

Competence matrix for working world 4.0 - mechatronics and electronics

These tables present the re-arranged competence profile by following the logics of competence matrix. However, for this purpose there were introduced some adaptations. Instead of competence area there is introduced competence change area, because the empirical study was based on such change areas identified in the literature analysis. For each additional competence change area we identified some work processes that require competence development. Then it is possible to identify the competences for each of these work processes.

COMPETENCE CHANGE AREAS		WORK PROCESSES FOR COMPETENCE DEVELOPMENT / Competences			
		1	2	3	4
1	Applying and development of the cyber-physical systems.	<p>1. He/She is able to install the autonomous systems with a remote monitoring.</p> <p>2. He/She is able to apply remote monitoring technologies to control the equipment, components and individual parts with CPS.</p> <p>3. He/She is able to execute the maintenance of the autonomous systems with a remote monitoring.</p>	<p>1. He/She is able to analyse the working environment with use of sensors.</p> <p>2. He/She is able to control the machines with the help of sensors.</p> <p>3. He/She is able to tune the machines in the production processes and systems with the help of sensors.</p> <p>4. He/She is able to define the sensors to place.</p>	<p>1. He/She is able to use multifunctional sensors.</p> <p>2. He/She is able to develop smart algorithms.</p> <p>3. He/She is able to elaborate the strategies on the basis of collected information.</p>	<p>1. He/She is able to use the industry-specific software products of production planning and preventive maintenance (PPS, ERP, MES, CAQ) to handle the production work process at workplace.</p> <p>2. He/She is able to use the industry-specific software products of production planning and preventive maintenance (PPS, ERP, MES, CAQ) to handle the order execution at the production unit.</p>
	<i>Possible transversal competences</i>				
	<i>EQF level</i>				
	<i>Referenced module</i>				

COMPETENCE CHANGE AREAS		WORK PROCESSES FOR COMPETENCE DEVELOPMENT / Competences				
		1 Use	2 Monitoring	3 Independent application	4 Installation and removal from disorders	5 Management
2	<p>Networking and connecting of the technical artefacts and processes by using Internet, linking and networking of the different production systems – CAD CAMMES, SAP, networking of all the processes of production and logistics.</p>	<p>1. He/She is able to execute operations with 3D printers.</p> <p>2. He/She is able to use the QR codes of production systems.</p> <p>3. He/She is able to use the process interfaces of the assistance systems as well as devices with local intelligence and decision capability.</p> <p>4. He/She is able to work with the visualization and assistance systems.</p>	<p>1. He/She is able to execute the monitoring of networked automatic manufacturing systems.</p> <p>2. He/She is able to adjust networked automatic manufacturing systems.</p>	<p>1. He/She is able to use the industry-specific software products of production planning and preventive maintenance (PPS, ERP, MES, CAQ) to handle the order execution at the production unit.</p> <p>2. He/She is able to operate networked equipment by applying SPS programming competence.</p> <p>3. He/She is able to connect the automation and information technology components horizontally and vertically to the Ethernet.</p> <p>4. He/She is able to select and configure bus systems of the automation technology (Ethernet, Modbus-TCP, Modbus RTU, CAN, SmartWire-DT, EtherCAT).</p> <p>5. He/She is able to apply networked planning and product management systems by using mobile terminals.</p> <p>6. He/She is able to be modify and test drive the different possible settings and parameters in a process.</p>	<p>1. He/She is able to conduct the introduction of information infrastructure of automated supply chains.</p> <p>2. He/She is able to apply and maintain the equipment and technologies of photonics and optoelectronics in the production processes.</p> <p>3. He/She is able to execute the monitoring of networked automatic manufacturing systems.</p> <p>4. He/She is able to apply trouble-shooting in network-based IT systems.</p> <p>5. He/She is able to adjust networked automatic manufacturing systems.</p>	<p>1. He/She is able to use material procurement management systems and the online portals of wholesalers for material procurement.</p> <p>2. He/She is able to perform independent work and individual business organisation by applying on-line solutions.</p> <p>3. He/She is able to create new algorithms and to create new applications in order to link many components or items and to synchronize them with the entire value chain. The following three bullet points indicate the important knowledge fields related to these competencies.</p> <p>4. He/She is able to extract the data from the sources of manufacturers and other relevant participants/partners of the production and business processes connected to the network, as well as to provide the data needed to ensure smooth organisation and execution of these processes. (e.g., exchanging the data of production orders, quality assurance data, information on logistics etc.).</p> <p>5. He/She is able to adjust working time organisation to requirements posed by communication with customers, suppliers and partners located in the different time zones.</p> <p>6. He/She is able to ensure and maintain the access of customers to monitoring and controlling of the own production process, including the production schedule and costs.</p> <p>7. He/She is able to ensure mutual transparent monitoring of the production management systems.</p>

						8. He/She is able to execute intelligent process control by using autonomy devices and adaptive systems.
	<i>Possible transversal competences</i>					
	<i>EQF level</i>					
	<i>Referenced module</i>					

COMPETENCE CHANGE AREAS		WORK PROCESSES FOR COMPETENCE DEVELOPMENT / Competences				
		1	2	3	4	5
3	Implementation and usage of Big Data, cloud computing.	1. He/She is able to understand the capacities of the fast Internet (4G and 5G).	1. He/She is able to use the services provided by the data-centers in the field of sorting and delivery of data. 2. He/She is able to apply identification systems (e.g., RFID) as well as system and Communication interfaces (OPC UA, ODBC). 3. He/She is able to execute maintenance of the production control systems based on Big Data and clouds.	1. He/She is able to analyse and select relevant data for the execution of work. 2. He/She is able to use the data from the cloud or BigData for the formulation of inquiries as well as to evaluate the data. 3. He/She is able to benchmark and compare production data on the level of workplace and on the level of enterprise / sector (between the different operators and producers). 4. He/She is able to evaluate and prove the validity of production/maintenance information from Big Data and clouds.	1. He/She is able to create productive and logistics cooperating models.	1. He/She is able to propose the solutions for application of Big Data in the production process by referring to the existing knowledge of the physical, technological and business (commercial) inter-relations.
	<i>Possible transversal competences</i>					
	<i>EQF level</i>					
	<i>Referenced module based on the proposed cases.</i>					

COMPETENCE CHANGE AREAS		WORK PROCESSES FOR COMPETENCE DEVELOPMENT / Competences					
		1	2	3	4	5	6
4	Implementation and usage of the Internet of Things	<p>1. He/She is able to understand the capacities of the fast Internet (4G and 5G).</p> <p>2. He/She is able to use digital measurement- and analysing equipment.</p> <p>3. He/She is able to use multifunctional sensors.</p> <p>4. He/She is able to execute PLC - and PC –programming, using interface/control programs.</p> <p>5. He/She is able to use new developed sensors, laser technology.</p>	<p>1. He/She is able to work with networked technologies by applying SPS programming competence.</p> <p>2. He/She is able to connect the automation and information technology components horizontally and vertically to the Ethernet.</p> <p>3. He/She is able to implement visualization software.</p> <p>4. He/She is able to ability to exchange of data between different network interfaces and manufacturers (gateways).</p> <p>5. He/She is able to execute “just in time” procurement of spare parts with the support of software.</p>	<p>1. He/She is able to apply software-based production planning systems in order to handle complex project planning and to design programming systems of different manufacturers in the automation technology.</p> <p>2. He/She is able to select and configure bus systems of the automation technology (Ethernet, Modbus-TCP, Modbus RTU, CAN, SmartWire-DT, EtherCAT).</p> <p>3. He/She is able to evaluate the information on the wear and tear of plant parts from a continuous monitoring of the machines by sensors.</p> <p>4. He/She is able to perform individualised maintenance of components of machines and plants by using continuous process of data acquisition.</p> <p>5. He/She is able to apply trouble-shooting in network-based IT systems.</p> <p>6. He/She is able to execute compilation of production systems.</p>	<p>1. He/She is able to execute PLC - and PC – programming, by using interface/control programs.</p> <p>2. He/She is able to develop smart algorithms.</p> <p>3. He/She is able to elaborate the strategies on the basis of collected information.</p>	<p>1. He/She is able to use the industry-specific software products of production planning and preventive maintenance (PPS, ERP,MES, CAQ) to handle the order execution at the production unit.</p>	<p>1. He/She is able to transform the projects based on software to the industrial projects by using PLC working processes</p>
	<i>Possible transversal competences</i>						
	<i>EQF level</i>						
	<i>Referenced module based on the proposed cases.</i>						

COMPETENCE CHANGE AREAS		WORK PROCESSES FOR COMPETENCE DEVELOPMENT / COMPETENCES			
		1	2	3	4
5	Protection against data leakages and protection of the sensitive data.	1. He/She is able to use security cameras in the processes of quality assurance and monitoring.	1. He/She is able to assess the sources of data in searches.	<p>1. He/She is able to deal with safety-relevant process steps and the corresponding steps in the software application.</p> <p>2. He/She is able to make decisions on the safety of exploitation of equipment through consistent use of existing safety measures (Backup, use of VPN and encryption, authentication, Anti-virus software, etc.).</p> <p>3. He/She is able to protect customers data in the case of production of personalized products in order to ensure, that personalized products would not get into mass production.</p> <p>4. He/She is able to protect the data in the personalized after-sales service and related contracting.</p> <p>5. He/She is able to handle new models and technological solutions of protection against hacking.</p> <p>6. He/She is able to apply business and production data and know-how standardization procedures to ensure data security, especially in the field of business-to-business.</p>	<p>1. He/She is able to setup IT networks using network routers.</p> <p>2. He/She is able to establish the access protection for automation systems as well as setup of IT networks using network routers.</p>
	<i>Possible transversal competences</i>				
	<i>EQF level</i>				
	<i>Referenced module based on the proposed cases.</i>				

Organisational changes

COMPETENCE CHANGE AREAS		WORK PROCESSES FOR COMPETENCE DEVELOPMENT / COMPETENCES		
		1	2	3
6	Dealing with flexible production process and direct involvement of customers and users in the design and production process.	<p>1. He/She is able to handle automatic manufacturing systems, also suitable for the production of small series and single pieces.</p> <p>2. He/She is able to understand and combine different machine programming languages.</p> <p>3. He/She is able to adjust micro-processors.</p> <p>4. He/She is able to execute software design and programming by using different programming languages.</p>	<p>1. He/She is able to work with new kind of User interfaces.</p> <p>2. He/She is able to apply the free-lancing business model in providing production services.</p>	<p>1. He/She is able to execute and maintain constant consultations with the customers, designers, main contractor and subcontractors.</p> <p>2. He/She is able to deal with quality control, safety and the environment, security of data and processes.</p> <p>3. He/She is able to reduce failure costs by applying fixed structured processes.</p> <p>4. He/She is able to comply with agreed acceptance procedures.</p> <p>5. He/She is able to minimize and prevent malfunction and failures.</p> <p>6. He/She is able to apply 3D visualization and modeling to detect design conflicts.</p>
	<i>Possible transversal competences</i>			
	<i>EQF level</i>			
	<i>Referenced module based on the proposed cases.</i>			

COMPETENCE CHANGE AREAS		WORK PROCESSES FOR COMPETENCE DEVELOPMENT / COMPETENCES			
		1	2	3	4
7	Planning, design and implementation of the intelligent work processes.	1. He/She is able to apply the work safety requirements for work with cobots.	1. He/She is able to analyse the customers' needs. 2. He/She is able to apply rapid "prototyping" solutions. 3. He/She is able to apply iterative design approaches in seeking for the target technological solution. 4. He/She is able to install and integrate various electrical and mechanical components into one solution	1. He/She is able to apply computer simulated copies of the real work process in solving the production problems. 2. He/She is able to test optimizations and separate/individual improvements of the production process. 3. He/She is able to apply the new kind of user interfaces. 4. He/She is able to work with secure computer communication, combined with the hardware. 5. He/She is able to review and analyse all the production and assembling processes and to provide the feedback for quality control of these processes. 6. He/She is able to develop interactive instruments and measures that use the possibilities of virtual reality.	1. He/She is able to plan and execute production processes by applying very flexible production and assembling facilities and equipment. 2. He/She is able to apply the flexible approaches of the work organisation and the operation and maintenance of the related equipment in the workplace.
	<i>Possible transversal competences</i>				
	<i>EQF level</i>				
	<i>Referenced module based on the proposed cases.</i>				

COMPETENCE CHANGE AREAS		WORK PROCESSES FOR COMPETENCE DEVELOPMENT / COMPETENCES		
		1	2	3
8	Dealing with quality processes based on measuring of the all processes and real time analysis of the data on their failures, forecasting and prevention of failures in the optimized processes.	<p>1. He/She is able to use complex systems to analyze and evaluate the quality of work.</p> <p>2. He/She is able to handle the feedback of quality control in the production and assembling processes with integrated quality assurance.</p> <p>3. He/She is able to deal with the monitoring and real time interaction in the integrated quality assurance processes.</p> <p>4. He/She is able to utilize real time data.</p> <p>5. He/She is able to work with intelligent systems.</p>	<p>1. He/She is able to execute interaction with help desk and technical support, online assistance.</p> <p>2. He/She is able to analyse and identify quality errors sources in the intelligent processing systems.</p>	<p>1. He/She is able to analyse the current customers' wishes.</p> <p>2. He/She is able to apply extrapolation techniques and methods in forecasting customers' wishes.</p>
	<i>Possible transversal competences</i>			
	<i>EQF level</i>			
	<i>Referenced module based on the proposed cases.</i>			

COMPETENCE CHANGE AREAS		WORK PROCESSES FOR COMPETENCE DEVELOPMENT / COMPETENCES				
		1	2	3	4	5
9	Application and development of the lean work organization in the production and provision of services	<p>1. He/She is able to update the basic data systems adapting to the requirements of changing operations.</p> <p>2. He/She is able to cooperate with the intelligent systems.</p> <p>3. He/She is able to update the new production data (technological and constructional) applied in the intelligent manufacturing systems.</p>	<p>1. He/She is able to handle integrated automatic systems operating in a highly computerized environment.</p> <p>2. He/She is able to maintain integrated automatic systems operating in a highly computerized environment.</p> <p>3. He/She is able to supervise integrated automatic systems operating in a highly computerized environment.</p>	<p>1. He/She is able to examine the efficiency and sustainability of the production processes.</p> <p>2. He/She is able to recommend the improvements and adjustments of the production processes.</p> <p>3. He/She is able to optimize the efficiency of the production process.</p> <p>4. He/She is able to reduce the stock material.</p>	<p>1. He/She is able to deal with the multiple tasks in the fields of mechatronics and electronics.</p> <p>2. He/She is able to cooperate with the different production units and departments in the field of design, production and service in dealing with multiple tasks.</p> <p>3. He/She is able to oversee and to plan the multitasked operations in the fields of mechatronics and electronics.</p>	<p>1. He/She is able to program integrated automatic systems operating in a highly computerized environment.</p>
	<i>Possible transversal competences</i>					
	<i>EQF level</i>					
	<i>Referenced module based on the proposed cases.</i>					

Societal changes

COMPETENCE CHANGE AREAS		WORK PROCESSES FOR COMPETENCE DEVELOPMENT / COMPETENCES	
		1	2
10	<p>Demonstrating increasing attention to the needs of users and consumers of technological products and services.</p>	<p>1.He/She is able to analyse the work processes and their requirements.</p> <p>2.He/She is able to design the individual career pathway for oneself and others in the field of production Do you mean his individual career pathway or career pathways in general??</p> <p>Example of reference to these competences in the assessment tasks by providing additional questions / tasks:</p> <ul style="list-style-type: none"> - Outline the main requirements of customers, enterprise, work safety and environment protection related to the execution of this task / operation. - Reflect on the possibilities of optimization of working time and resources in executing the task. - Indicate how the outcome of the performed task will be used in the further operations of production/service provision. 	<p>1.He/She is able to organise flexible work timing for workplace. Do you mean flexibly to organize or to organize flexible working times??</p> <p>2.He/She is able to handle the tasks of electricians for automation, including maintenance and assembling.</p> <p>3.He/She is able to ensure the smooth transferability of the systems of machines on further systems with the same systematic.</p> <p>4.He/She is able to act in highly robotized environment.</p> <p>Example of reference to these competences in the assessment tasks by providing additional questions / tasks:</p> <p>Prepare the schedule of work operations with application of robotized production lines.</p>
	Possible transversal competences		
	EQF level		
	Referenced module based on the proposed cases.		

COMPETENCE CHANGE AREAS		WORK PROCESSES FOR COMPETENCE DEVELOPMENT / COMPETENCES			
		1	2	3	4
11	<p>Dealing with changing modes of production and consumption towards increased focus on environment protection and environment friendly solutions</p>	<p>1.He/She is able to execute installation and start - up of battery packs for PV systems.</p> <p>2.He/She is able to execute maintenance of battery packs for PV systems.</p> <p>3.He/She is able to install and program smart home and smart grid systems and components.</p> <p>4.He/She is able to use and exploit sustainable energy and environment friendly technologies in the production processes.</p> <p>5.He/She is able to apply the mechatronic technologies, analogue controllers and sensors in the control of the hydro and wind energy generators.</p> <p>6.He/She is able to combine multiple energetic fields into the one solution.</p>	<p>1.He/She is able to analyse critically the technological solutions and applied work organization approaches.</p> <p>2.He/She is able to suggest the ideas on the optimization of the work processes of mechatronics and electronics.</p> <p>Example of reference to these competences in the assessment tasks by providing additional questions / tasks:</p> <p>Reflect (individually) or discuss in the group the performed work operations (in executing the task). Answer the following questions: What sources of waste of resources (materials, energy resources, water, etc.) can be identified in the execution of work processes?</p> <p>How to change the organisation of work or application of technologies at the workplace in order to reduce the waste?</p> <p>Reflect or discuss in the group the qualities of usage and consumption of produced item (product, part, unit,...) or provided service. Suggest the possibilities for improvement of the design and usage qualities of product (materials, design, safety of usage, impact to the environment).</p>	<p>1.He/She is able to adjust to the new ways and models of management of working time and space (24 hours designing, sharing workplaces, etc.).</p>	<p>1.He/She is able to participate in the planning of production.</p> <p>2.He/She is able to participate in the production management processes.</p>
	<i>Possible transversal competences</i>				
	<i>EQF level</i>				
	<i>Referenced module based on the proposed cases.</i>				

COMPETENCE CHANGE AREAS		WORK PROCESSES FOR COMPETENCE DEVELOPMENT / COMPETENCES		
		1	3	4
12	<p>Maintaining and development of communication and cooperation between the humans and CPS (like cooperation between humans and robots in the workplaces).</p> <p>Example of reference to these competences in the assessment tasks by providing additional questions / tasks:</p> <p>Any task based on the execution of the customers' order handled via Internet and using human-robot collaboration.</p>	<p>1.He/She is able to manage and apply assistance systems and tools.</p>	<p>1.He/She is able to handle robots and automation systems integrated in the production processes.</p> <p>2.He/She is able to manage intelligent systems.</p> <p>3.He/She is able to take professional and flexible actions in an environment of highly automated production processes.</p> <p>4.He/She is able to keep the systems running.</p>	<p>1.He/She is able to work in a highly automated and computer environment.</p> <p>2.He/She is able to produce and develop individual products (craftsmanship).</p> <p>3.He/She is able to apply production automation technologies.</p> <p>4.He/She is able to exchange the data in real time within the company and between the other elements of network, e.g. the client.</p> <p>5.He/She is able to apply flexible work organisation methods and approaches.</p> <p>6.He/She is able to counsel the colleagues and customers.</p>
	<i>Possible transversal competences</i>			
	<i>EQF level</i>			
	<i>Referenced module based on the proposed cases.</i>			

	COMPETENCE CHANGE AREAS	WORK PROCESSES FOR COMPETENCE DEVELOPMENT / COMPETENCES			
		1	2	3	4
13	Dealing with increasing integration of the production and service provision activities (e.g. technological development and healthcare, transformation of technological products to technological services).	<p>1.He/She is able to program the production processes.</p> <p>2.He/She is able to apply and adjust autonomous electronic systems for sharing management of production processes.</p>	<p>1.He/She is able to merger different core competences.</p> <p>Increasing role of inter-field competences</p> <p>2.He/She is able to adopt the increasing role of inter-field competences.</p>	<p>1.He/She is able to cooperate with robots.</p> <p>2.He/She is able to ability to use the newest and innovative solutions in the interest of activities.--> unclear</p> <p>3.He/She is able to generate the permanent need for finding the ways of improvement. →do you mean to comply with?</p> <p>4.He/She is able to productivity and reduction of the manufacturing costs, as well as improvement of cooperation and support principles between workers and CPS.</p> <p>5.He/She is able to develop and implement work models in teams.</p> <p>6.He/She is able to cope in a highly automated environment.</p>	<p>1.He/She is able to develop new ideas of products and services.</p>
	<i>Possible transversal competences</i>				
	<i>EQF level</i>				
	<i>Referenced module based on the proposed cases.</i>				