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Deliverable D 1.1:

Market Analysis and Curriculum Design

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Abstract

This deliverable presents the market analysis and initial curriculum design for the RESCHIP4EU project, which aims to enhance embedded systems education across Europe. The market analysis has two parts: European-level summary based on literature and EU reports, and regional analyses, which have been completed using several methods. The market analyses show clear need in enhancing embedded systems education and points out an additional need of 50,000 chip engineers in the European microelectronics industry from now to 2030. The presented curricula were completed before the market analysis was available. Hence, there will be updates for it for the following years.

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0.2	29.4.2025	Hannu-Matti Järvinen (TAU)	Added first version of the introduction and the common part of the market analysis.
0.3	20.05.2025	Tamás Dabóczy	Added Hungarian part to market analysis, and education
0.4	20.05.2025	Didier GOGUENHEIM (ISEN) Fabrice GRAIGNIC (ST)	Added the curriculum design of exit year at ISEN Méditerranée and French market summary
0.5	01.06.2025	Hannu-Matti Järvinen (TAU)	Added Finnish parts, abstract, and conclusion.
0.6	04.06.2025	Didier GOGUENHEIM (ISEN)	Update • Table version of ISEN curriculum • Size of tables in French market analysis + added figures and tables legends and tables • One add-on in abstract (quantitative estimation)
0.7	04.06.2025	Romane Léauté (EITD)	Added Admission requirement parts
0.8	05.06.2025	Yasir Al-Ameri (UTU)	Added I&E for entry year, two elective courses, and ETCS for all courses
0.9	13.06.2025	Franco Callegati (UNIBO)	Added description of workprogram for entry and exit at UNIBO.

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1. Introduction

This deliverable contains four main sections. Section 2 presents the market analysis for the embedded systems. The market analysis is divided into two parts: the European- and global-level analysis, and regional parts. The regional parts represent the situation in countries having participating universities in the programme. The purpose of the market analysis is to give background for the curricula design described in Section 5.

Section 3 describes the objectives of the Embedded Systems Design Programme and its structure.

Section 4 presents the admission criteria for the Embedded Systems programme.

Section 5, the curriculum design, is based on the market analysis. Curricula for all participating universities are presented on course level. Since the market analysis was finalised in spring 2025, the curricula described here were mostly designed before getting the final version of the market analysis. Therefore, there will be changes in curricula for the upcoming years.

2. Market analysis

This section first discusses the general context of embedded systems at the European and global level. The general section is followed by regional analyses. These may vary considerably as the profiles of companies in different countries are very different, and the methods for collecting the data differ. Some results emphasise the semiconductor level, others the link to software processes. The regional analyses are presented by country.

2.1 Common background

This section is a literacy analysis on relevant literacy, most of which was collected from project participants in autumn 2024. The list of the referred sources is included in the References. This part is a shortened version of the third chapter of Olivia Saukonoja's thesis.

Chips, Semiconductors, and Embedded Systems

A computer chip, or IC (Integrated Circuit), is a small electronic device made from semiconductor materials. Chips are found everywhere, for example in smartwatches, cars, credit cards, and computing. Chip design varies by application, and since the 1990s, chips have become smaller, measured in nanometres. Smaller chips are used in electronics, automotive, digital, health, and renewable energy ecosystems.

Advances in semiconductor technologies, like smaller chips, higher processing power, and improved energy efficiency, enhance embedded systems. Specialized chips enable customized hardware in embedded systems, which are used in mobility, energy, digital industry, health, agrifood, and digital society.

Growth in Chip, Semiconductor, and Embedded Systems Industries

Chip demand is rising due to AI integration, 5G adoption, IoT devices, electric vehicles, and quantum computing. Chip demand is expected to double between 2022 and 2030, with the semiconductor industry projected to exceed \$1 trillion by 2030. Embedded systems demand is growing in industrial automation, medical devices, consumer electronics, media, military, IT, telecom, manufacturing, agriculture, automotive, and AI applications. The global embedded systems market is expected to nearly double by 2030.

Supply Crisis and Global Chip Shortage

The global chip shortage from 2020-2023 was due to Covid-19 and US-China economic conflicts. Lockdowns halted chip production, increasing PC demand for remote work and healthcare hardware. In 2023, the US banned exporting advanced AI chips, and China banned exporting key raw materials, prompting interest in local manufacturing in Europe. The semiconductor industry's complex value chain means supply crises affect overall production, impacting embedded systems and causing delays.

Talent Shortage in the Chip, Semiconductor, and Embedded Systems Industries

The growing demand for embedded systems requires more semiconductor fabs and manufacturing plants, but there is a shortage of job candidates. By 2030, over one million additional skilled workers will be needed globally. The semiconductor industry faces challenges due to too few professionals being educated, an aging workforce, and a poor reputation among students. Students prefer consumer-oriented tech companies for better career opportunities, despite rising salaries in the semiconductor industry.

Talent Shortage in the US and Asia

The US faces a shortage of professionals for fabs, with an estimated 90,000 skilled workers needed by 2030. The Chips Act aims to address this by investing \$280 billion in factories, research, and training. Asia also faces talent shortages, with significant growth in the embedded systems industry in China, India, and Japan. Taiwan produces over 60% of chips, and South Korea and India are expanding chip production. China has a shortage of 200,000 employees in the semiconductor industry.

Talent Shortage in Europe

Europe's embedded intelligence market is growing, with stable growth in the UK and Germany. However, there is a shortage of professionals, and the workforce is aging. Germany's demand for electronic engineers is twice the number of graduates, and one-third of the workforce will retire in the next decade. The European Chips Act aims to increase the EU's global market share in semiconductors, requiring an additional 400,000 workers by 2030; of these workers, 50,000 will be chip engineers.

In-Demand Roles in the Embedded Systems Industry

There is a shortage of skilled engineers in cloud computing, IoT, and embedded systems, leading to competition for talent, especially in embedded software engineering. Key roles include AI chip designers, IoT semiconductor engineers, quantum computing experts, and cybersecurity specialists. In Europe, software and design engineers are highly sought after, along with data scientists and application engineers. Senior roles like advanced systems architecture designers and senior analog designers are also in demand.

In-Demand Skills in the Embedded Systems Industry

Chips are becoming more complex, requiring students to have knowledge in computer science, electrical, mechanical, and environmental engineering. Soft skills are also important.

In-Demand Hardware Skills

Key hardware skills include advanced processing architectures (CPUs, GPUs, accelerators, neuromorphic computing, FPGAs, ASICs), system-on-chip (SoC), system-in package (SiP), system-on-package (SoP), multi-physics design, 3D integration, analog design, microelectromechanical systems (MEMS), and low-power design. Knowledge of new semiconductor materials and secure chip design is also crucial.

In-Demand Software and Other Skills

The integration of AI, 5G, smart cities, autonomous driving, and blockchain increases the demand for advanced embedded software. Co-design between hardware and software, testing, and automatic circuit generation are important. Cross-disciplinary skills in AI, ML, data analysis, edge computing, and environmental knowledge are needed, along with business knowledge and soft skills like teamwork, communication, and creativity.

Current Challenges in Embedded Systems Industry

Major challenges include efficiency, Continuous Integration/Continuous Development (CI/CD), lifecycle management, data analytics and AI, sustainability, reliability, combining hardware with software, and privacy.

Efficiency: Embedded software must support sensor-powered systems and real-time data processing. However, inefficiencies in engineering and testing can consume over half the development budget. Solutions include smarter processes, better tools, and more automation.

CI/CD Integration: Integrating code changes into embedded and cyber-physical systems (ECPS) is difficult due to diverse hardware architectures and platforms. CI/CD methodologies like DevSecOps and ChatOps need adaptation for embedded systems, requiring specialized HIL testing setups.

Lifecycle Management: Complex systems like cars and airplanes have long lifetimes, making software control challenging. Efficient lifecycle management involves removing technical debt, using CI/CD processes, handling configurations, and updating software.

Data Analytics and AI: Embedding AI into systems like self-driving vehicles requires high performance, cybersecurity, and interoperability. Solutions include local edge computing, AI accelerators, streaming data, and hardware/software co-design.

Sustainability: Sustainable software design uses minimal hardware, is power-efficient, and produces little waste. Sustainable production techniques and energy-aware applications are essential.

Reliability and Trust: Ensuring reliability in distributed systems with concurrent computing is challenging. Security and privacy must be built into software architecture using standardized interfaces and monitoring techniques.

Combining Hardware with Software: Hardware virtualization, using tools like hypervisors and containerization platforms, improves software development and deployment by isolating applications and managing resources efficiently.

Privacy and Security: Embedded software faces privacy, security, and liability concerns. Cyberattacks can lead to data breaches, impacting profitability. Solutions include developing embedded security software for real-time protection, access control, data encryption, secure communication, and unauthorized access prevention.

IP Protection: The IC industry is largely based on the fabless paradigm, where chip fabrication is usually outsourced to a small number of companies. Large investments in chip design should be protected against reverse engineering and tampering.

How to overcome the educational gaps

To overcome educational gaps, collaboration between academia and industry is essential. Universities partner with companies to access resources like software, tools, and training. Rapid technological advancements challenge traditional embedded system education, which often lacks practical exercises and fails to develop independent problem-solving skills.

Academic learning frequently doesn't prepare students for practical work due to the complexity and cost of industry tools, causing gaps between theoretical knowledge and practical experience. Universities must foster a mindset of continuous learning, teaching fundamentals, and applying them to modern problems. Digital tools like generative AI can help students stay current post-graduation.

Engineering education should focus on developing problem-solving skills and adapting to digital transformation and new technologies. Models like integrated curriculum frameworks, efficient learning models, and experimental teaching reforms can enhance embedded systems studies. These models emphasize practical training through labs, projects, and competitions, combining theoretical studies with hands-on opportunities to meet industry demands

2.2 Regional analyses

In addition to the general European market analysis, the regional needs in the countries where the programme has participating universities were examined. The curricula include a thesis, which is to be carried out as a project, preferably in an enterprise environment. To make this possible, it must be ensured that regional educational provision meets local needs.

Countries involved are Estonia, Finland, France, Hungary, and Italy.

2.2.1 Estonia

The Estonian market analysis regarding embedded systems and microchip development was carried out in two separate studies: 1) A Report on Green Transition Scenarios in Estonia by the Foresight Centre, an independent think tank at the

Parliament (Riigikogu)¹ and 2) Market analysis by the consortium of the national Chips Competence Centre KIIP².

The Foresight Centre's report is based on the study "Alternative development trajectories to deep technologies and their significance for Estonia" which CIVITTA Estonia carried out at the request of the Foresight Centre. The study selected deep technologies or sets of them whose potential breakthrough would have the greatest impact in Estonia. The selection took into account the potential for the development, production, and commercialization of technologies, as well as the economic, social, health, environmental, and security impacts. The report finds "Embedded Systems and Chip Technologies" *among six most impactful upcoming technologies for Estonia* according to experts.

At first, the list of technologies was narrowed down based on the impact assessment methodology created by the Estonian Government Office and the Ministry of Justice and the European Commission's systematic report "100 Radical Innovation Breakthroughs for the future" resulting in a long list of 13 technologies. The process was based on combined expert assessments, where ten experts from Civita and TalTech assessed (1) the extent of the impact and (2) the strength of the impact for each technology on the long list. The final ranking of the technologies was based on the combined effect of the two.

The process itself was as follows:

1. Six areas or target groups were defined in which the impact is assessed: social area state security and foreign relations, economy, natural and living environment, regional development, organization of public sector institutions and revenues.
2. Each target area in turn had 3-10 sub-themes or second-level areas. For example, in the social area these were impacts on health, livelihoods, labour relations, equality. In turn, specific yes-no questions in sub-themes were helpful for more detailed assessments. For example, under coping, it was examined whether technological breakthroughs have an impact on poverty rate.
3. The impact was assessed on a scale of 0 (no impact) – 5 (very significant impact). The extent of the impact is significant if the current status of the target group (person, company, environment) may change significantly compared to the past and requires deliberate adaptation. For each technology, there were two scores – impact size and impact scope. Those with a higher combined score were ranked higher.

1 Foresight Centre, *Green Transition Scenarios in Estonia, Summary, Report 2023*. https://arenguseire.ee/wp-content/uploads/2023/06/2023_green-transition-trends-and-scenarios-in-estonia_report_summary-4.pdf

2 The chip technology competence center KIIP, which will be launched in Estonia, will support the development of the Estonian electronics sector (In Estonian). <https://metrosert.ee/eestis-kaivitav-kiibitehnoloogia-kompetentsikeskus-kiip-toetab-eesti-elektroonikasektori->

The report finds that Estonian businesses have a global potential in chip design and testing. The need for chips will skyrocket in the coming decade and experts are seeing opportunities opening up for Estonian businesses in chip design and verification and the testing of the security of chips, the brief report “Embedded Systems and Chip Technologies: The State of Play and Prospects” by the Foresight Centre reveals³.

The global market volume of chips and embedded systems is estimated at about 550 billion euros and the sector is projected to increase to a trillion by 2030. The Foresight Centre points out in its brief report that it is economically realistic for Estonia to fulfil certain stages in the production of novel high-temperature semiconductor devices, e.g., base crystals.

According to the data of Startup Estonia, Estonian technology companies operating in chip technologies include for example Selfdiagnostics (medical chip labs), Analooadisaini AS (mixed-signal chip design), LightCode Photonics (3D camera technology), Testonica (board system testing), GScan (particle sensor technology), and Evikon (sensor devices).

In March 2025, an Estonian national Chips Competence Centre for Knowledge transfer in Innovative Integrated circuits and semiconductor Processes (KIIP) was launched to provide consulting and support services for the local and the EU’s chip industry, academy and public institutions. The focus is on supporting the establishment of startups in the chip domain and supporting SMEs in acquiring the required competences.

2.2.2 Finland

The Finnish market analysis was carried out in two separate studies. The first of these examined job advertisements in the field of embedded systems and identified the skills needs mentioned therein. The purpose of this study was to obtain information on the current situation and the needs for the near future. The job advertisements covered the whole of Finland.

The second study involved interviews with company representatives. The questions were mainly introductory, and the interviewees were given a wide freedom to say what they wanted to say. This survey was an attempt to identify longer-term needs. The interviewees were mainly from southern and western Finland where universities participating in the RESCHIP4EU program reside.

Results based on job advertisements

The job advertisements were collected for one year (1.11.2023-31.10.2024) from a service called Duunitori. The keywords “embedded” and “sulautetut” (embedded in Finnish) were used as keywords. In total, 114 different advertisements were searched. The purpose of this study was to get know the current needs.

³ Foresight Centre Report: Estonian businesses have a global potential in chip design and testing. <https://arenguseire.ee/en/news/report-estonian-businesses-have-a-global-potential-in-chip-design-and-testing/>

In the graph below, the roles of jobs are shown.

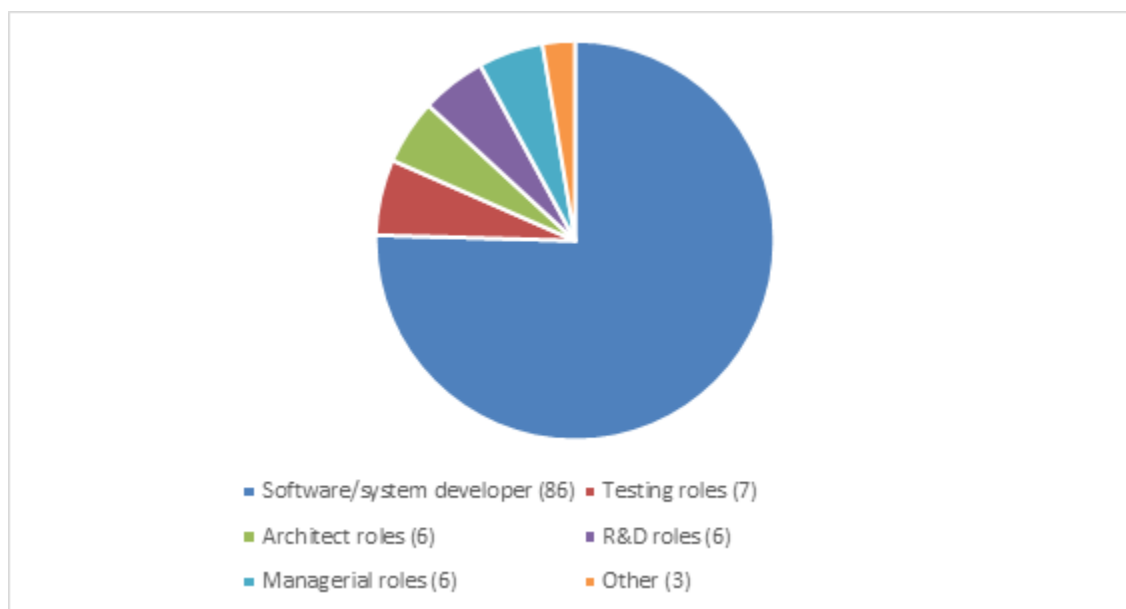


Figure 1: Results based on jobs advertisements (Finland)

There is a huge need for software professionals that can work on embedded systems. About half of the positions were for people having less than 5 years of experience. Formal qualification was mentioned in 76 percent of the advertisements. This probably indicates that employers focus more on skills and not titles, or they don't want to specify if they seek a bachelor or master level people.

Language requirements were not explicitly mentioned in all advertisements. In these cases, the language of the advertisement was taken as the required language skill. English was required by 69 percent of the advertisements, Finnish in 12 percent, and both in 32 percent. This shows that even without knowledge of the Finnish language, there are many jobs available.

Technical skills required in advertisements were classified to programming language and frameworks, development workflow, hardware knowledge, communication and networking, and specialised skills. In the following, the numbers indicate how many times a specific skill was mentioned; hence the number can be bigger than the number of advertisements.

Programming and framework skills included low-level languages (156 mentions to different languages), high-level languages (54 mentions to different languages), UI development (8 mentions), web technologies (16 mentions), system tools (11 mentions), and other (7 mentions).

Development workflow skills included architecture and integration (60), version control and collaboration (version control (e.g. Git) (38), technical documentation (20), Atlassian tools (Jira, Confluence) (11)), debugging (38), Valgrind (3)), testing and quality assurance (39), development methodologies (54), and workflow automation tools (26).

Hardware knowledge included embedded hardware (65), operating systems (125), development boards (9), and build and development (43).

Communication and networking included TCP/IP/networking (17), communication protocols (17), and wireless communication (5).

Specialized skills included cloud and IoT technologies (20), data processing and AI (13), security and compliance (11), and laboratory instruments (10).

Results from the interviews

People for interviews were selected from professors' contacts and member mailing list of FIMA (Forum for Intelligent Machines). A total of 11 interviews were done, representing 9 companies. Of the interviewed people, eight had experience between 15-20 years, one had longer than that and two less. The purpose of the interviews was to get an idea of future needs in the area of embedded systems.

The results were formed in four themes: technical competencies, industry trends and future needs, professional and soft skills, and educational gaps. Here the results are presented from the educational gaps' point of view.

The interviews revealed several perceived educational gaps in the field of embedded systems, which interview participants had noted from their experience. These include the overall number of talents, Linux expertise, deep technical knowledge, management of the entire system, cybersecurity, safety knowledge, embedded C programming, deep Qt knowledge, and hands-on experience.

The interview participants brought up a concern about **talent shortage** of embedded systems professionals. Their views indicate that there is shortage of talent coming from an overall number of graduates, and that sufficient expertise is not easily available in the field, which forces adapting work tasks for the available talent. As a solution, the participants offered that there could be more emphasis and guidance towards embedded systems education

Further, they suggest that especially **Linux and embedded Linux** are skills that have a high demand in embedded systems industry and that there could be more focus on that in education.

The interviewees indicated that there are needs for **deep technical expertise** in embedded systems especially on **hardware and electronics**, and that the number of embedded systems specialists is not sufficient, which can partly be due to the lack of genuine interest for developing themselves as experts in a specific technology.

One required skill was **managing the entire system** and designing the **whole architecture** of embedded system is something that is needed but those experts are not easy to find.

The interviews highlighted a lack of embedded systems professionals that have expertise in **cybersecurity and safety knowledge**. Their comments indicate that despite the growing importance of cybersecurity and safety in embedded systems, education has not yet adapted to meet this need.

The interviews also revealed a gap in deep **Qt knowledge** among graduates. These views reflect the broader theme in the interviews that surface-level experience of programming languages and frameworks are not sufficient in embedded systems development, since they demand an understanding of hardware integrations and constraints.

In the interviews, it was revealed that there should be more **hands-on experience**, especially at higher education levels as well.

Overall, participants expressed that educational programs often provide a good foundation, but there are gaps that are critical to embedded systems. These include educational gaps in the number of talents, deep technical knowledge, management of entire system, Linux expertise, cybersecurity, safety knowledge, embedded C programming, deep Qt knowledge, and hands-on experience. This requires companies to train employees to reach the required levels, which is partly seen as companies' responsibility especially in specific tools. However, there is a clear expectation that graduates would get sufficient level of knowledge and practical experience already at university.

Summary

The results of the advertisement study show that the current needs in embedded systems industry in Finland include skills and knowledge in embedded hardware, operating systems, development boards, build and deployment, communication and networking technologies, software development, quality assurance and testing, architecture, development processes, engineering, and soft and professional skills.

The results of the interviews show that the future needs in embedded systems industry in Finland include skills and knowledge in cloud and edge computing, AI and ML, embedded hardware and software, data analytics, security and system architecture. To conclude, these results can be used in creating and improving embedded systems educational program in Finland to close the gap between education and working life.

2.2.3 France

The semiconductor industry in France is closely aligned with European needs and future challenges⁴. Firstly, innovation remains essential, not only throughout the semiconductor supply chain but also within various vertical value chains such as automotive, industrial automation, space, and avionics. Secondly, the European semiconductor supply chain, now recognized as a strategic sector for the European economy, must strive to be as resilient as possible. This resilience should be built on European strengths and international cooperation in specific areas, which need to be defined between the EU and third countries.

Driven by strong political support, France has established a robust framework to enhance its semiconductor ecosystem and sustain its leadership in the coming years. The France 2030 initiative has been pivotal for the French semiconductor ecosystem,

⁴ ESCA (European Skills Chips Academy) - SKILLS STRATEGY 2024 report on addressing the talent gap in the EU semiconductor ecosystem.

particularly with the expansion of domestic production, such as the "mega-fab" in Crolles near Grenoble, led by STMicroelectronics and GlobalFoundries.

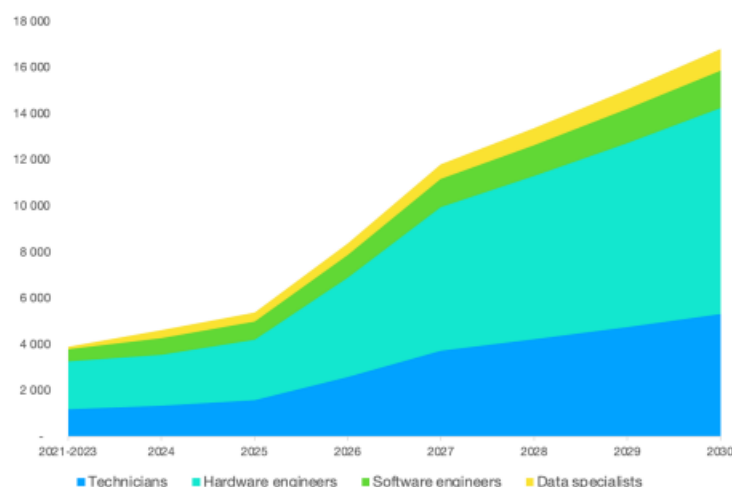
However, efforts in research and innovation must be intensified at both French and European levels like never before. These efforts should be undertaken within the European semiconductor ecosystem as a whole, as well as within key vertical European value chains such as automotive, industrial automation, healthcare, avionics, and space. In that sense, the French semiconductor ecosystem needs further strengthening, especially in chip design. An initial approach through the CHIPS Joint Undertaking is crucial in this regard, with the creation of design platforms linked to the European advanced pilot lines established by RTOs (CEA Léti, IMEC, Fraunhofer, etc.). This initiative aims to facilitate the emergence of fabless companies at the European level.

To sustain and enhance European leadership in the micro-nanoelectronics sector, efforts should remain concentrated on bolstering differentiated technologies such as FD-SOI and wide-band gap technologies. Furthermore, it is crucial to encourage the development of disruptive technologies related to Front-End and Back-End activities, including silicon photonics, quantum technologies, and heterogeneous integration. These advancements will empower European leadership in vertical value chains and artificial intelligence.

In conclusion, regarding the needs and strategic goals of the French industry, a skilled workforce will be essential to realize this ambition and vision. Unfortunately, projections indicate a growing workforce gap by 2030. All stakeholders involved in this strategic sector, crucial for the European economy and its security, must initiate coordinated actions in the following key areas: attracting young people to STEM education, optimally training individuals through traditional pathways (bachelor's, master's, engineering schools, doctorate), and ensuring continuous professional development to facilitate skill enhancement and even the retraining of individuals from other industrial sectors, in order to develop a qualified workforce.

To quantify these points, we see in the following picture the increasing annual scheduled talent gap in semiconductor industry at EU level, from 2023 to 2024 raising from 3,800 jobs in 2023 to almost 18,000 jobs in 2030.

Annual projected semiconductor workforce gap (2024-2030)



Source: DECISION Etudes & Conseil

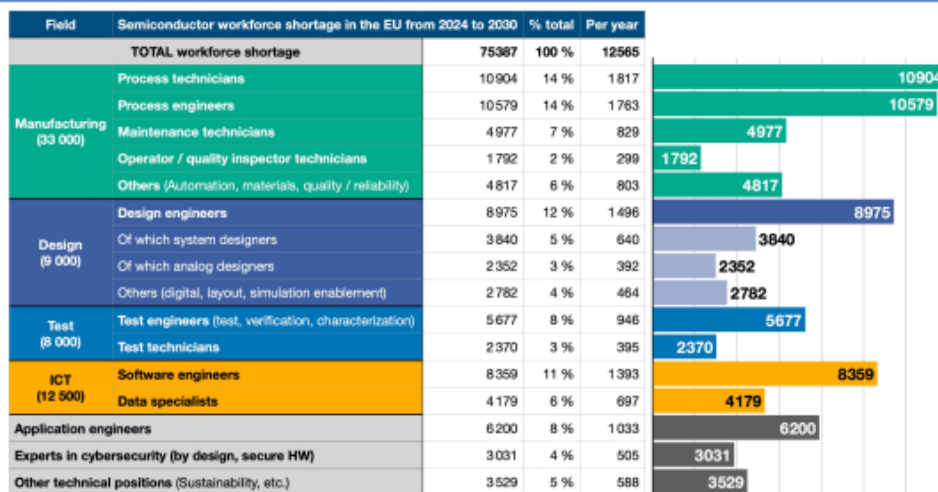
10

- 2021-2023: already facing a talent gap (3,800 jobs) => align with METIS
- To bridge this gap, companies turn to non-EU workers
- 2024-2030 : annual talent gap projected to rise due to a surge in job openings (+5%/year) outpacing the growth in graduates (+1%/year)

Figure 2 : Annual projected semiconductor workforce gap (2024-2030)

The following table details the job profiles mainly concerned by the talent gap, highlighting a huge lack in process and design competencies by 2030.

Talent gap by detailed job profile on EU soil by 2030



Source: DECISION Etudes & Conseil, European Chips Skills Academy

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Figure 3 : Talent gap by detailed job profile on EU soil by 2030

Finally, to illustrate these elements, the French and European leader STMicroelectronics (hereafter ST) has classified its expectations in 4 categories:

“Soft skills”

“Standards knowledge”

“Technical knowledge”

“Specific Design Concerns”

and has assigned priorities according to areas from 1 (high priority) to 5 (low priority). The results are given in the tables below highlighting the most critical needs in the coming years:

Soft Skills

Area	Item	Comments	ST priorities
Communication	English language	Read, write and speak english , able to read technical documents related to electronic industry	2
	Presentation	Able to elaborate and conduct a technical presentation in front of an audience	3
Behavior	Teamwork	Able to work within a team in an international context	1
	Team Spirit	Information sharing oriented, collective sense, good relationships with others	3
	Curiosity	Open-minded, willingness to learn, proactive for proposals bringing added-value	2

Basic learnings Willingness/Ability to build and share his own vision (ready opinion to be shared...) – facing the “why” to optimize his own vision – accept and listen to others

Table 1 : Priorities assigned by ST to most critical needs in Soft Skills

Standards Knowledge

Area	items	ST priorities
Technical Standards and Norms	Has knowledge and understand technical standards and norms. <i>Examples: USB, SPI, I2C, UART, RFID, Bluetooth, Mipi Standard Interfaces</i>	3
Standards for quality	Understand standards related to quality	5
	Basic understanding on ISO norms	5
	Contribute to the definition/deployment of these standards	5

Table 2 : Priorities assigned by ST to most critical needs in Standards Knowledge

Technical knowledge

Area	items	ST priorities
Electrical simulations - Knowledge and correlation with electrical measurements	Perform electrical simulation to verify a design <i>Ex: Spice simulations, electromagnetic (CEM) simulations, RF simulations</i>	1
Measurement instrumentation	• Metrology understanding • Knowledge on instrumentation for circuits measurements and characterization: be able to choose the adequate measurement tool for the parameter to be observed • Capability of each instrument?	1
		1
		5
Verification / Diagnostic / Validation	• Be able to analyze and solve any fault which may happen on the bench measures • Select & assess measurement tools • Measurement tools benchmarking • Validation plan: define a clear and optimized strategy in time and coverage for the circuit validation • Define the measures to be implemented to get the highest coverage	2
		3
		2
		3
		2

Table 3 : Priorities assigned by ST to most critical needs in Technical Knowledge (1)

Area	items	ST priorities
Electronic Systems	Has knowledge on electronics systems (architecture...)	1
	Understand what an electronic circuit is.	1
Programming and algorithm	Has knowledge on: Python , C, C++, GIT, Labview, Visual C, Basic, VHDL, System Verilog, TCL, Perl	2
	Has experience with Copilot	5
Operating Systems	Has knowledge on standard Operating Systems: Linux, Windows, real time system	5
Machine learning & AI	Gradient descent on MNIST learning on one framework (KERAS, Tensor Flow, Pytorch, JAX...),	4
	Decision tree and polynomial regression on SCIKIT-Learn	3
Quantum technologies	Quantum computing basics	5

Table 4 : Priorities assigned by ST to most critical needs in Technical Knowledge (2)

Area	items	ST priorities
Risk Analysis	Identify risk factors (risks matrix)	3
	Assess the risks level and associated impact	2
	Define appropriate ways/methods to control the impacts related to the risks	3
Electronic device know-how	Understand electronic device data sheet and application note.	1
	Ability to select, order and use electronic components	2
	Ability to develop complex circuit based on electronic component (discrete)	2
	Ability to master basic analog function such as transistors, resistors, capacitors, inductors, diodes	1
Electronic board development	Manage electronic board specifications to build the schematics and the layout and the associated user manual	3
	Be able to handle the schematic development on tools such as Altium or Allegro	5

Table 5 : Priorities assigned by ST to most critical needs in Technical Knowledge (3)

Area	items	ST priorities
System Level	Simple signal processing (Shannon theory & Analog-Digital Converters, low pass filters, FFT...)	1
	Hardware/Software partitioning	1
	Fixed point & Bit-accurate programming	2
	Use of tools like Matlab/Simulink	1
Data analysis	Collect and consolidate data (Knowledge in Big Data analysis tools and methods)	4
	Make a critical analysis of results	2
	Detect deviations related to measurements	2
	Prepare technical reports	3
Testability / Device test	Understand concepts of circuit testing, common analog and digital testing methods, test coverage	2
	Propose and define the solution to test the device:	3
	Write parts of the testing program	4
	Debug the test solution	3
	Specify test conditions	3
	Contribute to define reliability and industrialization tests	4

Table 6 : Priorities assigned by ST to most critical needs in Technical Knowledge (4)

Specific Design Concerns

Area	Items	ST priorities
Physics semiconductor	Fundamentals, Bipolar, MOS, modeling	1
Technology process and manufacturing	Understand technology of devices and device construction, process steps (Photo, etching, deposition, CMP...)	4
Digital design	Master design flow: RTL, gate level, logic synthesis, physical implementation (place and route and digital signoff – static time analysis, Irdrop and X-talk analysis), digital simulation, Universal Verification Methodology (UVM), power consumption, features optimization (performance), programing and algorithm (cf slide 1 /4)	2
Analog Design	Master basic analog design structures (current mirrors, differential pairs, cascode configurations, opamp compensations, switching and linear power units and converters, ..), analog simulation (spice), analog verification plan, analog modeling, mixed simulation, analog layout with process variability constraints (matching constraints, Montecarlo), statistic basics	1
MCU Programing	ARM (on STM32) and RISC-V architecture and programing environment knowledge	2

Table 7 : Priorities assigned by ST to most critical needs in Specific Design Concerns

As clearly shown both by the quantitative estimation and the assigned “1” priorities in ST analysis, the need focuses on engineers able to work in an international context, having a strong general knowledge of electronics systems architecture and basic components, and how to simulate or measure them. A specific attention must be paid to the training of engineers with specific skills in fundamentals of microelectronics devices (even back to physics) and analog design. This is a strong indication for the skills and courses that should be included in the general entry year and the specialized exit year of the Master Program.

2.2.4 Hungary

One of the driving forces of the Hungarian economy is automotive engineering. The share of this segment of economy is more than 20% of the GDP. This includes both manufacturing components, cars, but also there is a large share of research and development of these components and functions.

The most important automotive stakeholders of research and development companies in Hungary are the following:

- Robert Bosch
- thyssenkrupp
- Knorr Bremse
- Continental
- aiMotive.

These companies together employ more than 10 thousand highly trained engineers (electrical engineers, mechanical engineers, computer scientists, computer engineers, software engineers etc.).

BME have worked (and is working) in cooperation with these companies in national R&D projects (a recent example is a national Competence Centre on Safety Science and Technology) and regularly delivers customized trainings to them and also to SME partner companies in this field. Based on these interactions, the needs and gaps with respect to the education and continuous training of engineers could be identified.

There is a new worldwide tendency that component manufacturers need to provide more and more complex functionality and applications beside the basic operation of the component, recognizing the need of interoperability towards self-driving cars. Autonomous driving itself is a strong driving force as application development (and not component development). There is an increasing need for engineers who understand both the functionality of embedded systems and high-level information processing algorithms, including artificial intelligence techniques. Moreover, the market seeks researchers and engineers who can design and develop high-level ADAS (Advanced Driver Assistance Systems) functions or autonomous driving functionality for embedded systems with limited resources, making use of new chips accelerating embedded systems and enabling machine learning on these platforms.

Additionally, proficiency in model-based systems design and analysis is often expected, as model-based system engineering is considered an effective approach for managing and mastering complexity of contemporary embedded systems that are typically distributed, intelligent, mobile, and cooperative, and thus require the interaction of dozens of software and hardware components. Related skills include architecture design, considering extra-functional requirements such as safety and dependability, capturing interfaces and interactions, and model-based testing and verification.

BME-s Embedded Artificial Intelligence specialization and the related self-standing modules aim to reflect on these market needs.

2.2.5 Italy

The semiconductor industry in Italy is not just growing; it's experiencing significant growth. This growth, propelled by increased demand for advanced technologies and strategic initiatives aligned with the European Union's objectives, is a promising sign for the industry's future.

- In 2025, the Italian semiconductor market should generate revenues of approximately US\$2.33 billion.
- The Integrated Circuits segment is projected to lead, with an estimated market volume of US\$1.55 billion.
- The market might grow at a CAGR of 7.40% from 2025 to 2029, reaching US\$3.10 billion by 2029.

This upward trajectory in the semiconductor industry is not just about market numbers. It is also about its significant influence on university enrollment patterns, particularly in engineering and computer science. This influence, as we will see, is a clear indication of the industry's growing importance in shaping the future of education.

Italy's strategic alignment with the EU Chips Act significantly enhances its global semiconductor market position. As we will see, this alignment is a testament to Italy's commitment to the semiconductor industry. Notable initiatives that support this alignment include:

- Chips.IT: The Italian Center for the Design of Semiconductor Integrated Circuits in Pavia, Lombardy. This centre, launched in 2023 with a €225 million investment plan, aims to:
 - Promote the design and development of integrated circuits
 - Enhance professional training in the microelectronics industry
 - Serve as a network hub for universities, research centres and firms dedicated to innovation and technology transfer
- Investment in the Etna Valley: Focuses on developing applications in electric mobility and telecommunications.
- International Collaborations:
 - Singapore-based Silicon Box announced a €3.2 billion investment to establish an advanced packaging foundry in Novara, Piedmont.
 - Germany's Aixtron announced a €100 million investment in a new production site in the Piedmont area (in Orbassano, near Turin).

The growing semiconductor industry has led to increasing demand for skilled professionals. By analyzing the list of open positions, numerous job openings for IC design engineers indicate a shortage of qualified candidates. In general, companies require expertise in high-speed, low-power digital circuit design.

University Enrolment Trends

As of 2023, Italy's higher education system comprises approximately 1.9 million students. A significant fraction of these students enroll in engineering and computer science programs directly relevant to chip design and programming careers. This enrollment trend aligns with the industry's expanding needs.

Alignment with Industry Needs

Efforts to align university programs with industry requirements are in full swing, with initiatives like the ECS Summer School organized in collaboration by the industry associations AENEAS, EPoSS, INSIDE and the European Chips Skills Academy (ECSA) project. This program, held at the University Residential Centre of the University of Bologna in 2023 and 2024, is a testament to the industry's growing importance in shaping the future of education. It focuses on microelectronics and integrated circuit design, providing students with practical experience in chip design and programming. This year's edition will take place in August 2025 at the Budapest University of Technology and Economics (BME) and will feature lessons with industry representatives, lab and clean room tours and hands-on sessions for participants.

Financial research and analysis

The Ministry of Economics and Finance (MEF) is well aware of the importance of semiconductors in the global industry and has dedicated an in-depth analysis of the role of Italy in this context⁵. The report highlights the increasing geopolitical importance of semiconductors and the need to prepare Europe to face potential tensions in the supply chain by doubling Europe's market share through a coordinated approach. Italy is present in the global semiconductor market with companies such as ST Microelectronics, as well as companies that focus on production machinery and testing. Most players, however, concentrate in the utilization of semiconductors, in particular in areas such as automotive, mechatronics, consumer electronics and sensors.

As discussed, the forecast for the automotive sector emphasizes an increasing demand for semiconductors, which are central in future cars. Today, an electric car requires over 3,000 semiconductor components, compared to only hundreds for a conventional combustion engine. Automated driving will intensify this trend and will require the use of components of the latest generation. This may have a negative impact on European suppliers, which do not currently support the smallest technology nodes, which require substantial investments. There is therefore a need for professionals who can design high-performance components that can expand the product portfolios.

Another sector that is experiencing considerable expansion is industrial robotics. This is fostered by the transition from series production to flexible production, to adapt to an increasing varied and personalized demand. In this context, the report emphasizes the need of IoT components to optimize and safeguard the production environment, integrating hardware, software and services. Robots will be increasingly present in the digital industrial environment, especially in the form of collaborative robotics,

5 Maria Rita Pierleoni, Ministero dell'Economia e delle Finanze, Dipartimento del Tesoro, "L'Industrial Globale dei Semiconduttori e il Ruolo dell'Italia", Note Tematiche n. 3, December 2023, available at

https://www.dt.mef.gov.it/export/sites/sitodt/modules/documenti_it/analisi_programmazione/note_tematiche/Nota-Tematica-n-3-2023.pdf

providing safe and flexible tools that can easily repay the initial investment. In this sense, this technology is projected to spread also to medium and small enterprises. In addition to the electronics components, engineers will be called upon developing data analysis and artificial intelligence models, both from the perspective of the application, as well as for predictive maintenance and optimization.

The report finally reminds that the semiconductor industry will be characterized in the years to come by increasing complexity and capital investments. Italy, similarly to the rest of Europe, is not well positioned in that sense, and lacks the ability to produce semiconductors in the most advanced nodes, with a shrinking market share even in the “fabless” sector. For this reason, reinforcing the academic offer is crucial, especially since the demand is increasing and quickly evolving.

3.The Embedded Systems Design programme

3.1 Programme objective

The partners of the programme are building a curriculum to address the concerns and ideas found in the market analysis. The basic idea is to offer an entry year, after which the student can continue the exit year at any participating university. As a result, there is relatively little profiling of the starting year per university. The first version of the common first year was planned in autumn 2024, and it will be tuned in 2025.

The studies of the exit year are more profiled based on both the overall goals of the programme, and local circumstances, and the profile of the university. The first versions of these were made in autumn 2024. The scope of the profiles varies from chip design to adaptation of software to utilise the designed hardware.

The programme is a two-year programme, with the first year at an entry university and the second year at an exit university. The universities must be from different countries.

Entry universities offer the first year of studies. These studies must include a common core, which, once completed, can be continued at any exit university. In addition, all students will study an Innovation & Entrepreneurship (hereafter I&E) module between the first and second year. I&E continues for one more course (6 ETCS) at the exit university.

3.2 Intended learning outcomes

The Embedded Systems Design (ESD) programme focuses on enabling technologies and design methodologies for computing systems that are embedded as integral part of larger systems, designed for intelligent control of devices with various electronic and mechanical components. Graduates of the ESD programme will be world-class specialists and innovators in the field of embedded systems design. The programme provides students with in-depth knowledge and hands-on skills in both software and hardware design, for mastering modern techniques to build intelligent and energy-

efficient cyber-physical systems, covering a wide range of industries. They learn to deal with complexities of integrating computation, networking, and physical processes, enabling them to create impactful real-world solutions.

The intended learning outcomes of the ESD programme (with the combined technical and I&E education) are that a graduate:

- has a holistic and multidisciplinary view on embedded intelligent systems, their underlying technologies, their development, and their integration ;
- masters specification, modelling, implementation, and testing of complex embedded systems from both software and hardware perspectives;
- masters the use of contemporary design tools of embedded systems and is also able to invent and develop his/her own specific tools, methods, and techniques if not available;
- is able to work productively in a multidisciplinary design team and to communicate his/her visions, ideas, and solutions to others;
- has insight into the role of embedded systems in the modern society and ability to develop innovations into business ideas and high-tech embedded systems start-ups ;
- is capable of taking on leading management roles in embedded systems and more general ICT companies.

3.3 Structure

The Embedded Systems Design programme (120 ECTS) is a combination of an I&E Minor (30 ECTS), a Technical Major (90 ECTS):

- 20-30 ECTS mandatory courses ('common base')
- 30-40 ECTS elective and specialized courses ('specialisation')
- 30 ECTS master's thesis project.

Typically, during the entry year, students have to take 36 ECTS for the technical major and 24 ECTS for the minor in Innovation & Entrepreneurship whereas during the second year, they have to take 24 ECTS for the technical major, 6 ECTS for the minor and 30 ECTS for the master's thesis project. The Innovation & Entrepreneurship minor (30 ECTS) includes the mandatory Summer School (4 ECTS).

All Master School education will be held in English and all partner universities are assumed to use ECTS units.

Upon fulfilment of all degree requirements, students receive two degrees. Students also receive an EIT Label Certificate endorsed by the EIT and issued by EIT Digital.

3.4 Partner Universities offering the programme

The following partners provide a first year (entry) programme:

- Polytechnic University of Milan (POLIMI), Milan, Italy
- Polytechnic University of Turin (POLITO), Turin, Italy

- University of Bologna (UNIBO), Bologna, Italy
- University of Trento (UNITN), Trento, Italy
- University of Turku (UTU), Turku, Finland

The following partners provide a second year (exit) programme, and every exit partner has its own unique specialisation:

- Budapest University of Technology and Economics (BME), Budapest, Hungary
- ISEN Méditerranée (ISEN), Toulon, France
- Polytechnic University of Turin (POLITO), Turin, Italy
- Tallinn University of Technology (TALTECH), Tallinn, Estonia
- Tampere University (TAU), Tampere, Finland
- University of Bologna (UNIBO), Bologna, Italy
- University of Trento (UNITN), Trento, Italy
- University of Turku (UTU), Turku, Finland

3.5 Degrees

The general degrees and legal frameworks for the involved partner universities are as follows:

- BME, Hungary: Master of Science (abbreviated as MSc) in Computer Science Engineering.
- ISEN, France: To be specified
- POLIMI, Italy: Laurea Magistrale (equivalent to Master of Science) in Computer Science and Engineering (part of the LM-32 class in Computer Systems Engineering as per Ministerial Decree No. 270/2004).
- POLITO, Italy: Laurea Magistrale in INGEGNERIA INFORMATICA (COMPUTER ENGINEERING), classe LM-32, D.M. 270 dated 22 October 2004.
- TALTECH, Estonia: Master of Science in Engineering.
- TAU, Finland: Diplomi-insinööri, Diplomingenjör (Master of Science (Technology)), Decree of the Council of State on University Degrees (1665/2009).
- UNIBO, Italy: Laurea Magistrale (equivalent to Master of Science) in Computer Science and Engineering (inter-class LM-18 - Computer science and LM-32 - Computer systems engineering as per Ministerial Decree No. 270/2004)
- UNITN Italy: Laurea Magistrale in Ingegneria dell'Informazione - classe LM-27 (Master of Science in Information Engineering) D.M. 270 dated 22 October 2004.
- UTU, Finland: Diplomi-insinööri, Diplomingenjör (Master of Science (Technology)), Decree of the Council of State on University Degrees (1665/2009).

3.6 Grading systems

The partner universities use their own national grading systems.

4. Admission Criteria for the Embedded Systems programme

To qualify for admission, applicants need to have a complete and suitable Bachelor's degree in the relevant field of studies and demonstrate proof of English language proficiency.

4.1 Bachelor's degree

Applicants must have completed a Bachelor's degree encompassing a minimum of 180 ECTS credits or equivalent academic qualifications from an internationally recognized university. Students in their final year of undergraduate education may also apply and if qualified, receive a conditional acceptance. They must include a written statement from the degree administration office (or equivalent department), confirming that they are enrolled in the final year of their education and giving their expected completion date - which should be before the start of the Master's programme.

4.2 Relevant field of studies

The Master's programme is open to applicants with either a Bachelor of Science degree or who are in their final year of study in:

- Computer Science
- Information Systems
- Mathematics
- Electrical Engineering.

Applicants with reasonable knowledge of the fundamentals of computing and information sciences and technologies may also be considered. In some circumstances, relevant work experience may compensate for a lack of relevant degree.

4.3 Proof of English language proficiency

All programmes are taught in English. As a result, applicants must provide proof of their English language proficiency. This is generally verified through an internationally recognized test such as TOEFL or IELTS. Most TOEFL and IELTS tests results are only valid for 2 years from the test date.

4.3.1 General language requirements

IELTS Academic test (www.ielts.org) An overall band score of at least 6.5, with no section lower than 6.0, is required. IELTS-tests are verified online by the Admissions office, submitting a photocopy of your test together with your application documents is therefore sufficient.

TOEFL Internet-based test, iBT (www.toefl.org) A total score of at least 92 with a minimum for each section of at least 21 and for writing section 22 is required.

English test proficiency waiver: English proficiency tests are waived for applicants who have completed a degree instructed in English at a university that is physically located in one of the following countries: USA, Canada, UK, Ireland, Australia, or New Zealand.

University-specific language tests and exemptions: Find out more about the University-specific language tests and exemptions here: <https://masterschool.eitdigital.eu/admissions/university-specific-language-tests-and-exemptions>

4.3.2 Application necessary documents

To apply to the RESCHIP4EUx Master's programme, candidates are required to upload into the application portal the following documentation:

- **Degree Certificate/Diploma** in its original language and translated into English (If your university does not provide this service, the translation has to be done by an authorised translator and his/her credentials, signature and stamps must be visible in the translated document). In case of ongoing studies, a statement certifying that you are in the final year of your studies. The statement must be written by the degree administration office (or equivalent department) confirming that you are enrolled on the final year of your education and giving your expected completion date.
- **Official and stamped transcript of records in original language and translated into English.** All courses taken must be included. Please scan the front and back of every document- all stamps and signatures must be fully visible.
- **Proof of English proficiency.** The requirement of English proficiency will vary depending on the higher education institution/country selected by the applicant. Please refer to EITD Master School website 'Admissions' tab for more information.
- **Curriculum Vitae** including details on your academic and professional career.
- **A letter of motivation** (maximum 3 pages) to prove the innovative potential of the applicant and their need for financial support. In this letter, applicants will be required to discuss and/or propose an entrepreneurial idea and to explain their financial situation and need for financial support.
- **Supporting documents regarding the applicant's financial situation** (e.g. credit report).
- **An official ID**, such as passport or National ID.

Optional: Document stating the GPA or the Relative Ranking, a 2-minute video to accompany the motivation letter.

4.3.3 Selection process

The application and selection process is coordinated from Sweden by the KTH Admissions Office and the EIT Digital Master School Office. They determine whether candidates fulfil the specific admission requirements for their technical major, and

ranking of the applicants is performed by the Selection Committee which is composed of academics involved in the programme at partner universities.

The ranking is based on a total evaluation of the following criteria:

- Suitability of acquired bachelor's degree for intended study program
- Academic excellence (quality and recognition of home university, study success)
- Entrepreneurial excellence
- Innovative potential

Each criterion is assessed on a 5-point scale:

1 – Very Poor

2 – Poor

3 – Moderate

4 – Good

5 – Very Good

Selected applicants are offered a study track based on preference and availability. If an applicant cannot be offered a seat in the preferred study track, an alternative track will be offered.

The application portal for admissions opens in November each year. There are three admission batches:

- The first deadline closes around mid-February. (Period 1)
- The second batch opens immediately after and closes around mid-April. (Period 2)
- The third batch opens immediately after Period 2 and closes early June- (Period 3)

Students have the possibility to choose three options for their Entry university and three options for their Exit university, indicating the order of preference for each.

The universities selected as the first preference are involved in the evaluations.

In some cases, the application is evaluated by the next university chosen by the student according to their order of preference. These cases include:

- Insufficient evaluation (below the required threshold) by the selected university;
- Lack of admission requirements for the specific local program;
- Entry-Exit combination involving two universities from the same country.

If any of the evaluating coordinators (either from the entry or exit university) rejects an applicant, we ask for a third or even fourth opinion from the coordinators of the universities ranked second or third on the applicant's preference list. If any of them

accept the applicant, that university will be designated as the assigned entry or exit university.

The final score assigned to the student is an average of the evaluations from the assigned Entry and Exit universities, based on the criteria described above. If the final score is below 3.0, the applicant is rejected.

During the selection process, the ESD Program Lead assigns the applications to evaluate to each Local Lead, indicating the deadline by which the evaluations must be submitted.

4.3.4 Financial support to EU students

RESCHIP4EU provides eligible students the financial support to take part to the education programmes and offers scholarship programmes to promote diversity in terms of gender, age, social and economic background. RESCHIP4EU's scholarships allow the greatest number to have access to high-quality education in digital areas and increase diversity among students and future digital experts. The students awarded a scholarship will be financially supported during their two years of studies in the double-degree Masters' programme.

The number of scholarships awarded to students will be limited by the project's available budget. For the entire duration of the project, a maximum of € 360,000 is allocated for financial support to third parties. Within this budget, the consortium will strive to provide financial support to at least 60 EU students.

All details about the Cascade funding call are available on the Funding and Tender portal of the European Commission: <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/myarea/projects/cascade-funding-details/details/10365/43152860/101158828>

The actual number of scholarships awarded each year, as well as the specific attribution criteria, will be detailed in the annual reports on enrolment and scholarship allocation (deliverables D4.4, D4.5, D4.6, and D4.7). These reports will also provide all relevant information related to the financial support to third parties (FSTP), including details on eligibility, funding scope, allocation methodology, funding amounts, timing of disbursements, and selection processes.

5. Curriculum design

5.2 The entry year

The entry year is provided by the following partners: Politecnico di Milano, Italy (POLIMI), Politecnico di Torino, Italy (POLITO), Università di Bologna, Italy (UNIBO), Università degli Studi di Trento, Italy (UNITN), and University of Turku, Finland (UTU).

3.1.2 POLIMI

The first year of the Master's Degree in Embedded Systems Design provides a solid foundation in embedded systems development, combining core topics such as software engineering, data management, embedded architectures, and cybersecurity with advanced electives in AI, IoT, and edge computing.

Entrepreneurship and innovation are integral to the curriculum, supported by courses in digital business and a multidisciplinary project. The program's flexible structure allows students to tailor their learning to individual interests and career goals, preparing them to address the challenges of modern embedded applications.

Embedded system design – 36 ECTS

These courses provide fundamental skills in different topics of embedded systems design. Students can personalize their study plan by selecting two of the following courses in embedded systems (10 ECTS).

Innovation & Entrepreneurship (I&E) – 24 ECTS

In this part, students will acquire expertise in innovation, business, and entrepreneurship. Again, the study plan is composed of a mandatory part (15 ECTS) and a part that can be personalized by the students (9 ECTS).

Embedded Systems design/First & Second semester - MANDATORY – Total 26 ECTS	ECTS
SOFTWARE ENGINEERING 2	5
SYSTEMS AND METHODS FOR BIG AND UNSTRUCTURED DATA	5
EMBEDDED SYSTEMS	5
ADVANCED COMPUTER ARCHITECTURES	6
COMPUTER SECURITY	5

CS/Engineering – ELECTIVES - Total 10 ECTS	ECTS
ADVANCED OPERATING SYSTEMS	5
DISTRIBUTED SYSTEMS	5
SENSOR SYSTEMS	5
ADVANCED ALGORITHMS AND PARALLEL PROGRAMMING	5
MACHINE LEARNING	5
INTERNET OF THINGS	5
HARDWARE ARCHITECTURES FOR EMBEDDED AND EDGE AI	5
COMPUTING INFRASTRUCTURES	5

I&E - MANDATORY – Total 15 ECTS	ECTS
HIGH-TECH STARTUPS: CREATING AND SCALING UP I	5
DIGITAL BUSINESS LAB	10

Deliverable 1.1 Market Analysis and Curriculum Design

Project: RESCHIP4EU
(101158828)

I&E - ELECTIVE – Total 9 ECTS	ECTS
CREATIVITY, SCIENCE AND INNOVATION	5
BUSINESS INFORMATION SYSTEMS	5
MULTIDISCIPLINARY PROJECT (SUMMER SCHOOL)	4

Summer School – Total 4 ECTS	ECTS
Summer School	4

3.1.3 POLITO

The first year of the Master's Degree in Embedded Systems Design provides students with a comprehensive foundation in embedded systems design, development, and optimization. It balances theoretical knowledge with practical skills, equipping graduates to address the challenges of modern embedded applications across various industries. The program is structured into core and elective courses, offering flexibility to tailor the curriculum to individual interests and career aspirations.

Core Courses (Mandatory) – 30 ECTS

These courses provide in-depth knowledge and technical expertise in the fundamental areas of embedded systems design:

- **Computer Architectures (10 ECTS).** This course covers the principles of computer architecture, focusing on design methodologies, performance analysis, and optimization techniques for embedded systems. Students will explore processor architectures, memory hierarchies, and hardware-software co-design for embedded applications.
- **Operating Systems for Embedded Systems (8 ECTS).** Students will learn about operating systems internals (common and real-time ones), such as task scheduling, resource management, and power optimization. The course emphasizes the unique requirements of operating systems in resource-constrained embedded environments.
- **Software Engineering (8 ECTS).** This course introduces students to advanced software development methodologies, tools, and practices, focusing on designing, testing, and maintaining software.
- **Synthesis and Optimization of Digital Systems (6 ECTS).** This course provides an understanding of digital system design, emphasizing synthesis techniques and optimization strategies to improve performance, area, and power consumption.

Elective Courses in Computer Science and Engineering

Students can customize their learning by selecting one of the following specialized topics in embedded systems (up to 6 ECTS):

- **Microelectronic Systems (6 ECTS).** Focuses on designing and implementing microelectronic components for embedded systems, covering topics like analog/digital integration and low-power design.

- **Programming IoT Applications (6 ECTS).** Explores the programming paradigms and frameworks used in Internet of Things (IoT) applications, including cloud integration, security, and communication protocols.
- **Modeling and Optimization of Embedded Systems (6 ECTS).** Introduces techniques for modeling complex embedded systems and applying optimization methods to improve performance and resource efficiency.
- **Specification and Simulation of Digital Systems (6 ECTS).** Covers techniques for specifying, verifying, and simulating digital systems, focusing on hardware description languages (HDLs) and simulation tools.

Innovation & Entrepreneurship (I&E) – 12 ECTS

This module bridges the gap between technical expertise and business acumen, preparing students to innovate and lead in the tech industry, covering the I&E Minor of the program:

- **Company Economics (6 ECTS).** Provides foundational knowledge of business economics, covering financial analysis, cost management, and strategic planning for technology companies.
- **Innovation Management (6 ECTS).** Focuses on the principles of innovation and its role in the technology industry. Students will learn how to manage innovation processes in competitive markets, from ideation to commercialization.

Innovation & Entrepreneurship Electives

Students can deepen their understanding of business and finance by selecting one of the following courses (up to 8 ECTS):

- **Business Economics and Organization (8 ECTS).** Covers the principles of organizational structure, management, and decision-making within tech-driven companies.
- **Financial Engineering (8 ECTS).** Focuses on financial modeling, risk management, and investment strategies, with applications in technology-driven industries.

The POLITO courses are summarized in the below table:

Core Courses (all Mandatory) – Total 30 ECTS	ECTS
Computer Architectures	10
Operating Systems for Embedded Systems	8
Software Engineering	8
Synthesis and Optimization of Digital Systems	6

Elective courses (1 course to select) – Total 6 ECTS	ECTS
Microelectronic Systems	6
Programming IoT Applications	6
Modeling and Optimization of Embedded Systems	6
Specification and Simulation of Digital Systems	6

Innovation & Entrepreneurship Mandatory – Total 12 ECTS	ECTS
Company Economics	6
Innovation Management	6
Innovation & Entrepreneurship electives (1 course to select) – Total 8 ECTS	ECTS
Business Economics and Organization	8
Financial Engineering	8

Summer School – Total 4 ECTS	ECTS
Summer School	4

3.1.4 UNIBO

The first year of the Intelligent Embedded System curriculum in the Master program of Computer Science and Engineering provides the students with comprehensive foundations of Embedded systems design with particular focus on embedded system software development. The technical program is complemented with the I&E minor which provides basics of digital innovation management, company organization and leadership.

Intelligent Embedded Systems – Total 36 ECTS	ECTS
Distributed Systems	6
Embedded Sensors	6
Embedded Systems and Internet of things	6
Cybersecurity	6
Intelligent System Engineering	6
Programmable Networking	6

Innovation & Entrepreneurship – Total 24 ECTS	ECTS
Fundamentals of Management	6
Organization, Teams and Digital Leadership	6
Fundamentals of Accounting	6
Application of Digital Innovation	6

Summer School – Total 4 ECTS	ECTS
Summer School	4

3.1.5 UNITN

The first year of the Embedded System Design curriculum in the Master program in Information Engineering at UNITN provides a wide spectrum of competences, focusing in particular on architectures, embedded and distributed systems, and signal processing. The mandatory courses include:

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- **Advanced Computing Architectures (6 ECTS):** This course provides the students with the notions to understand, design and evaluate advanced architectures that use parallelism in all its different forms, analyze and evaluate the effect of design choices, comparing solutions on different metrics. The course also covers the basics of general-purpose GPU programming using CUDA.
- **Embedded Systems (6 ECTS):** Designing an embedded computing system is challenging because the requirements include manufacturing cost, performance, power consumption, user interface, hard deadlines, and rich functionality. The objective is to illustrate the embedded system design process, which includes requirements, specifications, architecture, components, and system integration phases. Real-life design examples complete the course to illustrate the design process.
- **Digital signal processing (mod 1) (6 ECTS):** This course introduces the fundamental concepts and techniques in digital signal processing. The course covers discrete-time signals/systems, the Fourier and z-transforms, and the design of filters. Laboratory sessions with Matlab provide practical knowledge in processing real signals.
- **Low-power embedded systems (6 ECTS):** The objective of this course is to explore both hardware and software techniques oriented toward the development of highly efficient intelligent applications on low-power edge devices. The students learn the main optimization techniques, focusing on popular topics such as automated learning on battery-less devices, spiking networks, and neuromorphic computing.
- **Distributed systems (6 ECTS):** The goal of the course is to expose the students to the core concepts of distributed systems, and to the main technologies underlying distributed applications. The main portion of the course is devoted to a discussion of the fundamental classical algorithms, chosen to exemplify commonly-used solutions. A second portion of the course is devoted to the middleware technologies commonly used to develop distributed applications. Alongside standard lectures, this topic includes hands-on sessions in the lab.

Besides the technical courses, the first year also includes mandatory courses on Innovation and Entrepreneurship. The following courses are offered:

- **Innovation and Entrepreneurship Basic (6 ECTS):** The goal of the course is to provide students fundamentals in the field of innovation theory and entrepreneurial practice (I&E) applied to the computing disciplines. The course has a particular emphasis on developing a critical understanding of innovation, entrepreneurship, and social impacts of computing. The course also aims to develop “soft skills” such as clear presentation and writing, and critical thinking.
- **Business Development Laboratory (9 ECTS):** The course introduces business design, a methodology for designing truly innovative products and services: desired by customers, economically sustainable, through an iterative and incremental methodology that allows you to test the main assumptions underlying the business model before launching on the market your product or service. The course combines traditional elements of market analysis and

business strategy with contents and methods taken from the disciplines of design thinking and human-centered design.

- **ICT Innovation (9 ECTS):** The course covers aspects such as creativity, or how to solve incompletely specified problems, intellectual transformations, or how to turn an idea into a product using concepts from economics and engineering, leadership and value judgement. In particular, how to decide which parts are important based on ethical and social considerations.

Elective courses complete the program. These courses cover topics such as **Machine learning, Software Development for Collaborative Robotics, High performance computing, Robot Planning and its application.**

The UNITN courses are summarized in the below table:

Core Courses (all Mandatory) – Total 30 ECTS	ECTS
Advanced Computing Architectures	6
Embedded Systems	6
Digital signal processing (mod 1)	6
Low-power embedded systems	6
Distributed systems	6

Elective courses (1 course to select) – Total 6 ECTS	ECTS
Machine learning	6
Software Development for Collaborative Robotics	6
High performance computing	6
Robot planning and its application	6

Innovation & Entrepreneurship – Total 24 ECTS	ECTS
Innovation and Entrepreneurship Basic	6
Business Development Laboratory	9
ICT Innovation	9

Summer School – Total 4 ECTS	ECTS
Summer School	4

3.1.6 UTU

Our entry year specialization, Embedded Systems, focuses on the design, optimization, and implementation of intelligent computing systems in real-time environments. The compulsory courses of this specialization are:

- **System Modelling and Synthesis with HDL (5 ECTS):** Covers the modeling, simulation, and verification of real-time systems using modular RTL design principles and the Vivado toolchain.

- **Heterogeneous Computing Platforms (5 ECTS):** Explores CPU-GPU-FPGA architectures and parallel programming models for optimizing performance across diverse computing units.
- **FPGAs for Embedded Systems (5 ECTS):** Teaches FPGA-based embedded system design, focusing on processor integration, HLS, and resource optimization.
- **Advances in System on Chip for Edge Computing (5 ECTS):** Examines modern SoC architectures tailored for edge environments and their research challenges.
- **Hardware Accelerators for AI (5 ECTS):** Focuses on the design and deployment of AI hardware accelerators on various platforms including CPUs, GPUs, and FPGAs.
- **Embedded Systems Design (5 ECTS):** Equips students with practical and theoretical skills for building low-power, real-time embedded systems using hardware-software integration.
- **I&E: Introduction to Innovation and Business (24 ECTS):** This course introduces concepts of technology entrepreneurship, covering business idea development, market analysis, product innovation, and the fundamentals of managing and growing tech-based ventures.

Elective studies may include courses such as **Multidimensional Sensing Techniques (5 ECTS)**, which covers both active (e.g., lidar, radar) and passive (e.g., image processing) remote sensing methods, along with sensor fusion and evaluating sensing instrumentation. Another option is **System Architecture of IoT (6 ECTS)**, which focuses on the design and deployment of IoT systems, addressing architectural considerations, sensor data processing, and edge computing integration.

Core Courses (all Mandatory) – Total 30 ECTS	ECTS
System Modelling and Synthesis with HDL	5
Heterogeneous Computing Platforms	5
FPGAs for Embedded Systems	5
Advances in System on Chip for Edge Computing	5
Hardware Accelerators for AI	5
Embedded Systems Design	5

Elective courses (max 2 courses to select) – Total 10 to 12 ECTS	ECTS
Multidimensional Sensing Techniques	5
System Architecture of IoT	6
GPU Programming	5
Machine Learning and Algorithmics Seminar	5

Innovation & Entrepreneurship – Total 24 ECTS	ECTS
Introduction to Innovation and Business (Mandatory)	5
Lean Digital Business Design (Mandatory)	10
Knowledge and Innovation Management	5
TJS17 Enterprise Architecture	6
TJS7 Digital Business	3
TJS7 Digital Business Models	3
I & E Project	4

Summer School – Total 4 ECTS	ECTS
Summer School	4

3.2. The exit year

The exit year is provided by the following partners: Budapesti Műszaki és Gazdaságtudományi Egyetem, Hungary (BME), Isen Mediterranee, France (ISEN), Politecnico di Torino, Italy (POLITO), Tallinn University of Technology, Estonia (TALTECH), Tampere University, Finland (TAU), Università di Bologna, Italy (UNIBO), Università degli di Trento, Italy (UNITN), and University of Turku, Finland (UTU). The profiles for each exit year are described below. The exit year contains 6 ETCS units of I&E, a thesis (30 ETCS) and subject studies (24 ETCS).

3.2.1 BME: Embedded Artificial Intelligence

The specialisation aims to educate engineers who develop intelligent applications based on embedded systems, using artificial intelligence methods. Application examples include (1) from the automotive field Advanced Driver Assistance Systems (ADAS) and support for different levels of autonomous driving; (2) from the healthcare field medical signal processing and sports/lifestyle support using wearable electronics; (3) from the smart manufacturing field predictive maintenance; (4) from the development field model-in-the-loop, hardware-in-the-loop, and software-in-the-loop testing. Engineers active in this area should have an understanding of hardware platforms including programmable circuits and hardware accelerators, as well as the intelligent signal processing methods and the artificial intelligence algorithms running on them.

The specialisation has the following main goals:

- It aims to present the sensing of physical signals and the methods for pre-processing the raw sensor data in embedded systems. It introduces the most commonly used sensors and the disturbing and distorting effects in sensing, and introduces the common steps of signal processing, independent of the applications.
- It presents artificial intelligence-based algorithms for information processing in embedded systems. Its special focus is the understanding of data derived from physical processes. In the implementation of algorithms, it addresses the

possibility of implementing them on embedded hardware platforms and accelerators.

- The specialisation also presents methods for developing intelligent embedded systems that are critical from the point of view of functional safety. Students learn about the life cycle models of safety-critical systems as defined in development standards, design principles, safety and reliability analysis to justify design decisions, and systematic testing and verification methods.

BME courses are summarized in the table below:

Compulsory Courses: Energy-Efficient and Reliable Embedded Systems – Total 15 ECTS	ECTS
Embedded Artificial Intelligence (VIMIMA22)	5
Safety Critical Embedded Systems (VIMIMB07)	5
Embedded Artificial Intelligence Laboratory (VIMIMB05)	5

Elective courses (2 courses to select) – Total 10 ECTS	ECTS
Intelligent Embedded Systems Laboratory (VIMIMA21)	5
Artificial Intelligence Based Control (VIMIMB06)	5
Perception and Signal Processing (VIMIMA20)	5
Data Processing Applications (VIMIMB06)	5

I&E – Total 6 ECTS	ECTS
Innovation & Entrepreneurship Study (VIMIMT06)	6

Master thesis and internship – Total 30 ECTS	ECTS
Diploma Thesis Design 1 (VIMIMT12)	10
Diploma Thesis Design 2 (VIMIMT13) - ECTS 20	20

3.2.2 ISEN: Analog and Digital Conception of Advanced IC and Embedded Systems.

The exit specialization year at ISEN-Méditerranée has been designed and suggested in 2025 for an effective opening during the 2026/2027 academic year. It focuses on the scholarship for engineers on Analog and Digital conception of advanced IC and application to IC conception dedicated to embedded systems

This is done from material to devices and circuits up to the architecture and system level with the help of AI developments and advanced tools (Synopsys, Verilog, labview).

The main focus of the courses is to extend the Engineering skills for the conception of advanced circuits with power consumption, performance and security criteria, for various technology applications as IoT, automotive, communication and Space.

Compulsory courses: *Analog and Digital Conception of Advanced IC and Embedded Systems*

Digital circuits and ULSI integration: This course focuses on basic knowledge of the different steps of ULSI circuit design, integration and fabrication:

- Digital Electronics from devices to nanometre circuits
- Physics of semiconductors
- Process for IC Fabrication
- VHDL modelisation
- Digital Design

Circuit Design and Layouts: This course is devoted to specific aspects of IC analog design from basic concepts and tools to layout, RF design and considerations on hardware security and robustness:

- Basic Design
- Conception and Tools
- Analog IC Conception
- Layout
- Analog RF
- Hardware & Architecture security

Microcontroller and communication Interface: This course develops design and operation concepts of embedded microcontrollers (use case: STM32) and FPGAs:

- STM32 level.1 and AI use
- Linux Shell
- Introduction to Labview
- Data Bus and communication protocols
- FPGA circuits & Labview

Elective courses: *Students can specialize further by selecting one of the following advanced courses (up to 6 ETCS)*

AI developments for circuits to system conception

Analog Circuits & Applications

Digital Electronics: System Programming

Innovation & Entrepreneurship: *This component bridges technical expertise with business and innovation skills, focusing on Innovation and Entrepreneurship study courses*

Compulsory courses – Total 21 ECTS	ECTS
Digital circuits and ULSI integration	7
Circuit Design and Layouts	7
Microcontroller and communication Interface	7

Elective courses (1 course to select) – Total up to 3 ECTS	ECTS
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AI developments for circuits to system conception	3
Analog Circuits & Applications	3
Digital Electronics: System Programming	3

I&E – Total 6 ECTS	ECTS
Innovation & Entrepreneurship	3
Innovation project or hackathon	3

Master thesis	ECTS
Master thesis and internship in company or R&D centre	30

3.2.3 POLITO: Energy-Efficient and Reliable Embedded Systems

The second year of this Master's Degree program focuses on advanced topics in embedded systems, strongly emphasizing energy efficiency, reliability, and innovation.

Compulsory Courses: Energy-Efficient and Reliable Embedded Systems (18 ECTS)

This core module ensures that all students gain advanced expertise in critical areas of embedded systems design:

- **Energy Management for IoT (6 ECTS).** This course focuses on the integration of smart energy management systems into renewable energy resource systems for IoT devices. Students will learn to:
 - Design and implement energy-efficient solutions for IoT devices
 - Understand the dynamics of energy harvesting and power management
 - Optimize energy consumption in IoT systems
- **System-on-Chip Architecture (6 ECTS).** This course equips students with the knowledge to design and analyze complex System-on-Chip (SoC) systems. Key topics include:
 - Integration of multiple components on a single chip
 - Performance optimization and power efficiency
 - Scalability in SoC design
 - Verification techniques for SoC systems
- **Testing and Fault Tolerance (6 ECTS).** This course provides a comprehensive understanding of embedded systems' fault tolerance methods and mitigation techniques. Students will:
 - Explore both software and hardware aspects of fault tolerance
 - Learn various fault injection techniques
 - Evaluate and select appropriate fault tolerance methods for different applications
 - Design systems that can withstand and recover from faults

Elective Courses

Students can specialize further by selecting one of the following advanced courses (up to 6 ECTS):

- **Cybersecurity for Embedded Systems (6 ECTS).** This course covers the principles and practices of securing embedded systems, including resource-constrained IoT devices. Topics include:
 - Hardware-based Security for embedded systems
 - Secure coding practices
 - Common Attacks on embedded systems
- **GPU Programming (6 ECTS).** This course covers the fundamental concepts in leveraging GPU as computational accelerators:
 - Programming models such as CUDA or OpenCL
 - Optimization techniques for high-performance computing
 - Applications of GPU computing
- **Edge Computing Systems for AI and ML (6 ECTS).** This course focuses on deploying AI and machine learning models at the network edge. Key areas include:
 - Architecture of edge computing systems
 - Resource management in constrained environments
 - Challenges and solutions for AI/ML model deployment at the edge
- **Software Engineering II (6 ECTS).** This advanced course builds on foundational software engineering principles, covering:
 - Software architecture and design patterns
 - Agile development methodologies
 - Version control systems and CI/CD pipelines
 - Large-scale software development project management

Innovation & Entrepreneurship (I&E)

This component bridges technical expertise with business acumen and innovation skills (up to 6 ECTS):

- **CraftingTech: Conceiving, Designing and Communicating Tech Ideas (6 ECTS).** This course focuses on:
 - Generating and developing innovative technological ideas
 - Enhancing presentation skills for effective communication of tech concepts
 - Practical, hands-on activities directly applicable to future careers
- **Technology and Innovation Management in Cybersecurity (6 ECTS).** While specific details are not available, this course likely covers:
 - Innovation strategies in cybersecurity technologies
 - Management of technological resources and projects in cybersecurity
 - Analysis of current trends and market demands in the cybersecurity sector

POLITO courses are summarized in the table below:

Compulsory Courses: Energy-Efficient and Reliable Embedded Systems – Total 18 ECTS	ECTS
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Energy Management for IoT	6
System-on-Chip Architecture	6
Testing and Fault Tolerance	6

Elective courses (1 course to select) – Total 6 ECTS	ECTS
Cybersecurity for Embedded Systems	6
GPU Programming	6
Edge Computing Systems for AI and ML	6
Software Engineering II	6

I&E (1 course to select) – Total 6 ECTS	ECTS
CraftingTech: Conceiving, Designing and Communicating Tech Ideas	6
Technology and Innovation Management in Cybersecurity	6

Master thesis – Total 30 ECTS	ECTS
Master thesis and internship in company or R&D centre	30

3.2.4 TALTECH: Distributed Control for Embedded Systems

The specialisation offered by Tallinn University of Technology offers mostly courses about control software supported by additional topics like communications and electronics. All courses are electives, except the master thesis and internship in the last semester. Compared against the other exit years, the main differences can be outlined as distributed control for embedded systems - systems that consist of multiple embedded devices and controlled in a distributed manner. In addition, courses to develop hardware accelerators on FPGA-s and/or ASIC-s for machine learning and artificial intelligence are offered for the students.

All courses are elective – the students must select 4 courses from Distributed Control module and 1 course from I&E module.

Distributed Control for Embedded Systems (4 courses to select) – Total 24 ECTS	ECTS
Applied Data Communication	6
Software Defined Electronics	6
Reliability and Quality in Nanoelectronics	6
Systems-on-Chip Design	6
Machine Vision	6
Intelligent Control Systems	6
Machine Learning for Embedded Systems	6
Foundations of Artificial Intelligence and Machine Learning	6

I&E (1 course to select) – Total 6 ECTS	ECTS
International Entrepreneurship	6
Innovation	6

Master thesis – Total 30 ECTS	ECTS
Master thesis and internship in company or R&D centre	30

3.2.5 TAU: Embedded Systems' Architecture and Software

The specialisation offered by Tampere university offers both hardware and software design for embedded systems, essentially closing the gap between hardware and software design. In embedded systems, interoperability between hardware and software is an absolute requirement. The specialization focuses on this part and provides students with the understanding of a complete system design, part of which is then implemented in hardware and part in software. Traditional hardware studies are complemented by studies on software engineering at the technical and process level.

The compulsory part of the second-year courses includes courses on dependable embedded systems and software testing. Dependable embedded systems emphasizes safety issues in creating software close to hardware. Software testing contains general testing and quality assurance, and it includes an embedded-systems-related assignment that covers cross-development and hardware-in-the-loop. Compulsory course on innovation and entrepreneurship is provided by the University of Turku. Other compulsory courses are related to the thesis.

Elective studies include courses Internet of things, Software design, Embedded systems and electronics productization, Software architectures, a project, and special topics. The topics of the two latter ones may change annually or even on a personal basis. In the project work, students make software for locally defined hardware. Special topics may be, for example, a seminar or small study on any interesting topic around embedded systems.

Compulsory courses – Total 15 ECTS	ECTS
Dependable embedded systems	5
Software testing	5
Tools for thesis	5

Elective courses – To be selected for a total of 9 ECTS	ECTS
Embedded systems and electronics productization	5
Internet of Things	5
Software systems architectures	5
Software development	5
Project work II (<i>Topics vary; many topics come from companies</i>)	5 – 10
Special Topics (<i>Student's own topic accepted too</i>)	1-5

I&E – Total 6 ECTS	ECTS
I&E course	6

Master thesis related – Total 30 ECTS	ECTS
Master Thesis and internship in company or R&D centre	30
Maturity test in English (<i>part of thesis</i>)	0

3.2.6 UNIBO: Intelligent Embedded Systems

The specialization at Unibo for the exit year is more focused on software development and smart applications of embedded systems to relevant fields such as robotics and vehicular systems. The students are free to select 4 courses out of a set 9 alternatives, to which is added the last course of the I&E minor.

Distributed Control for Embedded Systems (4 courses to select) – Total 24 ECTS	ETCS
Big Data	6
Human Computer Interaction	6
Machine Learning and data mining	6
Software Architectures and Platforms	6
Software process Engineering	6
Intelligent Robotic Systems	6
Operational Analytics	6
Smart Vehicular Systems	6
Advanced Software Modelling and Design	6

I&E – Total 6 ECTS	ECTS
Entrepreneurship	6

Master thesis – Total 30 ECTS	ETCS
Master thesis and internship in company or R&D centre	30

3.2.7 UNITN: High performance embedded and smart systems

The exit year concentrates on the design of high-performance, low-power architectures, with particular attention to embedded and smart systems. The specialization covers aspects related to architectural and micro-architectural design, focusing on high-performance computing, IoT and robotics. The conventional courses on advanced computing architectures and embedded systems, which may have already been acquired during the first year, are complemented by courses dealing with high performance computing, giving the basis of parallel programming

paradigms and techniques, and the implementation of systems on chip. A set of courses is dedicated to networking and low-power systems, both from the perspective of the architecture, and from the perspective of communication in the context of IoT devices, which are pervasive and must be able to operate autonomously without maintenance. In addition, the program offers courses on sensing and signal processing, including machine learning techniques, which today dominate performance requirements for both traditional and embedded architectures. Embedded software development in the context of collaborative robotics is also part of the program. The student is also able to conduct individual projects under the supervision of a faculty member. Innovation and entrepreneurship complete the student preparation to be effective in the industry.

Mandatory courses – Total 6 ECTS	ECTS
Low-power wireless networking for the Internet of Things	6

Elective courses (3 courses to select) – Total 18 ECTS	ECTS
Machine Learning	6
Digital Signal Processing	6
Software Development for Collaborative Robotics	6
High Performance Computing	6
Advanced Computing Architectures	6
Embedded Systems	6
Robot Planning and its application	6
Laboratory of Systems on Chip	6
Project course (<i>topics vary</i>)	6

I&E – Total 6 ECTS	ECTS
Innovation and Entrepreneurship Studies in ICT	6

Master thesis – Total 30 ECTS	ECTS
Internship	6
Master Thesis	24

3.2.8 UTU: Edge for AI and Robotics

In our exit year specialization, "Edge for AI and Robotics" at UTU, students will gain expertise in integrating System on Chips (SoCs), FPGAs, and GPUs for next-generation robotics. The programme delves into the main hardware and software components that drive autonomous drones (UAVs), unmanned ground vehicles (UGVs), and other intelligent mobile systems. Students will learn how to optimize the limited computational capabilities of these systems by leveraging advanced hardware acceleration platforms and efficient deep neural networks. With our comprehensive

robotic lab, students will have the chance to work on diverse robotic platforms, from aerial to quadrupedal and other ground robots, developing intelligent, context-aware systems. Graduates will be set to lead the future of AI-driven robotics and edge computing platforms.

The compulsory courses for this specialization are:

- **Algorithmic Foundations of Robotic and AI Systems (5 ECTS).** Introduces core robotics algorithms and the Robot Operating System (ROS), covering motion planning, control, mapping, and learning.
- **Perception and Navigation in Mobile Robotics (5 ECTS).** Covers sensor technologies and data processing for visual, lidar, radar, and inertial navigation systems in mobile robots.
- **Autonomous Systems Architecture (5 ECTS).** Focuses on single and multi-agent system design using agent-oriented programming and simulations.
- **Aerial Robotics and Multi-robot Systems (5 ECTS).** Prepares students to develop multi-robot systems, including autonomous drones, with capabilities for real-time communication, perception, and navigation.
- **I&E: Innovation and Entrepreneurship Study (6 ECTS).** Applies prior innovation and business knowledge to real-world challenges through supervised business analysis projects in industry contexts.

The recommended elective courses for this specialization are: **Analytics for Industrial Internet:** Focuses on signal processing, analytics algorithms, and system design for industrial data using MATLAB. **GPU Programming:** Covers practical GPU programming through case studies and comparison with traditional processors.

Mandatory courses – Total 20 ECTS	ECTS
Algorithmic Foundations of Robotic and AI Systems	5
Perception and Navigation in Mobile Robotics	5
Autonomous Systems Architecture	5
Aerial Robotics and Multi-robot Systems	5

Elective courses (1 course to select) – Total 5 ECTS	ECTS
Analytics for Industrial Internet	5
Multidimensional Sensing Techniques	5

I&E – Total 6 ECTS	ECTS
Innovation and Entrepreneurship Study	6

Master thesis – Total 30 ECTS	ECTS
Master thesis and internship in company or R&D centre	30

Conclusions

The market analysis reveals a clear gap between needs and education of embedded systems in Europe. There is need for tens of thousands of experts on embedded systems area. Country-specific needs vary depending on the type of industry in each country. The needs range from low-level circuit design to the integration of embedded systems into AI and software processes.

The general structure and admission criteria for the programme was given in Sections 3 and 4. At the moment of writing this document, there is no need to change these.

The wide range of regional needs leads to different profiles of second-year studies at the participating universities. The profiles presented here are not definitive, as market analysis was not yet available at the time of writing, but they give an indication of the diversity of profiles. This sets hard requirement to the entry-year studies to enable further studies at any exit university.

Based on the market analysis, enhancements for each exit-level specialisation will be made, and the learning outcomes of the entry year will be clarified to ensure successful studies regardless of the exit-university chosen by the students.

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Glossary

Community	A group of users, organised with a common purpose, and jointly granted access to resources. It may act as the interface between individual users and the resources. (see also [WISE-SCI])
EIT	European Institute of Innovation and Technology
KIC	Knowledge and Innovation Community
GDPR	General Data Protection Regulation
R&D	Research and development
I&E	Innovation and Entrepreneurship