EXAM 4.0

THE EXCELLENT ADVANCED MANUFACTURING 4.0

List of Promising Practices templates

Learning dialogues

04

THE EXCELLENT ADVANCED MANUFACTURING 4.0

Co-funded by the Erasmus+ Programme of the European Union

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EXAM 4.0 partners:

TKNIKA – Basque VET Applied Research Centre, CIFP Miguel Altuna, DHBW Heilbronn – Duale Hochschule Baden-Württemberg, Curt Nicolin High School, Da Vinci College, AFM – Spanish Association of Machine Tool Industries, 10XL, and EARLALL – European Association of Regional & Local Authorities for Lifelong Learning.

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Acronyms and Abbreviations

AR	Augmented Reality
AM	Advanced Manufacturing
AFM	Spanish Association of Machine Tool Manufacturers
CPS	Cyber-physical-system
DHBW	Duale Hochschule Baden Württemberg
EACEA	Education, Audiovisual and Culture Executive Agency
EXAM 4.0	Excellent Advanced Manufacturing 4.0
I4.0	Industrie 4.0
IoT	Internet of Things
IIoT	Industrial Internet of Things
HVET	Higher Vocational Education and Training
M2M	Machine-to-machine
OMR	Optical Mark Recognition
RFID	Radio Frequency Identification
VET	Vocational Education and Training
VR	Virtual Reality
WP	Work Package

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1 Abstract

"The general definition of Industry 4.0 is the rise of digital industrial technology … Industry 4.0 transformations allow us to work alongside machines in new, highly productive ways." (SAP Daniel Burrus).

A broad portfolio of Industry 4.0 solutions and promising practices in the market such as digital supply chain, reinventing production, focusing on customers, and connecting their entire organization are indicators that the Fourth Industrial Revolution, aka Industry 4.0, which takes the automation and computerization we saw in the Third Industrial Revolution into the future, is evolving strongly all over Europe and in different industry sectors.

Here are some benefits companies are experiencing:

Radical improvements in productivity and automation: Businesses are making data-driven decisions across their operations, improving forecast accuracy, supporting on-time delivery, and building profit-optimized plans.

Resiliency and agility no matter what the market or economy brings: Companies are shaping the future digital supply chain based on state-of-the-art planning.

Confidence to explore new business models and seize opportunities quickly: Thanks to Industry 4.0 solutions, businesses are reducing costs, improving market efficiency, and connecting supply chains by sea, land, and air.

Green and sustainable solutions without sacrificing profitability: Customers are becoming more efficient and cost-effective by going digital – while meeting their environmental objectives without compromising on other business goals, such as profitability and scalability.

The reason why these changes are called industrial "revolutions" is that the innovations they drive them do not just improve productivity and efficiency a little bit – it completely revolutionizes how goods are produced and how work is done.

The range of tasks of human work will shift more towards complex, non-automatable tasks with higher qualification requirements (Bonin et al., 2015). New content and methods need to be incorporated into apprenticeships and advanced training, while topics like cyber-physical systems, robotics, and social media play a key role in connected production. In the area of operations, at the specialist level, well-trained employees are needed who can actively shape work processes, optimize them continuously and consciously reflect developments in the company. They must have extensive knowledge of, for example, project management, lean management, or total quality management and be able to apply their relevant methods.

This is also having a strong impact on how we educate and teach in our institutions. There is no question that the fourth industrial revolution will change the workforce. But it’s not repetitive labour that leads to innovation – it’s ideas and creative thinking. A digitally augmented workforce is freed up to use their heads instead of just their muscles. In 1980, there were only a few thousand computer programmers in the whole world. Today there are over 20 million. While many physical tasks will be taken over by robots, many more tasks will be created to run a digitally enhanced business. Therefore it will be crucial for employees working in an advanced manufacturing environment to be able to use and handle technologies because they will be used in all areas of work. The project partners have detected promising practices in Europe regarding the approach and implementation by companies and VET/HVET institutions of new technologies.

2 Introduction

A task-specific, but generally very well-founded, technical training is required as the basis of I4.0 qualifications. On the one hand, this technical basic knowledge has to be deepened in a specialist manner and, on the other hand, should be very broad to be able to deal with complex tasks and to be able to quickly analyze problems or new requirements. The technical breadth is also necessary because part of the potential for personal savings in connection with Industry 4.0 lies in being able to use one person at the same time for several machines or process steps.

The skills evolution of qualified personnel and junior employees for current and future changes in the workplace will require employees who are 4.0 specialists and possess interdisciplinary skills, uniting classic mechatronics qualifications with sound IT knowledge and high levels of social competence. The transformation of the work environment will change the job profiles and therefore requires employees to be outfitted with a wide range of competencies.

The following chapters will present I4.0 use cases from Germany, Spain, Netherlands, and Sweden, the challenges to be solved, and what specific benefits were achieved. They also describe measures that have been taken to achieve the solution, what competencies are needed by an employee, and point out possible job profiles to work in such an industry environment. The templates and following graphs are illustrations of the **functional competencies** of different qualifications from HVET and VET institutions, as well as **skills, knowledge, and competences**, which are hierarchically structured and interrelated.

3 Job profiles for a cyber-physical working environment

A crucial component for the successful implementation of Industry 4.0 in companies, the sustainable design of the future world of work, and the empowerment of people for the digital age is the education and qualification of the employees. (acatech – Deutsche Akademie der Technikwissenschaften, 2016)

The world-of-work in I4.0 is asking for graduates that are interdisciplinary and practice-oriented educated. Some institutions already meet these expectations, using learning factories for realistic, action-oriented classes and training. Lecturers are confronted with the challenge to identify future job profiles and correlated qualification requirements, especially regarding the conceptualization and implementation of CPPS (cyber-physical production systems), and to adapt and enhance their education concepts and methods adequately and consequently. For the new, virtual world of Advanced Manufacturing, a proper understanding of engineering as well as computer sciences is essential. Industry 4.0 implies this interdisciplinary split. Integrated competencies for product and process planning and design, methodological competencies for a systematical idea and innovation management as well as a holistic system and interface competence will be crucial to achieving interconnection of physical and digital processes and machines.

Concerning the development and the different forms of work organization, the following two scenarios describe the role of human labor:

On the one hand side the polarized organizational view (also known as “growing gap” or "Automation scenario"), in which the increase of automated processes lead to a wider gap between highly qualified experts and technical specialists and high decision-making authority on one side and lower-skilled executing workers on the other side (Hirsch-Kreinsen, Ittermann, & Niehaus, 2018).

On the other hand, the work organization pattern of the swarm organization (also “General Upgrade” or “tool scenario”), in which a work team loosely builds a network of qualified and equal workers. Individual employees do not have a fixed job profile and definition and carry out more tasks in teamwork, self-controlled in the highly automated production system. In this scenario, high demands are on the cooperation and communication skills of employees and their ability to learn (Hirsch-Kreinsen, Niehaus et al., 2018).

Although it is uncertain which work organization and forms will prevail (Hartmann & Wischmann Steffen, 2018), there is a tendency towards an appreciation of the qualifications at level 5 in the EQF framework, often named as Higher Vocational Education (HVET). An even more important basis for a successful Industry 4.0 transformation is formed by well-trained specialists at this level. Educational offers must be adapted to changed requirements.

The cross-skills that Pfeiffer et al. elaborated in their analysis also include interdisciplinary cooperation (Sabine Pfeiffer, Horan Lee, Christopher Zirnig, Anne Suphan, 2016). This competence is not to be misunderstood with the meaning of “social competencies” such as the ability to work in a team. As the competence requirements for big data and cyber-physical systems are recognizable, closer cooperation and an intensive dialogue about various disciplines and hierarchical levels are of great importance.

The "how?" encompasses the question of the design of job profiles as well as the demonstration of concrete didactic consequences, e.g. the development of models for competence development and diagnosis, strategies for curriculum development and design, concepts in training and further education as well as teaching and examination concepts.

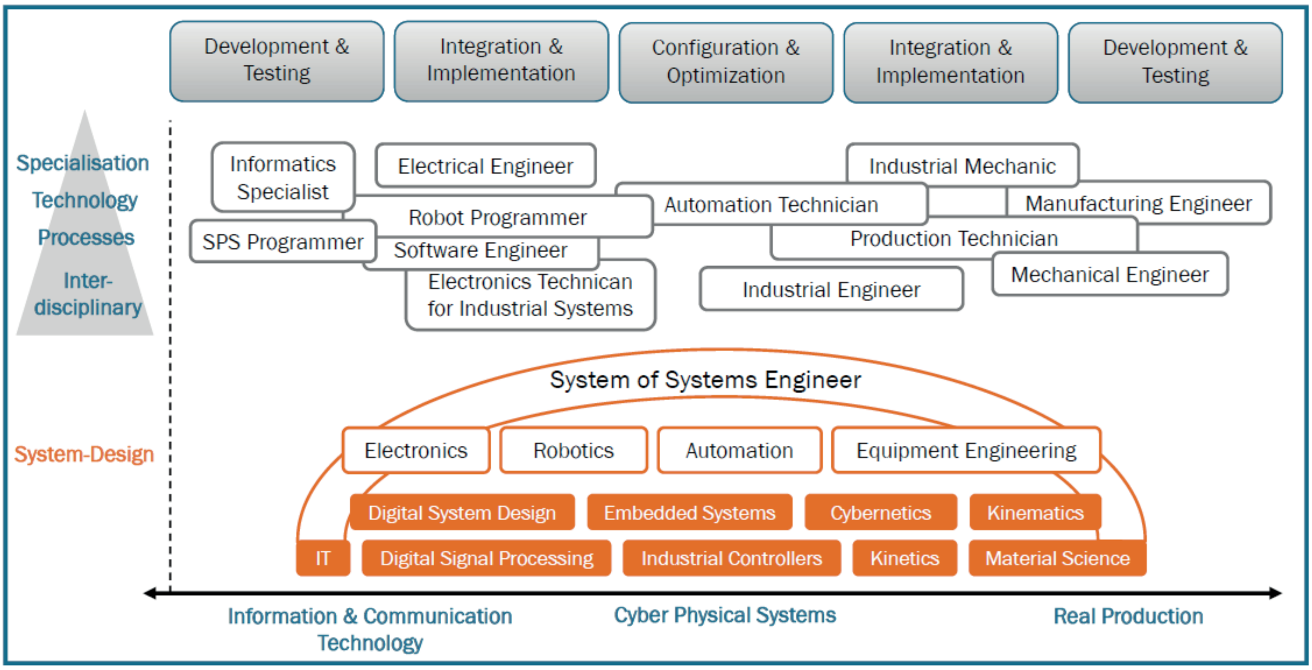


Figure 1 Cross-Skills - ESB Business School Reutlingen / Fraunhofer Austria Research / TU Vienna

The acatech study has shown that the need for the crucial skills of employees is complementary to the competence requirements for companies. The topics of **interdisciplinary thinking** and acting and increasing **process know-how** – which is the cross-departmental understanding of the interrelationships in Advanced Manufacturing, and the **understanding of the value chain** are central qualification needs in the foreground, as well as leadership skills are central element for the design of the change management processes (acatech – Deutsche Akademie der Technikwissenschaften, 2016).

CPS-based production systems will influence the human-machine interface, task organisation, and activity structures, as well as, ultimately, enterprise organisation overall (Hirsch-Kreinsen, Ittermann, & Falkenberg, 2018). When setting priorities the increasing process know-how is the key focus for the future competence development of I4.0-called workforces; in addition, the problem-solving and optimization competence has a high priority role in the future (acatech – Deutsche Akademie der Technikwissenschaften, 2016).

4 The Methodology of I4.0 Cube

The I4.0 cube presents an institutional overview of occupations and modules common in an advanced manufacturing environment. The example below shows the module of the degree course Business Administration and Engineering.

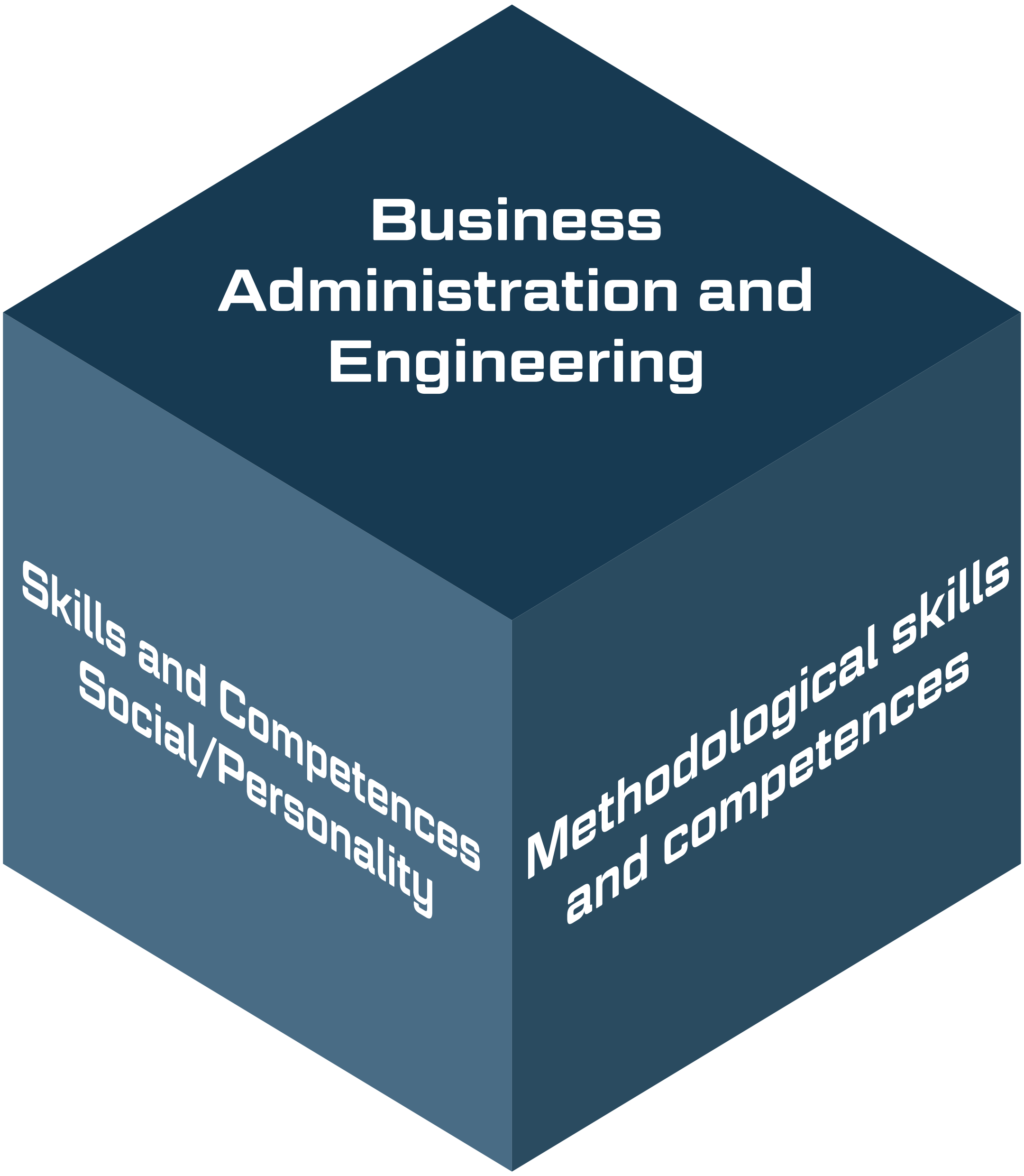


Figure 2: I4.0 Cube Business Administration and Engineering

The required skills and competences listed in the respective use case were marked in the competency framework EXAM4.0 Competence Model before being compared to current curricula of common job profiles in the AM. For example, skills required for working in a digital factory described in the first German use case, imply key competences such as project management, leadership, communication and presentation skills, process management, controlling, cybersecurity or programming. Business administration and engineering present a possible job profile for employees working in this digital factory. The linked job profile implies the majority of the required skills and competences listed in the use case as well as further skills important to the respective occupation. The top surface of the cube presents the overview of the degree course Business Administration and Engineering. In a later version, the cube should be an interactive instrument on the EXAM4.0 Hub, so that, e.g., the module description is deposited on the top face of the cube.

Business Administration and Engineering

Focus production and logistics Production Management, Logistics and Supply chain Management, Production systems, Process Management

Optional Module: sensors & actuators, industrial science, automation systms, automation technology

Basic module Year 1

Mathematics, technical mechanics, IT knowledge, computer science, material science, business administration, economics, engineering design, knowledge of supply chain management

Basic module Year 2

Electrical engineering, electronics, engineering design, marketing, law, finance and accounting, basic engineering, market-oriented product development, intelligent networked systems

Basic module Year 3

Quality Management, Strategic Management, Controlling

Figure 3: Module description Business Administration and Engineering

The two faces below display corresponding skills of the respective course referring to social and personality skills as well as methodological skills concerning responsibility and autonomy. In the interactive version, there will be a correlation between the respective modules, so users are provided with information about pending skills listed by year displayed in tables and the EXAM4.0 Competence Model. The competence model was developed in the course of EXAM4.0 and can be found in WP2.3.

Foundation	Social/Personality skills and competences
EQF level 6 - descriptors	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Basic module year 1	· Independent knowledge acquisition · Transfer skills · Responsibility
Basic module year 2	· Individual responsibility · Leadership · Cooperation · Integration of team members · Independent knowledge acquisition · Acting in a determined, sustainable and responsible manner evaluate social and socio-political impacts
Basic module year 3	· Self-management · Time management · Leadership · Ability to be critical · Ability to deal with conflicts · Enduringly and persistently solving tasks independently · Empathy

Fundation	Methodological skills and competences
EQF level 6 - descriptors	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study
Basic module year 1	· Systematic & structured working approach · Technical problem solving · Interdisciplinary understanding of processes · Analytical working approach · Integration · Teamwork · Data management
Basic module year 2	· Communication · Integration · Project Management · Management of financial resources · Transfer skills · Complex problem solving · Critical & collaborative thinking
Basic module year 3	· Interdisciplinary approach · Communication · Cooperation · Abstraction ability

5 Use Cases

Industry 4.0 evokes constant change and has contributed to new technologies and applications. In an advanced manufacturing environment, employees are and will be required to use and handle the different technologies. Therefore, it is important to make transparent the benefits of new technologies and the approach of practical use. Each project partner has prepared one to three use cases describing the benefits of I4.0 technologies and applications of those promising practices in local companies and educational institutions. The application examples in the use cases describe the practical implementation and a problem solution. The structure of the use cases is based on key questions implying information about challenges that had to be faced, benefits of the technologies, the approach towards Industry 4.0, learning outcomes, and competences required of employees working with the respective use case. Furthermore, according to the required competencies of employees each use case is linked to a possible job profile common in the AM. The qualification examples and templates (I4.0 cube) are illustrating the basis of knowledge graduates must bring, such as domain-related competencies on the one hand, but also the ability to apply expertise and use technology on the other hand. In the following, the summary gives an overview of the different use cases. The complete use cases can be found in the appendix.

Germany

The German use cases present two different digital factories, one as part of the company TE Connectivity, the second one implies a living lab and is part of the HVET institution DHBW Mosbach. While the digital factory of TE Connectivity refers to the application of predictive maintenance and process excellence, the digital factory and living lab of the DHBW is solely used for education and training. Based on a competence-oriented concept, the factory at the HVET institution implies an interdisciplinary center for students concerning production and information management. Due to the further implementation of technologies an interdisciplinary approach will be required of future employees to solve complex problems. The digital factory serves as a testbed for different technologies and methodologies. Moreover, the living lab, as part of the factory, can be adapted and extended continuously depending on needs and developments in the AM sector.

Spain

The three Spanish use cases imply descriptions of a hybrid cloud platform, technical remote assistance, and a cybersecurity system. The technical remote assistance ATR was developed by Innovae and refers to the application example of technical assistance. The benefits of this technology are to reduce maintenance costs while increasing the efficiency of maintenance and repair tasks as well as to improve the communication between the service center and technical teams. ATR visualizes real-time data of the respective machine and provides employees with immediate knowledge and information through augmented reality. As a result, employees can concentrate on main tasks. Indutry4.0 evokes an increasing interconnection of machines and devices. In consequence, the growing number of interconnected technologies and applications cause new risks as threats concerning cyber-attacks. Therefore, cybersecurity is a key concern in I4.0. The third use case describing keynetic cybersecurity technology presents a highly flexible and extensible network security solution for companies.

Netherlands

The use case TIMA of a Dutch company describes the use of robotics in the field of welding and cutting. This use case refers to the application example of maritime manufacturing. In the field of shipbuilding, there is a high request for customization through one-off products, mostly executed by specialists. To ensure competences of welding and cutting in one-off production in the future, the participants of TIMA collected the required expertise of professionals in databases and developed smart software. This software can directly control robots from a digital configurator that retrieves the correct information of the component to be produced.

Sweden

As in the use case of the Netherlands, one of the Swedish use cases presents the use of robots but for automated production. RUNEX is used to train students in advanced robotic programming workshops. The robots are typically used in the food industry and contribute to reducing monotonous tasks and work assignments while increasing effective and safe production operations. The second use case, a cooperation between the project partner and Siemens Energy AB, presents the production of metal molds for glassmaking using additive manufacturing. Before the project, the respective company had not yet been introduced to I4.0 technologies. The use case referring to the application of additive manufacturing also displays the benefit of a faster production process of unique art glass.

6 Conclusion

The illustrated templates are few examples and industry cases only. They are showing the future structure of the I4.0 platform and conceptual design and linkages between the industry demand, and VET and HVET education and qualifications as well as work-based training in labs. They have to be further developed to an interactive platform and tool, describing in the levels below, each characteristic and skills, which of them play an important aspect in teamwork, project management, and management ability, customer orientation, maintaining customer relationships, and creating business networks to name a few, all of them being part of the I4.0 curriculum design. The illustration helps to identify in which area graduates need to bring IT and what skills and competencies are required while working with engineers from different groups, where graduates should understand the integration of heterogeneous I4.0 technologies, gain knowledge about e.g., mobile technologies and embedded systems, and sensors. The illustration also shows which competencies are relevant in various qualifications, such as **Communication**, as one of the key competencies required from graduates. By putting the communication competency in relation with other competencies like literacy and technical communication, intercultural competency, or presentation ability, social skills like collaboration, compromising, and negotiating combined with emotional intelligence the illustration will show, which one will play a key role in I4.0.

The I4.0 model is a key element of the I4.0 platform for the three stakeholder groups, employers, institutions but also students and learners. Employers will navigate alongside their technology field and find examples of qualifications, the responding skills set, and identify which qualification setting matches their needs. Institutions will navigate and identify variations in the curriculum design, find work-based learning methods and labs. Students will look up industry examples, learn from assigned job qualifications and the Curriculum design as well as what kind of skills are trained to find out if it meets their expectations.

QUALIFICATIONS AND LEARNING OUTCOMES

In Europe, there are many different educational and training systems. Because of this diversity, it is often difficult to understand and compare the qualifications from other countries. The titles of the various qualifications, despite being the same, can conceal different contents. One way to make the various qualifications transparent, understandable and comparable is to **describe them in terms of learning outcomes.**

Qualification is understood following the recommendation of the European Qualifications Framework (EQF) to mean the formal outcome of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards.

Learning outcomes are defined as statements of what a learner knows, understands, and can to do upon completion of a learning process. In the EQF, learning outcomes are therefore defined in terms of knowledge, skills, and competence which are understood as follows:

"**Knowledge** means the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories, and practices related to a field of work or study. In the context of the European Qualifications Framework, knowledge is described as theoretical and/or factual."

"**Skills** means the ability to apply knowledge and use know-how to complete tasks and solve problems. In the context of the European Qualifications Framework, skills are described as cognitive or practical skills."

"**Competence** means the proven ability to use knowledge, skills, and personal, social and methodological abilities in work or study situations and in professional and/or personal development. In the context of the European Qualifications Framework, competence is described in terms of responsibility and autonomy.

Learning outcomes have several important **characteristics** that must be considered in the formulation:

- Learning outcomes principally refer to qualifications and not to individual learners. Although in practice there will always be people who perform above or below average when describing the learning outcomes of an educational programme an **average graduate** must always be assumed.

- Learning outcomes refer to the **day of testing**, i.e. to what the learner knows, can, and capable of doing on this day.

- The **current curriculum** of the educational programme and other **relevant documents** that contain references to the qualifications (e.g. laws and regulations) will form the basis for the learning outcome description.

- Learning outcomes will always be described from the perspective of the **learner** (outcome) and not from the perspective of the **teacher**.

- The optimal number of learning outcomes is dependent on the **complexity of the educational programme**. It is advisable to formulate neither too many nor too few learning outcomes. Too many could cause a lack of transparency, while on the other hand too few would not be conducive to transparency.

- Learning outcomes should be **externally verifiable**. The formulations are to be chosen such that they can be determined during an evaluation process if the learner has achieved the learning outcomes.

- How the learning outcomes are acquired is not relevant for the learning outcome description. This means that it does not matter if the contents have been acquired through an e-learning programme, classroom instruction, at the workplace, at school or through self-study.

THE EUROPEAN QUALIFICATION FRAMEWORK (EQF) AND INDUSTRY 4.0

The European Qualification Framework could be described as a ‘meta-framework’ designed to promote both a common terminology and common reference points for the comparison of the qualifications of the member countries of the EU (see Coles, 2007; Bjornavold & Coles, 2008; Markowitsch & Luomi-Messerer, 2008).

The EQF focuses on learning outcomes: what a person, holding a particular qualification, actually knows and can do. This approach is intended:

This approach is intended:

- to support a better match between the needs of the labour market (for knowledge, skills, and competences) and education and training provision
- to facilitate the validation of non-formal and informal learning
- to facilitate the transfer and use of qualifications across different countries and education and training systems

The eight levels of reference are described in terms of learning outcomes. The EQF recognizes that European education and training systems are so diverse that **only learning outcomes allow comparisons and enable cooperation between countries and institutions.**

	Knowledge	Skills	Responsibility and autonomy
LEVEL 5 The learning outcomes relevant to Level 5 are:	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge	A comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems	Exercise management and supervision in contexts of work or study activities where there is unpredictable change; review and develop performance of self and others
LEVEL 6 The learning outcomes relevant to Level 6 are:	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
LEVEL 7 The learning outcomes relevant to Level 7 are:	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research Critical awareness of knowledge issues in a field and at the interface between different fields	Specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields	Manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams
LEVEL 8 The learning outcomes relevant to Level 8 are:	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields	The most advanced and specialised skills and techniques, including synthesis and evaluation, required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or professional practice	Demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contexts including research

USE CASES GERMANY

Digital Factory TE Connectivity

The digital factory of TE Connectivity is a fully automated strip electroplating system. It pursues the objective to enable factories to make better decisions and optimise data processes.

https://www.te.com/deu-de/home.html

Figure 4: Plug connections

https://www.elektroniknet.de/elektronik-automotive/wirtschaft/einblick-in-die-fertigung-automobiler-steckverbinder-102029.html

OVERVIEW

Application examples:	Predictive Maintenance, Process Excellence
Product examples:	Automation Components, Connectors
Value creation:	Other
Development stage:	Production, Semi-finished products
Company size:	Large enterprise
Region:	Bavaria

What were the challenges to be solved and what specific benefits were achieved?

The strip electroplating system is a classic automated system with PLC technology. For preventive maintenance, data must be recorded on the one hand. A model of the process is required for the evaluation and a calculation linked to it to find the most economical point. Creating transparency about the process is a challenge. The data of a distributed PLC control must be summarized and displayed on a dashboard. Based on this, predictions for optimal maintenance can be generated and these can be made available to the staff in a suitable manner.

How can the Industry 4.0 approach be described?

With the technology from the Industrial Internet of Things IIOT, the data could be summarized.

What could be achieved?

- Specific application expertise with the possibility of demonstration and integration into teaching is available at the DHBW in the following areas:
- Manufacturing Execution Systems (MES) and integration technologies
- Decentralised automation technology
- Internet of Things - Technologies and Applications
- Innovative human-machine-system interfaces, mobile solutions for visualization and control
- Cost reduction and improve planning security

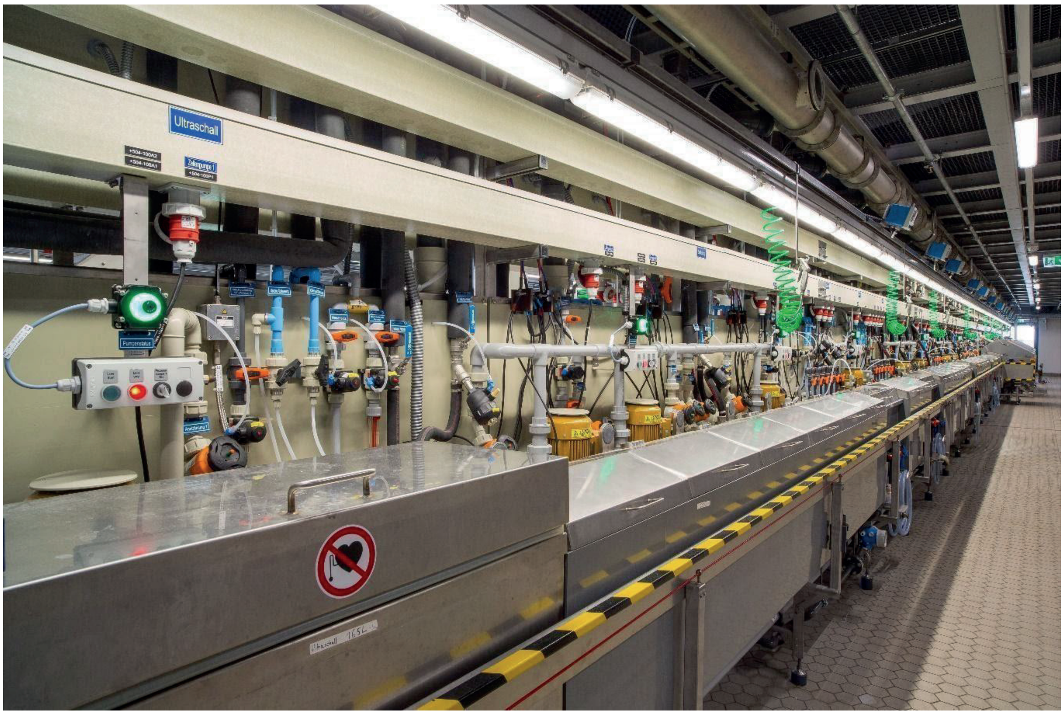


Figure 5: New assembly line for surface refinement at TE Connectivity (https://www.all-electronics.de/te-connectivity-eroeffnet-neue-galvanikanlage-in-dinkelsbuehl-fuer-automobilkunden-in-emea/)

What measures have been taken to achieve the solution?

The data is provided via an OPC UA server. Processing takes place in Node-RED. Finally, the process is shown transparently on a dashboard. Relevant parameters are stored in an SQL database.

What can others learn from it?

The special strip electroplating system within Tyco Electronics is a typical Process equipment in a production plant. The Methods of inter-process communication using an OPC-Server or the MQQT Protocol is an example for best practice in predictive maintenance.

What competencies are needed by the Employee to achieve the solution?

Project Management

- Resource management
- Leadership, Governance
- Budget Control
- Communication, Presentation

Process-Management

- Process Workflow: Gant Diagrams, Milestones, Quality Gates
- Databases: MySql
- Controlling

Industrial Communication

- Fieldbuses: Profinet, Modbus, IO-Link
- Networking: TCP-IP V4 and V6
- OPC/UA, MQTT, Rest protocol
- Internet Security

Industrial Safety

- Functional Safety
- General Data Protection Regulation GDPR DSGVO

Control Technology

- Node-Red
- PLC
- Dashboards

Possible job profile

	TECHNICAL	QUALITY, RISK & SAFETY	MANAGEMENT	COMMUNICATION	INNOVATION	EMOTIONAL INTELLIGENCE
GENERAL COMPETENCIES	**Knowledge in STEM** **ICT skills** Programming Coding **Computer skills** Design methodology Systems analysis **Data management skills** **Ability to interact with human - machine interfaces** **Interdisciplinary understanding (processes/ technologies / organisations)** Manufacturing skills **Modelling & simulation**	Quality management Health & security Industrial hygiene Equipment safety Emergency response & management **Data security** Ethics	Strategic analysis Analytical thinking Technology strategy Marketing Customer orientation **Project Management** Time Management Teamwork & ability to work in interdiscipli-nary environments Change management Risk management **Leadership**	**Interpersonal skills** Verbal communication Written communication **Presentation skills** Public communication Virtual collaboration Ability to deal with conflicts	Integration skills Continuous experimentation Complex problem solving Creativity **Abstraction ability** **Critical thinking** Transfer skills Collaborative thinking	Flexibility & Adaptability Responsibility Stress tolerance Ability to thrive on failures Work-life balance Self-control & discipline Decision making Mindset towards lifelong learning & continuous improvement Self management & organisation **Cooperation & collaboration skills** Intercultural competencies Structured & systematic working approach
SPECIFIC COMPETENCIES	Life cycle analysis Scalability analysis Specific lab skills Computer aided manufacturing/ engineering		Management of Personal resources **Management of financial resources** IP management Deal negotiation skills			

Figure 6: Competencies Use Case 1 Germany

I4.0 Cube Germany Use case 1

Job Profile: Business Administration and Engineering

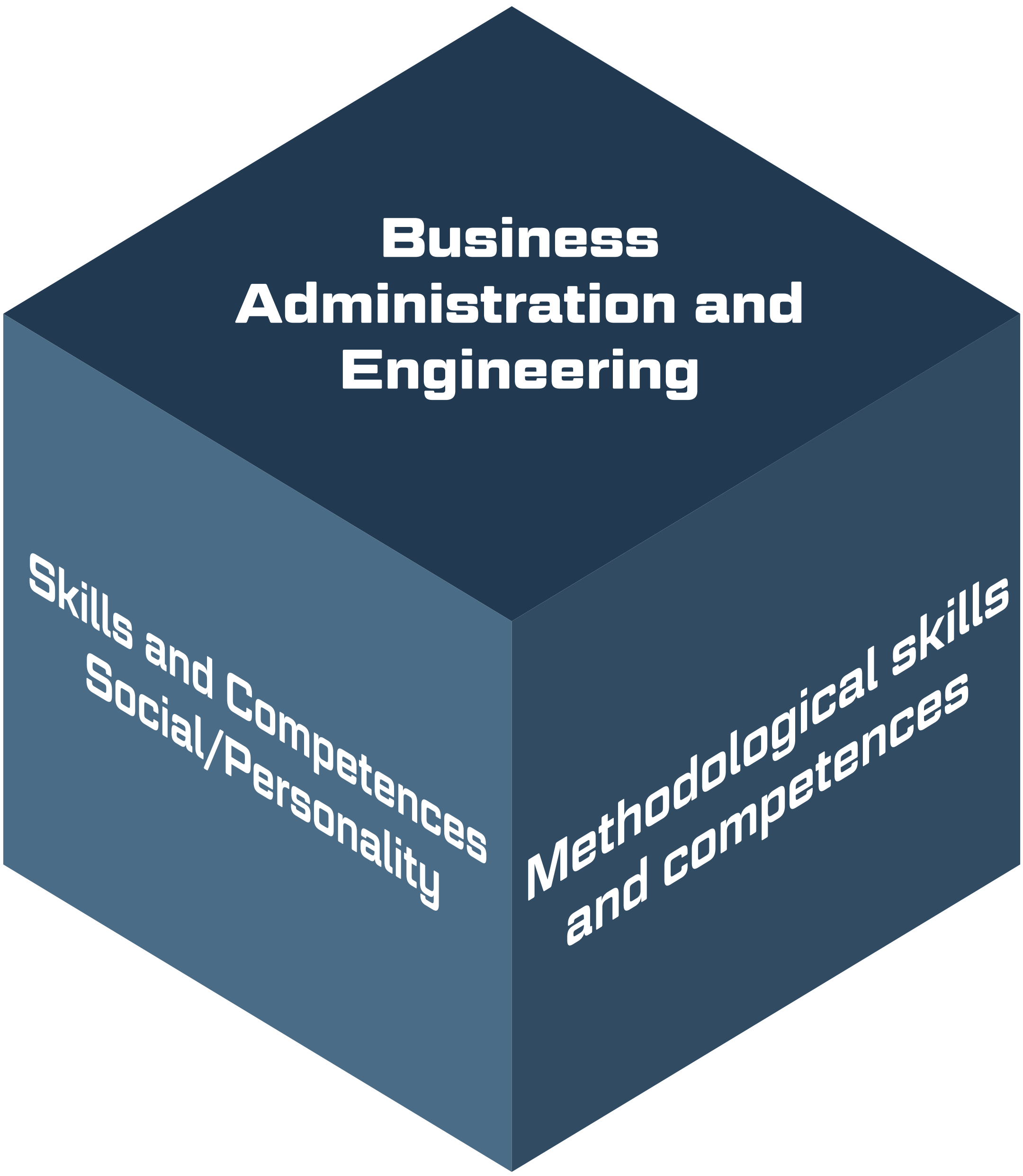
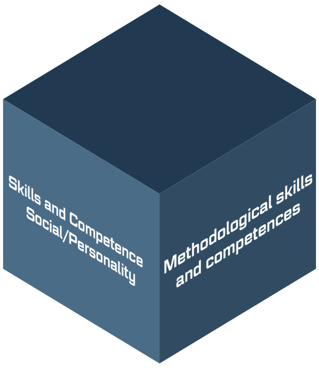


Figure 7: I4.0 Cube Use case 1 Germany



I4.0 Cube Germany Use case 1

Business Administration and Engineering

Focus production and logistics Production Management, Logistics and Supply chain Management, Production systems, Process Management

Optional Module: sensors & actuators, industrial science, automation systms, automation technology

Basic module Year 1

Mathematics, technical mechanics, IT knowledge, computer science, material science, business administration, economics, engineering design, knowledge of supply chain management

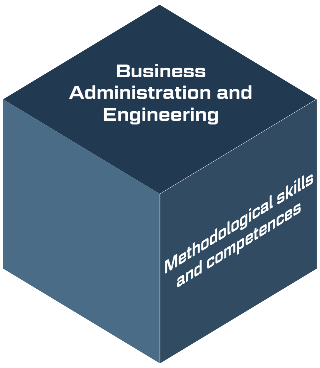
Basic module Year 2

Electrical engineering, electronics, engineering design, marketing, law, finance and accounting, basic engineering, market-oriented product development, intelligent networked systems

Basic module Year 3

Quality Management, Strategic Management, Controlling

Back to cube



I4.0 Cube Germany Use case 1

Skills and Competences Social/Personality

Business Administration and Engineering

Foundation	Social/Personality skills and competences
EQF level 6 - descriptors	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Basic module year 1	· Independent knowledge acquisition · Transfer skills · Responsibility
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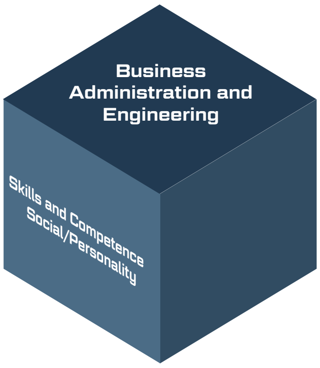
Basic module year 3	· Self-management · Time management · Leadership · Ability to be critical · Ability to deal with conflicts · Enduringly and persistently solving tasks independently · Empathy

Back to cube



I4.0 Cube Germany Use case 1

Methodological skills and competences

Business Administration and Engineering

Foundation	Methodological skills and competences
EQF level 6 - descriptors	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study
Basic module year 1	· Systematic & structured working approach · Technical problem solving · Interdisciplinary understanding of processes · Analytical working approach · Integration · Teamwork · Data management
Basic module year 2	· Communication · Integration · Project Management · Management of financial resources · Transfer skills · Complex problem solving · Critical & collaborative thinking
Basic module year 3	· Interdisciplinary approach · Communication · Cooperation · Abstraction ability

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Digital Factory of DHBW Mosbach

DHBW Mosbach

Living Lab - Industrie 4.0 Virtuelle Fabrik

Figure 8: The digital factory of DHBW Mosbach
(https://www.plattform-i40.de/PI40/Redaktion/EN/Use-Cases/374-dhbw-mosbach/article-dhbw-mosbach.html)

In the digital factory of DHBW Mosbach, students get insights and are taught about the production and logistics of the future. In cooperation with various dual partners, a model factory is being built with realistically simulated processes in production, logistics, service, and plant management. This digital factory should not only be used in teaching, research, and transfer, but also "live", i.e. constantly changed, adapted, and expanded ("Living Lab"). With this, the implementation of innovations in the field of "production of the future" is promoted in a targeted manner and transferred into operational practice.

OVERVIEW

Application examples:	Education and training
Product examples:	Automation components, Software solutions
Value creation:	Other
Development stage:	Demonstrator, Market launch/piloting
Company size:	Medium
Region:	Baden Württemberg

What were the challenges to be solved and what specific benefits were achieved?

The "Digital Transformation" will substantially change business - the implementation of the concepts of Industry 4.0 is not a “can”, but a “must'' for all manufacturing companies, especially the SMEs. To proactively address the resulting profiles of the engineers of the future, we need new competence-oriented concepts – didactically, with regards to content and organizationally. The DHBW Mosbach has established an interdisciplinary competence center “Production and Information Management” which is embedded in a future-oriented teaching context. "Interdisciplinary process knowledge is a crucial factor for the engineer of the future. In our digital factory, we model and implement the whole process from order creation through the complete assembly and quality assurance to logistics and delivery, together with the information flow. This is an ideal platform for application-oriented research and teaching in the era of Industry 4.0” (Prof. Dr. Christian Kuhn)

How can the Industry 4.0 approach be described?

The "Digital Factory" at DHBW Mosbach was developed as an Industry 4.0 model factory with practical processes in production, logistics, service, and plant management. Within a ‘Living Lab’ concept, the factory will be adapted continuously and expanded to reflect the latest developments. It is used in teaching and research, thus enabling practical training of students, but also the active participation of future engineers in the development of components, software, and processes with the latest concepts and technologies from science.

Figure 9: The Minister-President of Baden-Württemberg, Winfried Kretschmann, in conversation with Prof. Dr. Christian Kuhn & Prof. Dr. Stephan Hähre (Co-Speaker of the Competence Center Manufacturing and Information Technology) as well as the rector of the DHBW Mosbach, Prof. Dr. Jeck-Schlottmann

What could be achieved?

- Specific application expertise with the possibility of demonstration and integration into teaching is available at the DHBW in the following areas:
- Manufacturing Execution Systems (MES) and integration technologies
- Business and industrial information systems and their information networking
- Decentralised automation technology
- Internet of Things - Technologies and Applications
- Process data management, KPI management, digital quality assurance systems
- Innovative human-machine-system interfaces, mobile solutions for visualization and control
- Simulation Systems and Technologies
- Automatic identification methods, Digital Product Memory
- Education and Training for Industry 4.0

What could be achieved?

The foundation is the "Digital Factory", which serves as a "testbed" for new concepts, methods, and technologies. This model factory will be adapted within the concept of a "Living Lab" continuously and expanded to reflect the latest developments. The aim is to map the real world of information technology and systems and automation technology in the actual extension and complexity. For this purpose, a variety of real industrial systems, components, and technologies are fully integrated throughout the applications - in one room, with typical processes of production, logistics, service, and plant management. A wide range of typical business processes has already been implemented completely with real systems, from the ERP system to the physical material flow.

What can others learn from it?

The DHBW is a demonstration center and testbed for innovative concepts and technologies of the initiative Industry 4.0. The "Digital Factory" is ideally suited to embed specific new technologies, concepts, and methods into an existing typical landscape (test environment) to gather concrete experience, evaluate the results and transfer them to companies. The processes and innovations can be demonstrated to interested companies, in particular small and medium enterprises, and thus content and benefit of Industry 4.0 can be made accessible so that their implementations can be promoted.

What competencies are needed by the Employee to achieve the solution?

Project Management

Resource management

Budget Control

Communication, Presentation

Process-Management

Process Workflow: Gant Diagrams, Milestones, Quality Gates

Controlling

Industrial Communication

Fieldbuses: Profinet, ASI, IO-Link

Networking: TCP-IP V4 and V6

OPC/UA

Internet Security

Control Technology

PLC

Supply Chain Management

SAP

Additional Technologies

Simulation Technology

Augmented Reality

Artificial Intelligence, Data-Analytics

Contact

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Lohrtalweg 10, 74821 Mosbach
https://www.mosbach.dhbw.de

Possible job profile

	TECHNICAL	QUALITY, RISK & SAFETY	MANAGEMENT	COMMUNICATION	INNOVATION	EMOTIONAL INTELLIGENCE
GENERAL COMPETENCIES	**Knowledge in STEM** **ICT skills** Programming Coding **Computer skills** Design methodology Systems analysis **Data management skills** **Ability to interact with human - machine interfaces** **Interdisciplinary understanding (processes/ technologies / organisations)** **Manufacturing skills** **Modelling & simulation**	Quality management Health & security Industrial hygiene Equipment safety Emergency response & management **Data security** Ethics	Strategic analysis Analytical thinking Technology strategy Marketing Customer orientation **Project Management** Time Management Teamwork & ability to work in interdiscipli-nary environments Change management Risk management Leadership	**Interpersonal skills** Verbal communication Written communication Presentation skills Public communication Virtual collaboration Ability to deal with conflicts	**Integration skills** **Continuous experimentation** Complex problem solving Creativity **Abstraction ability** **Critical thinking** Transfer skills Collaborative thinking	Flexibility & Adaptability Responsibility Stress tolerance Ability to thrive on failures Work-life balance Self-control & discipline Decision making Mindset towards lifelong learning & continuous improvement Self management & organisation **Cooperation & collaboration skills** Intercultural competencies Structured & systematic working approach
SPECIFIC COMPETENCIES	Life cycle analysis Scalability analysis Specific lab skills Computer aided manufacturing/ engineering		Management of Personal resources **Management of financial resources** IP management Deal negotiation skills			

Figure 10: Competencies Use Case 2 Germany

I4.0 Cube Germany Use case 2

Job Profile: Business Administration and Engineering

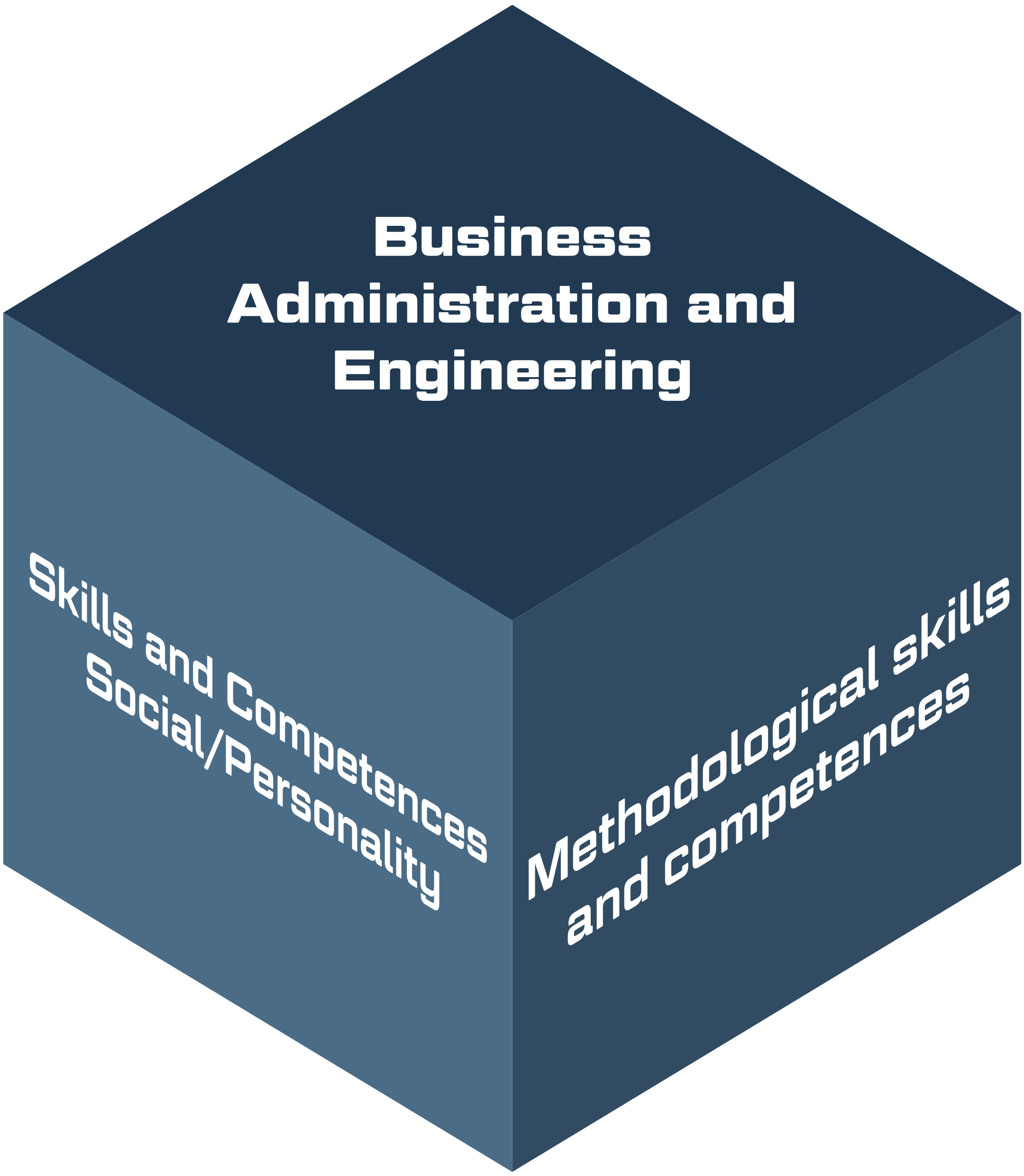
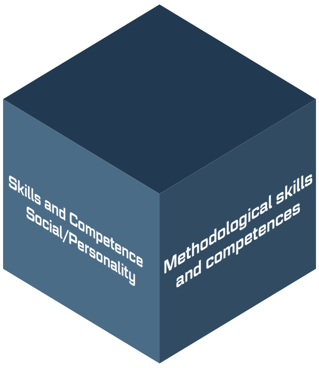


Figure 11: I4.0 Cube Use Case 2 Germany



I4.0 Cube Germany Use case 2

Business Administration and Engineering

Focus production and logistics Production Management, Logistics and Supply chain Management, Production systems, Process Management

Optional Module: sensors & actuators, industrial science, automation systms, automation technology

Basic module Year 1

Mathematics, technical mechanics, IT knowledge, computer science, material science, business administration, economics, engineering design, knowledge of supply chain management

Basic module Year 2

Electrical engineering, electronics, engineering design, marketing, law, finance and ac-counting, basic engineering, market-oriented product development, intelligent networked systems

Basic module Year 3

Quality Management, Strategic Management, Controlling

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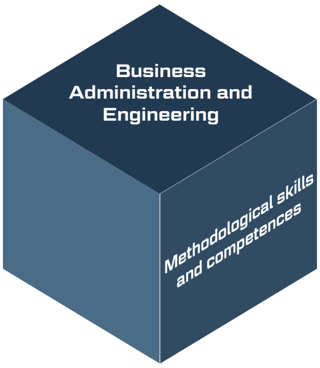

I4.0 Cube Germany Use case 2

Skills and Competences Social/Personality

Business Administration and Engineering

Foundation	Social/Personality skills and competences
EQF level 6 - descriptors	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Basic module year 1	· Independent knowledge acquisition · Transfer skills · Responsibility
Basic module year 2	· Individual responsibility · Leadership · Cooperation · Integration of team members · Independent knowledge acquisition · Acting in a determined, sustainable and responsible manner evaluate social and socio-political impacts
Basic module year 3	· Self-management · Time management · Leadership · Ability to be critical · Ability to deal with conflicts · Enduringly and persistently solving tasks independently · Empathy

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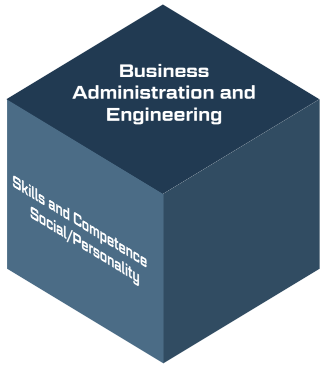

I4.0 Cube Germany Use case 2

Methodological skills and competences

Business Administration and Engineering

Foundation	Methodological skills and competences
EQF level 6 - descriptors	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study
Basic module year 1	· Systematic & structured working approach · Technical problem solving · Interdisciplinary understanding of processes · Analytical working approach · Integration · Teamwork · Data management
Basic module year 2	· Communication · Integration · Project Management · Management of financial resources · Transfer skills · Complex problem solving · Critical & collaborative thinking
Basic module year 3	· Interdisciplinary approach · Communication · Cooperation · Abstraction ability

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USE CASES – SPAIN

360° Platform

Savvy Data Systems has deployed a high-performance Hybrid Cloud platform, in which Arsys Cloud Servers reinforce the capacity of its infrastructure. The objective is to improve the efficiency of its clients' production processes and facilitate their transition to Industry 4.0.

OVERVIEW

Application examples:	Information technology and services
Value creation:	Production, Process, Maintenance, Quality, and Traceability
Development stage:	---------
Company size:	Small
Region:	Basque Country

What were the challenges to be solved?

Machine tool manufacturers compete in a highly technological sector, where the adoption of the latest electronics and components is common. They dedicate a significant effort to research and testing, as a means to generate products and thus generate unique knowledge that gives them a competitive advantage. Traditionally, they have focused on mechanical and automation improvements and are highly focused on observing the physical world. This approach, however, has been changing in recent years, and, progressively, the adoption of technologies for the analysis of large volumes of data as a means of generating non-obvious knowledge, which could hardly be discovered through physical observation, has gained strength.

These techniques also allow you to notably boost the servitization of your business, since, among other capabilities, they allow you to detect sales opportunities, predictive maintenance services, production and/or process optimization, etc.

At Savvy, their approach is based on allowing their clients to focus on the fields they dominate, and providing us with all the tools they will need to undertake their digitization and servitization plans. In other words, the delivery as a service of digital data capture, treatment, and analysis technologies allows their clients to focus on their area of knowledge, leveraging these tools. Their goal is to transform complex information processing technologies into understandable tools for use in the industrial sector.

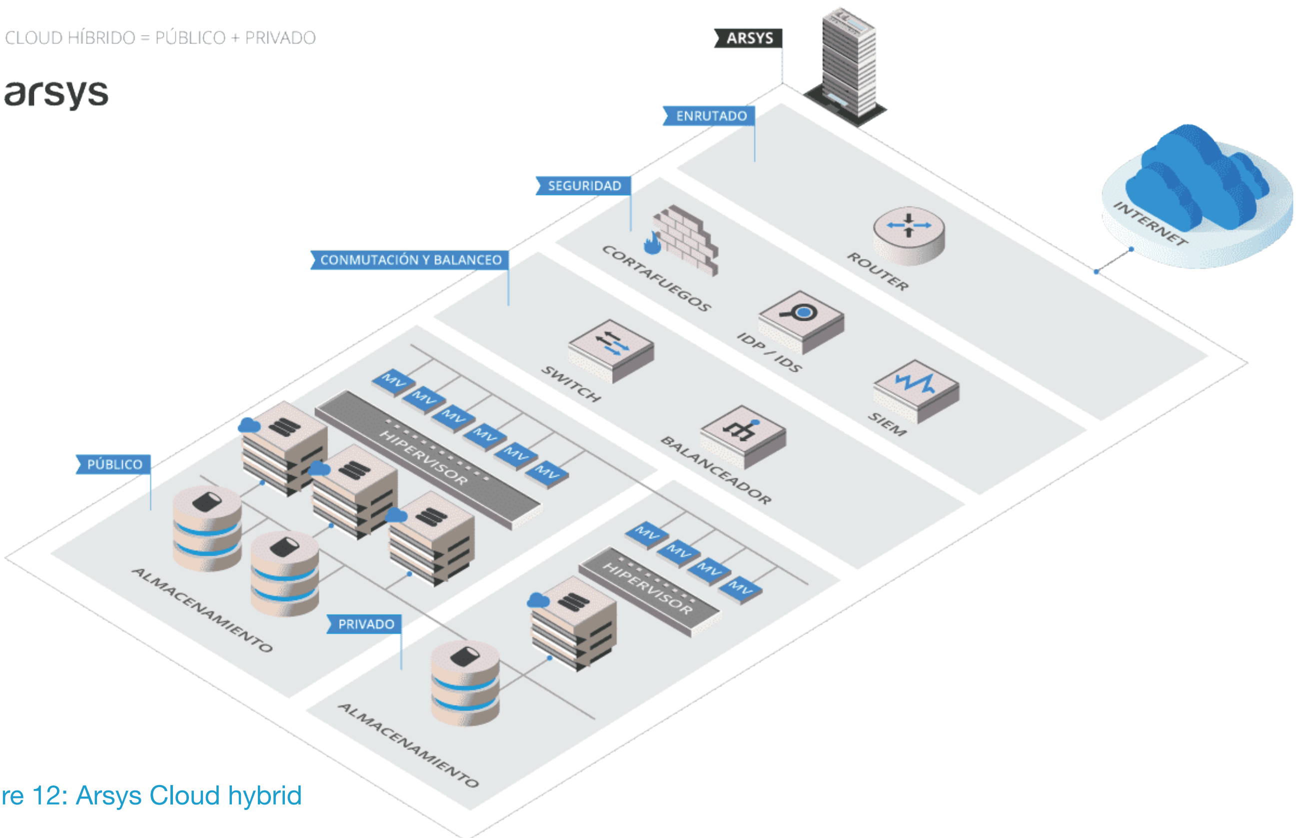

Figure 12: Arsys Cloud hybrid

How can the Industry 4.0 approach be described?

Industrial production processes are usually carried out using machines capable of operating automatically or semi-automatically. This automation of the operation is achieved through the inclusion of different electronic devices, such as sensors, actuators, control automatons, numerical controls, etc.

This complexity means that the engineers who work on its design, commissioning, and/or maintenance cannot always manage all the situations that may arise during the operation of the machine. For this reason, Savvy decided to increase the life cycle of the data, so that it does not “die” when managed by the control automaton, but can also be transmitted to a data repository (Big Data), where it becomes the raw material of a new research and analysis activity.

Used Technologies:

- SAVVY AMP (Asset Management Platform)
- SAVVY Industrial Cloud
- SAVVY Hybrid Platform
- SAVVY On-Premise
- SAVVY SMART BOX
- SAVVY ANALYTICS FRAMEWORK
- SAVVY EDGE

What could be achieved?

In 2018, Savvy's 360º Platform was awarded the 'Award for Innovation in Integration of Concepts 4.0 in Advanced Manufacturing Systems' granted at the Bilbao Machine Tool Biennial, the third most important industrial fair in Europe and the first of its sector in Spain.

Impact areas:

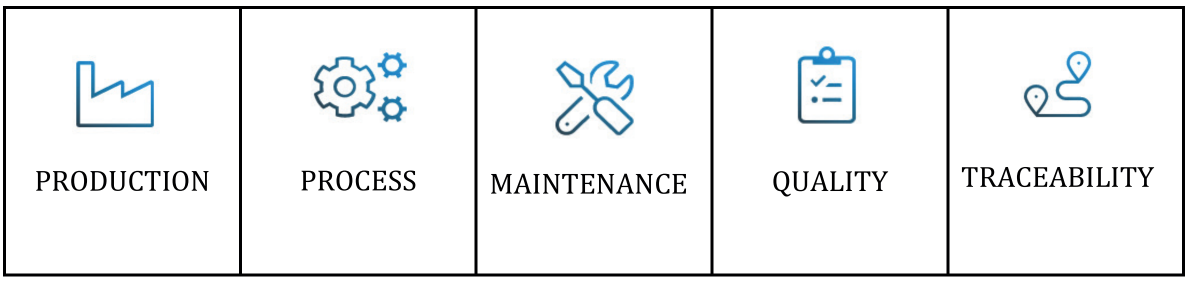

Figure 13: Impact areas

	TOOL	TECHNIQUES
WHAT HAPPENED?	**Advanced monitoring →**	Descriptive Analytics
WHY HAS IT HAPPENED?	**Early detection →**	Diagnostic Analytics
WHAT'S GOING TO HAPPEN?	**Anticipation →**	Predictive Analytics
MASTER EVENTS	**Optimization →**	Prescriptive Analytics

To do this, Savvy has deployed a high-performance Hybrid Cloud platform, in which Arsys Cloud Servers reinforce the capacity of its infrastructure to achieve an average combined capacity of 700,000 data transactions per second, which can be scaled very efficient and in real-time in blocks of 200,000 transactions per second thanks to the flexibility of the Cloud.

Since 2015, it has among its majority shareholders the DANOBAT GROUP, a European leader in the manufacture of Machine Tools for highly specialized niches with 15 production centers and employing more than 1,300 professionals. In 2018, Savvy joined the Basque technology center Digital Grinding Innovation Hub, which encourages research and development of innovative solutions in digitization and industrial grinding, which has the same Savvy platform as a strategic element.

What can others learn from it?

SME and Machine tool users that are involved in their digital transformations can validate advanced solutions for data acquisition, cloud systems, edge computing, smart maintenance, etc. All the information and successful use cases are very valuable to select the best solution that fixes their needs. SME's can contrast to what extent content and benefit of Industry 4.0 can be made accessible so that their implementations can be promoted.

What competencies are needed by the Employee to achieve the solution?

Machining processes

Resource management

Precision machining

Advanced metrology systems

Process-Management

Process Workflow Gant Diagrams, Milestones, Quality Gates

Controlling, Product Traceability

Industrial Communication

Fieldbuses Profinet, ASI, IO-Link

Networking TCP-IP V4 and V6

OPC/UA

Internet Security

Control Technologie

PLC

Additional Technologies

Simulation Technologies

Digital twins Augmented Reality

Artificial Intelligence, Data-Analytics

Possible job profiles

	TECHNICAL	QUALITY, RISK & SAFETY	MANAGEMENT	COMMUNICATION	INNOVATION	EMOTIONAL INTELLIGENCE
GENERAL COMPETENCIES	**Knowledge in STEM** ICT skills **Programming** Coding **Computer skills** **Design methodology** Systems analysis **Data management skills** **Ability to interact with human - machine interfaces** **Interdisciplinary understanding (processes/ technologies / organisations)** Manufacturing skills Modelling & simulation	Quality management Health & security Industrial hygiene Equipment safety Emergency response & management **Data security** Ethics	Strategic analysis Analytical thinking Technology strategy Marketing Customer orientation Project Management Time Management **Teamwork & ability to work in interdisciplinary environments** Change management Risk management Leadership	**Interpersonal skills** Verbal communication Written communication Presentation skills Public communication Virtual collaboration Ability to deal with conflicts	Integration skills Continuous experimentation Complex problem solving **Creativity** **Abstraction ability** **Critical thinking** Transfer skills Collaborative thinking	Flexibility & Adaptability Responsibility Stress tolerance Ability to thrive on failures Work-life balance Self-control & discipline Decision making **Mindset towards lifelong learning & continuous improvement** Self management & organisation **Cooperation & collaboration skills** **Intercultural competencies** **Structured & systematic working approach**
SPECIFIC COMPETENCIES	**Life cycle analysis** Scalability analysis Specific lab skills Computer aided manufacturing/ engineering		Management of Personal resources Management of financial resources IP management Deal negotiation skills			

Figure 14: Competencies Use Case 1 Spain

Contact

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I4.0 Cube Spain Use case 1

Job Profile: Industrial Automation and Robotics

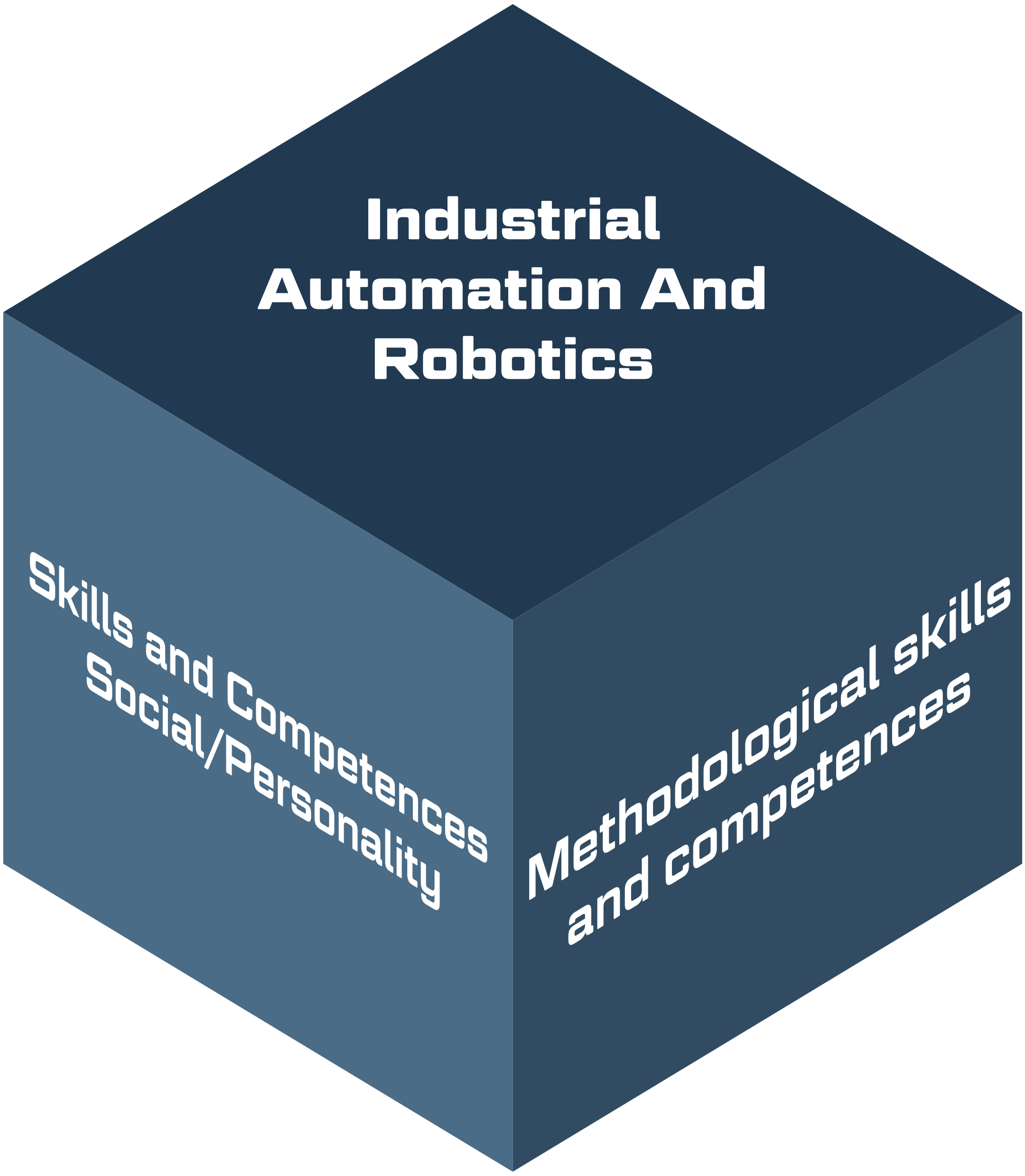
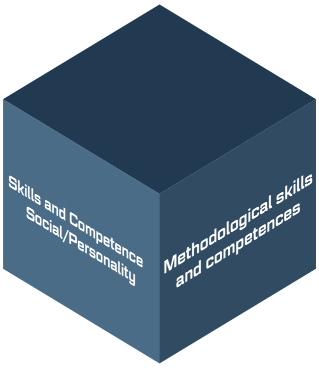


Figure 15: I4.0 Cube Use Case 1 Spain



I4.0 Cube Spain Use case 1

Industrial Automation And Robotics

Access condition:
(Technical) high school. Medium level specific training program (EQF4)

1st year

Electrical, pneumatic and hydraulic systems; . Sequential programmable systems; Measurement and regulation systems; Power systems; Technical documentation; Industrial computing; Career training and guidance

2nd year

Advanced programmable systems; Industrial robotics; Industrial communications; . Integration of industrial automation systems; Industrial automation and robotics project; Technical; English; Enterprise and entrepreneurship; Work placement

3rd year (specialization)

Digitalized Manufacturing Specialization program.
Intelligent productive processes; Metrology and intelligent instrumentation; Connected environments and Industrial Internet of Things; Virtualization of machines and production processes; Work placement.

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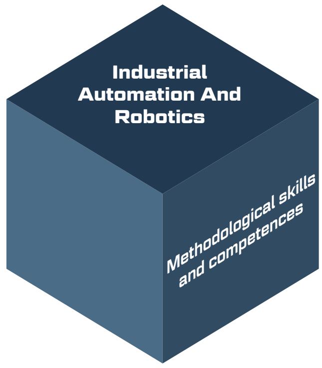

I4.0 Cube Spain Use case 1

Skills and Competences Social/Personality

Industrial Automation And Robotics

Foundation	Social/Personality skills and competences
EQF level 6 - descriptors	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Basic module year 1	· Independent knowledge acquisition · Transfer skills · Responsibility
Basic module year 2	· Individual responsibility · Leadership · Cooperation · Integration of team members · Independent knowledge acquisition · Acting in a determined, sustainable and responsible manner evaluate social and socio-political impacts
Basic module year 3	· Self-management · Time management · Leadership · Ability to be critical · Ability to deal with conflicts · Enduringly and persistently solving tasks independently · Empathy

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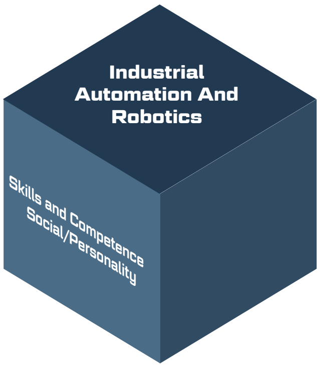

I4.0 Cube Spain Use case 1

Methodological skills and competences

Industrial Automation And Robotics

Foundation	Methodological skills and competences
EQF level 6 - descriptors	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study
Basic module year 1	· Systematic & structured working approach · Technical problem solving · Interdisciplinary understanding of processes · Analytical working approach · Integration · Teamwork · Data management
Basic module year 2	· Communication · Integration · Project Management · Management of financial resources · Transfer skills · Complex problem solving · Critical & collaborative thinking
Basic module year 3	· Interdisciplinary approach · Communication · Cooperation · Abstraction ability

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ATR (Technical Remote Assistant)

ATR is a collaborative tool based on Augmented Reality designed specifically to improve the quality and efficiency of technical assistance. It allows to quickly and efficiently identify the incident and give precise instructions in real-time for its resolution. All this with an intuitive and easy-to-use tool without the need having to install any applications.

OVERVIEW

Company:	Innovae
Application examples:	Technology company
Value creation:	Industry 4.0, Marketing and communication, Sales empowerment, Healthcare, Construction, and real estate development
Development stage:	Implementing
Company size:	Small/medium
Region:	Basque Country

Figure 16: Innovae at exhibition https://bedigital.bilbaoexhibitioncentre.com/en/information/image-gallery/

What were the challenges to be solved?

Innovae and Danobat plan to increase productivity with the help of Industry 4.0 solutions. The aim is to ensure lasting competitiveness in the long term. To this end, Innovae along with Danobat has developed a system to provide field technicians with remote assistance support in real-time to increase efficiency in technical interventions and remote industrial maintenance tasks.Benefits: increase the availability and performance of assets and reduce maintenance costs.

How can the Industry 4.0 approach be described?

The technician can visualize real-time data of the connected machine through a digital twin and access this data by overlaying the information about the machine through augmented reality. ATR allows creating a knowledge base about incident management which is stored in the administration panel (Big data). It works on iOS, Android, and Windows operating systems. It is compatible with any smartphone, tablet, PC, or smart glasses, as it is developed in Web technology.

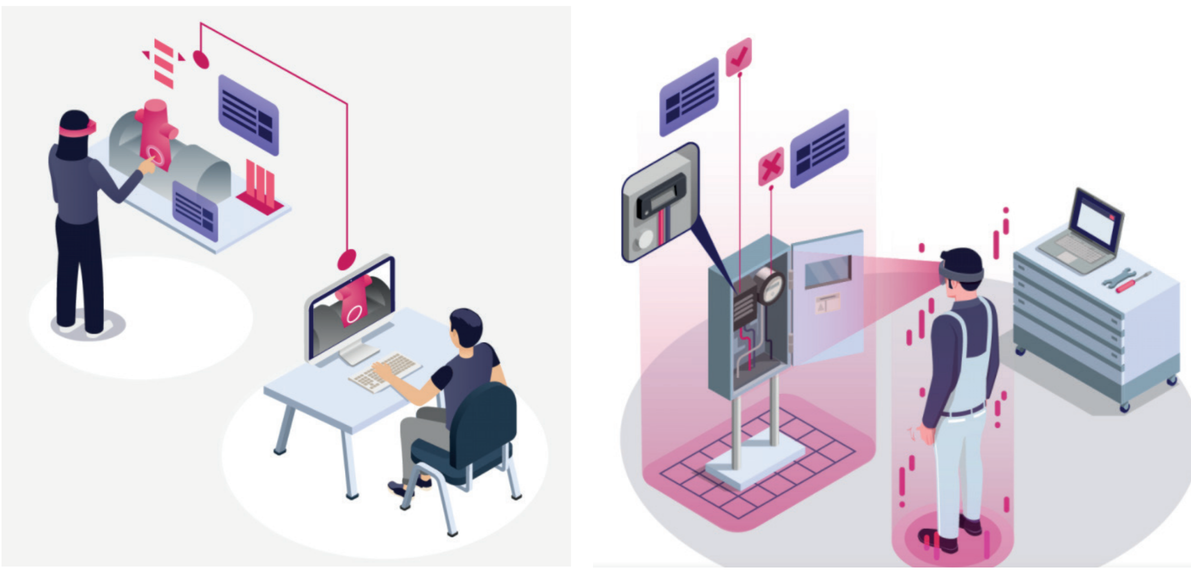

Figure 17: Schematic of ATR https://www.innovae.eu

What could be achieved?

- Manufacturing: Increase efficiency in maintenance and repair of facilities and production lines with real-time remote assistance from experts and suppliers. It provides a faster identification of errors, significantly reduces the response times and it minimizes the downtimes.

Figure 18: Technical remote assistant
https://bedigital.bilbaoexhibitioncentre.com/en/exhibitor/INNOVAE/product/ATR-Technical-Remote-Assistant/19652

- T.A.S: Optimization of the activity of Technical Assistance Service companies. The use of remote assistance with augmented reality improves the communication between the service centre and the technical team and provides immediate knowledge to the operators during the interventions. Unnecessary trips are avoided, the performance of field technicians is improved and the time of the interventions is reduced.

Figure19: Technical remote assistants and service center
https://bedigital.bilbaoexhibitioncentre.com/en/exhibitor/INNOVAE/product/ATR-Technical-Remote-Assistant

- Customer Support: Improvement of customer service provided by machinery manufacturers and turnkey project companies. By the use of remote assistance with augmented reality, the company offers immediate support when it comes to commissioning, repairs, and equipment maintenance, as well as in the training of the clients' workforce.

To ensure great development, the project has been carried out with this alliance. On the one hand, there are Innovae's solutions, based on augmented and virtual reality, and on the other those which have been developed with a range of high-precision grinders and hard turning lathes designed to adapt to the specific applications required by their customers.

What measures have been taken to achieve the solution?

What can others learn from it?

ATR offers solutions for different sectors and manufacturing processes. SME's interested in implementing AV/AR solutions in whatever process they are working in can find good examples of the use of AV/AR. The scope of the technology can be checked, its limits, features, and other characteristics that can support them to make correct decisions in their digital transformation journey.

What competencies are needed by the Employee to achieve the solution?

Extended reality

Augmented reality
Virtual reality
Mixed reality
Haptic technologies
HMD technologies

Manufacturing processes

Smart Maintenance

Process-Management

Process Workflow   Gantt Diagrams, Milestones, Quality Gates
Controlling, Product Traceability

Industrial Communication

Fieldbuses   Profinet, ASI, IO-Link
Networking   TCP-IP V4 and V6
OPC/UA
Internet Security

Additional Technologies

Simulation Technologies
Digital twins
Artificial Intelligence, Data-Analytics

Possible job profiles

	TECHNICAL	QUALITY, RISK & SAFETY	MANAGEMENT	COMMUNICATION	INNOVATION	EMOTIONAL INTELLIGENCE
GENERAL COMPETENCIES	**Knowledge in STEM** ICT skills **Programming** Coding **Computer skills** Design methodology Systems analysis Data management skills Ability to interact with human - machine interfaces Interdisciplinary understanding (processes/ technologies / organisations) **Manufacturing skills** Modelling & simulation	**Quality management** Health & security Industrial hygiene **Equipment safety** **Emergency response & management** Data security Ethics	**Strategic analysis** **Analytical thinking** **Technology strategy** Marketing **Customer orientation** Project Management Time Management Teamwork & ability to work in interdisciplinary environments Change management Risk management Leadership	**Interpersonal skills** Verbal communication Written communication Presentation skills Public communication **Virtual collaboration** **Ability to deal with conflicts**	Integration skills Continuous experimentation **Complex problem solving** Creativity Abstraction ability **Critical thinking** **Transfer skills** **Collaborative thinking**	Flexibility & Adaptability **Responsibility** **Stress tolerance** Ability to thrive on failures Work-life balance Self-control & discipline Decision making Mindset towards lifelong learning & continuous improvement Self management & organisation Cooperation & collaboration skills Intercultural competencies **Structured & systematic working approach**
SPECIFIC COMPETENCIES	Life cycle analysis Scalability analysis Specific lab skills Computer aided manufacturing/ engineering		Management of Personal resources Management of financial resources IP management Deal negotiation skills			

Figure 20: Competencies Use Case 2 Spain

Contact

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I4.0 Cube Spain Use case 2

Job Profile: Industrial Mechatronics

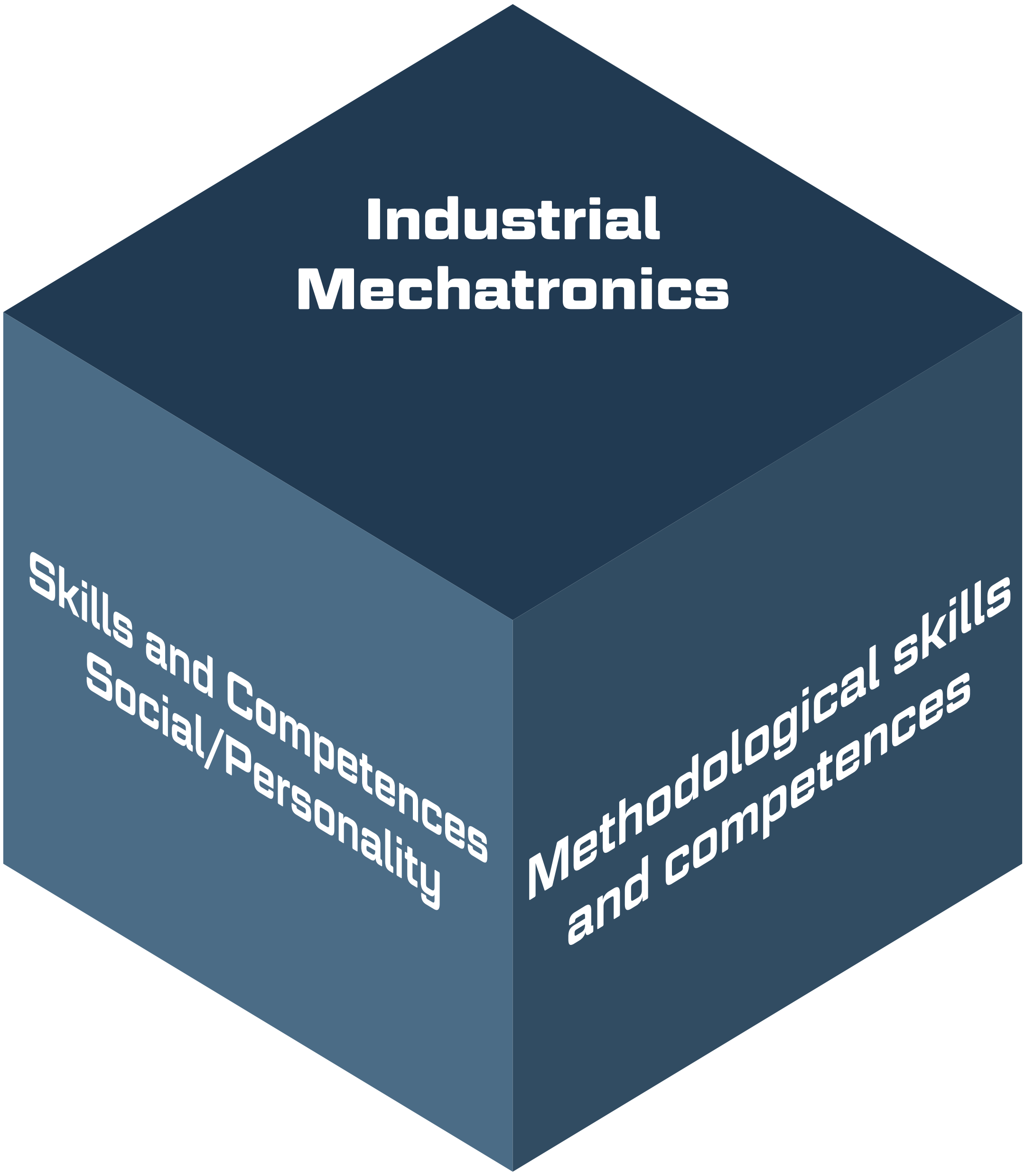
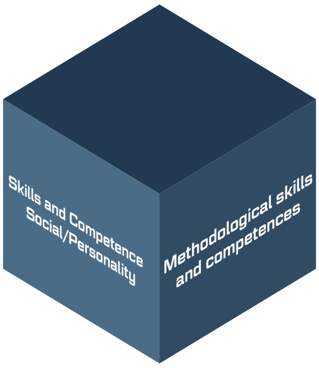


Figure 21: I4.0 Cube Use Case 2 Spain



I4.0 Cube Spain Use case 2

Industrial Mechatronics

Access condition:
(Technical) high school. Medium level specific training program (EQF4)

1st year

Hydraulic and pneumatic systems; Electrical and electronic systems; Machine elements; Manufacturing processes; . Graphic representation of mechatronic systems; System integration; Career training and guidance.

2nd year

Mechanical systems; Mechatronic system configuration; Maintenance and quality processes and management; Mechatronic system simulation; Industrial mechatronics project; Technical; English; Enterprise and entrepreneurship; Work placement .

3rd year (specialization)

Digitalized Manufacturing Specialization program.
Intelligent productive processes; Metrology and intelligent instrumentation; Connected environments and Industrial Internet of Things; Virtualization of machines and production processes; Work placement.

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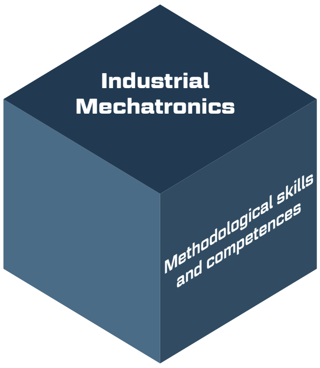

I4.0 Cube Spain Use case 2

Skills and Competences Social/Personality

Industrial Mechatronics

Foundation	Social/Personality skills and competences
EQF level 6 - descriptors	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Basic module year 1	· Independent knowledge acquisition · Transfer skills · Responsibility
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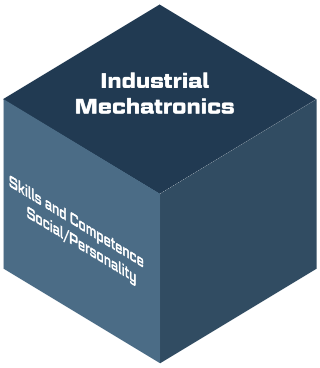

I4.0 Cube Spain Use case 2

Methodological skills and competences

Industrial Mechatronics

Foundation	Methodological skills and competences
EQF level 6 - descriptors	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study
Basic module year 1	· Systematic & structured working approach · Technical problem solving · Interdisciplinary understanding of processes · Analytical working approach · Integration · Teamwork · Data management
Basic module year 2	· Communication · Integration · Project Management · Management of financial resources · Transfer skills · Complex problem solving · Critical & collaborative thinking
Basic module year 3	· Interdisciplinary approach · Communication · Cooperation · Abstraction ability

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Digital Factory TE Connectivity

Keynetic Technologies has developed software that allows governing network equipment centrally and according to the policies of each company.

OVERVIEW

Application examples:	Computer and network security
Value creation:	CyberSecurity, SDN, NFV, Industry 4.0, Network Access Control y R&D
Development stage:	---------
Company size:	Small
Region:	Basque Country

What were the challenges to be solved?

The industrial sector is facing an exciting transformation towards Industry 4.0 with the digitalization of the factory, but the interconnection of machines and devices creates new risks and threats, as traditionally isolated devices now connected to IT resources become exposed to cyberattacks.

In industrial environments, the production assets must be protected to assure their availability and to avoid any impact on the actual production process and its associated cost. A production stop due to a security threat is unacceptable. Moreover, deploying a cybersecurity solution in the factory currently requires a huge amount of time and effort, and specialized expertise for the industrial sector.

Factories are constantly evolving – new assets and new projects towards full digitalization –, as well as its associated cybersecurity requirements. Managing proper cybersecurity across the whole factory over time is complex, time-consuming, and requires expert knowledge. If not properly defined – including people, process, and technology –, cybersecurity tends to relax to avoid impacting the production.

In such a scenario, their network security solution relies on simplicity, automation, and intelligence to reduce the risk and security management effort.

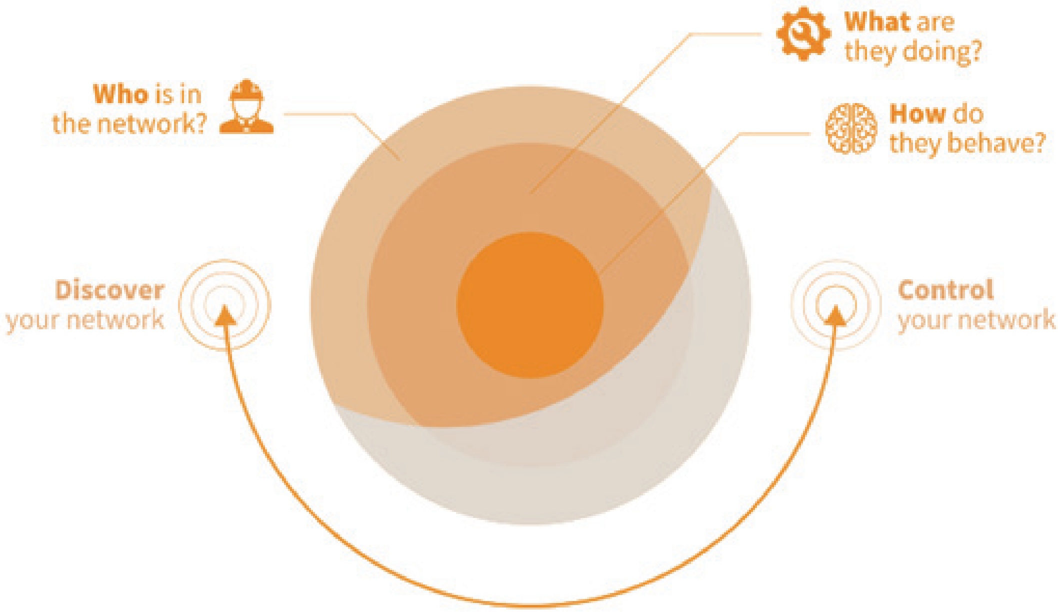
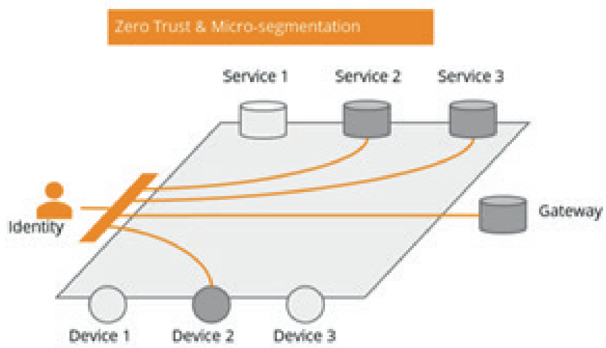


Figure 22: Schematic Keynetic https://keynetic.tech

How can the Industry 4.0 approach be described?

They extend current approaches for industrial cybersecurity with smart discovery and clustering of assets and security policies to automate this process, thus reducing the time and effort needed. Based on that information, their central orchestrator interacts with all the security components spread throughout the factory to automatically deploy the resulting security policies, simplifying this process and assessing the security posture of the factory.

Moreover, they enforce a zero-trust model and implement network micro-segmentation to avoid compromised devices affecting the rest of devices and machines connected to the same trusted segment, thus limiting lateral movement. This approach, based on a whitelist model, allows the hardening of the industrial network reducing the attack surface of systems and devices that cannot be updated nor patched. All their industrial environment solutions are based on Software Defined Networking (SDN) and Network Automation and Machine Learning (ML).



https://keynetic.tech/user/pages/flownac/flowNAC.pdf

What could be achieved?

They have focused on the design and implementation of added value cybersecurity solutions, for service providers and Industry 4.0, based on SDN and NFV technologies. They have achieved 3 solutions:

FLowNAC: A highly flexible and extensible network security solution that allows controlling access to authorized services based on the identity of the users or devices.

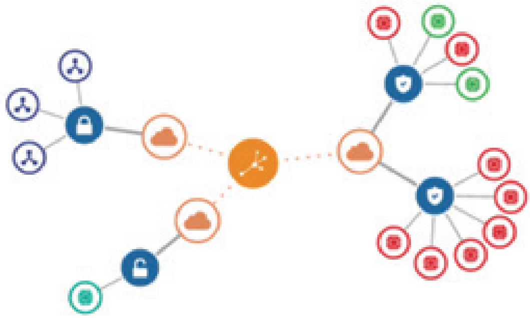


Figure 23: Schematic Flownac https://keynetic.tech/flownac

FlowSEC: Automated discovery of assets and security policies through advanced Artificial Intelligence and Machine Learning (AI/ML) techniques.

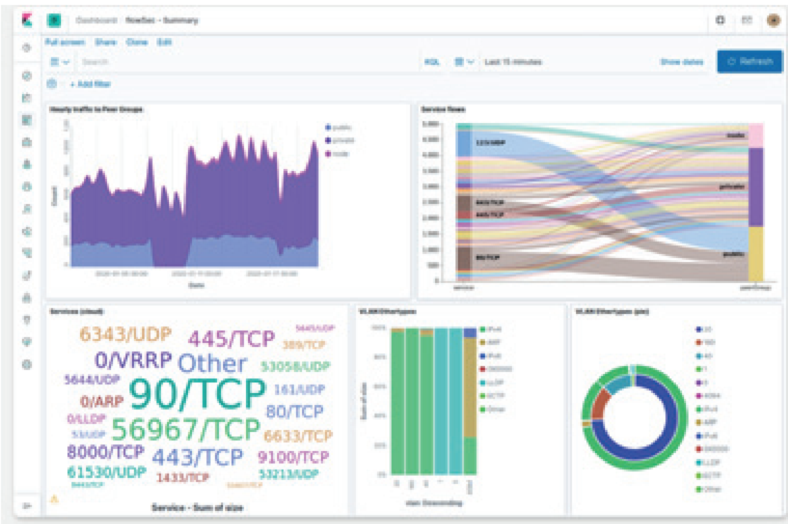


Figure 24: Schematic Flowsec https://keynetic.tech/flowsec

SmartGRIDS: Tools compliant with IEC standards to provide solutions to secure Smart Grids and protect critical infrastructure from cyberattacks.

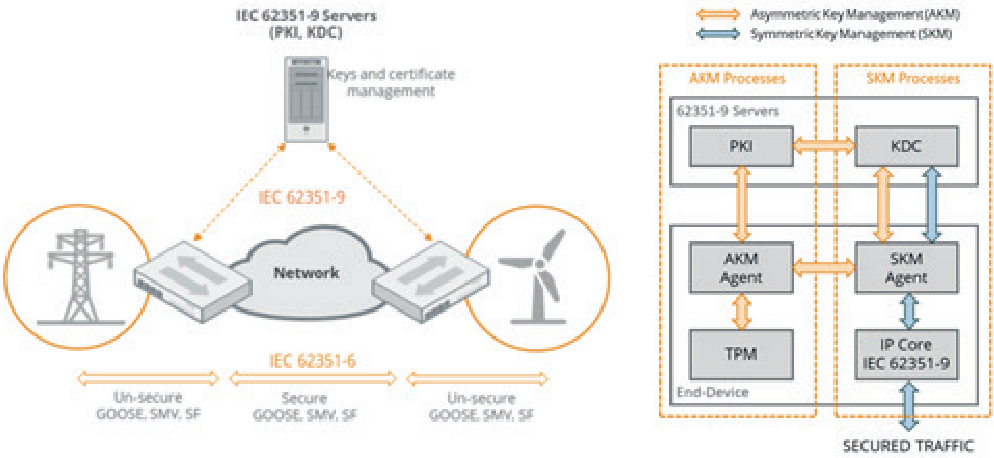


Figure 25: Schematic Smart Grids https://keynetic.tech/user/pages/smart-grids-security/smartGrids.pdf

To ensure a vast development Keynetic has collaborated with Danobat and Batz S.Coop. These collaborations have resulted in two successful cases:

- Danobat, as a manufacturer of connected machines, wanted a demonstrator to show that connections can be perfectly safe. Keynetics made a display that showed that if you protect the network infrastructure well, the connectivity of the machines is safe.

- Batz is a manufacturer that was in the process of restructuring its network and wanted to take advantage of it to provide it with security. They wanted a comprehensive solution that would cover the entire network, which would allow managing from a single system how users in the office and the different machines in the plant can connect. Thus, they could control how each person and each machine connects to their network.

What can others learn from it?

Cybersecurity is a key concern in industry 4.0.

Industrial organizations must identify and assess risks. To put in place the necessary policies, procedures, and staff training to manage industrial cybersecurity risks, here good examples of how it can be carried are shown.

SMEs that are planning to implement industry 4.0 related projects and connect their machines and equipment to the cloud, organizations need to consider specific protection for Industrial IoT which can become highly connected externally: before connecting their OT/ICS network to the cloud, using preventive maintenance or digital twins, we need to be sure that the system is secure.

What competencies are needed by the Employee to achieve the solution?

Industrial cybersecurity

IT/OT cybersecurity protocols

Cybersecurity standards: ISO/IEC 27001 IEC 62443 ISO/IEC 27002

Vulnerabilities in industrial environments

Cybersecurity diagnosis

Industrial firewalls, IDS, DMZ, interconnectivity nodes, traffic capture analysis

Industrial Communication

Communication architecture

Fieldbuses Profinet, ASI, IO-Link

Networking TCP-IP V4 and V6

OPC/UA

Internet Security

Possible job profiles

	TECHNICAL	QUALITY, RISK & SAFETY	MANAGEMENT	COMMUNICATION	INNOVATION	EMOTIONAL INTELLIGENCE
GENERAL COMPETENCIES	**Knowledge in STEM** ICT skills **Programming** **Coding** **Computer skills** Design methodology Systems analysis **Data management skills** **Ability to interact with human - machine interfaces** **Interdisciplinary understanding (processes/ technologies / organisations)** Manufacturing skills **Modelling & simulation**	**Quality management** Health & security Industrial hygiene Equipment safety **Emergency response & management** **Data security** **Ethics**	**Strategic analysis** **Analytical thinking** **Technology strategy** Marketing **Customer orientation** Project Management Time Management Teamwork & ability to work in interdisciplinary environments Change management **Risk management** Leadership	**Interpersonal skills** Verbal communication Written communication **Presentation skills** Public communication **Virtual collaboration** Ability to deal with conflicts	Integration skills Continuous experimentation **Complex problem solving** **Creativity** **Abstraction ability** Critical thinking Transfer skills **Collaborative thinking**	Flexibility & Adaptability **Responsibility** **Stress tolerance** Ability to thrive on failures Work-life balance Self-control & discipline Decision making Mindset towards lifelong learning & continuous improvement Self management & organisation **Cooperation & collaboration skills** Intercultural competencies **Structured & systematic working approach**
SPECIFIC COMPETENCIES	Life cycle analysis Scalability analysis Specific lab skills Computer aided manufacturing/ engineering		Management of Personal resources Management of financial resources IP management Deal negotiation skills			

Figure 26: Competencies Use Case 3 Spain

I4.0 Cube Spain Use case 3

Job Profile: Production Programming in Mechanical Manufacturing

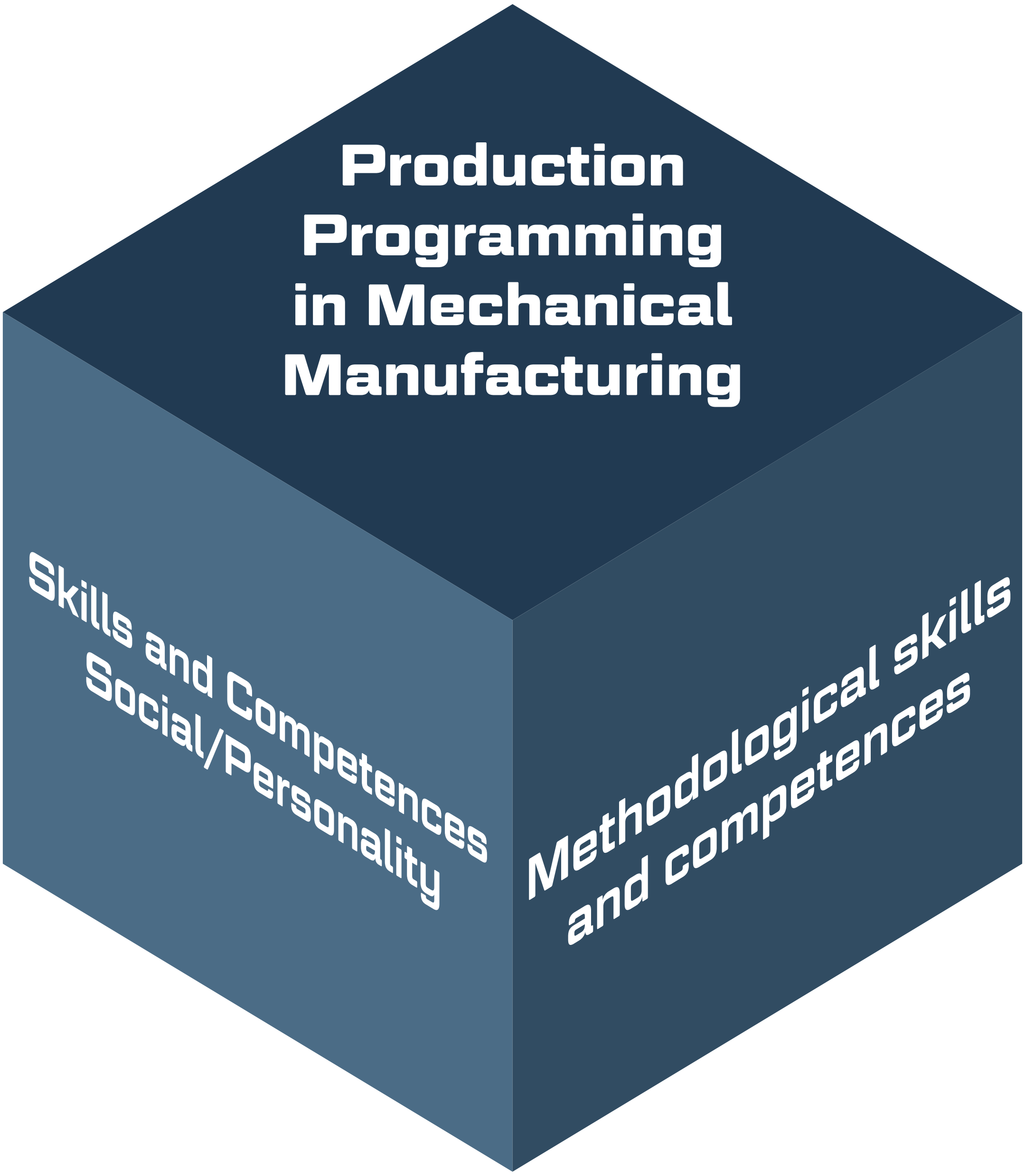
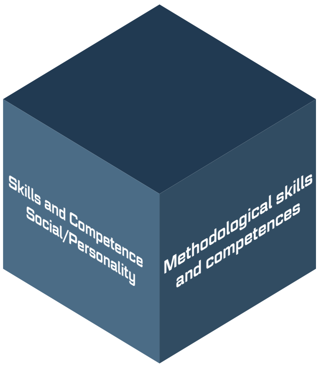


Figure 27: I4.0 Cube Use Case 3 Spain



I4.0 Cube Spain Use case 3

Production Programming in Mechanical Manufacturing

Access condition:
(Technical) high school. Medium level specific training program (EQF4)

1st year

Graphic interpretation; Machining process definition, forming and assembly; Manufacturing processes execution; Quality management, work risk prevention, environmental protection; Product verification; Career training and guidance

2nd year

Numerical control machining; Computer aided manufacturing (CAM); Programming of automatic mechanical manufacturing systems; Production planning; Machining product manufacturing project; Technical English; Enterprise and entrepreneurship; Work placement .

3rd year (specialization)

Digitalized Manufacturing Specialization program.
Intelligent productive processes; Metrology and intelligent instrumentation; Connected environments and Industrial Internet of Things; Virtualization of machines and production processes; Work placement.

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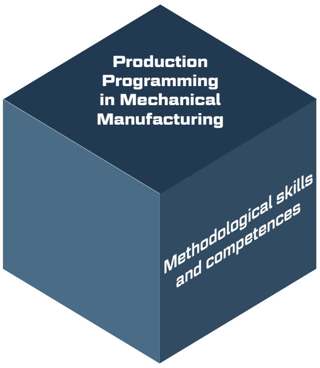

I4.0 Cube Spain Use case 3

Skills and Competences Social/Personality

Production Programming in Mechanical Manufacturing

Foundation	Social/Personality skills and competences
EQF level 6 - descriptors	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Basic module year 1	· Independent knowledge acquisition · Transfer skills · Responsibility
Basic module year 2	· Individual responsibility · Leadership · Cooperation · Integration of team members · Independent knowledge acquisition · Acting in a determined, sustainable and responsible manner evaluate social and socio-political impacts
Basic module year 3	· Self-management · Time management · Leadership · Ability to be critical · Ability to deal with conflicts · Enduringly and persistently solving tasks independently · Empathy

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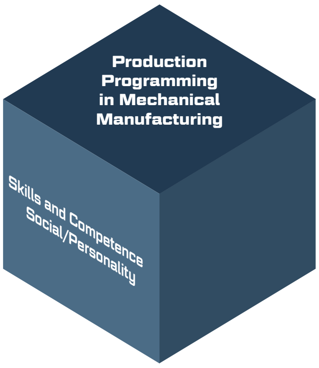

I4.0 Cube Spain Use case 3

Methodological skills and competences

Production Programming in Mechanical Manufacturing

Foundation	Methodological skills and competences
EQF level 6 - descriptors	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study
Basic module year 1	· Systematic & structured working approach · Technical problem solving · Interdisciplinary understanding of processes · Analytical working approach · Integration · Teamwork · Data management
Basic module year 2	· Communication · Integration · Project Management · Management of financial resources · Transfer skills · Complex problem solving · Critical & collaborative thinking
Basic module year 3	· Interdisciplinary approach · Communication · Cooperation · Abstraction ability

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USE CASES – NETHERLANDS

TIMA – Use of robots in one-off production

TIMA | TOEGEPASTE INNOVATIES VOOR MARITIEME AUTOMATISERING

Implementation of welding and cutting robots in the production of custom-made ships (luxury yachts).

OVERVIEW

Application examples:	Maritime Manufacturing industry
Value creation:	Production
Development stage:	Project
Company size:	Small/medium
Region:	Drechtsteden, The Netherlands

What were the challenges to be solved?

To strengthen its international competitive edge, the Dutch maritime manufacturing industry will have to produce ships and shipping components faster, better, and more sustainably. The maritime manufacturing industry, particularly yacht and shipbuilding, often requires customization through one-off products, mostly cut and welded manually and for which specialist knowledge and experience are essential. Due to ageing workforce, this special expertise is becoming scarcer. Many specialists are 'unconsciously competent' – their knowledge and expertise being stored in their brains and hands. When they leave or retire, there is always the risk of artisanship leaving the company. At the same time, fewer and fewer young people opt for 'traditional' technical VET courses, such as welding.

In the EFRO project Applied Innovation in Maritime Automation (TIMA) Da Vinci College and the Sustainability Factory together with three regional SMEs (Scheepswerf Slob, Machinefabriek De Waal, and Valk Welding) have cooperated for three years on innovations concerning the deployment of robotics in one-off production.

How can the Industry 4.0 approach be described?

In TIMA the partners worked on digitising the ever scarcer know-how and the automation of the process of cutting and welding unique components, using their combined expertise. The partners have managed to store the know-how of professionals in the shape of small 'building blocks' digitally in databases, from which a robot can be controlled.

The knowledge and experience of specialists were made explicit in this process, at the same time continually optimizing it in actual practice. To simplify this 'translation' from practical competences to programming language a 'smart stylus' was developed in TIMA. Using this digital welding torch, experienced welders can clarify exactly how welding should be done. Subsequently, the stylus converts this to a digital drawing enabling a robot to perform the welding. The exchange of knowledge between companies and VET was an important aspect of TIMA. The participation by Da Vinci College ensured that innovations were picked up and incorporated into education. It was an interesting phenomenon that level 4 Mechatronics students not only came to 'gather' knowledge (third-year students' internship on robot welding and programming) but that they also contributed knowledge, the young educating the older employees about the use of technology. During their graduation internship at Slob shipping, they assisted in the implementation and acceptance of the welding robot.

What could be achieved?

The partners succeeded in developing smart software that directly controls a robot from a CAD drawing. A so-called digital configurator retrieves the correct information about the component to be produced, using welding sequences based on databases containing data about welding components and welding algorithms, connected in an ITC architecture.

Automating welding and cutting also involves logistic challenges. In one-off production with different shapes and dimensions, a robot installation will have to be designed in such a way that it can process and adapt all these components: how does the robot grab the components, how does it move them, and will its arm reach all of these places? Many partial innovative solutions have been developed in the project, such as a turntable making it possible to clamp different shapes and sizes of components and a mobile robot installation.

The results of the technological innovations in TIMA are: enhanced productiveness, reduced lead time, and minimum physical accompaniment of the manufacturing process. During digitisation and automation, companies were able to implement optimisations, leading to less engineering in customisation.

The process of development of innovations in TIMA went hand in hand with the ability to apply and introduce them in manufacturing processes. 'Innovation in consort with the shop floor' has led to a great deal of latent knowhow in maritime companies and has meanwhile been secured in databases. The direct connection with education and training has secured the innovations in regular technical VET and the course structure of lifelong development. An ever-growing ecosystem has come about in which education (students and teachers) and companies (employees and management) are learning from each other.

Possible job profiles

	TECHNICAL	QUALITY, RISK & SAFETY	MANAGEMENT	COMMUNICATION	INNOVATION	EMOTIONAL INTELLIGENCE
GENERAL COMPETENCIES	**Knowledge in STEM** **ICT skills** **Programming** Coding **Computer skills** **Design methodology** Systems analysis Data management skills Ability to interact with human - machine interfaces Interdisciplinary understanding (processes/ technologies / organisations) **Manufacturing skills** Modelling & simulation	**Quality management** Health & security Industrial hygiene **Equipment safety** Emergency response & management Data security Ethics	Strategic analysis Analytical thinking **Technology strategy** Marketing **Customer orientation** Project Management Time Management Teamwork & ability to work in interdisciplinary environments Change management Risk management Leadership	**Interpersonal skills** Verbal communication Written communication Presentation skills Public communication Virtual collaboration Ability to deal with conflicts	**Integration skills** **Continuous experimentation** Complex problem solving Creativity Abstraction ability Critical thinking **Transfer skills** **Collaborative thinking**	Flexibility & Adaptability Responsibility Stress tolerance Ability to thrive on failures Work-life balance Self-control & discipline Decision making Mindset towards lifelong learning & continuous improvement Self management & organisation **Cooperation & collaboration skills** Intercultural competencies Structured & systematic working approach
SPECIFIC COMPETENCIES	Life cycle analysis Scalability analysis Specific lab skills Computer aided manufacturing/ engineering		Management of Personal resources Management of financial resources IP management Deal negotiation skills			

Figure 28: Competencies Use Case Netherlands

I4.0 Cube Netherlands Use case 1

Job Profile: Mechatronic Technician

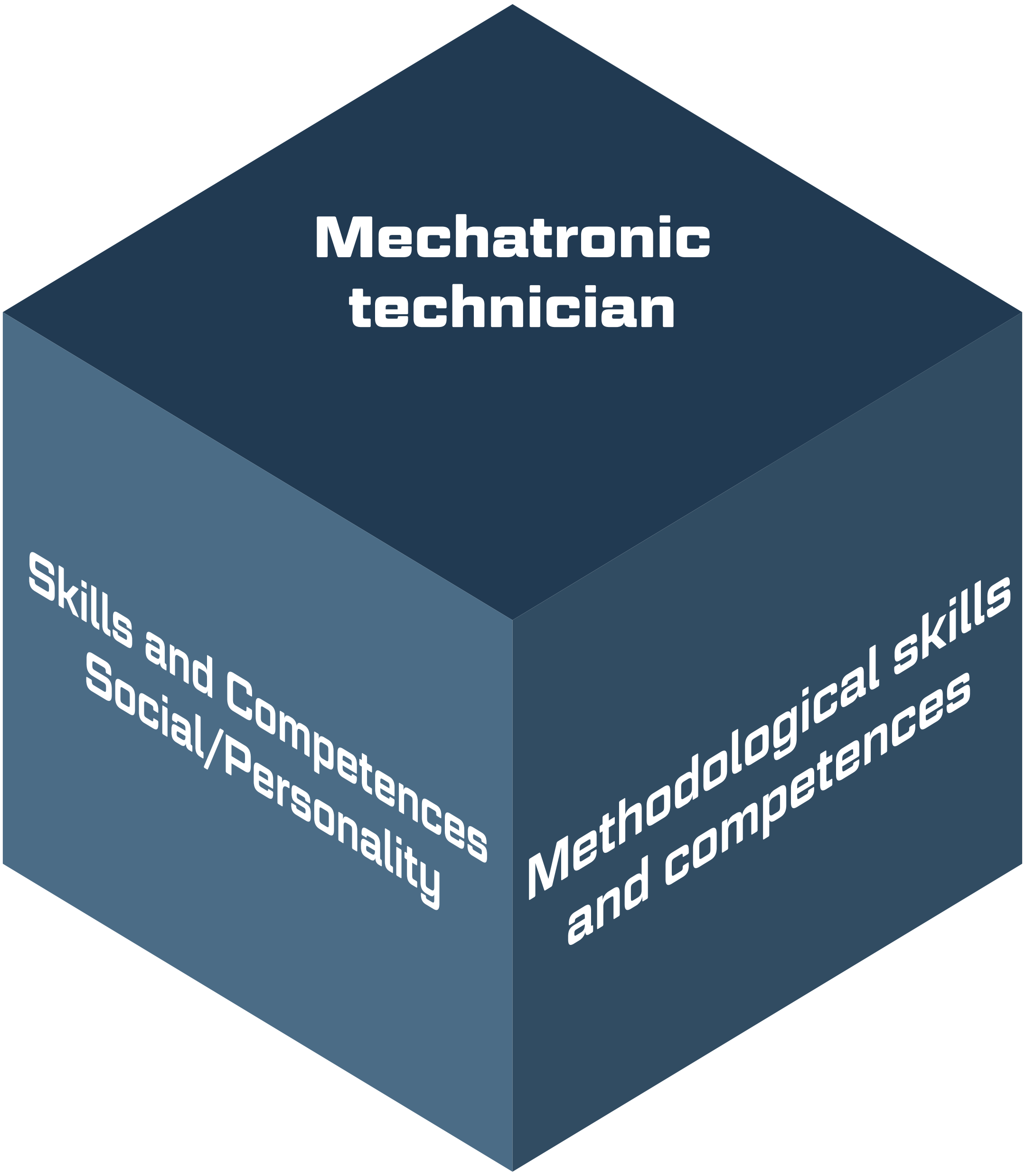
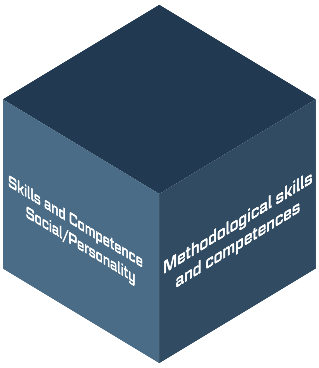


Figure 29: I4.0 Cube Use Case Netherlands



I4.0 Cube Netherlands Use case 1

Mechatronic technician

Year 1-4:

Vocational training, working law, collective bargaining law, safety & health protection, environmental protection.

Year 1:

Operational & technical communication, testing, marking, labelling, planning & controlling work process, checking & accessing work results, manual & mechanical machining, cutting & forming, installing electrical assemblies & components, measuring & testing electrical quantities, controlling.

Year 2

Operational & technical communication, planning & controlling work process, checking & assessing work results, installing electrical assemblies & components, installing & testing hardware & software, setting up & testing control systems, programming mechatronic systems, assembling components to form machines & systems, assembling & disassembling machines,/systems/equipment, testing & adjusting functions on mechatroninc systems, commissioning & operating mechatronic systems.

Year 3 & 4

Installing & testing hardware & software components, programming mechatronic systems, assembling components to form machines & systems, assembling & dismantling machines/systems/equipment, testing & adjusting functionson mechatronic systems, commissioning & operating mechatronic systems, maintaining mechatronic systems.

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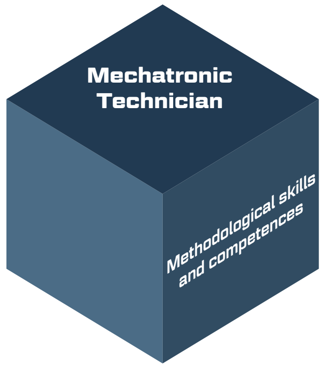

I4.0 Cube Netherlands Use case 1

Skills and Competences Social/Personality

Mechatronic technician

Foundation	Social/Personality skills and competences
EQF level 5 - descriptors	Exercise management and supervision in contexts of work or study activities where there is unpredictable change; review and develop performance of self and others
Basic module year 1	· Responsibility · Integration · Teamwork · Communication · Flexibility · Reliability & Punctaulity
Basic module year 2	· Individual responsibility · Cooperation · Ethics · Teamwork
Basic module year 3	· Self-management · Time management · Acting in a determined and responsible manner · Leadership · Ability to be critical · Ability to deal with conflicts · Solving tasks independently · Empathy · Cooperation

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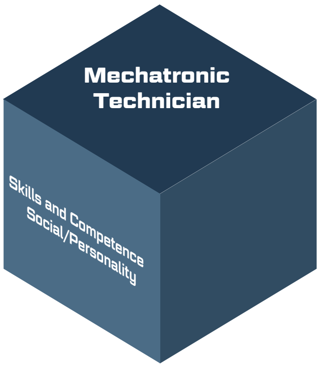

I4.0 Cube Netherlands Use case 1

Methodological skills and competences

Mechatronic technician

Foundation	Methodological skills and competences
EQF level 6 - descriptors	A comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems
Basic module year 1	· Analytical working approach · Transfer skills
Basic module year 2	· Linked thinking · Systematic & structured working approach · Technical problem solving · Interdisciplinary understanding · Customer oriented
Basic module year 3	· Interdisciplinary understanding · Abstraction ability · Systematic & structured working approach · Decision-making

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USE CASES – SWEDEN

Runex – Robotics used for automated production

Reducing monotonous work by implementing robotics.

OVERVIEW

Application examples:	Industry company
Value creation:	Production
Development stage:	Primary production under development
Company size:	22-29 employees, 22 in Finspång
Region:	East central Sweden

What were the challenges to be solved and what specific benefits were achieved?

The major challenge with new robots for Runex (with a quite low number of employees) was to create advanced robotic programs. Therefore a consultant is hired to complete these larger jobs. The manager and employees did however take training courses in programming robots and the manager is now creating the simpler programs by himself. A big success with the training course was that the manager can do the simplest programs in an hour and does not need to hire new people for these jobs.

How can the Industry 4.0 approach be described?

Even if Runex is in an early development stage of I4.0 the manager aims to implement new technologies in the future that would make the production even more effective. Robots are performing the most monotonous work in Runex current workshop resulting in a better work environment for employees. The products are food industry materials (from small to large products, made for mass production), produced by bending sheet metal, this is achieved by using a robot. The products produced in Runex workshop are mainly not welded by employees, instead of by robots, since it was implemented about three years ago. The robots are painting the products created in the workshop which otherwise would be a demanding work assignment for employees. The most recent investment was a universal robot which has not been implemented in the production yet. The workshop has become more automated in recent years and Runex is striving for an even further automated workshop in upcoming years.

What could be achieved?

Numerous things could be achieved regarding I4.0 implementations. The current robots are as aforementioned, removing monotonous work assignments, they do also work very effectively and perform safe production operations. Robots and autonomous systems can be used to make the production chain automated in the future, from the first weld to packaging. New requirements are coming with further development of I4.0 technologies, this will result in broader use of KEY technologies.

What measures have been taken to achieve the solution?

There has not been a significant load of measures for Runex to work with the new technologies except the training courses for programming robots. Consults were doing the major programming of robots and the manager had enough knowledge to do the easier tasks by himself. However, Runex will need to take new measures in the future when continuing working towards digitalisation with new I4.0 technologies and working towards automated production.

Possible job profiles

	TECHNICAL	QUALITY, RISK & SAFETY	MANAGEMENT	COMMUNICATION	INNOVATION	EMOTIONAL INTELLIGENCE
GENERAL COMPETENCIES	**Knowledge in STEM** **ICT skills** **Programming** Coding **Computer skills** Design methodology Systems analysis Data management skills **Ability to interact with human - machine interfaces** Interdisciplinary understanding (processes/ technologies / organisations) **Manufacturing skills** Modelling & simulation	**Quality management** **Health & security** Industrial hygiene Equipment safety Emergency response & management Data security Ethics	Strategic analysis Analytical thinking **Technology strategy** Marketing **Customer orientation** **Project Management** Time Management Teamwork & ability to work in interdisciplinary environments Change management Risk management Leadership	**Interpersonal skills** Verbal communication Written communication Presentation skills Public communication Virtual collaboration Ability to deal with conflicts	Integration skills Continuous experimentation **Complex problem solving** Creativity Abstraction ability Critical thinking **Transfer skills** **Collaborative thinking**	Flexibility & Adaptability Responsibility Stress tolerance Ability to thrive on failures Work-life balance Self-control & discipline Decision making Mindset towards lifelong learning & continuous improvement Self management & organisation **Cooperation & collaboration skills** Intercultural competencies **Structured & systematic working approach**
SPECIFIC COMPETENCIES	Life cycle analysis Scalability analysis Specific lab skills Computer aided manufacturing/ engineering		Management of Personal resources Management of financial resources IP management Deal negotiation skills			

Figure 30: Competencies Use Case 1 Sweden

I4.0 Cube Sweden Use case 1

Job Profile: Business Administration and Engineering

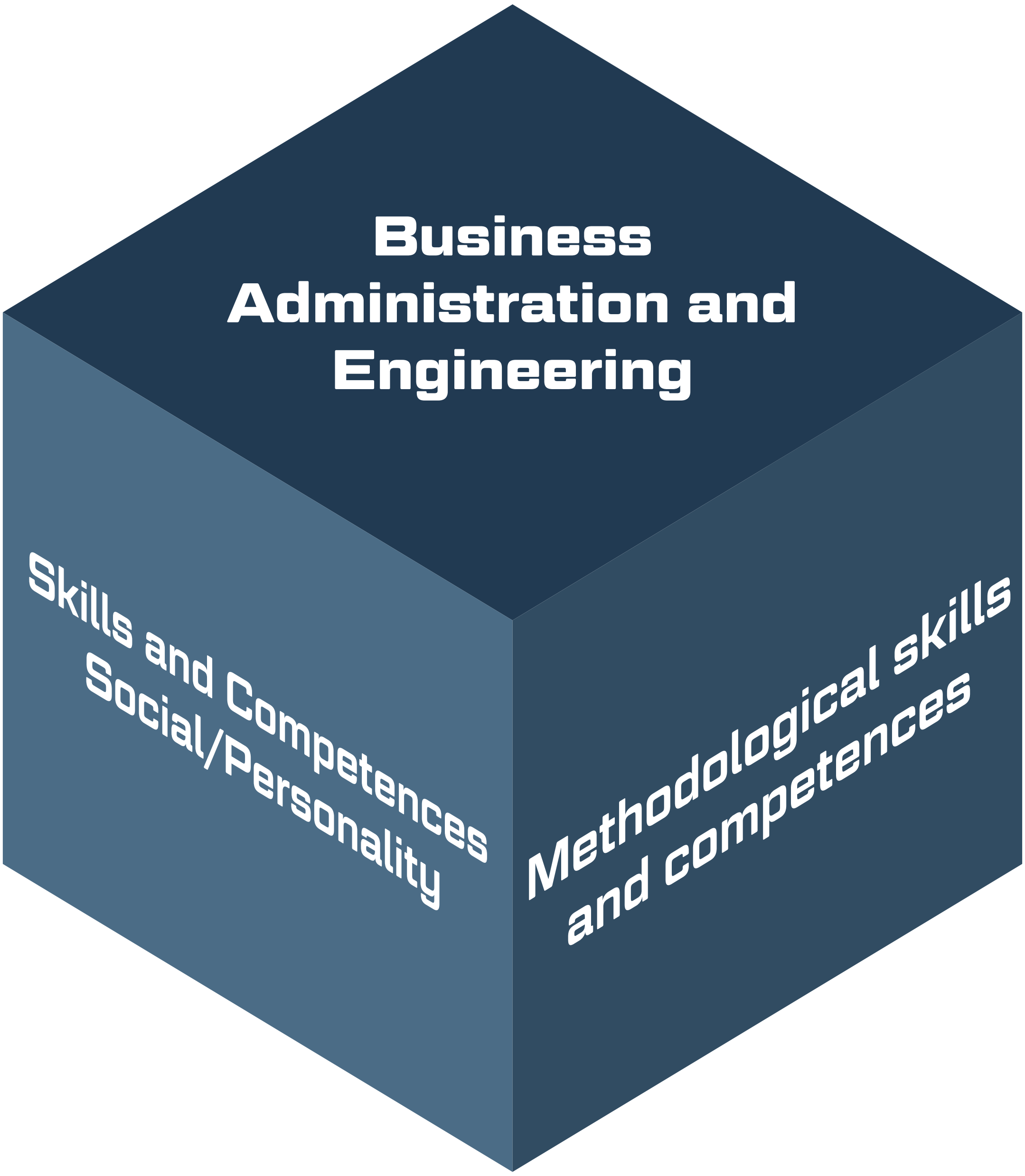
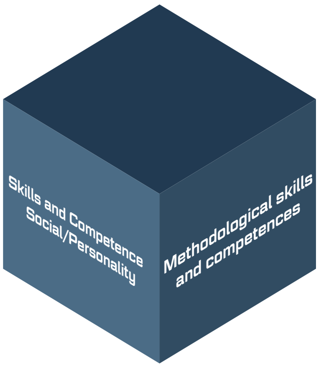


Figure 31: I4.0 Cube Use Case 1 Sweden



I4.0 Cube Sweden Use case 1

Business Administration and Engineering

Focus production and logistics Production Management, Logistics and Supply chain Management, Production systems, Process Management

Optional Module: sensors & actuators, industrial science, automation systms, automation technology

Basic module Year 1

Mathematics, technical mechanics, IT knowledge, computer science, material science, business administration, economics, engineering design, knowledge of supply chain management

Basic module Year 2

Electrical engineering, electronics, engineering design, marketing, law, finance and ac-counting, basic engineering, market-oriented product development, intelligent networked systems

Basic module Year 3

Quality Management, Strategic Management, Controlling

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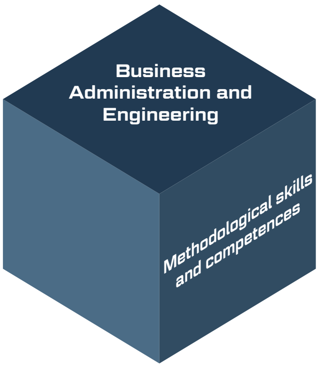

I4.0 Cube Sweden Use case 1

Skills and Competences Social/Personality

Business Administration and Engineering

Foundation	Social/Personality skills and competences
EQF level 6 - descriptors	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Basic module year 1	· Independent knowledge acquisition · Transfer skills · Responsibility
Basic module year 2	· Individual responsibility · Leadership · Cooperation · Integration of team members · Independent knowledge acquisition · Acting in a determined, sustainable and responsible manner evaluate social and socio-political impacts
Basic module year 3	· Self-management · Time management · Leadership · Ability to be critical · Ability to deal with conflicts · Enduringly and persistently solving tasks independently · Empathy

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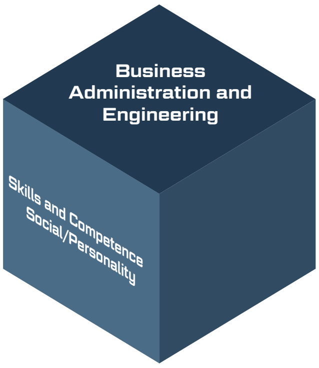

I4.0 Cube Sweden Use case 1

Methodological skills and competences

Business Administration and Engineering

Foundation	Methodological skills and competences
EQF level 6 - descriptors	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study
Basic module year 1	· Systematic & structured working approach · Technical problem solving · Interdisciplinary understanding of processes · Analytical working approach · Integration · Teamwork · Data management
Basic module year 2	· Communication · Integration · Project Management · Management of financial resources · Transfer skills · Complex problem solving · Critical & collaborative thinking
Basic module year 3	· Interdisciplinary approach · Communication · Cooperation · Abstraction ability

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Reijmyre Glasbruk, Siemens Energy AB

Additive Manufacturing

More time-efficient metal moulds implementation of Additive Manufacturing in glassmaking by producing metal moulds faster and developing the product.

OVERVIEW

Company:	Reijmyre Glasbruk
Application examples:	The craftsmanship industry
Value creation:	Production
Development stage:	Project
Company size:	Small, less than/around 15 employees
Region:	East central Sweden

What were the challenges to be solved?

Siemens Energy AB in Finspång and Curt Nicolin Gymnasiet (Digikoord) started a project together with Reijmyre Glasbruk (a craftsmanship company using conventional production methods to produce art glass-products). Reijmyre Glasbruk uses moulds (often made in metal) to create their glass. These moulds are produced with conventional production techniques, the production time is long and the price is quite high. Siemens and Curt Nicolin Gymnasiet cooperated with Reijmyre Glasbruk to create the first-ever Additive Manufactured metal mould for glassmaking in Sweden (maybe even in the world), with the hope of faster production and product development.

There were numerous challenges in this project. No one had earlier produced metal moulds for glass making using 3D-printing (from the knowledge of the participating parts of the project). There was therefore no expertise or examples to obtain knowledge from.

The participating individuals in the project had to start the work from scratch. Beginning with research about glass and glassmaking in general, the engineers asked Reijmyre Glasbruk about glassmaking production and studied glassmaking books. They also studied which metals are used in regular metal moulds. There was no clear answer to how the metal powder moulds would react when exposed to extreme heat, this was however essential to take into consideration. Comparing the knowledge about glassmaking, traditional moulds and I4.0 (Additive Manufacturing) moulds to find the right production methods was the last step before starting the production process.

There were also challenges regarding exactly how reduced the production cost could be without losing the quality of the mould. For example:

Can the surface smoothness of the moulds, produced with Additive Manufacturing, be good enough for glassmaking without doing expensive finishing work that will increase both production cost and time?

How much material can be reduced from the mould when being designed in CAD (to save print time=save money) and at the same time maintain the heat resistance which will prevent it from breaking after a short time?

How can these moulds be designed to be able to print as many moulds as possible in one print badge (290x290mm)?

How can the Industry 4.0 approach be described?

The new moulds were designed in CAD with close communication to Reijmyre Glasbruk to ensure the new moulds worked for glassmaking. CAD-models of the moulds were later used to print in an SLM 3D-printing machine with a metal powder mixture. The mould was printed with a certain metal powder mixture which could endure 1200 degrees (the temperature for melted glass). One mould was printed in one piece with finished hinges that could be used straight away. This was made to save time to make the production time lower.

What could be achieved?

The project resulted in fully functional moulds that delivered unique art glass. The moulds were produced during a drastically shorter time frame than by using conventional production methods. During the project Additive Manufacturing was implemented in a company that earlier did not know I4.0.

Reijmyre Glasbruk was introduced to the production method Additive Manufacturing by Siemens who could demonstrate its benefits. Reijmyre Glasbruk did not buy a 3D-printing machine themselves, but the method was used by Siemens and Curt Nicolin Gymnasiet to produce moulds for them. Reijmyre Glasbruk saw this cooperation and "new" technology very positively and considered it as a potential future manufacturing method for their metal moulds.

A positive result of the project was that it did get some dissemination in east-central Sweden. Three articles were written about the project, by two newspapers, and by one science park. The articles pointed out the remarkable combination between a "new" technology such as Additive Manufacturing and old craftsmanship. The Science park pointed out that Additive Manufacturing has significant potential to revolutionize the Swedish industry and that this project was a good example of digitalization.

Possible job profiles

	TECHNICAL	QUALITY, RISK & SAFETY	MANAGEMENT	COMMUNICATION	INNOVATION	EMOTIONAL INTELLIGENCE
GENERAL COMPETENCIES	**Knowledge in STEM** **ICT skills** **Programming** Coding **Computer skills** Design methodology Systems analysis Data management skills **Ability to interact with human - machine interfaces** Interdisciplinary understanding (processes/ technologies / organisations) **Manufacturing skills** **Modelling & simulation**	**Quality management** Health & security Industrial hygiene Equipment safety Emergency response & management Data security Ethics	**Strategic analysis** **Analytical thinking** **Technology strategy** Marketing **Customer orientation** **Project Management** Time Management Teamwork & ability to work in interdisciplinary environments Change management Risk management Leadership	**Interpersonal skills** **Verbal communication** Written communication Presentation skills Public communication Virtual collaboration Ability to deal with conflicts	Integration skills Continuous experimentation **Complex problem solving** Creativity Abstraction ability Critical thinking **Transfer skills** **Collaborative thinking**	Flexibility & Adaptability Responsibility Stress tolerance Ability to thrive on failures Work-life balance Self-control & discipline Decision making Mindset towards lifelong learning & continuous improvement Self management & organisation **Cooperation & collaboration skills** Intercultural competencies **Structured & systematic working approach**
SPECIFIC COMPETENCIES	Life cycle analysis Scalability analysis Specific lab skills **Computer aided manufacturing/ engineering**		Management of Personal resources **Management of financial resources** IP management Deal negotiation skills			

Figure 32: Competencies Use Case 2 Sweden

I4.0 Cube Sweden Use case 2

Job Profile: Mechatronics engineer

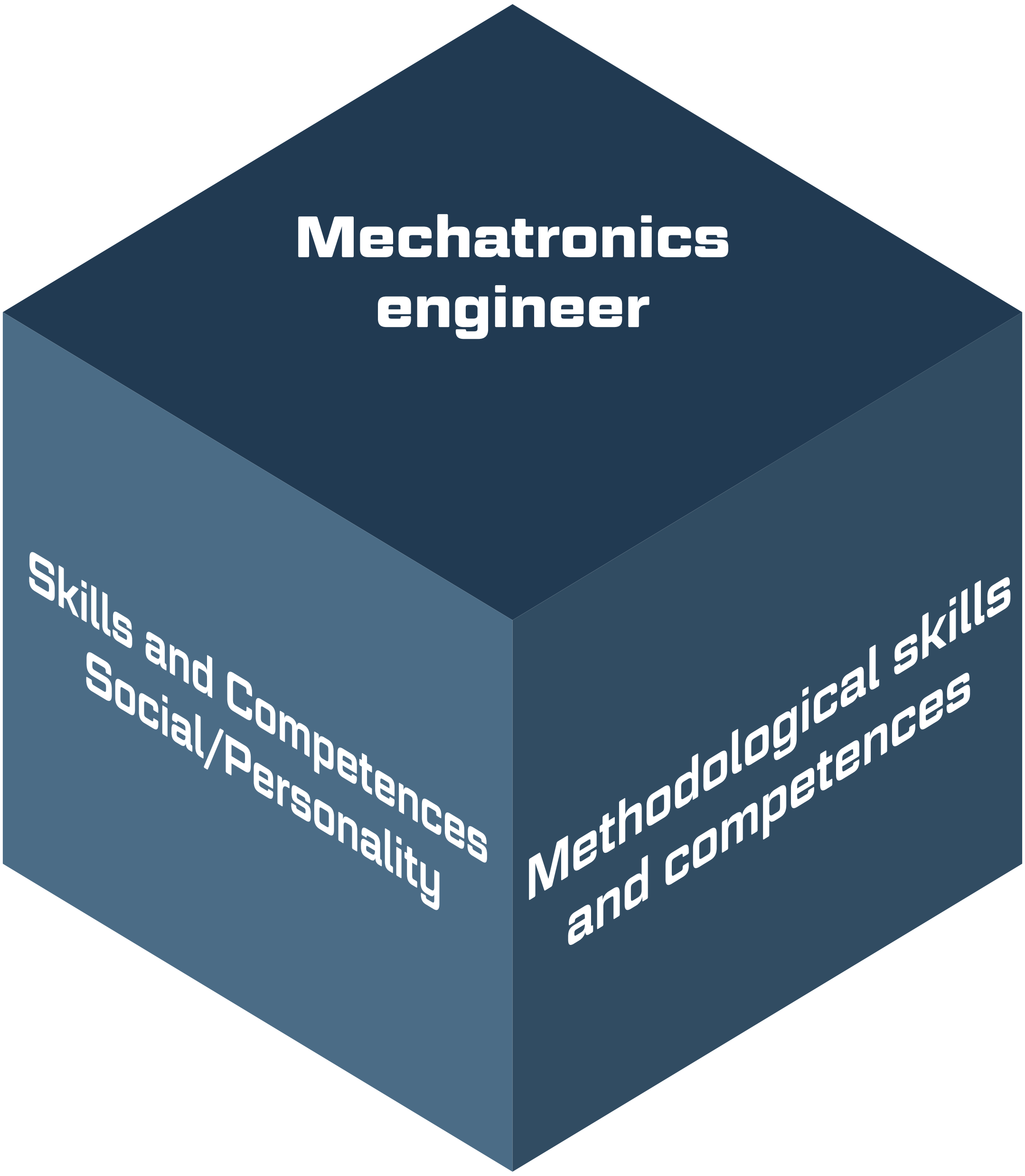
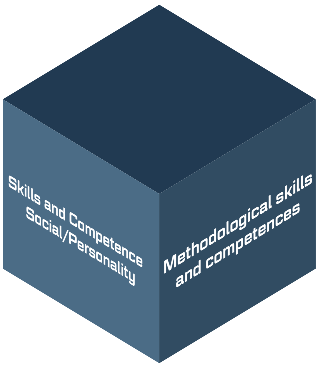


Figure 33: I4.0 Cube Use Case 2 Sweden



I4.0 Cube Sweden Use case 2

Mechatronics engineer

Optional Module: analogue circuit design, microsystems technology, safety in HV systems, electromagnetic compatibility, design of digital systems, finite elements in MT, reliability, energy storage systems, lightweight design.

Basic module Year 1

Mathematics, physics, electrical engineering, mechanical engineering, construction theory, material science, English & personal skills, computer science, programming, digital control engineering and industrial trade market rights.

Basic module Year 2

Mechatronic systems, computer science, programming, electronic, micro computer technology, construction design, production engineering, mathematics, business & economics.

Basic module Year 3

Mechatronic systems, research, sensor systems, actuator systems, automation & control systems.

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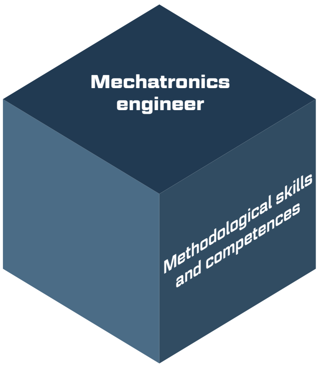

I4.0 Cube Sweden Use case 2

Skills and Competences Social/Personality

Mechatronics engineer

Foundation	Social/Personality skills and competences
EQF level 6 - descriptors	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Basic module year 1	· Responsibility · Acting in a determined, sustainable and responsible manner · Integration
Basic module year 2	· Individual responsibility · Cooperation · Integration of team members · Independent knowledge acquisition · Acting in a determined, sustainable and responsible manner · Communication
Basic module year 3	· Self-management · Time management · Responsibility · Flexibility · Lifelong learning · Independent knowledge acquisition · Enduringly and persistently solving tasks independently
Focus energy economics	· Ethics · Reflect impacts of economical actions · Reflect social & political impacts · Leadership · Empathy

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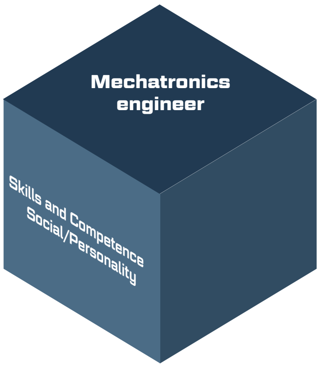

I4.0 Cube Sweden Use case 2

Methodological skills and competences

Mechatronics engineer

Foundation	Methodological skills and competences	
EQF level 6 - descriptors	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study	
Basic module year 1	· Systematic & structured working approach · Technical problem solving · Transfer skills	· Presentation skills · Teamwork /Cooperation · Intercultural competences
Basic module year 2	· Integration · Quality Management · Risk Management · Project Management · Transfer skills · Complex problem solving · Analytical thinking	· Structured working approach · Critical & collaborative thinking · Customer oriented · Continuous experimentation
Basic module year 3	· Interdisciplinary approach · Communication · Cooperation · Critical thinking · Ability to deal with conflicts & to be critical · Systematic, structured & analytical working approach	· Intercultural competences · Interdisciplinary understanding · Equipment safety · Complex problem solving · Customer orientation · Project management
Focus energy economics	· Decision-making · Renewable energies	· Ability to work in an interdisciplinary environment · Abstraction ability
Focus Vehicle Systems Technology	· Intercultural competences · Working in engineering environment	· Risk analysis of autonomous systems

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TYPICAL INDUSTRY 4.0 TECHNICAL QUALIFICATIONS FOR CASE 1 AND 2

The following graphs are illustrating different competencies, functional competencies of different qualifications from HVET and VET institutions. Functional or professional competencies describe specific abilities and professional skills, which are required to solve clear-defined tasks.

In the Industrial Engineering and Management course, two production-related study foci were identified: networked systems and the focus on production and logistics.

Business Administration and Engineering

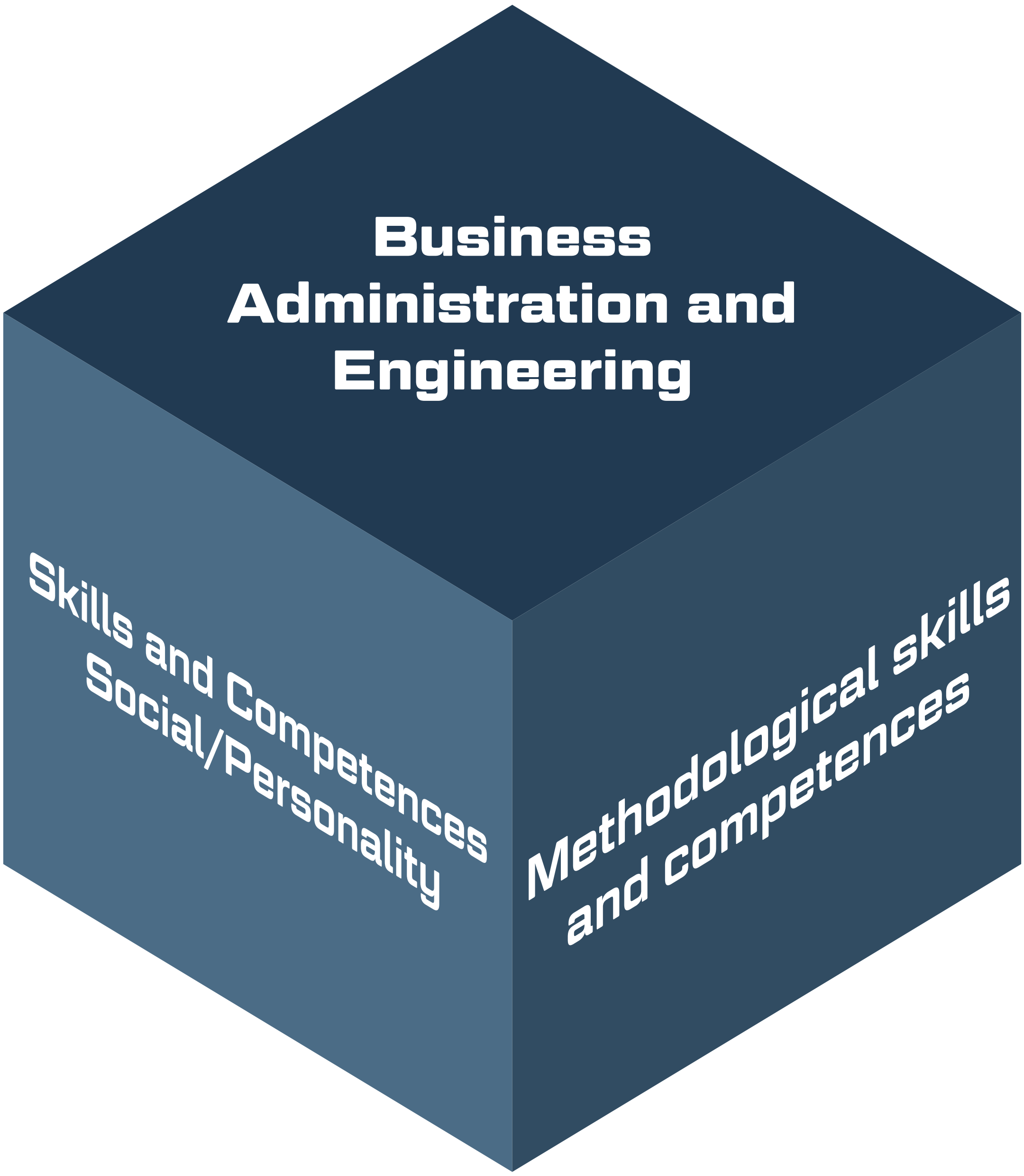
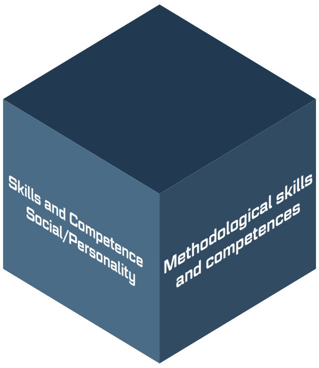


Figure 34: I4.0 Cube Business Administration and Engineering



I4.0 CUBE

Business Administration and Engineering

Functional Competencies Business Administration and Engineering

Focus production and logistics: Production Management, Logistics and Supply chain Management, Production systems, Process Management

Focus digital networked systems: Production Management, Logistics and Supply chain Management, Production systems, Process Management

Optional Module: sensors & actuators, industrial science, automation systms, automation technology.

Basic module Year 1

Mathematics, technical mechanics, IT knowledge, computer science, material science, business administration, economics, engineering design, knowledge of supply chain management

Basic module Year 2

Electrical engineering, electronics, engineering design, marketing, law, finance and accounting, basic engineering, market-oriented product development, intelligent networked systems

Basic module Year 3

Quality Management, Strategic Management, Controlling

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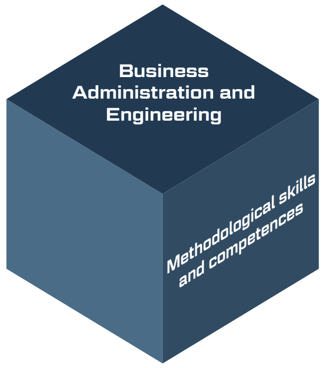

I4.0 CUBE Business Administration and Engineering

Skills and Competences Social/Personality

Business Administration and Engineering

Foundation	Social/Personality skills and competences
EQF level 6 - descriptors	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Basic module year 1	· Independent knowledge acquisition · Transfer skills · Responsibility
Basic module year 2	· Individual responsibility · Leadership · Cooperation · Integration of team members · Independent knowledge acquisition · Acting in a determined, sustainable and responsible manner evaluate social and socio-political impacts
Basic module year 3	· Self-management · Time management · Leadership · Ability to be critical · Ability to deal with conflicts · Enduringly and persistently solving tasks independently · Empathy

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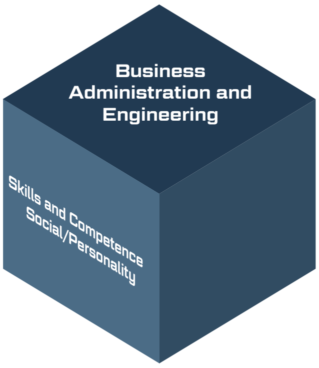

I4.0 CUBE Business Administration and Engineering

Methodological skills and competences

Business Administration and Engineering

Foundation	Methodological skills and competences
EQF level 6 - descriptors	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study
Basic module year 1	· Systematic & structured working approach · Technical problem solving · Interdisciplinary understanding of processes · Analytical working approach · Integration · Teamwork · Data management
Basic module year 2	· Communication · Integration · Project Management · Management of financial resources · Transfer skills · Complex problem solving · Critical & collaborative thinking
Basic module year 3	· Interdisciplinary approach · Communication · Cooperation · Abstraction ability · Systematic & analytical working approach · Intercultural skills · Deal negotiation skills · Risk analysis

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Computer Science

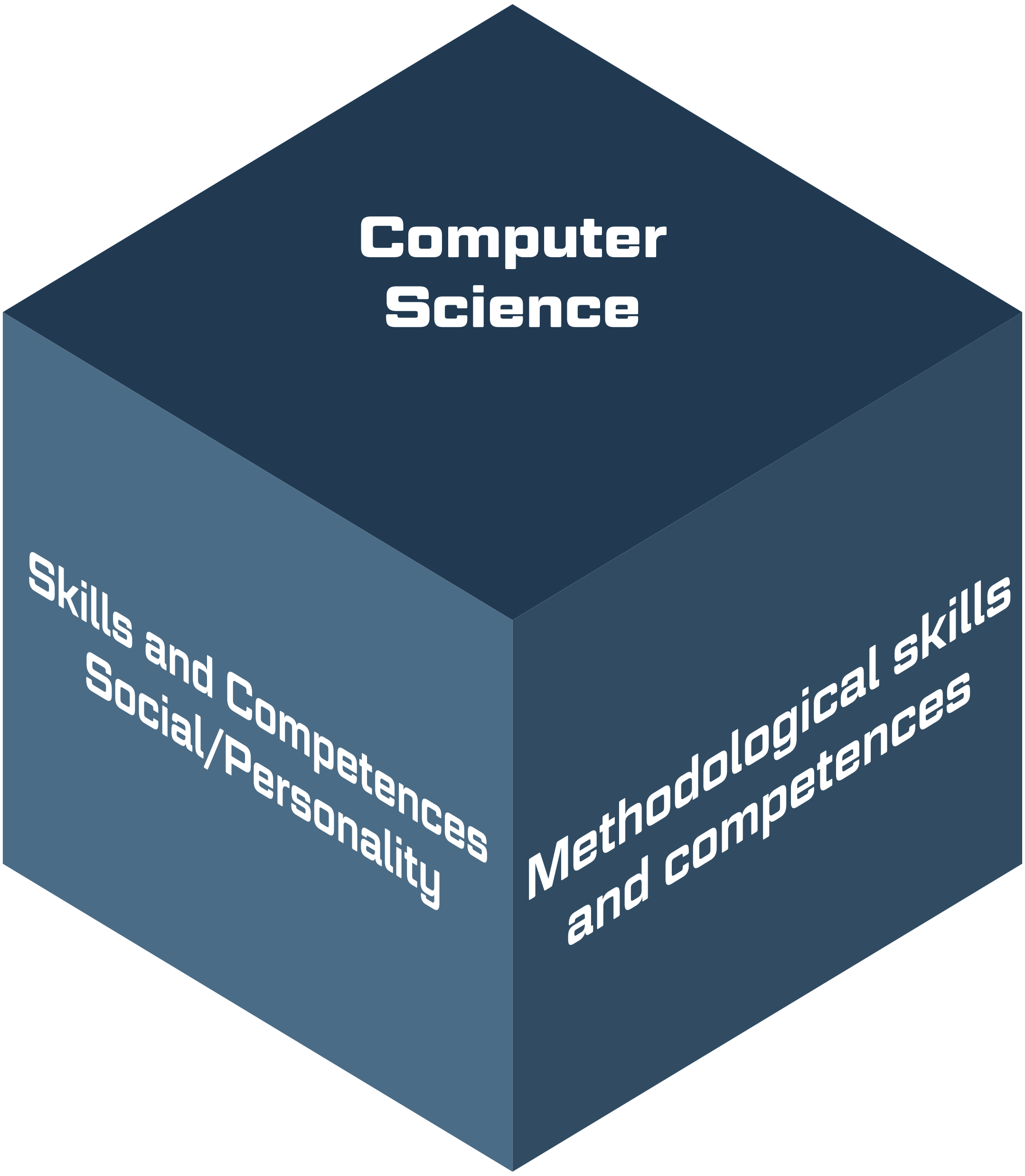
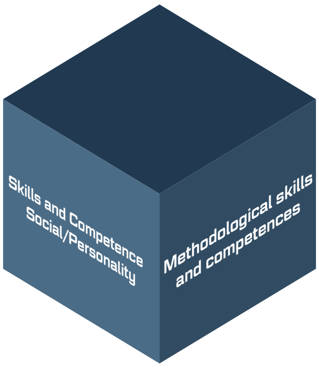


Figure 35: I4.0 Cube Computer Science



Computer Science

Functional Competencies in Computer Science and Automation

Optional Module: electronics, measurement data logging & visualisation, computer science, process automation, control engineering, information technology

Basic module Year 1

Mathematics, theoretical computer science, programming, computer science

Basic module Year 2

Mathematics, theoretical computer science, software engineering, database systems, computer science, communication & networks

Basic module Year 3

Software engineering, IT-Security

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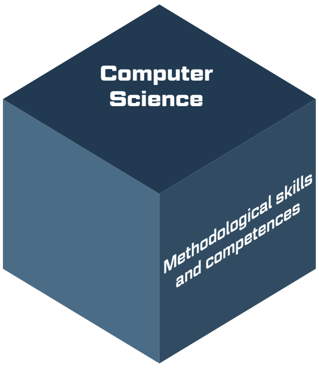

I4.0 Cube Computer Science

Skills and Competences Social/Personality

Computer Science

Foundation	Social/Personality skills and competences
EQF level 6 - descriptors	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups.
Basic module year 1	· Independent knowledge acquisition · Transfer skills · Responsibility
Basic module year 2	· Individual responsibility · Leadership · Cooperation · Integration of team members · Independent knowledge acquisition · Acting in a determined, sustainable and responsible manner · Decision-making · Ethics · Ability to work in intercultural environments
Basic module year 3	· Self-management · Time management · Independent acquisition of detailed topics · Leadership · Ability to be critical ability to deal with conflicts · Enduringly and persistently solving tasks independently

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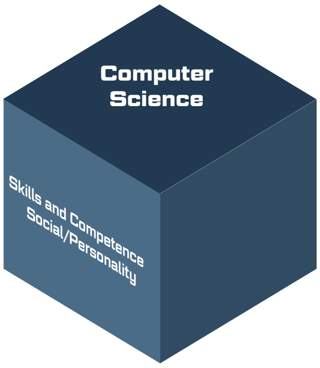

14.0 Cube Computer Science

Methodological skills and competences

Computer Science

Foundation	Methodological skills and competences
EQF level 6 - descriptors	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study
Basic module year 1	· Systematic & structured working approach · Data Mangement · Technical problem solving · Interdisciplinary understanding · Analytical working approach · Integration · Teamwork · Risk analysis
Basic module year 2	· Communication · Integration · Abstraction · Project Management · Transfer skills · Complex problem solving · Critical & collaborative thinking · Customer oriented
Basic module year 3	· Interdisciplinary approach · Empathy · Communication · Cooperation · Abstraction ability · Systematic & analytical working approach · Intercultural skills

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Mechatronics engineer

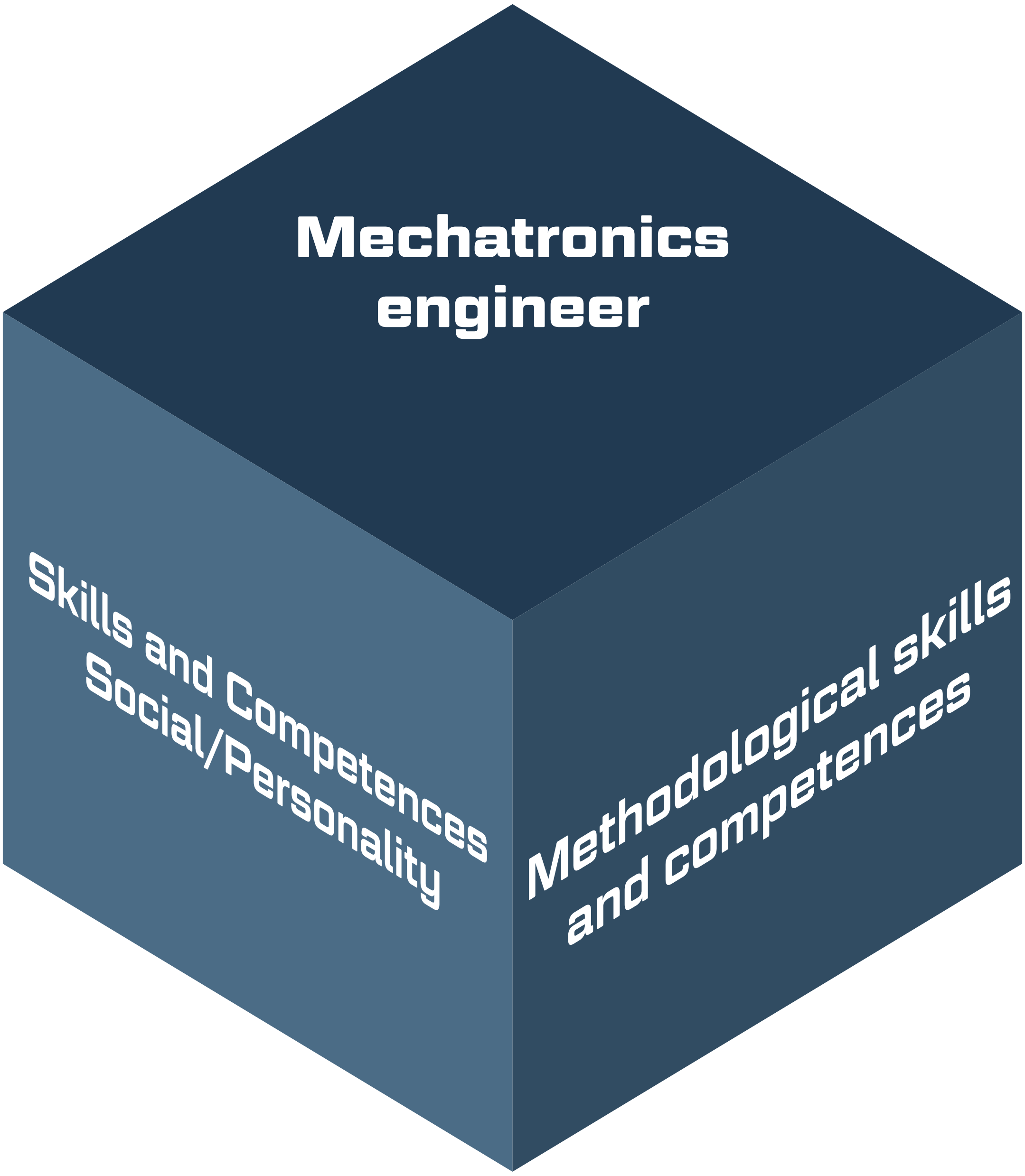
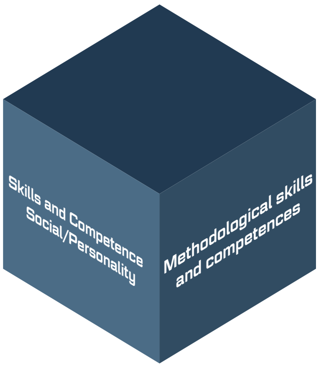


Figure 36: I4.0 Cube Mechatronics Engineer



I4.0 CUBE

Mechatronics engineer

Functional Competencies in Mechanical Engineering

Optional Module: analogue circuit design, microsystems technology, safety in HV systems, electromagnetic compatibility, design of digital systems, finite elements in MT, reliability, energy storage systems, lightweight design.

Basic module Year 1

Mathematics, physics, electrical engineering, mechanical engineering, construction theory, material science, English & personal skills, computer science, programming, digital control engineering and industrial trade market rights.

Basic module Year 2

Mechatronic systems, computer science, programming, electronic, micro computer technology, construction design, production engineering, mathematics, business & economics.

Basic module Year 3

Mechatronic systems, research, sensor systems, actuator systems, automation & control systems.

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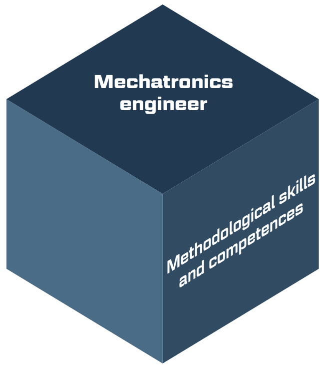

I4.0 Cube Mechatronics Engineer

Skills and Competences Social/Personality

Mechatronics engineer

Foundation	Social/Personality skills and competences
EQF level 6 - descriptors	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Basic module year 1	· Responsibility · Acting in a determined, sustainable and responsible manner · Integration
Basic module year 2	· Individual responsibility · Cooperation · Integration of team members · Independent knowledge acquisition · Acting in a determined, sustainable and responsible manner · Communication
Basic module year 3	· Self-management · Time management · Responsibility · Flexibility · Lifelong learning · Independent knowledge acquisition · Enduringly and persistently solving tasks independently
Focus energy economics	· Ethics · Reflect impacts of economical actions · Reflect social & political impacts · Leadership · Empathy

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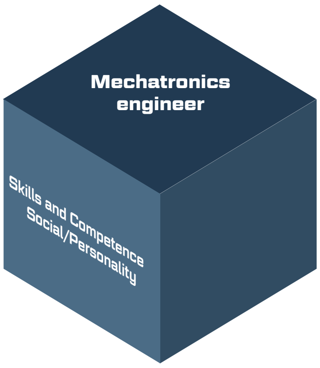

I4.0 Cube Mechatronics Engineer

Methodological skills and competences

Mechatronics engineer

Foundation	Methodological skills and competences
EQF level 6 - descriptors	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study
Basic module year 1	· Systematic & structured working approach · Technical problem solving · Transfer skills · Presentation skills · Teamwork /Cooperation · Intercultural competences
Basic module year 2	· Integration · Quality Management · Risk Management · Project Management · Transfer skills · Complex problem solving · Analytical thinking · Structured working approach · Critical & collaborative thinking · Customer oriented · Continuous experimentation
Basic module year 3	· Interdisciplinary approach · Communication · Cooperation · Critical thinking · Ability to deal with conflicts & to be critical · Systematic, structured & analytical working approach · Intercultural competences · Interdisciplinary understanding · Equipment safety · Complex problem solving · Customer orientation · Project management
Focus energy economics	· Decision-making · Renewable energies · Ability to work in an interdisciplinary environment · Abstraction ability
Focus Vehicle Systems Technology	· Intercultural competences · Working in engineering environment · Risk analysis of autonomous systems

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Mechanical Engineering

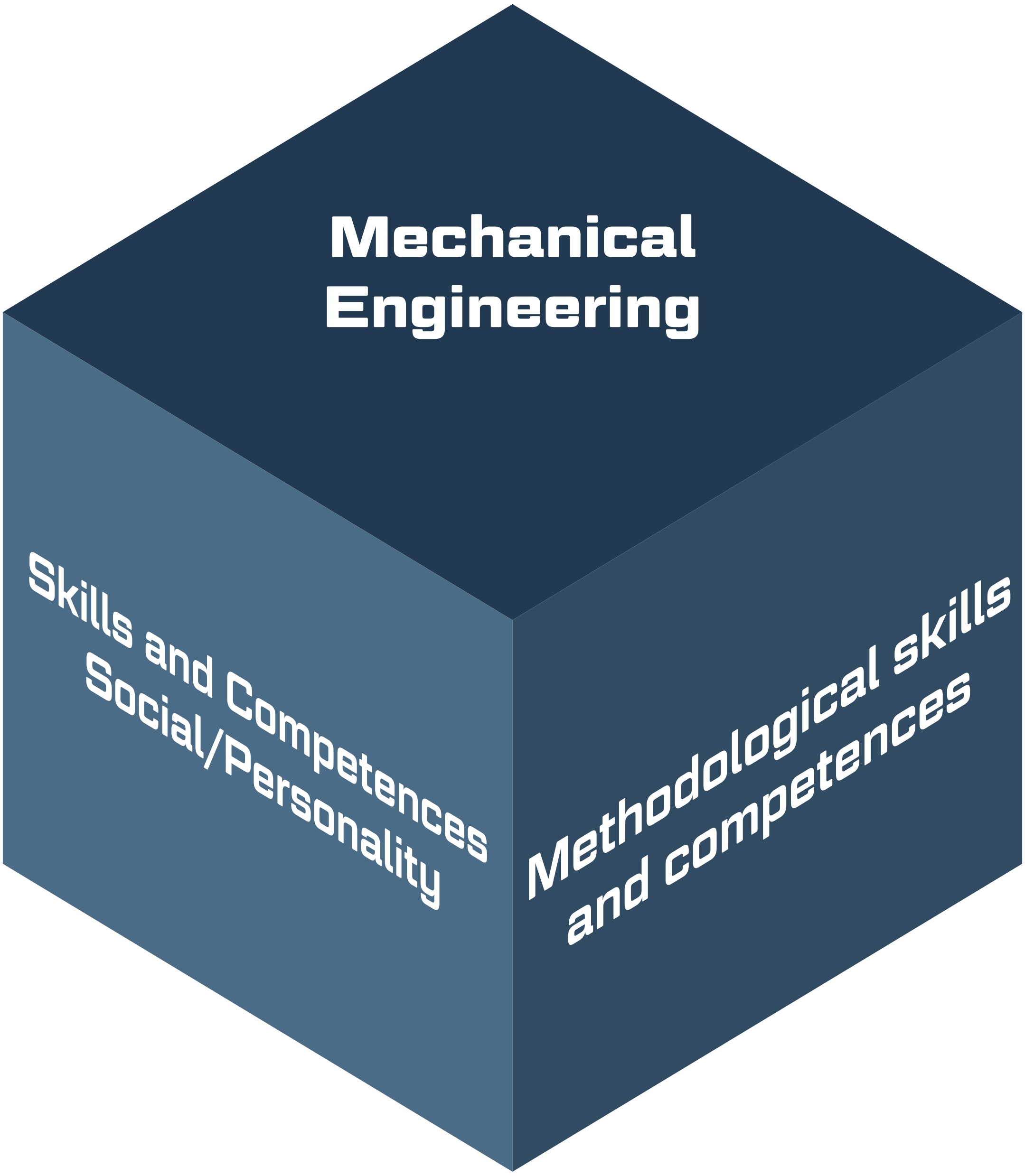
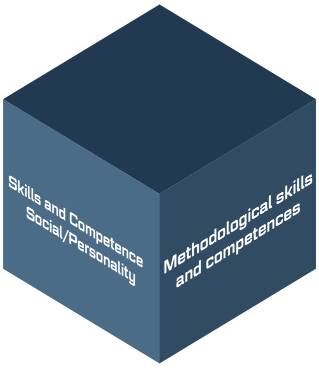


Figure 37: I40 Cube Mechanical Engineering



THE METHODOLOGY OF I4.0 CUBE

Mechanical Engineering

Functional Competencies Mechanical Engineering

Focus Design & Development: Mechatronic drive technology, machine dynamics / vibration theory, simulation technology, product development, construction/development engineering.

Focus Production Engineering: Manufacturing engineering, handling technology & automation, measuring technology & statistics, production planning, production engineering, production cost accounting**.**

Focus Mechatronics: Fluid mechanics, electronic & microcomputing, technology simulation, mechatronic systems.

Optional Module: Reciprocrating machinery, automotive transmission, air propulsion systems & fluid machinery, higher strength science, plant engineering, business law, IP management, robotics, marketing, composite structures, automotive technology, accounting &controlling, measurement technology, sensors & actuators.

Basic module Year 1

Mathematics, engineering design, manufacturing engineering, materials technology, engineering mechanics & stress analysis, computer science, electrical engineering.

Basic module Year 2

Mathematics, engineering design, thermodynamics, engineering dynamics & stress analysis, drive & transmission engineering, physics, business administration.

Basic module Year 3

Drive technology, quality management, control engineering.

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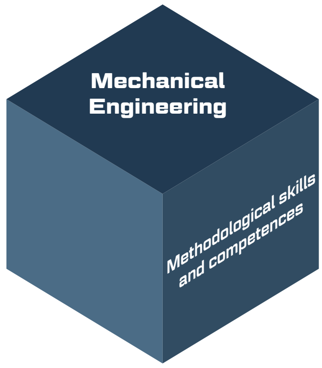

THE METHODOLOGY OF I4.0 CUBE

Skills and Competences Social/Personality

Mechanical Engineering

Fundation	Social/Personality skills and competences
EQF level 6 - descriptors	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Basic module year 1	· Ethics · Responsibility · Self-management · Integration/Cooperation · Teamwork · Communication
Basic module year 2	· Responsibility · Cooperation · Integration of team members · Independent knowledge acquisition · Acting in a determined, sustainable and responsible manner · Ethics · Communication
Basic module year 3	· Communication · Self-management · Time management · Responsibility · Enduringly and persistently solving tasks independently · Cooperation
Focus Production management	· Flexibility/Adaptability · Lifelong learning
Focus Automotive engineering	· Flexibility/Adaptability

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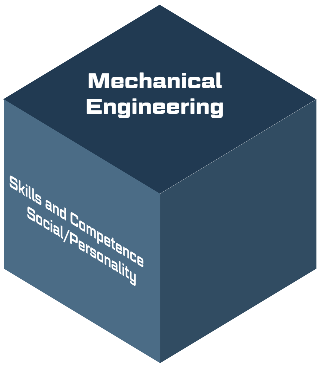

THE METHODOLOGY OF I4.0 CUBE

Methodological skills and competences

Mechanical Engineering

Foundation	Social/Personality skills and competences
EQF level 6 - descriptors	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study.
Basic module year 1	· Systematic & structured working approach · Complex problem solving · Transfer skills · Integration · Analytical thinking
Basic module year 2	· Project Management · Transfer skills · Complex problem solving · Analytical thinking · Structured & systematic working approach · Critical & collaborative thinking · Ability to work in an interdisciplinary environment · Decision-making · Intercultural competences · Ability to deal with conflicts & to be critical
Basic module year 3	· Quality Management · Project management · Systematic, structured & analytical working approach · Complex problem solving · Presentation skills
Focus Production management	· Production management · Abstraction ability
Focus Automotive engineering	· Technical transfer skills · Automotive engineering

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Mechatronic Technician

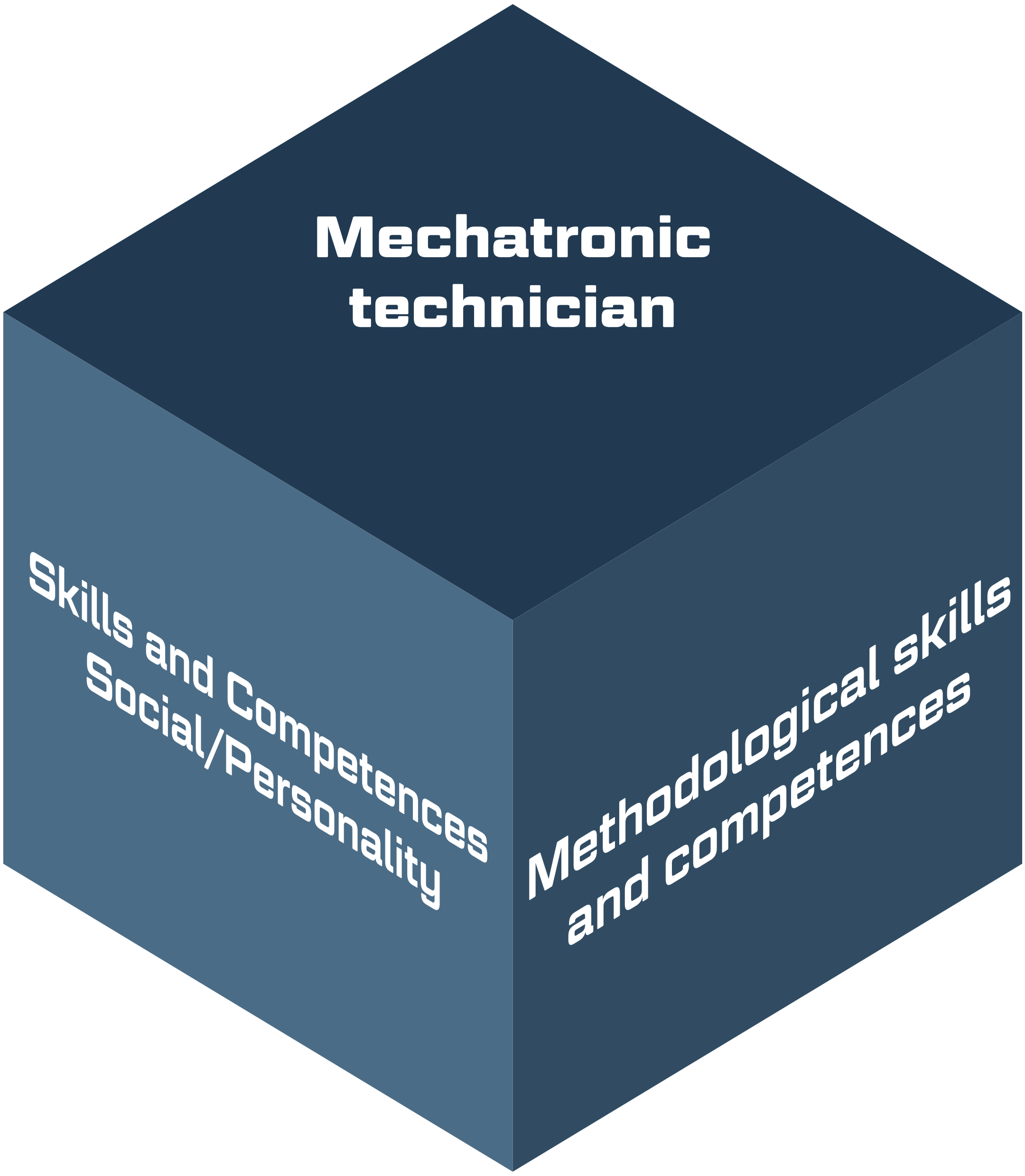
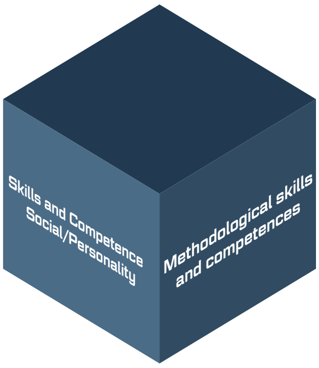


Figure 38: I4.0 Cube Mechatronic Technician



I4.0 CUBE

Mechatronic technician

Functional Competencies in Mechatronics technician

Year 1-4:

Vocational training, working law, collective bargaining law, safety & health protection, environmental protection.

Year 1:

Operational & technical communication, testing, marking, labelling, planning & controlling work process, checking & accessing work results, manual & mechanical machining, cutting & forming, installing electrical assemblies & components, measuring & testing electrical quantities, controlling.

Year 2

Operational & technical communication, planning & controlling work process, checking & assessing work results, installing electrical assemblies & components, installing & testing hardware & software, setting up & testing control systems, programming mechatronic systems, assembling components to form machines & systems, assembling & disassembling machines,/systems/equipment, testing & adjusting functions on mechatroninc systems, commissioning & operating mechatronic systems.

Year 3 & 4

Installing & testing hardware & software components, programming mechatronic systems, assembling components to form machines & systems, assembling & dismantling machines/systems/equipment, testing & adjusting functionson mechatronic systems, commissioning & operating mechatronic systems, maintaining mechatronic systems.

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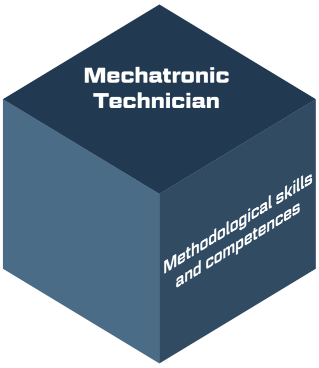

I4.0 Cube Mechatronics Technician

Skills and Competences Social/Personality

Mechatronic technician

Foundation	Social/Personality skills and competences
EQF level 5 - descriptors	Exercise management and supervision in contexts of work or study activities where there is unpredictable change; review and develop performance of self and others
Basic module year 1	· Responsibility · Integration · Teamwork · Communication · Flexibility · Reliability & Punctaulity
Basic module year 2	· Individual responsibility · Cooperation · Ethics · Teamwork
Basic module year 3	· Self-management · Time management · Acting in a determined and responsible manner · Leadership · Ability to be critical · Ability to deal with conflicts · Solving tasks independently · Empathy · Cooperation

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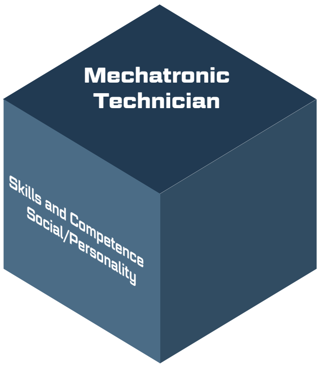

I4.0 Cube Mechatronics Technician

Methodological skills and competences

Mechatronic technician

Foundation	Methodological skills and competences
EQF level 6 - descriptors	A comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems
Basic module year 1	· Analytical working approach · Transfer skills
Basic module year 2	· Linked thinking · Systematic & structured working approach · Technical problem solving · Interdisciplinary understanding · Customer oriented
Basic module year 3	· Interdisciplinary understanding · Abstraction ability · Systematic & structured working approach · Decision-making

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- https://www.plattform-i40.de/PI40/Redaktion/EN/Use-Cases/374-dhbw-mosbach/article-dhbw-mosbach.html
- Innovae: https://bedigital.bilbaoexhibitioncentre.com/en/information/image-gallery/
- https://www.innovae.eu
- https://bedigital.bilbaoexhibitioncentre.com/en/exhibitor/INNOVAE/product/ATR-Technical-Remote-Assistant/19652
- https://bedigital.bilbaoexhibitioncentre.com/en/exhibitor/INNOVAE/product/ATR-Technical-Remote-Assistant
- https://keynetic.tech
- https://keynetic.tech/user/pages/flownac/flowNAC.pdf
- https://keynetic.tech/flownac
- https://keynetic.tech/flowsec
- https://keynetic.tech/user/pages/smart-grids-security/smartGrids.pdf

EXAM 4.0

THE EXCELLENT ADVANCED MANUFACTURING 4.0