ELEKTRONIKAS UN DATORZINĀTŅU INSTITŪTS

INSTITUTE OF ELECTRONICS AND COMPUTER SCIENCE

Institute of Electronics and Computer Science (EDI)

DEVELOPMENT STRATEGY
FOR YEARS 2021 — 2027

Riga, March 2022

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Abbreviations

Abbreviation	Meaning
3D	Three-Dimensional
5G	Fifth-generation mobile standards
ACM	Association for Computing Machinery
BCC	Body-coupled communication
BLE	Bluetooth Low Energy
CAD	Computer Aided Design
CERN	European Organization for Nuclear Research
COST	European Cooperation in Science and Technology
CPS	Cyber-Physical Systems
DIH	Digital Innovation Hub
DORA	Declaration on Research Assessment
DPU	Data Processing Unit
ECG	Electrocardiogram
ECSEL	Public-private partnership joint venture JTI ECSEL "Electronic components and systems"
EDI	Institute of Electronics and Computer Science
EEA	European Economic Area
EEG	Electroencephalogram
EIT	European Institute of Innovation and Technology
EM	Ministry of Economics
EMG	Electromyogram
ERA-NET	European Research Area Network
ESA	European Space Agency
ESIF	EU Structural and Investment Fund
EU	European Union
FLPP	Fundamental and Applied Research Projects
FPGA	Field Programmable Gate Array
FTE	Full-time equivalent

GDP	Gross Domestic Product
GPS	Global Positioning System
GPU	Graphical Processing Unit
GSNN	Global Satellite Navigation Network
H2020	European Union research and innovation support program Horizon 2020
HEI	Higher education institution
IEEE	Institute of Electrical and Electronics Engineers
ICT	Information and Communication Technologies
INSIDE-IA	Inside Industry Association
IMEC	IMEC, a Research Institute in Belgium
IMIS	Innovative Signal Processing Technologies
IoT	Internet of Things
IP	Intellectual Property
IPA	Fraunhofer Automation and Production Engineering Institute
IT	Information Technologies
ITS	Intelligent Transport System
KDT	Key Digital Technologies
KET	Key Enabling Technologies
KPI	Key Performance Indicators
LIAA	Investment and Development Agency of Latvia
LiDAR	Light Detection and Ranging
LR	Republic of Latvia
LU	University of Latvia
LAS	Latvian Academy of Sciences
LCS	Latvian Council of Science
LoRa / LoRaWAN	Long Range Wide Area Network communication technology
M2M	Machine-to-machine
MES	Ministry of Education and Science
MCU	Microcontroller

NRP	National Research Program
NDP	Latvian National Development Plan
NASA	US National Aeronautics and space Agency
NCP	National Contact Point
Q1, Q2	Quartile 1, Quartile 2
RTO	Research and Technology Organization
R&D&I	Research, Development and Innovation
RGB	Red / Green / Blue
RI	Research Institute
RIS3	Latvian Smart Specialization Strategy
RTU	Riga Technical University
SAR	Synthetic Aperture Radar
SECS	Smart Embedded Cooperative Systems
SME	Small and Mid-size Enterprises
SNIP	Source Normalized Impact Factor
SoC	System-on-Chip
SoPHIS	State Research Program "Cyber Physical systems, ontologies and biophotonics for safe & smart city and community"
STDIG	Science, Technology Development and Innovation Guidelines
SWOT	Strengths, Weaknesses, Opportunities, Threats analysis
TNO	Netherlands Applied Sciences research organization *TNO*
TRL	Technology Readiness Level
TSCH	Time Slotted Channel Hopping
URLLC	Ultra-Reliable Low-Latency Communications
UWB	Ultra-Wideband
V2X	Vehicle-to-everything
VLSI	Very Large Scale Integrated System
VPN	Virtual Private Network

VTT	Finnish Technical Research Center VTT
WSN	Wireless Sensor Network

Executive Summary

EDI Development Strategy aims to provide high level guidelines for decision-making and day-to-day activities at the institute. EDI is engaged in research and development of innovative technologies in the fields of electronics and computer science with a focus on the development of Smart Embedded Cooperative Systems. According to the international evaluation of Latvian scientific institutions in both 2013 and 2019, EDI is the highest rated scientific institution in Latvia in the field of engineering sciences and technologies.

The **mission** of EDI is to perceive the world and design a better future by creating new knowledge, developing innovative technologies and demonstrating their practical significance in real life applications. This mission, combined with a vision for the future of EDI, identifies five **priority research directions**: extremely precise timing of events, including space applications; remote sensing and space data processing; robotics and machine perception; signal processing and embedded intelligence; smart sensors and the Internet of Things. It also identifies the following main **application areas**: smart mobility; Industry 4.0; future health; digital life and space. EDI focuses on the technology readiness levels TRL3-TRL5, occupying a niche between universities and the industry.

EDI is managed by a collegial body of scientists: the Scientific Council and its elected director. In 2020, a total of 126 research staff was employed in EDI (143 employees in total), of which 56 (42.18 FTE) have been elected to academic positions — leading researchers, researchers and research assistants. The average age of employees in 2020 was 41.8 years, while the average age of scientists (researchers with doctoral degrees) was 49.9 years. In order to achieve the goals of the strategy, an analysis of strengths and weaknesses, as well as opportunities and threats (SWOT) has been performed, on the basis of which EDI development plans have been drawn up.

The Institutional Development Plan consists of an Organizational Process and Structure Development Plan, a Results-Based Development Plan and a Risk Management Strategy. **The organization of the process** envisages regular updating of the strategy and the involvement of the International Advisory Board in strategic planning. A cascading approach is used to achieve the goals and results defined in the strategy and to fulfill the functions of the institute.

The results-based development plan is based on the result management system, which consists of three parts: (1) cascading of tasks according to the results to be achieved by structural units and down to an individual level; (2) measurement and control of employees' performance, and (3) regular feedback. In addition, it is planned to develop a mentoring system for new employees, help them to develop specific personal goals and an individual career plan, as well as to automate the cascading and monitoring of the achievement of goals and results.

The risk management strategy includes risk management and assessment based on the threats and opportunities identified in the SWOT analysis, in accordance with the procedures defined in ISO 31000: 2018 standard. Risk identification is performed by management of EDI in cooperation with department, project and research team leaders. The identified risks are regularly updated and assessed and, if necessary, a risk response plan is developed and implemented.

EDI research involves the acquisition of new knowledge in the fields of electronics and computer science, with some research directions already having a long tradition at the institute with

renowned international influence. Examples include very accurate time measurement and digital signal processing. Other directions have recently been launched or modified, such as the Artificial Intelligence (AI) based robotics in the context of Industry 4.0. **The main challenges in research** relate to the development of scientific ideas to the extent that they can be used outside the research environment; choice of topical, sustainable and internationally important research topics; conducting good quality research at a relatively low amount of funding; acquiring and maintaining scientific excellence; and increasing the impact on the global scientific community.

The **impact on academia** by EDI is mainly visible in three ways: disseminating the results of quality research; training new research staff, including university students; organizing the editorial process of a SCOPUS indexed scientific journal *Automatic Control and Computer Sciences*. The **impact on the industry** by EDI on the other hand is mainly realized thorugh participation in projects together with industry partners, performing contract research, commercializing the results of this research, as well as contributing to the creation of new companies. The **impact on the society** at large by EDI is mainly realized through performing research in socially important areas, as well as through communication and dissemination activities.

The growth potential of EDI has been rated as excellent (“5”) in the international evaluation of scientific institutions. Consequently, the EDI **Human Resources Development Plan** both continues with existing activities and plans new activities aimed at raising the qualification of human resources and improving the efficiency of their work. In qualification growth, the emphasis is on the implementation of individual career plans, monitoring the progress of doctoral theses, mentoring as well as participation of employees in seminars, courses and high-level conferences. Recruitment efforts abroad will be increased to attract new skilled researchers. In order to retain the existing experienced employees, the potential risks of them leaving EDI will be identified, the improvement of working conditions at EDI will be continued, team building events will be organized, and the best employees will be recognized. For efficient use of human resources, improvements will be made to keep research topics focused, project calls with longer project durations and less bureaucratic overhead will be prioritized, and day-to-day processes at EDI will be digitalized and optimized.

The infrastructure required to support research in EDI, which includes buildings and their adjoining outdoor areas, laboratory equipment, as well as research support infrastructure such as a data center, prototyping equipment, test equipment, etc., has been upgraded in recent years to meet requirements of international-level research. In view of this fact, as well as the fact that no research infrastructure development activities are planned in the European Structural Funds in the coming years, the **research infrastructure development plan** focuses on maintenance of the existing infrastructure (mainly from indirect project costs), a widespread implementation of digitalization and IT systems (from institutional funding and ESIF), Open Science (from institutional funding and ESIF), upgrading and creating new personal work places (from the Baltic Bonus program and research base funding), and infrastructure development (from our own resources).

In order to ensure the full development of EDI in the coming years, given the realities of the level of institutional funding, the **important funding sources** for EDI are international research projects, contract research ordered by companies, and commercialization of our know-how and technologies. These funding sources will also be a strategic priority in the coming years to increase the total budget from €2.9 million in 2020 to €4.5 million in 2026, with the following

breakdown of funding sources: research base funding (30%, if the national government keeps its promises), international tender projects (25%), national projects (8%), contract research with industry (15%), projects related to infrastructure and cooperation development (15%), and other sources (licenses, patents, etc.) (7%).

Collaboration is an essential precondition for achieving the long-term goals of EDI, therefore the cooperation will continue with: universities in the development of talented students; research centers for high-level interdisciplinary research; industry (both SME and large enterprises) in joint and contract research; industry associations and digital innovation centers in shaping ICT policy and digitalization opportunities; state and local government institutions in raising the role and use of science. EDI has a large number of international partners (400+) and a successful cooperation with them in research projects; it is planned that we will additionally strengthen cooperation with local partners in the coming years.

EDI **communication and dissemination** activities aim to raise public awareness, inform and educate the public, promote higher education, social equality, integration and prosperity, public health, national security, sustainable development in the social, economic and cultural fields, public awareness of the importance of research, involve the society, to disseminate and "sell" our expertise, knowledge and research results, as well as to receive feedback and recommendations on the activities of EDI. To this end, we will maintain and update a public EDI website; publish on social media; create and publish press releases; prepare and distribute EDI representative materials — posters, brochures, presentation videos and demonstrators; organize and speak at conferences, seminars, exhibitions and other events; publish both scientific and popular scientific articles; engage in education and training activities; lead the development of academic works; ensure the editorial operation of the journal *Automatic Control and Computer Sciences*; document and display the historical achievements of EDI, as well as take other appropriate actions.

In order to increase the added value and impact of EDI research, EDI is interested in using the results for scientific, societal or economic purposes, due to the fact that properly used results promote innovation, new businesses, jobs and products, expand knowledge, increase Latvian and European innovation capacity, prosperity, etc. To ensure this, **our result exploitation strategy includes**: identifying the potential end-users / customers and their research needs; creating and developing new knowledge and technologies; identifying the research results that could be commercialized; performing risk management; carrying out proactive and regular monitoring of research results and analysis of technology transfer opportunities; taking action to manage and protect EDI intellectual property; attracting business leaders to facilitate technology transfer, *spin-offs* and startups, and generating additional revenue from intellectual property alienation and licensing.

Gender equality is one of the core values of EDI, as it ensures that everyone can reach their full potential and allows us to attract and retain more talent, thus promoting and improving the quality of research. EDI will continue to provide an inclusive work environment for all. All employees regardless of origin, gender, sexual orientation, nationality, etc. have the same opportunities. The recently established Gender Equality Commission will create, improve and develop a gender equality plan; promote appropriate measures; collect, analyze and publish gender data; follow the indicators to be achieved and promote their achievement by organizing appropriate activities; provide annual reports; and provide written recommendations for improving gender equality and

balance. The aims are: to promote a work-life balance; gender balance in decision-making; equality in the career development process; gender mainstreaming in research; to prevent gender-based violence; as well as raising awareness of gender equality and unintentional gender bias in employees and decision-makers.

1. Introduction

The Development Strategy of the Institute of Electronics and Computer Science (EDI) is a living document. It is updated when necessary, and the implementation of it is regularly monitored. The goal of this development strategy is to provide high level strategic guidance for decision-making and day-to-day activities at EDI. This document is a logical continuation of the EDI Development Strategy 2016-2021.

The Institute of Electronics and Computer Science was founded in 1960 within the framework of the Latvian Academy of Sciences. Its current legal status is a state scientific institute — a derived public entity, and it is located in Riga, Latvia. EDI is engaged in research and development of innovative technologies in the fields of electronics and computer science and, according to the international evaluation of Latvian scientific institutions in both 2013 and 2019, EDI **is the highest rated scientific institution in Latvia in the field of engineering sciences and technologies.**

Currently, the strongest competencies of EDI include signal and image processing, including artificial intelligence; the development of robotics, the Internet of Things (IoT) and cyber-physical systems; extremely precise timing systems; wearable technologies; ultrasound technologies; radar technologies; machine learning, computer vision and embedded intelligence; remote sensing, including earth observation and satellite data processing; connected and autonomous driving; edge and fog computation; cyber security etc. thus, it can be said that research activities of EDI focus on research and development in **Smart Embedded Cooperative Systems (SECS)** based on original or complex signal processing methods.

The **mission** of EDI is to perceive the world and design a better future by creating new knowledge, developing innovative technologies and demonstrating their practical significance in real life applications.

In order to fulfill this mission, EDI has defined its vision, analyzed the current situation, set goals, as well as developed a strategic action plan in its development strategy to achieve these goals. In order to achieve this mission, it is important to monitor and if needed update the **key performance indicators** and related **actions** that are needed for achieving them.

The cornerstone of the activities planned in the development strategy is the **strengthening of key capabilities**, which includes: the ability to launch new research directions and influence the scientific community on international level (Section 4); the ability to increase the international competitiveness of research staff and to attract students, doctoral candidates and foreign researchers (Section 5); the ability to provide the necessary infrastructure for research of international level (Section 6), the ability to attract funding through competition and to commercialize achieved results (Section 7), as well as, the ability to organize collaboration with academic, public and business partners (Section 8).

The development strategy is organized as follows:

1 In this section, we present our **vision** (Section 1.1), **mission** and specialization of SECS (Section 1.2). This is the basis of our **priority application areas, research directions** and the coverage of technology readiness levels of our research;
2 After that, we analyze the **current state of** EDI (Section 2), including our **competitors** (Section 2.1), our chosen research focus (Section 2.2), and we conclude this analysis with a full SWOT analysis (Section 2.3).
3 Based on this analysis,were identified and developed **specific action plans** in order to develop certain aspects of EDI:

- **Institutional and organizational development** (Section 3), incl. process and structure optimization, implementation of results-based development and risk management;
- **Research development strategy** (Section 4), incl. the main directions of research, research challenges, impact objectives, planned activities and management of the results in these activities;
- **Human resources development plan** (Section 5), incl. recruitment system, staff training and retraining, as well as efficient use, motivation and support of human resources;
- **Research infrastructure development plan** (Section 6), incl. development of buildings and territory, development of laboratory infrastructure and development of support infrastructure;
- **Financing strategy** (Section 7), incl. sources of targeted funding;
- **Collaboration** (Section 8), incl. cooperation with other research institutions and higher education institutions, industry and government institutions and local governments;
- **Communication and dissemination strategy** (Section 9), incl. scientific publications, technology transfer, events and public relations;
- **Exploitation strategy** (Section 10), incl. choice of the best exploitation venues and operational management of our research results to maximize impact;
- **Gender equality policy** (Section 11), incl. gender equality in recruitment and career development, decision-making; integration of gender aspects in research, etc.

1.1 Vision

The priority areas of activity, research directions, as well as the target technology readiness levels (TRL) of research at EDI must be based on **vision** for the future of the world and the role of the institute in it.

At EDI we envision that the future world is going to be even more connected, digital and automated than ever. This vision comes hand in hand with ambitious challenges, such as personalized predictive and preventive healthcare (incl. digital avatars); flexible, efficient, connected and autonomous (zero defect) factories; safe (zero fatalities), affordable, sustainable, connected, cooperative, automated and clean (zero emissions) mobility; secure, safe and trustable connectivity and system interoperability.

We have to continuously search for a niche where EDI can contribute to this future in a way that maximizes the added value to society. Based on the vision, and the strengths of EDI, our **target priority application areas** are:

 mobility  Industry 4.0  health  digital life  space.

In these areas we have identified the following **research directions** with the highest impact potential by EDI:

1. Extremely precise event timing including space domain;
2. Remote sensing and space data processing;

3. Robotics and machine perception;
4. Signal processing and embedded intelligence;
5. Smart sensors and IoT.

Our technology life-cycle is the process of turning funding into knowledge and technologies through research, and then back into a new capital and added value to the society through innovation and exploitation of the research results. This leads to benefits to the society as a whole, such as creation of more jobs, the development of a greener society, and improvements in the general quality of life (Figure 1.1.1). We must support this flow of knowledge and funding in order to sustain and grow the activities of EDI.

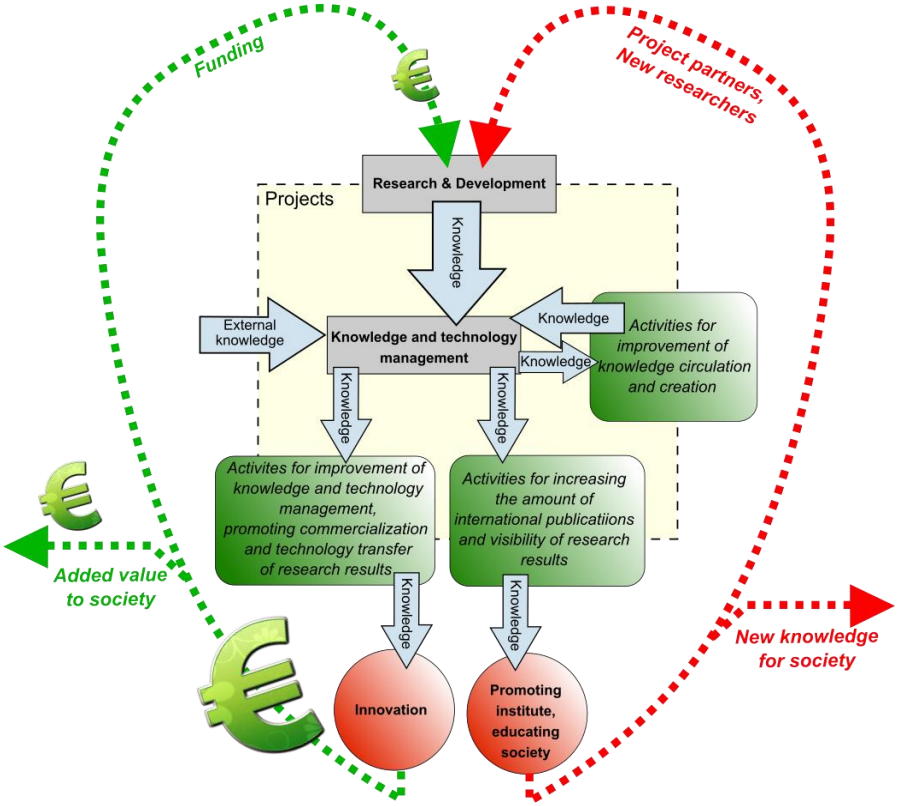


Figure 1.1.1 Technology life-cycle with knowledge and funding flows

We see our niche in bridging the technology gap between universities and the industry. The universities specialize in fundamental research (TRL 1-3), while the industry is mostly interested in innovation and product development (TRL 6-9). Hence, the target TRL of EDI are **TRL 3 to 5** (Figure 1.1.2). The role of EDI is to fill this TRL gap, and to perform active and continuous collaboration with universities and companies on the two sides of this gap.

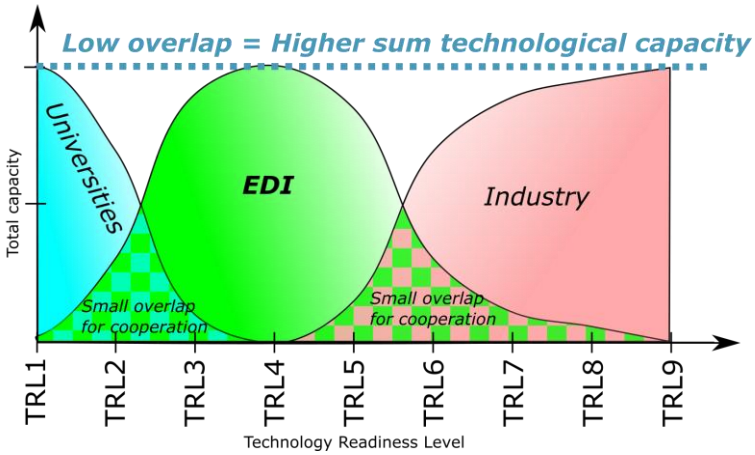


Figure 1.1.2 Strategic place of EDI research on TRL scale

1.2 Mission

According to the EDI Regulations, the goal of our activities is to acquire new knowledge and develop innovative technologies through scientific methods, to promote lasting development of information and communication technologies and connected scientific directions, and to strengthen the competitiveness of Latvia and the European Union.

According to the latest international evaluation of Latvian scientific institutions[1], EDI is the highest rated scientific institute in Latvia in the field of engineering and technology, and we have a unique perspective, competence and ability to contribute to the vision described in Section 1.1 both in Latvia and in the world. For this reason, we see it as our mission to perceive the world and design a better future by creating new knowledge, developing innovative technologies and demonstrating their practical significance in real life applications.

Our mission is developed in accordance with such Latvian and EU strategic research documents as Towards a Sustainable Europe by 2030, Latvian Digital Transformation Guidelines for 2021-2027, National Development Plan of Latvia for 2021-2027, Latvia's Smart Specialization Strategy (RIS3), Smart Specialization Areas and Growth Priorities, Horizon 2020 and Horizon Europe Work Programs, Digital Europe program, ECSEL (and KDT under development) multi-annual strategic plan, innovaton result review criteria, research ethics and other relevant strategic documents.

To best support this mission, we believe that in the medium term Latvia should establish a multidisciplinary RTO in the fields of smart specialization which would raise the innovation capacity, and that EDI should be a part of it. Such an RTO would provide an opportunity to create synergies between highly regarded scientific institutes, broadening their scope and raising their profile. EDI is ready to be an integral part of such an RTO, as it would allow us to focus on our competences to work on solving international-level research problems in the research fields described above, while targeting the needs of local and international industry leaders.

The goal for the next 6 years is to move from a leading research institution in engineering sciences and technologies in Latvia (according to the evaluation) to an internationally well regarded ICT

1 https://www.izm.gov.lv/lv/media/10707/download

research center focused on SECS. Long term goals of EDI include being part of an internationally recognized multidisciplinary RTO in Europe (see Figure 1.2.1).

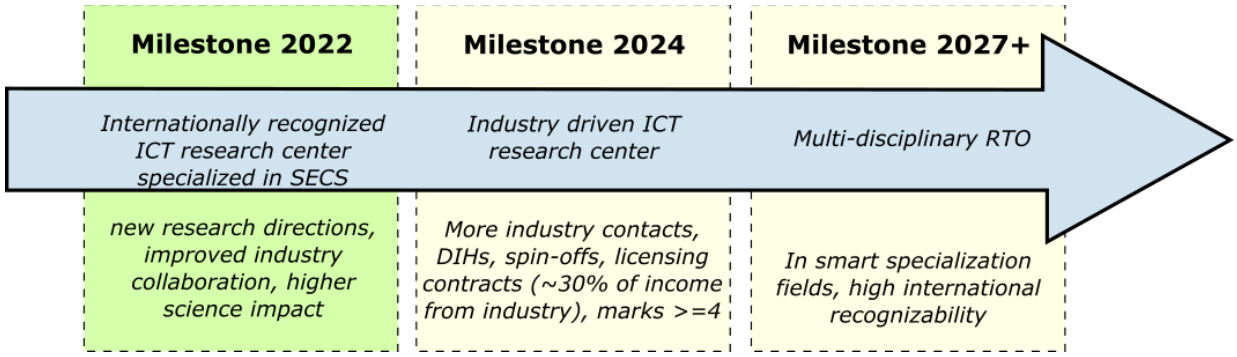


Figure 1.2.1. Figure: Short-term, medium-term and long-term milestones.

Accordingly, our **goals** are:

1 To become an internationally recognized RTO in ICT, and to grow our SECS expertise in our priority application areas and research directions;
2 To fill the technology readiness level gap between the basic research and the industry-ready innovations;
3 To develop results that increase the overall innovation capacity and raise Latvia in the country Innovation Scoreboard from the weakest group of innovators to the highest.

The mission and objectives set out a **roadmap with short-, medium- and long-term objectives**:

- **Short-term objectives:** based on the recommendations of experts of the international evaluation (1) to initiate new research directions in order to create a stronger fundamental basis for research in the long term; (2) to strengthen cooperation with industry to become an industry-led ICT research center in the future and increase the number of direct contracts with industry, and (3) to raise the "scientific impact" metrics of the institute (which had the lowest score in the evaluation relative to other of our metrics), including increasing the number of publications in Q1 and Q2 journals.
- **Medium-term objectives:** to become an industry-led ICT research center, to obtain only "4" and "5" marks in the next international evaluation of scientific institutions, and to increase cooperation with and the income from industry. To achieve this, it is necessary to increase the institute's scientific impact; to increase the number of research contracts with industry; the number of technology transfer licenses; the number of own *spin-offs*; and to continue to actively participate in Digital Innovation Hubs (DIH). At the moment EDI is a part of four DIHs (TRINITY[2], DIH-World[3], SCoDIHNet[4] and our own EDI DIH[5]). There are currently two companies (spinoffs, calle Eventech and HackMotion) competing on an international level, based on technologies we have developed at EDI.
- **Long-term objectives:** to become an important part of a multi-disciplinary Research and

2 https://trinityrobotics.eu/
3 https://dihworld.eu/
4 https://aioti.eu/scodihnet/
5 https://www.edi.lv/en/digital-innovation-hub/

Technology Organization (RTO) specializing in SECS with focus on technology readiness levels TRL3-TRL5. In order to do that, changes in national-level regulations are required, as well as improved understanding in policymakers and implementers, in conjunction with improved competitiveness of our scientific personnel in order to improve the image of EDI among foreign researchers.

2. Current situation analysis

According to the rules no. 1076 “Amendments to the law of Scientific Activity” of December 28 of 2006 by the Cabinet of Ministers, state agency “Institute of Electronics and Computer Science” became a derived public person on January 6 of the year 2007 and took over all of its previous rights and commitments. The Parliament of The Republic of Latvia confirmed this with accepted amendments of June 21 of the year 2007 in the Law of Scientific Activity. The work of EDI is based on the Law of Scientific Activity and The Regulations of the Institute of Electronics and Computer science. The Institute is overseen by a collegiate body of scientists of EDI — the Scientific Council. The director of the institute is elected by the Scientific Council. The director implements the general administrative management of EDI. In addition, the EDI International Advisory Board has been set up to address strategic issues. The Institute of Electronics and Computer Science is located under the oversight of the Minister of Education and Science.

EDI budget consists mainly of EU Framework Program projects, EU Structural and Investment Funds (ESIF) projects, European Space Agency projects, national research projects (such as State Research Programs, Latvian Council of Science (LCS) Fundamental and Applied Research Projects (FLPP) and others), knowledge and technology transfer projects, contract research projects, as well as research base funding (provided to scientific institutions by the government of Latvia), and other funding.

The functions, tasks, rights, governance, finances, property, and binding laws and reporting of EDI are described in Regulations of EDI, which conform to the law of Scientific Activity and are confirmed by the Scientific Council of EDI.

The structure of EDI consists of:

- Management, incl. the Director and his/her appointed Deputy Directors for Development and Administrative matters, project assistants, personnel specialist, procurement and information management specialists and other administrative personnel;
- Technical and maintenance division, managed by the head engineer, which consists of technical and maintenance personnel;
- Accounting, which is managed by the Head accountant, who oversees other accountants;
- Research laboratories: Discrete Signal processing laboratory[6], Space technology laboratory[7], Robotics and Machine Perception laboratory[8], and Cyber-Physical Systems laboratory[9].
- The editorial staff of a journal *Automatic Control and Computer Sciences*[10], responsible for the publishing of the scientific journal.

In 2020 EDI in total employed 126 research personnel (a total of 143 employees), of which 56 (42,18 FTE) are elected in academic positions — senior researchers, researchers and scientific assistants. EDI employed 17 people with doctorate degrees. The average age of employees in 2020 was 41.8 years, while the average age of scientists was 49.93 years.

6 https://www.edi.lv/en/labs/signal-processing-laboratory/
7 https://www.edi.lv/en/labs/space-technology-laboratory/
8 https://www.edi.lv/en/labs/robotics-and-machine-perception-laboratory/
9 https://www.edi.lv/en/labs/cyber-physical-systems-laboratory/
10 https://www.edi.lv/en/scientific-journal/

Figure 2.1: R&D organisational breakdown in 2020

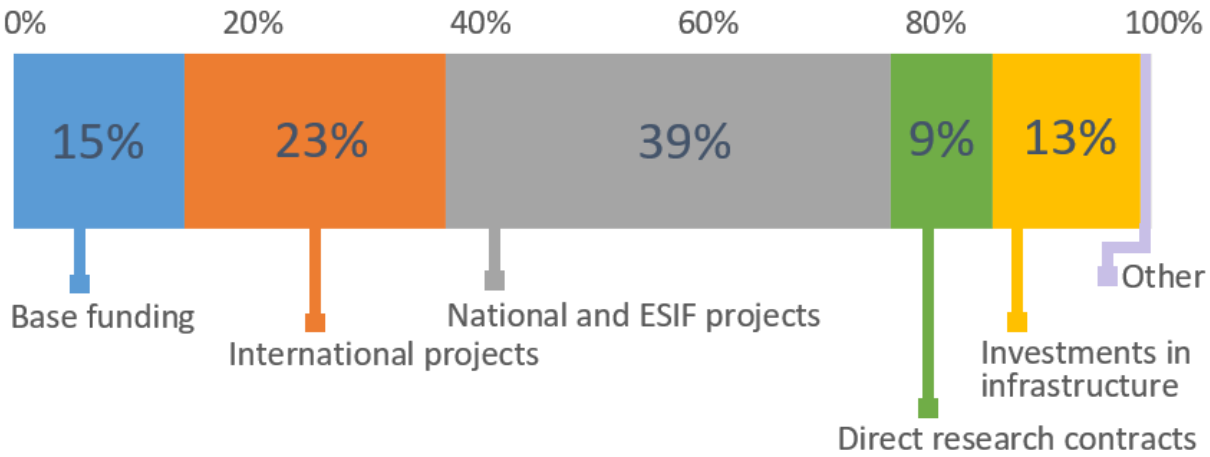


Figure 2.2. Budget breakdown 2015-2020.

More information about the EDI budget, projects and other activities can be found in the National Research Information System[11].

2.1 Competition

According to the latest international assessment of scientific institutions in Latvia (2019), EDI is the highest-rated institute in the field of engineering and technology[12]. The unique specialization in R&D of SECS is not covered by any other institution in Latvia, so there are no direct competitors to EDI. Institutions working in similar fields include the Institute of Mathematics and Informatics of the University of Latvia, which focuses on mathematics, computer science, including artificial intelligence, computer networks, semantic web technologies, computer linguistics, graph theory, modeling and simulations, real-time systems, but the research is not centered on electronic equipment, embedded systems and intelligence, robotics, IoT, etc. The RTU Faculty of Electronics and Telecommunications, on the other hand, focuses primarily on telecommunications (optical transmission systems, communication network analysis), signal processing, antennas, pulse converters, but does not cover intelligent sensors, machine learning, image processing (computer vision), robotics, systems integration (including CPS), etc.

11 https://sciencelatvia.lv/#/pub
12 https://www.izm.gov.lv/lv/zinatnisko-instituciju-stnationaliskais-novertejums

The RTU Faculty of Computer Science and Information Technology has put forward four areas of scientific activity in which it concentrates its scientific potential — comprehensive intelligent computing for evolving digital companies, comprehensive data processing (communication, computing, and management) in distributed complex environments, comprehensive intelligence for intelligent and autonomous systems development and integration, and mathematical modeling. Competition with EDI could be found in the fields of artificial intelligence and robotics.

EDI cooperates strategically with these institutions in joint research, thus mutually complementing each other's capacity and expertise.

Similarly, it is not easy to identify globally leading technology research institutions and their departments that strongly overlap with the research niche of EDI as we have identified and worked towards a complementary not competitive SECS specialty. Accordingly, the following comparison includes institutions with partially overlapping research interests. Such leaders as Fraunhofer Institute for Manufacturing Engineering and Automation IPA and VTT have approximately 10 and 20 times more employees than EDI. Therefore, the publication and citation scores are also much higher. The comparable score of field-weighted citation impact is 3x larger for the IPA and VTT than for EDI. However, EDI's budget is approximately 30 and 50 times smaller than that of IPA and VTT, so the cost-efficiency concerning the research results is significant. EDI has a similar number of registered patents, created spin-off companies, implemented contract research, and EU level projects as leading research centers such as VTT, TNO, Tecnalia, Fraunhofer, IMEC if calculated for one employee and available budget. Although these research organizations are much bigger and get much more funding we are still competitive, especially when working in niche areas such as embedded intelligence, event timers, radars, etc. Thus we rather cooperate and complement international partners than compete with them. We work together as equals on different international projects including more than ten Horizon 2020 projects.

The main differentiator from leading research organizations mentioned above is the rapid and flexible adaptation to the necessary changes due to the small and efficient administration of the institute, as well as the ability for any staff to contact management quickly. As a result, faster strategic and day-to-day operational decisions are possible, as well as a faster response to changes in external conditions and the market. Finally, EDI has exclusive know-how in a number of research areas (such as precise event timing), which makes it possible to impact the direction of these research areas globally.

2.2 Our research focus

During the last evaluation period, EDI had focused its research on the field of Smart Embedded Cooperative Systems. Based on the achieved success and the high marks of the international assessment, SECS will continue to be our focus.

SECS consists of four main components, all of which characterize existing competencies and uniquely position the niche of EDI:

- **Smart** — with focus on new and innovative signal / image / video processing algorithms, theory, methods and approaches (including artificial intelligence, machine perception, machine learning, etc.).
- **Embedded** — the implementation of the above mentioned intelligence in different embedded systems (MCU, FPGA, SoC, DPU and GPU based systems), which are characterized by limited resources (computing, memory, energy, size, etc.) and require the creation of innovative approaches, architectures, etc..
- **Cooperative** — with focus on embedded intelligence communication technologies (WSN,

IoT, 5G, BLE, LoRa, ZigBee, etc.) so that different embedded systems can communicate with each other, the infrastructure, the cloud, and other objects. EDI is interested in new protocols, energy efficiency, low latency, self-organizing networks, and similar technologies.

- **Systems** — the development of equipment and software to create fully-functional systems / technologies that enable the demonstration of the above solutions.

According to the strategic documents of Latvia and the European Union, in the next decade, SECS-related technologies will become increasingly important components of global research and development. They will help to fulfill the Europe 2030 strategy, which emphasizes smart, sustainable, and inclusive growth. SECS expertise and infrastructure have allowed us to participate in H2020 projects as a valuable partner, able to carry out the necessary research, integrate it into the joint developments, and develop technology demonstrators in a realistic environment. The fact that international partners value EDI as a partner is shown by the willingness of former partners to cooperate with EDI again in future projects and applications (for example H2020 3ccar[13] -> H2020 Autodrive[14] -> H2020 PRYSTINE[15]-> H2020 AI4CSM[16]).

2.3 SWOT analysis

In order to successfully plan the EDI strategy and draw up the plans in the following sections, we analyzed the strengths and weaknesses, as well as opportunities and threats (SWOT) of EDI.

Internal	Strengths	Weaknesses
	● EDI infrastructure meets the requirements for supporting a high level international research; ● A creative, motivated team of young researchers working in tandem with experienced scientists; ● Research on the world's latest challenges, including in collaboration with leading research centers and industry in Horizon 2020, European Space Agency (ESA), ERA-NET and other projects; ● Several outstanding achievements (event timers (NASA, ESA), self-driving and cooperative driving (Grand Cooperative Driving Challenge), WSN/IoT (EDI Testbed) etc. ● Extensive (400+) list of international partners, including leading European research centers and Industrial enterprises;	● Lacking infrastructure and knowledge for technology commercialization; ● Project oriented research due to small (~ 15%) institutional (base) funding and thus limited opportunities to focus on specific research topics in order to achieve excellence; ● As a result of generational change, the number of experienced scientific managers has temporarily decreased; ● Limited number of scientific publications due to 1) the writing of many project proposals, 2) focus on applied science projects, 3) the relatively large proportion of students in the research staff; ● Relatively low revenue from technology transfer that could be re-

13 https://3ccar.eu/
14 https://autodrive-project.eu/
15 https://prystine.eu/
16 https://ai4csm.automotive.oth-aw.de/

	● Small and efficient management that allows dynamic strategic and day-to-day decision making; ● Relatively low dependence on the national budget and financial stability; ● Active participation in higher education processes (internships, supervision and development of theses, teaching courses); ● Publishing of an international scientific journal AC&CS, distributed by Springer; ● Available premises for further development, "spin-off" companies, cooperation with industry, etc. ● Participation in a number of DIH and technology commercialization projects.	invested to take the next step from a prototype to a minimum viable product.
External	**Opportunities**	**Threats**
	● Improving the technology transfer system and its financing: further involvement in digital innovation hubs, closer cooperation with industry, incl. start-ups, attracting industry to EDI buildings in order to build the ecosystem; ● Flexible and fast adaptation of EDI operation in accordance with the changes in Horizon Europe, INSIDE-IA, KDT and other strategic documents; ● Involvement in the development of Latvian science and development policy, lobbying of EDI interests in various organizations; ● Attracting experienced researchers, post-docs and talented students by providing challenging research topics (including opportunities to start new ones) and internationally competitive infrastructure; ● Development towards a multisectoral RTO; ● Establishment of a development fund to increase revenues from technology transfer and donations.	● Non-compliance with the legislation (Latvian Law on Scientific Activity envisages an increase in funding for scientific activities by 0.15% annually) and planning documents (Science, technology development and innovation guidelines (ZTAIP), national development plan etc.), which envisage an increase in research and development funding. In case of such non-compliance, the development strategy and results of EDI must be reviewed; ● Decline in the success of obtaining project funding; ● Specialists moving abroad and / or towards industry due to higher salaries and instability of the research system in Latvia; ● Decrease in the number of graduates with appropriate qualifications and quality from the higher education institutions, due to the overall decrease in the level of education and the low prestige of the profession of scientist.

To benefit from this analysis and move EDI towards the vision and goals described above, in the following sections several development plans and strategies are described together with activities to be taken and key performance indicators to achieve these goals.

3. Institutional and organizational development

In order to improve the long-term capacity and management efficiency of EDI, an **institutional development plan** has been developed. It consists of several parts, which are described in detail in the following subsections:

- Development of organizational processes and structure;
- Result-based development;
- Risk management strategy and identified risks.

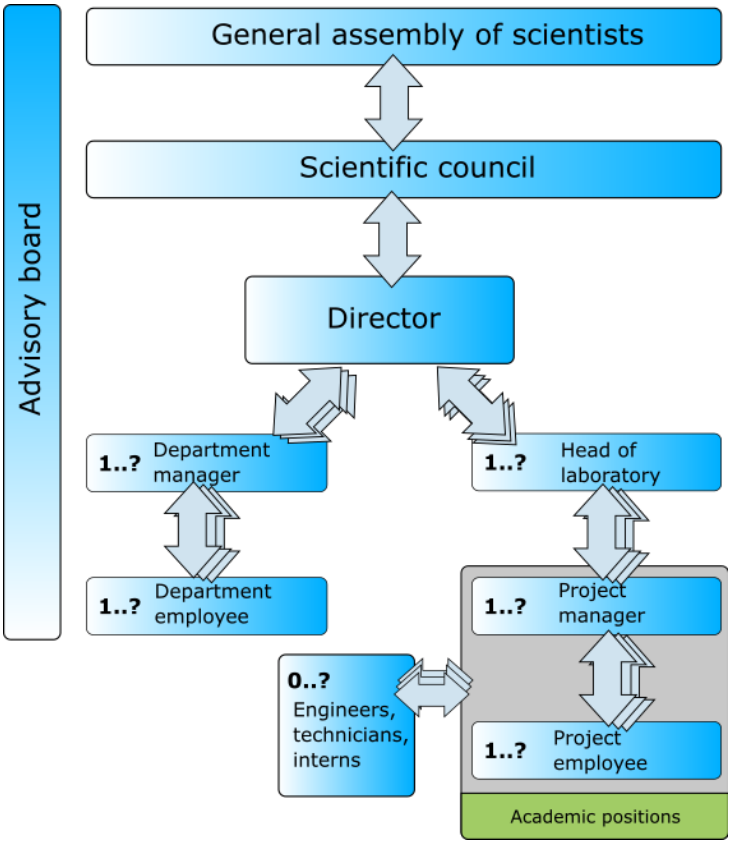
3.1 Processes and structure

The organization of work processes in EDI is currently in line with its status and strategy. In the long term, if EDI becomes part of a multidisciplinary research and technology organization, the organization and structure of processes will need to be adapted accordingly.

To support the strategic objectives and ensure that the results defined in the strategy are achieved and that all EDI functions are met, the Director uses the cascading of objectives described in the next section, “Results-Based Development.” An important source of information is the EDI Handbook, which is regularly updated and explains many important aspects of EDI work to employees, including security, documents, buildings, laboratories, tools (including digital tools), procedures, bonuses, laws, etc.

The overall structure of information flow and decision making is as follows:

- The General Assembly of Scientists elects the Scientific Council;
- The Scientific Council elects the Director and decides on the long-term objectives and strategy of the Institute;
- The Director proposes and approves the composition of the International Advisory Board, which in turn advises the Scientific Council and the Director;
- In order to achieve EDI objectives, the Director organizes the day-to-day running of the Institute and reports to the General Assembly of scientists and the Scientific Council on the results achieved;
- The Director sets up the organizational structure of the



Institute, such as accounting, technical and economic departments, laboratories, etc .;

- The director works by cascading tasks to the heads of laboratories and departments;
- The laboratories are staffed by academic staff elected by the Scientific Council, as well as the necessary scientific, technical and service staff;
- The research staff in the laboratories obtains funding for research projects and is responsible for the implementation of these projects and the achievement of the results defined by the Director and the Development Strategy.

The Director may reorganize this structured chain of responsibility, as necessary, to resolve conflicts of interest or for other reasons related to the quality or evaluation of the work. For example, the adoption of the Alert Law initiated a new appropriate process. Information on process developments related to results-based development, staff motivation, IT systems for document flow, and risk management is described in the following sections.

To achieve the development goals of EDI more effectively, a new post was created in May 2019 with the appointment of a suitable Deputy Director for Development. The main responsibilities of the Deputy Director for Development are: to plan, organize and control matters related to the development of the Institute and to represent the Institute in state and local government institutions, international scientific institutions, and other organizations within the scope of its competence; to ensure the cascading of the activities to be performed and the results to be achieved up to the level of laboratories and scientific groups and to control the fulfillment of the given tasks; participate in the work of standing and temporary committees; to submit proposals for the improvement of the development processes of the Institute and the development and efficient use of the resources of the Institute.

In order to ensure the efficient administrative management of the Institute, a Deputy Director for Administrative Affairs has been established. The duties are: to coordinate the administrative activities of the Institute, including the administrative process of research projects; to supervise the circulation of documents, record keeping, and archiving following the regulations; to ensure, in cooperation with the Director of the Institute, the proper management of intellectual property and the protection of the intellectual property rights of the Institute; to ensure the rational and efficient use of property and premises and to supervise the maintenance of the movable and immovable property.

Planned actions		Expected results		
Deadline	Action description	KPIs	Now	Goal
Progress	3.1.1. Strengthen the International Advisory Board by attracting new members from key organizations.	3.1.1. Number of updates of the development strategy per year.	1	1
2023	3.1.2. Establish a regular meeting group of EDI Scientific Group Leaders to facilitate the development of new, fully-fledged, and independent laboratories.	3.1.2. Number of meetings of the International Advisory Board per year for strategic advice.	1	2

2027	3.1.6. Involve EDI in the structure of Latvia's multidisciplinary RTO.	3.1.3. Consultation with other scientific institutes on the establishment of a multidisciplinary RTO.	0	1

3.2 Result-based development

A **results management system** has been established and is regularly updated. It allows to better align the development of EDI with its strategic goals and the goals of Latvia and the EU. This system is based on the vision, mission, goals, and strategic tasks described above and on other Latvian and EU strategic documents mentioned in Section 1.2. These documents have been used in the development of this development strategy.

This system aims to ensure the systematic planning, management, evaluation, and development of staff work and ensure the quality and productivity of this work. It should raise the international competitiveness of our academic staff and lead to more high-quality funded projects and a greater impact on the international scientific community.

The EDI performance management system consists of three parts:

1. **Cascading:** assigning staff in accordance with the EDI strategic plans and the results to be achieved, broken down by department and individual levels;
2. **Measurement:** task performance measurement and control;
3. **Feedback:** providing regular constructive and developmental feedback to staff based on measured performance and consistency with EDI deliverables (KPIs).

Cascading is a method by which EDI can achieve progress in its own goals, delegating specific measurable tasks from the institutional level down to the individual level. This cascading takes place both in the short and long term. The cascading process provides tasks both at the short timescale and on the annual timescale, drawing up an annual work plan for the coming year[17].

The EDI Development Strategy is a living document. Its relevance to the current internal and external situation is discussed and, if necessary, updated within the Scientific Council and the International Advisory Board.

Based on current goals and achievable results, each year the work plan of each EDI employee is prepared in cooperation with their immediate supervisor, taking into account the respective goals and results of the institute and departments, cascaded from the common goals and activities of EDI. For example, if the EDI Scientific Council sets the goal for the next year to achieve a certain number of scientific publications in journals with a high citation index, then this task is shared between laboratories. Laboratory managers then cascade this task by dividing the assigned number among project managers in the laboratory, who in turn plan their work so that the laboratory can achieve its annual overall plan. Next, project managers plan how many of these publications they will provide themselves and how much they will cascade for their subordinates. This means that both projects that are already running and project applications that are being prepared always take into account the objectives set out in the strategy. In this way, for each

17 Yearly planning is mandatory for the academic staff. The long-term plans of scientific and technical service staff are subordinated to the job description and therefore planning is optional (but recommended).

indicator to be achieved each year, there are specific action plans for certain employees.

Cascading objectives and monitoring workflows take place in two ways:

- *Cascading research support activities:* The EDI Director assigns tasks to and directs laboratory managers in accordance with the strategy and objectives approved by the Scientific Council. Laboratory managers, in turn, cascade these tasks on to project managers and / or research teams in their laboratories, further cascading to the individual staff level. Managers of other departments cascade tasks directly to employees of their departments. These managers also control how these results are achieved.
- *Cascading of research objectives*: In each project,[18] its leader is responsible for achieving the objectives of the specific project following the tasks and deliverables defined in the project application. The project manager reports on the fulfillment of the project objectives to the project monitoring authority, as well as cascades the project tasks and objectives to other project staff, either directly (in smaller projects) or through group leaders (in larger projects). In the same way, the project manager evaluates the progress towards the project objectives and either makes decisions within the project or cascades issues that affect the achievement of all EDI objectives to the director as needed.

In addition to this formal cascading chain of goals and results, an informal mentoring system provides staff with a mentor (such as a dissertation supervisor, laboratory leader, group leader, etc.) as needed to work together on next year's career plans as a whole. More about the mentoring system described in 5.3.1. subsection.

Measuring the achievement of EDI goals and results is performed in two ways: 1) the fulfillment of goals cascaded to the project level is monitored by project managers, who in turn initiate any changes in plans that may affect the successful achievement of these goals; 2) the general objectives and results of the institute are monitored by the director using the annual staff evaluation system. In the long term, the goal is to measure performance continuously using an automated results tracking IT system that allows you to see what goals and results are assigned to each employee at the moment and track their progress, allowing immediate action if goals are threatened or delayed.

Feedback is provided to EDI employees through evaluation, remuneration, and motivation systems. Those are regularly improved based on the achievement of EDI goals and are described in documents such as the Procedure for Evaluation and Motivation of Employees of the Institute of Electronics and Computer Science. EDI payment system also provides additional benefits for high-quality publications and project applications.

Planned actions	
Deadline	Action description
2022	3.2.1 Formulate a mentoring system for new employees to define goals and a plan
2023	3.2.2 Automate the cascading and monitoring of objectives and outcomes

Expected results		
KPIs	Now	Goal
3.2.1 Each employee has a clear understanding of the goals and objectives of EDI and actively participates in achieving them	Partly	Yes

18 In the context of this document, a “project” denotes either a research project (paid by various funding sources, including State Research Programs), research base funding, or contract research.

3.3 Risk management

The management and assessment of risks (including threats and opportunities) is an integral part of the EDI development strategy, as timely risk identification and assessment of new development opportunities are an essential part of any innovation-based R&D institution. EDI risk management procedures are based on global practices and the ***ISO31000:2018*** risk management standard. Figure 3.3.1 illustrates the general process of the risk management procedure.

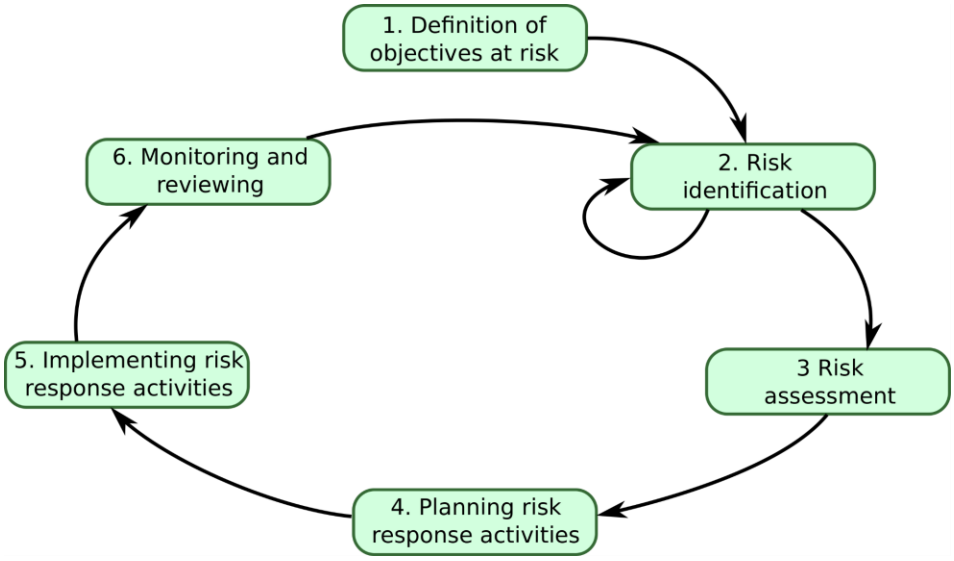


Figure 3.3.1. ISO31000:2018 general risk management process.

Ongoing risk management identification activities are performed by EDI management in collaboration with department and laboratory managers, project managers and research team leaders.

Following a standard procedure, if a new risk is identified during ongoing risk management, management performs a risk assessment and sets priorities. During this process, the risk management committee assesses the likelihood of a risk and its potential impact, making it possible to establish a prioritized list of risks and opportunities. In addition, possible risk-related activities are evaluated, leading to a risk response plan. If the benefits of the response plan outweigh the combination of risk impact, likelihood and mitigation costs, the plan is implemented. The implementation activities lead to changes in the risk itself, thus leading to the risk reassessment and restoration of the likelihood and potential impact evaluations. Table 3.3 summarizes the currently identified and monitored risks, and Figure 3.3.2 illustrates the risk placement in the probability-likelihood plane.

Table 3.3. Identified risks for a successful EDI development.

Impact (1-10)				Multiplication (Priority)	
Feasibility (1-10)					Risk management activities (preventive / corrective)
ID	Risk description				
Financial risks					
FR1	The nature of research projects can lead to fluctuations in	5	4	20	*Preventive*: The management of the institute maintains an overview of all available funding,

	available funding, which can bring difficulties in ensuring the continuity of employment.				active projects, deadlines, staff and workloads. This information is used for considering hiring new staff and planning expenditures covered by research base funding. *Corrective*: In case of risk fulfilment, the next steps are set by the management while evaluating the prospects and long-term goals of EDI.
FR2	Managing authorities and customers may hold payments due to various factors, which may bring difficulties in ensuring the continuity of employment.	2	5	10	*Corrective*: Our research base funding is used as a safety buffer. If the funding organization is a Latvian institution, a meeting is organized where EDI management presents the potential consequences. Each case is assessed separately.
FR3	As a result of changes in public policy, public funding for research may not increase, leading to greater reliance on contracts.	7	2	14	*Preventive*: EDI informs national organizations at various events and periodic meetings where researchers and management disseminate research results. *Corrective*: The needs of all employees are assessed, and the available budget is consolidated. All employees who are not directly involved in research activities focus on the research proposal preparation.
Personnel risks					
PR1	Difficult to impact factors or offers from other employers may lead to a situation where scientific and technical staff leaves EDI, leading to difficulties in the day-to-day management of staff.	5	4	20	*Preventive*: Employees are offered health insurance, a discounted lunch offer and an attractive work environment. In addition, the work is clearly defined so that, if necessary, another employee may overtake the relevant tasks. *Corrective*: Latvian law provides a possibility for an employer to delay employment's termination for a month. During this month, the employee's main task is to document his work and transfer intellectual property to colleagues or new employees.
PR2	Offers from other employers may lead to a situation where highly qualified scientific and technical staff leave EDI, creating difficulties in carrying out research and technical tasks.	5	6	30	*Preventive*: Twice a year, the whole EDI research staff is interviewed for feedback on their wishes, ambitions and needs of the research process. This information is used to develop new research directions, improve the structure of research teams and offer employees to improve their skills in various seminars and conferences (at least once a year). *Corrective*: Latvian law provides a possibility for an employer to keep the employee for another month before terminating the employment. During this month, the employee's main task is to document his work and transfer intellectual property to colleagues. Of course, hiring a new employee is a priority and, if one is identified, he or she will be involved in the process.
PR3	Difficult to impact considerations (incapacity for work, family, beliefs) may lead to a situation where highly qualified scientific	4	6	24	*Preventive*: Knowledge sharing is encouraged and even required by organizing weekly seminars as well as using various tools for intellectual property management, i.e. git and wiki. At the

	and technical staff may leave EDI, complicating research and technical tasks.				group level, group leaders and project managers are responsible for partial overlap of skills. *Corrective*: Latvian law provides a possibility for an employer to keep an employee for another month before terminating the employment. During this month, the employee's main task is to document his work and transfer intellectual property to colleagues. Of course, hiring a new employee is a priority and if one is identified, he or she will be involved in the process.
PR4	Difficult to impact considerations (incapacity for work, family, personal beliefs) or offers from other employers may lead managers to leave EDI, complicating research and technical tasks.	4	9	36	*Preventive*: Every manager has a potential substitute who assists in day-to-day work and partly takes over management tasks, so the potential substitute is already partially prepared for such a scenario. *Corrective*: Latvian law provides a possibility for an employer to keep an employee for another month before terminating the employment. During this month, the manager will transfer management to a potential replacement. EDI strives to maintain a good relationship with departed employees; thus, further consultations are possible if necessary.
Research risks					
RR1	Due to the lack of knowledge and a lack of cooperation between colleagues, research staff can invest a lot of time in the wrong direction, which would lead to unachieved research goals.	5	6	30	*Preventive*: Knowledge sharing is encouraged and even required by organizing weekly seminars and using various tools for intellectual property management, i.e. git and wiki. In addition, various networking events are organized, such as sports activities, board game evenings and work environment improvement activities.
RR2	Lack of knowledge and awareness of global research can lead researchers to invest a lot of time in the wrong research direction, which may lead to insignificant research results and impact.	5	6	30	*Preventive*: The leader of each research group is responsible for maintaining a list of major scientific publications and conferences, as well as organizing internal scientific seminars. Funds for participation in various conferences have also been allocated. *Corrective*: Weaker groups can be combined with stronger ones in the short term to gain important experience in high-quality research.
RR3	The activities of different research groups around the world may lead to a situation where an innovative idea or relevant research results are published sooner by someone else, which may lead to a lesser impact on the research direction.	2	6	12	*Preventive*: The research staff is encouraged to participate in world-class scientific conferences and international projects, thus gaining international experience. *Corrective*: The group is encouraged to continue research as such a situation is an indication that the chosen research direction is relevant. The results are compared, and different innovative aspects are identified; if the research results contribute to the original published work, the authors are encouraged to publish with modifications.
Implementation risks					
IR1	Lack of awareness and feedback from local and global	5	5	25	*Preventive*: Even for projects without industry partners, project managers are encouraged to

	industries can lead to insignificant and unusable research results that may reduce the available future funding.				contact the industry and learn about the topical challenges. If necessary, a non-disclosure agreement is signed. *Corrective*: Even if research results are not immediately applicable, they are documented and maintained in EDI knowledge databases, as the results may become relevant in the future and may form the basis for more relevant future research.
IR2	Burn-out of the research staff can reduce the quality of research results and lead to lower quality execution of different tasks, which may affect the overall reputation of EDI.	6	5	30	*Preventive*: Periodic meetings are organized between the project managers to maintain and update a plan for future research. Also, at least once a year, the research staff is interviewed for feedback. *Corrective*: A meeting of project managers is urgently organized, where priorities are reassessed, and a new strategy for employee employment is developed.
IR3	The need for unforeseen or non-availability of other (non-EDI) organization results may complicate the achievement of the set research objectives, which may affect the reputation of EDI and make it difficult to attract funding in the future.	4	7	28	*Preventive*: Already in the project application development process, attention is devoted to the identification of potential risks. This type of cooperation model is mostly allowed in cases where the partner has already had experience with previous projects. *Corrective*: The project manager urgently contacts the task/work package leaders and the project technical coordinator to resolve the situation on a higher level. Depending on the situation, changes may be made to the project agreement.
IR4	Due to the various factors related to the COVID19 pandemic, legislative and public health aspects may adversely affect the achievement of scientific goals due to teleworking, knowledge sharing and mental difficulties.	6	6	36	*Corrective*: A system has been set up to manage and monitor the tasks of remote workers. Remote meetings are organized more frequently, and mechanisms are put in place to inform colleagues each time some progress has been made in code development (using web-hook technology), which fosters a sense of community. Networking events are organized remotely. Employees are provided with appropriate audio/video equipment for quality remote collaboration.
Risks of collaboration					
CR1	Lack of interest from the industry can make it difficult to exploit research results, which precludes technology transfer and reduces the overall budget of the institute while jeopardizing the sustainability of the research direction.	5	5	25	*Preventive*: EDI actively participates in industry conferences and international projects with large industry participation, where EDI actively promotes its research results. *Corrective*: Research results are well documented and stored using EDI's internal intellectual property management tools to facilitate the potential use of the research results in the future.
CR2	As a result of insufficient publicity, potential EDI partners may not be aware of the opportunities for collaboration with EDI, which may reduce the	5	5	25	*Preventive*: EDI actively participates in various national and international events by promoting the achieved research results. In addition, EDI disseminates its research results on various social networks and television.

	importance of research results and future funding.				*Corrective*: Personalized communication is created with the potential partner and the results of the EDI research are presented.
CR3	Insufficient performance of a research team can damage EDI's reputation, which can interfere with future collaborations with potential partners.	4	5	20	*Preventive*: EDI sets communication standards, such as responding to emails within 3 hours, using code management tools and presenting results to colleagues. *Corrective*: The project manager is temporarily replaced by a more experienced specialist who leads the research team until its performance is improved.

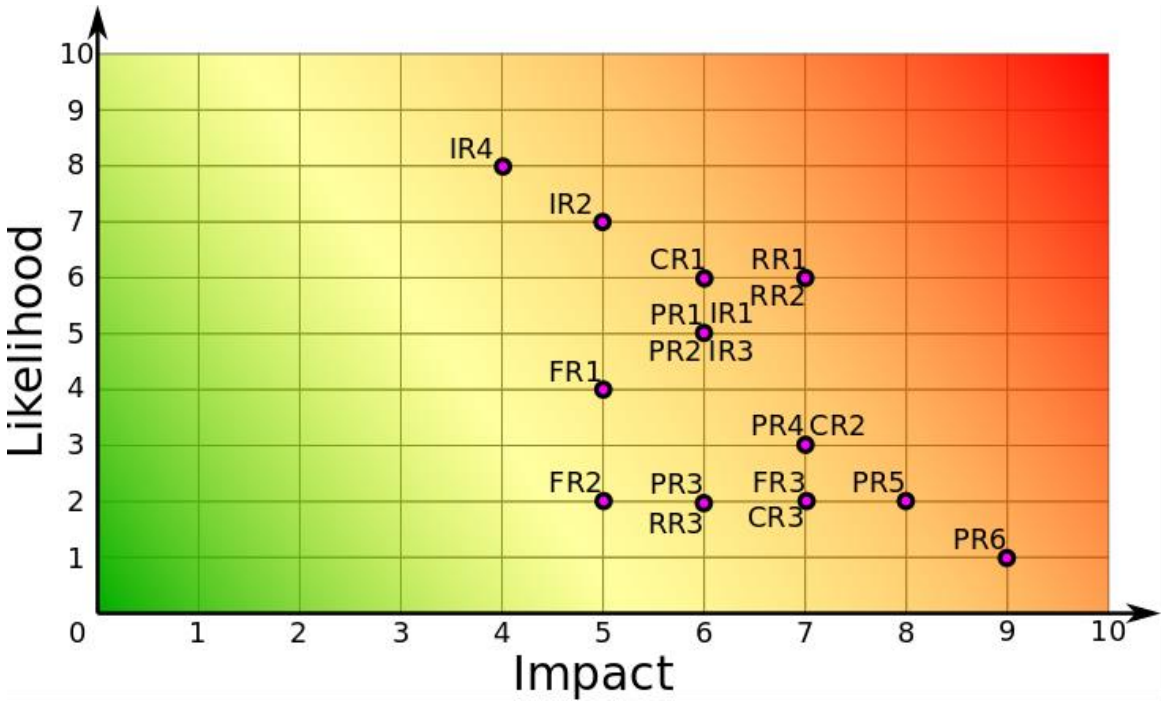


Figure 3.3.2. Risk visualization in the probability / impact plane (FR — financial risks, PR — personnel risks, RR — research risks, CR — cooperation risks).

4. Research and development strategy

4.1 Main research directions

EDI research is related to the acquisition of new knowledge in electronics and computer science. Some EDI research directions have long traditions at the institute and have already achieved international influence. Some examples in this category include our work on very accurate time measurement, and on digital signal processing. Other research directions have recently been launched or re-launched in a new context and are becoming increasingly important in the institute. Examples include Artificial Intelligence (AI) based robotics and *Industry 4.0*. In recent years, EDI has reassessed its historical and current research directions, identified their strengths and growth potential, and formulated **five key research directions**. This evaluation was followed by a reform of the Institute's laboratories with the objective to achieve better coherence between the research directions and laboratories.

The five priority research directions identified by the Scientific Council are:

1. Extremely accurate timing, including for space applications. This is the focus of the Space Technology Laboratory, which researches and develops innovative digital time processing technologies for highly accurate (2-3 picosecond) time measurements. The goal of EDI is not only to ensure that these event timers have excellent performance, but also to replace specialized analog hardware with digital signal processing components, in this way reducing hardware manufacturing costs. Research that started in 1976 has led to current technologies that can measure time intervals with an accuracy of better than 3 picoseconds and provide measurement frequencies of up to 20 MHz. At the same time, the technology is more efficient and simpler to implement than its alternatives. The main field of application is precision timers for the satellite laser range with millimeter accuracy. More than 50% of NASA's ILRS (*International Laser Ranging Service*) stations are equipped with EDI technology. Another outstanding achievement is that the time slot technology created by EDI is also used in the international JUNO project. It is now known that the European Space Agency intends to use EDI technology (created by ESA's Plan for European Cooperating States project MPET) in space missions on the asteroid Hera and in a joint mission with RosKosmos Luna-27 to the Moon. EDI research in this direction not only influences global knowledge in event timing technology, but also contributes to fundamental sciences such as particle physics and space exploration.

In the future, EDI plans to improve event timers, for example, to combine the recording of time synchronization pulses with the measurement of the amplitude of this signal and other parameters. In terms of applications, EDI intends to increase its involvement in space mission-related projects by finding appropriate partners and promoting space-based technology. We will also seek to increase our contribution to underground physics experiments, such as those conducted in the framework of the Large Hadron Collider, and otherwise cooperate with CERN. In addition, EDI is exploring high-precision applications of event-time technology, such as gravimetry, 3D-scan systems and time-of-flight spectrometry, as well as the evaluation of fiber network data transmission parameters.

2. The field of remote sensing and space data processing is covered by the scientific groups in the Space Technology Laboratory and the Discrete Signal Processing Laboratory.

One group is developing image processing algorithms for Earth observation applications. As a result of the research, an original image classification technology called Dynland has been developed. This technology uses a novel parameter-free clustering method. In general, this group

develops algorithms for processing RGB, multispectral, hyperspectral, X-ray, and synthetic aperture radar (SAR) images. The applications include satellite image processing algorithms for smart and secure cities, forestry, and land cover classification. Remote sensing image processing techniques have also been used to classify skin lesions using multispectral skin images.

Another group uses ultrawideband (UWB) radar sensor technologies for object detection, localization, motion detection and tracking, non-invasive diagnostics and parameterization of earth layers and materials. The applications include remote sensing and UWB radar systems for remote diagnostics of materials, contactless ice thickness monitoring, security systems: detection of small movements, detection of object defects, monitoring of non-contact vital signs, etc.

A third group studies ultrasonic testing, impact and vibration analysis and optical sensors based on improved signal processing and artificial intelligence. Applications here include non-destructive testing to characterize material properties, assess wear processes and detect internal defects; characterization of biological tissues for diagnostic purposes in biomedicine; measurement of environmental and weather parameters for monitoring, warning and control purposes.

In the future, our applied research aims to develop software products and services that use data processing from satellites, aircraft and drones using customized methods and algorithms. Specifically, we plan to use our classification technology to create Dynland software solutions for specific tasks in forestry, agriculture, nature conservation and wetland analysis. New methods for processing RGB, multispectral, hyperspectral, SAR and LiDAR data will be developed. Not only UWB technology, but also FMCW and other advanced technology radars will be used to process radar signals. In the field of ultrasonic applications, it is planned to develop a series of prototypes that could be demonstrated in real-world environments.

3. Research on robotics and machine perception is done by the laboratory of Robotics and Machine Perception, as well as the laboratory of Cyberphysical Systems. EDI explores systems that are able to perceive and analyze the environment, make decisions and act independently. Examples of such systems are industrial robots, autonomous cars and autonomous drones. EDI works with such complex systems, as well as fundamentally researches and practically applies their individual components: smart sensors, sensor systems, computer vision, artificial intelligence and robot control elements.

EDI develops various types of smart sensors for environmental and animal monitoring, industry and mobility. One of the most widely used types of sensors in EDI machine perception studies is video cameras, including hyperspectral and high-speed cameras. We develop computer vision algorithms that use camera data to solve various visual tasks, for example, image registration and classification, object detection and recognition, frame segmentation. We aim to use these computer systems in Industry 4.0 applications, where intelligent robots will be able to detect, grab and manipulate randomly placed objects in a changing environment; in agriculture, where a robotic weed killer in the field can distinguish crops from weeds; and in medicine, where image analysis can lead to automated diagnosis. We also use it in the field of mobility and intelligent transport systems, where on-road cameras and other sensors allow traffic flow to be analyzed and number plates to be recorded, and in-vehicle cameras to automate driving.

EDI also uses depth cameras and LiDARs, which provide 3D information about the environment and objects, and are especially useful for navigating mobile robotic platforms (drones, autonomous robots, and cars), as these platforms have to navigate environments with many variable and unpredictable obstacles.

For the processing of video camera and other sensor data, EDI explores both classical signal

processing methods and machine learning-based approaches, including Deep Learning: deep convolutional networks, recursive networks, generative adversarial networks. For the training of such networks, EDI is researching and developing synthetic data generation techniques that allow the use of supervised machine learning in tasks where labeled training data is difficult to obtain. To increase the reliability of these and other AI methods, EDI is also exploring the possibilities of explanatory AI.

EDI robotics research integrates the above-mentioned perceptual components into robotic systems, enabling the development of decision-making and control algorithms for both industrial robots and mobile platforms. EDI works on robots that can interact safely with both humans and other robots. In addition, we also explore the synergy between reality and simulations: in particular, we look at the possibilities of developing appropriate control algorithms on both a real robot and its digital twin are being explored, as well as the possibilities to train robots in simulation environments and subsequently transfer their knowledge to real environments.

In the future, we plan to focus on applications and research directions such as digital twins for industrial robots and other applications, reinforcement learning and simulation-based training for industrial and other applications, cognitive robotics, and lower TRL research in the area of explanatory artificial intelligence.

4. Research on signal processing and embedded intelligence is performed in the laboratory of Discrete Signal Processing and the laboratory of Robotics and Machine Perception. EDI develops algorithms to process signals from a variety of sensors, including ultra-wideband radars, accelerometers, gyroscopes, ECG, EEG, EMG, and others. Our signal processing research includes image processing in areas such as biomedicine (melanoma detection), satellite data processing (forest analysis), intelligent transport systems (vehicle and pedestrian detection), security (palm recognition), agriculture (crop and weed detection), and much more.

In the field of embedded intelligence, EDI is focusing on the challenges related to the end of Moore's Law, specifically, on finding new solutions to increase the performance of computing hardware. EDI develops new energy-efficient solutions for the implementation of data processing algorithms (such as specialized neural network architectures, image processing accelerators, asynchronous multiprocessor processing, toolkit development process automation, etc.) using heterogeneous single-chip systems (*SoC*) and field-programmable logic array (FPGA) based technologies. As a result of this research, it is possible to realize the perception of energy-efficient computer systems by performing, for example, stereo image processing, deep machine learning-based observation, infrared and visible image merging, and localization of drones.

EDI research on signal processing and embedded intelligence has also contributed to our fifth research priority (smart sensors and IoT), described in the next section. EDI researchers are currently working on hardware platforms ranging from the smallest microcontrollers to state-of-the-art heterogeneous single-chip systems. This work includes the design of printed circuit boards, the development of low-level software and algorithms, the engineering of digital and analog converters, prototyping, and the development of cooperative systems.

In the future, we plan to continue to use the accumulated knowledge in the field of signal processing and embedded systems to provide state-of-the-art solutions for next-generation industrial applications, large-scale sensor networks, construction, healthcare and smart mobility. In addition, EDI will expand its expertise in SoC systems and even offer its image processing silicon intellectual property (IP) cores to VLSI designers. Regarding future research directions, grid cell-based localization and its role in the photonics industry should also be noted.

5. Research on smart sensors and the Internet of Things (IoT) is carried out in the Cyberphysical Systems, Robotics and Machine Perception, as well as the Discrete Signal Processing laboratories.

Research focuses on efficient data collection, transmission and low-latency feedback. We develop intelligent sensors with original digital signal processing capabilities to effectively monitor a variety of environments and provide low-latency feedback, such as wearable sensors for posture monitoring in rehabilitation, motion tracking device for telemedicine and training, sensor-based knee rehabilitation device for prosthesis monitoring and control, head bandage for alternative mouse control, train integrity monitoring system, multimodal biometric system on one FPGA, high speed wireless sensor unit for industrial environment, hardware accelerators for Vehicle-to-X communication.

EDI has created a 100+ node wireless sensor network and IoT testbed (located in a 7-story building and the adjacent outdoor area), as well as a portable 50-node mobile testbed that allows us to thoroughly test the reliability of our own and third-party IoT hardware and software. We offer configuration, data transmission capacity and energy consumption testing in a close-to-real-world or real-world industrial environments. For convenient and energy-efficient use of wireless sensor networks, we have developed a real-time operating system MansOS, as well as participate in the development and maintenance of the well-known Contiki-NG Internet of Things operating system. EDI is also exploring low-power wireless protocols, such as Bluetooth Low Energy, IEEE 802.15.4 TSCH (Time Slotted Channel Hopping), LoRa / LoRaWAN and others. This has already led to several contract research projects in the field of low-power wireless networks. We make IoT systems stable, reliable and secure using the DevOps paradigm.

Our research on IoT and wireless sensor networks covers a number of applications, such as applications for eHealth and fitness, smart cities and infrastructure, environmental monitoring, agriculture, and industrial or transport-related cyberphysical systems. We also aim to apply industry-wide wireless sensor network research in Industry 4.0 use cases. Results here include low-latency (<500 microsecond) real-time wireless sensors with feedback for robotic and mechatronic systems.

In the future, we plan to launch new IoT directions based on new communication technologies, including body-to-body communication (BCC), body-wide sensor networks, ultra-reliable low latency communications (URLLC), and massive machine-to-machine (M2M) communications in the 5G context. We also plan to develop prototypes of wearable devices for joint projects with scientists in the medical, sports, and social sciences, including devices with innovative sensors and communication mechanisms. We also aim to increase technology transfer capacity by working closely with industry partners to turn our knowledge of IoT system architecture and implementation into successful commercial solutions.

In addition to the above, three **new research directions** currently are evolving at EDI:

- cybersecurity;
- defense technologies;
- biomechanics and motor control.

Planned activities		Expected results		
Deadline	Action description	KPIs	Now	Goal

Each year	4.1.1. Re-evaluate research priorities	4.1.1. International projects for each research direction	0-6	2-5
Every two years	4.1.2. Align research directions with the strategy of Horizon Europe	4.1.2. National (including European Structural Fund) research projects for each research direction	1-8	2-5
Annually	4.1.3. Educate scientific staff on how to produce high-quality scientific publications of sufficient quality to be accepted for publication in high-impact journals.	4.1.3. No. publications for each research direction (annual average)	2-6	5-10
Regular	4.1.4. Motivate researchers to publish their research results	4.1.4. No. publications per full-time equivalent researcher (annual average)	~0.45	1
Every year	4.1.5. Creation of new research groups, attracting new projects (*post-docs*, ERA*chairs* , etc.) and researchers.	4.1.4. Number of new research directions, with funded projects, by 2027	-	at least 3

4.2 Research challenges

As EDI sees its niche as a bridge between the basic research carried out at universities, and the innovation-based product development carried out by our partners in the industry (SME and enterprises), one of our main research challenges is **to develop academic ideas to a level where they are ready for use outside the research environment**. For example, our high-precision space mission timers must achieve the stability and reliability of the space category, while the autonomous vehicle detection system must achieve high accuracy in order to guarantee the safety of passengers and other road users. Systems used in production must also achieve accuracy, speed, energy efficiency and ease of use in order for these methods or devices to be economically viable for businesses. These aspects remain a challenge for researchers worldwide, and are well aligned with current EDI projects and research directions. Our approach in addressing these challenges includes improving our testing infrastructure and capabilities, deepening our research on various sensors (e.g. new types of radar, depth cameras), developing knowledge and failure models for autonomous cars, proposing research on interpretable and explainable artificial intelligence, and more.

Given the limited resources of EDI, we remain competitive by addressing specific, quite narrow challenges in a wide range of applications (space, mobility, manufacturing, health, digital life). As a result, we often develop a subset of key technologies for more ambitious activities, such as autonomous cars, satellite systems, artificial intelligence, etc. This understanding is important in order to be able to **choose topical, sustainable, and in-demand research topics**. EDI is flexible in this respect, as we have decades of experience in a number of topics, while maintaining the ability to launch and focus on new topics.

Latvia has low funding for research and development from both the state budget and the private sector. Both of these figures are among the lowest in the EU. The share of research and development in Latvia's GDP in 2019 was 0.64%[19], ahead of only Cyprus, Romania and Malta, but lagging behind most other EU countries. By comparison, the EU rate was 2.19% on average, and many countries, such as Sweden and Germany, exceeded the 3% threshold. Thus, **the amount of public funding for** EDI in absolute terms is insignificant compared to similar institutions abroad. For this reason, we focus on project applications in EU programs and contract research.

19 https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20201127-1

The above funding profile (EU projects with industrial partners and contract research) has reduced the amount of scientifically published work. There are few defended doctoral theses, as a result of which the number of employees with a doctoral degree in EDI has decreased. This is partly due to the specific nature of EDI's activities, which involve many projects with industrial partners and many commercialization projects, but also partly due to the fact that we are forced to some extent to take over the tasks of the universities, because due to legislative reasons it is not possible for us to recruit PhDs in academic positions (i.e. as researchers) who are already in academic employment relationships with other research institutions in Latvia.

Data acquisition security, and annotation issues are also challenging. Some modern approaches require large amounts of training data, so EDI works not only on different data acquisition approaches, but also on topics such as synthetic training data generation and tools to speed up data labeling. Our health research (biomedical imaging, automated diagnostics, rehabilitation devices) means that we also have to deal with data security, while topics such as object identification, human recognition and biometrics also need to pay attention to ethical aspects.

Achieving and maintaining scientific excellence in narrow directions of research is also challenging. Most EDI research projects last 2-4 years and are underfunded by large groups of full-time researchers. Therefore, in order to ensure the sustainability of research topics, EDI needs to continuously work on new project applications. In addition, our best researchers are simultaneously involved in a number of projects in different directions. This risks slowing down the development of EDI in each of these directions.

The impact of EDI on the global scientific environment should be increased. This should be done by increasing the number of Q1 publications. With regard to the quality of publications, we believe that it is primarily important to achieve a higher number of publications in Q1 and Q2 editions. There is also a need to make publications more accessible and known to researchers around the world by ensuring that publications are freely available on the EDI website, unless prohibited by copyright law. It is also planned to increase the number of conference publications and, consequently, the number of EDI scientific results presented at high-level scientific conferences.

Planned activities	
Deadline	Action description
In progress	4.2.1. Strengthen the capacity of selected scientific goals to influence the international scientific community
Every year	4.2.2. Participate in leading conferences in the fields of research
In progress	4.2.3. Focusing on research results with innovation potential (technology transfer)

Expected results		
KPIs	Now	Goal
4.2.1. Percentage of publications in Q1 and Q2 journals	<50%	> = 75% of journals
4.2.2. Number of conference proceeding publications per year per researcher	~ 0.2	> = 0.4
4.2.3. Number of projects by 2027 that have prepared research results for technology transfer	-	5-10

4.3 Impact targets

4.3.1 Impact on the academic community

The impact of EDI on academia is manifested in three main ways:

- **First, through high-quality research,** mainly in the form of journal articles and publications in conference proceedings. Most of the results of EDI research are already indexed in international scientific databases such as Scopus and in field-specific databases such as the IEEE Xplore and the ACM Digital Library. EDI recognizes the importance of high-quality scientific publications and aims to increase the share of Q1 and Q2 journal publications in research. EDI also makes research results publicly available. Many EDI research projects require open access, while researchers working on other projects are encouraged to make their results public, for example by posting them on the EDI website.
- **Second, by training new research staff, including university students.** Although EDI is not a higher education institution that can award diplomas on its own, EDI methodically promotes the scientific development of students who simultaneously attend higher education institutions. About one third of EDI researchers are students. EDI researchers have extensive experience in monitoring B.Sc, M.Sc. and the development of doctoral students' dissertations, which are later defended in higher education institutions. EDI also has experience in hosting Erasmus+ and other international students doing project work. It is also important to mention that many EDI researchers work as lecturers in universities, where they facilitate the transfer of knowledge from industry-oriented applied research. In the future, EDI aims to continue and strengthen our cooperation with universities, as well as to increase the share of international students we train, including postgraduate students.
- **Third, by editing a Scopus-indexed scientific journal** *Automatic Control and Computer Sciences* (ISSN: 0146-4116), which was established in 1967. According to the *Scopus Cite Score*, the journal has a SNIP of 0.676 in 2020; according to the *Scimago Journal and Country* ranking, it is a Q3 journal in the following areas: *Control and Systems Engineering, Signal Processing and Software*. In the future, we want to further strengthen the editorial board of the journal with high-level researchers from around the world and raise its Scopus SNIP above 1.

4.3.2 Impact on industry

The impact of EDI on industry is mainly realized **through participation in projects with industry partners**. EDI has been recognized as a reliable partner in *Horizon 2020* project consortia, where it successfully cooperates with large international companies. In the future, the aim in this regard is to strengthen our position and become more internationally recognized in our areas of competence, namely as a research institute in the middle of the technology creation chain, situated between basic research on the one hand and business-oriented companies on the other. EDI also acts as a digital innovation hub, implementing several Horizon 2020 DIH projects — DIH World, Trinity, being part of the SCoDIHNet network and maintaining its own EDI DIH, in which we support small and medium-sized enterprises by enhancing their productivity and efficiency. and competitiveness.

EDI also affects the industry by setting up **startups (spin-offs) to commercialize its research**. For this purpose, the potential for commercialization of scientific results is regularly discussed, as well as commercialization projects are implemented. During the last three years, 8 such projects have been implemented, which have led to the sale of commercialized technologies or the signing of a license agreement with entrepreneurs.

Last but not least**,** EDI conducts **contract-based research** with both domestic and foreign companies. EDI works closely with Latvian government agencies such as LIAA to attract companies interested in our offerings. In the future, EDI aims to increase the share of contract-based research in its budget, as well as to work towards a strong international profile as a contract research institution, focusing on the unique competencies that EDI can provide in its areas of specialization.

4.3.3 Impact on the society as a whole

EDI research can have a direct impact on the well-being and sustainability of the general public. Research in EDI priority directions has the potential to provide technological solutions to real socio-economic challenges, in particular in the application areas of smart health and smart mobility.

Social impact. Our goal is to build a technologically educated society through innovation in health (such as personalized healthcare), a sustainable environment (such as environmental monitoring), mobility (such as autonomous transportation technologies), manufacturing (such as automation technology) and space technology (such as remote sensing), all leading to positive and long-term sustainable change worldwide.

Social equality, integration and prosperity. Our goal is to conduct research that enables people with disabilities to better integrate into society and avoid being held back by their disabilities. Examples of such research include: the prototype of a smart headband, a system for monitoring and motivating physical activity in children with disabilities, sensor networks for monitoring people's biometrical parameters, and research on autonomous transportation systems, which can provide greater freedom of movement.

Public health. Our goal is research that contributes to the development of cost-effective, personalized and convenient healthcare. EDI has developed a number of technologies that have been tested in rehabilitation centers: for example, "smart" (sensor-equipped) clothing that can be used to treat scoliosis; a wearable device for knee rehabilitation; a telemedicine tracking system; ultra-wideband radar for remote monitoring of respiration; probability models for heart disease and diabetes risk prediction. EDI has also been actively involved in the State Research Program for the Prevention and Mitigation of COVID-19, developing, for example, an automated quality control system for hand washing for hospital staff, and a control system for a robot that disinfects hospital facilities.

National security. Our goal is to continue close cooperation with such state institutions as the Latvian National Guard, especially their Cyber Defense Unit and the Science Research Center. EDI is already successful in the field of wearable system security and EDI researchers will participate in various defense project competitions, participate as volunteers in hackathons, conferences and military exercises organized by the Latvian Defense Forces.

Public understanding of the importance of scientific activity. This aspect of the socio-economic impact of EDI is carried out through regular events, interviews and demonstrations to

inform the general public about our research and to raise public awareness of the importance of our research. For example, EDI regularly participates in the annual European Researchers' Night events. New videos about our research and interviews with our researchers are regularly and publicly available on local media organizations, social networks and YouTube. We want to continue this dialogue with the general public, both offline and online, through our presence in the society and on social media.

4.3.4 Alignment with the priorities of RIS3

The objectives of EDI are aligned with the priorities of the Smart Specialization Strategy (RIS3) of Latvia correspond to:

- Priority 2 of RIS3, "*Productive innovation system for the creation of new products and technologies in existing sectors, cross-sectoral sectors and new sectors with high growth potential*". EDI has the potential to increase the innovation potential of the local economy by transforming its research into new products and services with a high growth potential. EDI has already set up a number of companies in diverse areas that include accurate timing systems for space application, and sensor-aided training systems for athletes.
- Priority 4 of RIS3, "*Modern ICT (building a modern and up-to-date ICT ecosystem in the private and public sectors)."* EDI contributes to the development of ICT by engaging in research projects, in particular high-TRL projects that involve technology transfer and address societal challenges related to real-world ICT systems, such as smart city ICT systems, cyber-physical systems, and the use of artificial intelligence in various fields.
- Priority 6 of RIS3, "*Improved knowledge base and human capital in areas important for the transformation of the national economy."* EDI increases Latvia's knowledge base and human capital by attracting, training and maintaining computer science and engineering expertise in its fields of activity. In the future, we aim to attract more staff with recent international research experience.

Planned activities	
Deadline	Action description
In progress	4.3.1. Increase the number of open access publications
In progress	4.3.2. Increase international mobility
Independent	4.3.4 Strengthen cooperation with HEIs.
Annually	4.3.5 Update the*Control and Computer Science*editorial board

Expected results		
KPIs	Now	Goal
4.3.1 Percentage of open access publications out of all publications per year	~ 50%	100%
4.3.2. Staff with academic work experience abroad during the last 5 years	5%	10%
4.3.4 Number of defended doctoral and master's degrees developed per year per researcher	<10%	> 10%
4.3.5 Impact factor (SNIP) of the journal *Automatic Control and Computer Sciences*	0.68	1

5. Human resources development plan

5.1 Description of the situation

EDI's scientific staff is highly qualified and competitive in their fields of research, both in the European Union and globally. In addition to the scientific achievements of the employees, the abilities of the staff are also evidenced by the fact that several EDI researchers have been "lured" to industry and research organizations not only in Latvia but also in other European countries. In general, the organizational structure of EDI creates an attractive working environment and **is able to attract international projects and contract research**, so our researchers are motivated to pursue a career and pursue their scientific ambitions at the institute.

As the leading scientific institute in Latvia, EDI has certain advantages in attracting new employees. The growth of the EDI workforce is quantifiable, but the quality of young potential researchers does not always live up to EDI's expectations. The Latvian labor market is part of the total EU labor market, therefore the emigration of high-quality Latvian researchers to other EU member states with a higher level of remuneration is happening. The low salary of researchers in Latvia is also an obstacle to using the free movement of labor to attract researchers from other EU countries. Due to the free movement of labor within the EU, EDI as an employer has to compete in monetary and non-monetary terms with other EU research institutions, which due to more available funding are able to support better paid researchers (in Latvia, R&D funding is one of the lowest in the EU, only 0.64 % of GDP according to 2019 data).

Currently, EDI has good results in attracting students and doctoral students. The successful attraction of students is ensured by proactive activities of leading EDI researchers, regular organization of student visits to EDI, visits to Latvia's largest universities, involvement of EDI researchers in student training, etc. At the end of 2021, ~21% of all our scientific staff are doctoral students, and ~15% are master's / bachelor's students. Great efforts are made to train young researchers by assigning them an experienced supervisor, sending them to seminars, summer schools, and conferences, organizing in-house scientific seminars and supporting various informal groups, such as doctoral and reading groups.

To increase the chances of attracting new skilled workers and not to lose existing prospective employees, EDI is constantly improving the benefits of the workplace and strives to motivate employees to pursue scientific careers. The Institute holds in-house seminars to discuss project progress and EDI publications, and informal staff building events were organized and supported before the COVID-19 pandemic. The institute is offering health insurance to our employees, as well as promoting an active lifestyle (bicycle storage, participation in sports events and physical activities outside working hours, etc.).

In addition, EDI has introduced a financial **incentive system to increase staff involvement in writing quality scientific publications and preparing international project applications**. Such a motivation system works not only to increase the overall indicators of EDI but also promotes the development of Ph.D. theses, as the number and quality of publications is one of the most important factors for obtaining a doctoral degree. EDI conducts employee surveys to determine the effectiveness of the existing motivation system and to identify motivating or demotivating factors. The survey results have been taken into account when compiling this human resources development strategy.

5.2 Objective

Human resources are the main factor in achieving scientific excellence and scientific impact. The quality of the results of scientific work directly depends on the qualifications and experience of the researchers involved. Capable staffing is a necessary but not sufficient condition for achieving scientific impact, as the efficient use and management of human resources are equally important in creating and maintaining qualified and motivated research staff that is not hampered by research barriers and is provided with the necessary resources. In the latest international evaluation of Latvian scientific institutions, EDI received an estimated growth potential of 5 (the highest rating). At the same time, EDI has relatively few experienced scientists. To retain the high growth potential and turn it into a team of high-class researchers, EDI personnel management needs to continue some of the existing activities and practices and introduce new ones. We plan the activities envisaged in the human resources development plan for the coming years to achieve two sub-goals:

- raising the qualification of human resources;
- efficient use of human resources.

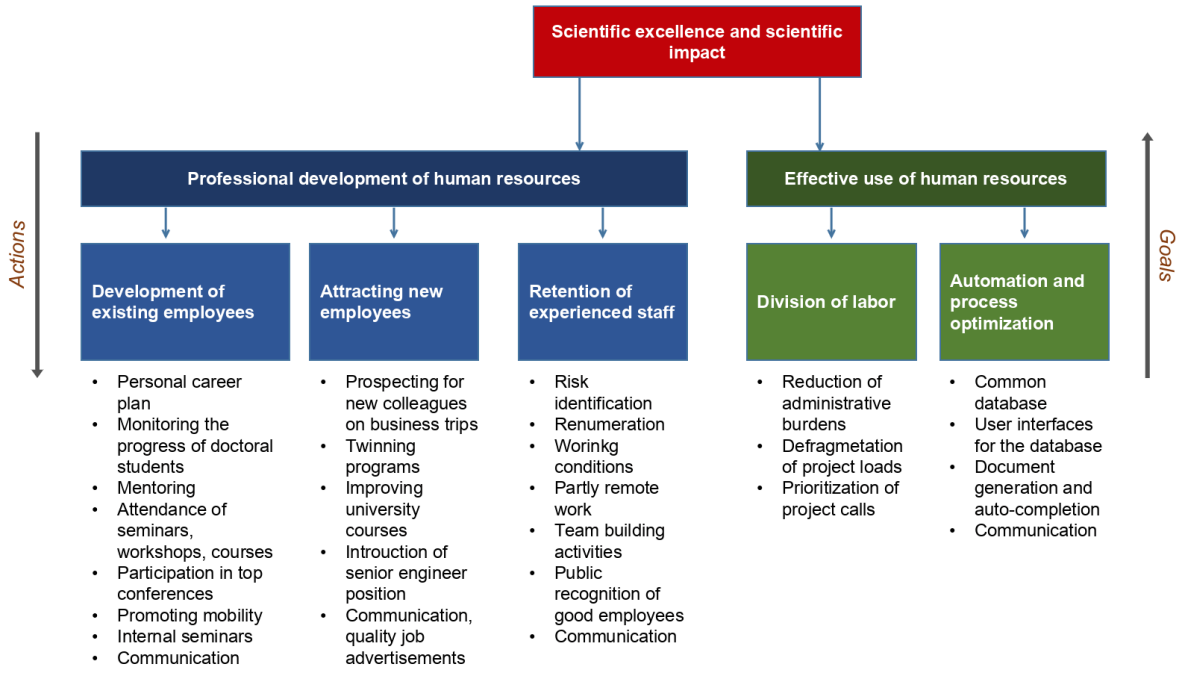


Figure 5.2.1. Objectives and activities of human resources development.

5.3 Professional development of human resources

Although EDI has attracted many doctoral students, five dissertations have been defended in the last six years. The sub-goal of EDI is to significantly increase the number of doctors in six years so that their share in the research staff reaches 50%.

To achieve this goal, EDI sees three lines of action:

- Support the growth of existing staff into researchers.
- Attract new experienced employees.
- Retain the experienced employees.

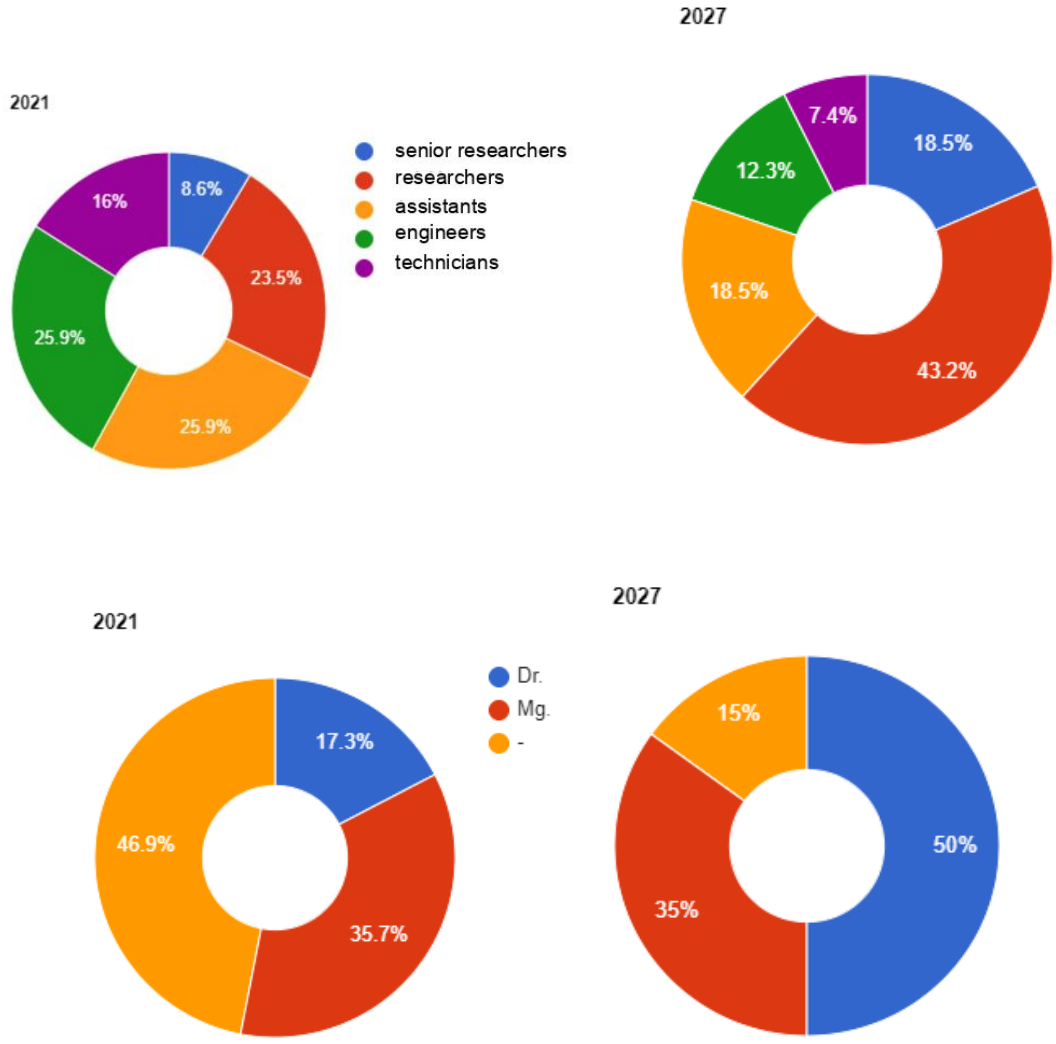


Figure 5.3.1. Current situation and goal in human resources qualification.

5.3.1 Development of existing employees

Personal career plan for each researcher. Annually, EDI's scientific staff plans their main activities and results for the year. EDI intends to expand this practice by requiring each scientific staff employee to develop a longer-term career and talent development plan. The development of such a plan would be carried out mainly by the employee him(her)self, assisted by the heads of scientific and structural units to clarify scientific issues and gain the support of the administration to identify career development opportunities. Career plans will be hosted in a common database that will allow the administration to review the ambitions of the scientific staff, monitor the implementation of career plans, and identify the most promising young researchers.

Monitoring and assisting the progress of doctoral theses. In the case of EDI scientific staff, who are doctoral students at a university, an important part of the career plan will be a strategy for writing and defending the doctoral thesis. The goal is to speed up the development and

increase the number of defended doctoral theses. Monitoring the progress of these employees (especially writing publications) will allow timely identification of the factors hindering the development of the dissertation and provide support for their elimination. The database of career plans will allow such monitoring. The database should be accessible by heads of departments and by informal leaders of scientific groups, who should seek solutions with staff in case of problems.

Mentoring. EDI plans to step up mentoring to effectively transfer knowledge relevant to the specifics of EDI research from experienced to less experienced staff. University doctoral students have scientific supervisors at the institute to whom to turn with scientific questions. Other employees have the opportunity to turn to project and department managers, group leaders, and other experienced colleagues. However, it is not enough to rely on less experienced employees to always notice the shortcomings and problems of their work and to seek help from mentors in a timely manner, ensuring rapid personal development and preventing delays in executing work tasks. Therefore, EDI intends to strengthen the second essential component of mentoring—supervision, and the proactive action of experienced staff, recognizing the progress of younger staff and the obstacles they encounter. To increase the role of mentoring, EDI will encourage project managers to assign common or partially overlapping project tasks to new and experienced staff, ensuring greater knowledge transfer and mentoring within projects.

Sending staff to seminars, workshops, courses and summer schools. EDI will continue to support attendance at seminars, workshops, and summer schools. Although there are limited possibilities for funding such trips, as the sources of EDI funding are mainly competitive research projects, various solutions are being actively sought to enable staff to take part in such activities. The plan also envisages a methodology for more focused training on dissertation development. It includes researching and compiling a list of resources on topics that are important but not sufficiently provided by the doctoral studies (writing publications, conducting research correctly, finding current and prospective scientific topics).

Sending staff to high-level conferences. EDI intends to use the project "Support for EDI International Cooperation Projects in Research and Innovation (EDI SS3)" to seek partners in the best scientific conferences in areas of interest to EDI. EDI plans to send not only experienced researchers to these conferences, but also emerging researchers. In addition to networking activities, young researchers can use such activities to improve their qualifications by meeting and gaining experience from leading researchers in the field. For the transfer of good practice, it would even be worthwhile to ensure that the first conferences attended by young researchers are high-level events, rather than low-level conferences that may reinforce mediocre scientific practices or reduce young researcher's interest in the field. The EDI strategy also envisages the search for a new networking project(s) to replace EDI SS3 by the end of 2023.

Promoting mobility. EDI plans to increase visits and short-term traineeships abroad for staff, especially young researchers. In order to motivate employees to seek such opportunities, EDI intends to take such activities into account in the annual appraisal of employees, as well as to use it as an additional criterion in the scientific position elections. In addition to working physically in various foreign institutions, EDI will encourage experienced staff to join various editorial boards, conference committees, and other scientific organizations.

Internal seminars. EDI will strengthen the tradition of holding internal seminars about the Institute's ongoing projects, recent publications, current scientific and organizational topics. All EDI researchers, engineers, and technicians are invited to such seminars. EDI will also continue to support the activities of informal groups on EDI premises (e.g. group of dissertation writers, group of paper readers).

Communication. EDI supports researchers who are prone to scientific careers, as well as offers training support for people with desire and initiative. Lack of awareness about opportunities and the support available at EDI can be a major obstacle to such an initiative. One of the responsibilities of the members of the EDI Scientific Council is to inform and remind all staff members about the objectives of the EDI strategy and actions taken and support provided for the achievement of those objectives. The planned communication activities include the development of a one-page **infographic on EDI career opportunities**, which will include information on the criteria for achieving different career positions, and on responsibilities and bonuses connected to those positions. This infographic will be included in the EDI Staff Handbook, adding a new section on **career guidance at EDI**. Personal career plans will be developed by referring to this section of the handbook.

5.3.2 Attracting new qualified employees

EDI is successful at attracting master students studying in Latvia and motivating them to enter doctoral studies. New and more intensive measures should be devoted to attracting doctoral students from local and foreign universities.

Searching for new, high-potential employees abroad. Until now, most of the researcher's trips abroad focused on presenting our scientific results, learning the newest developments in the relevant scientific fields, and establishing new contacts. EDI intends to complement the trip objectives with a search for prospective staff members and invitations to work at EDI. These actions can be performed by both senior and junior staff, if they are given a pre-arranged list of competencies sought, available short-term and long-term positions, and information on the salaries and benefits offered by EDI. The strategy intends the creation and maintenance of such a list.

Use of academic networks. To attract foreign talent EDI also intends to use cooperation-focused programs and funding, such as *MSCA*, *ERA-chairs, Twinning programs*.

Improving local university courses. To increase the qualification and specialization of local students (EDI potential employees), the Institute is also interested in improving courses at Latvian higher education institutions. The international evaluation recommended that EDI consider developing a doctoral program in collaboration with other institutes. Latvian higher education system limits the possibilities for EDI to implement doctoral studies, therefore we plan to increase our involvement in the existing doctoral programs and doctoral schools organized by the biggest Latvian universities (e.g. University of Latvia, Riga Technical University).

Highly paid scientific and technical staff positions. At present, EDI's wage system limits the recruitment of the scientific and technical staff (high-quality engineers) needed to develop high-TRL projects. A strategic solution would be an introduction of the position of “senior engineer” with a higher possible salary than currently allowed for non-academic positions.

Communication. More work is needed to **prepare quality advertisements** aimed at foreign researchers. Also, EDI researchers should become more active in using personal foreign contacts to find new EDI employees for specific positions, including short-term ones. A survey of EDI staff indicated that the biggest advantages of the institute compared to other workplaces are the possibility to combine work with studies, an internationally competitive infrastructure, and responsive, helpful colleagues. The relatively small size of EDI means that leading researchers attracted from foreign research institutions can significantly influence EDI's priority research directions and establish new laboratories. In this way, EDI provides strong researchers with easier opportunities to realize their visions and ambitions than they would have in larger organizations.

These factors should be summarized in information material and attached to EDI job advertisements. Currently, such advertisements are posted on the EDI website and social networks. EDI plans to increase the dissemination of such information within the institute, so that employees attending various events and traveling on business trips are aware of EDI's needs for additional staff and competencies, can identify and address relevant contacts, and can present the opportunities and benefits of EDI.

5.3.3 Retention of experienced employees

Identification of exit risks. EDI should regularly identify the risks of experienced or prospective employees leaving the institute. We plan to accomplish that through formal questionnaires and less formal interviews with employees, team leaders, and department heads. EDI intends to classify potential reasons for leaving according to whether or not there are possible actions to address the risks. If avoidable risks are identified, plans for mitigation will be developed.

Long-term salary increase. EDI intends to continue to lobby for an increase in the project wage ceilings for all the research staff positions to maintain the competitiveness of salaries with the private sector. We predict that this consideration will become even more pressing in the next planning period. As a result of the COVID-19 pandemic, the number of companies practicing remote cross-border work has increased. More remote jobs with salary levels approaching those of more developed countries may appear in the Latvian private IT sector.

Improving working conditions. EDI will continue to use part of its infrastructure funding to improve working conditions. Also, the current incentive system encourages employees to use publication and proposal-writing bonuses for workplace improvements. By maintaining this system, workplaces will become increasingly personalized, creating a modern and comfortable work environment.

Partly remote work. EDI intends to link the possibility of remote work to the issue of productivity, providing such an option for employees whose productivity increases or remains the same while working remotely.

Team-building activities. In the employee survey, colleagues were indicated as one of the most motivating factors to work at EDI. Due to the restrictions imposed by the pandemic, the impact of this positive factor has suffered. After the pandemic and related restrictions end, EDI plans to resume annual team-building events and, as far as possible, provide financial support for such activities.

Recognition of the best employees. The current staff appraisal system evaluates project work, success in technology transfer, performance in writing publications, work on academic theses, and other indicators that have contributed to the development and visibility of EDI. Institute intends to extend the appraisal system to include additional criteria, such as leadership and contribution to team building, and appreciation of the managers, subordinates, and other colleagues about the employee. Different employees can stand out positively in various ways, which allows recognizing the achievements and thus increasing the motivation of more employees. We plan to use the principles listed in the DORA (Declaration on Research Assessment) as an example of a more

inclusive evaluation system.

Communication. EDI has good career opportunities as well as opportunities to define and develop your research interests. These opportunities only play a role in motivating the staff to stay at EDI if the employees are aware of them. So, EDI intends to emphasize this type of information more often in joint EDI seminars. The latest survey of the employees showed that some employees are uncertain about the Institute's strategic goals. To increase staff awareness, the Scientific Council intends to intensify the transmission of information to staff on current issues addressed by the Scientific Council, decisions taken, and how these issues and decisions may affect the Institute. Such information would also include the progress on EDI's strategic objectives. EDI plans to set up a working group to ensure such communication.

5.4 Effective use of human resources

Division of labor. EDI's vision for the efficient use of human resources is to separate specific responsibilities between managers at different levels (departments, projects, groups, etc.) and workers (leading researchers, researchers, research assistants, technical and service staff) according to their competencies. Institute's overall administrative duties should be clearly separated from the project's management (scientific and administrative) and execution duties. Consequently, the indirect costs of the projects are split between EDI's administration and project executors. In addition, it is possible to create laboratory-level positions for administrative work, which would include project record keeping, procurement specifications, preparation of administrative reports and applications, collection and circulation of information, and other necessary work.

A narrower focus on topics. Due to limited institutional (base) funding, the growth of EDI, including the involvement of new staff, is only possible by increasing the number of competitive research projects. This has the effect of having researchers work part-time on several projects at once. Given that the simultaneous work on several different projects and topics often hinders the successful completion of tasks, specialization of researchers, development of doctoral theses, and affects the quality of results, EDI's vision is to reduce the number of projects at the expense of government funding. This will be possible if the government keeps the promise of increasing research base funding. In such a case, EDI will avoid, as far as possible, employing workers on more than two projects at a time and managers on more than three projects.

Prioritization of project calls. Given the different administrative burdens in different types of projects, EDI plans to develop and maintain a common list of project calls. The list will indicate which calls should be prioritized based on the duration of the projects, the possible amount of funding, and the administrative overhead it requires. Strategic focusing on the longer and bigger projects should help in reducing the fragmentation of the workloads among several smaller projects.

5.5. Digitalization and process optimization

To ensure timely and convenient monitoring of strategic indicators (number and quality of publications, project proposal applications, current and planned workloads and salaries of employees, execution of project deliverables, etc.), EDI plans to digitize and optimize several

administrative processes. EDI has the technical know-how to do this, but the development of digital systems will require time and financial resources, which EDI plans to devote where possible.

Database for tracking goals, results, and other data. EDI intends to set up a single database that is connected to relevant accounting and personnel systems and allows recording and storing of institute's objectives and achieved results, as well as data on staff, projects, workloads, planned estimates and actually paid salaries, employee publications, contract deadlines, and other relevant quantities. With different access permissions (read, edit, add), the database will be available to managers of different levels, administration personnel, and researchers. The purpose of such a database is to reduce the input of redundant information, reduce duplication of documents, enable the creation of automated reports, submissions, and other documents, and reduce the potential for errors each time information is copied between documents. However, it is important to maintain that the accuracy of the information is ensured by the "four-eyes principle". This database will allow the management of the institute to make sure that results-based management (including cascading and rapid feedback) works as required (Section 3.2).

User interface for updating the database. The usability of a database is determined not only by the coverage and timeliness of the information it contains but also by the convenience of the user interface. The interface must have different database access permissions and different input fields for different situations. EDI plans to define a specification for such a tool and search for means to develop it. In addition, procedures will be adapted to make data entry in the system the most convenient way to provide information (automated preparation of draft documents from a database, creation of annual staff reports from the data in the database, etc.)

Partial automatic filling of documents. The database and tools for appending data will allow the creation of tools to automatically generate various documents and automatic filling of some fields in those documents, relieving both scientific and administrative workforce resources from data copying tasks. Specific programs will be created for the generation of various documents, similar to the tool already developed to help employees fill in the monthly workload sheets.

The documents that could be generated in full or in part automatically, assuming that up-to-date information is available in the database, are:

- Applications for planned changes in staff workload.
- Agreement protocols for changes in employee workloads and projects.
- Orders for changes in staff projects and workloads.
- Monthly employee workload tables.
- Reports on the distribution of monthly staff hours in project work packages.
- Project financial reports.
- Project report tables about employees.
- Applications for launching a project.
- Orders for launching a project.
- Annual evaluation questionnaires for academic staff.
- Employee CVs in various project call templates and languages.

- Business trip applications.
- Orders for business trips.
- Initial and changed vacation schedules.
- Orders for vacations.

Communication. Not all administrative work can be fully digitized or removed from scientific staff. It is therefore important to communicate best practices and approaches to these tasks as clearly as possible in order to reduce the time and error involved in these tasks. EDI has experienced staff who, over time, have developed good practices and examples for the quick and efficient preparation of price inquiries and various submissions and reports. EDI plans to document this good practice in an updated employee handbook, which is intended to be the main resource for familiarizing employees with the various processes involved.

Planned actions		Expected results		
Deadline	Action description	KPIs	Now	Goal
2022	5.1.1 Develop and disseminate career guidance to employees.	5.1 Proportion of PhDs among scientific staff	17%	50%
2023	5.1.2 Develop personal career plans for each scientific staff employee and create a database of these plans.			
Every year	5.2 Train employees by increasing attendance of seminars, workshops, courses and conferences.	5.2 Average number of international conferences, seminar trainings, workshops, summer schools per year attended by scientific staff per person month	1	2.5
Annually	5.3 Organize seminars on science and institute strategy topics.	5.3 Seminars organized at the Institute per year	7	22
Every year	5.4. Address international candidates, strategically select the venues and distribute advertisements on positions available at EDI.	5.4 Long-term researchers from abroad per year	0	2
Every year	5.5.1 Identify the risks of employees leaving.	5.5 Positive evaluation of the importance of the Institute's activities by employees	-	75%
Every year	5.5.2 Improve work conditions.			
Annually	5.5.3 Support or initiate team-building activities.			
Annually	5.5.4 Acknowledge the best employees.			
Every year	5.6.1. Disseminate information about the institute's current affairs, decisions, and strategic goals to employees.	5.6 Communications on the issues discussed by the Scientific Council, management decisions, and the progress of EDI towards strategic goals.	1	4
Annually	5.6.2 Update and distribute the staff handbook to employees.			
2023	5.7.1 Recruit staff to support the administrative work of projects and departments.	5.7 Accuracy of compliance with activities allocated to project teams and institute administration.	70%	100%
Annually	5.7.2 Create and prioritize a list of project calls.			
2023	5.8.1 Create a common database of required information.	5.8 Common document management	0	1

2024	5.8.2 Develop a convenient interface for updating the database.	system integrated with accounting, personnel, and analysis systems, incl. monitoring of performance indicators.		
2025	5.8.3 Develop AutoFill Tools.			

6. Research infrastructure development plan

The research infrastructure currently used by EDI researchers — buildings, laboratory equipment and supporting facilities, has been upgraded to meet international research needs. This is also confirmed by "Panel Report: Engineering and Technology" of International Evaluation of Scientific Institutions Activity in Latvia (March 2021): "*The research infrastructure is at a good level and internationally comparable and is well managed and sustained*". As a result, EDI is already able to conduct internationally recognised and high-quality research at a relatively low cost, as well as EDI has the potential to launch new research areas.

EDI conditionally divides its research infrastructure into three categories:

1. Buildings and adjoining territory to provide a comfortable, modern, energy-efficient environment for R&D, technology transfer and event organization.
2. Laboratory infrastructure, including instruments, measurement and test devices, etc. to provide necessary state-of-the-art equipment for research projects and contract research.
3. Support infrastructure, including a data center and the various information systems and software enabling EDI to compete in today's dynamic environment and optimize processes, high-performance computing resources as well as prototyping and testing facilities that enable the development of prototypes and demonstrators at high technology readiness levels.

In recent years, EDI has made full use of its potential to improve infrastructure basically by leveraging the European Structural Funds (as far as the MoES gave the opportunity) and by investing its own resources — a total of several million euros. Given the success of EDI in Horizon 2020, these projects not only successfully ensure the efficient use of existing infrastructure, but the indirect costs also cover maintenance costs.

The most important objects of the EDI research infrastructure are:

In the **category of buildings and territories:**

- Laboratory building (renovated in 2015), where researchers have sufficient laboratory space (approximately 25 square meters per person) to carry out their research, and staff can be easily increased up to 1.5 times;
- Common functions building (complex energy efficiency improvements in 2018) includes conference hall with 250 seats and modern equipment, two auditoriums, administration, archive, canteen, etc.;
- Prototyping building (renovated in 2020) with modern equipment including professional, industrial electronics development equipment, industrial testing equipment, collaborative robotics systems, etc.
- Intelligent vehicle development and prototyping garages-workshops equipped with appropriate necessary equipment;
- territory used by ITS testbed, which includes road signs and horizontal markings and other road infrastructure elements for connected and autonomous driving, V2X (*vehicle-to-everything*) communication, advanced driver assistance, etc. for testing smart mobility solutions.

In the laboratory equipment category:

- 40+ upgraded workplaces for electronics researchers, including those equipped with standard (up to 1 GHz) measurement, testing and development equipment;
- High-level measurement and testing equipment: oscilloscopes, generators, vector analyzers, spectrum analyzers, etc. (up to 20 GHz);
- Two intelligent electric vehicles (based on KIA Soul commercial electrical vehicles) development platforms equipped with Drive-by-Wire systems, various radars, LiDARs, multi-camera system and 3D vision, GSNN, NVIDIA DRIVE PX2 computing system, etc.;
- UR5 and UR5e collaboration robots equipped with 3D vision, IoT devices, AI computing unit, etc.;
- Mobile and service robot platforms Jaguar V4 with manipulator and PAL Robotics;
- A range of different drone platforms and a testbed with a safety fence and a positioning system ("fake GPS");
- High-level 2D, 3D, multispectral, fast (up to 700,000 fps) cameras, microscope with camera, etc. as well as computer vision and video surveillance testbed equipment for security solutions;
- Optical table with appropriate accessories;
- Large-scale 100+ node heterogeneous IoT / WSN testbed, incl. DevOps readiness;
- Gigahertz (up to 77 GHz) radar and SDR development toolkits;
- Advanced SoC, FPGA development kits;
- Prototypes for the development of ultrasonic technology solutions;
- Equipment for development of Picosecond time interval measuring devices.

Support infrastructure category:

- Prototyping system (LPKF ProtoMat-S62, LPKF MiniContac-RS, Xytronic-IR620 Preheater, Unox thermal equipment for multilayer PCB, small volume electronic device production line with stencil printer, pick and place machine, reflow oven, conveyors as well as special additional components for semi-manual soldering and visual design), vibration and shock test platform, climate test chamber, professional IR/Thermal camera, professional 3D printer, mechanical workshop equipment, etc .;
- Tier II+ data center, with 10Gbps connection to Latvian NREN and GEANT gateway, IP network autonomous system, HPC with 4xA100 Nvidia cards, 12x16 CPU cores and 12 Tesla K40c cards each with 2880 GPU cores, several servers for virtual machines, 100 TB data storage. Computation infrastructure includes the necessary software: MATLAB, SIMULINK, ArcGIS, SolidWorks Altium Designer, Cadence, Quartus, Tensorflow, CUDA, etc;
- Information systems and software, incl. **public website** www.edi.lv for public information; **internal website** intranet.edi.lv, which are available only in the internal network or using the EDI Virtual Private Network (VPN) for distribution of internal and restricted access information; **cloud server**: https://makonis.edi.lv/, which is a local and secure data exchange platform; knowledge sharing systems as an **internal wiki page** http://hub.edi.lv/ and internal software version control **GitLab** tool http://git.edi.lv/; **Inventory management** systems — PartKeeper for consumable resource management http://parts.edi.lv/ and Snipe-IT for reservation and tracking of fixed assets http://inventory.edi.lv/; your **online email client** https://webmail.edi.lv/;accounting and resource management Visma Horizon software and institutional performance and research management software Jedox; various

project management tools: rsprojects.edi.lv, Basecamp, ClickUp according to the needs of specific projects, as well as **specific software server for** licensed software: 3dvm.edi.lv (virtual machine with Solidworks 3D CAD design software), robotlic.edi.lv (RobotStudio ®), matlab.edi.lv — Matlab license server and others.

An important aspect in all categories is the availability of open access to partners from academia and industry, in line with the guidelines set out in the European charter of access for research infrastructures. In this regard:

1. Information about significant infrastructure is available in the National Research Information System (NZDIS), the UseScience database and the Institute's website;
2. The concluded cooperation agreements include the procedure for access to research infrastructure;
3. Rules for infrastructure users, a standard contract form and a costing methodology have been developed.

So far, the greatest interest has been in the use of prototyping and testing equipment as well as high-performance computing resources.

In order to develop plans for the development of EDI infrastructure and human resources for the coming years, the research directions in which EDI is active have been analyzed. The rapid development of technologies and EDI's ability to launch new research directions require not only maintenance and renewal of existing equipment, but also buying of a new equipment for competitive research in the future, i.e. artificial intelligence technologies, cognitive robots, 5G and 6G, IoT, blockchains, connected and autonomous mobility, augmented reality, etc.

Given the limited financial resources available, the development of research infrastructures in the coming years is mainly based on Horizon Europe project opportunities (calls related to research infrastructure in Pillar I "Excellent Science" and in “Widening Participation”) and EDI’s own investments. EDI will make active use of the European Structural and Investment Funds and Recovery and Resilience Facility if such opportunities will be provided.

The commercialization of knowledge and technology transfer activities are very important to increase the economic and social value of research results. Unfortunately, currently EDI lacks sufficient infrastructure for such activities. In order to increase the efficiency of knowledge and technology transfer, as well as to extend the life cycle of the research and innovation services offered by EDI, it is necessary to find an opportunity for the development of the Technology Transfer Building. This may be linked to the European Digital Innovation Hub (EDIH) program, as well as to other activities that can attract appropriate funding.

The main goals of the further development of the research infrastructure are:

- ensuring the energy-efficient functioning of the buildings and the adjacent territory;
- maintenance and development of laboratory equipment in line with research priorities to provide all necessary for research and technical staff;
- Improvement of support infrastructure functionality (including prototyping, computing, etc.) and ensuring compliance with the requirements of "Open Science".

To achieve these goals, the following activities are planned:

- Digitization of the research process and management systems (see Section 5.5).
- Ensure continued compliance with the guidelines of the EU Charter on Open Access to Research Infrastructures — analysis of research infrastructure, updating of information on

the EDI website and the UseScience database (https://scientificservices.eu/), updating of access and pricing procedures.

- Adding 5G functionality to the IoT testbed (including edge computations and other equipment).
- Development of intelligent prototyping platforms extending the functionality of perception, communication, control and other subsystems.
- Purchase of equipment related to human-centered research areas and human-computer interaction, including the development of the testbed for human motion tracking, monitoring and analysis of life processes, motor control and biomechanics, etc.
- 60+ GHz frequency band equipment (if adequate funding will be found).
- Creation and upgrade of researchers' workplaces with appropriate equipment (annual improvements).
- Initiation of the renovation of the technology transfer building and the installation of appropriate infrastructure, including the facilities for the activities of the European Digital Innovation Hub, spin-offs, etc. (if appropriate funding will be found).
- Further modernization of prototyping infrastructure, including equipment for mechanical design, material handling, assembly, prototype inspection (including collaborative projects with industry).
- Renovation of building interiors and engineering networks.

7. Financing strategy

In order to ensure research, development and innovation activities, as well as to maintain the appropriate infrastructure and technical support for research, the EDI budget consists of the following funding sources:

- research base funding;
- international projects (e.g. Framework Program (Horizon 2020, Horizon Europe), ERA-NET, Eureka, ESA, EIT, EEA/Norway, etc.);
- national projects (e.g. SRP, European Structural and Investment Funds (ESIF), LCS FLPP, etc.);
- direct contract research with industry;
- revenue from technology transfer, licensing, intellectual property and patent sales;
- infrastructure and international cooperation development projects (e.g. ESIF),
- others (revenue from economic activities).

Each of the above-mentioned funding sources has (had) its own role in promoting the scientific and societal impact of research. Different sources of EDI funding, their ratio and amount are shown in Figure 7.1 (ESIF includes research, infrastructure and international cooperation development projects), while the dynamics of EDI's total revenue is shown in Figure 7.2. The fall in 2015-2016 is explained by ESIF cuts (especially for infrastructure) and the generational change of researchers.

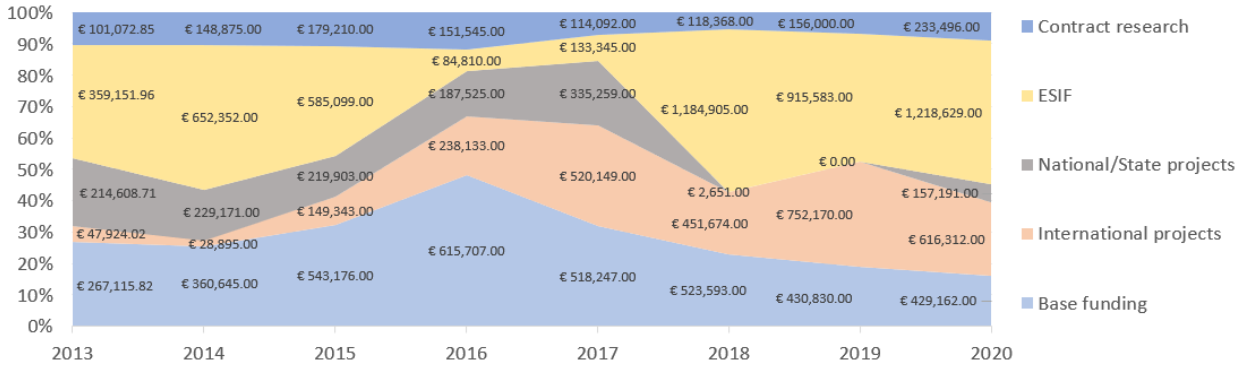


Figure 7.1. Sources of EDI funding, their ratio and amounts (2013-2020).

Although the revenue growth trend is positive and the activities in 2019 and 2020 have allowed for ~ 36% revenue increase compared to 2018, efforts are still needed to maintain this trend and grow even further.

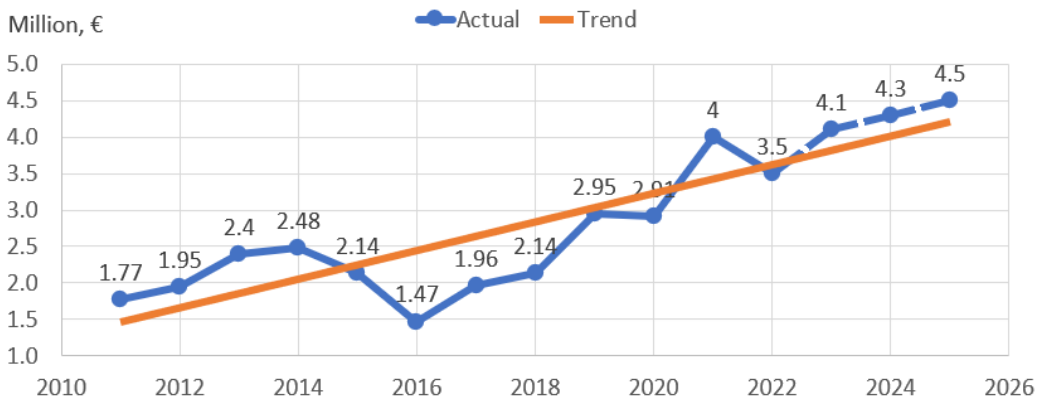


Figure 7.2. EDI revenue growth, 2011-2020 (+ forecast for 2021-2026)

In order to ensure the growth (development) of EDI in the coming years, given the reality of base funding, international projects, contract research with companies and the commercialization of know-how and technology must be the dominant sources of EDI funding. Therefore, further in this paragraph, we provide a global picture of desired funding mix as well as provide a description for each of the following funding sources:

- what is the current situation of the specific funding source (where are we now?), including the main risks and assessment of EDI opportunities and resources;
- where do we want to be, describing the main short-, medium- and long-term financial objectives of EDI and the financial development strategy;
- how do we get there? describing the specific actions that need to be taken to achieve the identified objectives.

The desired funding mix and level of general reserves

Currently, as can be seen in Figure 7.1, EDI has the following mix of funding (2020, total budget 2.9M€):

- base funding (**15%**);
- international research projects (**23%**);
- national level research projects (**39%**);
- contract research with industry (**9%**);
- projects related to the development of infrastructure and international cooperation (**13%**);
- Others (licenses, patents, etc.) (**1%**);

while our desired funding mix in 2026 with a total budget of 4.5M€ would be:

- base funding (**30%**);
- international research projects (**25%**);
- national level research projects (**8%**);
- contract research with industry (**15%**);
- projects related to the development of infrastructure and international cooperation (**15%**);
- Others (licenses, patents, etc.) (**7%**);

where at all times, the level of general reserves would allow us to operate up to 6 months even with delays in funding..

Research base funding

As highlighted by independent experts from the last international assessment of Latvian research institutes, the amount of base funding is too low. Besides, the support from the government is unpredictable and doesn't fit the plan/promises (planned gross domestic expenditure on research and development for 2020 in Latvia: 1.5%; actual: 0.64%, which is one of the lowest in the EU). It barely increased from 0.61% in 2013 to 0.64% in 2020. Between 2013 and 2020, this figure has risen by just 0.03% and is still lower than in 2006 when it was 0.65%. Therefore, the base funding for EDI accounts only for ~15% (2020). Due to this uncertainty and other factors (e.g. cancellation of the State Research Program in ICT after 2017), EDI has changed its funding strategy to focus more on European funding sources. Still, base funding has a vital role in EDI, as it is used for wages (giving an opportunity to work in research for new employees/students); to reduce the fragmentation of research topics; to maintain research infrastructure and patents; to ensure co-finance for different projects, thus promoting the scientific (it's used to explore new and risky research directions), societal (scientific articles, patents, lecture courses, technologies, dissemination activities, etc.) and economic impact of the research (co-financing of commercialization projects, maintenance of patents, etc.).

We will continue to put pressure on national authorities (the Ministry of Education and Science of Latvia), to keep their promises and increase the amount of funding for science, as it is crucial not only for the development of the EDI, but also for the development of Latvia in general. On the other hand, as the amount of the base funding for each research institute depends on specific parameters, such as number of scientific publications, number of defended master and PhD thesis, maintained or registered intellectual property, amount of funding attracted from the framework and other international projects as well as from national projects, contract research projects, etc. We plan to improve each of the above-mentioned parameters (more details in the table at the end of this section).

International research projects

International projects have a substantial social and scientific impact, as most of these projects address Europe-wide challenges (e.g. zero accident driving, personalized healthcare, industry automation), while scientific findings are published in open access journals and conference proceedings. Participation in such projects allows to acquire new knowledge and build new innovations/products; increase competitiveness in Latvia's and world's market; increase scientific quality/level; gives an opportunity to see and access state-of-the-art infrastructure and technologies in partners' premises; gives an opportunity to meet other scientist working in the field and discuss burning topics; gives a chance to motivate new generation/students to stay in science; increase EDI's visibility; gives an opportunity to work in interdisciplinary fields; allows to avoid brain drain.

Thanks to our ability to attract funding as a result of tenders, currently, the international projects are composing an impressive ~27,3% of all EDI R&D&I budget, having multiple ongoing international projects (Horizon2020 (incl. ECSEL-JU, EIT), European Space Agency, ERA-NET, COST, etc.). EDI has already proved itself to many local and international partners as a reliable, trustworthy and capable partner through several successful projects. This will help us to acquire more international projects and ensure sustainability. Still, there is always room for improvement, therefore we plan to increase the knowledge, skills, technical resources, scientific excellence and other resources of the institute to become even more attractive as a partner for participation in research and innovation support programmes and technology initiatives.

EDI's long term vision is to become one of the key partners in the consortium's and projects not only at the European Union level, but also, on a global level, working together in projects with partners from the USA, China, Japan and Southeast Asia as well as from other regions. Furthermore, in the long term, EDI must be capable of organizing and writing ambitious project proposals not only as a partner but also as a coordinator. To achieve that, we will organize target visits to potential partners as well as regularly inform our employees about relevant upcoming Horizon Europe and other research and innovation support programme and technology initiative calls (seminars, e-mails, communication with National Contact Point, etc.) and engage them (brokerage events, information days, face-to-face meetings, “how to write a proposal” seminars, etc.).

National research projects

In 2019 EDI was not implementing any national / state level research projects as the mechanism of State Research Programs (SRP) in ICT was discontinued. In the past, EDI coordinated large SRP projects such as IMIS and SoPHIS. This allowed EDI to develop unique know-how in many research directions, publish patents and scientific articles, defend dozens of bachelor, master and PhD thesis, develop new technologies, create spin-offs etc. This was a useful tool for the development of EDI expertise, which resulted in invitations as a partner in H2020 project consortiums.

In 2020, the situation slightly improved due to the short-term reappearance of SRP to reduce the effects of Covid-19. In our opinion, this program was not effective because the duration of the projects was relatively short (6 months) and the budget for each institution was not sufficient to carry out high-quality research. We, therefore, plan to continue to lobby for renewal of SRP, as well as the development of mission-oriented research programs in all RIS3 priority research directions, including ICT and smart materials and systems. This involves close collaboration and work with different ministries of Latvia as well as the scientific and industrial community. EDI, as a developer of ICT technologies, which today is a horizontal component in almost all sectors, sees opportunities in all mission-oriented research programs.

Meanwhile, EDI will continue to actively participate in Latvian Council of Science (LCS) Fundamental and Applied Research Project (FLPP) calls, especially by involving young scientists and emphasizing fundamental research, following the expert recommendations from the international assessment of Latvian research. Given the declining efficiency of the LCS FLPP program (the funding is not increasing, the number of project applications and evaluation costs are increasing due to re-submission of many previously not funded applications leading to <10% funding rate), we plan to organize internal evaluation and funding of project applications if the base funding will be increased and an “excellence grant” program created. It would improve the quality of applications and encourage EDI heads of the laboratories to motivate laboratory members to submit such project applications.

Contract research

Even though EDI has excellent collaboration with the industry in different national and international projects, the overall funding ratio coming from contract research projects is relatively low compared to other sources of funding. Such projects are very important for EDI as they allow researchers to transfer research results to industry and use them in real-life applications directly impacting society. Also, the challenges defined by the industry are demanding and often result in quality scientific articles. Therefore, for the coming years, one of our main priorities is to increase the funding coming from contract research projects. To achieve this, first, we plan to continue to identify key companies in Latvia and the European Union, visit them and discuss different

collaboration options (in the long term, we plan to extend our operation outside European level). We plan to prepare clear collaboration models and rules to be presented to our potential partners and perform many other activities (see Section 8). In addition, we plan to train and/or attract new personnel to be more successful in attracting private funding.

Infrastructure and support for science

In recent years, EDI has invested ~3M€ in infrastructure, which allows researchers to work in well built laboratories with state-of-the-art equipment. Currently, there is uncertainty about the available funding for the coming years for the development of EDI infrastructure, but EDI will look for all opportunities not only to maintain the existing infrastructure but also to find ways to develop it further (see Section 6).

As a non-profit organization, whose main income comes from public funding, it's hard to find funding for significant infrastructure procurement and upgrades. Mostly, it is supported by the government through ESIF type of funds, but not always with a clear and reasonable distribution between universities and state research institutes, including a political redistribution of funding according to certain but not well justified criteria. To maintain and improve our infrastructure in the future, we plan to argue with the ministries about the importance of state-of-the-art cutting edge infrastructure and the necessary amount of investments to perform top-class science, hoping to attract more funds for the development of our infrastructure. In next years major focus will be orientated to attracting Horizon Europe projects, exploiting "Widening participation and strengthening the European Research Area" sub-programs (e.g. Teaming for Excellence, Twinning, Excellence Hubs, ERA Chairs) to further improve our infrastructure, bring high quality human resources and increase our competitiveness in the international context. We will also consider The European Climate, Infrastructure and Environment Executive Agency (CINEA) funding instrument (including the Connecting Europe Facility) or similar, which aims to promote growth, jobs and competitiveness through targeted infrastructure investment at the European level.

ESIF projects

ESIF projects have been and will be a great tool to not only develop new technologies but also to commercialize them. ESIF projects have allowed EDI to develop several new technologies (HW, SW, algorithms, methods, theory, etc), based on which EDI has been invited to collaborate in many other projects, including the framework projects. Besides, several of those technologies are now in the commercialization phase. We plan to continue our active participation in tenders as well as project implementations in the upcoming year, with an even bigger focus on technology transfer projects. To do so, we will motivate our employees to develop solutions that are commercializable and to submit commercialization projects. However, due to the relatively high administrative burden of managing and monitoring EFSI projects and the range of local partners, these calls for proposals have a lower priority than international calls for proposals, contract research and LCS and SRP projects for national calls.

An important focus of EDI is also planned on the **Recovery and Resilience Facility (RRF)** funds, where we look forward to the opportunity and plan to participate in the following research-related activities "Internal R&D Grants", "Doctoral Grants", "Postdoctoral Grants", "Grants for the implementation of structural change", "Exit" grants for termination of employment with academic staff over 65, "Digitalization, technological development, improvement of research and education infrastructure (except construction)", "New study program of excellence" as well as in other activities related to the establishment of Digital Innovation Hubs.

Others

In addition to all the above mentioned funding options, EDI would like to significantly increase incomes from licenses, patents, know-how and shares(dividends) in/from companies. At the moment, funding coming from licenses, know-how and patents forms ~1% of the overall EDI budget, which is not sufficient. Therefore, as mentioned before, in the coming years we will focus more on contract research projects as well as on technology transfer projects. Such kind of income allows us to operate with the funds more flexibly, motivate researchers, invest in new and perspective, but more risky research directions, improve laboratories, fund ongoing research, and most importantly — ensure the sustainability of some research directions, etc., which in some cases is not always possible from other funding sources.

Specific planned actions and Key Performance indicators (KPIs) are given below:

Planned activities		Expected results		
Deadline	Action description	KPIs	Now	Goal
Regular	7.1 Put pressure on the national government to keep their promises (which are recorded in Latvia's national development plan and ZTAIP) and increase the amount of funding for science.	7.1 Overall EDI funding for R&D&I per year	~ 3M, EUR	4.5M, EURcore
Annually	7.2 Improve indicators, which allows to increase research base funding.	7.2 Amount of EDI research base funding per year	~ 450k, EUR	1.5M, EUR
Regularly	7.3 Promote participation in international competitions (Horizon Europe, ESA, ERA-NET, etc.), incl. dissemination of information, work with NCP, partner search, etc.	7.3 Amount of funding from international research projects per year	~ 750k, EUR	1.13M, EUR
Regularly	7.4. To promote participation in national tenders (LCS, SRP, EFSI, etc.)	7.4 Amount of funding from national projects per year (incl. EFSI)	~ 832k, EUR	1M, EUR
Regularly	7.5. To promote contract research, and research which is defined by companies, incl. Identification and visiting of key companies.	7.5 Amount of funding from direct research contracts with industry per year	~ 233k, EUR	675k, EUR
Regular	7.6 Facilitate technology transfer, increase revenue from licenses, patents, know-how transfer, etc.	7.6 Amount of funding from selling licenses, patents, know-how, etc. per year	~ 15k, EUR	350k, EUR
Work in progress	7.7 Attract more funding for infrastructure development (mostly from ministries).	7.7 Number of submitted project proposals in different programmes per year	~ 40	60
		7.8 Number of strategic documents in the development of which EDI staff participated, thus influencing the research directions of the programs, the topics of the calls, etc.	5	7
		7.9 Organization / participation in annual training seminars / workshops training on successful project application development.	3	4
		7.15 Number of employees involved in coordinating the writing of new project	~ 15	25

proposals		
7.16 Number of commercialized technologies resulting in a spin-off company, start-up or license agreement / sale of IP	4	10
7.17 Number of registered patents every 3 years	4	10
7.18 Number of implemented Widespread projects per year	0	2

8. Targeted collaboration

Targeted collaboration is a crucial component for the successful development of EDI and is a prerequisite for achieving EDI's long-term goals (see section 1). Therefore, we have identified several targeted collaboration groups, which plan to address in this strategy:

- Higher education institutions (universities);
- Research and technology organizations and research institutes;
- Industry (both SMEs and LEs);
- Industrial associations, Digital innovation hubs and non-governmental organizations;
- Government institutions and municipalities.

In the last 7 years, thanks to more than 15 Horizon 2020 projects, we have significantly increased the number of our international partners and thus our international recognition (see Fig. 8.1).

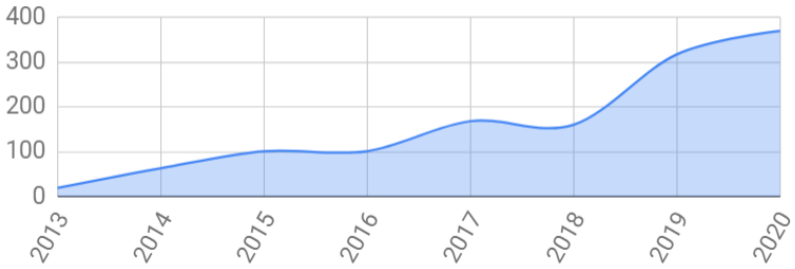


Figure 8.1. Number of EDI international partners by year

Even though we have a large number of international partners and successful collaboration in research and innovation projects worldwide, in the coming years we would especially like to strengthen our direct collaboration through contract research projects with both local and international industry. Besides, we are willing to maintain and extend our collaboration with the most important local and European industrial associations as well as local ministries and municipalities. In addition, we are especially impatient to extend our already existing strong collaboration with universities and research organizations to perform cutting-edge research (strengthening excellence). In the subsections below a basic strategy on how we plan to maintain and improve our collaboration with all the institutions from the above-mentioned categories is

described. At the end of section-specific actions and key performance indicators are provided to fulfill these plans.

Higher education institutions

Tight cooperation with Higher education institutions (HEI) in the related fields is very important to reach EDI's long-term plans. Not only because of their role as the main source of human resources and place for the future education of the employees but also because of the symbiosis of higher education institutions (opportunities to extend EDI basic research at lower TRL) and applied research institutes (conduct research at higher TRL) in research and technology life cycle as well as technology transfer, where each has a key role to play.

To ensure the above mentioned and have "win-win" cooperation with both Latvian and international HEI, we plan to increase the involvement of students from HEI in EDI R&D projects. At least once a year we will continue to visit local HEI (e.g. University of Latvia, Riga Technical University, Transport and Telecommunication Institute, Ventspils University College, etc.) and inform students about the opportunity to participate in EDI research as well as to take an internship and/or develop their graduate theses (the response is quite big already, so we have to carefully select only the best students, including foreign students). Besides that, we will promote the employment of students for research in EDI by uniting their studies in HEI with scientific work in EDI, while planning finances that are required to support it in projects. Also, we plan to continue and even increase our presence in HEI study programs as lecturers and professors, as well as in promotion boards as experts. Last but not least, we will visit and encourage HEIs to build long-term relationships in science to promote high-level research and results that are published in Q1 journals and high-level conference proceedings around the world.

Research and technology organizations and research institutes

Close collaboration with leading Research and Technology Organizations (RTO) and research institutes (RI) has always been one of our priorities as it allows us to significantly increase research capacity, exchange resources, share state-of-the-art infrastructure and know-how. To maintain and improve our collaboration with RTOs and RIs, such as VTT, SINTEF, RISE, Fraunhofer Institutes, IMEC, TNO, AIT, EPFL, CEA, IST. Tecnalia etc., we plan to stimulate the mobility of our researchers (both for short term experience exchange or long term positions), by letting the employees get acquainted with the functioning and research of other RTOs and RI, which will lead to a better understanding of the research performed abroad, how different technologies are developed and tested, and how commercialization and other activities take place.

The fact that lots of EDI researchers are recruited abroad shows that they are very competitive at the international level and it is particularly important to have these researchers back at EDI after they have gained their experience abroad (this depends not only on EDI activities but also on the overall attitude of the Latvian government towards R&D). Still we can and we do exploit our former employees working abroad to establish new and fruitful cooperations.

In order to strengthen relations, exchange ideas and establish new collaborations, we will invite key RTO and RI representatives to EDI-organized events, such as EDI days, project seminars, conferences, etc. Also, we plan to exchange resources (including research and piloting infrastructure) with our RTO and RI partners to find and implement synergies and cross-disciple research topics. To better understand the management and operation of other RTOs, we plan to continue our visits to them to discuss different related questions, in order to improve our operation and efficiency.

Industry (both SMEs and large companies)

Even though we have had and still have dozens of successful collaborations with different industry representatives in different kinds of projects, it is especially important for us to extend our collaboration to have more direct contract research projects and constant funding streams (sustainability) as well as fruitful know-how and technology transfer (commercialization).

Being part of several Digital Innovation Hubs (DIH) helps us to get in touch with SMEs while performing R&D in big industrial H2020 ECSEL-JU projects allows us to reach large enterprises.

It is important to note that EDI plays a crucial role in industrial growth towards a high-tech society both at the European level and especially in Latvia. On one hand, we provide the high-tech R&D competence that is sometimes lacking in the industry (especially in Latvia), but at the same time we educate future industry professionals who will be able to bring significant value / competence to their careers.

In order to stimulate our target collaboration with the industry, we plan to continue to organize the annual event, called “EDI day”, inviting our partners from HEI, RI, and especially industry to exchange information, generate new ideas, understand their needs and challenges, etc. and allows to establish trust, which is crucial to raise awareness that EDI can create a win-win situation for both sides. Also, plan to develop a presentation/document which presents clear rules and options for collaboration with EDI, which we plan to present to the industry representatives while increasing the number of on-site visits to the industry. We plan to participate in new DIHs and industrial associations to reach even more SMEs and LEs and offer them different services, such as: R&D of smart embedded cooperative systems; collaborative research in smart production, smart mobility, smart health and space topics; concept validation and prototyping; testing and validation of the developed solutions; consulting; awareness creation; ecosystem building, scouting, brokerage, networking; visioning and strategy development for businesses; education and skills development; and mentoring. We are especially targeting manufacturing enterprises, as we believe digitalization/automation of production is key for Europe’s competitiveness.

Industrial associations, digital innovation hubs and non-governmental organizations

In addition, EDI is also a member of the KET Technology Centre and an associated member of the Time Machine network. In the coming years, we plan to maintain our connections with the above-mentioned associations, clusters and networks and continue to use their benefits, while increasing our presence in Europe with DIHs as we see them as a handy tool for commercialization of our scientific results and establishment of different collaborations.

For us, it is important to be part of leading industry associations in our field. This provides us a network and opportunities to better reach companies, find new partners, move different political initiatives, disseminate project results, increase our visibility and be informed about the latest updates in the field.

At this moment, EDI is part of 4 Digital Innovation Hubs (DIH) — TRINITY DIH[20], DIH-World[21], SCoDIHNet[22] and our own EDI DIH[23] (+ we are partners in two national European DIHs (EDIHs)

20 https://trinityrobotics.eu/
21 https://dihworld.eu/
22 https://aioti.eu/scodihnet/
23 https://www.edi.lv/en/digital-innovation-hub/

currently under evaluation); in 4 significant international associations/networks — INSIDE-IA[24], CLAIRE[25], HiPEAC[26], ILRS[27]; and in the 3 largest industrial associations/clusters in Latvia — LIKTA[28], Letera[29] and Latvian IT cluster[30]. In addition, EDI is a member of the KET Technology Center[31] and associated member in Time Machine Network[32]. Finally, EDI is also an associated member in VEFRESH[33], actively engaging in the creation of an innovation ecosystem and planning and development of pilot city areas (so-called "VEF's areas").

In the coming years, we plan to maintain our connections with the above-mentioned associations, clusters and networks and continue to use their benefits, while increasing our presence in Europe with DIHs as we see them as a handy tool for commercialization of our scientific results and establishment of different collaborations.

Public authorities and municipalities

Collaboration with local ministries, national funding agencies and municipalities is very important for us. For example, collaboration with the Ministry of Education and Science of Latvia (MES) and the Ministry of Economics gives us an opportunity to shape future national and also European R&D priorities and directions; contribute to the development of the "National development plan" and impact government action plans, contribute to the improvement of the education system; receive research base funding, additional funding from different R&D programmes, etc. EDI strongly lobbies for the renewal of State Research Programs (SRP) across all RIS3 priorities.

EDI considers that the cancellation of the SRP in the field of ICT was rushed and not well thought through and needs to be renewed, so that SRP would cover and contribute to all RIS3 priority areas. As an alternative, an initiative by the Ministry of Economics could be put forward to establish mission-oriented research programs in all areas of RIS3. EDI is ready to take the lead in the field of ICT, bringing together relevant high-level research teams from all over Latvia and providing high quality research, as was done in the implementation of the previous SRP, specifically in the SoPHIS project.

In cooperation with national funding agencies — Latvian Council of Science, Investment and Development Agency of Latvia, State Education Development Agency, Administration of studies and science, Rural Support Service, we work together to improve the quality of project monitoring systems and to make them more uniform and easier understandably for researchers in the terms of the execution of projects and submitting of reports. The reduction of the overall administrative burden is a major future challenge in this cooperation.

On the other hand, close collaboration with different municipalities and cities (e.g. Riga, Valmiera, Ādaži, Jelgava etc.) allows us to identify actual citizen needs and provides the opportunity to develop different technologies, which solves those challenges. Besides, they also allow testing of these technologies in the actual "smart city" environment.

24 https://artemis-ia.eu/
25 https://claire-ai.org/
26 https://www.hipeac.net/
27 https://ilrs.cddis.eosdis.nasa.gov/
28 https://likta.lv/en/home-en/
29 http://www.letera.lv/en/about-us/
30 https://www.itbaltic.com/
31 https://www.ket4sme.eu/
32 https://www.timemachine.eu/
33 https://www.vefresh.com/

Last but not least, we see the Latvian Academy of Sciences (LAS) as one of our most important partners in improving the research and innovation ecosystem in Latvia. LAS is the only science center of national importance in Latvia, which unites all stakeholders in the field of science, consolidating the interests of universities, scientific institutes and innovative industry. We believe that the prestige of the LAS in the eyes of officials and the public must be significantly enhanced. In collaboration with LAS we are able:

- to take an active part in the development of the science policy of Latvia and to promptly advise the Saeima and government in matters of science;
- to participate in scientific expertise of different governmental programmes, in stating the research level of studies, projects, programmes, and scientific institutions;
- to care about involving of researchers of new generations into science and the social protection of the retired scientists, including the state emeritus ones;
- to develop and encourage international contacts of Latvian scientists, to collaborate with other academies of sciences, scientific unions and associations;.
- to prognosticate processes of Latvia's development, to report promptly to the government and the community about scientific forecasts on desirable and undesirable consequences of different economic, cultural, and social processes and projects.

In order to improve our already existing good collaboration with the above-mentioned organizations, we plan to participate in different expert/working groups for ministries; involve municipalities and cities in different project proposal applications; to have more experts in the Latvian Council of Science, etc.

Planned actions	
Deadline	Action description
Regular	8.1 Provide internships to selected talented students. Involvement of the best students in research and development projects
Regular	8.2 Increase EDI presence in HEI study programs as lecturers and professors, as well as in promotion boards as experts.
Regularly	8.3 Visit research centers to understand their operation and management with a view to improving the EDI system.
Regularly	8.4. Participate in Digital Innovation Hubs and help SMEs to implement various technologies, providing premises in the EDI building, etc.
2022	8.10 Develop presentation/document with clear rules and options on how to collaborate with EDI.
Annually	8.18 Organize networking activities with partners from HEIs, industry, other research centers and end-users.
Regularly	8.22 Actively participate in various expert and working groups in ministries.

Expected results		
KPIs	Now	Goal
8.1 Number of university interns per year	22	20-25
8.2 Number of study courses delivered per year	10	15
8.3 Number of research and technology organizations visited per year (to improve EDI governance)	2 *	4
8.7 Number of offices from spin-offs, start-ups, SMEs and others related to EDI organizations in our building, which are interested in EDI results	5	10
8.10 Number of companies we have helped to implement new digital solutions during the year.	9	10

** — Effects of Covid-19*

9. Communication and dissemination strategy

Despite the impact of the Covid-19 virus, EDI communication and dissemination activities are (were) at a very good level, having hundreds of social media and web-page posts, conference, event, exhibition and workshop participation and organization, presentations, publications, lectures, videos, etc. each year.

The communication and dissemination activities within the EDI aim to raise awareness, to inform and educate the community, to promote higher education, social equality, integration and welfare, public health, national security, sustainable development of the social, economic and culture field, public understanding of the significance of the scientific activity, to engage to get input/feedback from others, as well as to promote and sell the knowledge, outputs and results of our research in the field of Smart Embedded Cooperative systems (SECS).

We plan to continue to widely communicate and disseminate on a national, European and world width level to the following audiences/stakeholders: academic/scientific organizations; other related EU/national projects as well as our ongoing project participants; end-users (citizens and professional users); industry & business associations, clusters and networks; academic communities and other interest groups; specific (SECS related) forums, exhibitions and exchange groups; applied researchers in the industry; researchers/experts from the field of policy, science and industry; students (PhD, Master and Bachelor thesis); public authorities; European Union/European Commission; standardization organizations (industry, national, international); regional, national and international media (incl. social media); and the general public.

The activities that are already taking place and that are going to take place in the future to communicate and disseminate our scientific results and other activities include but are not limited to:

- Public EDI website, continuously updated;
- Social media (Facebook, Instagram, LinkedIn, ResearchGate, Youtube, Twitter, etc.)
- EDI flyers and brochures;
- Press releases;
- General EDI presentation material (e.g. pictures, videos, USB flash drives, shirts, stands, etc.);
- Posters, presentations, invited speeches, demonstrators, etc. at conferences, workshops, seminars, exhibitions and other events;
- (Co-) organization of conferences, workshops, exhibitions and other events;
- Participation in national and international events;
- Publications in scientific journals and conference proceedings (Open Access) as well as articles for the general public; and specific target groups;
- Education and Training activities providing material to disseminate via lectures, courses or (industrial or technology transfer) training seminars
- Academic dissemination and exploitation, e.g. in supporting PhD, Master and Bachelor thesis development;
- The scientific journal of EDI (*Automatic Control and Computer Sciences*)
- Documenting and exhibiting the historical achievements of EDI, and others.

All the above-mentioned activities allow EDI to have an impact on the international scientific community; attract students, doctoral candidates, and foreign researchers; as well as show the international competitiveness of our academic staff.

Still, there is definitely room for improvement. Specific planned actions, as well as key performance indicators for improvement, are shown below:

Planned actions		Expected results		
Deadline	Action description	KPIs	Now	Goal
Regularly	9.1 Maintain EDI home page	9.1 Web page visits per year	1k	5k
Regularly	9.2 Active communication in popular social- networks: Facebook, Youtube and home page.	9.2 People researched from our social-media posts	15k	50k
Update every 2 years	9.3 Develop new videos, posters, booklets, stands, demonstrators, etc. representing EDI research activities	9.3 Number of scientific conferences, workshops, networking events, etc. attended per year	36 *	70+
Regularly	9.4. Demonstrate research results, prototypes in exhibitions and other events	9.4 Number of exhibitions attended per 3 years	~ 6	9
Regularly	9.7 Organization of conferences, seminars and other events.	9.7 Number of jointly organized scientific conferences over a period of three years	0	1
Completed	9.6 Active participation in conferences, workshops, exhibitions and other events. Identification of key events.	9.8 Number of invited speakers per year	1 *	5
Annually	9.11 Organize “EDI Days” and Scientists 'Night events.	9.11 How many participants participate in “EDI day” each year.	70+ 100 *	150+ 800
2022	9.13 Start EDI blog (including videos).			

** — Effects of Covid-19*

10. Exploitation strategy

To maximize the value-added and impact created of our research, EDI is very much interested in making use of the results for scientific, societal or economic purposes, as appropriate exploitation leads to innovation, new businesses and jobs, new products, increased knowledge, increased innovation capacity of Latvia and Europe, welfare, etc.

In order to facilitate the knowledge (technology) transfer (commercialization), it is necessary to develop high TRL (TRL6+) technologies that are more attractive to companies as high TRL technologies allow them to have the end-user-ready product faster. Working at high TRL levels usually means more development and testing activities, but fewer research activities, so EDI researchers need to be specifically motivated to focus on these kinds of activities. Working at high TRL levels helps to gain insights into new scientific challenges as well as generate additional revenue to support a research direction(s) or specific group(s) of researchers, increase EDI visibility and reputation, bring new contract research projects, ensure sustainability, etc. From our point of view, in the long-run, technology transfer, commercialization and contract research projects are the most sustainable form of funding.

Currently, EDI is taking all the necessary actions to ensure exploitation of our research results — either by ourselves (e.g. for further research) or by others (other beneficiaries or third parties, e.g. through reading our open access publications, licensing or by transferring the ownership of results). These actions include, but are not limited to:

- Identification of end-user/customer and their needs/problems/challenges;
- Creation and development of new knowledge, findings, new products, technology, services, etc.;
- Identification of potentially exploitable results;
- Risk management (planning, identification, analysis, response (mitigation), monitoring);
- Proactive and continuous monitoring of research outputs and technology transfer opportunities;
- Management and protection of IPR (know-how, background, ownership, patents (technical inventions), copyright (software, written works, engineering drawings, etc.), design rights (appearance), licenses, publication of knowledge, access rights, confidentiality, liability, etc.);
- The attraction of business leaders as mentors (to develop a feasibility study, market analysis, commercialization plan, business model/plan, etc.)
- Technology transfer/commercialization activities
- Dissemination of the research outputs and exploitable results (see Section 9)
- Supporting Bachelor, Master and PhD theses.
- Doing R&D for private companies, which directly use the results for their businesses.

In the last 6 years, EDI has created ~130 new exploitable results.

Even though in recent years we have put a considerable effort to establish new partnerships with the industry and have started to implement several commercialization projects, more effort should be put into technology transfer and commercialization of our research results, which should result in new spin-off and start-up companies, as well as license fees from our partners, shares in

companies, etc. Specific planned actions as well as key performance indicators to improve this are shown below:

Planned actions	
Deadline	Action description
Regular	10.1 Identify key companies in the industry facing challenges, which could be solved by technologies developed by EDI and establish collaboration.
2027	10.2 Develop innovation support infrastructure, allowing rapid technology transfer (renovated rooms at EDI, space for start-ups, legal entity and dedicated personnel for commercialization activities (technology transfer department))
2022	10.5 Detailed IPR management and protection plan and guidelines. Educate researchers on how to apply know-how, prepare patents, etc. for activities to prepare for technology commercialization.
regular basis	10.4 Follow up the results of research more actively and further evaluate their potential and improve their use by organizing seminars inviting all stakeholders.
Regular	10.9 Engage business leaders as consultants for researchers to develop feasibility studies, market analyzes, commercialization plans, business models / plans, etc.
Regularly	10.12. To support the development of bachelor's, master's and especially doctoral theses, using the results obtained in projects.

Expected results		
KPIs	Now	Goal
10.1 Total revenue from contract research with industry in relation to total EDI revenue	6%	15%
10.2. Amount of proceeds from the alienation of intellectual property (spin-off, licensing, sale, etc.) (EUR)	15k	315k
10.3 Established Spin-off / Start-up Companies based on EDI-developed technology, licensed and marketed technologies.	2	10
10.4 Number of new results to be used (prototypes, algorithms, etc.) per year	20	25

11. Gender equality plan

Gender equality is one of the core values of the Institute of Electronics and Computer Science (hereinafter Institute), as it promotes the advancement of research, improves the quality of research and innovations, allows to attract and retain more talents, and ensures that everyone can fully develop their potential. The Institute wishes and will conduct respective activities to create an inclusive working environment that provides equal opportunities for every employee of the Institute regardless of their origin, gender, sexual orientation, ethnicity, etc. including the opportunities to develop oneself and, of course, to be oneself in the Institute.

One of the fundamental human rights enshrined in Article 91 of the Constitution of the Republic of Latvia is that “All human beings in Latvia shall be equal before the law and the courts. Human rights shall be realised without discrimination of any kind”.

According to the European Institute for Gender Equality, gender mainstreaming is the process of assessing the impact of any planned activities, including the impact of legislation, policies or programs, on women and men in all areas and at all levels. This means recognizing the equal role of men and women in the development of society, providing them equal rights and responsibilities, ensuring equal access to resources and their use to ensure equal benefits for women and men.

Equality means that the contribution of men and women to society and their concerns are perceived and addressed on an equal footing. Gender equality is important in all areas of life and applies to both women's and men's rights.

Article 2 of the Treaty on European Union states that “human dignity, freedom, democracy, equality, the rule of law and human rights, including the rights of minorities” are possible only in a society in which in addition to pluralism, tolerance, justice and solidarity there is also a prohibition of discrimination and different treatment and equality of women and men; furthermore, Article 3 of the aforementioned Treaty includes the commitment to combat social exclusion and discrimination, promote social justice and protection, equality between women and men, intergenerational solidarity and the protection of the rights of the child.

Given that the Republic of Latvia is a member state of the European Union, the Charter of Fundamental Rights of the European Union prohibits discrimination in the Member States, including that on the grounds of gender (Article 21), as well as imposes the obligation to ensure equality between men and women in all areas, stipulating that the gender equality principle does not prohibit from preserving or setting measures that provide for special advantages for the gender that are under-represented in a particular area (Article 23).

In order to implement the provisions of the Treaty on European Union and the Charter of Fundamental Rights of the European Union, the European Union institutions propose targeted measures to reduce gender equality-adverse practices. The European Commission's Gender Equality Strategy 2020-2025 sets out six lines of action:

1. Freedom from violence and stereotypes: ending gender-based violence and combating gender stereotypes;
2. Gender-sensitive economic growth: tackling gender inequalities in the labour market, equal participation in different sectors of the economy, closing the gender pay and pension gap, tackling gender inequalities in care;
3. Equal leadership in society as a whole: achieving gender balance in decision-making and politics;

4. Gender mainstreaming and an intersectional perspective on European Union policies;
5. Funding for actions aimed at making progress on gender equality in the European Union;
6. Ensuring gender equality and full opportunities for women worldwide.

The UN Universal Declaration of Human Rights states that all human beings are born free and have the right to equal dignity and rights, and everyone has the right to enjoy their fundamental rights and freedoms without any restrictions, including those on the basis of gender.

Based on all the above, the goal of the Institute is to observe the human rights specified in the Constitution of the Republic of Latvia as well as the principles specified in the European Union's legislation, and to implement actual (de facto) gender equality in the following directions:

1. The Institute, as an employer, equally treats all employees in the performance of their duties, including the establishment of employment relationships, promotion / appointment to positions, involvement in decision-making, appointment as an expert, etc.;
2. Equal treatment with regard to pay;
3. Equal treatment with regard to the provision of an adequate working environment;
4. Equality with regard to the employees, giving the opportunity to pursue a career at the Institute.

Allocated resources, data collection and monitoring

In order to mainstream gender equality and promote gender balance in the Institute, a gender equality commission consisting of 3 women and 3 men has been established by Order no. 1.1.-2 / 55-21. The Commission shall convene a meeting at least once a year to:

- design, improve and develop a gender equality plan;
- promote and implement measures to promote gender equality and balance;
- collect, analyse and publish gender data on staff (including students);
- follow up the indicators to be achieved (see Table at the end of this Section) and promote their achievement by organizing appropriate activities;
- provide annual reports based on the indicators achieved;
- provide written recommendations for improving gender equality and gender balance at the Institute.

Work-life balance and the Institute's culture

The Institute supports a healthy work-life balance. The Institute intends to develop transparent and gender-sensitive practices so that overtime does not reduce the opportunity to spend enough time in one's private life. In addition, the Institute provides support for the physical and sporting activities of its staff, thus promoting a healthy lifestyle. Furthermore, in order to take care of the health of the Institute's employees, the Institute's employees have access to health insurance. In addition, the Institute is very flexible in terms of working hours, allowing employees to address the issues related to their private life (eg doctor's visits, taking a child to kindergarten, etc.) during official working hours and subsequently making up for the time they were absent. It is important for the Institute that all its employees are satisfied with their work and are in good mental and physical health; therefore, the Institute is committed to continuing to look for new ways to further

improve work-life balance and the Institute's work culture such as staff surveys, drawing on good examples from other organizations, etc.

Gender balance in the management and decision-making of the Institute

The Scientific Council of the Institute as well as the entire management of the Institute (director, deputy director, heads of laboratories) have supported and will continue to support gender balance in decision-making, although not only in Latvia but all over the world there are unfavorable gender balance statistics in the information and communication technology (ICT) sector. When forming the internal commissions of the Institute, there is always an effort to ensure the aspect of gender balance, so that the representatives of one sex do not exceed more than 2/3 of the composition of the commission.

At the end of 2021, the Institute had 122 employees, of whom 21% were women. There is already a good gender balance in the Directorate, Technical and maintenance department and Accounting department — 46% of employees are men and 54% are women, while special attention needs to be paid to gender balance in scientific laboratories, where only 12% are women, mainly due to the specifics of the ICT sector.

When the Institute's International Advisory Board is set up and candidates selected, particular attention, besides qualifications, is paid not only to the balance of local (Latvian) and foreign members but also to gender balance in each of these groups.

Gender equality in recruitment and career development

Every employee regardless of their origin, gender, sexual orientation, nationality, etc. have the same rights and opportunities. The Institute treats all employees equally including the establishment of the employment relationship, promotion / appointment to elected positions, appointment as an expert, etc.; equal treatment with regard to pay (which is determined by the position held, education, qualification and other objective indicators); equal treatment with regard to the provision of an adequate working environment; equality between employees, giving them the opportunity to pursue a career at the Institute; equal access to and use of the Institute's resources; etc.

Gender equality in research

The Institute supports and promotes the integration of gender into the Institute's research, development and innovation activities, as we believe that gender and other aspects of diversity are essential to achieving a high level of scientific results. These aspects are taken into account when setting research priorities, defining concepts, formulating research questions, developing methodologies, collecting and analysing data aggregated by gender, evaluating and reporting results, and carrying out knowledge transfer / commercialization activities. Researchers are also reminded about the importance of gender and other diversity aspects in their research and in their team when preparing project applications for EU and national calls. For research activities involving humans in experiments, the Institute has established an Ethics Commission to specifically assess ethics as well as gender aspects. Gender aspects in research, development and innovation activities will be addressed in the Institute's internal annual seminars.

Measures against gender-based violence, including sexual harassment

To date, there have been no complaints of gender-based violence or sexual harassment at the Institute. If such a case were reported, it would be individually assessed and appropriate action would be taken. Each member of staff of the Institute has free access to the project leaders, heads

of laboratories, and even the director of the Institute and, where appropriate, can report any behavioural abnormalities, including behaviour that offends the dignity of any individual or creates an intimidating, hostile, degrading, or offensive environment. In order to ensure a professional and pleasant environment, the Institute has developed a code of ethics, which clearly highlights the basic principles of professional ethics of the Institute's employees, ethical principles of scientific activity, work ethics, mutual relations, etc.

Awareness raising and training on gender equality and unintentional gender bias in employees and decision-makers

Starting from 2022, at least once a year, the Institute plans to organize awareness-raising seminars and / or training on gender equality and unintentional gender bias among staff and decision-makers, involving all employees. Gender training will be based on an evidence-based assessment of the Institute's needs.

Knowing the benefits of gender equality and balance, we believe that our gender equality plan/policy will foster an inclusive and open environment that will lead to excellent and influential research at the Institute and abroad.

In order to promote gender equality and in particular gender balance in the Institute, the Table below defines clear objectives, planned activities and expected results.

The strategy sets out the main principles of gender equality, while a detailed Gender Equality Plan with specific actions and achievable indicators is developed, regularly improved and developed by the Gender Equality Commission.

Planned actions	
Deadline	Action description
Every year	11.1 Gender equality plan establishment, improvement, development and performance monitoring
Regular	11.2 awareness-raising and training workshop on gender equality, unconscious gender bias, a gender equality plan and how each employee can contribute to its implementation.
Once a year	11.2 Collect gender data on staff, analyze specific indicators and make recommendations for improving gender balance.
Regularly	11.4 Ensure gender equality in the recruitment process, career development, involvement in commissions and other activities.

Expected results		
KPIs	Now	Goal
11.1 Gender Equality Commission meetings a year	-	at least 1
11.2 Proportion of the Institute's staff who are aware of the Institute's gender equality plan, the need for and benefits of gender equality, etc.	-	100%