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Robotics in Application Areas and Coordination & Support

Flexible Assembly Manufacturing with Human-Robot Collaboration and Digital Twin Models

D9.3: Dissemination, exploitation, standardization activities report and impact assessment I

Abstract: This deliverable provides the results of the actions on long-term sustainability and exploitation up to month 25. It sketches the roadmap for further exploitation, dissemination and standardization in the FELICE project. This document also reports the exploitable outputs identified and the new potentially exploitable assets discovered during this reporting period.
It outlines the exploitation strategies using up-to-date business models based on the interests of the consortium, and according to the market segmentation of potential customers. It reports on the dissemination and communication activities performed in the first phase of the project as well as the current status of the quantitative dissemination key performance indicators.

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List of Abbreviations

AI	Artificial Intelligence
AWS	Adaptive WorkStation
BMC	Business Model Canvas
CA	Consortium Agreement
DIH	Digital Innovation Hub
EU	European Union
EN	European Norm
GA	Grant Agreement
KPIs	Key Performance Indicators
IA	Innovation Action
IMP	Innovation Management Plan
IMS	Innovation Management System
IoT	Internet of Things
IPR	Intellectual Property Right
ISO	International Standard Organisation
ISO/TC	Technical Committee of International Standard Organisation
M	Month
PPP	Public Private Partnership
SoA	State of the Art
STA	Scientific Technical Achievements
TRL	Technology Readiness Level
WP	Work Package

Executive Summary

This deliverable describes the strategy for exploiting the results as well as the actions taken for the dissemination of the FELICE project results during the first phase of the project (M1 to M25). The main purpose of this report is to ensure that research activities, technological developments, and project results are–consistent and aligned with the objectives and also useful in the implementation phase.

The document also reports the most important aspects related to the identification of the exploitable outputs in the long-term and the path to achieve the expected exploitation. It sketches the roadmap for exploitation, related business models, and innovation activities for the FELICE solution but also for individual partners. This approach is based on the strategy implemented by each participant and then more homogeneously by the whole project consortium strategy. The alignment of the twofold strategy is ensured by the exploitability of the single part of the system as well as the integrated system. This exploitation strategy translates into a business plan and roadmaps for each component of the product system.

The potential for exploiting the results is incremental depending on the innovativeness of the solutions. Innovations are analyzed from the point of view of sustainability and their strengths and weaknesses. This analysis is also accompanied by an evaluation of the licensing strategy already identified in the deliverable D1.4 that will be refined in the following months of the project.

Based on the results, the expected business is analyzed, elaborating any intellectual property rights (IPR) and revenue sharing models.

Compared to Deliverable 9.2: "Dissemination, Exploitation, and Communication Plan", the analysis is deepened here to include the description of the evolution of individual strategies using up-to-date business models on the profile and interests of partners, as well as on the identification of target groups and customer segmentation.

This report also includes a more detailed report on the Dissemination and Communication activities performed in the first phase of the project as well as the current status of the quantitative dissemination Key Performance Indicators (dKPIs) for FELICE. Various channels including the project website, the ZENODO repository, LinkedIn, YouTube, and Twitter are being used to communicate with the target audiences of FELICE and for disseminating results. Roadmaps for dissemination processes, project flyers, newsletters, and videos have been created to aid the consortium. FELICE partners contributed to the dissemination of the project's results by publishing scientific papers and participating in or organizing several workshops and conferences.

1 Introduction

The main objective of this deliverable is to update the exploitation strategy by incorporating the incremental evolution of the project during the 25 months of development.

In the FELICE project, to achieve valid results from the point of view of sustainable and exploitable business, a strategy was defined to guide the technologies and products under development in the project toward the derivation of competitive solutions.

In particular, the main objective of this deliverable is to present the individual and joint business models that aim at the commercialization of the FELICE solution.

This document describes the structure on which the FELICE project will manage the expected results within the project organization, trying to maximize the impact of its results and assets.

Exploitation and dissemination management are also linked to research activities in order to guide the project from a scientific and technological perspective.

Furthermore, this document reports the activities necessary to protect the intellectual property developed in the project in accordance with the GA and the CA.

1.1 Purpose of the document

The main purpose of this report is to orient the project's research activities, technological developments, and results towards exceeding the state of the art but also that they can be linked to external technological developments being competitive with them.

A further objective of “*Dissemination, exploitation, standardization activities report and impact assessment I*” is the identification of the most interesting solutions for a potential market.

This document aims to describe the strategy adopted for planning the exploitation of innovations. The document is then focusing on all the main aspects to be considered in the activities management for dissemination, standardization and exploitation. In particular:

- the continuous identification of innovative technologies and products
- the analysis of the weak points, and possible risks concerning the scientific and technological achievements
- the evolution of the Business Model Canvas (BMC) content in terms of user needs, market trends, stakeholders, and competitors
- the actions for fostering asset implementation and the measures for protecting the Project’s IPR

Furthermore, this report summarizes and discusses the current status of the consortium's dissemination, communication, and standardization efforts until Month 25 of the project. Providing transparency in dissemination and communication activities and processes involved in the creation of dissemination material.

Therefore, providing evidence of the successful execution of the first phase of the dissemination and communication plan defined in Deliverable 9.2, with the goal to promote the project as well as ensuring the visibility of FELICE activities to relevant stakeholders to support the successful exploitation of the project's results and its impact.

The deliverable is organized into four sections that meaningfully connect the various innovative elements and enhance the ability to understand the exploitation path.

The first section is related to the **innovations, exploitation analysis and strategy plan**. In this section there is a description of the main ideas for exploitation of the innovation assets identified in the deliverable D1.4. The most important link of the project to the policy context of the call for proposals is also reported.

The outputs created and the innovation solutions that we want to exploit are analyzed considering the needs arousing from manufacturing process analysis that can be addressed based on the scientific and technological achievements. Furthermore, the advantages as well as weak points, and possible risks of the detected innovations are evaluated before further internal or external exploitation.

The second section concerns the **exploitation roadmap.** After a review of the exploitable assets carried out in the previous section, the aim here is to define the steps necessary to translate the innovative findings into useful and exploitable assets.

These assets, to be appealing on the market, must be oriented to the needs of the target customers, therefore it is important to identify the main *potential users of results*. It is also important to define the *involvement of potential end-users and stakeholders* in this process. Steps for implementing the exploitation roadmap must also consider the barriers to any release of results. The graphical representation of these steps is reported in the roadmap for exploitation chart. The chart can support and drive the business models of each partner as well as the whole business model of the project including the actions for safeguarding IPR that are created within the project.

The third section is dedicated to the **dissemination, standardization and communication activities.** The exploitation is strictly linked to the consortium's dissemination and communication efforts, as the targeted stakeholder's knowledge of developed FELICE assets, a description of their advantages as well as possible risks involved in their adoption, support the realistic applicability of the project results and create interest in the market for the project outcomes.
Exploitation efforts need to be supported by a *strategy for dissemination and communication* as well as the tools to detect the impact of the proposed strategy. Finally, standardization efforts planned for phase II are reported and an overview of possible standardization bodies for cooperation is given.

The fourth and last section deals with **further steps for practical application** that can be taken beyond the project mission. Any further action useful to transfer the innovations developed in the laboratory outside the experimental environment have to be considered and elaborated. This section reports the list of ideas to support this goal.

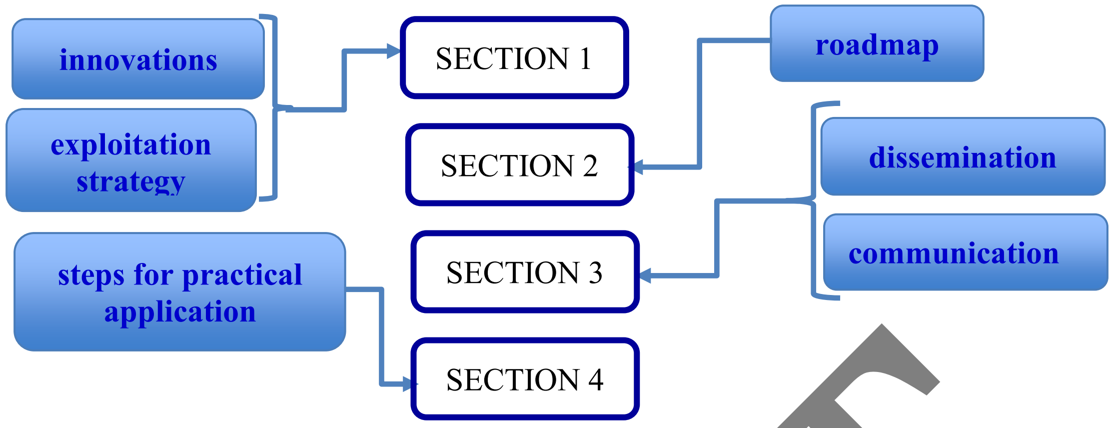

Figure 1 - Overview of the deliverable

1.2 Intended readership

Deliverable D9.3 "Dissemination, exploitation, standardization, and impact assessment I" is a public (PU) document. Its intended readership is considered to be the European Commission, the FELICE Project Officer, project partners involved in the FELICE consortium, beneficiaries of other Horizon 2020 funded projects as well as the general public.

1.3 Relationship with other FELICE deliverables

The relationship of this deliverable to other deliverables and WPs is due to the need to monitor the development of the technological system and its assets, as well as the technical activities related to their implementation. In this regard, the main interactions are in the following areas: Work Package 3 related to "System baseline", Work Package 4 focused on "Perception mechanisms", Work Package 5 concerning "Cognitive robotics and adaptive workstations", as well as Work Package 6 concerning "Data driven digital twin of production process" and finally the Work Package 7 about "AI for predictive models of human behavior and production evolution".

Following the same approach as described in deliverable D1.4, these Work Packages can contribute to the possibility of extracting some innovative aspects that could be exploited by specific customer targets.

To some extent, the work described here is also linked to Work Package 8 (WP8) as it captures innovations from the FELICE pilots, benchmarking, impact analysis and the evaluation of the solution against individual business needs.

Moreover, the organizational structure should help to foster the connections and the collaboration among the Work Packages, deliverables and outcomes of the project.

2 Innovation, exploitation strategy [SECTION1]

Innovation is steering the exploitation. As reported in the GA, FELICE is a research project whose mission is innovation. The results described in the following sections include both intellectual results (i.e., methodologies, working methods, and analyses) and products and technologies that can be sold or used independently.
In D9.2, some exploitable assets were identified as described in section 4.4.2.2 (Table 11: List of exploitable software assets) that now have been further developed and better defined.

The exploitation strategy is mainly oriented to exploit the individual assets, but also to further exploit the "*integrated system*" that benefits from the synergy among assets.
In both cases, structured activities are being developed to exploit the results within the consortium. Actions are also being envisaged to exploit the results in the form of a commercial product, also outside the project, especially after the end of the project. On the basis of this path, in the coming months, work will be done to develop potential commercial partnerships (initially with SMEs) in order to promote a commercialization path for the system or any subsystems derived from it.

As far as the exploitation of intellectual results is concerned, including the development of new knowledge, it is envisaged to strengthen the diffusion and communication trend. In this way, we intend to increase awareness of the potential of the system under development through communication actions on the FELICE website and social media channels (e.g. posting videos and news on the development progress and first results of the project), as well as dissemination of FELICE results via newsletters, scientific as well as non-scientific publications and standardization efforts.

To achieve long-term exploitation and sustainability of project results, a plan and procedure must be developed and implemented to make best use of available resources.
The exploitation plan is also supported by the road map for exploitation as reported in this document later, based on the list of exploitable assets initially reported in D1.4 and further updated in this document.

To the list of innovative assets mentioned in D9.2, the mobile cobot is included that integrates several of the project's innovations and outcomes.
Furthermore, the Adaptive Workstation (AWS) is an innovative hardware device exploitable within and beyond the project that can be included to the list as already mentioned in D9.2.
Several partners are involved in exploiting the project achievements, but the main driver will be the end-user and its needs for assembly systems with collaborative robotics.
The identified assets offer several benefits in terms of reduced implementation time, less risk when implementing a work assistance robot, greater flexibility when switching between tasks, easy interfacing with multiple tools, shorter setup time for a new technology operation, and a proven, standardized framework for those tasks. It also provides the possibility to improve HRC in cooperative work by reducing the risks of human activity interference with (albeit collaborative) robots. All these benefits apply differently to the individual use cases of the project (small and big scale).

Exploitation Strategy

The exploitation strategy, as described in D9.2, includes eight different phases that aim to lead to a concrete business model and a go-to-market plan, and support industrial readiness, as depicted in the list below and in Figure 2:

i) analysis of market insights
ii) business requirements
iii) definition of project's assets and value proposition
iv) requirements validation
v) elucidation of business model
vi) viability of scenarios and post-project partnership planning
vii) identification of open issues and consolidation
viii) business plan to go-to-market and for industrial readiness

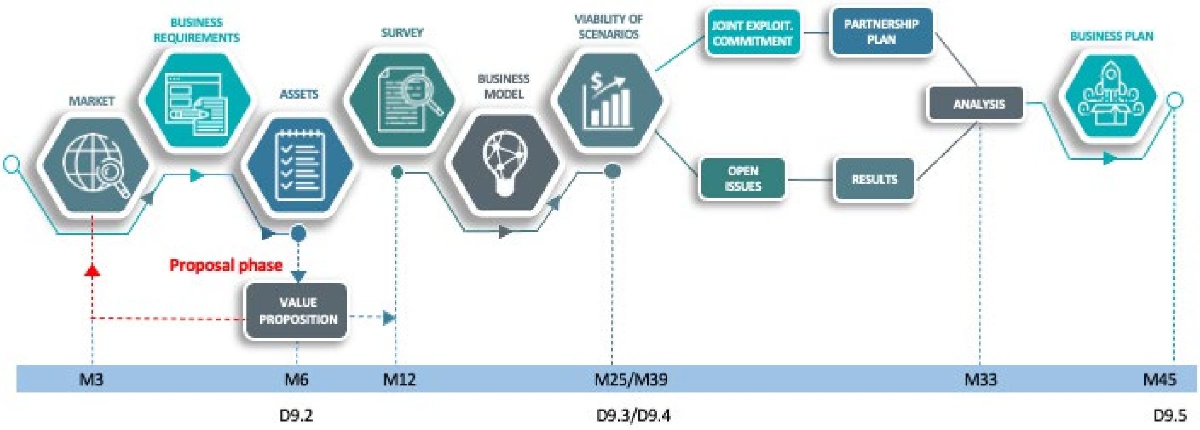

Figure 2 - Phases of the FELICE exploitation strategy of the whole project

Up to month twenty-four (M25) the analysis of market insights, business requirements, and a definition of the project's assets as well as a value proposition have been drafted and will be improved during the rest of the project.
These activities aim to establish a procedure to recognize, capture and characterize the project's results and are based on common techniques from the business management literature, the objectives of the project, and the assets described in chapter 4.4.2 of D9.2.
A dedicated workshop for sharing and discussing the exploitability of the assets identified was developed according to the strategy. The workshop contents are described in section 5.
The assets are analyzed in regard to the value they create for the stakeholders.
The procedure for capturing project results is going to be respected by all partners and continuously applied, e.g., through notification of partners of any publication. Moreover, in the procedure, it is foreseen to regulate and define appropriate arrangements to ensure that the legitimate interests of the project partners are not compromised (e.g. the filing of a patent, or the need to keep results confidential) - such as pre-publication reviews.

2.1 Link of the project to the policy context of the call for proposals

In accordance with European policies and with the "Digital Agenda" document, the objective of research and innovation activities in the ICT sector is to support and exploit technological advances in the sector for the benefit of European citizens and industries, as well as scientific communities. From this point of view, the development objectives and the subsequent exploitation of the results planned in the FELICE project are well aligned with European policies as they make the improvement of manufacturing efficiency and the workers well-being possible.

As Europe is among the largest information technology markets in the world, it needs to continue to support and lead the development of the ICT sector and its companies, with the help of governments, R&D centers and of universities. In this context, the partnership of the FELICE project, comprising universities and research centers, allows to push forward the knowledge in the sector of collaborative robotics and business digitization by marrying the needs of the community.

Soon through ICT all key processes of production, critical commercial and public services and knowledge in science, learning, cultural and creative sectors will be more usable and more accessible. Information technologies will also participate in major societal challenges, as well as in social processes such as community formation, consumer behavior, and political participation. It is therefore important to support and integrate research to develop competitive user-centered solutions. FELICE is moving in this direction by facilitating process flexibility by integrating robotic systems and adaptive workstations and digitizing the process to allow its remote control and management in accordance with the future challenges of the EU.

In addition, SMEs, with EU support in the field of research and innovation, can grow and exploit the size of EU-wide markets. High-tech enterprises can strengthen the collaboration and a network of excellence among Union scientists and engineers. The FELICE project is the perfect context in which this integration and strengthening can take place due to its excellent partnership and the plurality of objectives.

The support of H2020 to the research and development of ICT systems, which takes place in compliance with the fundamental rights and freedoms of natural persons and their private life, also allows the progress and use of technology in all sectors of life including the interaction between humans and technology. The objectives of the FELICE project regarding human-robot cooperation and flexible planning given by the orchestrator, are coherent and connected to these development policies. All the innovative assets identified and included in the exploitation plan, both individually and in an integrated manner, can be linked to the points set out above.

2.2 Outputs created and innovation solutions

The outputs created during the project development were initially mentioned in the previous deliverables (D1.4 and D9.2) but during the 24 months of R&D efforts additional innovative and exploitable assets were derived, and others were better defined and unified.

Through the analysis of outcomes based on the innovation process, some further innovative assets were identified and are currently under evaluation and monitored to be included in the assets list of exploitable innovations.

The following Table 1 includes a revised list of exploitable assets in which one asset definition was revised as "Real-time object detection and 6D localization to facilitate human-robot interaction"

As depicted in D9.2 the exploitable innovations were divided into software assets and hardware assets. In the last category (hw) the Adaptive Workstation and the Mobile Collaborative Robot were included. In the following Table, these two items are now part of the general asset list.

The list also reports the responsible main partners involved in the development as well as the physical location of these assets.

Table 1 - Exploitable assets and their location

Asset n°	Asset description	Partners involved	Asset location
A1	***Digital twins***		
	Multi-paradigm and multi-model Digital Twin for what-if analysis, experimentations and mirroring of the Assembly Line.	CAL-TEK s.r.l.	Italy
A2	***Pervasive scene perception***		
	Perception module that combines information from multiple cameras in real time for producing environment representations	Foundation for Research and Technology – Hellas (FORTH); Institute of Communication and Computer Systems (ICCS)	Greece
A3	***Real-time object detection and 6D localization to facilitate human-robot interaction***		
	A module for real-time object detection and 6D pose estimation of objects with challenging characteristics in industrial environments. It exploits information from on-robot camera images to support human-robot collaboration and facilitate object grasping by the robot.	Institute of Communication and Computer Systems (ICCS)	Greece
A4	***Fluent human-robot interaction***		
	A decision making and human-centric reasoning module aimed at robots equipped with action primitives for enhancing Human-Robot collaboration fluency	Foundation for Research and Technology – Hellas (FORTH). PROFACTOR Gmbh (PRO)	Austria

A5	***Assembly Line Orchestration***		
	Intelligent manufacturing execution system for improved productivity and ergonomics in assembly line tasks by orchestrating the interplay between human workers, cobots, and adaptive workstations.	FH Oberösterreich Forschungs & Entwicklungs GmbH (FHOOE)	Austria
A6	***Domain Specific Workflow Modelling Language***		
	Improved workflow modeling language for collaborative assembly line tasks	FH Oberösterreich Forschungs & Entwicklungs GmbH (FHOOE)	Austria
A7	***Adaptive WorkStation (AWS)***		
	Adaptive workstation for manual industrial assembly tasks on large work objects, adapting based on anthropometric and biomechanical principles as well as selected environmental factors	Institute for Ergonomics and Human Factors (IAD) - Technical University Darmstadt (TUD)	Germany
A8	***Advanced Interactive Screen (AIS)***		
	Advanced Interactive Screen (AIS) for Human-Computer Interaction (HCI) and Decision-Making activities	AEGIS IT Research GmbH (AEGIS) Leibnitz Research Centre for Working Environment and Human Factors (IfADo) FH Oberösterreich Forschungs & Entwicklungs GmbH (FHOOE)	Germany
A9	***Mobile Collaborative Robot***		
	Mobile platform, a central column with the possibility of changing the height, an arm equipped with a gripper, and a head with a touchscreen on a motorized neck.	ACCREA Engineering (ACC)	Poland

2.3 The needs that can be solved based on the scientific and technological achievements

Most of the assets declared in the GA are part of a wider idea to make the production system more flexible and more efficient than it is today. The FELICE system addresses these needs and is based on several subsystems able to face and overcome several obstacles and issues. Each of these subsystems is an outcome able to solve a subset of problems either in cooperation with other subsystems or stand alone. In the following table the business requirements of each partner are reported for exploiting R&D results of the project.

Table 2a - Business requirements for the exploitation of results

Partner	Business Requirements
ICCS	The exploitation of R&D results will be through providing services, licensing specific products to industrial partners, contracting with industrial partners to jointly develop new products, and participating in start-up/spin-off companies and joint ventures.
CRF	The FELICE system must be commercial with a CE mark with an after-sales service network available. Moreover, it must be affordable enough to be competitive with other MES. Finally, it has to be compliant with standards ISO 11228-1/2/3 EN 1005-1/2/3/4/5 and ISO 10218-TS 15066.
FHOOE	The prototypical implementation is also geared towards scientific evaluation and needs to be implemented using a rigorous software engineering process in order to achieve a maintainable and stable product. This will potentially take 1-2 years for a dedicated team of developers.
FORTH	The R&D results will be exploited through providing services, licensing specific products to industrial partners, contracting with industrial partners to jointly develop new products, and participating in start-up/spin-off companies and joint ventures.
CAL-TEK	Considering that the main output of the FELICE project will be a prototype (and also the Digital Twin will be realized as s prototype according to the selected case study e.g. assembly line), an industrialization process is required to bring the TRL up to the maximum level and the Digital Twin on the market. Obviously, this will require a specific study to understand how to carry out the industrialization as well as additional resources (e.g. people, funds, etc.) to be used. Once the Digital Twin is ready for the market, specific development work will be needed for each customer as their own Digital Twin is a replica of a real production environment and real production environments are varying. Therefore, while the core engine of the Digital Twin can be reusable and scalable, additional activities are required to adapt the solution to the real production environment considered.
TUD	A functioning demonstrator of an adaptive workstation for manual industrial assembly tasks at the end of the FELICE project is planned based on the requirements concerning environmental and physical ergonomics that are specific to the use case as well as national and international standards.
ACCREA	The mobile manipulator developed within this project will extend the ACCREA commercial offering of product i) to be sold as one time investment or ii) to be leased on monthly/subscription basis. The specific software capabilities of the robot will be consortium - wide harmonized with the owners of the respective IP.
PROFACTOR	The implementation is also geared towards scientific evaluation and needs to be further developed using a rigorous software engineering process in order to achieve a maintainable and stable product. However, some aspects of the R&D results will be exploited through providing services, licensing specific products (task based execution system) to industrial partners, contracting with

	industrial partners to jointly develop new products, and participating in start-up/spin-off companies and joint ventures.
AEGIS	The exploitation of R&D results will be through providing services, licensing specific products to industrial partners, contracting with industrial partners to jointly develop new products, and participating in start-up/spin-off companies and joint ventures.

The exploitable assets detected, aim to solve problems based on the technical, scientific or technological achievements.

In Table 2b, some of the scientific and technological achievements are evaluated in terms of opportunities to exploit the outcomes of the project further. In this table, opportunities are categorized as internal or external to the consortium.

Table 2b: Opportunities for scientific and technological achievements (to be revised and updated)

Scientific and technological achievements	Internal context	External opportunities
1. Safety for Human–Robot Interaction	Synergy, Internal Standards	Regulations and international standards. New IoT devices.
2. Human Cyber Physical Production Systems:	AR tools and smart assistance systems availability	Technologies integration and highly customized products
3. Open, scalable and secure IoT infrastructure	Existing IoT structures and procedures, Cybersecurity dept of the plant (CRF) hosting the IoT solution.	Centralised IoT operating environment. Blockchain-Based IoT. Extended connectivity.
4. Robot navigation in dynamic environments	Synergy with other project, Internal Standards	Transversal application to different sectors.
5. Object detection and 6D pose estimation	Transversal use of results	Transversal application to different sectors.
6. Human behavior analysis	Synergy with other project, Internal safety standards	Extension to the artificial intelligence application; Transversal application to different sectors.
7. Task-level programming	Transversal use of results, existing robotics task-based programming	New technique for programming and user-friendly visual programming
8. New implicit measures for the design and assessment of HRC	Knowledge and skills synergy at project level and end user level	Regulations and international standards. Cognitive modeling.
9. Machine learning for embedded industrial applications	Synergy with other project, Internal Standards	Maintenance and intelligent asset management in various industrial sectors
10. Skill-based orchestration and adaptation in assembly lines	Knowledge and skills synergy at project level and end user level	Transversal application to different sectors. Real-time condition-based monitoring in industrial environments.

Several of the scientific and technological achievements reported in the table above have a strong impact on the exploitable assets. In the following a table is provided that includes exploitable assets, while crossing them with the scientific and technological achievements.

In Table 3, this correlation matrix is finalized to detect any further impact useful to enhance the manufacturing environment and to make each single asset more exploitable and useful.

Table 3 - Impact of scientific and technological achievements on exploitable assets (to be revised and updated)

	Exploitable Assets*								
Scientific and technological achievements	A1.	A2.	A3.	A4.	A5.	A6.	A7.	A8.	A9.
1. Safety for Human–Robot Interaction	x		x	x	x	x		x	x
2. Human Cyber-Physical Production Systems:	x	x	x		x	x	x	x	x
3. Open, scalable and secure IoT infrastructure		x			x	x	x	x	
4. Robot navigation in dynamic environments	x	x							x
5. Object detection and 6D pose estimation			x						x
6. Human behavior analysis				x		x	x		
7. Task-level programming	x	x	x		x		x	x	x
8. New implicit measures for the design and assessment of HRC		x	x	x	x				x
9. Machine learning for embedded industrial applications				x				x	
10. Skill-based orchestration and adaptation in assembly lines	x	x	x	x	x	x	x	x	x

***List of exploitable Assets**
A1. Digital twin
A2. Pervasive scene perception
A3. Real-time object detection and 6D localization to facilitate human-robot interaction
A4. Fluent human-robot interaction
A5. Assembly Line Orchestration
A6. Domain Specific Workflow Modelling Language
A7. Adaptive WorkStation (AWS) for manual assembly tasks on large work objects
A8. Advanced Interactive Screen (AIS)
A9. Mobile Collaborative Robot

The utility and the exploitability of the mentioned assets is depending on the possibility to solve problems in their application domain. Then, any scientific and technological enhancement is finalized to overcome limitations and solve the related problems.

A minimal list of problems that can be solved by the exploitable assets is reported in the following table:

Table 4 - Problems that can be solved by each asset

Exploitable asset n°	Problem that can be solved
A1	Interfacing of robots and humans as well as a right setting of the tasks sequences depending on the human performances during the car production needs to be carefully evaluated in a short time. This is hardly possible without digitalization of the scenario. A digital twin that also includes a simulation environment can be used to predict a priori all the possibilities, identifying optimal decisions before physical actions. In this sense, the Digital Twin must be jointly used with Orchestrators where AI can be used to find optimal solutions.
A2	The task of monitoring the work environment is critical because of the large number of related variables and their implications for safety. The detection of humans with respect to the cobot and the objects used for work operations must be performed fast and reliably. Scene perception can overcome these issues, facilitating a safe and effective interaction of mobile cobot and workers.
A3	Estimation of objects with challenging characteristics in industrial environments still remains a problem for mobile cobot application. The object detection and localization is necessary to support human-robot collaboration and facilitate object grasping by the robot considering safety aspects.
A4	Human-Robot collaboration fluency is not completely achieved in this field, reducing the efficacy and the efficiency of the HM system. Balancing between high-level goals and task execution may introduce inconsistencies and increase human waiting time, which create obstacles to the exploitation of available robotic skills. The human-centric reasoning module aims to overcome this problem.
A5	High level of productivity along with ergonomics maximization in a variable and complex work environment is becoming an optimization problem. To face and manage this problem in frequent updating of the working condition (due to the variation of production requests), the development of an appropriate orchestrator (advanced MES) is a possible solution.
A6	Workflow modeling is an important task that has influence on the ergonomics. With a domain-specific set of actions, decisions, and assets modeling can be improved and sped up. In addition and in conjunction with A5, optimization can be enabled by focusing on a description of the degrees of freedom in the workflow rather than the predetermination of the human-robot interaction, as well as the ergonomics adjustment in every detail.
A7	For large work objects, whose dimensions exceed ergonomic grasp spaces, an ergonomic “one-size-fits-all” position does not exist. Changing the work object's position according to the average anthropometry of a theoretical worker mid-process is used to address this point to some degree, but fine-tuned individualization is impossible. To overcome this problem, the workpiece position is to be adapted automatically multiple times during the work cycle according to the task, work object geometry, and the anthropometry of the worker using actuators.

A8	The problem to be solved is the interactivity between worker and system as whole. This interaction is carried out by interactive screens that have limited functionalities and are bonded to traditional workplaces. The interactive screen aims to improve the human-worker interaction with the system and the Decision-Making activities from the Orchestrator. It adds humans in the loop of decision making while improving the HRC.
A9	The assistance on demand carried out by cobots is still missing in the manufacturing environment but could be essential to improve ergonomics well-being and efficiency of the workers and the system as whole. The mobile cobot is dedicated to the fulfillment of this need.

2.4 Advantages of the new solution

This section is dedicated to the evaluation of the advantages (synergies of the research group or optimization costs or resource commitment) applied to the manufacturing process by the introduction of a new concept solution such as the FELICE system. This evaluation is carried out on the industrial use case of the project, in which it is possible to analyze positive effects (against negative effects) based on a realistic working environment. The advantages can be:

- **Direct** - like a manual, test, model, better product or process, or improved understanding of mechanisms
- **Indirect** - like reduced material or energy usage, improved safety, efficiency, or better-trained staff.

The **direct advantages** of the FELICE system can be summarized in:

- *Flexibility of the process* for easy accommodation of several car model variants (introduction of different task for each model variant without impacting on the micro logistic)
- *Adaptability of workplace* to the needs of the workers (better configuration of the workstation to the worker needs and related improvement of the working organization)
- *Simplification of equipment* and tools for assembling operations (reduction of the number of items for holding components in the position or for storing them)
- *Simplification of the plant layout* by the reduction of constraints for the assembly line (it is the mobile cobot that can bring components and tools to the worker allowing to place them in a remote position instead of close to the assembling chain)
- Scheduling improvement and process management optimization (due to the orchestration of the work sequences and interconnection of different tools and instruments)

The **indirect advantages** of the FELICE system:

- *Safety improvement* of the system (due to the sensorization of the working environment and the detection of possible drift of the process parameters)
- *Ergonomics optimisation* and risk index reduction (considering the personalization of the workplace according to the anthropometry of the worker and keeping operations and postures in golden zone)

- *Quality improvement* and process errors reduction (better working conditions and ergonomics enhancement affect the quality of the manual work in the last part of the shift when fatigue occurs)
- Efficiency increasing for better task allocation as well as for cycle time optimization (concentration of value-added activities on worker and not value-added activity assigned to the cobot)
- *Energy saving* of the sub-processes for better organization of the operations and for the cycle time reduction (less time for processing means less energy used for performing of the same tasks)
- *Investment reduction* for specific dedicated equipment and tools (the general purpose mobile cobot can standardize the ancillary operation leaving the diversifications to the SW programming and to the scheduling organization)

2.5 Weak points, and possible risks of the detected innovations

This section is dedicated to the analysis of the weak points of the FELICE system under development. The system is made up of several integrated subsystems. Some subsystems can be adapted to be used as standalone systems, but in this section, these are evaluated as integrated into the FELICE production system.
Based on the weaknesses and strengths of the system, it is possible to identify early the corrective actions that need to be implemented to reinforce the final result.

The knowledge of the weaknesses and strengths as well as the possible threats and opportunities that the external environment and the potential market can present to a new system, allows the definition of exploitation strategies adapted to the characteristics of the output.

As already considered in a previous deliverable (D1.4), there are risks associated with the development of the prototype system, which can also influence the creation and industrialization of the final product. Among these, the following groups can be mentioned:

(i) *development risks.*
In the development phase, various difficulties are being faced related to the need to expand the economic resources to be introduced to achieve the best possible result. Since it is not possible to have resources higher than those budgeted for, some functions can be delegated to an industrial development phase and applied to later releases of the future product.
(ii) *technical risks.*
In this case, there are typical risks of innovative products in which some technical aspects (such as, for example, the manipulation of some objects and the end effector in general) may present the need for a more extensive experimentation before being deemed sufficiently reliable. To overcome this type of risk, it was agreed to focus the development only on the components of the (CRF) use case and to create a reliable end effector only for the selected components/tools.

(iii) *External risks*.

These risks are always present from the very beginning of the development, starting with the idea and remain relevant even in the industrialization and commercialization phases. These are the risks associated with:

a) no full usability of the results inside and outside the project's context due to a difficulty in adapting the system to different scenarios
b) similar competing technical approaches with more performing characteristics
c) possible strategies for replication of project results by third parties

All assets will flow into the FELICE system which must be considered in its entirety. It must therefore be considered that all innovative developments are aimed to apply to the FELICE system and are based on scientific studies of many other research groups that are developing similar products or industrial technical solutions, also in other fields such as medicine, logistics or services.

The risk of a similar approach by competitors exists and is higher for innovations with a high level of maturity.
The following table also shows (only as an overview) an estimate of the various risks.

Table 5: Risk analysis for assets list

Asset	Development risks		Tech. risks	External risks		
	Planning problems	Consortium collabor. issues		Usability of the results	Competing approaches	Replication by third parties
A1. Digital twin		✔	✔	✔	✔	✔
A2. Pervasive scene description		✔	✔	✔		✔
A3. Real-time object detection and 6D localization to facilitate human-robot interaction		✔	✔		✔	✔
A4. Fluent human-robot interaction	✔	✔	✔	✔	✔	
A5. Assembly Line Orchestration	✔	✔	✔	✔		✔
A6. Domain Specific Workflow Modelling Language	✔	✔	✔	✔		✔
A7. Adaptive Workstation (AWS)	✔	✔	✔	✔		✔
A8. Advanced Interactive Screen (AIS)		✔	✔		✔	✔
A9. Mobile Collaborative Robot		✔	✔		✔	✔

The SWOT analysis for the moment is focused on the FELICE system ideally described in the sketch below. Its further deployment in subsystems will be defined towards the end of the project with more technical details and innovative solutions for each subsystem.

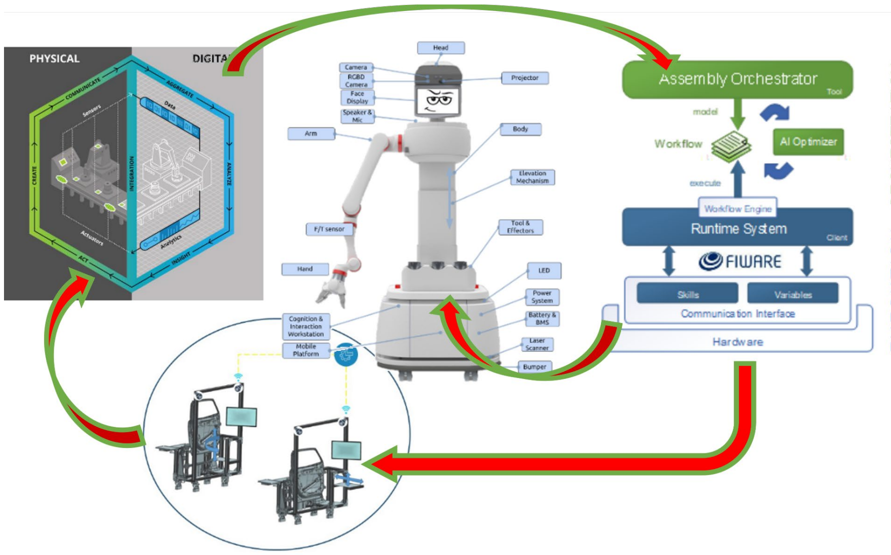

*Figure 3 - Sketch of the*FELICE system

SWOT chart

We begin the description of the analysis with a description of the four groups of elements constituting the SWOT graph and their content.

Strengths: the orchestrator remains one of the main strong points. This subsystem is intended to organize work activity between workers, mobile robots, and workstations. Together with the production scheduling management, based on customer requests, it gives an added value to the system. So the "production orchestration" is highly innovative and represents a good lever for the competitiveness of the entire "FELICE system". Even the "adaptability of the workstation" to the needs of the worker and the demands of the job represents an innovative concept that has not yet been fully developed in the industrial sector. There are different approaches to "adaptation" of the workplace to the ergonomic needs of the workstation, but there are two types observed so far. The first one makes an adaptation of the working area according to the task (Twin Trolley System to rotate the car body in production operations) and the other one makes an adaptation of the working area according to the height of the worker (mobile platform for height compensation). Both adaptation approaches are not applied simultaneously on a single workstation.

Another strong point is the availability of a mobile collaborative robot to assist the worker during the processing phases. The cobot is developed to have constant close cooperation as if it were another worker helper of the operator. This is an advance in HRI over the current state of the art in the industry.
The last strength is the digitization of the process based on the application of a digital twin model. This will allow the orchestrator's decision-making process to predict the best configuration in near real-time.

Other positive aspects are related to HRI development of strong human-robot interaction, based on cobotics and orchestration. Furthermore, the aim is to improve the safety and ergonomics of the workers thanks to the optimization and reduction of the workload. In parallel, there are further benefits in terms of increased efficiency and productivity due to the reallocation of tasks according to value-added operations that can be concentrated on the worker while leaving non-value-added operations to the cobot.

Weaknesses: the complexity of the system is one of the biggest weaknesses. Many different subsystems have to work together effectively communicating with each other efficiently. Complexity does not help the management of such a structure by making it sensitive to misalignments and defects.
Productivity needs require the entire system to be interfaced with the plant's existing production systems. This condition sometimes leads to various problems depending on the compatibility of the commercial IoT devices used in the plant and the related communication protocols. Not all factories have standardized IoT.

The speed of intervention and resolution of the problem represents another potential weak point of the FELICE system. No reference data are currently available, and a specific experiment will be carried out in the coming months to acquire more information.
Some auxiliary operations must be carried out following a safety procedure (for example, the operator confirming that objects have been taken from the robot). These extra checks require time with a potential increase in the risk of loss of competitiveness and efficiency which clearly represents a possible weak point.

Finally, an aspect of weakness for the system is represented by the still evolving standardization. The lack of certified, harmonized procedures in the collaborative industrial robotics sector specific for complex interoperable systems in a structured environment despite the existing regulations and standards[1] could weaken the possibility of exploiting the system.

Opportunities: one of the opportunities given by the FELICE system is its modularity which can help the implementation of several subsystems to be further developed as autonomous systems. For example, a mobile robot with voice interaction capable of entering the small or medium industry could represent one of the exploitable assets. Modularity also means the adaptability of the system to customer needs.
Another opportunity given by the development of this innovative system derives from the studies and the application of an advanced HMI interface for the reduction of the cognitive workload induced by cobotics.

Fluid and natural interaction using human language can increase interest in this area and create a stronger market for not yet fully defined cognitive devices.
Even the management of the workforce becomes easier through the application of the FELICE system, especially when there are numerous limitations on the worker's working capacity due to health problems or aging. This aspect can create the opportunity to extend the application of the system to the security and management objectives of the companies.

[1] The Ethics Guidelines for Trustworthy AI, High-Level Expert Group on Artificial Intelligence set up by the European Commission, April 2019

The new concept offers the opportunity to increase the personalization of the workstation and the working environment by moving production systems toward a realistic "design for all".

Threats: among the threats are the aspects of vulnerability related to the use of interconnected equipment and robotics that must fully comply with the highest standards of assurance and safety (before any release) in order not to jeopardize the reliability of the system.

Even the continuous evolution of the rules in the management of data confidentiality according to the environment in which the system operates (industry, logistics and services) can represent a possible threat to the exploitability of the system.
Other possible threats come from the unclearly regulated use of these systems using artificial intelligence in an integrated human-robot environment.

In fact, the abuse of productivity management rules could push the system to replace human decisions in many activities, creating a bad perception of this technology from the worker's point of view.

The autonomy of the system in the decision-making action can cast a dark shadow on the management logic adopted and the workforce could hinder the system to prevent its application.

It also raises potential issues regarding the safety and appropriateness of the system, or more complex issues of accountability. Ethical evaluation of innovation should mitigate risk, but future, as yet unknown applications could be critical.

Certain aspects of these issues might be mitigated by conforming with well-established ethical principles for Trustworthy AI[2].

That is, for example, by preserving by-design human oversight and "human-in-the-loop" in the system, ensuring transparency and interpretability of decision-making using explainable AI techniques, and regularly auditing and testing the systems in these aspects.

Nevertheless, the lack of relevant provisions in the regulatory landscape and the difficulties in harmonizing relevant future regulatory initiatives at a global level makes it difficult to ensure that appropriate governance mechanisms and rules will be put in place to monitor and address the diverse aspects that constitute such concerns and provide workers with stronger assurances in this direction.

The international situation relating to the availability of strategic electronic components could represent a further threat also linked to the reliability of the components collected on the market at affordable costs.

[2] The Ethics Guidelines for Trustworthy AI, High-Level Expert Group on Artificial Intelligence set up by the European Commission, April 2019

If the quality standard of the subsystem is not the best in its category, the reliability of the "FELICE system" could decrease making the system not reliable enough to compete with other similar innovative devices.

Furthermore, the broad protection of intellectual property rights on the subject of cobots and production systems in general could pose a threat to the exploitation of the overall system.

The unpredictable impact of competitors' patents in the next years of the project should be considered by applying constant patent monitoring on this topic and further developing a comprehensive IPR policy of the project.

The following table collects the synoptic framework of the SWOT analysis based on the above considerations.

Table 6 - SWOT analysis for "FELICE system"

Strengths	Weaknesses
- safety and ergonomics improvement - orchestration of the production process - workstation adaptability - reduction/optimization of the workload - digitalization of the process for collaborative and mobile robotics - HRI enhancement - efficiency and productivity increasing	- interfacing with the existing production system - system complexity - communication protocols selection for connection of several systems - low speed of intervention for effective and efficient support - unavailability of certified procedures

- customization of the workplace - modularity of the system - advanced HMI interface for not-skilled workers - cognitive workload reduction - easier management of the workforce in case of limitation and ageing	- poor security assurance - management complexity of data privacy - unregulated use of the system and ethics issues - scarcity of reliable components - impact of competitors patents on subsystem and components
Opportunities	**Threats**

3 Exploitation roadmap [SECTION2]

In this section, after the analysis of the above-mentioned outline (issues and potentialities), the operational actions are reported in the road mapping chart. The viability of this outline is then considered in the description of the roadmaps through the actions to undertake to concretize the plan. The roadmap also depicts the scenario for the next period and over the project end. Alongside the roadmap description there are some further considerations that can support the viability analysis based on the investigation of the potential users and their involvement, as well as the detection of the stakeholders for the exploitable innovative assets. Moreover, in this viability analysis the potential barriers and the rules for managing of data are considered to concretize the path.

3.1 Potential users of results

The main users of the FELICE system are in the manufacturing area of the car makers industry. In addition to automotive and automation applications, which are the markets already addressed by consortium members, there is also potential for exploitation in other markets, where collaborative and work-assistance robots will be required. The key technical features of applications suitable for work assistance robots include the following combination of features:

• The parts to be assembled or processed more generally must be manipulable by a single person and by a single robot. They must therefore weigh less than 5kg and to be not too bulky. This includes any component like a hand tool or small objects, but excludes large plates and flexible bodies, where specific types of grippers for mobile robots are used.
• The operations must be complex and require manual intervention, i.e. not easily automated.
Manual operations must also be carried out in ergonomic conditions that are difficult to solve in order to exploit the potential of FELICE's innovations.

A possible sector for this application is the area of the system integrators in which there are many SME operating for several markets. Among the most interesting potential markets and end-users we can mention:

- Food and beverage packaging
- Aeronautic assembling process (for small components)
- Logistics and goods distribution
- Appliance industry
- Mechanics operations and machining assistance

This list obviously is not exhaustive and can be increased depending on the specific target of the operation. The different domains must be briefly characterized at the technical level, identifying the possible applications, and the expected economic evolution of this domain in the coming years. This will be defined at the end of the testing process of the FELICE system based on the full clarification of the applicability limitations and related potentialities.

3.2 Involvement of potential end-users and stakeholders

Most of the potential users and stakeholders in the field of automotive manufacturing can be involved by traditional channels, for example via workshops in which experts share information and knowledge about a specific topic. Another possible involvement of end users or stakeholders from the automotive field can be pursued by the purchasing office (through its contact network) of the companies involved in the innovation development. The supply chain is a tank of small, medium and big enterprises that can be interested in joining the development of a new system and industrialization.

The fundamental element that must be considered in this phase regards the industrialization of the innovative assets in order to propose an exploitable product to the market in a manufacturing environment. In fact, although the innovative asset in consideration is an effective and successful potential result, it needs to be industrialized and brought on the market with all the ancillary measures to be sold and used in industry (like standards of references, CE mark, insurances, maintenance service, spare parts, etc.).

To face these aspects the best way is to involve an external company (or a company inside the project partnership) able to transform the innovation into a product or a service including it in their catalog.

To do that, a direct contact with the SME companies to attract the business on the possible innovative assets developed into the project is recommended and is planned according to the road map description.

For the automotive manufacturing process the list of system integrators will be used for a direct contact with SME and big companies in the field and to assess possible interest in the industrialization and implementation of the FELICE system or subsystems (separate modules).

3.3 Open access and managing of data

FELICE strives to maximize its impact by adopting public data repositories such as those described in the Data Management Plan (D1.2). FELICE provides publicly available datasets, using the Zenodo online platform, a general-purpose open-access repository operated by CERN. Zenodo stores files and metadata, provides version control and assigns DOIs to all uploaded elements. Zenodo is an open and accessible repository that enables access to data without restrictions and retains datasets for the lifetime of the repository, which is at least 20 years.

3.4 Barriers to any application of results

Barriers and obstacles foreseen in the beginning of the project, still remain actual. They are mainly focused on political, economic, social and technological aspects.
A possible obstacle is political instability, which could condition strategic choices in application plans due to lack of specific resources or conflicts in countries supplying strategic materials such as for the automotive sector. Digitalization pushed towards hard automation could also have an impeding effect on the exploitation of results that are oriented towards supporting the human workforce.

Possible barriers include the flow of data that must be shared between various platforms and stored. Even though the technologies that will be developed in FELICE will be fully compliant with the GDPR practices for data protection and confidentiality, data protection and privacy issues could arise especially for those involving the monitoring of workers' actions. In particular, with potential restrictions in the use and sharing of data between countries.

The economic obstacles are linked, primarily, to an effective productivity of the system and to the related investment and management costs. Industrial automation is drastically reducing the prices of robots making collaborative solutions less attractive. The cost-benefit ratio for a complex solution must therefore be supported by careful cost analysis which is updated very quickly due to market evolutions. The possibility that ***inadequate financing*** in the phase of industrialization and commercialization slows down the implementation of these solutions is concrete. The right selection of stakeholders in this case becomes fundamental to avoid stopping the process before facing the market.

As mentioned, the market evolution is fast and polymorph and possible ***mismatch between market needs and the solution*** developed can occur during the lifespan of the project. The most dangerous mismatching is related to automation versus “supported manual work”. In fact, the trend to implement more and more industrial robots highlights a drift towards hard automation instead of supportive solutions for manual work which is a target in the scope of the project. This can be a barrier to the exploitation if this trend is operating in the next two or three years before the consolidation of results from the FELICE project.

The ***intellectual property right issues***, for the moment, are faced by a management organization that is ongoing and despite them being a possible obstacle, up to now the rules and the agreement found inside the consortium seems to be good enough to overcome the barrier. Of course, in the next months with the development of the integrated system more details and emphasis will be put on this topic mainly in view of possible future commercialization of the whole system. This will be faced with the last mile supplier (SME) as also reported in the road map.

From a *societal point of view*, currently, collaborative robotics applications are few in percentage compared to industrial robotics and cobot applications are often not used at all in conditions of true collaboration. In this case, the social benefits are reduced and the lack of awareness of the possibilities and advantages of collaborative robotics for the manufacturing industry could slow down the market uptake of these new solutions.
In this context, ***skills shortage*** could be a possible obstacle if the training of workers that should be in contact with the mobile cobot and AI is inadequate. The innovative system has to be then supplied together with a training program to be developed in the industrialization phase from the supplier of the system.

The FELICE system is a complex integrated system and the risk of ***incompatibility between parts of systems (and related lack of standards)*** is realistic. Although the nature of the project and the several tests carried out specifically for the integration and harmonization of all parts minimize this risk. Based on that, for the moment, the integration of the subsystems seems to be an surmountable obstacle.

As far as ***regulation that hinders innovation***, a complex solution like that of the FELICE system certainly exposes shortcomings in the regulatory aspects and in the certification of the complete solution. These shortcomings can hinder the implementation and exploitation of the results. Furthermore, the lack of specific interoperable solutions (technical standards) and practices (process standards) for AI-managed mobile cobots can certainly represent an obstacle to their application.

Both of the above-mentioned points lead to possible barriers in the ***traditional value chains that are less keen to innovate*** than the companies inclined to innovation. The manufacturing process often is based on structural systems and rules consolidated and not ready to include innovations that can jeopardize the efficiency or the effectiveness of the whole process of transformation. To overcome this obstacle, the extended experimentation of the new system in a restricted area of the manufacturing (a model area) is strongly recommended. Experiments in a dedicated environment (pilot plant) as carried out in the FELICE Project have shortened the distance between the prototype system and its application in a realistic environment but each production plant has different needs and characteristics. This is true mainly in case of different sectors (e.g. appliance industry). In these cases, a preventive analysis of the value chain, together with a specifically designed demo to be applied in the model area of the selected plant is fundamental for the acceptance of the system and its exploitability.

3.5 Roadmap for exploitation

The exploitation of an invention requires actions necessary to transfer the innovation from the theoretical project to the functional prototype while adhering to reality. The study and definition of these actions follow a strategic process that can be represented through roadmaps.

The roadmap is a plan for the implementation of activities during the course of the project and after its conclusion. It is a provision in the short and medium term. The long-term vision and sustainability are described better through the BMC.

The plan outlines the short and medium term activities that should be undertaken by each of the project partners to achieve exploitation of results.

This section also includes a dedicated paragraph for each developer-partners or user-partner describing the BMC it intends to follow for the long-term exploitation of innovations/methodologies. References to the exploitable assets are reported in the list described in paragraph 2.3 (Table 2).

Depending on the results of a research project, there are different levels of exploitation. There may be exploitation characterized as **internal exploitation** that means *within the consortium* and **external exploitation** that means *outside the consortium*.

For ***external exploitation*** we mean:

- Industrial exploitation (for production process efficiency improvement)
- Technological exploitation (quality process and product increasing)
- Scientific exploitation (innovative concept enabling knowledge enhancing)

For **internal exploitation** we mean:

- Application for demonstration
- Incremental innovation of existing processes for partners
- Problem solving for the specific use case and inside the end-user domain
- Commercial development for the partners able to face the market

Commercial exploitation is more difficult as in order to attract private investment, the technological readiness level of the results must be sufficiently high.

For external exploitation, emphasis should be placed on the social added value (e.g. social benefits) and the broader aspects of public interest.

It is clear that the value of the results for the moment is significant when considering the social and scientific dimension, and therefore it makes more sense to evaluate the social return of the results, rather than their potential financial return on investment.

In the roadmap the first step towards commercial exploitation is indicated as a "further development of an AI project" that plans to raise the TRL up to levels suitable for seeking private funding useful to produce and commercialize the result (in this case the FELICE system).

The exploitation strategy focuses on continuous development, the use of project results, the use of subsystems in modules that derive from the overall development.

These steps of the roadmap are presented in the following figure.

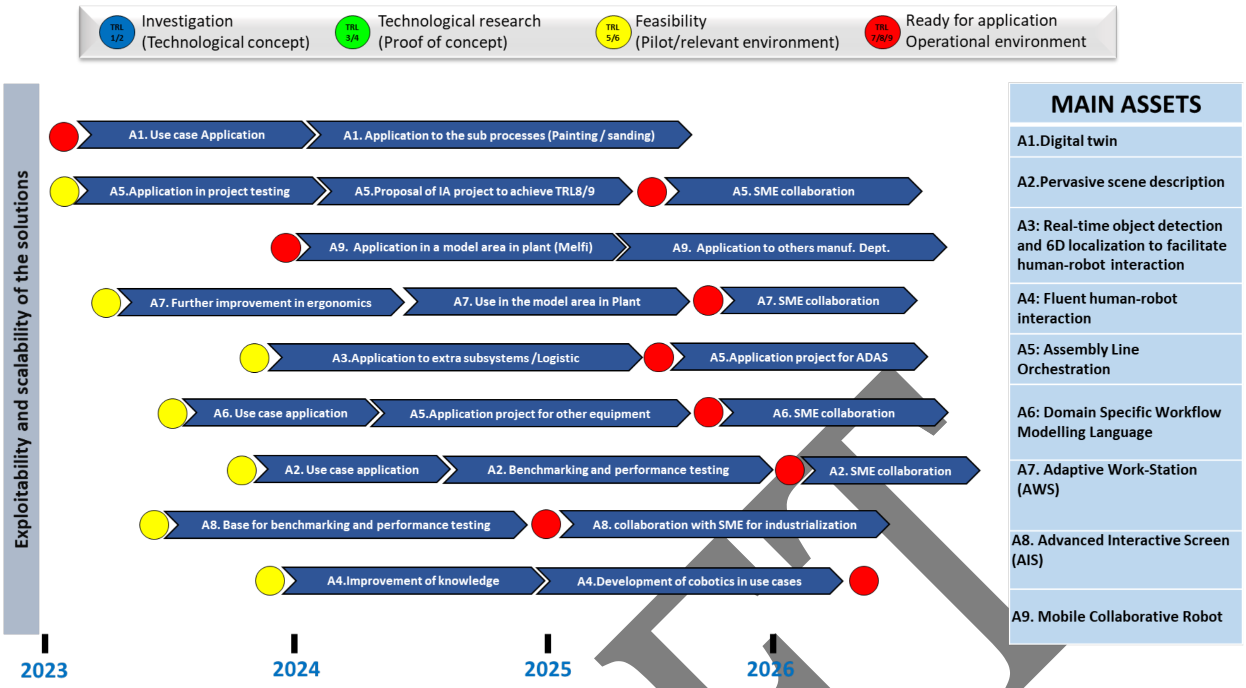

Figure 4 - Exploitation Roadmap of FELICE project for facing research challenges

Based on this transparent exploitation strategy, the dissemination plan (dissemination) is also developed through a series of workshops (models), conferences and bilateral meetings.

These moments of sharing and dissemination are intended not only to present the results to stakeholders, but also to explore their knowledge needs and improve research according to stakeholder expectations.

Moreover, the planned activities will be developed alongside an IP rights policy to prevent premature disclosure. The exploitation plan is supported also by a revenue sharing model.

3.6 Business Models

The road-mapping activities for the exploitation of the results of the FELICE project are based on the progress of the outputs obtained through the research conducted, throughout the duration of the project and on the possibilities of transforming these results into products and services that can be used by the members of the consortium or by external bodies interested.

This is a short-medium scope in which it is easier to exploit the subsystems. For a long term sustainability of the integrated FELICE system, a business model on which to base the exploitation can be more suitable to drive the planned actions instead of roadmaps.

On a long term basis, the consortium is in contact through its partners with the manufacturing technologies and robotics technologies community to share useful approaches to the implementation of the innovations created by the project. These innovations resulting from the development of project activities can thus also be communicated to other interested parties and decision-makers involved in the technological and industrial improvement policy according to the BMC.

Furthermore, the training seminars could help stakeholders to easily familiarize themselves with the use of the results.

In the following table it is possible to see the single BMC for each partner as well as the BMC for the whole integrated system sponsored by the consortium.

Table 7 – Business Model Canvas of the FELICE system

Business Model Canvas

Designed for:	Designed by:	Date:	Version:
CRF	Factory Engineering	06/12/2022	2.0

Key Partners	Key Activities / Key Resources	Value Propositions	Customer Relationships / Channels	Customer Segments
• FELICE system developers • FELICE system producers • CRF researchers' team with high knowledge of the system to guide its customization, installation and training	**Key Activities** • Implementation of dedicated ICT network • Training for correct use of the FELICE system • Setup and tuning (customization on plant needs) by Manufacturing Engineering • Privacy data management • Guideline and protocols for system application • ICT maintenance service • Legal agreement with Unions **Key Resources** • HR team and psychologists • ICT team & services • WCM training and consulting infrastructure • Social media channel with Institutional account on YouTube, Facebook, Instagram, Twitter, LinkedIn	FELICE system supplying high quality service for improvement of: – Wellbeing (Reducing, stress, fatigues and diseases) of workers – Human Robot collaboration safety – Process efficiency – Productivity Through: • Smartwatch and Smartphone • Orchestrator for managing work tasks / Method (based on rules and AI) Having CHARACTERISTICS of: • Newness, • Performance • Convenience • Usability, • Customization • Accessibility	**Customer Relationships** • The relationship is mainly based on direct contact with the team leader or others colleagues of WCM dept. Guidelines • The relationship is already established for other topics • It is fully integrated because already existing **Channels** • Plants promotional videos with stories of experience • Internal newsletters • Dedicated workshops • Direct contact with team leader or dept. manager or by phone or email	• Final users (assembly line workers) • Team leaders / Assembly line managers • HR managers • The market is both segmented and niche market — Segmented, because is oriented of some dept. of the company (productive segment) and in several different production plants. — Niche market, because from our perspective is involving only workers of our company and in a limited number.

Cost Structure	Revenue Streams
• IoT infrastructure (sensors, cameras, smartphone and smartwatch combos) • Connection to external HW • FELICE app licence or FELICE embedded system • Training courses	• Workers wellbeing improvement at work and beyond • Mitigation of risks and accidents • Reduction of costs for sickness and diseases • Productivity increasing • Flexibility of workplace management • Knowledge and competences keeping • FELICE-system customer segment dependent, Volume dependent

Only one BMC for the end user (CRF) is shown above as an example.

In the following table, the BMC is presented in a different format, integrating the business models of the partners.

SECTION	***Based on BMC of partners***
Key partners	● Software Licenses Suppliers (e.g., Unity 3D, AnyLogic, processSimulate, etc.); ● Companies acting as Dealers Network. ● FELICE system developers, producers, integrators, and teams for the system customization, installation and training ● Standard part suppliers (e.g., Bosch, Item, …) ● Actuator suppliers (e.g., LINAK) ● Illumination system supplier (e.g., Bosch) ● Sensor suppliers (e.g., Pepperl & Fuchs) ● Controller supplier (e.g., B&R, LINAK, or own development)
Key activities	➔ Software Development: Design, Development, Test and Release of the Software ➔ Maintenance and Help: Design, development, test and release of Help, FAQ, Chat Service and Community, Documentation, Knowledge Base Articles ➔ R&D activities: Increase the solution innovation level, Keep under control and introduce technological advances ➔ Marketing: CRM, Digital and Traditional Marketing, Search for Commercial Partnership, Customer Satisfaction monitoring ➔ Implementation of dedicated ICT network ➔ Training for correct use of the FELICE system ➔ Setup and tuning (customization on plant needs) by Manufacturing Engineering ➔ Privacy data management ➔ System application: guideline and protocols ➔ R&D activities: Faster algorithms, more complex problem definitions, more accurate prediction models ➔ Marketing: Success Stories, Digital and Traditional Marketing, Search for Commercial Partnership ➔ Service provisioning ➔ Integration with existing services ➔ Ergonomic evaluation ➔ Configuration of adjustable workstation system due to ergonomic requirements ➔ Consulting

Value propositions	— Creation of Digital Twin assets — Monitoring, Reasoning and Control over the real manufacturing process using Key enabling technologies — Reduced times and costs for education and training — Better Knowledge Management — Greater simplicity in identifying solutions to already encountered problems — Long-term efficiency and productivity gains — Real time data to predict and improve assets and processes. — "What if" simulations for better decision making — 3D virtual scenarios — Wellbeing (Reducing, stress, fatigues and diseases) of workers — Human Robot collaboration safety — Process efficiency — Productivity — Monitoring through Smartwatch and Smartphone — Managing of work tasks / Method- (based on rules and AI) — Monitoring and control of assembly line processes can consider a much larger number of factors than human line managers. — Reaction to changes in stress levels increases human worker satisfaction and reaction to changes in demand, as well as optimization of the use of robots increases productivity. — Analysis of historic data and reports provide insights for the continuous improvement processes. — Detection and localization of 3D objects with challenging characteristics — Unobtrusive monitoring of human activities to support action phase classification and ergonomic risk analysis during assembly task execution — Development and assembly of adaptive workstation — Better ergonomics analysis — More real-time data conveyed to operators in an innovative way — Having CHARACTERISTICS of: — Newness, — Performance — Convenience — Usability, — Customization — Accessibility

Customer relationships	➢ Collecting Customers Feedback ➢ Self Service Assistance (Help/ FAQ) ➢ Dedicated Assistance (Chat) ➢ On-site Assistance ➢ CRM ➢ Webinars ➢ Customers Involvement to increase the Value Propositions through the actions described above ➢ Direct contact with the team leader or other colleagues of SPW dept. ➢ Workshops ➢ Client communities ➢ Provide feedback and technical support
Customer segments	★ Manufacturing Systems Industry (Revenues>500K, Employees> 25) ★ Companies having a good attitude toward knowledge management and the digitization process already ongoing. Big investments planned in digitalization in the next 3 years ★ Manufacturing systems user and industry with complex production processes where workers carry out more than just one small action (e.g., automotive assembly industry) ★ Companies that carry R&D Activities ★ Final users (assembly line workers) ★ Team leaders / Assembly line managers/ HR managers ★ Segmented and niche markets ★ Productive segment in several different production plants. ★ Robot companies ★ Companies developing AR technologies ★ Companies integrating vision technologies for detection and tracking objects (e.g., surveillance, quality management etc.) ★ Market owners and solution providers ★ High number of employees (at assembly line)

Key resources	● Personnel ● Developers/Programmers ● R&D Team ● Marketing Specialist Manager ● Accounting Personnel ● Sellers ● PCs ● Offices Spaces, Laboratory space, Shopfloor space ● Software ● Budget for Digital Marketing, Ads, etc. ● Database Access for Market Analysis ● HR team and psychologists ● ICT team & services ● Company training and consulting infrastructure ● Social media channel on YouTube, Facebook, Instagram, Twitter, LinkedIn ● Software Licenses, Marketing and Market Analysis Budget ● Software architects ● Repository ● Provision of ground truth data ● Communication ● R&D, Production
Channels	● Company Website/Store online ● E-mail Marketing ● Ads and social media & networks (e.g. Google, FB, LinkedIn) ● Commercial Partners and Dealers network ● Technical Review ● Scientific fora and journals ● Plants promotional videos with stories of experience ● Internal newsletters ● Dedicated workshops ● Direct contact with team leader or dept. manager or by phone or email ● Industry fairs ● Existing Direct Contacts /Existing customer base

Cost structure	➔ Personnel Costs, Hardware Costs, Software Licenses Costs, Marketing Costs, ➔ Commercial Partnership Costs, Dealers Network Costs, IPR and Legal Costs, ➔ Personnel Update Costs, Offices Space Costs and Utilities, Administrative and Accounting Costs, Bank Services Costs. Legal and other infrastructure and administrative costs (10%) ➔ IoT infrastructure (sensors, cameras, smartphone and smartwatch combos) ➔ Connection to external HW ➔ FELICE app license or FELICE embedded system ➔ Training courses ➔ Technology development and updates ➔ Customization and integration ➔ Equipment (wearables and measurement systems) ➔ Traveling expenses ➔ Overheads
Revenue streams	- Selling the Digital Twin according to different configurations and different prices, - Digital Twin Maintenance and After Sale Services - Specific consultant works for the Design additional development work - Mitigation of risks and accidents/ Reduction of costs for sickness and diseases - Productivity increasing - Flexibility of workplace management - Knowledge and competences keeping - FELICE-system customer segment dependent, Volume dependent Licensing of the orchestration software - Customization of the software and development of customer-specific features - Licensing, SaaS offering / Subscription fees - Selling of adaptive workstation system - Consulting and maintenance fees - R&D fees

3.7 Safeguarding IPR that are created within the project

This section is dedicated to the guidelines for the creation of intellectual property rights (IPR) , to ensure a consistent and transparent protection process.

First, some general considerations on IPR are presented, including important concepts that need to be clearly defined and distinguished. Then, IPR concerning the *FELICE* project and its results are described.

Within the content of the CA, several definitions are included and that are crucial to be considered in this deliverable.

Background: means information and/or knowledge which is held by a Parties prior to their accession to the Consortium Agreement, as well as copyrights or other IPRs pertaining to such information and/or knowledge, the application that has been filed before their accession to this Consortium Agreement, and which is needed for carry out the Project or for Using the Foreground.

Controlled License Terms: means terms in any license that require that the use, copying, modification and/or distribution of Software or another copyright work ("Work") and/or of any copyright that is a modified version of or is a derivative work of such work (in each case, "Derivative Work") be subject, in whole or in part, to one of more of the following:

a) (where the Work or Derivative Work is Software) that the Source Code be made available as of right to any third party on request, whether royalty free or not;
b) that permission to create modified version or derivative works of the Work or Derivative Work be granted to any third party;
c) that a royalty-free license relating to the Work or Derivative Work be granted to any third party.

Foreground: means the results, including information, whether or not they can be protected which are generated by the Project. Such results include rights related to copyright; design rights; patent rights; plant variety rights; or similar forms of protection.

Intellectual Property Rights (IPR): means patent, patent applications and other statutory rights in interventions; copyrights (including without limitation copyrights in Software); registered design rights, applications for registered design rights, unregistered design rights and other statutory rights in designs and other similar or equivalent forms of statutory protection, wherever in the world arising or available; but excluding rights in Confidential Information or trade secrets.

Sideground: means information, other than Foreground developed or otherwise acquired by a Party after entering into the CA, as well as copyright or other IPRs pertaining to such information, and that is introduced into the Project by that Party for use in execution of the Project.

Starting from the set-up described in the Grant Agreement (GA) some more aspects will be considered.

The GA reports that each participant, who contributes intellectual property to the project or has developed intellectual property within the project, must make a declaration about its IPR to the coordinator.

This declaration shall include any special requirements for the use of this IPR in addition to or in derogation of the standard rules on rights in the Consortium Agreement.

Confidentiality and exploitation issues shall be determined at the start of the project and reflected in the Consortium Agreement.

In particular, the following commercial issues shall be addressed:

- (i) confidentiality of information disclosed by the parties during the development of the project;
- (ii) ownership of the results resulting from the execution of the project;
- (iii) legal protection of the results through patent rights;
- (iv) commercial use of the results, taking into account also the joint ownership of the results;
- (v) patents, know-how and information concerning the use of knowledge, owned by either party, resulting from work carried out prior to the agreement;
- (vi) sub-licensing of commercial offers to third parties within clearly defined limits;
- (vii) availability of information, products, results, etc., for other EU-funded projects; and
- (viii) liability exclusion rules.

As far as concerns the background of the project the CA is regulating the IPR of this part of knowledge and the Attachment 1 is reporting the declared owner for this part.

Anything not identified in Attachment 1 shall not be the object of Access Right obligations regarding Background.
In the section 9.2 of the CA is also reported "Any Party may add further own Background to Attachment 1 during the Project by written notice to the other Parties. However, approval of the General Assembly is needed should a Party wish to modify or withdraw its Background in Attachment 1".

Foreground shall be owned by the Party who carried out the work generating the Foreground, or on whose behalf such work was carried out.

Dissemination, use of knowledge and results generated in the project is governed by the terms of the Consortium Agreement.
In order to make sure that these terms are followed, to avoid disputes and to facilitate business planning, an IPR Directory is going to be kept and updated throughout the lifetime of the project. The IPR directory presents the IPR rules accepted by all partners

at the beginning of the project and that can influence the options for future exploitation and commercialization of the results.
This document listed all items of knowledge ***relating to the work of the project*** (results developed in the project), and make explicit for each item:

- The owner(s).
- The nature of the knowledge, and its perceived potential for exploitation.
- The currently agreed status of the item concerning access rights, plans to use the knowledge in exploitation, or plans to disseminate it outside the Consortium.
- Measures required, or in place, to ensure protection of IPR for the item.

Table 8 – Initial version of IPR directory

Partner (owner)	The nature of the knowledge	IPR	Deliverable
ICCS	Concept, methods and software implementation for object detection and tracking	According to the CA	D4.1, D4.2, D4.3
CRF	Methodologies for process testing and optimization	No IPR necessary	D8.4
FHOOE	Algorithms and software implementation for adaptive control, based on sensor measurements and environmental feedback	According to the CA	D7.3
FRAUNHOFER	Intelligent policies for handling complex situations or failure cases	According to the CA	D7.3
ACCREA	The design and implementation of the mobile robot, its hardware and the control system	According to the CA	D5.1
PRO	Concept, software implementation for online skill parametrization of robot actions, including robot arm movement and grasping; Software Implementation of online robot task verification	According to the CA	D5.2, D5.4 and D5.5
CAL-TEK	Concept, methods and software implementation for the Digital Twin	According to the CA	D6.1, D6.2
TUD	Design, implementation, and ergonomic methodology behind adaptive workstations and adaptive processes	According to the CA	D2.1, D5.1
FORTH	Algorithms, methods and software codes for visual localization and scene perception	According to the CA	D4.1, D4.2, D4.3

3.8 Liaising with Digital Innovation Hubs

FELICE is liaising with the ongoing Digital Innovation Hubs TRINITY and DIH², which aspire to improve the agility of the European manufacturing sector. It is foreseen that FELICE will employ toolkits from these DIHs but also contribute certain of its developments in order to extend existing toolkits and introduce new ones.

For that purpose, FELICE is assessing the current states of development and content of deliverables of the DIHs like assets, methods and tools. Subsequently, these outcomes are matched against the intended work of FELICE and additionally against the current state of work. In parallel, the existing and newly formed DIH are screened continuously. In case promising DIH are found to fit the content of FELICE, we contact the respective partners and propose initial meetings.

These meetings help FELICE to get deeper insights and align similar or complementary work. The FELICE consortium evaluates the outcomes of the other DIH to find synergies and exploitation possibilities. The evaluation of the modules are discussed in section “Section 3 - Networking with DIHs”.

4 Dissemination and communication activities [SECTION 3]

This section reports on the dissemination and communication activities performed by the dissemination manager (TUD) and FELICE consortium members, as outlined in the Dissemination, Communication, and Exploitation plan (DECP) in deliverable D9.2.

Section 4.1 outlines the next steps in the Dissemination and Communication strategy. Section 4.2 provides a report on the current state of dissemination Key Performance Indicators (dKPIs). The number of dissemination and communication activities performed by partners in the first phase of the project is presented in section 4.3. Activities are subdivided into different categories and explained in more detail in the following subchapters. Section 4.4 provides a list of published and accepted FELICE publications. The next steps for FELICE standardization activities are discussed in section 4.7 while the liaison between FELICE and Digital Innovation Hubs (DIHs) is outlined in section 4.8.

4.1 Strategy for dissemination and communication

The strategy for dissemination and communication for the FELICE project has been outlined in D9.2 as part of the Dissemination, Exploitation, and Communication plan (DECP). Outlining the target audiences as well as the tools and channels available to Consortium members and their responsibilities for supporting DECP activities.
In D9.2, dissemination and communication goals, types of information to be shared, main target audiences, and key channels have been defined for the three phases of the FELICE project as seen in Table 9. The table has been updated to reflect the three-month project extension.

Table 9 - Phases of communication and dissemination activities

Phase	Month	Goals /Types of Information	Main target audiences	Key Channels
I	M1-25	Create awareness and greater visibility Approach-oriented content Project presentation Objectives and expected results	Robotics and manufacturing industry Scientific community DIHs	Project Website Social media E-newsletters Scientific publications

II	**M25-39**	Result-oriented content; Project intermediate and final results Inform targeted industry stakeholders and early adopters in the project activities.	Robotics and manufacturing industry Scientific community DIHs and PPPs Standardization bodies Open source communities	Exhibitions Info days Focused publications Conferences
III	**M39-45**	Result-oriented content; Project final results Integrated platform, all pilot showcases, and lessons learned Long-term sustainability and potential commercialization	Robotics and manufacturing industry Scientific community Industry associations DIH Policymakers Open source communities General public	Exhibitions Info days Partner announcements Press releases Publications

The defined goals for the first phase have been successfully completed. The project has been presented at a multitude of workshops, events, and conferences, communicating its objectives, expected results, and development progress. All targeted social media channels as well as the FELICE website have been set up and are actively managed. Multiple scientific publications have been released (see section 4.4) and four newsletters have been published on the FELICE website (section 4.3.9).
From June 2022, reporting on social media and newsletters included the first information on the phase I prototype of the combined FELICE system and implemented technologies. This trend will continue from 2023 onwards, providing more content on early results and FELICE technology during the development and testing of the phase II system prototype, also specifically focusing on additional target groups in standardization and industry.

4.2 Dissemination Key Performance Indicator (dKPI) status

Table 10 lists the current status of the 20 quantitative dissemination Key Performance Indicators (dKPI) that have been defined in the proposal. Activities and partner efforts are specified in section 4.3 of this document.

Table 10 – status report on the 20 quantitative dKPI defined for FELICE

dKPI	Description	Status
dKPI-1	Num. of site visitors/country >100 visitors (monthly)	~140 individual users/month with ~120 being new users Users in 2022 were mainly located (in order) in Germany, Italy, USA, Greece, China, Spain, Austria, UK, France and India
dKPI-2	Num. of site access annually >5000 (annually)	>75% (~3900) page accesses in 2021 >95% (~4780) page accesses in 2022
dKPI-3	Num. of downloads per month >100 (monthly)	est. 66% fulfillment in 2022 (website only)
dKPI-4	Num. of push announcements > 20 (monthly)	~5.8 in 2021 (LinkedIn and Twitter) ~7.5 in 2022 (LinkedIn and Twitter) Values under target, but ~29% increase in 2022. dKPI-5 values are still above the set target.
dKPI-5	New followers worldwide/month >20 (monthly)	~620 total followers on Twitter ~130 total followers on LinkedIn ~31 followers a month FELICE Twitter ranking second best under ICT-46-2020 presences in follower count
dKPI-6	Num. of re-tweets per month >20 (monthly)	~6.5 shares/month on Twitter in 2021 ~10.5 shares/month on Twitter in 2021 ~3.5 additional shares/month on LinkedIn Values are for FELICE and FELICE partner content Values are under target, but an increase of 64% has been achieved from 2021 to 2022 on Twitter
dKPI-7	Num. of views to *FELICE* YouTube videos >500 views	>72% achieved for the end of project goal with ~360 views
dKPI-8	Num. of *FELICE* YouTube videos >5	3 videos published including a project overview and two development progress videos on FELICE hardware
dKPI-9	Num. of downloads to *FELICE* newsletters >1000	est. ~300 in 2022 with 4 newsletters published
dKPI-10	Num. of press echoes (from all over Europe) = 10	FELICE was featured in press and magazines from: Austria (Austria Innovativ, der Standard supplement); Italy (Platinum magazine); France (ERCIM news); Germany (Discover Logistics)

dKPI	Description	Status
dKPI-11	Num. of international refereed journal publications >8	6 conference publications published & 3 accepted 1 conference poster presented 1 book chapter published 2 journal publications published
dKPI-12	Special issues in international refereed journals >2	FELICE members are editors in a planned 2023 special issue at Frontiers in Robotics and AI titled Robotic Applications for a Sustainable Future
dKPI-13	Num. of articles in printed and online magazines, newspapers >25	6 articles have been published in online or print magazines 1 Article has been included in a newspaper supplement
dKPI-14	[scientific] Num. of presentations in conferences and other events > 12	Presentations were held at 9 different conferences Overall, partners attended conferences 20 times
dKPI-15	[scientific] Num. of international workshops and summer schools organised >2 events with >100 attendees	Fulfilled: 1 special session at ISM 2021 conference 1 special session at I3M 2021 conference 1 workshop at ERF 2021 (over 800 registered participants) 4 workshops at ERF 2022, jointly with the euRobotics Topic group "Robotics for Sustainability and Environmental Aspects" (over 1000 registered participants)
dKPI-16	Num. of info days >2	Not started, no concerns at this stage
dKPI-17	[PPPs, initiatives, clusters] Num. of initiatives to collaborate > 7	Cooperation with euRobotics Topic group "Robotics for Sustainability and Environmental Aspects" Exploitation opportunities at Stellantis under discussion and several discussions held with Trinity and DIH² digital innovation hubs
dKPI-18	Num. of standardization groups to interact > 4	Target groups have been identified Next step is an internal standardization workshop
dKPI-19	[European DIHs] Num. of toolkits to link with *FELICE* modules >3	Started, expected in later stages due to availability of results
dKPI-20	[EU commission & regulatory sessions] Num. of events in the field of interest to participate >4	Invitation to participate in a EU commission session for ICT-46 projects at ERF 2021

4.3 Dissemination and Communication activities report

Table 11 gives an overview of the number of dissemination and communication activities performed by FELICE partners. Additional information on FELICE materials, activities, events, workshops and conferences is presented in the corresponding section 4.3.1 to 4.3.10. Scientific publications are listed separately in the following section (4.4).

Table 11 – Report of partner dissemination and communication activities in categories

Number of Dissemination and Communication activities in categories														
Partner	**ICCS**	**CRF**	**FHOOE**	**AEGIS**	**IFADO**	**FORTH**	**CALTEK**	**TUD**	**UNISA**	**FRAUNHOFER**	**ACC**	**PROFACTOR**	**EUNL**	**A**
Conference Coorganisation			1											1
Conference special sessions organized							2							2
Conference attendance		1	3			4	7	1	1	2		1		20
Organisation of a Workshop	2	1										5		8
Workshop participation		2										1		3
Popularised publications	1		3						2	1				6
Exhibitions										10				10
Flyers	2							1		1				4
Social Media posts				16	1		1	76		1	3		1	105
Website updates	1			1			1	11			1		1	16
Videos/Films	1							3			1			5
Brokerage Events												1		1
Trade Fairs										1				1
Other events	1					1						2		4
Joint activities with other EU projects	2											8		10
Newsletters								4						4

Table 12 gives an overview of the estimated number of persons reached in the different target groups. The data has been estimated taking event target audiences, website and social media statistics, LinkedIn user profession data, or magazine media kits into account.

Table 12 – Estimated number of people reached by partners split in target audiences

Number of persons reached, in the context of all dissemination and communication activities, in categories														
Partner	**ICCS**	**CRF**	**FHOÖ**	**AEGIS**	**IFADO**	**FORTH**	**CALTEK**	**TUD**	**UNISA**	**Fraunhofer**	**ACC**	**PRO**	**EUNL**	**ALL**
Academics	1k		13k	300	200	1k	300	1.3k		1.5k		400		19k
Industry	500			100		500		1.1k		2k		300		4.5k
Civil Society								120						120
General Public	500		tbd*	1k	200			3.1k		500	950		790	7k*
Policy Makers	50											75		125
Media									3.6k					3.6k
Investors								150				50		200
Customers								100		100		100		300
Other								1k						1k

*Information on the FELICE project was included in a supplement of *Der Standard* newspaper with a potential print run of 58.000-95.000 copies. The engagement rate could not be determined.

4.3.1 Workshops and Conferences

Table 13 lists the special sessions and conferences (Co-)organized by FELICE partners:

Table 13 – Conferences or special sessions at conferences (Co-)organized by FELICE

Name of Conference	**Organizer**	**Presenter**
18th International Multidisciplinary Modelling & Simulation Multiconference (I3M 2021)	CALTEK	FHOOE, FORTH, CRF, CALTEK, ICCS
International Conference on Industry 4.0 and Smart Manufacturing (ISM 2021)	FHOOE, CALTEK	FORTH, CRF, FHOOE, ACCREA, CALTEK, PRO

The FELICE Special Session at the 18th International Multidisciplinary Modelling & Simulation Multiconference (I3M 2021) was held on September 16th, 2021, and included four presentations related to FELICE project, focusing on the Orchestration of the Human-

Robot Collaboration, Designing of a Data Driven Digital Twin and Definition of use cases in automotive production:

- Manolis Lourakis (FORTH): *The FELICE EU Project*
- Felice Tauro (CRF): *The use case at FIAT Research Center (CRF use case)*
- Antonio Padovano, (CALTEK): *FELICE: Design of a Data Driven Digital Twin*
- Florian Holzinger (FHOOE): *Orchestration of Human-Robot Collaboration*

The International Conference on Industry 4.0 and Smart Manufacturing (ISM 2021) was held online from 17 to 19 November and represented a knowledge exchange platform for Industry 4.0 and Smart Manufacturing topics. The venue was provided by the Upper Austria University of Applied Sciences (FHOOE). A FELICE special session was organized by CALTEK and held on 17th November. The session focused on the main aspects of the FELICE project:

- Manolis Lourakis (FORTH): *Overview of the FELICE Project*
- Felice Tauro (CRF) & Roman Froschauer (FHOOE): *FELICE Use Cases in Industry and Education: the CRF and FHOOE use cases*
- Bartlomiej Stanczyk (ACCREA): *The FELICE robot*
- Francesco Longo (CALTEK): *The FELICE Digital Twin*
- Andreas Beham (FHOOE): *FELICE Orchestration and control at the global and local layer*
- Andreas Beham (FHOOE) & Sharath Chandra Akkaladevi (PRO): *Orchestration and Robot task execution*

Table 14 lists additional conferences FELICE partners presented at or participated in to disseminate the FELICE project:

Table 14 – Conferences presented at or participated in by FELICE

Activity	Name of Conference	Presenter	Participants
Conference participation	25th International Conference on Pattern Recognition (ICPR) 2021	FORTH	
	26th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA) 2021	IML, IfADo	
	13th International Conference on Applied Human Factors and Ergonomics (AHFE 2022)	IML	
	27th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA) 2022	PRO	
	11th IEEE International Conference on Cloud Networking (CloudNet) 2022	ICCS	

	31st IEEE International Conference on Robot and Human Interactive Communication (RO-MAN) 2022	UNISA	UNISA
	International Conference on Industry 4.0 and Smart Manufacturing (ISM) 2022		CAL-TEK, FHOOE
	18th International Multidisciplinary Modelling & Simulation Multiconference (I3M) 2022 *This multiconference includes eight conferences*		CAL-TEK
	International Conference on Industry 4.0 and Smart Manufacturing (ISM) 2021	FORTH, CRF, FHOOE, ACC, CALTEK, PRO	FORTH, CRF, FHOOE, ACC, CALTEK, PRO
	18th International Multidisciplinary Modelling & Simulation Multiconference (I3M) 2021 *This multiconference includes eight conferences*	FORTH, CRF, CALTEK, FHOOE	FORTH, CRF, CALTEK, FHOOE
	European Robotics Forum 2021 (ERF 2021)	FORTH, CAL-TEK	

International Conference on Pattern Recognition (ICPR)

ICPR is a leading research conference in the field of pattern recognition and computer vision. The conference attracts a large number of submissions and attendees from around the world, bringing together researchers, engineers, and practitioners from academia and industry to discuss the state of the art in pattern recognition and related areas. The conference is held every two years and is considered a leading event in the field of pattern recognition.

International Conference on Emerging Technologies and Factory Automation (ETFA)

ETFA is an annual Conference of the IEEE Industrial Electronics Society (IES) focusing on developments and technologies in the field of industrial and factory automation. Topics include information and communication technology, automated manufacturing, intelligent sensors and robotics, cyber-physical and embedded systems. The conference aims to disseminate ideas, trends, research results, and practical accomplishments in these topics.

International Conference on Applied Human Factors and Ergonomics (AHFE)

The conference aims to disseminate information on theoretical, generic and applied human factors and ergonomics research. The conference includes keynote presentations, parallel sessions, demonstrations, and poster sessions as well as tutorials and exhibitions. Participants include people from academics, industry, and business as well as policymakers.

IEEE International Conference on Cloud Networking (CloudNet)

CloudNet brings together researchers and industry experts in Cloud Computing and related fields of research. The CloudNet program includes keynotes, technical sessions, tutorials, and discussion panels.

International Conference on Robot & Human Interactive Communication (RO-MAN)

RO-MAN is a leading forum where state-of-the-art innovative results, the latest developments as well as future perspectives relating to robot and human interactive communication are presented and discussed. The conference covers a wide range of topics related to Robot and Human Interactive Communication, involving theories, methodologies, technologies as well as empirical and experimental studies. It collects papers related to the study of robotic technology, psychology, cognitive science, artificial intelligence, human factors, ethics and policies, interaction-based robot design and other topics related to human-robot interaction.

International Conference on Industry 4.0 and Smart Manufacturing (ISM)

ISM is a yearly open forum fostering the smart culture and exploring the transformative impact of digital technologies characterizing the 4th industrial revolution across the full breadth of economic sectors.

International Multidisciplinary Modelling & Simulation Multiconference (I3M)

I3M is held annually and brings together researchers, scientists and practitioners from around the globe, who are concerned with Modeling and Simulation in Industry and Academia. I3M is a multiconference including the following eight conferences: EMSS 2022, MAS 2022, HMS 2022, IWISH 2022, DHSS 2022, SESDE 2022, FOODOPS 2022 of which FELICE consortium members attended one or several.

European Robotics Forum (ERF)

ERF is an annual conference that brings together researchers, industry leaders, and policymakers from across Europe to discuss the latest developments in robotics and artificial intelligence. The conference features keynote speeches, panel discussions, and technical presentations on a wide range of topics, including industrial robotics, service robots, medical robots, drones, and autonomous systems.

Table 15 lists the workshops that have been (Co-)organized be FELICE partners:

Table 15 – Workshops (Co-)organized by FELICE

Activity	Name of Workshop Event/Conference	Organizer	Presenter
Workshops organized	*Human Robot collaboration and AI for Sustainable Production*. Workshop Conducted at the European Robotics Forum 2021	PRO, ICCS	CALTEK, CRF, FORTH
	Application of Robotics in Sustainability and Environmental aspects. Workshop Conducted at the European Robotics Forum 2022	PRO; ICCS	
	Industrial Robots and Sustainability. Workshop Conducted at the European Robotics Forum 2022	PRO	

	Social Robots: the duality of sustainability and societal applications. Workshop Conducted at the European Robotics Forum 2022	PRO	
	Robotics for Sustainability - Manufacturing of Sustainable Robots. Workshop Conducted at the European Robotics Forum 2022	PRO	

The FELICE project co-organized a workshop entitled *Human-Robot Collaboration & AI for Sustainable Production*. This workshop focused on the aspect of collaborative robots for the development of sustainable production, mainly dealing with topics related to remanufacturing, recycling, and robot collaboration to reduce the workload of human workers.

The following year, FELICE co-organized four additional workshops on the Application of Robotics in Sustainability and Environmental aspects at ERF 2022. The workshops were conducted in conjunction with the newly formed euRobotics Topic Group *Robotics for Sustainability and Environmental Aspects*. As a first step, sustainable and environmental aspects in different sectors (manufacturing, agriculture, marine, energy, etc.) were defined and the role of robotic applications in solving those challenges was clarified. This was followed by some ongoing applications and case studies where robotic applications have successfully progressed in creating a difference for sustainability. The workshop was conducted to trigger an information exchange between academia and industry about the current challenges and possible solutions for sustainable production with the application of robots.

4.3.2 Non-scientific or non-peer-reviewed publications

Table 16 gives an overview of non-scientific or non-peer-reviewed publications of the FELICE consortium, e.g. in newspapers and scientific or business journals:

Table 16 – List of non-scientific or non-peer-reviewed publications by FELICE

Name of magazine	Name of article	Author
Shortcuts - Die FHOÖ Zeitung für Schnellleser September 2021 issue	Mensch und Roboter in der Fabrik der Zukunft	FHOOE
Magazine in “der Standard” newspaper	Mensch und Roboter in der Fabrik der Zukunft	FHOOE
Austria Innovativ 06-2021 issue	Fachhochschulen im Vormarsch, Leuchtturmprojekte der FHs	FHOOE
Platinum Magazine March 2022 issue	Artificial intelligence in the field	UNISA
Discover Logistics Magazine (Issue #22)	Kolla(ro)bor(t)ation	Fraunhofer
ERCIM news issue 123, January 2023 issue	Automatic Vision-based Monitoring of Work	FORTH, ICCS

	Postures and Actions for Human-Robot Collaborative Assembly Tasks	
ERCIM news issue 123, January 2023 issue	Speech and Gesture Command Recognition to Improve Human-Robot Interaction in Manual Assembly Lines	UNISA

Shortcuts - Die FHOÖ Zeitung für Schnellleser September 2021 issue & magazine supplement of Der Standard newspaper

Shortcuts is FHOOE’s in-house magazine. As the name suggests, Shortcuts provides exemplary insights and shows new perspectives from the four faculties of FHOOE - and presents, among other things, research projects in a short and concise form.
An excerpt of this article also appeared in a magazine supplement of the daily newspaper *Der Standard*, which is one of the biggest daily newspapers in Austria with a potential reach of ~558.000 people (58.000 to 95.000 in print).

Austria Innovativ 06-2021 issue

FELICE was featured in the 06-2021 issue of *Austria Innovativ* as one of the best research projects of the Universities of Applied Sciences in Austria. It has a circulation of 12,500 units.

Platinum Magazine March 2022 issue

FELICE was featured in an article published in *Platinum*, a journal on business, research and innovation made in Italy by the Sole 24 Ore group. The article describes the research activities of DIEM in the field of Artificial Intelligence.

Discover Logistics Magazine (Issue #22)

The *discover LOGISTICS* magazine is the in-house and customer magazine of Fraunhofer IML. It informs about current events and results of applied research and development work in the field of logistics. FELICE was featured in an article in this magazine, introducing the research aspects and demonstrator setup at Fraunhofer IML and the project's relation to logistics.

ERCIM news issue 123, January 2023

ERCIM News is the magazine of ERCIM, the European Research Consortium for Informatics and Mathematics. It reports on the joint actions of the ERCIM partners and aims to reflect the contribution made by ERCIM to the European Community in Information Technology. Through short articles and news items, it provides a forum for the exchange of information between the institutes and also with the wider scientific community. Each issue focuses on a special theme identified by the editorial board and has a circulation of 6,000 printed copies and more than 8,200 epub subscribers. The results on human posture monitoring as well as speech command and gesture recognition tasks obtained in the project have been described and discussed in two separate articles.

4.3.3 Exhibitions

Fraunhofer has set up a robotic demonstrator facilitating multiple research aspects covered within the FELICE project, including planning, manipulation, and reinforcement learning tasks.

This demonstrator has been part of at least 10 internal exhibitions on site at Fraunhofer Institute in Dortmund, Germany - showcasing the potential of machine learning research within the robotics domain to potential industrial customers.

Figure 5 - Demonstrator at Fraunhofer IML

4.3.4 Fliers and Handouts

A project Flyer was created in M10, describing the project's main developments, goals, and expected benefits. The aim of the flier is on the one hand to provide an overview of the general content and goals of the project and on the other hand to direct people to the FELICE website or social media channels. To make these offers easily accessible, a link tree page was set up for the FELICE communication channels: https://linktr.ee/FELICE_H2020, from which those can be easily accessed with a single click. A link to the FELICE linktree page was embedded on the flier using a QR code.

Partners reviewed the content of the flier, after which printable.pdf version was distributed in the consortium to be used at conferences, workshops, or other events. The flier was also made available to the public via the FELICE website:

https://www.felice-project.eu/resources/dissemination-material/.

Figure 6 - Front and backside of the FELICE trifold project flier

Furthermore, a targeted flier for Makita was created to address the collateral impact of FELICE on the industrial tool sector for vision and robotic-related activities such as object detection and grasping as seen in Figure 7.

Figure 7 - Excerpt from the second FELICE flier

4.3.5 Social Media activities

Social media is used to disseminate FELICE material to a wide audience and communicate the project's goals, results, and activities. Using Twitter and LinkedIn channels, FELICE can engage directly with users and promote their content and other modes of communication e.g. the FELICE website.

FELICE consortium members will use their own channels to promote FELICE content and report on their activities, as outlined in D9.2 while providing contributions to TUD managing the FELICE social media accounts.

To generate interest in the project the slogan '*next generation assembly processes*' was created to be used in social media headers and channel descriptions. Until M25 the FELICE Twitter has tweeted 103 times and aggregated over 620 followers, managing continuous growth.

Twitter follower numbers exceed the dKPIs defined for the project by 50% making the FELICE Twitter channel rank in second place among the thirteen projects funded under its topic. Likewise, 132 people follow the FELICE LinkedIn page, which is used to crosspost Twitter content, while striking a more professional tone.

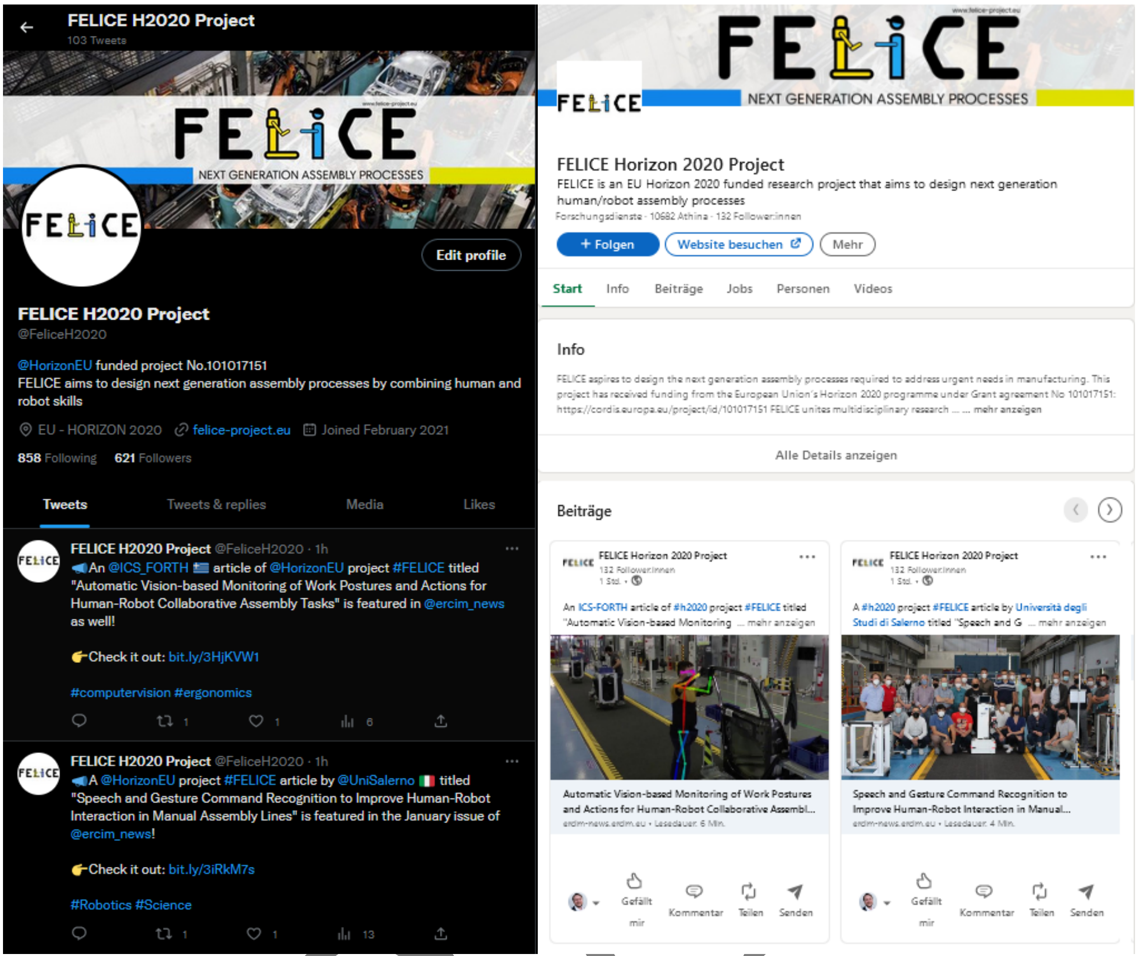

Figure 8 - FELICE Twitter (left) and LinkedIn (right) pages

4.3.6 Website activities

The FELICE project website was created in the first month of the project, and its structure and design were reported in D9.1 in M2. The website is the main communication channel to provide material, information, and updates to the public, scientific community, industry, and other stakeholders and target groups defined in D9.2. The website was created and is hosted by UNISA while TUD is managing the content.

FELICE News e.g. the progress on the project as well as FELICE events, workshops, or conferences are posted as news. Until M25 of the project 13 website news have been posted. Dissemination material, like the project flier, public deliverables, and newsletters can be downloaded from the website.
In 2021 (M1 to M12) website pages were accessed ~3900 times while in M13 to M25 ~4800 page accesses were registered (+23%).

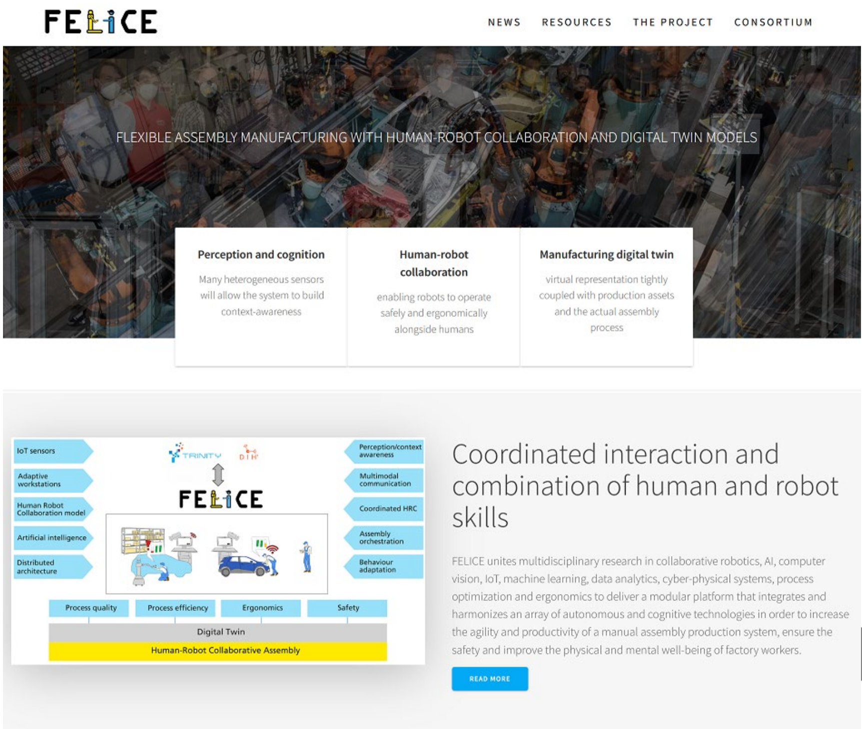

Figure 9 - Main page of the FELICE website

4.3.7 Brokerage events, Trade fairs and other events

Table 17 gives an overview of brokerage events, trade fairs, or other events FELICE partners participated in to disseminate the project:

Table 17 – Brokerage events, trade fairs or other events FELICE partners participated in

Type of event	Name of Event	Venue	Participants
Other	aMAZEing Robot Challenge	Technical University of Crete, Chania, Crete	ICCS
Other	Invited talk on the topic “AI-Enabled Human-Robot Interaction In Industrial Scenarios”,Lecture Series Trust in Robots, TU Vienna (online), 21st January, 2021	Online	PRO
Other	6th FITCE Technology Forum	The Great Arsenali, Chania	FORTH

Other	3rd edition of the GMAR Industry talks	Online	PRO
Trade Fair	LogiMAT 2022	Stuttgart, Germany	IML
Trade fair at conference	European Robotics Forum 2022	Rotterdam, Netherlands	IML

aMAZEing Robot Challenge

FELICE Project coordinator M. Pateraki (ICCS) presented the FELICE project at the aMAZEing Robot Challenge at the Technical University of Crete in Chania, Crete.

GMAR industry talks

On February 21st 2022, PRO presented the FELICE project at the 3rd regional and transregional Industry Talks GMAR. The presentations spanned various topics related to Industry 4.0 & the field of Robotics. PRO gave a brief overview of the FELICE use cases and expected results.

FITCE Technology Forum

On June 3rd, 2022, M. Lourakis (FORTH) gave a talk titled *Computer vision for safety monitoring and human-robot collaboration in the workplace* in a session themed *Convergence of Telecoms and IT towards the Evolution of Advanced Services* at the 6th FITCE Technology Forum in Chania, Greece.

LogiMAT 2022

Fraunhofer has presented a robotic demonstrator facilitating multiple research aspects covered within the FELICE project, including planning, manipulation, and reinforcement learning tasks.

This demonstrator has been presented at LogiMAT - the international trade show for intralogistics solutions and process management - to showcase the potential of machine learning research within the robotics domain to potential industrial customers.

4.3.8 FELICE Videos

Two videos showcasing the development of the two main hardware components of the FELICE system, namely the adaptive workstation (TUD) and the mobile cobot (ACC), have been published in the first phase of the project. Additional video material of the phase I system modules have been captured by partners during the phase I integration periods to be used in the future, while more activities are planned for the phase II integration period from Q2 2023 onwards and at the end of the project (M45). Additionally, a voice-over of an introductory presentation of the FELICE project (ICCS & FORTH) has been made available to the public.

FELICE videos are distributed on a dedicated YouTube channel, which is managed by TUD. Video thumbnails are created by TUD as well, to create a uniform look for videos appearing in the video feed. To this date, three videos have been uploaded to the channel as seen in figure 10, which have been viewed ~350 times.

Figure 10 - Video feed of the FELICE project YouTube presence

A roadmap has been created by TUD, outlining the five-step video creation process in FELICE with the requirement that partners can engage in the creation of videos without specialized tools or software.

The roadmap includes:

- *Guidelines:* videos should be in 16:9 format and at least in 1080p (1920 x 1080 pixels) resolution and text should use Quicksand font if supported by the user's software.
- *Recommendations:* for free natural sounding text-to-speech software to create voice overs in the absence of professional speakers or sources for royalty-free music that may be added to videos
- *Instructions for templates:* for video title cards and end cards (figure 11) that have been distributed to aid FELICE partners in the creation of videos and to ensure consistency and compliance with EU guidelines for the dissemination of material

Figure 11 - Title card and end card for FELICE videos, which ensure compliance to EU guidelines

4.3.9 FELICE Newsletters

Since the beginning of the project, four FELICE newsletters have been published on the FELICE website, while being promoted using the social media channels:

- FELICE Newsletter December 2021
- FELICE Newsletter April 2022
- FELICE Newsletter June 2022
- FELICE Newsletter September 2022

FELICE newsletters feature current activities of the consortium as well as progress reports. The last pages are reserved for news on conferences, workshops, and events as well as publications and public deliverables. In each newsletter, specific technologies are highlighted, e.g. the adaptive workstation, FELICE robot (see figure 12), or intelligent execution system.

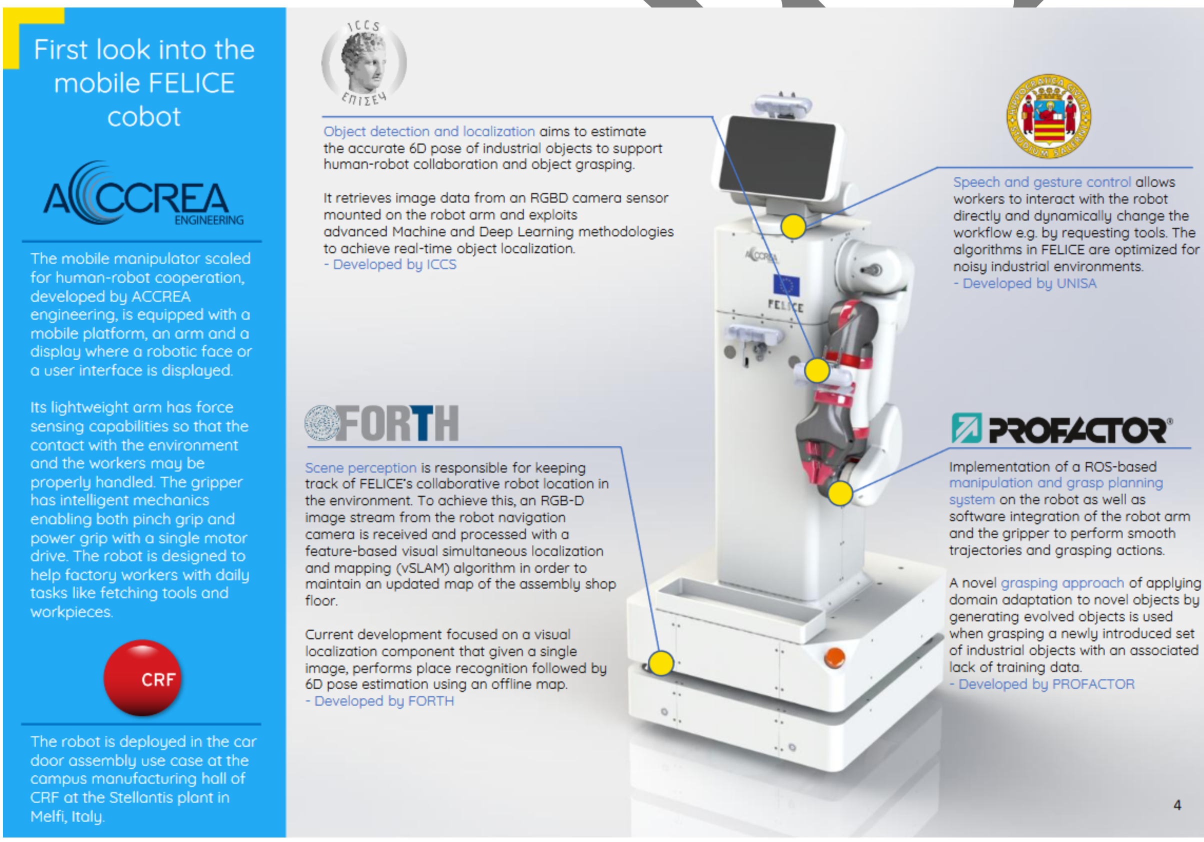

Figure 12 - example page from newsletter 4 (September 2022) featuring the robot and technologies deployed by other partners on the robot hardware

4.3.10 Joint activities with other EU projects

Table 18 lists joint activities or events between the FELICE consortium and other EU-funded projects:

Table 18 – Joint activities between FELICE and other EU projects

Name of Project	Topic	Partner
TRINITY	Participation in TRINITY Deep Dive event	ICCS
Robotics4EU & other ICT-46-2020 projects	ICT-46-2020 EU projects meeting initialised by Robotics4EU	PRO
Workshops with other EU projects (COLLABORATE)	Workshop conducted at the European Robotics Forum 2021	PRO, ICCS
	Four workshops conducted at the European Robotics Forum 2022	PRO, ICCS
DIH^2	Joint Demonstrator at European Robotics Forum in 2022	IML
IMPROVE Interreg Europe	Presentation of FELICE project overview to Interreg AT-HU project "IMPROVE!" Consortium at March 2021	PRO

FELICE coordinator M. Pateraki attended a Deep Dive networking event of the EU-funded TRINITY project. Other Research projects and DIHs at the event included ADMA TranS4MErs, Drape Bot, and smart^3.

Furthermore, FELICE is in contact with H2020 funded Digital Innovation Hub DIH^2. Fraunhofer presented a joint FELICE/DIH^2 demonstrator at the European Robotics Forum 2022. Details on the networking between FELICE and DIHs are described in section 4.6 of this document.

Other collaborations included the creation of five workshops at the European Robotics Forum 2021 and 2022 with the EU project COLLABORATE, as well as attending a networking event organized by the H2020 project Robotics4EU together with other ICT-46-2020 projects next to FELICE. PRO also presented the FELICE project to the EU-funded IMPROVE Interreg Europe project.

4.4 Scientific publications

Scientific publications published by FELICE partners until M25 are summarized in Table 19:

Table 19 – Published scientific publications by FELICE

Partner	Authors	Type	Date	Title	DOI	Published in
FORTH	M. Lourakis, G. Terzakis	Conference publication	May 2021	A Globally Optimal Method for the PnP Problem with MRP Rotation Parameterization	10.1109/ICPR48806.2021.9412405	25th International Conference on Pattern Recognition (ICPR)
PRO	S. C. Akkaladevi, M. Propst, M. Hofmann, L. Hiesmair, M. Ikeda, N. C. Chitturi, A. Pichler	Book chapter	June 2021	Programming-Free Approaches for Human–Robot Collaboration in Assembly Tasks	https://doi.org/10.1007/978-3-030-69178-3_12	Advanced Human-Robot Collaboration in Manufacturing. Springer, Cham.
IML IfADo	J. Jost, T. Kirks, S. Chapman, G. Rinkenauer	Conference publication	Sep. 2021	Keep Distance with a Smile - User Characteristics in Human-Robot Collaboration	10.1109/ETFA45728.2021.9613601	26th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA)
IML	M. Frychel, S. Hoose, J. Jost, J. Gerken, T. Kirks	Conference poster	July 2022	A Concept for Three-Dimensional Proxemics in Human-Robot Collaboration	-	13th International Conference on Applied Human Factors and Ergonomics
PRO	A. Pratheepkumar , M. Hofmann , M. Ikeda, A. Pichler	Conference publication	Oct. 2022	Domain Adaptation With Evolved Target Objects for AI Driven Grasping	10.1109/ETFA52439.2022.9921470.	2022 IEEE 27th International Conference on Emerging Technologies and Factory Automation (ETFA)
IML	J. Eßer, N. Bach, C. Jestel, O. Urbann, S. Kerner	Journal publication	Jan. 2022	Guided Reinforcement Learning – A Review and Evaluation for Efficient and Effective Real-World Robotics	https://doi.org/10.1109/MRA.2022.3207664	IEEE Robotics and Automation Magazine (IEEE RA-M)
FORTH/ICCS	K. Papoutsakis G. Papadopoulos, M. Maniadakis, T. Papadopoulos, M. Lourakis, M. Pateraki, I. Varlamis	Journal publication	Mar. 2022	Detection of Physical Strain and Fatigue in Industrial Environments Using Visual and Non-Visual Low-Cost Sensors	10.3390/technologies10020042	MDPI Technologies 2022
ICCS	M. Dimolianis, D. Kalogeras, N. Kostopoulos, V. Maglaris	Conference publication	Nov. 2022	DDoS Attack Detection via Privacy-aware Federated Learning and Collaborative Mitigation in Multi-domain Cyber Infrastructures"		IEEE Cloudnet22
UNISA	S. Bini, A. Greco, A. Saggese, M. Vento	Conference publication	Sep. 2022	Benchmarking deep neural networks for gesture recognition on embedded devices	10.1109/RO-MAN53752.2022.9900705	IEEE RO-MAN 2022

Table 20 lists additional publications in active preparation that have been accepted for conferences.

Table 20 – Accepted scientific publications by FELICE

Partner	Authors	Type	Date	Title	Published in
FHOOE	F. Holzinger, A. Beham	Conference publication	tbd	Multi-criteria optimization of workflow-based assembly tasks in manufacturing	18th International Conference on Computer Aided Systems Theory - EUROCAST 2022
ICCS FORTH	M. Pateraki, P. Sapoutzoglou, M. Lourakis	Conference publication	Jan. 2023	Crane Spreader Pose Estimation from a Single View	18th International Conference on Computer Vision Theory and Applications - VISAPP 2023
TUD	M. Pätzold	Conference publication	Mar. 2023	Adaptive positioning of large work objects to reduce physical load in industrial assembly	69th GfA spring conference

To ensure transparency for the publication of results and compliance with EU regulations and the consortium agreement, a roadmap has been prepared by TUD in coordination with the other partners. The consortium has agreed to follow a publication process that includes informing the consortium about the planned publication via Email in a timely manner at least 30 days before submission.

The notification shall include sufficient information about the results that will be published which is especially important if those results were generated in a combined effort with other partners. Sufficient information includes a short description, authors, and data used as most likely no draft is available at the moment of disclosure. Partners may object to the dissemination of results 15 days after being notified if they feel that their interests are harmed as specified in section 29.1. of the GA or CA 8.4.2.

The roadmap also outlined in which situation an objection is justified. Furthermore, partners shall provide information about their publication in a document managed by TUD, after their disclosure. Partners may update the status (Accepted, Submitted, Published) of their publication during the publication process and provide additional information when ready. As expected, no objections have been raised by partners during the publication of results until M25.

After publication, consortium partners inform TUD to disseminate the results using the FELICE channels and inclusion in the ZENODO repository (Figure 13).

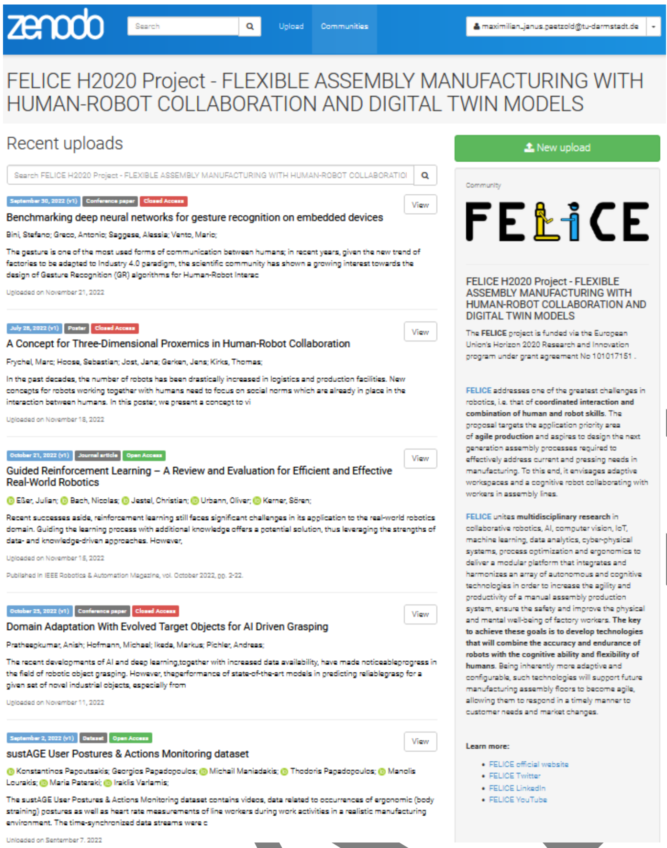

Figure 13: The FELICE community on ZENODO

4.5 Standardization activities

Disseminating and communicating FELICE results to standardization bodies will have increased importance in phase II of the project, as capabilities and opportunities of the FELICE system and its assets become more clear.

The goals of the FELICE project standardization activities are to:

- identify and discuss existing standards for inclusion in the development of the FELICE system
- explore possibilities to contribute to existing standards
- incorporate FELICE results into standards currently under development

Compliance with standards is of utmost importance, as it ensures a systematic and internationally agreed-upon approach to solving the challenges to be addressed by the FELICE system, ensuring compatibility with current design methods and removing barriers for market exploitation. Compliance with standards has to be ensured to operate the FELICE system safely and for the possibility to acquire the certification needed for its application. To ensure safety in human-robot collaborative assembly, the FELICE consortium agreed to ensure compliance to at least four standards in safety, security, or incident management for robot and adaptive workstation requirements and operation as well as robot task execution as part of its evaluation objectives.

Incorporating FELICE results in Standardization will maximize the impact of the FELICE project and accelerate its market adoption. Taking part in standardization will also

disseminate the project's results to professionals and will provide access and visibility of relevant data after the completion of the project.
In phase I of the project, relevant standards and standardization bodies or Technical Committees in the fields of ergonomics and human factors, as well as robotics have been identified. Normative requirements from standardization to be included in the FELICE system development process have been outlined in deliverable D3.1.
TUD monitors the status of Standards currently in development in the field of robotics as seen in Table 21. Including the ISO International harmonized stage codes to refer to their development status.

Table 21: Standardization in the field of Robotics under development, including the current stage of development.

Standards for Robotics under development		Stage
ISO/AWI PAS 5672	Robotics — Collaborative applications — Test methods for measuring forces and pressures in quasi-static and transient contacts between robots and human	20.00
ISO/FDIS 10218-1	Robotics — Safety requirements — Part 1: Industrial robots	50.00
ISO/FDIS 10218-2	Robotics — Safety requirements — Part 2: Industrial robot systems, robot applications and robot cells	50.00
ISO/AWI 13482	Robotics — Safety requirements for service robots	20.00
ISO/CD 18646-2	Robotics — Performance criteria and related test methods for service robots — Part 2: Navigation	30.00
ISO/CD 22166-201	Robotics — Modularity for service robots — Part 201: Common information model for modules	30.00
ISO/AWI 22166-202	Robotics — Modularity for service robots — Part 202: Information model for software modules	20.00
ISO/DIS 31101	Robotics — Application services provided by service robots — Safety management systems requirements	40.20

To identify which standardization bodies should be targeted by FELICE dissemination activities, a consortium internal Standardization Workshop is planned. The goals of the workshop will be to find common ground between FELICE output and assets and standardization activities. Table 22 outlines relevant standardization bodies for the dissemination of results.

Table 22: Standardization bodies and Technical Committees in robotics, ergonomics, safety, and risk management

Relevant body	Short Description
ISO/TC 299 https://committee.iso.org/home/tc299	**Technical Committee 299:** Objective: Standardization in the field of robotics, excluding toys and military applications
ISO/TC 159 https://www.iso.org/committee/53348.html	**Technical Committee 159:** Objective: Standardization in the fields of general ergonomics principles, anthropometry and biomechanics, ergonomics of human system interaction and ergonomics of the physical environments…
ISO/TC 262 https://www.iso.org/committee/629121.html	**Technical Committee 262 - Working Group 9:** Objective: Standardization in the field of risk management
ISO/TC 199 https://www.iso.org/committee/54604.html	**Technical Committee 199:** Objective: Standardization of basic concepts and general principles for the **safety of machinery** incorporating terminology, methodology, guards and safety devices within the framework of ISO / IEC Guide 51

4.6 Networking with DIHs

Liaising with the Digital Innovation Hubs DIH^2 and Trinity has been carried out. In the process, the deliverables of the two DIHs were screened and evaluated. The project coordinators were contacted and initial meetings were set up to identify synergies between the projects. The following Table depicts the concrete measures that have been performed.

Table 23: Events between FELICE and Digital Innovation Hubs

Type of event	DIH	Date	Participants
Module Screening	DIH^2	18.05.2021	IML
Initial Meeting	DIH^2	12.11.2021	IML
Extended Meeting on modules	DIH^2	19.05.2022	FIWARE.ORG, IML

Content Alignment	DIH²	23.01.2022	IML
Trade Fare Demonstrator at ERF 2022	DIH²	28.06.2022 – 30.06.2022	IML
Module Screening	TRINITY	06.07.2023	IML
Initial Meeting	TRINITY	27.07.2022	FHG IWU, IML
Deep Dive	TRINITY	06.12.2022	FHG IWU, ICCS, et al.
Corporate Module Discussion	TRINITY	01.02.2023 (Planned)	FHG IWU, ICCS, IML, FORTH, FHOOE

For DIH² the following modules were identified to be of potential use in FELICE:

- DIH Marketplace
- DIH Digital Platform
- LER Procedures (Local Evangelists in Robotics)
- Robots and Digitization - Needs for Standardisation
- PERD (Plan for the Exploitation and Dissemination of Results)

For TRINITY the following modules were identified to be of potential use in FELICE but we decided against those for the given reasons:

Safe Human Detection in a Collaborative Work Cell:

It is a useful module, for its purpose and the possibility of integrating into FELICE. Trinity is using off-the-shelf "safety certified" hardware, which has both positive and negative consequences.

Positive - it is all safety certified, in most cases by some kind of TÜV or a similar body. So if we use them, we can rely on their certification. If we have to perform our own safety functions, we get all the safety-related data (like PL/SIL levels, MTBF - mean time between failures, failure rates), so it makes it easier to use.

However, since they are all off-the-shelf products we can simply buy them and use them if we need them, and we do not need the institution (Centria University of Applied Sciences) to implement a similar module on our own.

From the description on the website, it is difficult to figure out what is the added value of the module, that would go beyond the off-the-shelf certified components. Certainly, the added value would be the art of combining those components together and configuring them into a working system. It depends on the business model of Centria University of Applied Sciences, and the price of this module. If it is offered for free, or at a reasonable cost I would implement it. Otherwise, we decide to implement it on our own.

ROS Peripheral Interface

The idea is that the TRINITY-provided module will do all requested initializations to the unit at boot time and then it will (i) keep track of the dynamic state of the unit at run time, which is reported to ROS, or (ii) provide an interface for sending commands to the unit, thereby changing its state on demand.

Although it sounds interesting, in the case of FELICE the module is not that useful because we have already implemented the interface between all interacting components either by linking them directly to the ROS environment or through FIWARE which has been interfaced with ROS.

Projection-based Interaction Interface for HRC

This module monitors components of a projection-based AR interface. It seems geared to simple UI choices and assumes a static workstation - hardware installations on the ceiling. This will be problematic for CRF use-case.

Robot Trajectory Generation Based on Digital Design Content

The Module uses an AR/VR setup to model the environment with required objects and settings as well as the robot in a simulation environment to train and thereby generate robot trajectories. Since AR/VR is not in the scope of FELICE we decided against the implementation of this module.

Task Orchestration

Task orchestration is about workflow modeling, which uses Node-RED components. It interconnects with an ERP and specific brands of Autonomous Mobile Robots, AGV and OPC. But there is no integration with FIWARE, which is necessary in our use case.

Digital Twin and Plan Visualise Control

This module uses a Digital Twin of the robot only - the human operator is not considered. Integration with FIWARE is not given. In conclusion, there is no possibility to model & simulate the entire assembly line with fast time simulation.

Digital Shop Floor Smart Production

This module handles a UI for a manufacturing execution system. Only limited details are provided, and the module's applicability/generality is unclear.

Object Detection

The object detection in this deliverable requires depth information for the object position, which is not applicable for certain objects with challenging appearance (reflectivity, shininess, darkness and transparency of surfaces) and for camera-to-object distances shorter than the minimum depth distance of the used RGBD sensor.

Easy Programming Module

Very similar to the XROB programming framework. We are already using the XROB framework available at TRL 5 Workflow modeling.

5 Further steps for practical application [SECTION 4]

In this section, further steps undertaken to foster the innovation and the application of the project results are summarized and described. The most important actions are the following:

- Workshop on the exploitation of results
- Drafting the Revenue sharing model
- Identification of additional innovations in accordance with the innovation plan, which should be transformed into exploitable assets

Workshop on the exploitation of results

The application of the results is a complex process that needs a series of elements to be effective.

In this view, to raise the effectiveness of the exploitation phase, a specific exploitation workshop was developed and held on July 22nd during the integration meeting in Melfi, with the participation of the whole partnership.

The promoters of the workshop were TUD, CRF, IML, and ICCS in the scope of the WP9 - Dissemination, exploitation and long-term sustainability.

The objectives of the workshop were:

- Exploitation plan discussion and confirmation
- Discussion about the Revenue sharing model (RSM)
- First exploitation of the outcomes in the integration phase carried out in a near real production environment
- Revision of expected innovations list of the FELICE system

The workshop allowed us to discuss the four most important steps toward a consistent exploitation phase. The first objective was concretized in the above-mentioned exploitation plan to which an increase of the TRL of the project results was proposed. Some details are reported below. The second objective of the RSM discussion led to the request for the involvement of the legal departments of the partners before the final approval.

The third objective led to the formulation of a proposal for innovation within Stellantis (CRF), based on the experience of the integration phase. More specifically, a sanding operation was considered.

The last point was concerning the discussion of the revised list of innovative items. The list was shared and tuned during the workshop with the agreement of the partnership.

The plan for going on the market through a credible path and at the appropriate timing is depending on the commercial and industrial maturity of project results.

One of the most important aspects is concerning the level of maturity of a specific innovation or technology.

The higher the maturity, the more exploitable the results. Thus, one possibility for further increasing the TRL of FELICE technologies would be a followup IA project targeting a TRL 9, as shown in the following figure.

DESCRIPTION	TRL
Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)	9
System complete and qualified	8
System prototype demonstration in operational environment	7
Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)	6
Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)	5
Technology validated in lab	4
Experimental proof of concept	3
Technology concept formulated	2
Basic principles observed	1

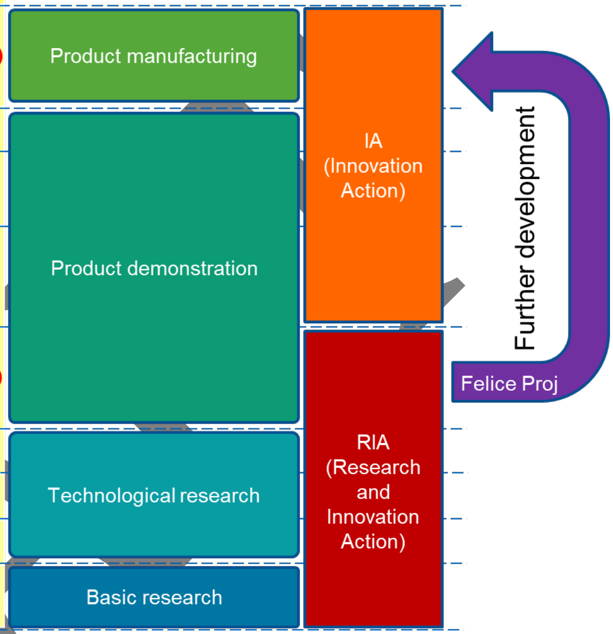

Figure 14 - TRL classification of the FELICE project and proposal to increase TRL

On the basis of these considerations, we started to investigate the possible calls in the field of AI for a project proposal.

Revenue sharing model

As mentioned also in the GA, a revenue sharing model can facilitate the exploitation of the result. During the second year of the project a revenue sharing model was drafted and here are reported synthetically the relevant elements of the model.

<u>Background / Results Direct Use:</u>

- In case of direct use of products or services, a compensation fee of 2-10% relating to the net selling price of products or services shall be agreed.
- If there is more than one "providing beneficiary", that holds the background and results needed to be requested by the "exploiting beneficiary", each "providing beneficiary" shall get X% of this compensation fee. This X% can be calculated considering the "providing beneficiary" project costs contribution.

<u>Background / Results Licensing (Indirect Use):</u>

- In the case of licensing the "licensor beneficiary" shall at first receive a bonus of 20%.
- From the remaining amount (80%), if there is more than one "providing beneficiary", each "providing beneficiary" (including the "licensor beneficiary") shall get X%. This X% can be calculated considering the "providing beneficiary" project costs contribution.

The full framework of the model is available in a separate document, which is currently being evaluated and revised by the consortium's legal departments. The description above reports only the core elements with respect to the economic aspects.

Extra innovations

Following the innovation process, some new solutions have been identified that can increase the portfolio of assets that can be exploited and even used stand-alone at the end of the project.

These new solutions, not defined at the beginning of the project, become concrete thanks to the development activities and the definition of the needs of the case studies.

They are reported in this section because they represent one of the useful steps to increase the exploitability of the project results. In fact, the improvement is due to the numerical increase of the available solutions for the possibility of application to other sectors and case studies.

The following table shows the new results that are ready to become exploitable assets.

Table 24 - New potentially exploitable assets

nr	WP	Partner	New potential Asset	Asset description	Time
10	WP5	PRO	A grasping solution	Novel grasping solution for a given set of novel industrial objects; applicability in developing grasping solution for product variants	1-2 year
11	WP5	FORTH/PRO	Tool manipulation (Handover)	Initiating fluent physical collaboration with humans by taking ergonomic aspects into consideration	1-2 years
12	WP5	PRO	(online) Robot Execution Parameters	Dealing with dynamic situations (locally) by re-parametrizing robotic tasks	1 year
13	WP7	FRAUNHOFER	Resilient assembly line operation	Intelligent Recovery Policies for Robust Task Execution in Failure Cases and Handling Complex Situations	1 -2 years

As part of the innovation process, some verification and detailed analysis will be carried out for the inclusion of these additional items in the exploitable assets list.

6 Conclusions

This document provides the vision of the exploitability of the project outcomes and related technologies. The document also includes an evaluation of the strengths and critical aspects pertaining to these assets. Moreover, there is also some information about how the assets can be used and exploited to increase the potential impact of the project.

The document provides useful guidelines to identify a common framework able to guide the project to implement systematic innovation, facilitate exploitation and benchmarking.

Overall, the project activities have produced several innovations which can maximize the exploitation opportunities for individual partners and the sustainability of the FELICE system beyond the project duration.

Regarding exploitation, the partners outlined a common understanding of the possibilities of application both within the project and beyond the project and its use cases. In addition, the aspects of innovation were evaluated both in terms of tangible and intangible results (knowledge, skills, and technical inspiration).

The final objectives remain in line with those established in the proposal phase but have been expanded and detailed.
The scenario selected to test the FELICE system represents one of the most effective and realistic contexts, in which to exploit the knowledge developed in the project. This situation was shared by many of the technical contacts we had in recent months.

Therefore, the objective of designing, developing, testing and offering a solid solution is fully achieved in methodological terms, it is understood that the final result will be the one that will give validity to the developed solution.

The research related to behavioral effects carried out within the project could make implementation easier, thus bringing even more value to the project results.

The FELICE system will overcome the major shortcomings of existing work assistive devices. Today's existing solutions do not meet customer expectations in terms of integrated performance (productivity, ergonomics, flexibility, and modularity).

The consortium also verified the reality of the business models and finalized the design and proposition of a robust business plan for the FELICE system, oriented towards potential commercialization.

Assuming the possible commercialization of the overall system, the partners have clearly identified three distinctive phases: Innovative conception, prototype development, and engineering of defined solutions. These phases are perfectly supported by the mix of skills incorporated in the Consortium.

The different characteristics of the system are also distinguished, and therefore the individual modules represent a further capitalization opportunity, in addition to the entire system.

Considering also the targeted TRL, all partners agree on the need to continue the development process of the FELICE system, selecting follow-up key activities (e.g., to obtain homologation and Certificate of Conformity according to European standards) and hoping to extend the collaboration with the Consortium Partners even beyond the duration of the project. Possibilities for further project financing and the detection of interested investors have already been recognized.

The analyses carried out revealed elements that threaten the success of the project both internally and externally. However, partners immediately responded with suggestions for mitigating actions, showing intent to strengthen collaboration and maintain a realistic view of required effort and achievable goals.

Successful exploitation and publicity could be achieved when the functional tests of the integrated system will be completed, and by highlighting its architecture together with the first operational results. Within these scenarios, stakeholders of additional automotive and non-automotive manufacturing use cases, could be encouraged to test FELICE cooperative technology.

This document also includes a detailed report on the dissemination, communication and standardization activities carried out in the first phase of the project, as well as the current status of the quantitative FELICE dissemination Key Performance Indicators (dKPIs). Overall, the project is being successfully promoted to a variety of different audiences. The FELICE consortium members have disseminated the project at conferences, conference special sessions and workshops, and engaged with the different stakeholders at trade fairs, academia and industry talks, and other events. This report also outlines the activities on the FELICE communication channels and the different media available to the public and target audiences and gives an overview of the scientific and non-scientific publications that have been published. These activities will support the exploitation goals of the FELICE project outlined above.

References

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