshop on Reliability, Security and Quality, ETS17 Fringe Workshop
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2016

03.–05.10.2016	15th Biennial Baltic Electronic Conference – BEC'15 (in cooperation with Thomas Johann Seebecki Department of Electronics)
28.–29.09.2016	1st International Workshop on Resilience in Nanoelectronic Systems – RENS'16
26.–28.09.2016	IFIP/IEEE International Conference on Very Large Scale Integration – VLSI-Soc 2016
27.–29.06.2016	11th International Symposium on Reconfigurable Communication-Centric Systems-on-Chip Conference – ReCoSoc16

2015

10.–11.11.2015	MEDIAN Finale – Workshop on Manufacturable and Dependable Multicore Architectures at Nanoscale
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2014

08.–10.10.2014	14th Biennial Baltic Electronic Conference – BEC'2014 (in cooperation with Thomas Johann Seebecki Department of Electronics)
08.–11.06.2014	11th International Baltic Conference on Databases and Information Systems DBIS 2014
14.–16.05.2014	10th Workshop on Microelectronics Education – EWME 2014

DEPARTMENT OF COMPUTER SYSTEMS:

INTERNATIONAL COLLABORATIONS

The many active research directions of the department lead to numerous international collaboration with well-known institutions across the globe. A sample of these partners is given below, collected from joint publications from the year 2020.

**Carnegie
Mellon
University**



**POLITECNICO
DI TORINO**



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