tourings

training for collaborative
robotics integration

TOURINGS

Blueprint Priorities

Erasmus+

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Content

Introduction

Nowadays, the integration and use of Collaborative robotics, specially in the manufacturing sector in Europe, is continuously increasing. Knowing what are the difficulties by using collaborative robotics and finding the gaps helps developing an adequate training course to better assist the users using and cooperate with the robot. Thus we conduct a research with the aim of identifying possible shortcomings and finding gaps at European training level addressed to collaborative robotics at manufacturing by collecting, analysing and reporting information about different case studies from five different countries in Europe. The partnership collects and identified in a specific activities also national strategies, agendas and policies concerning education, labour, health, research and innovation related to collaborative robotics. In a next step the collected results were assessed and analysed using the specific analysis tool, Strength, Weaknesses, Opportunities and threats (SWOT). From that results five priorities actions addressed to HE/VET programmes to adopt the TOURINGS curriculum and its training course (section 4), were defined and developed.

The purpose of this document is to present **the actions that the consortium considers as priorities for adopting the curriculum and the training course TOURINGS**: InnovativeTraining Solution for the Installation of Collaborative Robotics in Manufacturing Sectors (EQF Level 5 "Higher VET Technician", X hours in total).
This document is structured in 4 main sections:

- **Section 2** describes briefly how the use of collaborative robotics growth during the years and how important is the TOURINGS course in the manufacturing sector and what impact it could provide in this sector.
- **Section 3** goes again throw the educational program and provides a brief summary of the developed joint curriculum and the course developed within the framework of the TOURINGS project.
- **Section 4** briefly describes in a comparative way the results gained using the (SWOT) analysis tool on the most pertinent national and regional strategies, policies and agendas performed by the partnership to select and asses HE/VET programmes and national strategies in the five partner countries and in Europe.
- Finally, **section 5** presents in a defined way five priorities developed by the partnership with proposal of actions according to how the gaps, identified during the previous activities of this project, are going filled.

The Impact and importance of TOURINGS in the manufacturing sector

During the last years the number of collaborative robots installed in the manufacturing sectors marked a big increase from the previous years, and this has the tendency to continuous big increase in the future with a 40% CAGR during the next five years (Statzon, 2022) . Collaborative robots as the name said should share the workspace and work smaller and easier hand in hand in a continuous interaction with human. Thus, means that they should be also intuitively and effortlessly integrated in the production. To reach this, workers should have a continuous training in order to achieve a smooth transition in terms of employability and new jobs in Europe. Collaborative Robotics will foster the employee training and adaptation to Industry 4.0 while improving his health and work conditions. Conformed to the safety standards ISO-TS 15066 which regulates Collaborative Robotics, TOURINGS proposes a training course totally aligned with the mentioned standard, addressing:

- I) safety requirements for the human-robot interaction,
- II) ergonomic assessment in human-robot interaction,
- III) installation of collaborative robotics in the assembly line, and
- IV) design of different robot modules and behaviours to address the production line needs

The Objective of TOURINGS

The aim of this training program is twofold:

- First to help learners to gain knowledge about what is collaborative robotics, how it works, what are the safety rules and how to put it in place in company.
- Second, to help some learners to be able to solve some concrete problems by putting in place collaborative robotics in the assembly line in their (future company).

The educational approach proposed by TOURINGS address a highly interconnected training covering all the aspects related to Collaborative Robotics, its installation, design, human interaction, use and digital measurement. Its outcomes will have an impact in three aspects:

- I) alignment of educational policies between institutions/regions related to TOURINGS topic,

II) ensuring the relevance of modernizing and automatizing of Manufacturing Sectors through the use of Collaborative Robotics, and

III) including the labour needs in terms of healthcare and well-being in the work environment.

TOURINGS will consider different features of Collaborative Robotics; technical aspects, human-robot interaction, installation in the assembly line and robot design aspects. Collaborative Robotics make assembly lines more flexible, but it is important to install them without disrupting the balance of the production line. TOURINGS will address cycle times and process reengineering in the assembly line, it will cover ergonomics assessment of the human-robot interaction by following the ISO/TS 15066, Human Digital models and Human Digital Simulations along with the RULA (Rapid Upper Limb Assessment) method.

The Educational Program

The objective of the TOURINGS Project is to design and develop a common curriculum and learning approach on Collaborative Robotics and its installation and proper integration on manufacturing companies. The joint curriculum summarizes, and define training Objectives, learning Outcomes and training and assessment methods which correspond with the EQF Level 5., which match more with the description of the IT specialist (certified) (IT-Spezialist (Zertifizierter)), service technician (certified)* (Service-techniker (Geprüfter)) of the German Qualification Framework, at EQF Level 5, “Higher VET Technician”.

This will compromise in addition a training materials and a common collaborative platform in line with needs of the different target users identified. The content developed under the TOURINGS approach comprises a joint curriculum and a training content and will be recognized and adapted to the recommendations of the European Commission to establish a European Credit System for VET(ECVET) and the European Qualification Framework with x ECVET within two years after the end of the project.

This chapter will summarize the joint curriculum and Learning Outcomes and gives an overview over the didactic content of the programme.

1. Joint Curriculum and Learning Outcomes

The training course of TOURINGS contains 5 differnt Modules which are structured in different units and described the way of learning outcomes in terms of knowledge, skills,and competences.

I) **Collaborative Robotics Basics**: it includes all the pertinent aspects related to mechanics, electronics, computer science, , control engineering and physics among others.

II) **Collaborative Robotics Modular Design and Behaviour**: it shows the possibilities of modularity and re-programmability of collaborative robotics' functionalities and different robotic cells

III) **Collaborative Robotics Safety Requirements:** it covers all the relative aspects related to a safe physical human-robot interaction aligned to the requirements of ISO/TS 15066

IV) **Collaborative Robotics Installation on the Assembly Line:** it introduces the learners in some assembly line and manufacturing principles to take into account before installing collaborative robotics to the make the most of it Collaborative Robotics Interactions.

V) **Digital Human Model, Digital Human Simulation andthe RULA Method:** this module shows how a digital human model can be created to measure physical human-robot interaction using different methods

2. Overview of the 5 Modules of the joint curriculum

Below a summarized short overview of the developed joint curriculum.

1

Basic of collaborative robotics

1 History
1.1. Industrial Revolutions
1.2 Robotics from the beginning to present
1.3 Impact of Robotics in the production process

2 Structure of Collaborative Robots
2.1 Axes
2.2 Coordinate Systems
2.3 Digital inputs and outputs
2.4 Analog inputs and outputs

3 Characteristics of Collaborative Robots
3.1 Weight and Payload
3.2 Reach
3.3 Precision and Repeteability
3.4 Speed and acceleration

4 Initial Collaborative robotic Configuration
4.1 Installation files
4.2 TCP (Total Center Point)
4.3 Center of mass
4.4 Limits

5 Basic Programming Techniques
5.1 Program structure
5.2 I/O Instructions
5.3 Movement instructions
5.4 Control instructions

2

Collaborative Robotics Modular Design and Behaviour

1 Hardware Collaborative robotic
1.1 Collaborative robotic Frame. Links and Joints
1.2 Collaborative robotic / Robot technical Capabilities. Drive systems
1.3 Collaborative robotic / Robot selection principles

2 Gripping Technologies
2.1. End of Arm Tooling construction and classification
2.2. Using end effectors in different applications
2.3. EOAT selection and use in the company

3 Sensor and AI
3.1. Sensor classification and applications
3.2. Needs for using sensors
3.3. Integration of sensor information in the collaborative robotic working cycle
3.4. AI technologies for process improvement

4 Typical collaborative robotic applications
4.1. Assembly
4.2. Quality inspection
4.3. CNC machine tending
4.4. Machining

5 Risk assessment and cost-benefit analysis
5.1. Risk Assessment
5.2. Cost-benefit analysis

3

CR safety requirements

1 Standards
1.1 DIN EN ISO 12100 standards
1.2 ISO/TS 15066 standards
1.3 Their limits in their application
1.4 Points of attention while implementing collaborative robotics in production lines

2 Biomechanical Limits
2.1 definition of biomechanical limits
2.2 Types of measures of the biomechanical limits

3 CE-Conformity & Risk Assessment
3.1 Definition of the risk assessment
3.2 Ways of the risk assessment

4 Planning a safe cell
4.1 Principles of a safe cell
4.2 Bases of design
4.3 Bases of project management
4.4 CAD models
4.5 Needs to implement a safe cell
4.6 Design of safe gripping fingers

5 Safety Technologies
5.1 Types of safety sensors and their way of working
- 5.1.1 Light barriers
- 5.1.2 Light grids
- 5.1.3 Optical systems
- 5.1.4 Others

4 Collaborative Robotics Installation in the Assembly Line

1 Basics of integration project
1.1 Integration general understanding
1.2 Collaborative robotic integration principles
1.3 Benefits of collaborative robotic integration
1.4 Main mistakes in the integration process

2 Implementation principles and Workplace layout
2.1 General principles of robot implementation
2.2 Main stages of the implementation project
2.3 Robot workplace design principles
2.4 Workplace layout
2.5 The impact of work task on workplace design

3 Integration of collaborative robotic in assembly line and assembly line balancing
3.1 Assembly system
3.2 Main steps for collaborative robotic successful integration
3.3 Integration tools and methods
3.4 Assembly line balancing meaning
3.4.1. Tact time calculation
3.4.2. Definitions considered with line balancing

4 Configuration and recon-figuration of assembly line
4.1. Human – robot collaboration
4.1.1. Human-robot collaboration basic
4.1.2. Humans and collaborative robotics possibilities to work together in a workplace
4.2. Collaborative robots on a production line
4.3. Configuration and reconfiguration principles
4.3.1 System configuration
4.3.2 Hardware and software configuration

5 Production in an assembly line and its performance
5.1. Production processes in an assembly line
5.2 Workplace and assembly line performance

5 Collaborative Robotics Interactions. Digital Human Model, Digital Human Simulation and RULA Method

1 Collaborative robotics interactions
1.1 Definition of collaborative robotics interactions
1.2 Risks of WMDs
1.3 Risks of psychological disorders by using collaborative robotics

2 Digital Human simulation and RULA method
2.1 Definitions of digital human model, digital human simulation and RULA method
2.2 Reasons to use those methods
2.2.1 more productivity
2.2.2 Better well being of the employees
2.2.3 Better employer brand
2.3 Ways to mesure those methods

3 Analysis of the results of digital human simulation and RULA method
3.1 Evaluation of the risk
3.2 Calculate the most effective way to apply solutions
3.3 Measurement of the advantages led by use of collaborative robotics
3.4 Ways to improve current situations

Market-Analysis

The following analysis summarizes the information collected by cases of study and through a SWOT analysis. The main objective is to identify the use of collaborative robotics in the manufacturing sector.

O1-A1: Current practices: Identification of Case Studies.

Type of products/services that uses Collaborative robotics	**Services**	**Products**
	Security electronics solutions Developers of automation solutions, Sequence of actions Energy Component, processes and solutions,	Mechatronic and Electronic Industries Audio Technologies Household Appliances Manufacturer of high quality power tools,
	Car parts maker, Pick & Place, Easy assembly, collaborative robotics of heavy charges	Automotive, Automobile space products, elements for planes
	Metal processing, Smart welding, provide innovative welding	Sheet Metal Working, Model and Mould Making, Demonstrator / Competence Center, manufacturer of welding applications
	Quality control, Testing and sorting objects, Operations requiring high precision and reliability quality control	Quality: manufacturer of quality details
	Machine for Dosing and distribution of granules,	Agricultural machinery manufacturer
	Machine tending, Vocational Education and Training, , luxury products, , , elements and full products, medicine and drugs, engineering, , electronics, defense, , surgey, consulting solutions, transportation, Cosmetics products and research	
	Packaging	

	Disc Spring Production	Food and airline catering, Feeding, Dairy Products
Types of HRC that are being implemented by cases of study	cooperation, collaboration, coexistence, cooperation collaboration in case of an error, UR, UR10e, UR10, UR3, UR5, Four UR3, four UR5, Faude, Onrobot, Fanuc, Doosan	
At what phase of production are robots used	Assembly, Packaging, Pick & Place, Loading and Unloading, One Piece Flow Assembly, welding and cutting , Cleaning and painting, Machining, Bin-picking, Palletizing/Depalletizing, Handling of packaging units, AGV integration, clutch production, automation of quality control, Automation of depalletizing and placing on filling line, Placing plastic trays on the vacuum packaging line, End of line and palletizing, R&D +, construction	

SWOT-Analysis

Following is a description of the swot analysis in the different partner countries and a summary of all similarities and differences.

Strengths

Germany

Diverse application industries in Mecklemburg-Vorpmmern, technologies of interest to SMEs with the strengths in production process. The aim is ‘Increasing the growth and competitiveness of SMEs (SC iii)”.

Spain

The collaborative robotics an emerging solution for production related problems in factories and it will continue to evolve in most of industries (especially in Navarra). The concept of new sustainable, intelligent, and integrative industry in the most advanced industrial regions. 7/17 Regions from Spain considers Collaborative Robotics in their RIS3/RIS4 Strategy to foster advanced manufacturing assets and services within Industry4.0 concept.

Italy

Development of variety of technologies ranging from innovative manufacturing process, validation of advanced/smart materials, human inclusion and empowerment in the factory and support for these technologies, has significantly improved. Deployment of technological solutions useful for vertical and horizontal process integration concerns the hardware and software including embedded systems in production and supply chain.

France

Some of the regions mostly given priority to develop modelling, virtual prototypes, digital mock-upthe simulation of production processes, allowing to visualize the activities, the constraints, risks, vocational training through “serious games”, training by simulator (driving of vehicles, aeronautics, medicine), telepresence and videophone, experimentation in neuroscience, scientific visualization (architectural, urban or landscape heritage etc.). All those priorities will permit to develop the use of Collaborative Robotics, because all those elements constitute tools for the use of this technology. In the different RIS: strengthening the visibility of the region in the digital sector and accompanying the digital transition is aim, by consequence, collaborative robotics use corresponds to this objective supported by some French regions. Improvement of components, advanced materials, advanced manufacturing systems appear as a strength for the development of collaborative robotics use.

Estonia

The manufacturing companies in estonia is interested in digitization, automation and robotization. There has been created digital innovation hub AIRE, or AI & Robotics Estonia, that is a technology hub dedicated to making Estonian manufacturing more competitive by helping businesses to introduce artificial intelligence and robotics solutions. AIRE offers through its partners diferent services to manufacturing SMEs, including trainings, robotisation suitability analysis, AI suitability analysis, demoprojects to realize some robotisation solution as a prototype, financial councelling services. IMECC is one of the partners of AIRE. In the framework of AIRE, the services are provided as de minimis aid, without extra cost to the manufacturing SMEs.

Weaknesses

Germany:

Various technologies such as IoT, Data Analytics, Distributed ledger technologies, AI, extended realities, and quantum computing (DARQ) are vital for the development of the country in field of digitalization and its potential in digital area must be fully exploited to compete globally.

Spain:

Though various theories and strategies exists for growth of business model, but nothing takes or most ignores the potential of use of collaborative robotics. Most of workforce in manufacturing industries are retiring, new generation are not efficient and don't show interest in traditional manufacturing area. Most of industries doesn't have proper resources to invest in R&D and business. Some companies acquire technological solutions through their suppliers/providers. Private companies have very few collaborations with public institutions and research organizations for technology transfer and business models, which is considered as not sufficient for growth.

Italy:

Implementations of innovative work culture in industries, development of hybrid tools for improvising the quality of life and safety at work through various hardware and software upgradation such as ergonomic workstations, interior design solutions etc. Intelligent industry model deployment in manufacturing sectors, enhancing the automated machines, networks, and digital technologies for interaction between machines and co-workers. Automated systems for higher performance, minimal environmental impacts from micro mechanics to biomedical fields.

France:

Geographical wise developments of various technologies, such as for some parts of the country, priority is given over advanced production, handling of digital infrastructure (like cybersecurity, databases) and educating about those topics, promotes the use of collaborative robotics workflow. In contrast to this other region are given importance for improvement of necessary tools for the functioning of robotics such as simulations, software and tools, 3D modulization, sensors and interfaces for efficient processes. And priority is given for 'Factory of the Future' is an implementations of advanced manufacturing methods for SMEs and decreasing the inequalities between large companies and SMEs in terms of development.

Estonia

Implementation of collaborative robotics in the companies, micro and smart manufacturing still difficlut and there is a lack of ressources for digitalization and robotization, both in terms of finances as well as engineers in addition there could be opposition of the side of workers who could be against of changes fearing that robots/collaborative robotic will replace human work. There is also no special training programmes or higher or vocational education dedicated especially to collaborative robotics. They are mentioned in the framework of robotisation courses in higher or vocational education.

Germany & Estonia	• Deployment of ICT and IoT in various industries to improve production line capabilities and in Estonia in addition to production they are using this digitalization technology to for product development, led green products and welfare technologies as well.
Italy & Spain	• Implementation of digitalization in SMEs could slower the production and growth due to lack of current and advancing technical knowledge in employees, public grants, and few resources. • Collaboration between companies and public institutions (like universities and research) is not good or very poor compared to many EU countries for many technological advancements, business strategies and knowledge transfer
France & Italy	• Use of Robotics, digital technologies in industrial companies for development, it is difficult to find some dedicated person for only collaborative robotics and employees are not fully efficient to adapt to these technologies for working in no time. Lack of R&D for proper implementation, it is very hard to select specific type of robots for use in industries for various functions. Deploying robotics and automation will lose jobs of many workers also main concerns for many SMEs and large industries as well • Development of hybrid tools for improving the quality of life at work and intelligent networking in production processes, various applications of robotics (Industry 4.0 and Smart Factory) cause a fear within employees as they will be replaced

	completely by machines, robots, and automated lines in industries

Opportunities

Germany

Distributed ledger technologies, artificial intelligence, extended realities, and quantum computing (DARQ) will be the central drivers in the field of digitization in the future. They hold the potential to significantly change value creation and reshape entire industries.

Spain

Collaborative robotics are recognised as part and parcel of digital transformation among many information technologies within the new generation and adoption of different technologies is part of digital transformation of SMEs. Great potential of autonomous interconnection of the manufacturing systems processes with each other (collaborative robotics). The creation of DIHs is one of the assets that facilitates the development of some of its scientific-technological priorities (Asturias, Euskadi). Some of the bigger companies in the manufacturing sector produces a 'tractor effect' by which smaller companies put their focus on the activities performed by the bigger company to take them as a 'mirror'.

Italy

Discrepancy showed in the implementation new technologies from north and south of Italy. Deployment of collaborative robotics is not considered as a progressive step in most of the regions, and most of the companies lack proper resources to invest in innovation. Work force lacks proper preparation to deal with emerging technologies.

France

Deployment of collaborative robots in France is not a difficult scenario for most of the companies in the automation process, but if the robots need too much time to learn how to do a perfectly realized task, it could lead to loss of productivity, which is a limit at the use of collaborative robots in production lines. In France, there are no specialists with master's degree dedicated for operating collaborative robots, cause fluctuant lack of skills of the employees of about the implementation and use in industrial companies. And use of these collaborative robotics could also potentially decrease the no. of employees in the company this created a fear within the workers because they might be replaced by bots, or they lack competences about collaborative robotics.

Estonia

Collaborative robotics have a potential in Estonia as they are cheaper and easier to implement and to use than industrial robots. The most of manufacturing companies have begun to understand its importance with the aim to be more competitive. They are SMEs of which many do not have much resources to invest in robotisation and lack engineering support. There could be growing interest towards training programs supporting digitalization, robotisation and automation related to collaborative robotics.

Threats

Germany:

The process of digitalization and intelligent networking of production systems in production (Industry 4.0 and Smart Factory) has greater impact on the industries in future. And cloud computing, mobile applications, big data & Internet of Things (IoT) will continue to decide the advancements of digitalization and ICT, to compete globally, these areas of technologies should also be given much priority.

Spain:

Great distinction has been shown in between SMEs from various geographic regions within the country in the fields of automation and digitalization of companies. The chances of getting public grants for R&D and innovation is very less. Difference in between students from VET and HE, as VET students are not practice oriented enough and lack of some knowledge while HE students fail at the very beginning in industrial sector, only dual VET students are going to bridge the gap in industries.

Italy:

Variance in the implementation of new technologies in SMEs could decrease the growth in low developed areas. Work force is not ready to handle the new technologies and lack of preparation may decelerate developments. The dedicated amount spent for R&D is less than average wages of employees. Lack of MoU’s and tie-ups between research institutions, universities and factories resulted in less technology transfer and business models compared to highly competitive European regions. Disruptions in financing regional, national and European industrial research, and experimental projects. High cost of innovation introduction in micro and small enterprises and craft enterprises.

France:

Most challenging issue faced by most of companies using collaborative robotics is during the moment of choice of right robot. The plethorically offer of robot suppliers would lead to an inertia in decision making by the companies. These robots' usage should also consider the potential risk of cybersecurity. Automation/digitalization variation is shown from Northern, Southern, Western and Eastern French regions with huge companies.

Estonia:

Due to the uncertain ecomic and politic situation in Estonia, many companies postpone their investments however much training about collaborative robotics has to be done as the is no HE/VET programmes specialised on collaborative robotics.
the more digitization (incl. automation and robotization), the more there exist risks related to cybersecurity. At the moment, much companies have not turned much attention to cyber safety.

Differences

- Green ICT aims to stimulate and develop innovation-led long-term business cooperation between Estonia and Norway. Programme focuses on supporting business initiatives in three areas: digitalization of industries, product development and application of innovative ICT-led green products and services; and development of new products and services in Welfare Technology, whereas in Germany ICT is mostly used in production area, not in the development of the green products and services. – Germany and Estonia
- Great differences among SMEs from North and South and huge differences on automation/digitalisation degree of companies – Spain and France.
- Technology transfer, startup incubations support, public funds for growth of SMEs and industrial research, experimental development projects is very less compared within European area like Germany and France, where the utmost priority is given for R&D and more support from government and public institutions, companies and the grants for innovation and R&D in Italy spend by companies is less than average values of employees. This kind of scenarios is existing in Spain as well. – Germany, France, Spain, Italy

Priorities

During the Pilot Action phase, the project partners of the TOURINGS developed 5 priorities. Each priority comprises several actions which will be described below,

1. Impact of TOURINGS results on Vocational Education and Training

At European level, there are several initiatives to support VET-education. The aim of these initiatives is to deepen the scope to fulfil the existing demand for qualified personnel in manufacturing sectors.

The European Quality Assurance Reference Framework for Vocational Education and Training (EQAVET) delivers a quality assurance system for VET-providers and want to establish common approaches for the assessment of learning processes and competences.

In this sense, ESCO is another initiative linked to the framework which focuses on the different relationship among concepts and categories of skills and competences within the European Union, which are key for the labour market.

Digital Education Plan (2021-2027) is the renewed European Union policy initiative that sets out a common vision of high-quality, inclusive, and accessible digital education in Europe and aims to support the adaptation of the education and training systems of Member States to the digital age.

The Council Recommendations on Key Competences for Lifelong Learning are:

- Literacy,
- Multilingualism,
- **Numerical, scientific, and engineering skills,**
- **Digital and technology-based competences,**
- **Interpersonal skills, and the ability to adopt to new competences,**
- Active citizenship,
- Entrepreneurship,
- Cultural awareness and expression.

TOURIGNS impacts on 3 of them which directly linked to coding and robotic, and the adaptability to adopt new competences. These are key skills in the current scenario which is developing more and more highly modular robots which development is resulting in modular robots and in control schemes using sensors in the robot arm structure, that are being used to have a redundant safe control but could be also used to provide data, achieve efficiency and quality indicators, productivity ratio and so on.

In this sense, we would like to highlight TOURINGS as an inclusive learning tool due to its impact on:

- Special needs,

It does not matter which are the needs, TOURINGS results are available both as interactive videos, presentations, or text documents.

- Sociaeconomical status,

The contents are going to be uploaded at the project website during 5 years after the end of the project and will be always free for those interested in TOURINGS.

- Cultural diversity,

As the technical complexity of the robotics subject, the contents are mainly developed in English, but we will offer to our learners the EU Tool eTranslation to easier the adoption of the TOURINGS contents into different VET schools.

- Gender.

As established in our initiative, TOURINGS is committed to fulfil the gender gap on technical subjects and robotics by encouraging the involvement of girls on STEM educationas it is showed in our Consortium team (6/10 people in the Consortium were females).

In this sense, TOURINGS is not just aware of the Digital Transition but also on the Green Transition. The consortium really trusts the potential of Collaborative Robotics to perform waste management activities that could led to potentially new business models and Circular Economy processes within the EU. According to TwinRevolution Project Report;

Twin Transition in the Manufacturing Sector there are some barriers to achieve a Twin Transition in Europe.

- **Economic barriers,**
- Lack of intention towards secondary raw materials,
- **EU current waste management**
- Information flow problems,
- **Development speed differences between manufacturing sectors,**
- **Lack of standardisation across EU,**
- **Societal barriers,**
- Barriers related to the use of Blockchains (scalability and efficiency of solutions).

In this sense, the impact of TOURINGS and Collaborative Robotics in these aspects is the following:

- Economic barriers. Collaborative Robotics are cheaper than industrial robotics, save more space and do not need that high programming knowledge.
- EU current waste management. By using collaborative robotics, a better and automated waste management could be performed within manufacturing sectors (as CROCEMS project aims)
- Development speed differences between manufacturing sectors. By using collaborative robotics, the speed differences between different manufacturing sectors will be kept due to its different products and processes, but some of the tasks will be standardized due to this automation.
- Lack of standardization across EU. The use of Collaborative Robotics will encourage and improve standardization within manufacturing sectors, as the related ISO 10218:1, ISO 10218:2 and ISO/TS 15066 (Collaborative Robotics).
- Societal barriers. Senior workers within manufacturing believe robotics and automation will replace them into the assembly line. In this sense, initiatives as TOURINGS put the focus on the human-robot collaboration rather than the substitution of human beings by robots.

Collaborative Robotics as opposed to Industrial Robots, are more modular and adaptable than Industrial Robots which mostly has one unique purpose.The introduction of these highly modular robots is increasing the need of robot installation support due to the changes in manufacturing sectors companies related to COVID-19 pandemic. These companies have gone from mass-produced large batches to small batches produced on a very customised basis.

One of the main problems that arose from the pandemic was the contact between workers in the manufacturing chain, contact caused many contagions and therefore loss of jobs and slower manufacturing. Mostly, in manufacturing sectors there are already robots that collaborate in the assembly and production line. After the pandemic and with the situation of social distancing in companies, there robots were practically indispensable in large assembly lines in order not to stop production. The need for qualified personnel in these field is another priority, in a sector that is expected to grow exponentially over the next few years. In Spain, there are centres working on training qualified personnel in the use of Collaborative Robotics, the Autonomous Community of Navarre offers Vocational Training focused on these robots or the international INCOBOTICS or CROCEMS Project.

Other initiatives as ROBOT4ALL, highlighted two different policy recommendations:

- Support of an attractive VET-system across Europe to establish VET education as a 'first choice' among young people (it was one of the EU 2020 goals)
- Robotic Education for everyone. EU supports research about robotics to establish in fields like 'AI and cognition', 'Cognitive Mechatronics' or 'socially cooperative human-robot interaction' as TOURINGS aims.

According to the Report What Future for European Robotics? (2021) the challenges and future directions for Robotics in Education could be:

- Protection of children's privacy. regarding social reinforcement learning, which focuses on the ways robots learn from how children engage in social learning and how robots should consider differences on children's engagement in learning,

- Priorisation of children's wellbeing. it will be ensured that these solutions improve the learning outcome and children's well-being by supporting interventions that solve existing problems. This should be done in a way that promotes equity which means that all the involved stakeholders should be aware of the existing digital divide and work towards technology that contribute to its mitigation.

Digital technology, artificial intelligence and robotics will have an increasing role in the ways human develop and behave. For this reason, the need for a systematic reflection on child-robot interaction and children's rights seems relevant for responsible and child-centred developments in robotics[1].

As shown in this document, robotics impact goes well beyond industrial productivity, and it is our responsibility to make the robots ethical and safe to be socially accepted by the introduction and use of training as the performed by TOURINGS project which focuses on the different manufacturing perspectives and educational approaches needed to fill the gap at European level.

2. Impact of TOURINGS results on Higher Education

At European level, there are several initiatives to support higher education. Through the cooperation with higher education institutes and EU member states, the EU supports and enables the higher education sector to adapt to changing conditions, to thrive and to contribute to Europe's resilience and recovery. The goal is to develop a European dimension in the higher education sector, built on shared values.

The European Commission highlights the importance of higher education. Higher education is crucial:

- in achieving the European Education Area (EEA) and the European Research Area (ERA), in synergy with the European Higher Education Area
- in shaping sustainable and resilient economies, and in making our society greener, more inclusive and more digital

- in providing highly skilled Europeans with excellent prospects for employment, and engaged citizens participating in democratic life - 80% of recent tertiary graduates in the EU gain employment in less than 3 months after graduating

Due to the shortage of people with high level skills, EU Member States have set the target that by 2030, at least 45% of 25-34 year-olds should obtain a higher education qualification.

The European strategies for Universities are:

1. Strengthen the European dimension in higher education and research

2. Support universities as lighthouses of our European way of life

3. Empower universities as actors of change in the twin green and digital transitions

4. Reinforce universities as drivers of Europe's global role and leadership

TOURINGS impacts on the three of the strategies:

1. TOURINGS is based on a transnational approach and the cooperation of EU members is essential for the success of the project. The 3-year duration and the joint elaboration of the project objectives strengthen the transnational cooperation between EU members (Germany, Spain, Italy, France, Estonia). Through the positive experiences in the cooperation and the joint project successes, TOURINGS helps in the further development of transnationality and the development of new, joint project ideas and initiatives.

3. TOURINGS marks the beginning of a further step toward paperless, digital work and thus also contributes to digitization. The interactive trainings are accessible in a resource-efficient way via a collaborative platform developed in the project. The project relies on the use of digital media and thus contributes to the conservation of resources.

4. Through the successful cooperation in international projects such as TOURINGS, the Higher Education project partners can orient themselves more outwardly and thus increase their own attractiveness. By developing interactive training materials and contributing to EU funding lines, higher

education project partners can increase their visibility within the EU and thus increase their attractiveness for new, international project alliances as well as their attractiveness for students.

Four EU flagship initiatives support the implementation of the strategies:

ERASMUS+: The aim is to develop and share joint long-term structural, sustainable and systemic collaboration in education, research and innovation. This will allow students, teachers and researchers from all parts of Europe to benefit from seamless mobility and create new knowledge together, across countries and disciplines.

Establishment of a legal status for alliances of higher education institutions

Examination of options and necessary steps towards a joint European degree

Scale up the European Student Card Initiative

TOURINGS is part of two flagship initiative:

1. Being part of the ERASMUS+ project, TOURINGS helps to develop joint collaboration in education, research and innovation. Due to the 3-year project duration and the 5 year continuity of the project website after completion of the project, the long-term cooperation is also guaranteed. In addition, TOURINGS fosters the mobility within the EU of the researchers through the regular transnational project meetings and the creation of common knowledge and research results through the joint development of the training content.

3. Upon successful completion of the TOURINGS training catalog, the learner receives a certificate. Since the training catalog is developed in English and is available on a public website, it can be used barrier-free by students from different countries. Thus, the project contributes a small part to a common European learning success.

Further actions of the Commission are:

- working towards automatic recognition of academic qualifications
- enhancing quality assurance

- pursuing graduate tracking for better comparability of higher education outcomes
- developing new STEAM (science, technology, engineering arts mathematics) and Information and communications technology (ICT) curricula

- fostering research and innovation through the European Institute of Innovation and Technology (EIT)
- developing a European framework for attractive and sustainable academic careers
- developing a European framework for diversity and inclusion
- enhancing support for green and digital skills
- Available in English: not specific language barriers

- For Higher Education training in the digital transformation

TOURINGS also applies to further actions of the EU Commission:

Quality Assurance

The three pillars of the project management (Coordination, Dissemination and Quality) ensure on the one hand the public presentation of the project, and on the other hand the monitoring and the compliance with the quality of the project and the results.

STEAM curricula

The content of the TOURINGS training curriculum is related to collaborative robotics. The training covers technological, engineering and informatics contents and thus contributes to the development of new STEAM curricula.

3. Collaborative Robotics acceptance factors by workers

This document is divided into two main parts: a first one dedicated to acceptance factors of collaborative robotics by workers and a second one dedicated to change management actions which could be put in place, based on materials developed by TOURINGS .

1. Acceptance factors of collaborative robotics by workers

Several studies and analyses have been conducted to identify factors of collaborative robotics acceptance, or non-acceptance, by factory workers, and more broadly acceptance of robots. Baumgartner et al. (2022) offer an interesting overview on collaborative robotics acceptance factors by factory workers. Pauliková et al. (2021) drew an interesting SWOT table (table about strengths, weaknesses, opportunities and threats) while implementing collaborative robotics in companies. Here are the main factors identified in the papers indicated in the bibliography:

- **Potential job losses (1)**
- **Safety while using collaborative robotics (2)**
- **Changes in the Daily Work Routine (3)**
- **Human centered-design (4)**
- **Lack of skills (5)**
- **Management support (6)**

(1) As Baumgartner et al. (2022) mentioned it, the use of collaborative robotics, and more broadly robots, inevitably generates the fear of job losses. They quote the result of the 2019 Eurobarometer survey which stressed the fact that "70% of the 26,751 respondents from the member states of the European Union believe that the adoption of robots could lead to job losses". They also indicate that among workers the introduction of robots can be perceived in different ways. Some workers could perceive robots as a chance for their career (to get a more interesting position) and some others as a threat (due to the risk to lose their jobs). This dichotomy between job opportunities and job losses risks has also been identified by Pauliková et al. (2021).

(2) Baumgartner et al. (2022) underline the fact that safety while using collaborative robotics at work, and generally speaking robots, is another reluctance factor of collaborative robotics use. They also indicate that collaborative robotics are some kind of different robots by their design: they "move much faster, have greater force and sharp edges". They finally indicate on this point that users are not always aware about safety features of collaborative robotics. Pauliková et al. (2021) also mentioned in their SWOT table that collaborative robotics could also help in decreasing the number of occupational diseases. Storm et al. (2022) propose a very interesting SHELLO model to analyse all aspects of physical and

(3) mental health aspect while using collaborative robotics. SHELLO is the acronym of Software-Hardware-Environment-Liveware-Liveware-Organization.

(4) “The introduction of a collaborative robotic might lead to multifaceted changes in the daily work routines, such as changes in workload, workflow, responsibility, or complexity of the task” (Baumgartner et al., 2022). As mentioned by the authors, all these changes can be perceived by workers in different manners. Some could appreciate the “reduction of the mental and physical workload” (Baumgartner et al., 2022). Some other could lack the complexity of their tasks, simplified by robots.

(5) On this point, Baumgartner et al. (2022) emphasize the fact that the feeling of “self- determination” is an important factor of acceptance of robot. The possibility to control the speed of the work belong for instance to this “human centered-design”. Another group of researchers, Elprama et al. (2016) also stressed the fact social cues and anthropomorphic robots could ease the acceptance of collaborative robotics by factory workers.

(6) Pauliková et al. (2021), in their SWOT table, clearly note the fact that a skilled workforce could lack to implement collaborative robotics in companies. The lack of skills by users is also a quite common factor identified in some others acceptance factors models.

(7) Baumgartner et al. (2022) stressed the point that corporate culture can have an impact on factory workers acceptance of robots. Among this corporate culture, management support and colleagues can have a negative or positive impact on acceptance by workers.

2. Change management actions, based on materials developed by TOURINGS project, which could be put in place

“Change management” correspond to all actions put in place to convince and help employees to use a new technology put in place in a company (Baudoin et al., 2017). Three main categories of actions can be put in place in a change management phase (just after the technological implementation): **communication actions (1), training actions (2), support actions (3)**.

(1) Communication actions are all actions put in place to inform employees concerned about the implementation of a new technology about the advancement of the projet. Communication actions are also used to try to

convince users about the benefits of using a new technology and to try to reduce fear of using this technology.

(2) Training actions are all actions put in place to train the future users of the new technology like on the job training sessions or digital training sessions.

(3) Support actions are all actions put in place to help users when they are facing some difficulties in using some technologies. Hotline are an example of support actions which can be put in place.

By its design, materials developed by TOURINGS project, could be use in some communication actions and/or some training actions put in place by some collaborative robotics manufacturers or some companies in their factories. The following table sums up these potential actions.

Main categories of change management actions	**Targets**	**Potential uses of TOURINGS materials**
Communication actions	Decision makers in company	Three kinds of materials developed by the TOURINGS project could be used: the report, the videos developed in TOURINGS modules, and TOURINGS modules per se. Videos developed in the different modules of TOURINGS could help the decision maker to have a better understanding of what collaborative robotic is about. These videos could also help them to broaden knowledge of people around them about collaborative robotics is. In this purpose, a youtube chanel could be created to diffuse these videos and make them available to everybody.

	Workers	All modules could also be attended by decision makers. It's more uncertain, due to time constraints, that this target could find time to attend this digital training format. Report for some key points could be used by decision makers to make their decision. In this way, a sum-up of the report, with the main information could be an interesting tool. As for decision makers, videos and modules could be some interesting tools to try to convince workers about benefits of collaborative robotics.
Training actions	Workers (and more specifically) future users of collaborative robotics at different level Person in charge of safety in companies	Thanks to its different modules, TOURINGS offer a wide view about the different aspects of implementation of collaborative robotics in factories. The workers could attend all modules or just a few of them, depending of the use they will have of collaborative robotics. It's important to notice that TOURINGS modules will make it possible to develop knowledge but will never replace on the job training which make it possible to develop workers skills.

		Modules 3 and 5 could be interesting for them.

4. What impact TOURINGS has in complementary initiatives (Robotics initiatives)

As Europe's ageing population increases, collaborative robotics (cobots) has experienced rapid development, allowing a reduction in the physical effort of workers and at the same time making production lines more dynamic and efficient. In order to enforce and encourage the use of collaborative robotics a broad landscape of robotics initiatives has been created to spur the human robot cooperation and design the most suitable solutions to support the workforce in their daily activities.

In this panorama the attention is focused in:

- the integration of new forms of interaction between robots and workers to enhance their synergy effect. This means to efficiently combine and exploit the robot's precision, repeatability and strength with the human's intelligence and flexibility.
- The creation of a safe and shared workspace thanks to the usage of fully sensorized laboratory environment for studying human-robot collaboration, enabling to enhance robots' capabilities of learning, working and assisting people in their natural environments.

Clearly the use of this new technology entails the necessity of highly trained practitioners and a skilled workforce to accommodate the needs of their production.

While the existing initiatives are more concentrate in the technological development, the TOURINGS approach are focused in the acquisition of the relevant skills and competences indispensable for the labour force.

The TOURINGS Project aims to design and develop a common curriculum and learning approach on Collaborative Robotics and its installation and proper integration on manufacturing companies. The accomplishment of this objectives will meet the learning needs of manufacturing companies in terms of training, both for workers and managers, in order to have a fully understanding of collaborative robotics, both in terms of technology, security, adaptability and interaction with staff.

In the landscape of the Robotics activities the project may become a reference for:

- the existing activities aiming to enhance the implementation of collaborative robotics by supporting the small and medium enterprises in becoming familiar with the technology and overcoming any prejudices associated with their use.

- workers which need support in understanding their new role in the manufacturing line and how to interact with a collaborative robot. The TOURINGS' course will in this case support and encourage the worker in understanding how:
    - interact with collaborative robotic;
    - identified and solve real life problems in the collaboration set;
    - identify possible security risk;
    - understand how to avoid possible misbehavior.

Being developed under EU funding lines and having a transnational approach, the results of TOURINGS will automatically support ongoing robotics activities, providing a solid knowledge base that will facilitate collaboration with a robot, making the opportunity to work synchronously an advantage in performing expert tasks.

5. What impact TOURINGS on awareness of manufacturing sectors

Modern robots at production site have changed beyond separate work areas and working together with humans. These new kinds of robots are called collaborative robots (cobots). These perform various works along with human, not limited to sequential but also parallel tasks. The using of collaborative robotics is generally known as human-robot collaboration (HRC). According to the ISO standard (ISO, 2011a), HRC is defined as a “state in which a purposely designed robot system and an operator work within a collaborative workspace”. Manufacturing industry is main consumer of robot installations. Since 2010, the annual robotics installations in intelligent manufacturing increased by 13% on an average each year (CAGR). Collaborative robotic solutions also increased by 12 % per annum on average from 2020 to 2022 [1].

The human and the collaborative robotic are to some extent sharing the workplace, even if the level of cooperation can differ. An HRC scenario can be an interaction between both single and multiple operators and robots (Kumar et al., 2021). The collaboration can take place in varying degrees. Four possible levels of interaction are coexistence, synchronization, cooperation, and collaboration (Baumgartner et al., 2020; Chiabert & Aliev, 2020; Fast-Berglund & Romero, 2019; Malik & Bilberg, 2019; Wang et al., 2019; Villani et al., 2018). See figure 1.

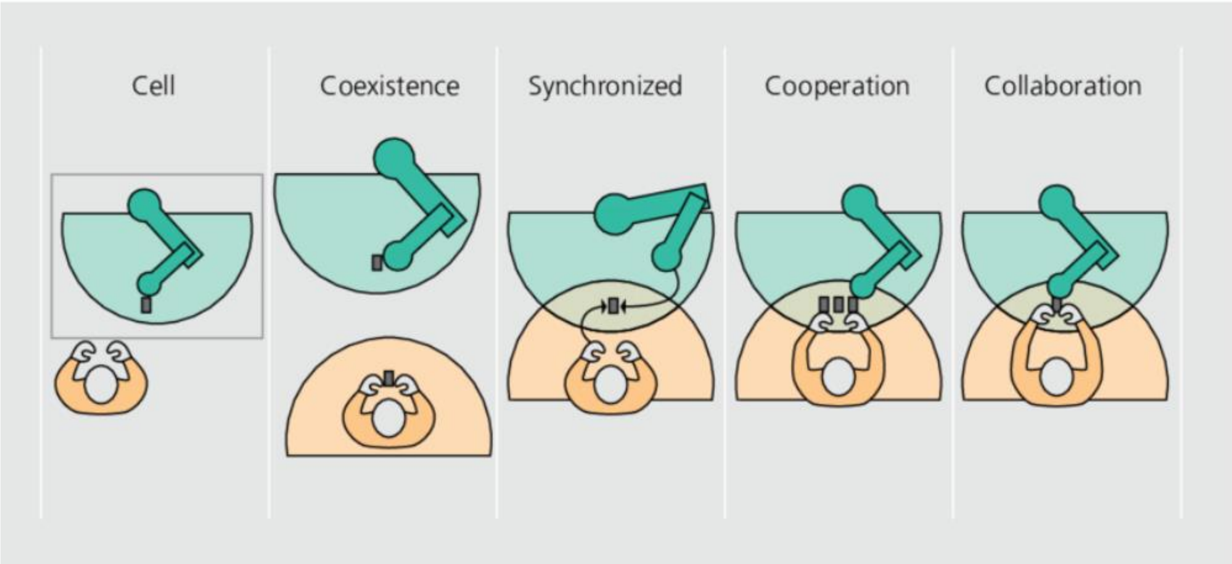


Figure 1 Levels of interaction between human and robot, from Bauer et al. (2016)

At the coexisting level, the operator and the robot are close to each other, but they don’t share the workplace. At a synchronized level they do share the workplace, but not at the same time. At the cooperation level, the operator and the robot are in direct contact with each other but work on different tasks. At the most collaborative level, they work together and have direct contact. Collaborative robots can be used in several industrial applications, for example, handling, welding, and assembly (Villani et al., 2018). Several automotive manufacturers have been introducing collaborative robots in assembly production lines recently (Sherwani et al., 2020). The collaborative robotics are flexible and can easily adapt to different tasks which is an important factor in today´s production systems, with the paradigm shift from mass production to mass customization and a need to handle more variation in production, with shorter life cycles and smaller batch sizes.” [2]

Implementation of HRC in series production, allows to reduce the ergonomic adverse and stressful situations. This allows human operators to use their cognitive abilities to maximum effect. Human operators can work together with robots without protective fences. Efficiency and effectiveness at the workplace – more room for creativity. Experts note that after the introduction of HRC in production, the implementation of processes has increased by up to 30% and this may affect many other areas of production in the future in the long term [3]. This ensures the efficient distribution of tasks on the production line. This helps to eliminate negative human factors in the work process, leaving time and energy to solve more complex and creative tasks.

Implementation of collaborative robots in SME, Harrsion Manufacturing, Mission based injection molding plastics company,a family-run firm faced several ongoing challenges relating to repetitive tasks its workers were required to take, often leading to muscle strains, mistakes and general deterioration in quality levels, after deploying the Sawyer model collaborative robotic from Rethink Robotics, it helped ensure a more predicable level of parts quality – a key requirement for its customers. Other key advantages included a sharp drop in the risk of staff injuries, as well as the ease of programming the collaborative robotic.

Businesses are always looking to improve the ways they work, and digitalization and automation have given them more options to do this than ever before. Collaborative industrial robots offer one kind of automation solution to SMEs. And just like marketing, accounting or data management automation helps companies remove repetitive, time-consuming and manual tasks in the back office, collaborative robotics utilize cutting--edge software and hardware to remove the need for humans to perform tasks like assembly and packaging. They provide a high degree of precision, are highly scalable and can easily integrate into multiple applications – all of which improves product quality, lowers costs and boosts profitability.

SMEs are the most important aspects of the economies and in European union they represent 99% of all businesses. Manufacturing SMEs are widely increasing equipped with collaborative robot systems. “The human-robot collaboration helps combine the precision, strength, and speed of industrial robots with the judgment, ingenuity, and dexterity of human workers. It also helps in enhancing competence, reducing costs, and increasing energy efficiency and sustainability of the organization." Use of collaborative robotics enables the potential to reduce waste in manufacturing, with minimum turnaround time means improved market coverage and revenue in manufacturing process, and these robots are specifically designed for vast number of repetitive tasks with precision and quality, which enables high amount of output and less defective products. And also, deployment of collaborative robotics decrease the emissions from transportation and process the production closer to global supply hub and become more resilient in process. Collaborative robotics are also increasingly deployed on assembly lines handling screw driving, gluing and welding, as well as other production processes such as polishing, laser marking, life cycle testing, packaging and palletizing. The electronics manufacturing sector uses collaborative robotics to perform tasks such as lifecycle testing and epoxy filling in circuit boards. These also helps in saving space at working area and enabling workers to work alongside with them ensuring utmost safety and accuracy without intensive redesigns of production site. Besides these manufacturers can minimize energy consumption and also cost saving from less labor force with automation of production line with a greater number of collaborative robotics.

Installation of collaborative robotics

To ensure good performance and safety, please place the controller and robot in an environment with the following conditions. Do not install a collaborative robotic in a closed environment. And keep away from direct sunlight, dust, oil, smoke, salinity, metal powder, corrosive gases, and other contaminants. It must be set away from the flammable materials and from cutting and grinding fluids. Keep away from sources of electromagnetic interference.

When the collaborative robotic is installed, the collaborative robotic must be fixed on a sufficiently strong base. The base must be able to withstand the reaction force of the robot during acceleration and deceleration and the static weight of the robot and the workpiece.

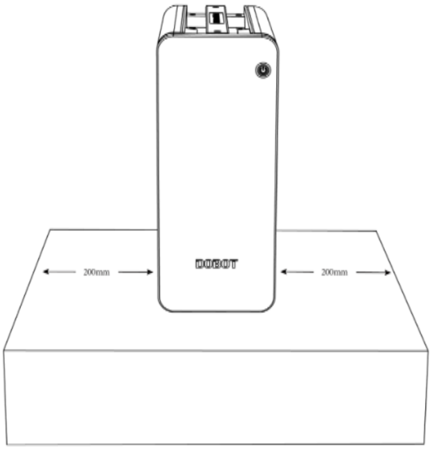
Place the controller on the horizontal surface outside robot's workspace and reserve enough space for connecting cables and operating controller. Make sure there's at least

200mm (≈8in) on either side of the controller. Ensure there is nothing near the fan outlet for sufficient heat dissipation.

Benefits of HRC

The benefits of automating manufacturing and industrial processes can be grouped into two broad categories: commercial and workplace.

HRC-capable robots are rendered mobile and capable of performing different tasks



flexibly using mobile platforms. They can thus be individually deployed at whatever location and for whatever purpose corresponds to production requirements – dependent on the required batch size.These types of robots offer maximum flexibility using so-called spontaneous automation: They support a user as an assistant in the case of workload peaks and resource bottlenecks in production operations.

HRC changes industrial production and manufacturing and can bring several advantages over traditional automation or manual labor:

It increases flexibility in production. Relief of employees by performing ergonomically unfavorable work steps that could not previously be automated

It reduces risk of injuries and infections. It supplies high-quality performance of reproducible processes without requiring type-specific or component-relevant investment. It also increases productivity and improved system complexity thanks to integrated.

HRC performance can be explained and studied easily through three case studies

1. Lightweight robots supporting operators in adhesive bonding processes.

2. Human-robot collaboration during the adjustment of headlights.

3. Using a collaborative robotic to install pump wells.

SMMs may be aware of trends and potential benefits of robotics, but they often are hesitant to invest without certainty of success. Even with commercially available technologies, manufacturers may be left to their own resources to determine whether a collaborative robot will actually perform as expected.

SMMs may lack a dedicated programmer, and programming complexity varies by collaborative robotic OEMs. It is essential to have a clearly defined outcome in order to achieve proper integration and implementation. Otherwise integration can become more of an ongoing expense than anticipated.

Limitations of collaborative robotics:

Collaborative robots also have limitations, including:

- They often operate at a slower speed than standard automation.
- Many collaborative robotics have limited payload capacity and reach, though a few models are available that address those areas.
- Collaborative robotics for some dangerous applications may require additional safety infrastructure such as caging or area scanners.

Outlook

This document serves the different experts and stakeholders with main principles and content, to better apply the priorities and the action plan during the next months until project end in August 2023.

The aim is to tracking all impacts through collecting as much as possible information and feedback from a wider range of experts stakeholders, testers and learners that contribute ideas and suggestions to improve the described priorities and to implement the proposed educational programm.

The objective is to fostering the installation of collaborative robotics in the manufacturing companies, the educational programm and the collaborative platform for the training course will be available for free of charge to all the experts and stakeholders such as policy makers, industries, educational community and current and future workers for further uses during the next 3 years after project end. This will ensure that the course can better achieve his goals throughout europe and even worldwide at least without financial barriers. Because the attendance is to achieve at least 150 people that complete the course in the first 4 months after project end and more than 100 companies worldwide which should be interested in the TOURING course.

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