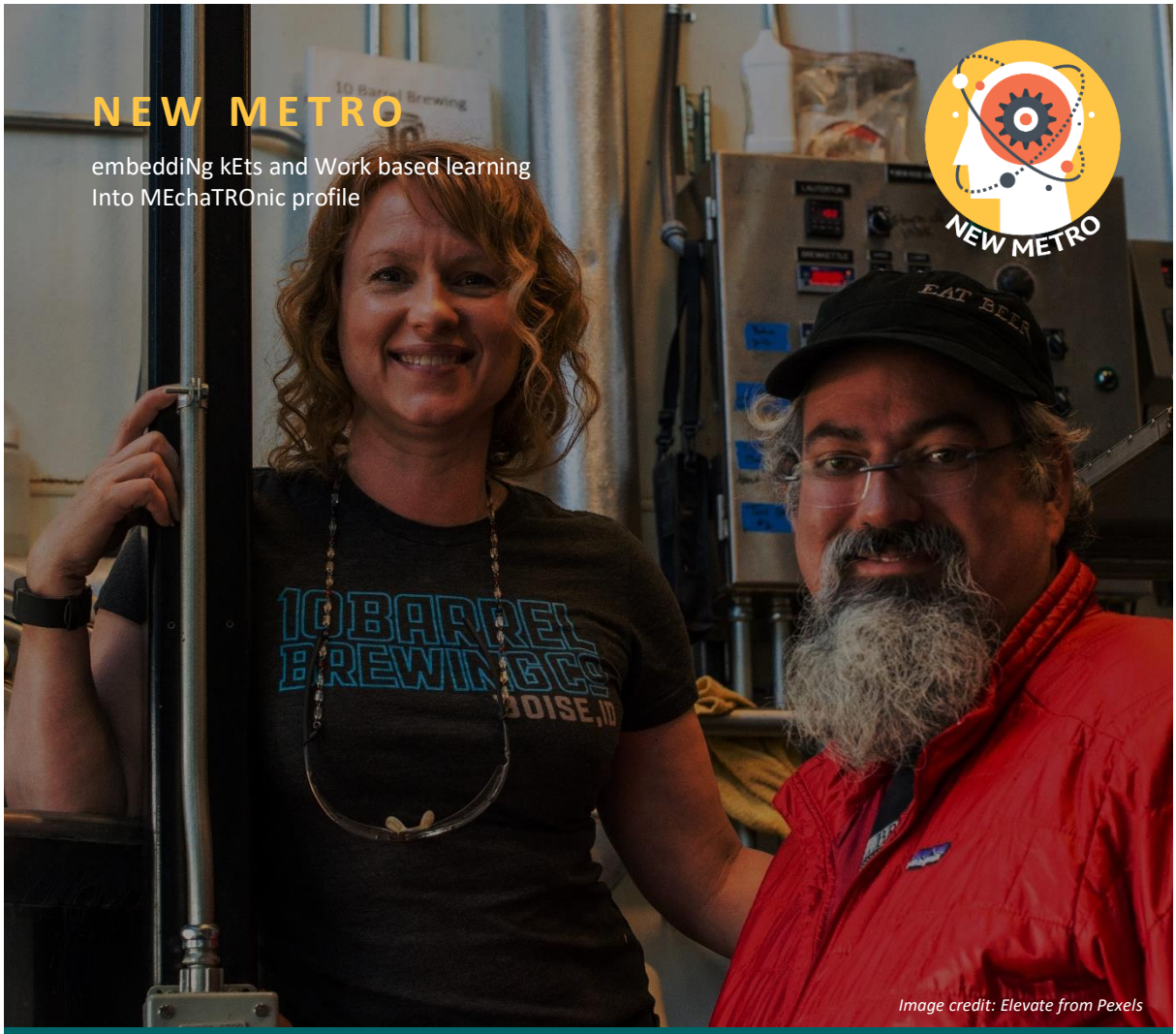


Image credit: Elevate from Pexels

NEW METRO

embeddiNg kEts and Work based learning
Into MEchaTROnic profile

INTELLECTUAL OUTPUT 3

The NEW METRO curriculum

European multi competences framework related to KETs and European assessment approach and tools

This project has been funded with support from the European Commission.
This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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

Image credit: This Is Engineering from Pexels

1. DOCUMENT INFORMATION

Project name	NEW METRO embeddiNg kEts and Work based learning into MEchaTROnic profile
Project number	600984-EPP-1-2018-1-IT-EPPKA2-SSA
Project web site	http://www.newmetro.eu/
Document Identification	
Document type	Report
Filename	NEWMETRO_D3.1_NEW METRO CURRICULUM
Current status	Draft
Current version	0.1
Contact person	Maria Pascal – Vincent Pastor
Peer Reviewer	
Dissemination level of the final version	☒ Public (final version) □ Restricted to other E+ Programme participants (only for members of the consortium including EACEA, Commission services and project reviewers) □ Confidential (only for members of the consortium including EACEA, Commission services and project reviewers)

Version history		
Version	Contributor(s)	Contribution
V 1	All partners	Compiling existing curricula from the partners
V 2	All partners ROLD company Italian Ministry of Education NEW METRO Stakeholder Community through the participation in the European Design Workshop	Work process analysis Identifying required competences Definition of the training paths Definition of the competences according to the ECVET Comparison between national qualifications and NewMetro curricula

V 3	ENSE (by Vicent Pastor Jordi Sanchez Antonia Rodriguez Raquel Morales	Final revision
V 4	FH Joanneum (by Maja Pivec)	Final Peer review

INDEX

Image credit: Kindel Media from Pexels

2. INTRODUCTION

According to the description of the NewMetro project, this work package (WP) will develop a European shared framework of competences in Mechatronics and the related KETs competences. Once the project has been able to elaborate a competences framework it will be necessary to provide not only a broad description of all the competences included in the framework, but also an explanation of the process to certify those competences deriving from both formal and non-formal learning processes.

The work package aims to define a framework of competences to innovate the profile of technicians in the mechatronic sector which can be recognized and used at the European level and is clearly linked to the NQF, EQF and the ECVET.

This WP will design a European competences framework linked to a post – secondary VET curriculum (EQF5)

This work package aims at defining a framework of competences of technicians in the mechatronic sector which can be recognized and used at the European level and is clearly linked to the EQF and the ECVET.

Once the project has been able to elaborate a competences framework it will be necessary to provide not only a broad description of all the competences included in the framework, but also an explanation of the process to assess and certify those competences deriving from both formal and non-formal learning processes.

In this document, the description of the European Framework of competences of the mechatronic technician will be based both on professional and training standards, and indicates training inputs as well as learning outcomes (explicit reference to the EQF and the ECVET), skills and competences necessary for the mechatronic technician to carry out his/her job.

The Framework will also include a shared model to assess and certify the competences at European level.

To implement this WP, with partner collaboration, it has been carry out these tasks:

3.1 Compiling existing curricula: Comparison of existing curricula for the mechatronic sector at the national and regional level.

3.2 Work process analysis: analysis the work process of the technician in the mechatronic sector in terms of functions, tasks, duties, levels of performance (i.e. the professional standards)

3.3 Identify required competences: identify and map the mechatronic technician's knowledge, skills, abilities, competences (including transversal ones) necessary to carry out the job tasks.

3.4 Definition of the European Framework of competences: The Partners will agree on the final formulation and definition of the European framework of competences

3.5: Analysis of the respective national or regional qualifications:

3.6 Providing tools for the identification, validation and certification of knowledge, skills and competences which have been acquired by young people or adult workers.

Europe holds a significant share in the growth potential of KETs, which could create new jobs at various occupational levels: from researchers and scientists holding university and postgraduate degrees to a range of technicians and specialists with secondary, post-secondary and non-university tertiary education.

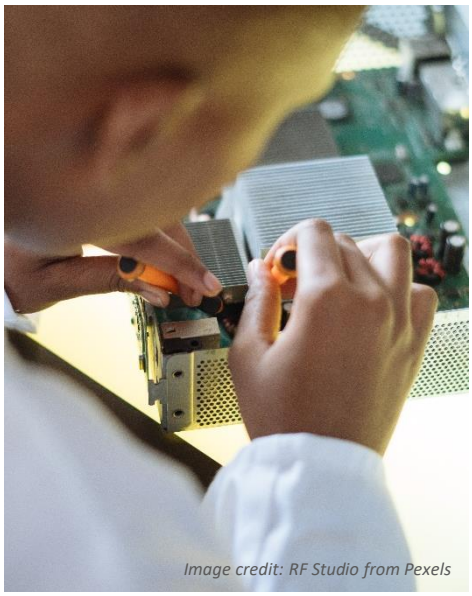


Image credit: RF Studio from Pexels

However, skills imbalances in KETs are likely to significantly diminish KETs growth potential and employment effects, furthermore, the EU is currently facing increasing competition from both developed and emerging economies. In this scenario there is the need to ensure a good alignment of educational programs with industry and to facilitate regular training of current employees.

The NEW METRO project addresses the skills gap in mechatronics, and aims to joint design, develop, concept-validating and validating:

- An innovative European shared competence framework,
- The related assessment and certification methods
- A European Learning delivery model, based on WBL, Virtual mobility and European set of VOOC.

The definition of the NEW METRO emerging skills was initiated with the key study produced within the first project action where the Consortium, thanks to a special involvement of the selected stakeholders, identified several knowledge, skills and competences, which a Mechatronic Technician working in the field of Mechatronic should have.

This document proposes a systemic approach to prioritize all the emerging mechatronic Competences according to the NEW METRO “three-circles model” and to describe each major Learning Outcome corresponding to these Competences. It is worth to mention that It was agreed that the result of this working phase is to develop an indicative, future-oriented competence framework and pilot curriculum that will not have to be immediately applied by each partner VET provider, but rather orient a medium-term-innovation path. Some elements of it will be experimented in a 3-year-training path, others will take more time to find the regulatory and organizational feasibility conditions to be applied.

Image credit: Andrea Piacquadio from Pexels

3. METHODOLOGY

3.1 COMPILING EXISTING CURRICULA

The comparative chart has been carried out with the aim of searching for similarities among the different CVs of the NEWMETRO project partners.

In this comparison, looking for similarities among the different modules, training units, etc, but only in how they are stated (Subject's statement) and how long they have. Therefore, for a more exhaustive analysis, the Learning outcomes, knowledge, skills, and competences of each of the previous titles should be analyzed.

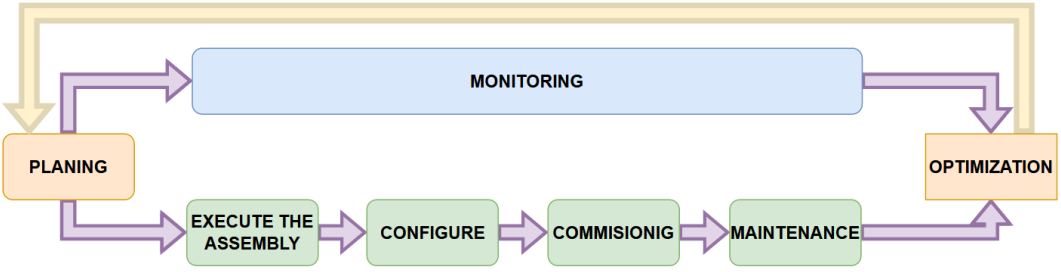
The comparison is based on the documentation supplied by the partners. The information provided is not directly comparable, because the study systems are different, titles EQF4, 5, 6 level, dual or non-dual are provided. Due to these differences, we have been forced to interpret the information to be able to present this comparative table for the title of Mechatronic level EQF5.

3.2 WORK PROCESS ANALYSIS

The WP leader, in collaboration with the other Partners, analysed the work process of the technician in the mechatronic sector in terms of functions, tasks, duties, levels of performance (i.e. the professional standards):

The first step was the recap of the mechatronic technician competences, as emerged in the previous NEW METRO Work Package.

A mechatronic is a professional which organizes and manages the assembly, configuration, commissioning, adjustment and repair of electromechanical equipment in industries that have a productive process implemented.



Competences of the profile:

1. Develop, represent, simulate and verify electronic, electric and mechanical products.
2. Program, configure, structure and manage automatic production control systems.
3. Manage, use, develop collection data systems to operate using artificial intelligence tools.
4. Configure, manage and maintain artificial intelligence systems.
5. Design, analyse and develop mechatronic systems using virtual prototyping and physical computing tools

These professionals are also responsible for organizing the loading / unloading and assembly / disassembly of electromechanical equipment and carry out the commissioning of electromechanical equipment by adjusting their operating parameters.

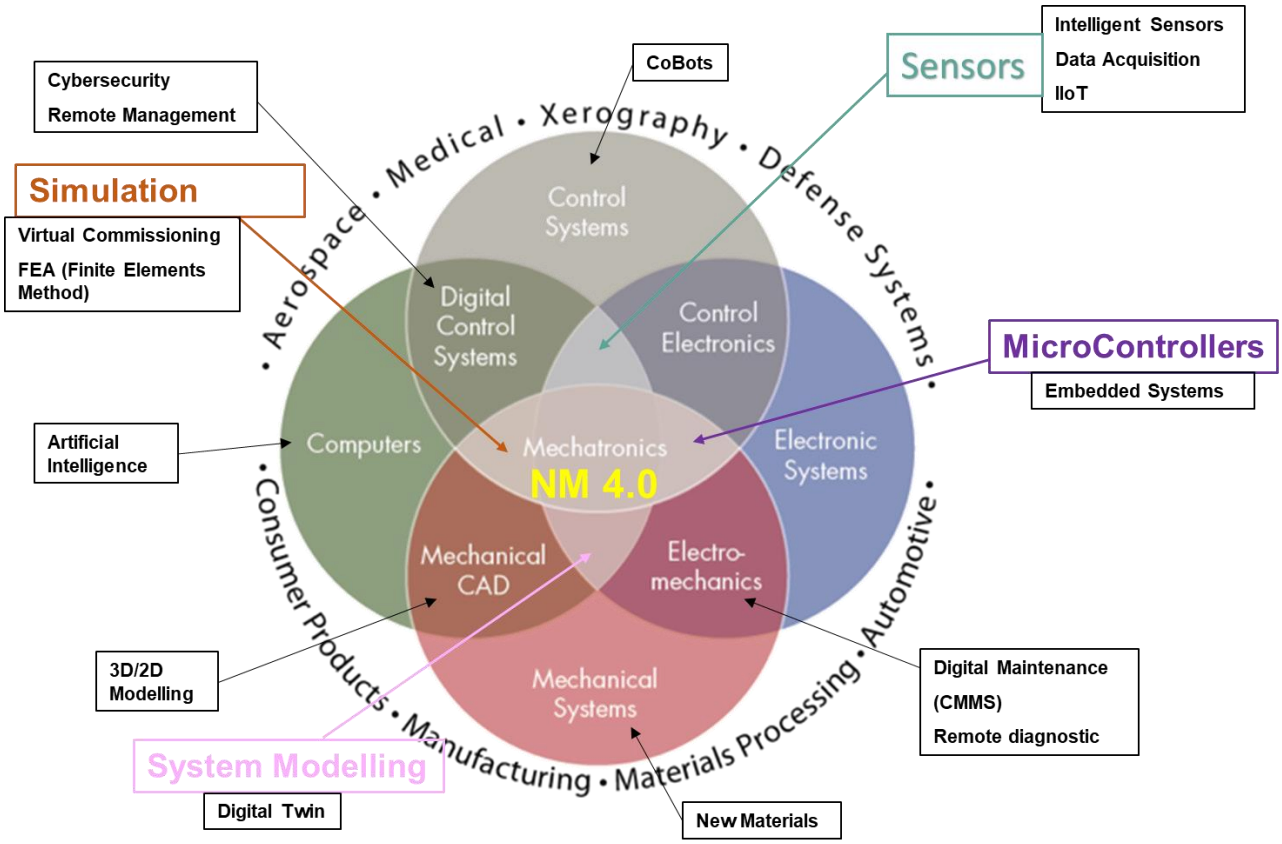
The electromechanical equipment maintenance technician must comply with the environmental, quality, safety and health standards at work.

The work group **revised and confirmed** the 17 Competencies identified in the **NEW METRO Work Package 2**, and included the new technologies (**KETS**) that impact on Mechatronic Skills.

Considering the 5EQF curricula already existing in the countries involved in the NEW METRO project, all the 17 competences present elements of innovativeness, with respect to the definition of Learning Outcomes and to the learning methodologies used. In particular, the partnership identified 4 "new" competences, i.e. not included in existing curricula.

1. Aptly choosing advanced materials that can suit product or process needs ***(new)***
2. System design and integration/interfacing between electronic and mechanical components (*assemble and test mechatronic units, set up machine controls, customize software, adjust engineering design)*
3. System automation, control and system support
4. Evaluate environmental impact both from product manufacturing and product whole life cycle ***(new)***
5. Define preemptive maintenance protocols and early diagnostic maintenance protocols (*maintain mechatronics equipment)*
6. Robotics programming (*set up automotive robot) assembly and manufacturing robots, collaborative robots*)

7. Design virtual testing and validation using modelling and simulation tools (*simulate mechatronic design concepts, use cae SOLUTIONS (computer aided engineering) as for example: cad (computer aided design) cam (computer aided manufacturing) fea (finite element method) smbd (simulation model based design)*
8. Develop the virtual prototypes in the real environment also thanks to physical computing tools
9. Utilize, choose, customize monitoring and data management systems *(monitor automated machines, record test data)*
10. PLC programming
11. Carry on diagnostic activities interfacing machines/assembly lines and collecting data by visual programming tools (*resolve equipment malfunctions, maintain control systems for automated equipment, perform test run)*
12. Access and manage database using SQL (record test data)
13. Identify and utilise the main artificial intelligence tools
14. Manage, utilise, storage data network tools
15. Evaluate ergonomic aspects of industrial logistics *(workloads, movements, time constraints, use of mobile devices, etc.)* ***(new)***
16. Evaluate advanced logistics project aspects like cost/benefit ratio, safety, impact, threats, maintenance, etc. *follow safety standards* ***(new)***
17. Cybersecurity awareness.



New technologies (KETS) that impact on Mechatronic Skills

3.3 IDENTIFYING REQUIRED COMPETENCES

Referencing to the "Three-circles model" (see box 1) An attempt was made to place each of the 17 competences into the first or the second circle, leaving the third circle empty and available for specific competences required by the local labour market. While the first circle represents the common learning outcomes to be developed in the first part of the course, the second circle includes the areas of profile differentiation according to the four functional areas agreed in WP1 and 2 (R&D, Operational and Logistics, Information Technology, QA, diagnostic and maintenance). The main reason for differentiating profiles in the second circle is also the fact that if all competencies were developed at an advanced level, two years of course would not be enough.

As the exercise began, it became evident that practically each competence could generate two, one with a basic level that every mechatronics technician should faster, and a second one, that we called advanced, that belongs rather to the second circle (meaning that some students who are addressing one or two of our profile will cover it, but not the others. In this way the objective of designing earning paths of 120 ECTS credits/1800-2000 hours of classroom and work-based learning (plus autonomous study) will be achievable. The result of this exercise is reported in the figure 1, in which

the position of the competences according to our functional areas is significant in circle 2, while it has no practical implications for the core circle (all the competences will be covered at the basic level by all students). The four areas are: IT (Information Technologies), R&D (Research and Development), Op&Log (operations and Logistic), QA (Quality Assessment).

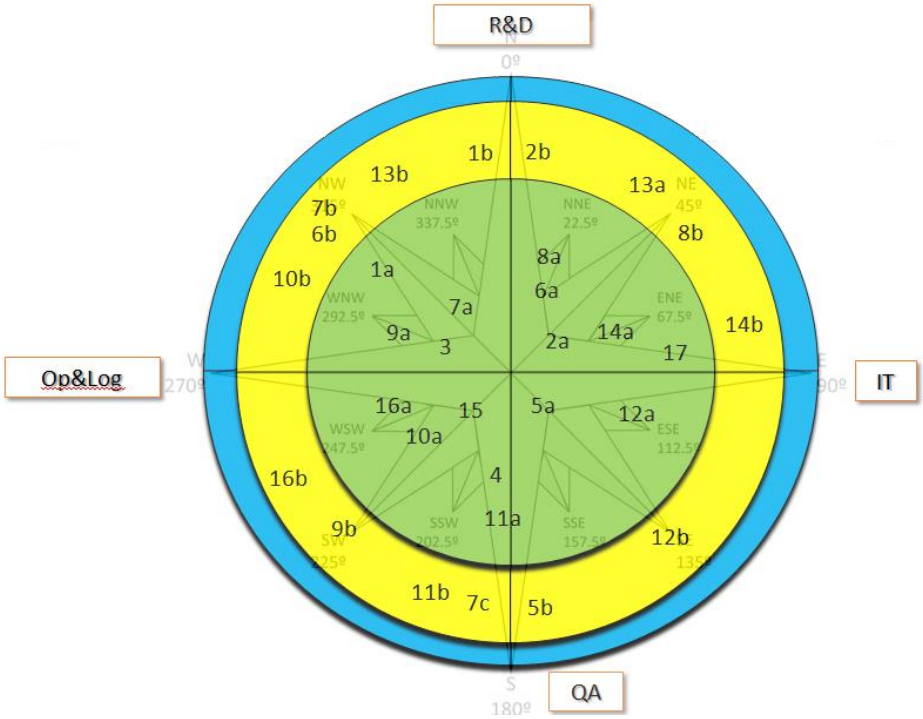


Figure 1: THREE-CIRCLES DIAGRAM

*BOX1_The **three-circles diagram** has been adopted by NEW METRO as « Structure of the new European Qualification". In the **smaller circle** we want to identify the absolute common core (both technical and soft skills) of the new qualification to be developed at EQF Level 5. In the **second circle** we can identify those competences (or higher levels of performance –compared to the core circle) that are required to perform one of the functions/operational profiles or specialisations towards which the learners will differentiate their training paths (see below), also depending on the industrial sector in which he/she will probably be employed. In the **third circle** other competences can be added to satisfy specific requirements of a local context (for example a cluster of specialized enterprises expressing similar skills shortages). This proposed structure gives the possibility to differentiate training paths while keeping a common recognisable framework, a common methodology and a central core of learning outcomes that identify the new qualification*

Once the mapping was concluded, the **Module Description Format** was defined, assuming (in first instance) that each of the Competences in the "Three-circles map" will become a Module of 3-4 ECVET Units. However, this does not need to be applied in all cases, and for organisational or practical reasons a Module might contain more than one major learning outcome.

An interesting element to note is that these descriptions have a different degree of "regulatory value" even as proposals: while the left side of the description suggests some assessment criteria/approaches that are directly related to the macro-competence that gives the name to the module (**and should preferably integrate knowledge, skills and transversal skills in the execution of a complex performance**), the specific learning outcomes on the right side - divided into the classic three categories Knowledge, Skills (technical) and Transferable Skills (including attitudes and ways of performing tasks) - are just examples of how the development of a module might be planned by the design and teaching team in a given provider of high level VET. **In principle all micro-learning outcomes, including those referring to cognitive objectives (knowledge, the first group on the right side) should be defined as observable behaviour (e.g. the categories and verbs suggested by Bloom's taxonomy), not just by mentioning a content item.**

3.4 DEFINITION OF THE EUROPEAN FRAMEWORK OF COMPETENCES

Once the mapping was concluded, the **Module Description Format** was defined, assuming (in first instance) that each of the Competences in the "Three-circles map" will become a Module of 3-4 ECVET Units. However, this does not need to be applied in all cases, and for organizational or practical reasons a Module might contain more than one major learning outcome.

The format of the description is as show in the next figure:

Functional Area:	
Pre-Requisites:	
Assessment criteria	**Knowledge**

	Skills
	Transferable skills

An interesting element to note is that these descriptions have a different degree of "regulatory value" even as proposals: while the left side of the description suggests some assessment criteria/approaches that are directly related to the macro-competence that gives the name to the module (**and should preferably integrate knowledge, skills and transversal skills in the execution of a complex performance**), the specific learning outcomes on the right side - divided into the classic three categories Knowledge, Skills (technical) and Transferable Skills (including attitudes and ways of performing tasks) - are just examples of how the development of a module might be planned by the design and teaching team in a given provider of high level VET. **In principle all micro-learning outcomes, including those referring to cognitive objectives (knowledge, the first group on the right side) should be defined as observable behavior (e.g. the categories and verbs suggested by Bloom's taxonomy), not just by mentioning a content item.**

The NEW METRO collection of Competences is available in the **results** section of this document.

At this point, we ask stakeholders' evaluation and feedback on the proposed competences and a validation of learning outcomes. More specifically, considering the form each competence is articulated, we ask to stakeholders:

Functional Area: Is this competence properly allocated?	
Pre-Requisites: Is this definition important for the module? Are the prerequisites well expressed? If not, please give your motivations and an example pertinent with the competence to be validated	
Assessment criteria	**Knowledge**
Considering your point of view: ● Are the assessment criteria applicable? ● Are they measurable? ● Would you add some more assessment criteria, referred to specific sectors? (e.g. considering the 3rd circle in the NEW METRO competences model, you can add assessment criteria relevant for specific sectors or local industrial district)	Is it proper for this LO?
	Skills
	Is it proper for this LO?
	Transferable skills
	Is it proper for this LO?

The goal was analysis and validation of NEW METRO competencies.

The targets involved in Stakeholders Community represent:

- Companies (Managers, Workers)
- Public administration
- Universities and schools (Teachers, Students)

Due to the pandemic situation, the meeting was replaced by an online survey, relevant follow-on results collections and online meetings. Some of the meetings were held in person and also by telephone interviews.

The consultation was carried out in accordance with the methodology jointly adopted by the NEW METRO Partnership, by means of:

A first online meeting as introduction to the NEW METRO module competences description, in order to align the Stakeholder's interpretation based on key document "NEW METRO_ emerging skills and LO_def". Aim for the NEW METRO working group was "prioritizing the emerging skills in Mechatronic Technician Profile".

A second step supported by an online survey, aimed at collecting Stakeholders' contributions on selecting 12 emerging competences, assuming a vision for the future development of KETs in manufacturing processes. 10 of these 12 competences were to be chosen from the 17 identified in the previous NEW METRO steps, while further 2 new competences were going to be proposed by the Stakeholders, expressing a need for sectoral or territorial mechatronic development.

The result of this feedback is available in the **results** chapter of this document.

3.5 ANALYSIS OF THE RESPECTIVE NATIONAL QUALIFICATIONS

Partners will highlight the key occupational activities with the aim of mapping which are the common areas among the different qualifications systems. This will allow us to identify converging occupational activities that result most requested, and hence particularly suitable, to fit the European dimension. ***Common (European) learning outcomes*** will be identified and grouped in different units in terms of knowledge, skills and competences and the partners will develop accompanying documents related to:

-the conditions for 'accessing' the learning module or unit (i.e. a description of the technical and methodological prerequisites that learners need);

-the validation of the modules or unit (assessment grid and guidelines).

They will highlight the key occupational activities with the aim of mapping which are the common areas among the different qualifications systems. This will allow us to identify converging occupational activities that result most requested, and hence particularly suitable, to fit the European dimension. ***Common (European) learning outcomes*** will be identified and grouped in different units in terms of knowledge, skills and competences and the partners will develop accompanying documents related to:

- The conditions for 'accessing' the learning module or unit (i.e. a description of the technical and methodological prerequisites that learners need).
- The validation of the modules or unit (assessment grid and guidelines).

3.6 PROVIDING TOOLS FOR THE IDENTIFICATION, VALIDATION AND CERTIFICATION OF KNOWLEDGE, SKILLS AND COMPETENCES WHICH HAVE BEEN ACQUIRED BY YOUNG PEOPLE AND ADULT WORKERS IN DIFFERENT LEARNING CONTEXTS, FORMAL, INFORMAL AND NON-FORMAL ONES

The academic recognition for learning achieved through work experience or social activities is aimed at people who want to have an academic recognition of the learning acquired **in different learning contexts** related to a specific training VET program.

In our opinion this academic recognition can be divided in two different Steps:

1st STEP: Assessment of the user: It can be carried out by any organization.

The vocational training advice board aims to define and guide the training and professional itinerary of the person concerned in order to improve their qualification. It has the personalized attention of experts from the chosen professional family.

During the counselling/advice process, which takes place over 2 or 3 face-to-face sessions, the user provides all the documentation available to assess the training and employment record/portfolio.

As a result of the process the user obtains an advisory report that contains his itinerary with the recommendations to carry it out.

This report is a prerequisite for applying for the academic recognition for learning that has been achieved through different learning contexts.

2nd STEP: Recognition of the knowledge, skill or competence: It can be carried out **Only** by an Official Academic Organization *(If it is an official recognition it has to be carried out by an official Organization)*

A recognition board evaluates the user. This is made up of two teachers/experts from the training VET program.

The board analyses the advisory report, obtained in the advisory service, and the other documents provided by the person from the training units or competences that he/she wants to be recognized.

It also summons the person to do a personal interview of contrast and value, in a collegial way, the learnings achieved through different learning contexts.

If the board academically recognizes certain training units or competences, the centre issues a partial certificate with academic value.

Subsequently, if you want to obtain the title of the corresponding VET program and validate the training units or competences (recognized) you must enroll, in whole or in part, in the corresponding training VET program, accrediting the academic access requirements established for the cycles intermediate or higher level training, as appropriate.

Image credit: Tiger Lily from Pexels

4. RESULTS

This section summarises the work package results. On the one hand, the development of a competence embedded European framework for Mechatronics vocational studies (EQF 5). On the other hand, several specialisation VET courses have been designed, taking into account the 3circle model. Also, all the mechatronic VET studies in all the partner countries have been analysed, in order to be the competencies in those, compared with the ones included in the NewMetro developed model. Last but not least, as mentioned before, the New Metro proposed model will be used to identification, validation and certification of knowledge, skills and competences which have been acquired by young people and adult workers in different learning contexts, formal, informal and non-formal ones.

4.1 COMPARISON BETWEEN THE DIFFERENT CURRICULA OF THE PARTNER'S COUNTRIES/REGIONS

→ Curricula Comparison Chart

The attached comparative map of existing Mechatronics curricula shows the different areas, the duration in hours, the main contents provided in each national program. Having a glance at the chart looking for differences, we realize that:

- "Hydraulics and pneumatics" are not present in three curriculums. The second language is only offered by two countries.
- One of the syllabi is based on automotive studies differing from the Mechatronics area.
- Some of the syllabi include basics such as Maths, office studies, Geography, religion.
- One of the syllabi includes CNC studies.
- Similar subject statements among syllabi have different numbers of hours of dedication.

If we have a look to find similarities, we can find:

- Mechanical systems, assemblies, maintenance operations and protocols, elements.
- Electrical, electronic systems
- Pneumatic and hydraulic systems
- Computer-assisted design and graphic representation
- Workplace safety and health protection
- Introduction to business

Valuing all this information, having in mind how technology has developed in the last decade, we need to add all the new technologies, second language, and standardise the current syllabi.

In order to standardise the educational programs of the different countries, it is first necessary to define what constitutes a mechatronics profile for each country and to reach a consensus on the European profile.

To find factual similarities and standardise the Mechatronic Technician profile, it's compulsory to identify the competences of each knowledge area, but the information is not complete in the documentation provided.

It would also be necessary to agree on the levels of knowledge and skills of each competence to acquire, and therefore on their previous knowledge. Another topic to be taken into account would be to define the hours of formation of the formative cycle, the hourly distribution by course or semester, and by competence in each level. It would be advisable to define the hours to be given of the first course or first semesters that would be common for the four specializations, which could be chosen after the base course. These four specialities are those already defined in the working group: R&D, Op&log, IT, QA. In this way, the hours to be given in the second or subsequent semesters in these four specialties must also be defined. It would also be necessary to define the hours of internship to be taken into account in the curriculum of the mechatronic profile.

We have to emphasize the use of E-learning methodology, talking about VOOC format. These platforms have allowed, to a greater extent, unemployed people to acquire basic and even advanced knowledge of subjects necessary for their employability.

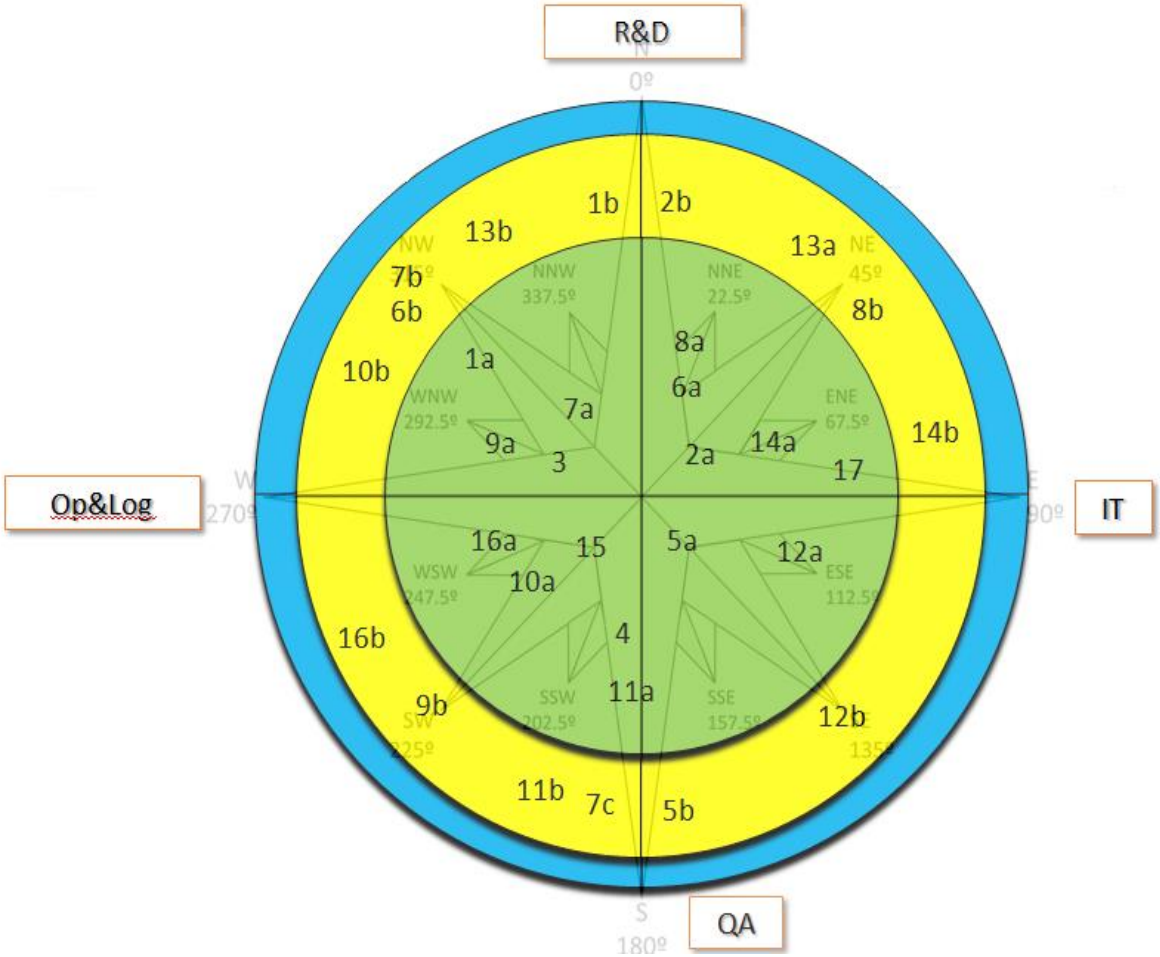
As well, VOOCs have also served to increase satisfaction in more advanced courses since the people who signed up for these higher-level courses came from a predetermined level; that they were interested in continuing to advance in that learning, thus avoiding frustrations of false expectations or demotivating topics due to lack of interest.

That can be a standard, tailored and personalized training is a value to develop our professional capacity, our competences and therefore knowledge that makes us be much more productive, and therefore achieve self-fulfillment.

4.2 DISTRIBUTION OF COMPETENCES IN THE 3CIRCLE-MODEL

Competence	n.	Position in the 3 Circle Model	Functional Area
Aptly choosing advanced materials that can suit product or process needs (new)	1.a	Core	Op&Log / R&D
	1.b	Technical	R&D
System design and integration/interfacing between electronic and mechanical components	2.a	Core	R&D / IT
	2.b	Technical	R&D
System automation, control and system support	3	Core	Op&Log
Evaluate environmental impact both from product manufacturing and whole life cycle	4	Core	QA
Define preemptive maintenance protocols and early diagnostic maintenance protocols	5.a	Core	QA
	5.b	Technical	QA
Robotics programming (set up automotive robot) assembly and manufacturing robots, collaborative robots)	6.a	Core	R&D
	6.b	Technical	R&D / Op&Log
Design virtual testing and validation using automatic and simulation tools	7.a	Core	R&D / Op&Log
	7.b	Technical	R&D / Op&Log
	7.c	Technical	QA
Develop the virtual prototypes in the real environment also thanks to physical computing tools	8.a	Core	R&D
	8.b	Technical	R&D / IT

Utilize, choose, customize monitoring and data management systems (monitor automated machines, record test data)	9.a	Core	Op&Log/R&D
	9.b	Technical	Op&Log / QA
PLC Programming	10.a	Core	Op&Log / QA
	10.b	Technical	Op&Log/R&D
Carry on diagnostic activities interfacing machines/assembly lines and collecting data by Visual Programming tools (resolve equipment malfunctions, maintain control systems for automated equipment, perform test run)	11.a	Core	QA
	11.b	Technical	QA
Access and manage database using SQL (record test data	12.a	Core	IT
	12.b	Technical	IT/QA
Identify and utilize the main Artificial Intelligence tools	13.a	Technical	R&D / IT
	13.b	Technical	R&D / Op&Log
Manage, automat, storage data network tools	14.a	Core	IT
	14.b	Technical	IT
Evaluate ergonomic aspects of industrial logistics (workloads, movements, time constraints, use of mobile devices, etc.) (new)	15	Core	Op&Log / QA
Evaluate advanced logistics project aspects like cost/benefit ratio, safety, impact, threats, maintenance, etc.) (follow safety standards, new)	16.a	Core	Op&Log
	16.b	Technical	Op&Log / QA
Cybersecurity Awareness.	17	Core	IT



4.3 DEFINITION OF THE TRAINING PATHS

According to the ECVET model it has been defined as a temporization of the competencies adding a value in ECVET units of each competence.

Proposal NEW METRO Mechatronics Technician training paths.

First-year course (Two semesters)			
Competences	Hours	Ecvet units	Previous Knowledge
1a Aptly choosing advanced materials that can suit product or process needs	66	4	Chemicals. Nomenclature and formulation of simple and compound substances.

			Mathematics: Scientific notation. Significant figures. Solving equations. Physics: Units. Conversion factors.
2a System design and integration/interfacing between electronic and mechanical components	132	8	Physics: Force analysis. Electromagnetic spectrum. Work, energy and power. Units. Conversion factors. Applied electronics: DC circuits and electromagnetism. Alternating current circuits. Analog electronics. Non-programmable digital electronics. Microprogrammable digital electronics. Mathematics: Scientific notation. Significant figures. Solving equations.
3 System automation, control and system support	132	8	Fundamentals of physics Fundamentals of electricity Fundamentals of electromagnetism Fundamentals of math
4 Evaluate environmental impact both from product manufacturing and whole life cycle	33	2	Communication: Research, understanding, management and treatment of information. Production of oral, written and audio-visual speeches. Digitals: ICT tools. Earth and environmental sciences: Problems and environmental impact assessment.
5a Define pre-emptive maintenance protocols and early diagnostic maintenance protocols	99	6	Basic offimatic knowledge
6a Robotics programming (set up automotive robot) assembly and manufacturing robots, collaborative robots)	66	4	Fundamentals of kinematics Fundamentals of dynamics Fundamentals on electric motors
7a Design virtual testing and validation using automatic and simulation tools	198	12	
8a Develop the virtual prototypes in the real environment also thanks to physical computing tools	66	4	Fundamentals of Algorithms formulation Base of C programming Fundamentals of mechanism Fundamentals on actuators (electric motors,

			pneumatic actuators, etc) Fundamentals on basic sensors (encoders, limit switches, etc..)
9a Utilize, choose, customize monitoring and data management systems (monitor automated machines, record test data)	66	4	Some basics knowledge of 3 (intelligent sensor, regulation loop systems..) and 10a (basic programming, variables types)
10a PLC Programming	66	4	ST language requires C programming
11a Carry on diagnostic activities interfacing machines/assembly lines and collecting data by Visual Programming tools (resolve equipment malfunctions, maintain control systems for automated equipment, perform test run)	99	6	
12a Access and manage database using SQL (record test data)	66	4	
14a Manage, automatize, storage data network tools	66	4	
15 Evaluate ergonomic aspects of industrial logistics (workloads, movements, time constraints, use of mobile devices, etc.)	33	2	Communication: Research, understanding, management and treatment of information. Production of oral, written and audiovisual speeches. Digitals: ICT tools.
16a Evaluate advanced logistics project aspects like cost/benefit ratio, safety, impact, threats, maintenance, etc.) (follow safety standards, new)	33	2	Communication: Research, understanding, management and treatment of information. Production of oral, written and audiovisual speeches. Digitals: ICT tools. Physics. Force analysis. Work, energy and power. Kirchoff's laws. Applied electronics: DC circuits and electromagnetism. Alternating current circuits. Analog electronics. Non-programmable digital electronics. Microprogrammable digital electronics.

			Chemicals: Relationship between structure, properties and applications of some materials. Mathematical competence: Scientific notation. Functions from tables and graphs.
17 Cybersecurity Awareness.	99	6	
	1320	**79**	

Second-year course (One semester) + internship (One semester)			
Research and Development			
1b Aptly choosing advanced materials that can suit product or process needs	99	6	Chemics. Nomenclature and formulation of simple and compound substances. Relationship between structure, properties and applications of some materials. Classification, description and applications of metals and polymers Mathematics: Scientific notation. Functions from tables and graphs.
2b System design and integration/interfacing between electronic and mechanical components	66	4	2a
13a Identify and utilize the main Artificial Intelligence tools	66	4	
13b Identify and utilize the main Artificial Intelligence tools	66	4	13a
7b Design virtual testing and validation using automatic and simulation tools	66	4	7a
	363	**22**	

Operations and logistics			
10b PLC Programming	99	6	10a
16b Evaluate advanced logistics project aspects like cost/benefit ratio, safety, impact, threats, maintenance, etc.) (follow safety standards, new)	66	4	Communication: Research, understanding, management and treatment of information. Production of oral, written and audiovisual speeches. Digitals: ICT tools. Earth and environmental sciences: Problems and environmental impact assessment.
6b Robotics programming (set up automotive robot) assembly and manufacturing robots, collaborative robots)	66	4	6a
7b Design virtual testing and validation using automatic and simulation tools	66	4	7a
9b Utilize, choose, customize monitoring and data management systems (monitor automated machines, record test data)	66	4	9a
	363	**22**	

Quality Assessment			
7c Design virtual testing and validation using automatic and simulation tools	66	4	7a
5b Define pre-emptive maintenance protocols and early diagnostic maintenance protocols	66	4	5a
11b Carry on diagnostic activities interfacing machines/assembly lines and collecting data by Visual Programming tools (resolve equipment malfunctions, maintain control	99	6	11a

systems for automated equipment, perform test run)			
9b Utilize, choose, customize monitoring and data management systems (monitor automated machines, record test data)	66	4	9a
12b Access and manage database using SQL (record test data)	66	4	12a
	363	**22**	

Information Technologies			
14b Manage, automatize, storage data network tools	165	10	Communication: Research, understanding, management and treatment of information. Production of oral, written and audiovisual speeches. Digitals: ICT tools. Applied electronics: DC circuits and electromagnetism. Alternating current circuits. Analog electronics. Non-programmable digital electronics. Microprogrammable digital electronics. Mathematics: Scientific notation. Functions from tables and graphs. Automated systems: Basic preparation and programming of automatic systems.
12b Access and manage database using SQL (record test data)	66	4	12a
8b Develop the virtual prototypes in the real environment also thanks to physical computing tools	132	8	8a
	363	**22**	

4.5 DEFINITION OF THE COMPETENCES ACCORDING TO THE ECVET

In addition, we have added a small, but enlightening, learning outcome in each competence.

(in green)

1a. Aptly choosing advanced materials that can suit product or process needs	
Functional Area: Op&Log / R&D	
Assessment criteria	**Knowledge**
LO1a.1. Selects the material to be used in a mechatronic system, linking the technical and commercial characteristics with the product specifications to be obtained. • Prepare list of appropriate materials by interpreting detail drawings and determine correct quantities of such materials • Read and analyse the specifications to ascertain the material requirement, relevant tools, and machining /assembly /maintenance parameters	• Knowledge of laws of strength, deformation, kinematics, dynamics, plastic/inelastic deformation • Be familiar with the principles of QA in mechatronics • Be capable to perform as member of a team in collecting and interpreting experimental data • Be familiar with concept of basic science (e.g. Material science, mass, weight, density, speed, velocity, pressure, heat treatments, friction, etc)
	Skills
	• Capability to properly read and understand technical specifications and material description • Identify type of materials and components for machining/assembling or storing in appropriate environment • Identify and propose adequate types of material for product/process • Identify appropriate machining procedures • Identify relevant parameters (eg temperature, humidity, RPM, clean room level...) • Machine/construct components on the basis of relevant specification

	Transferable skills
	• Capability to communicate in English in a interdisciplinary / international team, in virtual and real modality • Understand descriptions, specifications, technical data and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner • Be capable to interface/report with the R&D/Engineering/Maintenance departments in a logical and coherent manner

1b. Aptly choosing advanced materials that can suit product or process needs	
Functional Area: R&D	
Assessment criteria	**Assessment criteria**
LO1b.1. Selects new materials for the manufacture relating their characteristics with the functional, technical, economic and physical requirements of the designed products and test results. • Based on a real example of a process/realization of a product, propose improvements to the use of materials/machining, underlining pros/cons • Select appropriate measuring instruments and tools to test and validate characteristics of given material sample • Evaluate appropriateness of testing at lab level vs production process	LO1b.1. Selects new materials for the manufacture relating their characteristics with the functional, technical, economic and physical requirements of the designed products and test results. • Based on a real example of a process/realization of a product, propose improvements to the use of materials/machining, underlining pros/cons • Select appropriate measuring instruments and tools to test and validate characteristics of given material sample • Evaluate appropriateness of testing at lab level vs production process
	Skills
	• Capability to properly read and understand technical specifications and material description

	• Identify type of materials and components for machining/assembling or storing in appropriate environment • Identify and propose adequate types of material for product/process • Identify appropriate machining procedures • Identify relevant parameters (eg temperature, humidity, RPM, clean room level...) • Machine/construct components on the basis of relevant specification
	Transferable skills
	• Capability to communicate in English in a interdisciplinary / international team, in virtual and real modality • Understand descriptions, specifications, technical data and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner • Be capable to interface/report with the R&D/Engineering/Maintenance departments in a logical and coherent manner

2a. System design and integration/interfacing between electronic and mechanical components	
Functional Area: R&D / IT	
Assessment criteria	**Assessment criteria**
LO2a.1: Identifies the elements of the regulation loop of industrial systems, relating their role to the elements making up	LO2a.1: Identifies the elements of the regulation loop of industrial systems, relating their role to the elements making up • automation processes. Describe the main characteristics of a mechatronics assy and its potential use applications

• automation processes. Describe the main characteristics of a mechatronics assy and its potential use applications • Based on a real example of an implementation of a process/realization of a product, propose improvements to its design, underlining its pros/cons • Demonstrate function of different sensors [e.g. proximity, inductive, capacitive, magnetic, photoelectric, temperature, haptic, etc.] LO2a.2. Integrates mechatronic systems. • Perform project work on Mechatronics (e.g. involving fitting, drilling, turning, milling, grinding, electrical wiring & soldering, programming, hydraulic circuit assembly, pneumatic circuit assembly, drives, system assembly and interfacing, functional testing, troubleshooting and repair. Safety measures in each stage	• Based on a real example of an implementation of a process/realization of a product, propose improvements to its design, underlining its pros/cons • Demonstrate function of different sensors [e.g. proximity, inductive, capacitive, magnetic, photoelectric, temperature, haptic, etc.] LO2a.2. Integrates mechatronic systems. • Perform project work on Mechatronics (e.g. involving fitting, drilling, turning, milling, grinding, electrical wiring & soldering, programming, hydraulic circuit assembly, pneumatic circuit assembly, drives, system assembly and interfacing, functional testing, troubleshooting and repair. Safety measures in each stage
	Skills
	• Capability to properly read and understand technical specifications and material description • Identify type of materials and components for machining/assembling or storing in appropriate environment • Identify and propose adequate types of material for product/process • Identify appropriate machining procedures • Identify relevant parameters (eg temperature, humidity, RPM, clean room level...) • Machine/construct components on the basis of relevant specification
	Transferable skills
	• Capability to communicate in English in a interdisciplinary / international team, in virtual and real modality • Understand descriptions, specifications, technical data and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner

	• Be capable to interface/report with the R&D/Engineering/Maintenance departments in a logical and coherent manner

2b. System design and integration/interfacing between electronic and mechanical components	
Functional Area: R&D	
Assessment criteria	**Assessment criteria**
LO2B.1. Designs prototypes and mechanisms of mechatronic systems. • Describe the main characteristics of a mechatronics assy and its potential use applications • Propose solutions for the design of a simple product/process • Design, on the basis of an outline design draft, a prototype of a product/process	LO2B.1. Designs prototypes and mechanisms of mechatronic systems. • Describe the main characteristics of a mechatronics assy and its potential use applications • Propose solutions for the design of a simple product/process • Design, on the basis of an outline design draft, a prototype of a product/process
	Skills
	• Capability to properly read and understand technical specifications and material description • Identify type of materials and components for machining/assembling or storing in appropriate environment • Identify and propose adequate types of material for product/process • Identify appropriate machining procedures • Identify relevant parameters (eg temperature, humidity, RPM, clean room level...) • Machine/construct components on the basis of relevant specification

	Transferable skills
	• Capability to communicate in English in a interdisciplinary / international team, in virtual and real modality • Understand descriptions, specifications, technical data and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner • Be capable to interface/report with the R&D/Engineering/Maintenance departments in a logical and coherent manner

3. System automation, control and system support	
Functional Area: Op&Log	
Assessment criteria	**Knowledge**
LO3.1: Defines and designs mechatronics systems 1. Identifies the elements of an electrical-electronic nature in a machine, industrial equipment or automated line, describing the function they perform and their relationship with the other elements. 2. It configures automated systems, at machine level and to automated installation, adopting the most appropriate solution and complying with the established operating conditions. 3. Identification and functions of the elements of the regulating loop. Intelligent sensors	**1. Identification of circuits and components of machinery feeding, protection and starting electric systems:** 1.1 Fundamentals of alternating current. 1.2 Electrical switchgear elements. 1.3 Actuators of an electrical nature. 1.4 Sensors and transducers. 1.5 Electrical-electronic protection and safety systems. 1.6 Industrial communication components and buses. 1.7 Characteristics of DC and AC motors. 1.8 Characteristics of transformers. 1.9 Parameters and connection of AC and DC motors, transformers. In-service and vacuum operation. 1.10 Start and stop systems. 1.11 Power factor correction systems.

Data acquisition Intelligent sensors, i Iot Remote management Remote diagnostic 4.Differentiates the different operating modes and their specific characteristics from real or simulated systems, in real and digital systems. Digital twin and Virtual commissioning Digital twin Virtual commissioning	1.12 Quantities to be controlled in speed control systems **2. Configuration of automatisms and elements of electrotechnical technology:** 2.1 Calculation and selection of elements in electronic electrical systems. 2.2 Characteristics and parameters of the components of the electronic devices of the control and manoeuvring equipment. 2.3 Development of functional diagrams. 2.3.1 Development of schematics for command, force and start-up systems, among others. 2.3.2 Software for the representation and simulation of electrical-electronic systems. 2.3.3 Calculation of values of the quantities of the installation parameters. 2.3.4 Standard graphic symbology of electrical-electronic systems. **3. Identification and functions of the elements of the regulating loop:** 3.1 Components of a regulation and control system. Intelligent sensors 3.2 Control and power schemes. 3.3 Types of control (open and closed loop). 3.4 Control of discrete event processes. 3.5 Control of continuous processes. 3.6 Transfer function. Stability. 3.7 Elements of controlled systems. Regulators. 3.8 Typology and functional characteristics. 3.9 Control systems (P, PI, PID). 3.10 Data acquisition 3.11 Iot **(NEW Knowledge linked to assessment criteria 5)** *4. Characterisation of different operating modes and their specific characteristics of real or simulated systems, in real and digital systems. Digital twin and Virtual commissioning*

	4.1 Components of a real and simulated system. *4.2 Characteristics and parameters of the components of Digital Twin* *4.3 Start-up in simulated systems. Virtual commissioning* *4.4 Modes of operation of simulated systems.* *4.5 Relationship between the different operating modes (PLC, CNC, Robots, among others).* *4.5 Simulation software for simulated systems*
	Skills (CA)
	1. Identifies electrical-electronic elements in a machine, industrial equipment or line automated, describing the function they perform and its relationship with the other elements. 1.1 Recognizes the characteristics of the AC signal. 1.2 Identifies the structure and components of power supply facilities on an automated machine or line. 1.3 Identifies actuators of an electrical nature present on automated machines or lines. 1.4 Relates the sensors and transducers of the machine to the rest of the elements. 1.5 Identifies the devices and structure of communication buses in an automated machine or line. 1.7 Relates the parameters of AC motors (single and three-phase) and continuous motors and transformers with in-service and empty operation. 1.8 Recognises start and stop systems. 1.9 Identifies power factor correction systems and their influence on installations. 1.10 Draw up a sketch of electronic control and regulation systems. 1.11 Identifies the quantities to be controlled in speed control systems. 1.12 Calculates parameters and quantities of installations. 1.13 Characterizes the protective elements.

	2. Configures electrotechnical automatisms in terms of machine or installation automated, adopting the most appropriate solution and complying with the established operating conditions. 2.1 Defines the functional characteristics of electrical automation to be used to the different parts of the machine or automated line. 2.2 Proposes solutions for the configuration of electrical automatisms with regard to the machine or the installation automated. 2.3 Calculates the values of the quantities of the installation parameters. 2.4 Adopts the most appropriate solution, meeting the required performance and cost requirements. 2.5 Selects the elements of electrical nature to perform the requested function. 2.6 Performs drawings and operating schematics of electrical automatisms, using computer tools. 2.7 Uses standardized symbology. 2.8 Draws up functional diagrams. 2.9 Select from the catalogues the elements of the control and manoeuvring systems. **3. Identifies the elements that make up the regulatory loop of industrial systems, relating their function with the elements that make up the automation processes.** 3.1 Identifies the different types of regulation used in industry, especially in the field of continuous processes. 3.2 Relates the characteristics and variables of a continuous process to its regulatory ties. 3.3 Establishes the relationship between the parameters of a PID controller and the response of the variables of a process. 3.4 Identifies the equipment, elements and devices of electrotechnical technology (automata, temperature regulators and level regulators, among others) and fluidics of the automatic systems, defining their function, the typology and characteristics. **Intelligent sensors** 3.5 Obtains information from documentation and schematics. **Data acquisition**

	3.6 Identifies the devices and components that configure the global automatic system (control, regulation, force, protections, measures, and inputs and outputs, among others), explaining the characteristics and the functioning of each. **IoT. Intelligent sensors** **3.7 Differentiates the different operating modes and their specific characteristics from real or simulated systems. Virtual commissioning and digital twin** 3.8 Calculates the magnitudes and basic parameters of a system, and contrasts them with the real values measured in the aforementioned system.
	Transferable skills
	● Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner ● Ability to communicate effectively, orally and in writing with "engineering" community and with "society", extrapolating concepts for "non-experts" through an abstraction approach

3. System automation, control and system support	
Assessment criteria	**Knowledge**
LO3.2: Performs the assembly of the installation and verifies the operation and commissioning of mechatronics systems 1. Assembles automated installations, interpreting schemes and applying mounting techniques. with data acquisition technologies, intelligent sensors and IoT. Data acquisition Intelligent sensors, IoT	**1. Installation of power supply systems and electrotechnical automation systems:** 1.1 Installation and maintenance procedures. 1.2 Preparation of assembly plans. 1.3 Rethinking of installations. 1.4 Techniques of assembly. 1.5 Installation and connection of equipment and plant elements. 1.6 Making of adjustments.

2. Complies with the standards for the prevention of occupational hazards and environmental protection in the assembly, identifying the associated risks, measures and equipment to prevent them.	1.7 Assembly operations and functional tests. 1.8 Regulation and commissioning of the system. **2. Risk prevention, safety and environmental protection in the installation of automated electrical and electronic systems:** 2.1 Regulations for the prevention of occupational hazards. 2.2 Prevention of occupational hazards in assembly processes. 2.3 Personal protective equipment: characteristics and criteria for use. Collective protection. Means and equipment protective.
	Skills
	1. Assembles feed installations and associated automation systems, interpreting schemes and applying mounting techniques. 1.1 Identifies the procedures used in the installation and maintenance of the installations. 1.2 Select the tools according to the type of intervention. 1.3 Prepare an installation plan. 1.4 Carry out plant reassessments. 1.5 Assemble and connect equipment and plant elements. 1.6 Identifies the physical variables that need to be regulated or controlled. 1.7 Makes adjustments to it. 1.8 Documents the assembly process. **2. Complies with the standards for the prevention of occupational hazards and environmental protection in the assembly, identifying the associated risks, measures and equipment to prevent them.** 2.1 It identifies the risks and the level of danger involved in the handling of materials, tools, equipment, machinery and means of transport. 2.2 Operates with machines and tools, respecting safety standards.

	2.3 Identifies the most frequent causes of accidents in the handling of materials, tools, cutting and forming machines, among others. 2.4 Recognizes the safety features, personal and collective protective equipment (footwear, eye protection, clothing, etc.) to be used in the different assembly operations. 2.5 Identifies the correct use of safety elements and personal and collective protective equipment. 2.6 Relates the handling of materials, tools and machines to safety and personal protection measures required. 2.7 Values the order and cleanliness of installations and equipment as the first risk prevention factor.
	Transferable skills
	Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for the next phase of project/Customer in understandable manner. Ability to communicate effectively, orally and in writing with "engineering" community and with "society", extrapolating concepts for "non-experts) through an abstraction approach

4. Evaluate environmental impact both from product manufacturing and whole life cycle	
Functional Area: QA	
Assessment criteria	**Knowledge**
• LO4.1: Evaluates environmental impact, identifying the measures and equipment to prevent them. • Describe the main pollutant which could derive from a given process/production/machining	• Knowledge of laws of physics, chemistry as applicable to environmental issues • Be familiar with basic regulations as regards discarded material, selective dumping et sim • Be able to analyse different solutions for waste management in a methodical way including interpretation of experimental data, literature

• Given a real example, propose the best methodology to reduce waste to a minimum and/or contain it to be separately discarded • Based on a real example of an implementation of a process/realization of a product, calculate the RoM of energy/water/oil/etc. (depending on the case) needed • For a given material to be used in a process/product suggest the best solution for recycling its waste or the product at the end of its life cycle • Describe the main concepts related to energy conservation, global warming and pollution and contribute in day to day work by optimally using available resources • Recognize and report all non-compliant situations according to site policy • Identify, handle and store/dispose-off dangerous/unsalvageable goods and substances according to site/local policies and procedures following safety regulations and requirements • Identify Personal Protective Equipment (PPE) and use the same as per related working/process environment and disposal procedure	• Have a full awareness of environmental concerns and be capable to dispose waste following standard procedures
	Skills
	• Capability to properly read and understand characteristics of materials and of their behavior during machining/production • Capability to work in multidisciplinary teams for overall environmental impact assessment • Identify and propose adequate processes for minimum waste • Identify relevant parameters (e.g. temperature, humidity, RPM, clean room level, etc.) within which the production/machining process must remain for minimum waste and maximum yield • Be capable to report the findings including all negative aspects • Represent (through drawings. Workflow, automatic) the entire life cycle from production to disposal
	Transferable skills
	• Capability to communicate in English in an interdisciplinary/international team, in person or tele-conference • Understand descriptions, specifications, technical data and other info typical of the profession in English • Be ready to acquire new knowledge, skills, competences and responsibilities • Be capable to report the findings of Laboratory work in a logical and coherent manner • Awareness about concept of energy conservation, global warming, pollution and use of available resources optimally and remain sensitive to avoid environmental pollution

5.a Define preemptive maintenance protocols and early diagnostic maintenance protocols	
Functional Area: QA	
Assessment criteria	**Knowledge**
LO5a.1: Applies techniques of pre-emptive maintenance at mechatronic systems, realising operations and interpreting plans of maintenance. • Recognises different types of mechatronic systems, applying specific techniques of pre-emptive and/or early diagnostic maintenance. • Substitutes elements, configure and parameterize controllers and records the works carried out. • Uses CMMS software management for remote maintenance.	• Interpretation of plans of maintenance and documents of registry. • Maintenance and adjustment of mechatronic elements. • Machines, equipment, assembly devices, tools and resources employed at the maintenance. • Techniques and procedures for the replacement of simple elements. • Measurement and diagnostic equipment and techniques. • Use of digital management maintenance systems resources (CMMS) • Intelligent sensor for data acquisition (IIOT)
	Skills
	• Identifies the procedures described in a maintenance intervention plan. • Identifies equipment and items to be inspected based on maintenance schemes, plans and programs. • Select the right tools for maintenance. • Applies techniques of observation and measurement of variables in the systems to obtain data from the machine or the installation (noises, vibrations, levels, consumption, temperatures, flow, pressures, voltage, among others). • Compare the results with the set benchmarks. • Properly records detected anomalies and data required for machine history. • Apply the techniques for replacing the elements.

Maintenance Systems *IIOT-Industrial internet of things*	● Assertively manages and simulates digital maintenance management software.
	Transferable skills
	● Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for the next phase of project/Customer in understandable manner. ● Ability to communicate effectively, orally and in writing with "engineering" community and with "society", extrapolating concepts for "non-experts) through an abstraction approach.

5.b Define pre-emptive maintenance protocols and early diagnostic maintenance protocols	
Functional Area: QA	
Assessment criteria	**Knowledge**
LO5b.2: Diagnoses the condition of the machine elements, applying the techniques of monitoring, measurement and analysis described in the pre-emptive and / or early diagnostic procedure ● Uses the diagnostic techniques corresponding to the different elements of the mechatronic system.	● Techniques for identifying the damaged part. ● Analysis of typical defects in mechatronic systems. ● Symptoms of malfunctioning. ● Causes of malfunctioning. ● Measurement and diagnostic equipment. ● Program monitoring ● Intelligent sensor for data acquisition (IIOT)
	Skills
	● Selects the technical documentation related to the item being analysed. ● Identifies normal and abnormal wear.

	• Performs the measurement of the characteristic parameters of the element. • Compare the actual measurements with the originals on the map, user manual or technical data sheets. • Uses appropriate measuring elements. • Provides solutions to prevent or minimize breakdowns.
	Transferable skills
	• Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for the next phase of project/Customer in understandable manner. • Ability to communicate effectively, orally and in writing with "engineering" community and with "society", extrapolating concepts for "non-experts) through an abstraction approach.

5.b Define preemptive maintenance protocols and early diagnostic maintenance protocols	
Functional Area: QA	
Assessment criteria	**Knowledge**
LO5b.3: Diagnose breakdowns and malfunctions in mechatronic systems, linking the malfunction to the cause. • Troubleshoot malfunctions, develop action plans and hypotheses on possible causes. • Prepares breakdown records.	• Interpretation of technical documentation of the installation. • Identification of the symptoms of the breakdown. • Intervention procedures. • Measurement of characteristic parameters. • Techniques for troubleshooting. • Diagnostic methods.

	Skills
	• Obtain information from the system technical documentation. • Relates the symptoms of dysfunction to their effects. • Develop an intervention procedure for the localization of the dysfunction. • Performs measurements of the characteristic parameters of the installation. • Hypotheses of the possible causes of the dysfunction or malfunction. • Isolates the section of the system that causes the malfunction or malfunction. • Identifies the element that causes the malfunction or the dysfunction. • Recognizes points that could be at fault. • Document the process followed in the location of malfunctions and malfunctions.
	Transferable skills
	• Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for the next phase of project/Customer in understandable manner. • Ability to communicate effectively, orally and in writing with “engineering” community and with “society”, extrapolating concepts for “non-experts) through an abstraction approach.

6.a Robotics programming (set up automotive robot) assembly and manufacturing robots, collaborative robots

Functional Area: R&D

Pre-Requisites: Fundamentals of kinematics Fundamentals of dynamics Fundamentals on electric motors	
Assessment criteria	**Knowledge**
LO6a.1. Recognizes different types of robots and/or motion control systems, identifying the components that form them and determining their applications in industrial automation Starting from a given task that a robot has to perform the student will describe: ● How to accomplish the task using Parallel and/or Serial mechanisms ● What are stable and unstable systems and the influence of those on the task to perform ● Feedforward and feedback approaches to accomplish the tasks	● Planar Parallel and Serial linkages/mechanisms ● Spatial Parallel and Serial linkages/mechanisms ● Concept of stability of a system ● Feedforward control Feedback control ● Fundamentals on Motion Lows ● Difference between robot and cobot ● Methods for program commercial robots and cobots ● Languages for program commercial robots and cobots ● Fundamentals of Teleoperational and remote robotic ● Safety aspects of Robots and Cobots
LO6a.2: Configures robotic and/or motion control systems, selecting and connecting the component elements. Starting from a given task that a robot has to perform the student will describe: ● Trajectory of end-effector ● Sequence of displacements of the different joints ● Motion Laws graphs (displacement and velocity vs time Starting from a given task that a robot has to perform the student will describe the algorithm and create the code needed to program the robot/cobot	**Skills** ● Understand the difference between parallel and serial mechanisms. Pros and cons of booth architectures and ability to choose when to use a parallel kinematic and when a serial one. ● Define a stable or unstable behavior of a robot (from a time-displacement representation) ● Represent the behavior and the trajectories of the joints and the end-effector of a robot. ● Understand a motion low description and representation (displacements and velocity vs time) ● Program robots for base tasks as sequential single joints movements

• Open questions on Remote controlling, tele operational and Safety aspects • Practical tasks on programming robots	• Program robots for base tasks as multiple joints movements • Ability to calculate the working space of a robot in particular for designing the safety spaces • How to setup a robot/cobot for maintenance process
	Transferable skills
	• Understand descriptions, specifications and documentations of commercial robots (in English) • Ability to communicate the designed behavior of a robot/cobot

6.b Robotics programming (set up automotive robot) assembly and manufacturing robots, collaborative robots)	
Functional Area: R&D/Op&Log	
Pre-Requisites: COMPETENCE 6-A	
Assessment criteria	**Knowledge**
LO6b.1. Programs robots and/or motion control systems, using programming and data processing techniques. Starting from a trajectory of an end effector the student has to describe/calculate: • Number of actuated joints and affordable dimension of the robot arms • Sequence of displacements of the different joints	• Advanced on Motion Lows • Advanced Methods for program commercial robots and cobots • Advanced Languages for program commercial robots and cobots • Advanced Tele-operational and remote robotic • Integration of Robots and Cobots for operations and assembly process • Design of a robotic manufacturing process • Design of a robotic assembly process

• Motion law (acceleration, velocity, displacement vs time) • Possibility of singularity points and how to avoid it Starting from a given manufacturing process (with 2 or more operations) the student has to: • Describe the order of the operations • Kinds of robots to use for the single operational • Estimation of time cycle for the single operational • Total number of robots needed to perform the manufacturing process (considering also the parallelisation of a task according to the time cycles) Starting from a given assembly process (with 2 or more operations) the student has to: • Describe the order of the operations • Kinds of robots to use for the single operational • Estimation of time cycle for the single operational • Total number of robots needed to perform the manufacturing process (considering also the parallelisation of a task according to the time cycles) • Open questions on Advance Remote controlling, tele operational and Safety aspects • Practical tasks on advanced programming robots	**Skills** • Understand a motion low description and representation also with second order information (Acceleration, displacements and velocity vs time) • Create a motion low starting from a given trajectory of end effector; • Describe the operations that a robot has to perform in order to perform a manufacturing process • Describe the operations that a robot has to perform in order to perform an assembly process • Understand the issues on remote control of robots (latency, computational effort, different networks protocols) • Program a robot for simple tasks • Manage the maintenance of a robotic station **Transferable skills** • Understand descriptions, specifications and documentations of commercial robots (in English) • Ability to communicate the designed behavior of a robot/cobot • Create code for robotic controlling • Create a maintenance program for a robotic station

7.a Design virtual testing and validation using automatic and simulation tools	
Functional Area: R&D/Op&Log	
Assessment criteria	**Knowledge**
LO7a.1. Designs prototypes and mechanisms of mechatronic systems, using specific programs for three-dimensional simulation. • Observe and comment on a drawing/specification, also in English, (is it complete, all info contained, something additional should be required?), and make an example of how a virtual test could be carried out • Design and realize virtual test protocols/models for testing a prototype, using the proper tools (CAD/CAM/CAE) • Based on a real example of a process/product, describe its overall function and the interrelationship amongst the various electromechanical components (through a flow diagram), also through a brief written summary	• Knowledge of modelling tools • Knowledge of material (physical, electromagnetic characteristic…) • Understand parameters at the basis of automatic functions • Be able to analyse different solutions in a methodical way including interpretation of experimental data, literature • Understand the main functions of product/process
	Skills
	• Properly size/dimension components from form/fit/function aspects • Suggest appropriate techniques for the process • Be proficient in the use of SW tools (CAD tools, CFD tools, model-based tools…) • Formalize the variables on function (physical/process) • Formalize the interaction amongst the variables/functions • Represent (through drawings, Workflow, automatic tools) the interactions and dynamics amongst functions/components • Validate the correct input/output relationship • Select proper tools and understand their capability and limitations
	Transferable skills

	• Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner • Ability to communicate effectively, orally and in writing with "engineering" community and with "society", extrapolating concepts for "non-experts" through an abstraction approach

7.b/7.c Design virtual testing and validation using automatic and simulation tools	
Functional Area: Op&Log/R&D/QA	
Assessment criteria	**Knowledge**
LO7b.1. Simulates robotic cells and mechatronic prototypes, validating the design by using simulation software. Based on a real example of a process/product: • describe its overall function and the interrelationship amongst the various electromechanical components • Describe the main issues and problems that could rise (finding the correct variable which could allow to monitor the various effects) • Describe a hypothetical protocol test	• Knowledge on the main tools for virtual testing (3d Cad Simulation tools Labview, Matlab, Modelica,etc) • Abstraction of a processes into a formalized model • Concretization of an abstract process in to a partial use case • Fundamental on statistical analysis for data analysis • Test protocols guidelines • Design of Experiments • Basics of QA (for 7.c) • Parameter capture and correction action for out-of-range data (for 7.c) • Control and inspection (for 7.c)
Starting from a described real case: • simulate it using the correct tool among the presented one • Justify the tool choice • Discuss the results	**Skills** • Simulate a given process/product test • Ability to set up the more used simulation tools • Ability to set up the more used analysis tools

LO7b.2. Determines actions for the implementation and maintenance of systems for quality assurance, for the continuous improvement of productivity in the maintenance and installation of facilities, performing basic concepts and requirements. ● Apply QA controls and procedures to on of above cases (for 7.c)	● Process data for statistical validation ● Create a test protocol the virtualized model
	Transferable skills
	● Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner ● Ability to communicate effectively, orally and in writing with "engineering" community and with "society", extrapolating concepts for "non-experts" through an abstraction approach

8.a Develop the virtual prototypes in the real environment also thanks to physical computing tools	
Functional Area: R&D	
Pre-Requisites: Fundamentals of Algorithms formulation Base of C programming Fundamentals of mechanism Fundamentals on actuators (electric motors, pneumatic actuators, etc) Fundamentals on basic sensors (encoders, limit switches, etc..)	
Assessment criteria	**Knowledge**
LA8a.1. Plans, manages the assembling and executing operations of adjustment of mechatronics prototypes from virtual models. Starting from a given description of a product/process function (aim, functions drawings, etc..) the student will describe how	● Knowledge of application of kinematics lows ● Knowledge on actuators categories (electrical, pneumatics, automatic, etc,) ● Knowledge on sensors categories (optical, automatic, resistive, etc,)

to create a prototype focusing on the following steps: ● Parameters needed to prototype and replicate the main behaviour of the product/process I the real word ● Relations among the identified parameters ● Sketch of the mechanism needed to simulate the fundamental behaviour of the product/process machines ● Identification of a kind of sensors and actuators needed Starting from a given description of a product/process which contains: ● The aim of the mechanism/machine ● the main function, ● the kinematics ● The equipped kind of sensors and actuators The student will describe and will formulate: ● the algorithm which connect all the functions described ● Selection of a microcontroller and/or embedded system ● Low level code (C) needed to control the prototype Starting from: ● a given description of a product/process function (aim, functions drawings, etc..) the student	● Knowledge on microcontrollers (components, functions, characteristics, etc.) ● Knowledge on embedded microcontrollers boards (Arduino, ST Nucleo, etc..) ● Knowledge of low-level programming for prototypes controlling
	Skills
	● Identify the fundamental functions/parameters (components, movements needed, connections, etc..) needed to replicate the main behavior of the product/process I the real word ● Simplify the product/process in its fundamental parameters/functions needed to prototype and simulate the product/process in the real word. ● Formulate the kinematic model of the prototype ● Identify the control logic connect and connect the fundamental parameters ● Identify the fundamental mechanical, electrical and electronics components needed to prototype and simulate the product/process in the real word. ● Create the mechanical and electrical connections among actuators, sensors and end effectors and connect them to a microcontroller (or other control platforms) ● Program the microcontroller in order to simulate the behavior of the product/process ● Ability to understand if the physical behavior corresponds to the desired one. ● Manual skills to create the physical prototype
	Transferable skills
	● Ability to explain the behavior of a system simplifying its behavior to the fundamental functions

• A selection of simple actuators (DC motors, pneumatic pistons, etc..) • A selection of simple sensors (encoders, limit switches, switches, etc..) • Simple connection elements (modular profiles, 3d printed, etc) • Partial low-level code which has to be completed The student will create a prototype assembling the provided components (actuators, sensors, connectors, etc) according to the function to simulate. After that the student will connect the prototype to an embedded system. The student has to complete the provided code, compile and upload it on the embedded system in order to control the prototype. The prototype will be equipped with a simple user interface (start/stop buttons, knobs, etc..). The evaluation will be formulated according to the written description provided by the student and the testing of the behaviour of the created prototype.	

8.b Develop the virtual prototypes in the real environment also thanks to physical computing tools

Functional Area: IT/R&D

Pre-Requisites:

Develop the virtual prototypes in the real environment also thanks to physical computing tools

Fundamentals of High-Level Programming

Fundamentals of Mechanism Dynamic

Assessment criteria	Knowledge
LO8b.1. Executes and verifies the operations of adjustment, configuration and programming of automatic devices, based on the technical design and using software tools and hardware required. Same evaluation process of module B but with the following added points: ● Considering Dynamics of the system ● The user interface will be not composed by simple components (buttons, knobs) but by a digital dashboard on a PC/Mobile ● The prototype has to be controlled also using network communication.	● All the module of Module A r ● Knowledge of application of dynamics laws ● Knowledge user interfaces ● Knowledge on high level programming for user interaction ● Fundamentals of PID control ● Remote control (Master – Client) of a prototype (network connection)
	Skills
	● All the skills in Module A ● Ability to formulate the simplified dynamic model (linear) ● Applicate a PID control to a real case and estimate the coefficient models ● Design a User Interface ● Program the Digital User Interface (control the prototype by a dashboard on PC or Mobiles) ● Ability to create a remote connection between master and client in order to remotely control a prototype
	Transferable skills
	● Ability communicate in a symbolic way (user interfaces2)

9.a Utilize, choose, customize monitoring and data management systems *(monitor automated machines, record test data)*	
Functional Area: Op&Log/R&D	
Pre-Requisites:	
Assessment criteria	**Knowledge**
LO9a.1: Defines and designs monitoring and data management systems. 1.Identifies the elements that make up the regulatory loop of industrial systems, relating their function to the elements that make up the automation processes with technologies, such as data acquisition intelligent sensors and IoT Data acquisition Intelligent sensors, IoT 2.Integrates industrial communications and monitoring systems into the overall assembly of discrete and continuous process mechatronics systems controlled by PLC. Remote and diagnostics control systems. Remote management Remote diagnostic 3.Differentiates the different operating modes and their specific characteristics from	3. Identification and functions of the elements of the regulating loop: 1.1 Components of a regulation and control system. **Intelligent sensors** 1.2 Control and power schemes. 1.3 Types of control (open and closed loop). 1.4 Control of discrete event processes. 1.5 Control of continuous processes. 1.6 Transfer function. Stability. 1.7 Elements of controlled systems. Regulators. 1.8 Typology and functional characteristics. 1.9 Control systems (P, PI, PID). **1.10 Data acquisition** **1.11 Databases and spreadsheet applied** **1.12 IoT** **4. Integration of industrial communications:** 1.1 Industrial communications and distributed control: communication elements, communication networks, industrial communications and standardization. 1.2 Integral control of processes. CIM fundamentals. Automation pyramid.

real or simulated systems, in real and digital systems. Digital twin and Virtual commissioning ● Digital twin ● Virtual commissioning	1.3 Communication protocols: functions and characteristics, standardization and levels. 1.4 Most extended industrial networks and field buses to the European market (AS-y, Profibus, Ethernet Industrial and Profinet, among others. 1.5 Physical configurations. Communication programming. Fault diagnosis. 1.6 Machine-user interface: different types of HMI interface such as operating panels or screens tactile. 1.7 SCADA systems: system description. **Diagnostic control and remote control.** 1.8 Databases and spreadsheet applied (NEW **Knowledge relationated with assessment criteria 3)** ***5. Characterisation of different operating modes and their specific characteristics of real or simulated systems, in real and digital systems. Digital twin and Virtual commissioning*** *5.1 Components of a real and simulated system.* *5.2 Characteristics and parameters of the components of Digital Twin* *5.3 Start-up in simulated systems. Virtual commissioning* *5.4 Modes of operation of simulated systems.* *5.5 Relationship between the different operating modes (PLC, CNC, Robots, among others).* *5.5 Simulation software for simulated systems*
	Skills
	3. Identifies the elements that make up the regulatory loop of industrial systems, relating their function with the elements that make up the automation processes. 3.1 Identifies the different types of regulation used in industry, especially in the field of continuous processes.

	3.2 Relates the characteristics and variables of a continuous process to its regulatory ties. 3.3 Establishes the relationship between the parameters of a PID controller and the response of the variables of a process. 3.4 Identifies the equipment, elements and devices of electrotechnical technology (automata, temperature regulators and level regulators, among others) and fluidics of the automatic systems, defining their function, the typology and characteristics. **Intelligent sensors** 3.5 Obtains information from documentation and schematics. **Data acquisition** 3.6 Identifies the devices and components that configure the global automatic system (control, regulation, force, protections, measures, and inputs and outputs, among others), explaining the characteristics and the functioning of each. **IoT. Intelligent sensors** **3.7 Differentiates the different operating modes and their specific characteristics from real or simulated systems. Virtual commissioning and digital twin** 3.8 Calculates the magnitudes and basic parameters of a system, and contrasts them with the real values measured in the aforementioned system. 3.9 knows the Basic Databases and Spreadsheet **4. Integrates industrial communications and monitoring systems into the overall assembly of systems mechatronics of discrete and continuous processes controlled by PLC, verifying the operation.** 4.1 Establishes the relationship between industrial communication systems in the market and pyramid levels CIM (computer integrated manufacturing). 4.2 Determines the types of communication of the European market according to the technical characteristics of the requirements. 4.3 Relates the different monitoring systems and/or display and actuation equipment (HMI user machine interface) to the requirements of automated systems. Diagnostic control and remote control. 4.4 Relates the Basic Databases and Spreadsheet

	Transferable skills
	• Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner • Ability to communicate effectively, orally and in writing with "engineering" community and with "society", extrapolating concepts for "non-experts) through an abstraction approach

9.a/b Utilize, choose, customize monitoring and data management systems *(monitor automated machines, record test data)*	
Assessment criteria	**Knowledge**
LO9b.1: Performs the assembly of the installation and verifies the operation and commissioning of monitoring and data management systems 1. Assembles communications installation of the associated automated systems, interpreting schematics and applying assembly techniques . Data acquisition Intelligent sensors, IoT 2. Complies with the standards for the prevention of occupational hazards and environmental protection in the assembly,	**1. Assembles communications installation of the associated automated systems** 1.1 Installation and maintenance procedures. 1.2 Preparation of assembly plans. 1.3 Rethinking of installations (9b). 1.4 Techniques of assembly. 1.5 Installation and connection of equipment and plant elements. 1.6 Making of adjustments. 1.7 Assembly operations and functional tests. 1.8 Regulation and commissioning of the system (9b) **2. Risk prevention, safety and environmental protection in the installation of automated electrical and electronic systems:** 2.1 Regulations for the prevention of occupational hazards.

identifying (9b) the associated risks, measures and equipment to prevent them.	2.2 Prevention of occupational hazards in assembly processes. 2.3 Personal protective equipment: characteristics and criteria for use. Collective protection. Means and equipment protective.
	Skills
	1. Assembles communications installations of the associated automated systems, interpreting schemes and applying mounting techniques. 2.1 Replace the wiring of some PLC inputs and outputs, which control the pneumatic and/or hydraulic, electrical, and mechanical technologies, and a manipulator and/or robot used, by the appropriate field diver, maintaining reliable and quality operation. 2.2 Implements an industrial diver, replacing some inputs and outputs of the PLCs, which control the pneumatic and/or hydraulic, electrical and mechanical technologies, and a manipulator and/or robot used, by periphery decentralized, maintaining reliable and quality operation. 2.3 Communicates programmable automata and Pcs with an industrial diver, at the cell level and at the field or process level, connecting sensors and actuators to automation control systems (automata, PC and operator terminals, among others), obtaining a reliable and quality operation. 2.4 Implements an industrial network for communication between PLCs and for the connection of two cell PLCs or automated production system through the telephone network (9b) **3. Complies with the standards for the prevention of occupational hazards and environmental protection in the assembly, identifying the** **associated risks, measures and equipment to prevent them.** 3.1 It identifies the risks and the level of danger involved in the handling of materials, tools, equipment, machinery and means of transport. 3.2 Operates with machines and tools, respecting safety standards. 3.3 Identifies the most frequent causes of accidents in the handling of materials, tools, cutting and forming machines, among others.

	3.4 Recognizes the safety features, personal and collective protective equipment (footwear, eye protection, clothing, etc.) to be used in the different assembly operations. 3.5 Identifies the correct use of safety elements and personal and collective protective equipment. 3.6 Relates the handling of materials, tools and machines to safety and personal protection measures required. 3.7 Values the order and cleanliness of installations and equipment as the first risk prevention factor.
	Transferable skills
	● Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner ● Ability to communicate effectively, orally and in writing with "engineering" community and with "society", extrapolating concepts for "non-experts) through an abstraction approach

10.a PLC Programming	
Functional Area: Op&Log/QA	
Assessment criteria	**Knowledge**
LO10a.1. Recognizes programmable devices involved in the control of dynamic systems, identifying its functionality and determining its technical characteristics Basic:	**1. Recognition of programmable devices:** 1.1 Automatic applications with programmable sequential systems. 1.2 Functionality of the devices of a programmable sequential system. 1.3 Operational of programmable devices. Operating principle and basic concepts: internal structure, programming, programme

Data acquisition Intelligent sensors Remote management Remote diagnostic 1. Recognizes programmable devices, identifying their functionality and determining their technical characteristics. Intelligent sensors 2. Program the programmable automaton and know its programming. 3. It recognizes the control sequences of the programmed systems, interpreting the requirements and establishing the necessary programming procedures. Intelligent sensors 4. Program combination and sequential systems, starting from the control conditions and using structured techniques. 5. Configures programmable systems by selecting the component elements.	transmission and programme implementation cycle, among others. 1.4 Classification of programmable devices. Classification criteria. Programmable relays, PLC compacte, modular PLC, PLC for specific applications and programmable security devices, among others. 1.5 Components of programmable devices. Classification, typology and functionality. Module type 1.6 Technical characteristics of programmable devices. Power supply, inputs and outputs, communication ports, program execution time and memory capacity among others. **Intelligent sensors** 1.7 PLC for security. **2. Configuration of programmable systems:** 2.1 Technical specifications of the installation. Functionality requirements, compatibility with other systems and environmental conditions, among others. 2.2 Selection and sizing criteria for programmable devices. 2.3 Criteria for selecting components. 2.4 Security elements in a PLC. Safety relay, redundant PLC, among others. 2.5 Representation of the sketch. 2.6 Schematics of connection. 2.7 Standardised symbology. 2.8 Existing regulations and rules **3. Recognition of programmable automata and programming:** 3.1 Numbering and coding systems. Conversion between systems. 3.2 Logical functions applied to automaton programming. 3.3 Techniques for designing circuits of combinational control automatisms by systematic methods. 3.4 PLC programming languages. Standard IEC 61131-3. Textual languages: instruction list (IL) and structured text (ST). Graphical languages: contact diagram (LD), logical functions (FBD) and function diagram

	sequencing (SFC), among others. 3.5 PLC programming instructions. Treatment of binary inputs and outputs, retention functions, flank functions, timers, counters, comparators, motion of values and displacement registers, between 3.6 Linear programming techniques and structured programming. Program organization blocks or units. 3.7 Programming techniques of automata from different manufacturers. 3.8 Technical and commercial documentation of manufacturers. 3.9 Existing regulations and rules **4. Recognition of control sequences of programmed systems:** 4.1 Interpretation of requirements. Technical and functional characteristics. 4.2 Systematic methods for programming control sequences. 4.4 Programming phases. Identification of inputs and outputs, program sections and program sequence, among others. 4.5 Programming Environments. 4.6 Critical point location techniques. 4.7 Planning for programming. General data, requirements, order calendar, receipt of material and schedule of action, among others. **5. Programming of combinational and sequential systems:** 5.1 Automated applications of combinational and sequential systems. 5.2 Automated control sequence applications with programmed logic. 5.3 Techniques for implementing systematic programming methods for sequential systems using different programming languages. 5.4 Program blocks or organizational units.

	Skills
	1. Recognizes programmable devices, identifying their functionality and determining their technical characteristics. 1.1 Recognizes automatic applications with programmable sequential systems. 1.2 Identifies the function of sequential devices within a sequential system. 1.3 Identifies the operation of programmable devices. 1.4 Classifies programmable devices according to different criteria. 1.5 Relates the components of programmable devices to their functionality. 1.6 Determines the technical characteristics of programmable devices. 1.7 Identifies security features in PLCs. 2. Configures programmable systems, selecting and connecting the elements that compose it. 2.1 Identifies technical specifications for automation. 2.2 Selects the appropriate components depending upon the technical and safety specifications**. Intelligent sensors** 2.3 Represents the automatic system sketch. 2.4 Draws the installation connection schemas. 2.5 Uses standardized symbology. 2.11 Use the appropriate tools for each operation. **3. Program the programmable automaton and know its around programming.** **3.1 Relates numbering systems and information coding systems.** 3.2 Identifies logical functions. 3.3 Uses systematic methods to solve cases of cablings electrical automatism circuit applications. 3.4 Uses different programming languages.

	3.5 Know the different PLC programming instructions. 3.6 Identifies programming techniques. 3.7 PLC program from different manufacturers and compares its functionalities. 3.8 Analyzes the technical and commercial documentation of the different manufacturers. **4. Recognizes the control sequences of the programmed systems, interpreting the requirements and establishing the necessary programming procedures.** 4.1 Determines technical and functional requirements. 4.2 Sets the control sequence. 4.3 Determines the different types of operation. 4.4 Identifies the programming phases. 4.5 Recognizes different programming environments. 4.6 Evaluates the critical points of programming. 4.7 Develop a detailed programming plan. **5. Programme combined and sequential systems, based on control conditions and using structured techniques.** 5.1 Design and analyze the program of combinational and sequential systems. 5.2 Design and program control sequences using structured techniques. Apply different programming languages. 5.3 Identifies the different blocks or units of program organization. 5.4 Carries out the program, facilitating future modifications. 5.6 Considers the expected process times.
	Transferable skills
	• Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner

	• Ability to communicate effectively, orally and in writing with "engineering" community and with "society", extrapolating concepts for "non-experts) through an abstraction approach

10.b PLC Programming	
Functional Area: Op/Log/ R&D	
Assessment criteria (RA)	**Knowledge**
LO10b.1: Defines and designs advanced programmed automated systems **<u>Advanced:</u>** **Data acquisition Intelligent sensors, IoT** **Remote management** **Remote diagnostic** **"Artificial Vision"** current technology (note: not as a uto but a current technology can be associated with artificial intelligence base **(artificial intelligence**) **<u>Basic</u>** **Cybersecurity** **Virtual commissioning or advanced in the future** 1. Recognizes programmable devices involved in the control of dynamic systems, identifying their functionality and determining their technical characteristics.	**1. Recognition of programmable devices involved in the control of dynamic systems:** 1.1 Automatic applications for dynamic control systems. Structure of dynamic control systems. Dynamic controls of speed, position, among others. 1.2 Criteria for selecting, sizing and integrating programmable devices for use in dynamic control systems. Voltage, intensity, pulse signals, among others. **2. Advanced programming of logic controllers:** 3.1 Data types in programmable automata. 3.2 Conversion of different types of data. 3.3 Advanced PLC programming functions. Displacement, calculation, processing and storage functions of data, among others. 3.4 Treatment and conditioning of analogue input and output signals in programmable automata. Type of standard voltage and running signals, scaled and de-scaled, analog/digital and digital/analog converters. 3.5 Programmable automata programming blocks. Standard library and user blocks. 3.6 Treatment of warnings and alarms using blocks or interruption routines.

2. Program logic controllers applied to advanced sensors, identifying the typology of process data and using advanced programming and parameterization techniques. **Intelligent sensors** 3. Recognizes the advanced sensors involved in the control of automatic systems, identifying their functionality and determining their technical characteristics. **Intelligent sensors** 4. Program logic controllers applied to advanced sensors, identifying the typology of process data and using advanced programming and parameterization techniques. **Intelligent sensors** 5. It configures the different control and monitoring equipment involved in an automatic system, programming the equipment and integrating communications to a production plant. **Diagnostics and remote control. (remote management, remote diagnostic) Data Acquisition** 6. Program and configure the different buses used in the industrial field, identifying the elements that integrate it and relating them to the rest of devices that configure an automatic system. 7. Program and configure the different buses used in the industrial field, identifying the elements that integrate it and relating them to the rest of devices that configure an automatic system**. Basic cybersecurity**	3.7 Configuration and programming of special cards: temperature, PID, positioning, among others. 3.8 Applications of static control systems. Control of temperature, flow, pressure, among others. 3.9 Applications of dynamic control systems. Control of motors by means of a frequency converter. Positioning control with quick counting, servo motor control, step-by-step motor control, brushless and special, among others. 3.10 Structuring of equipment programs and documentation with maintenance criteria. 3.11 Programming of applications with energy-saving and efficiency techniques. 3.12 Systems of protection. **3. Recognition of advanced sensors involved in the control of automatic systems:** 1.1 Automatic applications for control systems incorporating advanced sensors. **Intelligent sensors** 1.2 Selection criteria for advanced sensors. **Intelligent sensors** 1.3 Characteristics of RFI identification and traceability systems: interface modules, read/write units, data carriers, handheld terminals, among others. 1.4 Characteristics of the systems of identification and traceability by printing. Type of barcodes in 1D, in 2D, among others. 1.5 Features of the 2D, 3D artificial vision systems, among others. **4. Programming of logic controllers applied to advanced sensors:** 3.1 Processing and storage of advanced sensor data in programmable automata. **Intelligent sensor** 3.2 Configuration and programming techniques for identification and traceability control equipment. 3.3 Machine vision equipment configuration and programming techniques. **Artificial vision** 3.4 Configuration and programming of special cards.

	3.5 Application of logic controller programming to advanced sensors. Identification, traceability, quality control, among others. **Intelligent sensors** 3.6 Structuring of equipment programs and documentation with maintenance criteria. 3.7 Systems of protection. **5. Configuration of the different control and monitoring equipment: Diagnosis and remote control. (remote management, remote diagnostic)** 1.1 Definition and classification of monitoring and control systems involved in an industrial communication system. Systems based on operator panels: keyed, tactile with or without keys. Computer-based systems (SCADA). **Diagnostic and remote control. (remote management, remote diagnostic)** 1.2 Main features of monitoring and control systems. **Diagnosis and remote control. (remote management, remote diagnostic)** 1.3 Ergonomics in the design of monitoring equipment. Graphic design, display distribution and navigation. Use of colours. Textual information. Control and insertion of data by the operator. Representation of trend graphics and tables. Alarms. Among others. **Diagnostic and remote control. (remote management, remote diagnostic)** 1.4 Design of different screens and interaction between them. Hierarchical structure of access to different screens. Security by access to specific application screens (start-up and maintenance). 1.5 Visualization and writing of local and global variables. 1.6 Generation of small programs or application scripts in monitoring systems. **Diagnostic and remote control. (remote management, remote diagnostic)** 1.7 Graphic representation of dynamic signals. Analogue display tools: clocks, graphs and trend curves. 1.8 Recording of values and processing of files.

	1.9 Link between applications using DDE, OPC, ActiveX, among others. 1.10 Data management for use in maintenance techniques: warnings, numerical and graphic recordings, and reporting. **Data acquisition systems. Remote control and diagnostic systems (remote management, remote diagnostic)** **6. Scheduling and configuration of the different communication buses of an industrial plant:** 1.1 Study and classification of current industrial buses according to the scope of application. 1.2 Interconnection of networks. Repeaters. Ponts (bridges). Router (router). Gateway. Among others 1.3 Field buses at sensor-actuator level. 1.4 Communication network between a controller and decentralized periphery. 1.5 Communication network for data exchange between controllers. 1.6 Industrial communication network (programmable automata) with office network integration (computers). 1.7 Incorporation of different control equipment in the same communication system with data monitoring between them. **Diagnostic and remote control. (remote management, remote management)** **7. Programming and configuration of the different communication buses of an industrial plant: Basic cybersecurity** 1.1 Systems for access in industrial networks from the outside. **Basic cybersecurity** 1.2 Configuration of industrial networks using wireless technology. 1.3 Process control by computer. **Diagnostic and remote control. (remote management, remote diagnostic)** 1.4 Drawing up plans and plans for a communication network in industrial automation systems. 1.5 Development of service instruction manuals of communication networks.

	Skills
	1. Recognizes programmable devices involved in the control of dynamic systems, identifying their functionality and determining their technical characteristics. 1.1 Recognizes automatic applications for reading and controlling dynamic signals. 1.2 Identifies the structure of the programmed analog control system. 1.3 Relates the components of programmable devices to their functionality. 1.4 Determines the technical characteristics of the programmable devices seconds the type of control to be perform. 1.5 Selects the second programmable device the required application. **2. Program logic controllers applied to advanced sensors, identifying the typology of process data and using advanced programming and parameterization techniques intelligent sensors.** 3.1 Relates programmable logic controller data types to the signals to be treated. 3.2 Uses programming techniques for storing process signals in data blocks. 3.3 Configure and program identification and traceability control devices. 3.4 Configures and programs machine vision equipment. 3.5 Addressing and configuring signals from special modules of programmable logic controllers. 3.6 Program logic controllers applied to advanced sensors. **Intelligent sensors** 3.7 Optimizes the program, taking into account its ease of maintenance. 3.8 Complies with safety standards.

	3.9 Acts responsibly in the accomplishment of the assigned tasks. 3.10 Satisfactorily solves the problems presented. **3. It recognizes the advanced sensors involved in the control of automatic systems, identifying their functionality and determining their technical characteristics. Intelligent sensors** Criteria for the assessment 1.1 Recognizes the different types of advanced sensors used in automatic applications. **Intelligent sensors** 1.2 Identifies the technical characteristics of the different sensors used in identification and traceability and in artificial vision systems. 1.3 Select the most suitable sensor according to the required application. 1.4 Identifies the structure of the programmed analog control system. 1.5 Relates the components of programmable devices to their functionality. **4. Program logic controllers applied to advanced sensors, identifying the typology of process data and using advanced programming and parameterization techniques. Intelligent sensors** 3.1 Relates programmable logic controller data types to the signals to be treated. 3.2 Uses programming techniques for storing process signals in data blocks. 3.3 Configure and program identification and traceability control devices. 3.4 Configures and programs machine vision equipment. 3.5 Addressing and configuring signals from special modules of programmable logic controllers. 3.6 Program logic controllers applied to advanced sensors. **Intelligent sensors**

	3.7 Optimizes the program, taking into account its ease of maintenance. 3.8 Complies with safety standards. 3.9 Successfully solves the problems presented. **5. Configures the different control and monitoring equipment involved in an automatic system, programming the equipment and integrating communications to a production plant. Diagnostic and remote control. (remote management, remote diagnostic)** 1.1 Relates the functions of a monitoring and control system to industrial applications automation. **Diagnostics and remote control. (remote management, remote diagnostic)** 1.2 Recognizes all configuration tools, and relates them to the function they will perform within the application. 1.3 Configures warnings and alarms, and records them in a file for further processing. 1.4 Configure and program control and monitoring systems from different manufacturers**. Diagnostic and remote control. (remote management, remote diagnostic)** 1.5 Integrates operator panels and computers as control, monitoring and data acquisition devices in an industrial communication network. 1.6 Configures a monitoring and control system for graphical data reporting. **Data acquisition (date acquisition). Diagnosis and remote control. (remote management, remote diagnostic)** 1.7 Gives functionality to the control system to work with data related to machine maintenance or industrial process. 1.8 Applies established quality criteria. **6. Program and configure the different buses used in the industrial field, identifying the elements that integrate it and relating them to the rest of devices that configure an automatic system.** 1.1 Identifies the different current industrial buses, and relates them to the communications pyramid. 1.2 Configures the equipment of an industrial network for communication between devices.

	1.3 An industrial network for data exchange between devices is planned. 1.4 Configures the components for use in the interconnection of different networks by protocol change or physical means. 1.5 Represents industrial communication systems using functional blocks. 1.6 Selects equipment and installation elements from manufacturers' technical documentation. 1.7 Takes into account the expected process times. 1.8 Applies established quality criteria. **7. Program and configure the different buses used in the industrial field, identifying the elements that integrate it and relating them to the rest of devices that configure an automatic system. Basic cybersecurity** 1.1 Configures the equipment of an industrial network for communication between devices. **Basic cybersecurity** 1.2 Program an industrial network for data exchange between devices. 1.3 Configures the components for use in the interconnection of different networks by change of protocol or physical medium. 1.4 Uses remote access techniques for process control and communication between different industrial equipment**. Data acquisition (Acquisition date). Diagnosis and remote control. (remote management, remote diagnostic)** 1.6 Uses different physical means for communication between equipment and systems. 1.7 Represents industrial communication systems using functional blocks. 1.8 Selects equipment and installation elements from manufacturers' technical documentation. 1.9 Takes into account the expected process times. 1.10 Applies established quality criteria
	Transferable skills

	• Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner • Ability to communicate effectively, orally and in writing with "engineering" community and with "society", extrapolating concepts for "non-experts) through an abstraction approach

11.a Carry on diagnostic activities interfacing machines/assembly lines and collecting data by Visual Programming tools (*resolve equipment malfunctions, maintain control systems for automated equipment, perform test run)*	
Functional Area: QA	
Pre-Requisites:	
Assessment criteria	**Knowledge**
LO11a.1. Develops plans of assembly and maintenance of installations, applying programming techniques and establishing procedures for execution monitoring and control. • Follow and maintain procedures to be in line with HMI general requirements • Test the Electronic components using proper instruments and tools • Carry out a simple debugging procedure and report results • Carry out a procedure on an ATE on production/assembly line	• Knowledge of Basic Electronic components (active and passive) and relevant symbols • Reading of electronic circuit drawing. • Knowledge of Types of Resistors, capacitors and their identification • Understanding of Working and operation of Diodes, Rectifier circuits. Zener voltage Regulators • Knowledge of Transistors and their applications.
	Skills
	• Collaborate effectively within multidisciplinary teams • Identify, analyse, synthesize and act on information from a range of sources, verbal, written and in electronic format

	• Understand functional application of different levers, stoppers, adjustment etc. • Install Operating Systems and Device Drivers, Install/Uninstall Application software
	Transferable skills
	• Understand descriptions, specifications, manuals and other info typical of the profession in English • Ability to communicate effectively, orally and in writing with "engineering" community and with "society" (extrapolating concepts for "non-experts) through an abstraction approach • Ability to submit and discuss presentations on practical cases

11.b Carry on diagnostic activities interfacing machines/assembly lines and collecting data by Visual Programming tools (*resolve equipment malfunctions, maintain control systems for automated equipment, perform test run)*	
Functional Area: QA	
Pre-Requisites:	
Assessment criteria	**Knowledge**
LO11b.1. Diagnoses breakdowns in discrete and continuous simulated mechatronic systems, identifying the nature of the breakdown, making the necessary corrective interventions to eliminate the dysfunction and restore function.	• Reading of electronic circuit drawing. • Knowledge of Types of Resistors, capacitors and their identification • Understanding of Working and operation of Diodes, Rectifier circuits. Zener voltage Regulators

• Carry out a procedure on an ATE on production/assembly line, following instruction manuals • Demonstrate possible solutions and agree tasks within a team	• Knowledge of Transistors and their applications.
	Skills
	• Capability to Check PC Power Supply, SMPS cables and connections to mother boards, connection of I/O devices to PC, HDD/DVD cables. • Identify, analyse, synthesize and act on information from a range of sources, verbal, written and in electronic format • Understand functional application of different levers, stoppers, adjustment etc.
	Transferable skills
	• Collaborate effectively within multidisciplinary teams • Analyze descriptions, specifications, manuals and other info typical of the profession in English, providing comments on how to improve them • Ability to communicate effectively, orally and in writing with “engineering” community and with “society” (extrapolating concepts for “non-experts) through an abstraction approach • Ability to prepare draft operational procedures on practical cases

12.a/ 12.b Access and manage data base using SQL (record test data)	
Functional Area: IT	
Pre-Requisites:	
Assessment criteria	**Knowledge**

LO12ab.1. Carries out the physical design of databases using wizards, graphic tools and data definition language. • Debug their own programs, use logical reasoning to explain simple algorithms (including their own), and detect and correct errors in both algorithms and programs. • Select, use and combine data on a range of given examples • Analyse and Evaluate data of an example • Analyse and Evaluate information of an example	• Logical reasoning to explain how some simple algorithms work • Logical reasoning to detect and correct errors in algorithms
	Skills
	• Work with various forms of input • Work with various forms of output • Use logical reasoning to detect and correct errors in programs • Understand how computer networks can provide multiple services, such as the World Wide Web • Collect data • Present data • Analyse information • Evaluate information
	Transferable skills
	• Solve problems by decomposing them into smaller parts • Use selection in programs and work with variables • Understand difference between data and information

13.a / 13.b Identify and utilize the main Artificial Intelligence tools

Functional Area: R&D/Op&Log	
Assessment criteria	**Knowledge**

LO13ab.1. Selects and applies different techniques of Artificial Intelligence and has criteria to select one for each problem. Starting from a selected method/model: ● describe how it works, pros and cons, use cases and applications. Starting from given application describe: ● How AI could be used and the related advantages ● Select a method and describe motivations of the choice ● Describe how to train the model Starting from a given aim of AI usage and a data set the student has to select different models and by means of provided tools (prepared executable files or codes for AI applications) it has to train the model and perform some simple analysis commenting the results.	● Fundamentals on unsupervised methods ● (Autoregressive model, Hoteling Distance T2, others) ● Fundamentals on supervised methods (Neural network, Support Vector Machines, Envelope Analysis) ● Training datasets and class definitions ● Main tools and software for AI algorithms application ● Main applications of AI in industrial use cases ● Main applications of AI for data managing, signals analysis, image tracking and voice-controlled application for data analytics
	Skills
	● Understand the difference between a supervised and unsupervised method ● Decision making on the correct method to apply ● Describe pros and cons of the different methods ● Selection and integration in a given process of different AI tools (commercial HW and /or SW ready to use) ● Use in a simple way AI algorithms inside already known programming software (using ready AI libraries)
	Transferable skills

14.a/ 14.b Manage, utilize storage data network tools

Functional Area: IT	
Pre-Requisites:	
Assessment criteria	**Knowledge**
LO14.ab.1. Configures database management systems, interpreting technical specifications and operation requirements • Use logical reasoning to explain how some simple algorithms work and to detect and correct errors in algorithms and programs • Use search and storage technologies effectively, appreciate how results are selected and ranked, and be discerning in evaluating digital content	• Basic of computer Networks (using real life examples), and Internet Local Area Network (LAN), Wide Area Network (WAN), Internet, Concept of Internet (Network of Networks), Meaning of World Wide Web (WWW), Web Browser, Web Site • Web page and Search Engines. Accessing the Internet using Web Browser • Information Security and antivirus tools, Do's and Don'ts in Information Security, Awareness of IT, types of cyber crimes
	Skills
	• Select, use and combine a variety of software (including internet services) on a range of digital devices to design and use a range of programs, systems and content that accomplish given goals, including collecting, analysing, evaluating and presenting data and information • Use technology purposefully to create, organise, store, manipulate and retrieve digital content
	Transferable skills
	• Understand computer networks, including the internet; how they can provide multiple services, such as the World Wide Web, and the opportunities they offer for communication and collaboration

15. Evaluate ergonomic aspects of industrial logistics

Functional Area: Op&Log/QA	
Assessment criteria	**Knowledge**
LO15a.1. Identifies and designs plans to incorporate ergonomic aspects into industrial processes. ● Follow and maintain procedures to be in line with HMI general requirements ● Ensure dimensional accuracy of assembly by using different instruments/gauges/measuring tools ● Set up workplace/ assembly location with due consideration to operational process and HMI and safety requirements ● Demonstrate possible solutions and agree tasks within a team ● Mount the work and tool holding devices with required alignment and check for their functional usage to perform machining operations	● Knowledge of Principles and theories relevant to mechanical, electrical, electronic engineering, and manufacturing technologies. ● Know the principles of HMI design and development within the field of mechatronics engineering and its disciplines ● Knowledge of material (physical, electromagnetic characteristic…)
	Skills
	● Judge engineering/manufacturing decisions considering balanced costs, safety, quality, reliability vs HMI aspects ● Collaborate effectively within multidisciplinary teams ● Identify, analyse, synthesize and act on information from a range of sources, verbal, written and in electronic format ● Understand functional application of different levers, stoppers, adjustment etc. ● Understand anatomy of robots/cobots and their interactions with human operators
	Transferable skills
	● Understand descriptions, specifications, manuals and other info typical of the profession in English ● Ability to communicate effectively, orally and in writing with “engineering” community and with “society” (extrapolating concepts for “non-experts) through an abstraction approach ● Ability to submit and discuss presentations on practical cases ● Appreciate limits and future developments of human-robotics interaction, from social/labour related point of view

16.Evaluate advanced logistics project aspects like cost/benefit ratio, safety, impact, threats, maintenance, etc.)	
Functional Area: Op&Log	
Assessment criteria	**Knowledge**
LO16.1. Determines the operational costs of a mechatronic system, analyses and interprets the results of the process/operational control charts and operates in accordance with quality systems. • Determines the operations costs, identifying and calculating the times of configuration, optimization, monitoring, assembly or maintenance in mechatronic systems. • Detects deviations in automatic processes, analyzing and interpreting process control charts and/or operations • Acts in accordance with quality procedures and standards associated with the professional profile competences, relating them to quality systems and models.	• Maintenance mechanization, assembly, commissioning, and supervision time calculation. • Preparation time and manual operation • The cost calculation attributed to the operations time. • Costs calculation rigour. • Operational or process control charts interpretation. • Process capacity concept and index that values it. • Interpreting criteria for control graphs. • Purpose and consequences of standardized times. • Interest in providing technical solutions to problems • Quality register complementation • Fundamental concepts of quality systems. • Standards applicable to the process inherent in this professional figure. • Personal initiative to provide ideas and agree on procedures. • Intervention in quality management systems and models • Rules applicable to the process inherent in this professional figure. • Personal initiative to provide ideas and agree on procedures
	Skills

	• Identify variables involved in the assembly and mechatronic systems maintenance. • Calculates the time of operations phases. • Identifies non-productive times of mechatronics operations using standard tables. • Estimate the cost of the product through the associated documentation. • Relates process efficiency to production costs. • Does the calculations with rigour and accuracy. • Relates the concept of process capacity and indexes that evaluate to process adjustment interventions. • Interpret the alarms or evaluation criteria of the control charts used • Breaks down work processes into elements, analyzes tasks and applies time. • Explain the factors that can influence the length of each item. • Distinguishes the different types of charts depending on their application. • Explains the control limit value. • Identifies the rules and procedures related to the manufacturing or control process. • Fill in the documents associated with the process. • Assesses the influence of quality standards on the whole process. • Explains the quality systems characteristics and models that affect the technological process of this professional profile. • Assesses the influence of quality standards on the whole process. • Identifies the rules and procedures related to the manufacturing or control process. • Fill in the documents associated with the process. • Maintains an orderly and methodical attitude.

	Transferable skills
	• Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for the next phase of project/Customer in understandable manner. • Ability to communicate effectively, orally and in writing with "engineering" community and with "society", extrapolating concepts for "non-experts) through an abstraction approach.

16.Evaluate advanced logistics project aspects like cost/benefit ratio, safety, impact, threats, maintenance, etc.)	
Functional Area: Op&Log/QA	
Assessment criteria	**Knowledge**
LO16.2. Applies preventive and/or predictive maintenance techniques to industrial pollutant treatment equipment, performing maintenance operations, diagnosing and using monitoring techniques. • Establishes the stages in a maintenance process of industrial equipment for the environmental pollutants treatment, analyzing the technical documentation, the safety plan and the instruction manuals, applying programming techniques and establishing procedures for monitoring and controlling execution. • Elaborates the spare parts catalog and the management and provisioning program, establishing the storage conditions of the components, tooling, materials and	• Description of the types of pollutants (emissions, discharges, waste, water and energy). • Analysis of existing environmental practices and procedures • Air, waste water and solid waste material treatment equipment. • The main pollutants description. • Pollutants measurement and monitoring. • Pollutant emission sources continuous measurement. • SAM automatic measuring system • Management methodology ISO 14001-2015 EMAS • Causes of non-conformities and environmental accidents • Equipment history register • Legislative requirements, environmental standards

equipment for the treatment of emissions, dumping and waste. • Diagnoses breakdowns in control equipment emissions and production process waste treatment, identifying the nature of the matter, and performing the necessary corrective interventions to eliminate dysfunction and restore functioning. • Integrates and launches industrial communications to SAM automatic emission metering systems, fulfilling operating conditions.	• Environmental assessment instruments • Amount of pollutants that can be emitted by an industrial company. • Parameter capture and correction action for out-of-range data. • Control and inspection.
	Skills
	• Identifies circuits, auxiliary elements and components of equipment and installations. • Determines the activities of predictive and preventive maintenance to be performed on environmental treatment equipment • Select the necessary equipment, and tools. • Indicates and establishes the sequencing of the commissioning, assembly and maintenance operations. • Defines the assembly and maintenance plan stages, and the materials required for the installation. • Represents the diagrams of manpower, materials and means, optimizing the terms and resources. • Prepares the maintenance interventions register. • Apply the safety regulations during the execution of the process • Documentarily makes specific planning, determining activities and resources. • Identify the elements and quantities of each unit of work for the preparation of budgets. • Classifies the units of work involved in the installation, details the discounted prices and obtains the total amount • It breaks down the annual costs of preventive-corrective and predictive maintenance • Applies maintenance management software.

	• Determines the ways of provisioning and storage in relation to the needs of maintenance plans. It sets the storage criteria as well as the spare levels. • Identifies the typology and symptoms characteristics of the most common breakdowns that may occur in an automated equipment management system for industrial waste. • Defines the general procedure that will be used to diagnose and locate breakdowns in the different systems (from each system independently and integrating all or some of them) in the automated production waste treatment processes. • Find the breakdown responsible element. • Determines the types of communication in the European market based on the technical requirements characteristics. • Checks and / or selects the elements of the system, from the necessary commercial technical catalogs and calculations. • Anticipates the emergency situations that may occur in the systems. • Document the installation and commissioning procedures for the installation. • Assemble and connect the elements and networks of mechanical, electrical, pneumatic and / or hydraulic and control systems, with the established quality and safety conditions • Achieves the correct operational at start-up by regulating and controlling the physical variables that affect the system.
	Transferable skills
	• Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for the next phase of project/Customer in understandable manner. • Ability to communicate effectively, orally and in writing with “engineering” community and with “society”, extrapolating concepts for “non-experts) through an abstraction approach.

16.Evaluate advanced logistics project aspects like cost/benefit ratio, safety, impact, threats, maintenance, etc.)	
Functional Area: Op&Log/QA	
Assessment criteria	**Knowledge**
LO16.3. Applies protection and prevention measures, analysing risk situations in the labour setting of the Higher Technician in Industrial Mechatronics. • Defines actions to facilitate the implantation and maintenance of occupational risk prevention systems and interprets their concepts and basic factors.	• Provisions and regulations at the state, regional or local level that affect the sector and the company's activities. • The risks prevention in the internal rules of companies. • Functional areas of the company related to prevention. • The prevention organization in the company. ISO 45001:2018 • Promotion of the risk prevention culture as a model of business policy • Risks, prevention and protection measures, and emergency plans specific to the activities of the sector • Norms classification by activity sector and type of risk. • Personal protective equipment in relation to the dangers they protect. • Risk assessment. • Risks sources. • Conservation and maintenance standards. • Self-protection plans.
	Skills
	• Identifies the foundations, principles and legal requirements established in the occupational risk prevention systems. • Explains through the diagrams and flowcharts the occupational risk prevention functional structure in a typical company.

	• Describes the requirements and procedure that should be included in an internal audit of occupational risk prevention. • Describes the minimum requirements that must be contained in the document system for occupational risk prevention and its control. • Describe the techniques for promoting occupational risk prevention. • Describes the characteristics and requirements of preventive and individual and collective protection measures, and emergency plans for companies in the sector. • Determines the risks associated with a production means in companies in the sector. • Describe the elements that make up an emergency plan at the company level. • Classifies personal protective equipment in relation to the dangers they protect • Describes the personal protective equipment maintenance, conservation and replacement operations. • Describe the occupational risk prevention promoting techniques.
	Transferable skills
	• Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for the next phase of project/Customer in understandable manner. • Ability to communicate effectively, orally and in writing with “engineering” community and with “society”, extrapolating concepts for “non-experts) through an abstraction approach.

17. Cybersecurity Awareness

Functional Area: IT (60h)

Pre-Requisites:	
Assessment criteria	**Knowledge**
LO17.1. Apples cybersecurity strategies in the phases of Mechatronics projects to minimize the impact of any possible incident. • Resolve the cybersecurity elements to be included in the design, establishes the cybersecurity measures in the execution and implementation of an industrial project. • Implements the cybersecurity activities of the operation and maintenance phase of an industrial project documenting the activities carried out. • Plans purchase management determining the cybersecurity requirements to be met by suppliers • Dismantles the facilities complying with the requirements established in destruction and / or conservation of the systems in a safe way.	• Cybersecurity activities in the design of an industrial project. • Cybersecurity equipment in the purchasing management process. • Measures cybersecurity in the execution and implementation of the industrial project • Cybersecurity activities in the operation and maintenance phase of an industrial project. • Cybersecurity activities in the dismantling of facilities.
	Skills
	• Evaluates the design of the industrial project: • Identifies the actors and managers involved in the project, as well as their functions, competences and liabilities in cybersecurity. • Maps the threats, risks and attack scenarios. • Executes and implements the project after analysing cybersecurity functions and responsibilities. • Establishes a detailed plan of cybersecurity measures. • Take into account the principles of circular economy. • Incorporates in factory acceptance tests (FAT) cybersecurity and safety criteria. • Establishes quality control plans and audits. • Identifies and implements cybersecurity improvements on the installation. • Implements and documents operation and maintenance cybersecurity activities.

	• Implements cybersecurity awareness and training plans. • Establishes the acquiring management process for suppliers. • Execute analysis and manage the risks associated with the supply chain. • Defines cybersecurity activities in the dismantling, decontamination, declassification, demolition and replacement of project facilities. • Implements and verifies systems destruction measures documenting incidents. • Implements and verifies systems conservation measures documenting incidents.
	Transferable skills
	• Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for the next phase of project/Customer in understandable manner. • Ability to communicate effectively, orally and in writing with “engineering” community and with “society”, extrapolating concepts for “non-experts) through an abstraction approach.

4.6 OVERALL CONCLUSIONS OF THE STAKEHOLDER’S FEEDBACK

Industry is aware of its digitization importance: transformation to Industry 4.0 improves its processes efficiency. 'Our industry considers it important to digitalize the industry in order to obtain more flexible production, higher productivity and the development of new business models'.

The digital implementation for the entire company, which encompasses each of the phases of product and services development with the use of new technologies such as IoT, analytics, AI, robotics, 3D printing and digital twin, as well as cybersecurity, achieves new income and a level full collaboration with customers, employees and Smart industry partners.

Improvements in its implementation have already been observed:

- Reduction of time to market: more productive workers with wearables, reducing errors and optimizing setup.
- The new value of connected products: Design and development of products and services, including hardware and software.
- Digital Engineering: Data-based engineering for the management of the life cycle of products with twin digital technology.
- Production & Ops (digital operations), End to End Digilitation: Full integration with MES, MOM, connected worker, 3D printing and production based on AI (artificial intelligence)

The Catalan SMA considers the training of its workers very important, and the incorporation of new technologies in their curricula, since today's world is characterized by rapid, exponential and, above all, continuous change. Although only 15% of them already incorporate these improvements. (The large Catalan industrial block, 85% of the industry, includes medium and small companies, which are in tow due to economic difficulties in the face of global competitiveness).

The entire industrial sector values the NewMetro project as necessary because it provides solutions in knowledge for a complete digital transformation that affects speed, flexibility, quality, efficiency, new business models, environmental efficiency, health, safety and cybersecurity.

Another remark, and no less important is the educators training in innovative areas of knowledge proper for an EQF6-7 in those competences, as well as the possibility of development support in companies which work based learning experience about the competences.

It would also be necessary to have its own software and work tools available for each competition, which by making a mass purchase for institutes and universities in a large geographical area, purchase agreements could be negotiated.

Wearable technology can be a game changer by talking to the industry where it is going on a grand scale - to a fully digital mindset, all the time. In this way, cutting-edge technologies will bring new opportunities for both the discrete and process industries to meet the individual requirements of their customers.

4.7 COMPARISON BETWEEN NATIONAL QUALIFICATIONS AND NEWMETRO CURRICULA

To facilitate this comparison between national/regional qualifications and the NewMetro curricula we propose different ways, depending on the national/regional qualification description/definition.

If the national/regional qualifications are defined in Learning Outcomes, the partner is able to use the list below that summarize NewMetro curricula in a wide Learning Outcomes for each competence.

1. Aptly choosing advanced materials that can suit product or process needs

1a Aptly choosing advanced materials that can suit product or process needs

- LO1a.1. Selects the material to be used in a mechatronic system, linking the technical and commercial characteristics with the product specifications to be obtained.

1b Aptly choosing advanced materials that can suit product or process needs

- LO1b.1. Selects new materials for the manufacture relating their characteristics with the functional, technical, economic and physical requirements of the designed products and test results.

2. System design and integration/interfacing between electronic and mechanical components (assemble and test mechatronic units, set up machine controls, customize software, adjust engineering design)

2a System design and integration/interfacing between electronic and mechanical components (assemble and test mechatronic units, set up machine controls, customize software, adjust engineering design)

- LO2a.1: Identifies the elements of the regulation loop of industrial systems, relating their role to the elements making up.
- LO2a.2. Integrates mechatronic systems.

2b System design and integration/interfacing between electronic and mechanical components (assemble and test mechatronic units, set up machine controls, customize software, adjust engineering design)

- LO2b.1. Designs prototypes and mechanisms of mechatronic systems.

3. System automation, control and system support

- LO3.1: Defines and designs mechatronics systems
- LO3.2: Performs the assembly of the installation and verifies the operation and commissioning of mechatronics systems

4. Evaluate environmental impact both from product manufacturing and product whole life cycle

- LO4.1: Evaluates environmental impact, identifying the measures and equipment to prevent them.

5. Define preemptive maintenance protocols and early diagnostic maintenance protocols (maintain mechatronics equipment)

5a Define preemptive maintenance protocols and early diagnostic maintenance protocols (maintain mechatronics equipment)

- LO5a.1: Applies techniques of pre-emptive maintenance at mechatronic systems, realising operations and interpreting plans of maintenance.

5b Define preemptive maintenance protocols and early diagnostic maintenance protocols (maintain mechatronics equipment)

- LO5b.1: Diagnoses the condition of the machine elements, applying the techniques of monitoring, measurement and analysis described in the pre-emptive and / or early diagnostic procedure.
- LO5b.2: Diagnose breakdowns and malfunctions in mechatronic systems, linking the malfunction to the cause.

6. Robotics programming (set up automotive robot) assembly and manufacturing robots, collaborative robots)

6a Robotics programming (set up automotive robot) assembly and manufacturing robots, collaborative robots)

- LO6a.1. Recognizes different types of robots and/or motion control systems, identifying the components that form them and determining their applications in industrial automation.
- LO6a.2: Configures robotic and/or motion control systems, selecting and connecting the component elements.
- 6b Robotics programming (set up automotive robot) assembly and manufacturing robots, collaborative robots)
- LO6b.1. Programs robots and/or motion control systems, using programming and data processing techniques.

7. Design virtual testing and validation using modelling and simulation tools (simulate mechatronic design concepts, use CAE solutions (Computer Aided Engineering) as for example: CAD (Computer Aided Design) CAM (Computer Aided Manufacturing) FEA (Finite Element Method) SMBD (Simulation Model Based Design)

7a Design virtual testing and validation using modelling and simulation tools

- LO7a.1. Designs prototypes and mechanisms of mechatronic systems, using specific programs for three-dimensional simulation.

7b/c Design virtual testing and validation using modelling and simulation tools

- LO7b.1. Simulates robotic cells and mechatronic prototypes, validating the design by using simulation software.

- LO7b.2. Determines actions for the implementation and maintenance of systems for quality assurance, for the continuous improvement of productivity in the maintenance and installation of facilities, performing basic concepts and requirements.

8. Develop the virtual prototypes in the real environment also thanks to physical computing tools

8a Develop the virtual prototypes in the real environment also thanks to physical computing tools

- LA8a.1. Plans, manages the assembling and executing operations of adjustment of mechatronics prototypes from virtual models.

8b Develop the virtual prototypes in the real environment also thanks to physical computing tools

- LO8b.1. Executes and verifies the operations of adjustment, configuration and programming of automatic devices, based on the technical design and using software tools and hardware required.

9. Utilize, choose, customize monitoring and data management systems (monitor automated machines, record test data)

9a Utilize, choose, customize monitoring and data management systems (monitor automated machines, record test data)

- LO9a.1: Defines and designs monitoring and data management systems.

9.b Utilize, choose, customize monitoring and data management systems (monitor automated machines, record test data)

- LO9b.1: Performs the assembly of the installation and verifies the operation and commissioning of monitoring and data management systems

10. PLC Programming

10a PLC programming

- LO10a.1. Recognizes programmable devices involved in the control of dynamic systems, identifying its functionality and determining its technical characteristics.

10b PLC programming

- LO10b.1: Defines and designs advanced programmed automated systems.

11. Carry on diagnostic activities interfacing machines/assembly lines and collecting data by Visual Programming tools (resolve equipment malfunctions, maintain control systems for automated equipment, perform test run)

11.a Carry on diagnostic activities interfacing machines/assembly lines and collecting data by Visual Programming tools (resolve equipment malfunctions, maintain control systems for automated equipment, perform test run)

- LO11a.1. Develops plans of assembly and maintenance of installations, applying programming techniques and establishing procedures for execution monitoring and control.

11.b Carry on diagnostic activities interfacing machines/assembly lines and collecting data by Visual Programming tools (resolve equipment malfunctions, maintain control systems for automated equipment, perform test run)

- LO11b.1. Diagnoses breakdowns in discrete and continuous simulated mechatronic systems, identifying the nature of the breakdown, making the necessary corrective interventions to eliminate the dysfunction and restore function.

12. Access and manage database using SQL (record test data)

12.a/ 12.b Access and manage database using SQL (record test data)

- LO12ab.1. Carries out the physical design of databases using wizards, graphic tools and data definition language.

13. Identify and utilize the main Artificial Intelligence tools

13.a / 13.b Identify and utilize the main Artificial Intelligence tools

- LO13ab.1. Selects and applies different techniques of Artificial Intelligence and has criteria to select one for each problem.

14. Manage, utilize storage data network tools

14.a/ 14.b Manage, utilize storage data network tools

- LO14ab.1. Configures database management systems, interpreting technical specifications and operation requirements.

15. Evaluate ergonomic aspects of industrial logistics

- LO15.1. Identifies and designs plans to incorporate ergonomic aspects into industrial processes.

16. Evaluate advanced logistics project aspects like cost/benefit ratio, safety, impact, threats, maintenance, etc.)

16a/16b Evaluate advanced logistics project aspects like cost/benefit ratio, safety, impact, threats, maintenance, etc.)

- LO16ab.1. Determines the operational costs of a mechatronic system, analyses and interprets the results of the process/operational control charts and operates in accordance with quality systems.
- LO16ab.2. Applies preventive and/or predictive maintenance techniques to industrial pollutant treatment equipment, performing maintenance operations, diagnosing and using monitoring techniques.
- LO16ab.3. Applies protection and prevention measures, analysing risk situations in the labour setting of the Higher Technician in Industrial Mechatronics.

17. Cybersecurity Awareness

- LO17.1. Apples cybersecurity strategies in the phases of Mechatronics projects to minimize the impact of any possible incident.

If the national/regional qualification is not expressed in learning outcomes the comparison can be carried out on the basis of the evaluation criteria defined in the previous point, that is summarized and harmonized below.

1.Aptly choosing advanced materials that can suit product or process needs

1a Aptly choosing advanced materials that can suit product or process needs

- Prepare list of appropriate materials by interpreting detail drawings and determine correct quantities of such materials
- Read and analyze the specifications to ascertain the material requirement, relevant tools, and machining /assembly /maintenance parameters

1a Aptly choosing advanced materials that can suit product or process needs

- Based on a real example of a process/realization of a product, propose improvements to the use of materials/machining, underlining pros/cons
- Select appropriate measuring instruments and tools to test and validate characteristics of given material sample
- Evaluate appropriateness of testing at lab level vs production process

2.System design and integration/interfacing between electronic and mechanical components (assemble and test mechatronic units, set up machine controls, customize software, adjust engineering design)

2a System design and integration/interfacing between electronic and mechanical components

- Describe the main characteristics of a mechatronics assay and its potential use applications
- Based on a real example of an implementation of a process/realization of a product, propose improvements to its design, underlining its pros/cons
- Demonstrate function of different sensors [e.g. proximity, inductive, capacitive, magnetic, photoelectric, temperature, haptic, etc.]
- Perform project work on Mechatronics (e.g. involving fitting, drilling, turning, milling, grinding, electrical wiring & soldering, programming, hydraulic circuit assembly, pneumatic circuit assembly, drives, system assembly and interfacing, functional testing, troubleshooting and repair. Safety measures in each stage)

2b System design and integration/interfacing between electronic and mechanical components (assemble and test mechatronic units, set up machine controls, customize software, adjust engineering design)

- Describe the main characteristics of a mechatronics assay and its potential use applications

- Propose solutions for the design of a simple product/process
- Design, on the basis of an outline design draft, a prototype of a product/process

3.System automation, control and system support

- Defines and designs mechatronics Systems
  - Identifies the elements of an electrical-electronic nature in a machine, industrial equipment or automated line, describing the function they perform and their relationship with the other elements.
  - It configures automated systems, at machine level and to automated installation, adopting the most appropriate solution and complying with the established operating conditions.
  - Identifies the elements that make up the regulatory loop of industrial systems, relating their function to the elements that make up the automation processes with technologies, such as data acquisition intelligent sensors and IoT
  - Integrates industrial communications and monitoring systems into the overall assembly of discrete and continuous process mechatronics systems controlled by PLC. Remote and diagnostics control systems.
  - Differentiates the different operating modes and their specific characteristics from real or simulated systems, in real and digital systems. Digital twin and Virtual commissioning
- Performs the assembly of the installation and verifies the operation and commissioning of mechatronics systems
  - Assembles automated installations, interpreting schemes and applying mounting techniques. with data acquisition technologies, intelligent sensors and IoT. Data acquisition Intelligent sensors, IoT
  - Complies with the standards for the prevention of occupational hazards and environmental protection in the assembly, identifying the associated risks, measures and equipment to prevent them.

4.Evaluate environmental impact both from product manufacturing and product whole life cycle

- Describe the main pollutant which could derive from a given process/production/machining
- Given a real example, propose the best methodology to reduce waste to a minimum and/or contain it to be separately discarded
- Based on a real example of an implementation of a process/realization of a product, calculate the RoM of energy/water/oil/etc. (depending on the case) needed
- For a given material to be used in a process/product suggest the best solution for recycling its waste or the product at the end of its life cycle
- Describe the main concepts related to energy conservation, global warming and pollution and contribute in day to day work by optimally using available resources
- Recognize and report all non-compliant situations according to site policy
- Identify, handle and store/dispose-off dangerous/unsalvageable goods and substances according to site/local policies and procedures following safety regulations and requirements
- Identify Personal Protective Equipment (PPE) and use the same as per related working/process environment and disposal procedure

5.Define preemptive maintenance protocols and early diagnostic maintenance protocols (maintain mechatronics equipment)

5a Define preemptive maintenance protocols and early diagnostic maintenance protocols (maintain mechatronics equipment)

- Apply techniques of pre-emptive maintenance at mechatronic systems, realizing operations and interpreting plans of maintenance.
  - Recognizes different types of mechatronic systems, applying specific techniques of pre-emptive and/or early diagnostic maintenance.
  - Substitutes elements, configure and parameterize controllers and records the works carried out.
  - Uses CMMS software management for remote maintenance.

5b Define preemptive maintenance protocols and early diagnostic maintenance protocols (maintain mechatronics equipment)

- Diagnoses the condition of the machine elements, applying the techniques of monitoring, measurement and analysis described in the pre-emptive and / or early diagnostic procedure
  - Uses the diagnostic techniques corresponding to the different elements of the mechatronic system.
- Diagnose breakdowns and malfunctions in mechatronic systems, linking the malfunction to the cause.
  - Troubleshoot malfunctions, develop action plans and hypotheses on possible causes.
  - Prepares breakdown records.

6.Robotics programming (set up automotive robot) assembly and manufacturing robots, collaborative robots)

6a Robotics programming (set up automotive robot) assembly and manufacturing robots, collaborative robots)

- Starting from a given task that a robot has to perform the student will describe:
  - how to accomplish the task using Parallel and/or Serial mechanisms
  - What are stable and unstable systems and the influence of those on the task to perform
  - Feedforward and feedback approaches to accomplish the tasks
- Starting from a given task that a robot has to perform the student will describe:
  - Trajectory of end-effector
  - Sequence of displacements of the different joints
  - Motion Laws graphs (displacement and velocity vs time
- Starting from a given task that a robot has to perform the student will describe the algorithm and create the code needed to program the robot/cobot
- Open questions on Remote controlling, teleoperation and Safety aspects
- Practical tasks on programming robots

6b Robotics programming (set up automotive robot) assembly and manufacturing robots, collaborative robots)

- Starting from a trajectory of an end effector the student has to describe/calculate:
  - Number of actuated joints and affordable dimension of the robot arms
  - Sequence of displacements of the different joints
  - Motion law (acceleration, velocity, displacement vs time)
  - Possibility of singularity points and how to avoid it
- Starting from a given manufacturing process (with 2 or more operations) the student has to:
  - Describe the order of the operations
  - Kinds of robots to use for the single operation
  - Estimation of time cycle for the single operation

- Total number of robots needed to perform the manufacturing process (considering also the parallelisation of a task according to the time cycles)
- Starting from a given assembly process (with 2 or more operations) the student has to:
  - Describe the order of the operations
  - Kinds of robots to use for the single operation
  - Estimation of time cycle for the single operation
  - Total number of robots needed to perform the manufacturing process (considering also the parallelisation of a task according to the time cycles)
- Open questions on Advance Remote controlling, teleoperation and Safety aspects
- Practical tasks on advanced programming robots

7.Design virtual testing and validation using modelling and simulation tools (simulate mechatronic design concepts, use CAE solutions (Computer Aided Engineering) as for example: CAD (Computer Aided Design) CAM (Computer Aided Manufacturing) FEA (Finite Element Method) SMBD (Simulation Model Based Design)

7a Design virtual testing and validation using modelling and simulation tools

- Observe and comment on a drawing/specification, also in English, (is it complete, all info contained, something additional should be required?), and make an example of how a virtual test could be carried out
- Design and realize virtual test protocols/models for testing a prototype, using the proper tools (CAD/CAM/CAE)
- Based on a real example of a process/product, describe its overall function and the interrelationship amongst the various electromechanical components (through a flow diagram), also through a brief written summary

7b/c Design virtual testing and validation using modelling and simulation tools

- Based on a real example of a process/product:
  - describe its overall function and the interrelationship amongst the various electromechanical components
  - Describe the main issues and problematics that could rise (finding the correct variable which could allow to monitor the various effects)
  - Describe an hypothetical protocol test
- Starting from a described real case:
  - simulate it using the correct tool among the presented one
  - Justify the tool choice
  - Discuss the results

8.Develop the virtual prototypes in the real environment also thanks to physical computing tools

8a Develop the virtual prototypes in the real environment also thanks to physical computing tools

- Starting from a given description of a product/process function (aim, functions drawings, etc..) the student will describe how to create a prototype focusing on the following steps:
  - Parameters needed to prototype and replicate the main behavior of the product/process I the real word
  - Relations among the identified parameters
  - Sketch of the mechanism needed to simulate the fundamental behavior of the product/process machines
  - Identification of a kind of sensors and actuators needed
- Starting from a given description of a product/process which contains:

- The aim of the mechanism/machine
- the main function,
- the kinematics
- The equipped kind of sensors and actuators

The student will describe and will formulate:

- the algorithm which connect all the functions described
- Selection of a microcontroller and/or embedded system
- Low level code (C) needed to control the prototype

- Starting from:
  - a given description of a product/process function (aim, functions drawings, etc..) the student
  - A selection of simple actuators (DC motors, pneumatic pistons, etc.)
  - A selection of simple sensors (encoders, limit switches, switchers, etc.)
  - Simple connection elements (modular profiles, 3d printed, etc)
  - Partial low level code which has to be completed

8a Develop the virtual prototypes in the real environment also thanks to physical computing tools

Same evaluation process of module B but with the following added points:

- Considering Dynamics of the system
- The user interface will be not composed by simple components (buttons, knobs) but by a digital dashboard on a PC/Mobile
- The prototype has to be controlled also using network communication

9.Utilize, choose, customize monitoring and data management systems (monitor automated machines, record test data)

9a Utilize, choose, customize monitoring and data management systems (monitor automated machines, record test data)

- Defines and designs monitoring and data management systems
  - Identifies the elements that make up the regulatory loop of industrial systems, relating their function to the elements that make up the automation processes with technologies, such as data acquisition intelligent sensors and IoT
  - Integrates industrial communications and monitoring systems into the overall assembly of discrete and continuous process mechatronics systems controlled by PLC. Remote and diagnostics control system.
  - Differentiates the different operating modes and their specific characteristics from real or simulated systems, in real and digital systems. Digital twin and Virtual commissioning

9.b/c Utilize, choose, customize monitoring and data management systems (monitor automated machines, record test data)

- Performs the assembly of the installation and verifies the operation and commissioning of monitoring and data management systems
  - Assembles communications installation of the associated automated systems, interpreting schematics and applying assembly techniques
  - Complies with the standards for the prevention of occupational hazards and environmental protection in the assembly, identifying (9b) the associated risks, measures and equipment to prevent them.

10. PLC Programming

10a PLC programming

- Define and design automated systems
  - Recognizes programmable devices, identifying their functionality and determining their technical characteristics. Intelligent sensors
  - Program the programmable automaton and know its programming.
  - It recognizes the control sequences of the programmed systems, interpreting the requirements and establishing the necessary programming procedures. Intelligent sensors
  - Program combination and sequential systems, starting from the control conditions and using structured techniques.
  - Configures programmable systems by selecting the component elements

10b PLC programming

- Define and design advanced programmed automated systems
  - Recognizes programmable devices involved in the control of dynamic systems, identifying their functionality and determining their technical characteristics.
  - Program logic controllers applied to advanced sensors, identifying the typology of process data and using advanced programming and parameterization techniques. Intelligent sensors
  - Recognizes the advanced sensors involved in the control of automatic systems, identifying their functionality and determining their technical characteristics. Intelligent sensors
  - Program logic controllers applied to advanced sensors, identifying the typology of process data and using advanced programming and parameterization techniques. Intelligent sensors
  - It configures the different control and monitoring equipment involved in an automatic system, programming the equipment and integrating communications to a production plant. Diagnostics and remote control. (remote management, remote diagnostic) Data Acquisition
  - Program and configure the different buses used in the industrial field, identifying the elements that integrate it and relating them to the rest of devices that configure an automatic system.
  - Program and configure the different buses used in the industrial field, identifying the elements that integrate it and relating them to the rest of devices that configure an automatic system. Basic cybersecurity

11 Carry on diagnostic activities interfacing machines/assembly lines and collecting data by Visual Programming tools (resolve equipment malfunctions, maintain control systems for automated equipment, perform test run)

11.a Carry on diagnostic activities interfacing machines/assembly lines and collecting data by Visual Programming tools (resolve equipment malfunctions, maintain control systems for automated equipment, perform test run)

- Follow and maintain procedures to be in line with HMI general requirements
- Test the Electronic components using proper instruments and tools
- Carry out a simple debugging procedure and report results
- Carry out a procedure on an ATE on production/assembly line

11.b Carry on diagnostic activities interfacing machines/assembly lines and collecting data by Visual Programming tools (resolve equipment malfunctions, maintain control systems for automated equipment, perform test run)

- Carry out a procedure on an ATE on production/assembly line, following instruction manuals
- Demonstrate possible solutions and agree tasks within a team

12.Access and manage database using SQL (record test data)

12.a/ 12.b Access and manage database using SQL (record test data)

- Debug their own programs, use logical reasoning to explain simple algorithms (including their own), and detect and correct errors in both algorithms and programs.
- Select, use and combine data on a range of given examples
- Analyze and Evaluate data of an example
- Analyze and Evaluate information of an example

13.Identify and utilize the main Artificial Intelligence tools

13.a / 13.b Identify and utilize the main Artificial Intelligence tools

- Starting from a selected method/model: describe how it works, pros and cons, use cases and applications.
- Starting from given application describe:
  - how AI could be used and the related advantages
  - Select a method and describe motivations of the choice
  - Describe how to train the model
- Starting from a given aim of AI usage and a data set the student has to select different models and by means of provided tools (prepared executable files or codes for AI applications) it has to train the model and perform some simple analysis commenting the results.

14.Manage, utilize storage data network tools

14.a/ 14.b Manage, utilize storage data network tools

- Use logical reasoning to explain how some simple algorithms work and to detect and correct errors in algorithms and programs
- Use search and storage technologies effectively, appreciate how results are selected and ranked, and be discerning in evaluating digital content

15. Evaluate ergonomic aspects of industrial logistics

- Evaluate ergonomic aspects of industrial logistics
  - Follow and maintain procedures to be in line with HMI general requirements
  - Ensure dimensional accuracy of assembly by using different instruments/gauges/measuring tools
  - Set up workplace/ assembly location with due consideration to operational process and HMI and safety requirements
  - Demonstrate possible solutions and agree tasks within a team

- Mount the work and tool holding devices with required alignment and check for their functional usage to perform machining operations

16.Evaluate advanced logistics project aspects like cost/benefit ratio, safety, impact, threats, maintenance, etc.)

16a/b Evaluate advanced logistics project aspects like cost/benefit ratio, safety, impact, threats, maintenance, etc.)

- Mechatronic costs systems, process/operational control and quality.
  - Determines the operations costs, identifying and calculating the times of configuration, optimization, monitoring, assembly or maintenance in mechatronic systems.
  - Detects deviations in automatic processes, analyzing and interpreting process control charts and/or operations
  - Acts in accordance with quality procedures and standards associated with the professional profile competences, relating them to quality systems and models.
- Applies preventive and / or predictive maintenance techniques to industrial pollutant treatment equipment, performing maintenance operations, diagnosing and using monitoring techniques
  - Establishes the stages in a maintenance process of industrial equipment for the environmental pollutants treatment, analyzing the technical documentation, the safety plan and the instruction manuals, applying programming techniques and establishing procedures for monitoring and controlling execution.
  - Elaborates the spare parts catalog and the management and provisioning program, establishing the storage conditions of the components, tooling, materials and equipment for the treatment of emissions, dumping and waste.
  - Diagnoses breakdowns in control equipment emissions and production process waste treatment, identifying the nature of the matter, and performing the necessary corrective interventions to eliminate dysfunction and restore functioning.
  - Integrates and launches industrial communications to SAM automatic emission metering systems, fulfilling operating conditions.
- Occupational risks prevention management
  - Defines actions to facilitate the implementation and maintenance of occupational risk prevention systems and interprets their concepts and basic factors.

17. Cybersecurity Awareness

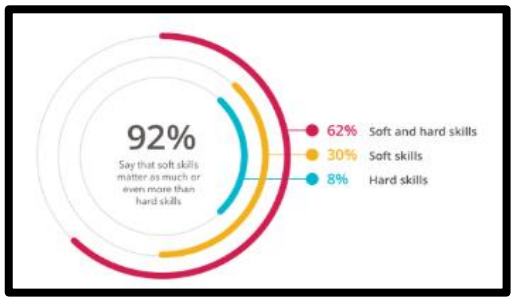
- Resolve the cybersecurity elements to be included in the design, establish the cybersecurity measures in the execution and implementation of an industrial project.
- Implements the cybersecurity activities of the operation and maintenance phase of an industrial project documenting the activities carried out.
- Plans purchase management determining the cybersecurity requirements to be met by suppliers
- Dismantles the facilities complying with the requirements established in destruction and / or conservation of the systems in a safe way.

4.8 RELATIONSHIP BETWEEN WORD ECONOMIC FORUM SOFTSKILLS REPORT AND NEWMETRO TRANSFEREABLE SKILLS

Soft Skills are increasingly in demand in the labour market given these skills are not readily substitutable with technology *(Autor and Dorn, 2013; Autor and Dorn, 2015),* and are particularly valuable for young boys and girls leaving school with a high school diploma or some more *(Lordan and Neumark, 2018)*

Soft skills matter even more than hard skills when it comes to hiring decisions.

The 2019 Linkedin Global Trends report that a majority or hiring and firing decisions come down to soft skills. Whereas there are ways to evaluate hard skils, it is harder to identify soft skills. Poor soft skills are frequently discovered after someone has been hired. The report also states that talent professionals prioritize soft skills alongside hard skills during hiring processes. For more information check out their report.



LinkedIn Releases 2019 Global Talent Trends Report

The UK Government has acknowledged that personal, social, health and economic education (PSHE) at school is a means to provide young people with the skills to become more self-aware, resilient and suitable in making more informed life-choices *(House of Commons, 2015)*

Word Economic Forum Top 10 Skills

Developing and enhancing human skills and capabilities through education, learning and meaningful work are key drivers of economic success, of individual well-being and societal cohesion.

Greater adoption of technology will mean in-demand skills across jobs change over the next five years, and skills gaps will continue to be high.

For those workers who stay in their roles, the share of core skills that will change by 2025 is 40%, and 50% of all employees will need reskilling (up 4%).

Critical thinking and problem-solving top the list of skills that employers believe will grow in prominence in the next five years. These have been consistent since the first report in 2016.

But newly emerging this year are skills in self-management such as active learning, resilience, stress tolerance and flexibility.

4.9 SUMMARY OF TRANSFERABLE SKILLS DEFINED IN NEWMETRO FRAMEWORK COMPETENCE

- Ability to communicate in a symbolic way.
- Ability to communicate effectively, orally and in writing with “engineering” community and with “society”, extrapolating concepts for “non-experts, through an abstraction approach
- Ability to communicate the designed behaviour of a robot/cobot
- Ability to explain the behaviour of a system simplifying its behaviour to the fundamental functions
- Ability to prepare draft operational procedures on practical cases
- Ability to submit and discuss presentations on practical cases
- Analyse descriptions, specifications, manuals and other info typical of the profession in English, providing comments on how to improve them
- Appreciate limits and future developments of human-robotics interaction, from social/labour related point of view
- Awareness about concept of energy conservation, global warming, pollution and use of available resources optimally and remain sensitive to avoid environmental pollution
- Be capable to interface/report with the QA/Engineering/Maintenance departments in a logical and coherent manner
- Be capable to interface/report with the QA/IT/Engineering department in a logical and coherent manner
- Be capable to interface/report with the R&D/Engineering department in a logical and coherent manner
- Be capable to report the findings of Laboratory work in a logical and coherent manner
- Be ready to acquire new knowledge, skills, competences and responsibilities
- Capability to communicate in English in a interdisciplinary / international team, in virtual and real modality
- Collaborate effectively within multidisciplinary teams
- Create a maintenance program for a robotic station
- Create code for robotic controlling
- Solve problems by decomposing them into smaller parts
- Understand computer networks, including the internet; how they can provide multiple services, such as the World Wide Web, and the opportunities they offer for communication and collaboration

- Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner
- Understand difference between data and information
- Use selection in programs and work with variables

4.10 RELATIONSHIP BETWEEN WORLD ECONOMIC FORUM SOFTSKILLS REPORT AND NEWMETRO TRANSFERABLE SKILLS

Analytical thinking and innovation

- Ability to communicate effectively, orally and in writing with “engineering” community and with “society”, extrapolating concepts for “non-experts) through an abstraction approach
- Ability to explain the behaviour of a system simplifying its behaviour to the fundamental functions
- Analyse descriptions, specifications, manuals and other info typical of the profession in English, providing comments on how to improve them
- Awareness about concept of energy conservation, global warming, pollution and use of available resources optimally and remain sensitive to avoid environmental pollution
- Solve problems by decomposing them into smaller parts
- Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner
- Understand difference between data and information
- Use selection in programs and work with variables

Active learning and learning strategies

- Be ready to acquire new knowledge, skills, competences and responsibilities
- Understand descriptions, specifications, manuals and other info typical of the profession in English and prepare them for next phase of project/Customer in understandable manner

Complex problem-solving

- Be capable to report the findings of Laboratory work in a logical and coherent manner
- Solve problems by decomposing them into smaller parts

Critical thinking and analysis

- Ability to prepare draft operational procedures on practical cases
- Appreciate limits and future developments of human-robotics interaction, from social/labour related point of view
- Solve problems by decomposing them into smaller parts
- Use selection in programs and work with variables

Creativity, originality and initiative

- Ability to explain the behaviour of a system simplifying its behaviour to the fundamental functions
- Awareness about concept of energy conservation, global warming, pollution and use of available resources optimally and remain sensitive to avoid environmental pollution
- Solve problems by decomposing them into smaller parts

Leadership and social influence

- Ability communicate in a symbolic way (user interfaces2)
- Be capable to interface/report with the QA/Engineering/Maintenance departments in a logical and coherent manner
- Be capable to interface/report with the QA/IT/Engineering department in a logical and coherent manner
- Be capable to interface/report with the R&D/Engineering department in a logical and coherent manner
- Collaborate effectively within multidisciplinary teams

Technology use, monitoring and control

- Ability to communicate the designed behaviour of a robot/cobot
- Awareness about concept of energy conservation, global warming, pollution and use of available resources optimally and remain sensitive to avoid environmental pollution
- Create code for robotic controlling
- Understand computer networks, including the internet; how they can provide multiple services, such as the World Wide Web, and the opportunities they offer for communication and collaboration

Resilience, stress tolerance and flexibility

- Collaborate effectively within multidisciplinary teams
- Solve problems by decomposing them into smaller parts

Reasoning, problem-solving and ideation

- Ability to submit and discuss presentations on practical cases
- Be capable to report the findings of Laboratory work in a logical and coherent manner
- Create a maintenance program for a robotic station
- Solve problems by decomposing them into smaller parts

4.11 KETS RELATED TO THE NEW METRO CURRICULA

The NEW METRO - High technician in mechatronic training path includes extensive reference to the 5 among the 6 broad Key Enabling Technologies (KETs)

- advanced manufacturing
- advanced materials
- life-science technologies
- micro/nano-electronics and photonics
- artificial intelligence
- security and connectivity

		Applicable to Competence											
KET	**Brief Description**	1a	1b	2a	2b	3	4	6a	6b	7a	7b	7c	TS
Advanced manufacturing	Use of knowledge and innovative technology to produce complex products and improve processes to lower waste, pollution, material consumption and energy use. Robotics, 3D, and 4D printing, digitization and high-performance computing for modelling are important elements*												

Advanced materials	Use of materials that have novel or enhanced properties that improve performance over conventional products and processes to boost the transition to greener technologies, with improved characteristics and enhanced performance, contributing to a more sustainable future*	■	■				■						
Micro/Nano electronics & photonics	Millimetres in the micro level, nanometers - one millionth of a millimeter - at the nano level. Technologies and solutions for electronic components and systems at the basis of our everyday devices, such as computers*		■		■				■		■	■	
Artificial Intelligence	S/W (and possibly also H/W) systems that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting collected structured or unstructured data, reasoning on knowledge, or processing information, derived from this data and deciding best action(s) to take to achieve the given goal.*				■	■			■		■	■	■
Security & Connectivity	Cybersecurity including privacy Connectivity at local, regional, national, international level			■		■	■	■		■			■

During the NEW METRO piloting phase, a specific focus will be dedicated to better knowing how to implement the key directions for action regarding both qualitative and quantitative KETs skills-related challenges, as detailed in the Pricewaterhouse study (2016). Those directions for action include:

- ensuring a good alignment of educational programmes with industry needs (quality);
- facilitating regular (re-)training of current employees (quality);
- raising awareness about KETs in the society (quantity);
- improving the image of KETs as a field to work in (quantity).

5. BIBLIOGRAPHY

- (2014) RESOLUCIÓ ENS/1138/2014, de 19 de maig, del procediment de reconeixement dels continguts curriculars d'ensenyaments de formació professional inicial d'arts plàstiques i disseny o esportius cursats en el marc de programes o accions de mobilitat i cooperació acadèmica internacional.

  (https://dogc.gencat.cat/ca/pdogc_canals_interns/pdogc_resultats_fitxa/?documentId=663175&language=ca_ES&action=fitxa)

- https://www.weforum.org/agenda/2020/10/top-10-work-skills-of-tomorrow-how-long-it-takes-to-learn-them/
- https://intelligence.weforum.org/topics/a1Gb0000000LPFfEAO?tab=publications
- (2016) Pricewaterhouse for EUROPEAN COMMISSION Directorate-General for Internal Market, Industry "Skills for Key Enabling Technologies in Europe Vision for the Development of Skills for Key Enabling Technologies (KETs)"
- (2019) European Commission Directorate-General for Research and Innovation Prosperity, "Future technologies for prosperity"
- https://op.europa.eu/en/publication-detail/-/publication/ae785b63-dba9-11e9-9c4e-01aa75ed71a1/language-en/format-PDF/source-116042367
- (2019) Pricewaterhouse for EUROPEAN COMMISSION Executive Agency for Small and Medium-sized Enterprises (EASME), Curriculum Guidelines for Key Enabling Technologies (KETs) and Advanced Manufacturing Technologies (AMT) https://skills4industry.eu/sites/default/files/2019-10/EA0319099ENN.en_.pdf
- (2011) Italian Law Decree of 7 September 2011 on "general rules concerning diplomas of Higher Technical Institutes and related national reference figures, verification and certification of competences"
- (2013) Italian National Law of 8 November 2013, art.14 https://www.indire.it/wp-content/uploads/2017/05/art14legge128_2013.pdf
- Higher Education in the Era of the Fourth Industrial Revolution, Gleason, Nancy W.
- The Nature of Technology: What It Is and How It Evolves Arthur, W. Brian, Simon&Schuster, New York
- Building skills for the future, Dassault Systemes
- The future of work in Europe discussion paper, McKinsey
- Transferable Skills Checklist, SEEK
- The Teachers Inspiring Lifelong Learning project (TiLL), TiLL final conference - 5 May 2020

- The Fourth Industrial Revolution and manufacturing's great reset, McKinsey
- 2018 Manufacturing Skills Gap Study, Deloitte US
- Electro-mechanical Technicians / Occupational Outlook Handbook, U.S. Bureau of Labor Statistics
- 2018 Skills gap and future of work in manufacturing study, Deloitte
- Toil and Technology, International Monetary Fund
- US manufacturing skills gap, Deloitte
- Learning innovation in the digital age, McKinsey

NEW METRO

embeddiNg kEts and Work based learning
Into MEchaTROnic profile

This project has been funded with support from the European Commission.
This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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