REMODEL - Robotic tEchnologies for the Manipulation of cOmplex DeformablE Linear objects

Deliverable 8.10 – Final exploitation plan

Version 2023-10-31

Project acronym: REMODEL
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Lead Beneficiary: TECNALIA
Authors: All partners
Dissemination level: Public
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1 Executive Summary

On M24 of the project, under D8.9 the intermediate version of REMODEL exploitation plan was documented. Throughout the next months of the project, project partners worked on the refinement and enhancement of their exploitation plans in parallel with the development of the exploitation results.

The following objectives for the exploitation of the project results have been set:

• The detailed definition of the project's Final Exploitable Results (ERs) has been enhanced and is presented in this deliverable.

• Following the formulated business strategy for the project, final business plans are presented.

• An updated plan for the commercialization of the project results has been developed using the ownership of the Intellectual Property Rights (IPR) of the ERs declaration.

2 Introduction

REMODEL exploitation plan focuses on the economic, technical, and social benefits foreseen by project consortium based on the developed technologies in the REMODEL project.

A key activity in WP8 was to analyze and update the potential of REMODEL results along project duration. During the last months, a deep analysis about the main contributors and interested partners in each of the Exploitable Results (ERs) have been performed. As a result of this, initial ERs have been modified and better declared to highlight the assets ownership and their exploitation channels. Later on, this document, final analysis on the ERs unique value proposition will be presented.

REMODEL addresses issues that are critical for the implementation of robotic systems able to manipulate wires, cables, and wiring harnesses. REMODEL outcomes are applicable to several industrial manufacturing activities that nowadays are manually executed, such as switchgear wiring, wiring harness manufacturing and assembly, manipulation of hoses for medical devices and many others.

Considering the exploitable results of REMODEL, it is evident that universities, RTDs and companies have different ways of modelling, declaring, structuring, and presenting their exploitation plans. This is also motivated by the different Technology Readiness Levels (TRLs) that are achieved for each of the project results. An update on the ER intermediate collection that was presented on M24 of the project has been made by the consortium, exploitation strategy and results have been improved and it is presented in this document.

3 Exploitable results

In preliminary version of D8.8 were defined 12 Exploitation Results (ERs), but it was decided to eliminate the ER2 since it was redundant with the ER9.

During the last months, the analysis of the main contributors and partners interested in each of the ERs has continued. As a result of this work, new ERs has been added (its corresponding background has been included in the annex to this document)

Complete ERs are now updated and summarized in the following table:

N	Previous ER	Updated ER	Nature	Main Exploiter	IPR partners
1	CAD platform for flexible robotics programming	CATIA application for flexible robotics programming	Software (tool)	TECNALIA	TECNALIA
2	Dual arm manipulation of deformable linear objects in Aeronautical Industry	ELIMINATED		TECNALIA	TECNALIA
3	Generation of robot planning from product CAD files for switchgear wiring	Generation of robot planning from product (3D) CAD files for switchgear wiring	Software (tool)	IEMA	IEMA UNIBO
4	Manipulation tools for deformable linear objects	Multi-sensorized modular and reconfigurable manipulation tools.	HW – gripper & SW – Software	Joint Agreement (UNIBO + UCLV	UNIBO UCLV
5	Dual arm robotic platform for switchgear wiring	Dual arm robotic platform for switchgear wiring	REMODEL PILOT	IEMA	IEMA UNIBO
6	Manipulator for Quality Checks in Extrusion Processes in biomedical industry	Manipulator for Quality Checks in Extrusion Processes in biomedical industry	REMODEL PILOT	ENKI	ENKI UNIBO UCLV
7	Dual arm robotic platform for Automotive Industry	Dual arm robotic platform for Automotive Industry	REMODEL PILOT	ELVEZ	TAU UNIBO ELVEZ UCLV

8	CAD Platform Interface to provide the system planner, the layout and product inputs	CAD Platform Interface to provide the system planner, the layout and product inputs	Software (tool)	UNIBO	TAU UNIBO ELVEZ IEMA ELIMCO UCLV
9	Integrated dual arm manipulation system for interconnection systems automatic manufacturing process.	Integrated dual arm manipulation system for interconnection systems automatic manufacturing process.	REMODEL PILOT	ELIMCO	ELIMCO TECNALIA
10	Automated robot / sensor calibration toolkit	Automated robot / sensor calibration toolkit	Software (tool)	TUM	TUM IEMA ELVEZ ELIMCO VWP
11	Bimanual manipulation system for wiring harness manipulation.	Bimanual manipulation system for wiring harness manipulation.	REMODEL PILOT	VWP	VWP PUT UNIBO TAU
12	Interactive perception module exploiting vision and touch	Interactive perception module exploiting vision and touch	Software (complete)	PUT	UNIBO UCLV TAU TUM PUT
13		NEW ER Streamlined User Interface for Enhanced ROS Interaction	Software (tool)	TAU	IEMA ELIMCO ELVEZ ENKI TAU UNIBO TECNALIA

					UCLV
14		NEW ER Dual arm robotic platform for autonomous switchgear connection checking	HW – Connection checking tools & Software	IEMA	UNIBO

REMODEL aspires to narrow the gap between research and industry by transferring that latest R&D results in robotics towards various industrial sectors. Each partner will pursue and execute different actions to maximize the benefit from the project outcomes beyond REMODEL duration.

The role of the REMODEL partners can be segmented into different roles according to their organization profile, that is:

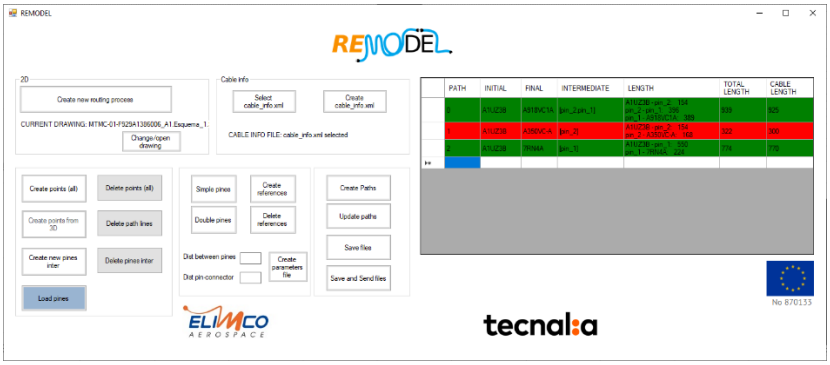
- End users which represent the market needs and provide the product requirements to be satisfied by the REMODEL project.
- Research and academic partners that may carry out new research activities built upon REMODEL results. This includes research institutes, laboratories attached to schools and universities.

Because of the reasons above, the exploitation paths followed by each partner will be developed according to their capabilities and convenience, as can be seen in the defined ERs.

4 Foreground charts

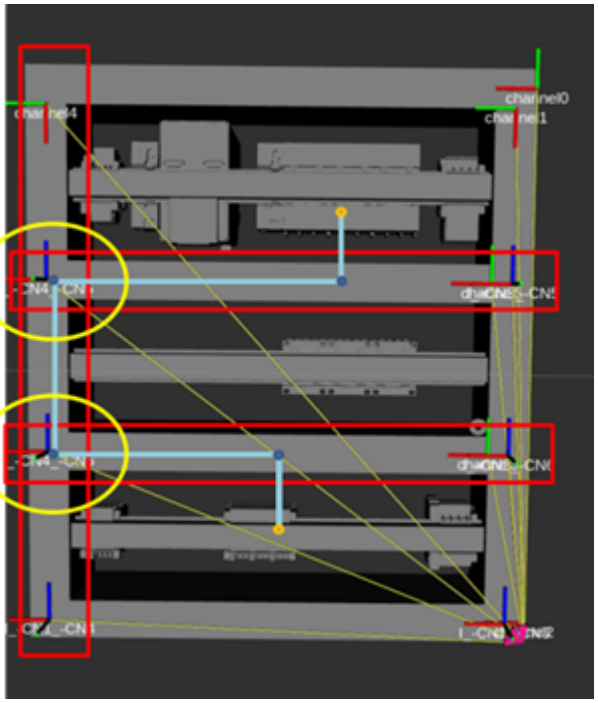
This section summarizes the foreground produced by each partner for each Exploitable Result. Each Foreground chart mentions the Background IP used to produce the Exploitable Result

4.1 ER1- CATIA application for flexible robotics programming

Foreground - CATIA application for flexible robotics programming - TECNALIA	
ID	ER1 - CATIA application for flexible robotics programming 
Owner(s)	TECNALIA
Nature	Software
Registration / Protection	Copyright, trade-secret
Description	Task or WP where the Foreground has been produced: WP3 – T3.1 CAD platform interface WP7 – T7.2 Wiring harness manufacturing.
	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: It is a development own by TECNALIA as explained in the background. During REMODEL, a restructuring of this tool has been carried out in order to obtain both 3D and 2D data from CAD models. Skills such as cable routing have been added. The user interface uses CAD models and the user can generate the programmed process easily from the developed application
	Background required to use the Foreground if Background needed, refer to background IDs.
Access conditions for research in the project / Limitations	Inside REMODEL, ELIMCO have been using the tool for commissioning of pilots. In order to use this tool is mandatory to own a CATIA licence.
Access conditions for use / Limitations	The CATIA programming tool is used internally at Tecnalia to develop robotic processes. Depending on the process, different skills are used and although they have many parameters in common, each process has its own restrictions and particularities. In the case of REMODEL, new specific functionalities of the process have had to be added. In order to use this tool is mandatory to own a CATIA license
Licensees in the project	Names of the licensees: 1st set to ELIMCO.

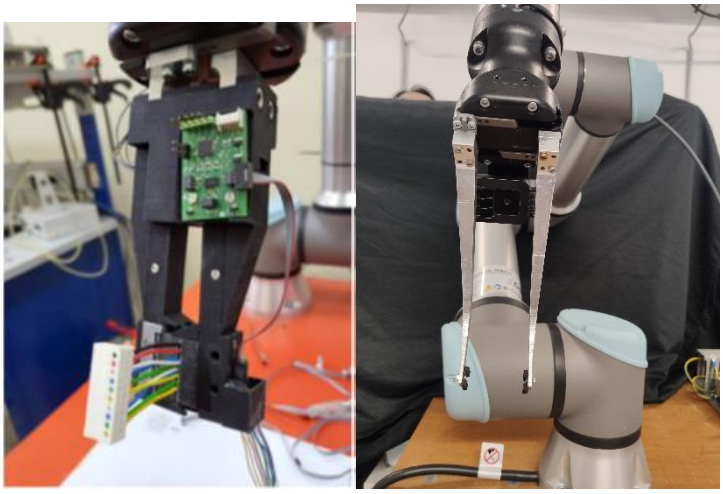
	Date of allocation: 2022
	Type of license: Restrictive
Licensees for use	Names of the licensees - 1st set
	Date of allocation: N.A.
	Type of license: N.A.
Dissemination	Dissemination undertaken for the Foreground outside licensing (publications, technology transfer, etc.). This ER1 will be shown as part of the use case of wiring harness manufacturing in the aeronautical sector.

4.2 ER3- Generation of robot planning from product (3D) CAD files for switchgear wiring (IEMA)

Foreground - Generation of robot planning from product (3D) CAD files for switchgear wiring – IEMA and UNIBO	
ID	ER3 - Generation of robot planning from product (3D) CAD files for switchgear wiring 
Owner(s)	UNIBO, IEMA
Nature	Software
Registration / Protection	Confidential Information
Description	Task or WP where the Foreground has been produced: WP3 – T3.1 CAD platform interface WP7 – T7.1 Switchgear cabling

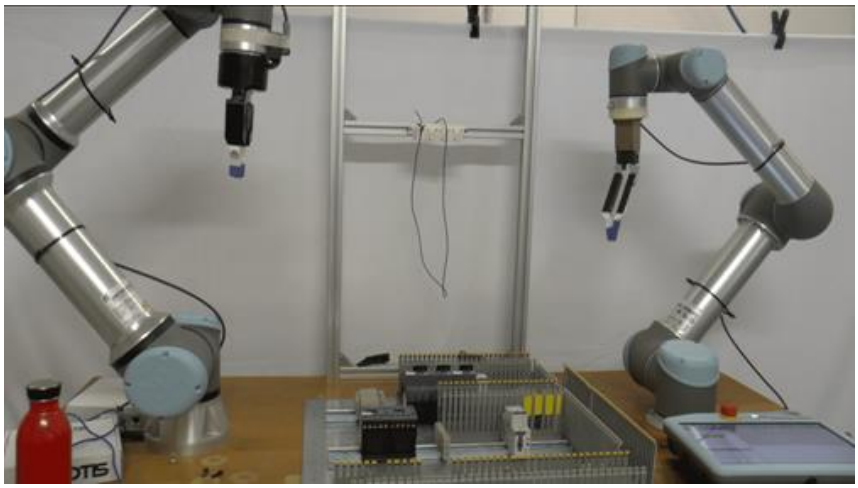
	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: IEMA provided the data for the creation of this software. The software developed by UNIBO takes as input the design files of the switchgear and generates all the software references for the robot and create the robot path according to the connection list of the considered switchgear and the allocation of cable collectors in the product design.
	Background required to use the Foreground if Background needed, refer to background IDs: UNIBO software package for switchgear CAD interface.
Access conditions for research in the project / Limitations	Inside REMODEL, IEMA will use the tool for commissioning of pilots.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: To be treated confidential, by the rules of project CA.
Licensees for use	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: It can be used for project activities. No available use for commercial purposes. Other research activities can be evaluated after the definition of a Non-Disclosure Agreement (NDA) document.
Dissemination	Dissemination undertaken for the Foreground outside licensing (publications, technology transfer, etc.). This ER3 will be shown as part of the use case of switchgear cabling (T7.1).

4.3 ER4 - Multi-sensorized modular and reconfigurable manipulation tools (UNIBO)

Foreground - Multi-sensorized modular and reconfigurable manipulation tools – UNIBO and UCLV	
ID	ER4 - Multi-sensorized modular and reconfigurable manipulation tools 

Owner(s)	UNIBO, UCLV
Nature	Hardware and software
Registration / Protection	Confidential Information
Description	Task or WP where the Foreground has been produced: WP6 – T6.2 Development and optimization of sensory system components WP6 – T6.3 Cable grasping and connection tools
	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: The platform integrates a specific version, with a 2x6 matrix of taxels, of the tactile sensors developed by UCLV and described in Background ER4 and ER5. Additionally, proximity sensors based on ToF technology are integrated in the fingertip and mechanical fingernails are integrated for wires manipulation. A 2D or 3D vision sensor has been integrated for scene reconstruction. Suitable algorithms have been integrated with the sensors to allow the estimation of both object and environment features. For example, tactile sensors can estimate wire shape and indicators related to contact forces, proximity sensors can estimate the presence of an object and the distance from the object itself and fingertip. The camera can be used to distinguish cables on the base of their color, 3D shape reconstruction, manipulation planning and cable motion tracking.
	Background required to use the Foreground if Background needed, refer to background IDs: Background ER5 - Multi-sensorized modular and reconfigurable manipulation tools
Access conditions for research in the project / Limitations	Inside REMODEL, end users will use the tools for commissioning of pilots.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: To be treated confidential, by the rules of project CA.
Licensees for use	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: It can be used for project activities. No available use for commercial purposes. Other research activities can be evaluated after the definition of a Non-Disclosure Agreement (NDA) document.
Dissemination	Dissemination undertaken for the Foreground with publications and technology transfer. This ER4 will be shown as part of the use case about switchgear cabling in T7.1 and wiring harness manufacturing in T7.2.

4.4 ER5- Dual arm robotic platform for switchgear wiring (IEMA)

Foreground - Dual arm robotic platform for switchgear wiring – IEMA and UNIBO	
ID	ER5- Dual arm robotic platform for switchgear wiring 
Owner(s)	UNIBO, IEMA
Nature	Hardware and software
Registration / Protection	TODO
Description	Task or WP where the Foreground has been produced: WP6 – T6.1 Development of the robotic platforms WP6 – T6.3 Cable grasping and connection tools WP7 – T7.1 Switchgear cabling
	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: IEMA provided the data and the constraints for the design of the robotic platform to be used for the switchgear cabling use case UNIBO selected the manipulators and designed the software tools for the coordinated control of the manipulators avoiding collisions, the cable routing procedure and the cable connection procedure in all the component typology by integrating proper tool (screwdriver and clip opener). IEMA and UNIBO design the cable warehouse to store the cable to be connected.
	Background required to use the Foreground if Background needed, refer to background IDs: Background ER5 - Dual arm robotic platform for switchgear wiring
Access conditions for research in the project / Limitations	Inside REMODEL, IEMA will use the tool for commissioning of pilots.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: To be treated confidential, by the rules of project CA.
Licensees for use	Names of the licensees: N.A.

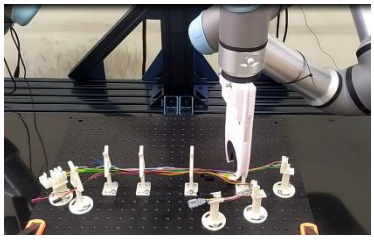
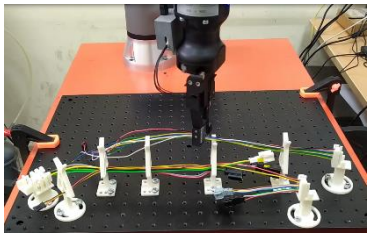
	Date of allocation: N.A.
	Type of licence: Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.
Dissemination	Dissemination undertaken for the Foreground outside licensing (publications, technology transfer, etc.). This ER5 will be shown as part of the use case of switchgear cabling.

4.5 ER6- Manipulator for Quality Checks in Extrusion Processes in biomedical industry (ENKI)

Foreground - Manipulator for Quality Checks in Extrusion Processes in biomedical industry – ENKI, UNIBO and UCLV	
ID	ER6- Manipulator for Quality Checks in Extrusion Processes in biomedical industry 
Owner(s)	UNIBO, UCLV, ENKI
Nature	Hardware and Software
Registration / Protection	Confidential Information
Description	Task or WP where the Foreground has been produced: WP6 – T6.1 Development of the robotic platforms WP6 – T6.2 Development and optimization of sensory system components WP6 – T6.3 Cable grasping and connection tools WP7 – T7.4 Hose manipulation use case
	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: The platform is constituted by tactile sensors developed by UCLV and described in Background ER6. Suitable algorithms have been integrated with the sensors to allow the interaction of grasped tubes with the environment, to check tube section with the execution of a pass/no pass task. A cutting machine has been developed by UNIBO to prepare the tube surface for visual inspection. Design of the robot procedure to grasp the sample, cut the sample and move it in front of the microscope has been implemented. Centering and focusing has been achieved by mechanical and/or software tools.
	Background required to use the Foreground if Background needed, refer to background IDs: Background ER6 - Manipulator for Quality Checks in Extrusion Processes in biomedical industry

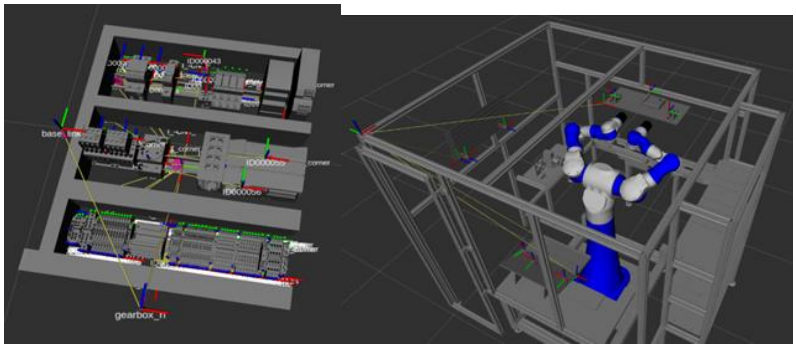
Access conditions for research in the project / Limitations	All partners involved in this ER6 can use the developed platforms, and single components.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: To be treated confidential, by the rules of project CA.
Licensees for use	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: It can be used for project activities. No available use for commercial purposes. Other research activities can be evaluated after the definition of a Non-Disclosure Agreement (NDA) document.
Dissemination	Dissemination undertaken for the Foreground with publications and technology transfer. This ER6 will be shown as part of the use case in hose manipulation in T7.4.

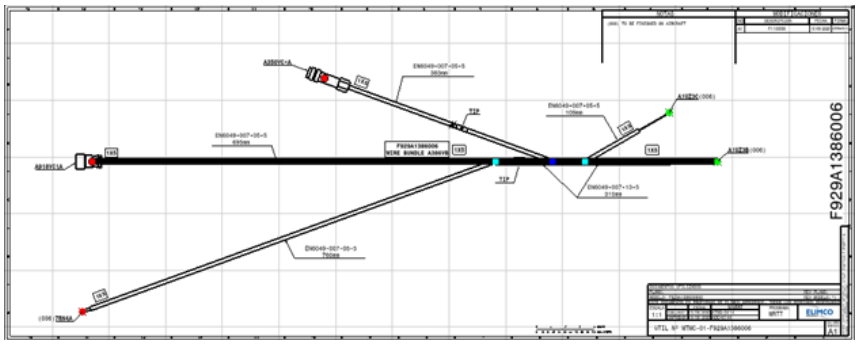
4.6 ER7- Dual arm robotic platform for Automotive Industry (ELVEZ)

Foreground - Dual arm robotic platform for Automotive Industry – TAU, UNIBO, UCLV and ELVEZ	
ID	ER7- Dual arm robotic platform for Automotive Industry  
Owner(s)	UNIBO, UCLV, TAU, ELVEZ
Nature	Hardware and Software
Registration / Protection	Confidential Information
Description	Task or WP where the Foreground has been produced: WP2 – User Interface WP6 – T6.2 Development and optimization of sensory system components WP6 – T6.3 Cable grasping and connection tools WP7 – T7.2 wiring harness manufacturing use case
	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: The platform exploits thinner tactile sensors suitably developed by UCLV with a matrix of 2x6 taxels based on the Background ER5. The solution initially planned for UC1 has been optimized for UC2 in automotive sector. The sensorized fingers integrate also proximity sensors. Suitable mechanical nails have been added for wires manipulation. Specific algorithms have been

	developed for routing. The whole integrated platform is used to execute the wiring harness task. UNIBO developed a suitable design of the clips to hold the cables and of the housing to hold the connectors during cable routing. UNIBO also developed a new taping gun compatible with the dimensions of the robotic setup both from the mechanical and from the control point of view.
	Background required to use the Foreground if Background needed, refer to background IDs: Background ER5 - Dual arm robotic platform for switchgear wiring
Access conditions for research in the project / Limitations	All partners involved in this ER7 have access to the developed components and algorithms.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: To be treated confidential, by the rules of project CA.
Licensees for use	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: It can be used for project activities. No available use for commercial purposes. Other research activities can be evaluated after the definition of a Non-Disclosure Agreement (NDA) document.
Dissemination	Dissemination undertaken for the Foreground with publications and technology transfer. This ER6 will be shown as part of the use case in wiring harness manufacturing for the automotive sector in T7.2.

4.7 ER8- CAD Platform Interface to provide the system planner, the layout and product inputs (UNIBO)

Foreground - CAD Platform Interface to provide the system planner, the layout and product inputs – TAU, UNIBO, UCLV, ELVEZ, IEMA and ELIMCO	
ID	ER8 - CAD Platform Interface to provide the system planner, the layout and product inputs 

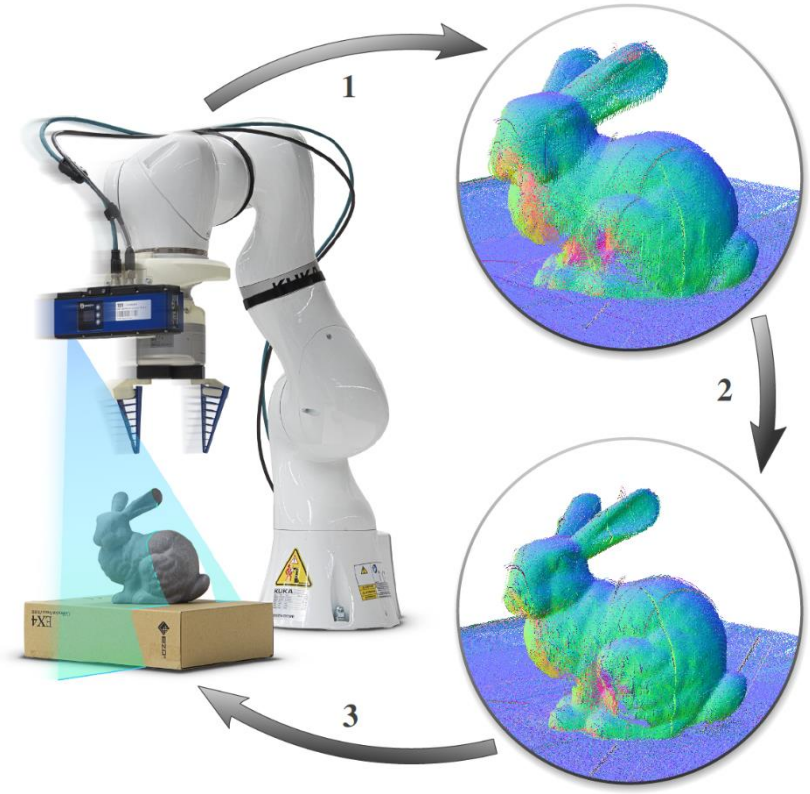
	
Owner(s)	UNIBO, TAU, UCLV, TECNALIA, ELVEZ, IEMA, ELIMCO
Nature	Software
Registration / Protection	Confidential Information
Description	Task or WP where the Foreground has been produced: WP3 - T3.1 CAD platform interface WP7 - T7.1 Switchgear cabling use case WP7 - T7.2 Wiring harness manufacturing use case
	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: ELVEZ, IEMA, ELIMCO provided the data for their respective use cases to generate the database for the software. UNIBO, UCLV, TAU and TECNALIA designed the software to extract from the product design all the reference points needed for the manufacturing.
	Background required to use the Foreground if Background needed, refer to background IDs: UNIBO software package for switchgear CAD interface.
Access conditions for research in the project / Limitations	All partners involved in this ER8 have access to the developed components and algorithms.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: To be treated confidential, by the rules of project CA.
Licensees for use	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: It can be used for project activities. No available use for commercial purposes. Other research activities can be evaluated after the definition of a Non-Disclosure Agreement (NDA) document.
Dissemination	Dissemination undertaken for the Foreground with publications and technology transfer. This ER8 will be shown as part of the use case in switchgear wiring (T7.1) and wiring harness manufacturing for the automotive sector (T7.2).

4.8 ER9- Integrated dual arm manipulation system for interconnection systems automatic manufacturing process (ELIMCO)

Foreground - Integrated dual arm manipulation system for interconnection systems automatic manufacturing process – ELIMCO and TECNALIA	
ID	ER9- Integrated dual arm manipulation system for interconnection systems automatic manufacturing process 
Owner(s)	ELIMCO and TECNALIA
Nature	Software and hardware
Registration / Protection	Copyright, trade-secrets
Description	Task or WP where the Foreground has been produced: WP2 – T2.5 WP3 – T3.1, T3.2. T3.3 WP4 – T4.3 WP5 – T5.4 WP6 – T6.1, T6.3 WP7 – T7.2
	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: It is a development own by ELIMCO. During REMODEL, the system has changed in order to improve its performance, materials such as magnetics pins have been added. The system can be used by the users easily due to the user interface, generating the necessary trajectories to the manufacturing process.
	Background required to use the Foreground if Background needed, refer to background IDs: ER1-ER9
Access conditions for research in the project / Limitations	Inside REMODEL, ELIMCO and TECNALIA have been using all HW and SW tools for commissioning of pilots. If the CATIA application for flexible robotics programming is used (ER1), then it

	is mandatory to own a CATIA licence.
Access conditions for use / Limitations	To be used exclusively in Elimco factory in Seville.
Licensees in the project	Names of the licensees: N.A.
	Date of allocation:
	Type of licence:
Dissemination	Aerospace use case was presented during some events along REMODEL.

4.9 ER10- Automated robot / sensor calibration toolkit (TUM)

Foreground - Automated robot / sensor calibration toolkit – TUM, IEMA, ELVEZ, ELIMCO and VWP	
ID	RobotSelf-CalibrationUsingActuated3DSensors 
Owner(s)	TUM
Nature	Software
Registration / Protection	Confidential Information
Description	Task or WP where the Foreground has been produced: WP4 – T4.2 WP5 – T5.5

	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: The software toolkit was developed solely by TUM and is owned by TUM. During REMODEL, the software toolkit has been extended to be capable of whole robot-camera calibration, meaning that the entire kinematic chain can be calibrated without external markers and/or tools. Moreover, the functionality has been widened for a wide range of 2D and 3D range sensors.
	Background required to use the Foreground if Background needed, refer to background IDs: ER10
Access conditions for research in the project / Limitations	All partners inside REMODEL
Access conditions for use / Limitations	Not transferable.
Licensees in the project	Names of the licensees: N.A.
	Date of allocation:
	Type of licence:
Licensees for use	Names of the licensees: N.A.
	Date of allocation:
	Type of licence:
Dissemination	TUM Lab courses and conference presentations (IROS).

4.10 ER11- Bimanual manipulation system for wiring harness manipulation (VWP)

Foreground - Bimanual manipulation system for wiring harness manipulation – VWP, PUT, UNIBO, UCLV and TAU	
ID	Bimanual manipulation system for wiring harness manipulation
Owner(s)	VWP
Nature	REMODEL Pilot
Registration / Protection	Copyright / Confidential Information
Description	Task or WP where the Foreground has been produced: WP6 – T6.1 Development of the robotic platforms WP6 – T6.3 Cable grasping and connection tools WP7 – T7.3 Wiring harness assembly use case
	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: The REMODEL Pilot is combined of equipment and software (results) developed in others WPs. Pilot is based on know-how, experience and knowledge belonging to industrial partner. Then is further developed at VW

	plant by the cooperation of all involved partners in order to finish the REMODEL Pilot. In VWP case it means UC3 – wiring harness assembly. To assure the real production conditions, test station must be adjusted properly. Following the progress according TRL requirements, main achievements were: **To TRL 4:** The robotic platform developed in T6.1 will be tested in laboratory testbeds set up both at PUT and at UNIBO. Spare parts provided by VW will be used for this investigation. The manipulation abilities developed in T5.4 will be used to arrange the wiring harness according to a predefined pattern. **To TRL 5:** The integration of the wiring harness installation testbed in the VW production line will be considered, and suitable tests will be executed to evaluate application constraints in terms of execution time, robotic platform footprint and safety with respect to human operators. **To TRL 6:** A test plant for the evaluation of the wiring harness installation use case will be set up at the VW factory considering the moving cockpit assembly line. Demonstration during the wiring harness arrangement on the cockpit with synchronization with the moving line and online calibration of the robot task.
	Background required to use the Foreground if Background needed, refer to background IDs: VWP Pilot
Access conditions for research in the project / Limitations	Access: Free to be used inside the project. Limitations: Confidential
Access conditions for use / Limitations	Access for use is enabled for whole VW AG concern regarding to Consortium Agreement, where whole concern was reported as a third parties for simplified transfer of results (see attachment 3 of the CA). Free to be used only for the partners inside the project (for project purposes). VWP and VW AG are interested in using of together performed results in order to manufacture the car cockpits (commercial purposes) – free of charge or on very concessional terms.
Licensees in the project	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: Licensees for use is enabled for whole VW AG concern regarding to Consortium Agreement, where whole concern was reported as a third parties for simplified transfer of results (see attachment 3 of the CA). VWP and concern VW AG are interested in using of together performed results in order to manufacture the car cockpits (commercial purposes) – free of charge

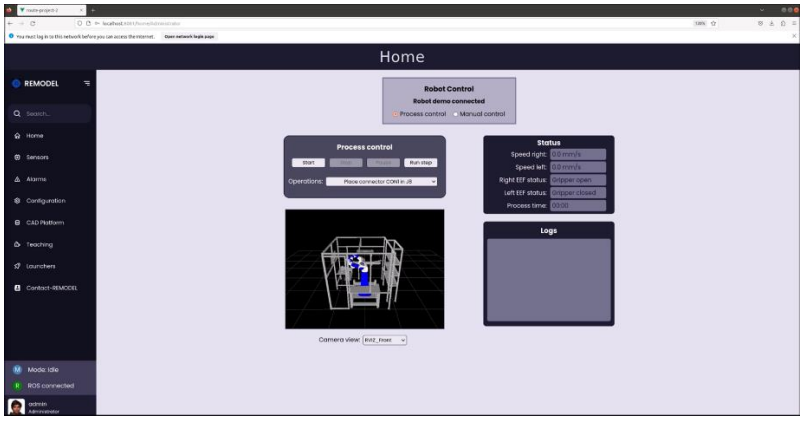
	or on very concessional terms. It strictly forbidden to share individually all drawings, data and other company's information (know-how, knowledge) to the third parties – both during the project and after finishing of him. These data should be authorized by VWP.
Dissemination	Bimanual manipulation system for wiring harness manipulation is under development by the involved partners at Volkswagen Poznan and is expected to reach TRL-6 by the end of the REMODEL project. The results may only be used for publication within the REMODEL Project. Any other sources which have not be authorized by VWP may be treated as CA infringement. 14.07.2023: Final decision about a possible implementation in a mass production after REMODEL Project has not been decided. It depends on such factors like feasibility, efficiency and viability (ROI Factor – return on investment). A final decision on the exploitation path has not been taken yet.

4.11 ER12- Interactive perception module exploiting vision and touch (PUT)

Foreground - Interactive perception module exploiting vision and touch – UNIBO, UCLV, TAU, TUM and PUT	
ID	Interactive perception module exploiting vision and touch
Owner(s)	PUT
Nature	Software
Registration / Protection	Knowhow
Description	Task or WP where the Foreground has been produced: WP5 T5.5. Interactive Perception
	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: While providing the industry grade vision and planning system working in sense-plan-act methodology we concurrently perform research on interactive perception Interaction system improves vision by bending cable with the robotic arm to provide information on physical properties of the cable. The system interacts in the loop: cable bending, observing deformation with the camera to estimate physical parameters of the cable. We provide internal representation of the physics of the cables so the robotic system seeing a cable might have prior on its physical properties and then only confirm it through purposeful and deliberate selected interaction point. TRL process was followed to increase the readiness level of the module technology: To TRL 4: Tactile-vision system for interactive perception tested in a laboratory setting for different wires To TRL 5: Tactile-vision based system for interactive perception with internal cable parameters representation tested in a relevant environment To TRL 6: Improved interactive perception with an internal model of cable

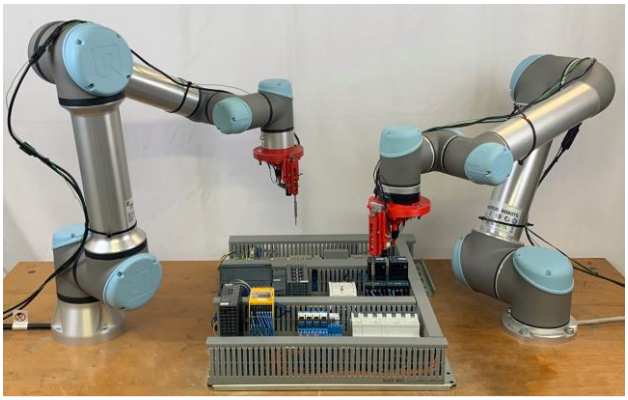
	parameters to provide faster system response will be demonstrated in a relevant environment.
	Background required to use the Foreground if Background needed, refer to background IDs: Exploiting subproducts from WP4, WP5 and WP6.
Access conditions for research in the project / Limitations	Access: Free to be used inside the project. Limitations: Confidential
Access conditions for use / Limitations	Access: Some of the system elements will be open-sourced (better if written where it will be available!!) Limitations: Open-source for non commercial purposes.
Licensees in the project	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: N.A.
Licensees for use	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: N.A.
Dissemination	Presentation for the consortium members. Selected aspects of the system will be presented on the scientific conference, but not revealing the full knowhow.

4.12 ER13- Streamlined User Interface for Enhanced ROS Interaction (TAU)

Foreground - Streamlined User Interface for Enhanced ROS Interaction – TAU	
ID	ER13 - Streamlined User Interface for Enhanced ROS Interaction 
Owner(s)	TAU
Nature	Software
Registration / Protection	Copyright, trade-secret
Description	Task or WP where the Foreground has been produced: WP3 – T3.2 User Interface

	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: The REMODEL user interface (UI) is a development own by TAU as explained in the background. This UI allows the users to interact with the REMODEL ROS system in an easy and intuitive manner. The REMODEL UI includes the following functionalities: multirole security clearance, dynamic modules launching and monitoring, sensors' data visualization, safety state visualization, CAD Platform files dynamic update, trajectory/routines recording and execution, robot manual motion control, robot production process control and monitoring, system and process configuration, and simulation stream visualization.
	Background required to use the Foreground if Background needed, refer to background IDs.
Access conditions for research in the project / Limitations	Inside REMODEL, Four out of the five use cases have implemented the UI (i.e., IEMA, ELIMCO, ELVEZ, and ENKI). Additionally, the UI was also implemented and tested by some of the research partners, including TAU, UNIBO, TECNALIA, and UCLV. The user interface is a web-based application that incorporates a technology stack consisting of HTML, JavaScript (JS), CSS, and the Vue.js framework. Additionally, the communication with ROS is handled by the ROSbridge package, which establishes a Web socket connection with the UI. All these libraries, packages, and programming languages are open-source and do not require a license.
Access conditions for use / Limitations	The REMODEL UI consists of a generic and scalable framework, which incorporates some of the functionalities that are common for all the use cases, and a set of specific features which can be easily integrated within this framework for every use case implementation. The use of the UI does not require any license.
Licensees in the project	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: N.A.
Licensees for use	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: N.A.
Dissemination	The REMODEL UI provides a generic solution for interfacing a ROS system in an easy an intuitive way, which can be very interesting within the robotic community. To disseminate it we will use scientific publications, social media (youtube videos, LinkedIn posts…), and robotic/software relevant forums (ROS answers, StackOverflow…). Additionally, ER13 will be shown as part of four of the REMODEL use cases (IEMA, ELIMCO, ELVEZ, and ENKI).

4.13 ER14 - Dual arm robotic platform for autonomous switchgear connection checking (UNIBO)

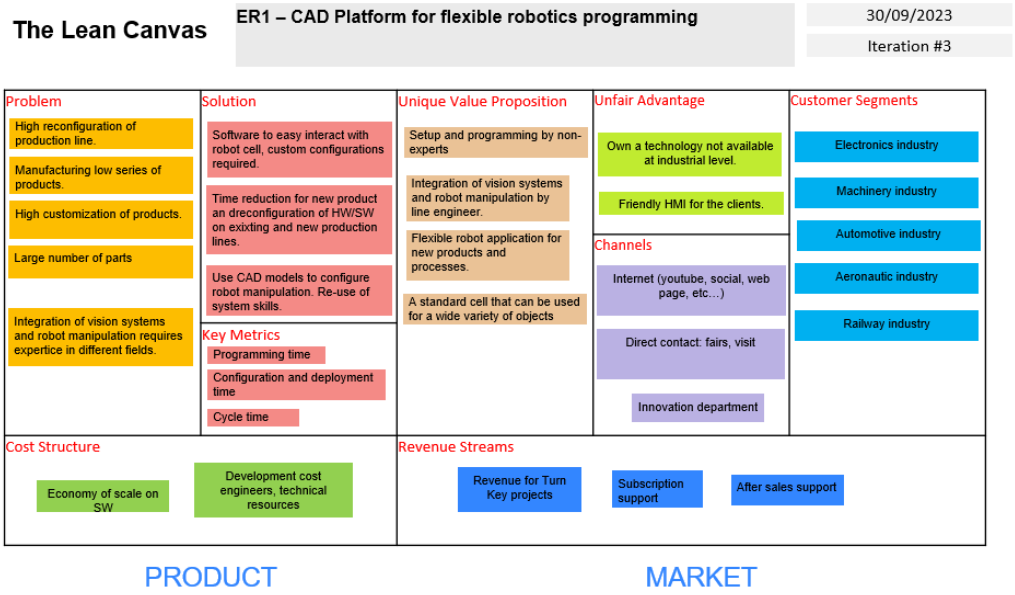
Foreground - Dual arm robotic platform for autonomous switchgear connection checking (UNIBO)	
ID	ER14- Dual arm robotic platform for autonomous switchgear connection checking 
Owner(s)	UNIBO
Nature	Hardware and Software
Registration / Protection	Patent Pending
Description	Task or WP where the Foreground has been produced: WP4 – T4.4 Detection of functional components WP6 – T6.3 Cable grasping and connection tools WP7 – T7.1 Switchgear cabling use case
	Description of the Foreground and when relevant, if the Foreground is co-owned by several participants: UNIBO selected the manipulators and designed the software tools for the coordinated control of the manipulators avoiding collisions, the connection checking procedure and the cable connection procedure in all the component typology by integrating proper tool for connection checking. A spin-off called RoboSECT has been created on the base of this result, for the further development and the commercialization.
	Background required to use the Foreground if Background needed, refer to background IDs: Background ER3 - Generation of robot planning from product CAD files for switchgear wiring
Access conditions for research in the project / Limitations	Available through RoboSECT
Access conditions for use / Limitations	Not transferable.
Licensees in the project	Names of the licensees: N.A.
	Date of allocation: N.A.
	Type of licence: To be treated confidential, by the rules of project CA.
Licensees for use	Names of the licensees: N.A.

	Date of allocation: N.A.
	Type of licence: It can be used for project activities. No available use for commercial purposes. Other research activities can be evaluated after the definition of a Non-Disclosure Agreement (NDA) document.
Dissemination	Dissemination undertaken for the Foreground with publications and technology transfer. This ER14 will be shown as part of the switchgear cabling use case T7.1.

5 Business cases

5.1 ER1- CATIA application for flexible robotics programming (TECNALIA)

5.1.1 Business model



As analysed from the beginning of REMODEL, the targeted customers are end-users that want to program new applications using existing CAD models. In this ER is used in an intuitive and graphical user interface that can be used by non-experts, based on CATIA software, allows the robot program to be generated from CAD models.

We anticipate reaching customers interested in this tool through the robotic platform proposed in this ER and the final objective is to develop the system and license it.

5.1.2 Cost structure and KPIs

- Software: development and scalability
- Costs of licenses – to be defined till the end of REMODEL Project.

Main KPI to be considered:

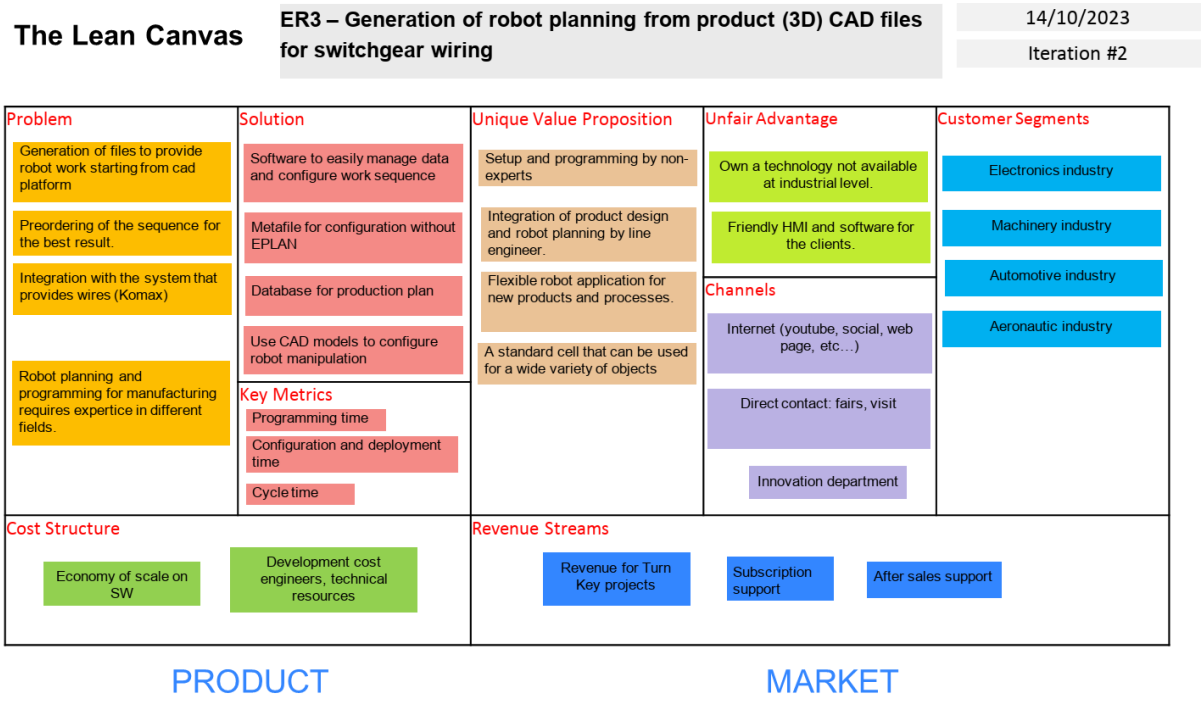
- Programming time
- Scalability
- Configuration and deployment time
- Flexibility to manufacturing different wire harness

5.1.3 Return of investment

Return of Investment (ROI) is difficult to calculate since more data is required.

5.2 ER3- Generation of robot planning from product (3D) CAD files for switchgear wiring (IEMA)

5.2.1 Business model



At the beginning, the target customer is IEMA itself and the company connected, involved in electric switchgear production. The output of the system will be a set of data useful not only for the switchgear wiring process but also for other process like quality check, pin to pin test, etc.

5.2.2 Cost structure and KPIs

- Hardware: infrastructure cost to organize data.
- Software: development of macro to prepare data.
- Possible costs of licenses – to be defined till the end of REMODEL Project.
- Cost of reorganization, necessary for implementation after REMODEL Project – should be estimated.
- Possible cost of lack of required infrastructure - should be estimated.

Main KPI to be considered (and achieved in REMODEL):

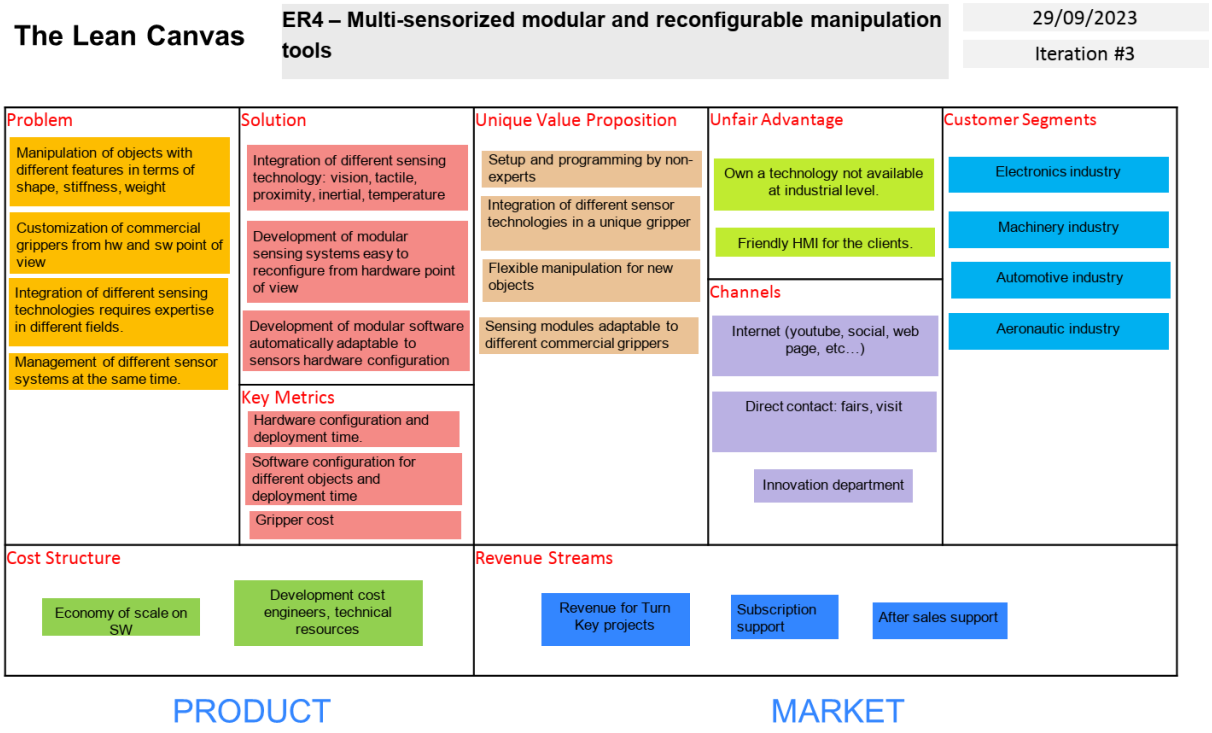
- Flexibility to manage different switchgears (1 additional model verified)
    - In REMODEL a single switchgear has been considered, but the software solution has been verified on a different model successfully
- Percentage cabling operation correctly planned over cabling operations affordable by the robot (85%)

5.2.3 Return of investment

Return of Investment (ROI) is difficult to calculate: we expect to integrate this part to the wiring system to automatize the process.

5.3 ER4 - Multi-sensorized modular and reconfigurable manipulation tools (UNIBO)

5.3.1 Business model



As analysed from the beginning of REMODEL, the targeted customers are system integrators which are involved into the design of suitable robotic platforms for flexible manipulation tasks, requested by end-users from different application field. The competitive advantage of ER4 is to increase the adaptability of manipulation tools to different scenario by exploiting modular sensory systems that can easily be added to and/or removed from the manipulation tool, on the basis of task requirements. This easy adaptability concerns both the hardware aspects (e.g., mechanical assembly of the various modules, compatible interfaces) and the software aspects (e.g., drivers for the recognition and automatic configuration of the connected sensor modules).

5.3.2 Cost structure and KPIs

The following sensing modules have been developed (from hardware and/or software point of view) and tested in the various use cases: tactile sensors, proximity sensors, vision sensors. The development of hardware requested will cost between 20k and 30k (PCBs, deformable pad, mechanical part) for different commercial grippers. Additional work needs to make the hardware compliant with CE regulations. The software has been developed in ROS and a porting work is needed for a future commercialization. The software costs will depend on the programming environment selected for the porting. The actuation part can be implemented with commercial electric drives and mechanical components to reduce the costs.

Main KPI to be considered (and achieved in REMODEL):

- Number of different sensing modules mounted on a single gripper (3: tactile, proximity, vision).
- Time needed to add and/or remove a sensing module, e.g., to add new features, for system maintenance (5 to 10 minute)

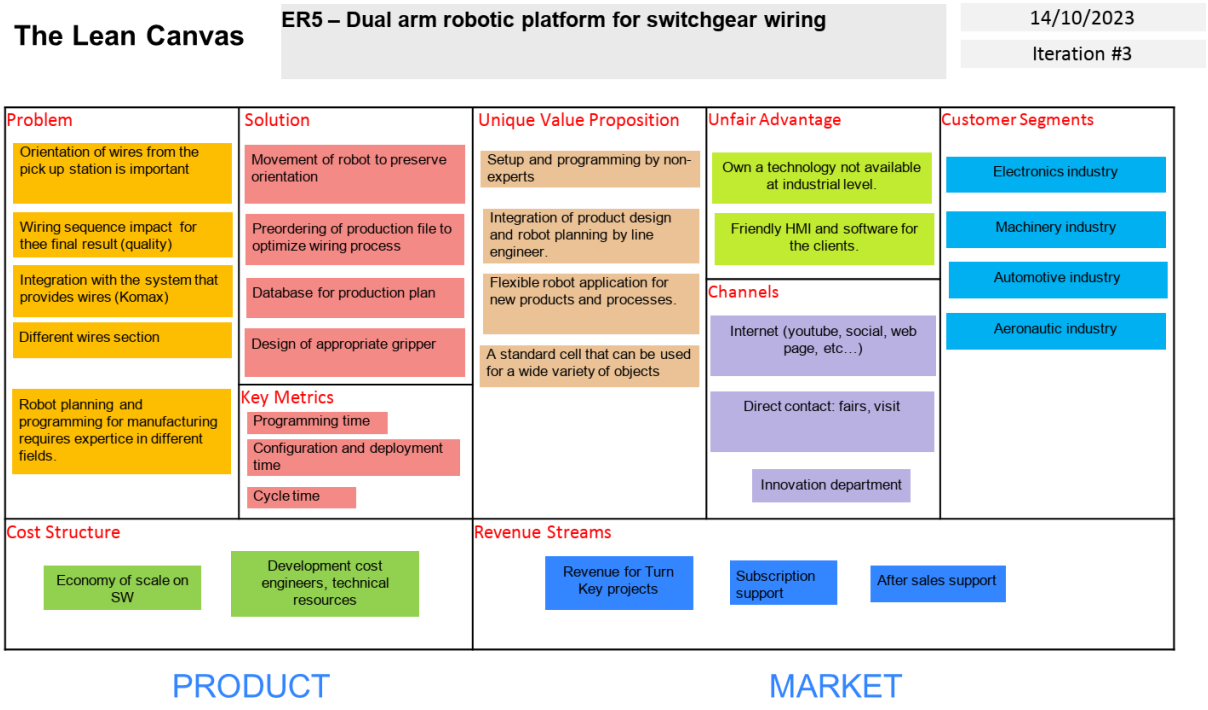
- Time needed to update software after a hardware modification (1 to 2 minutes).
- Resolution of the installed sensors (tactile 25x25 taxels, proximity 0.5 mm, vision 1024x768 pixel).
- Actuation precision (tactile 0.1 N, proximity 0.1 mm, vision 0.5 mm).

5.3.3 Return of investment

Return of Investment (ROI) is difficult to calculate since a company for the production is needed. Two possibilities can be pursued: 1) contact system integrators via dissemination activities (e.g., fairs, forum, conference); 2) found a specific spin-off company. Anyway, academic partners are exploiting these results in new Horizon Europe Projects and for preparation of new projects' proposals.

5.4 ER5- Dual arm robotic platform for switchgear wiring (IEMA)

5.4.1 Business model



IEMA developed this platform acting as target customer, being this their main objective in the project. IEMA was interested in an automatic robotic system electric switchgear production. The goal is to increase productivity, using the platform to perform repetitive operation mainly, to arrive to produce an entire switchgear without humans handwork, being the workers available for tasks with more added value. This technology will be a translated to other functionalities in plant, such as pin-to-pin test, quality check, etc.

5.4.2 Cost structure and KPIs

The following costs must be taken into account for cost structure calculation:

• Hardware – robots, grippers, cameras, logistic racks, safety fencing and devices, any other tools or devices previously not defined.

• Software – programming of robots and safety – safety Profinet, SafeMove etc.

• Software integration in server repository of CAD data.

• Integration of robotic station – with all rules and regulation, in accordance with the Machinery Directive (CE sign).

• Management of Komax wire preparation (wires store).

• Possible costs of licenses – to be defined till the end of REMODEL Project.

• Cost of reorganization, necessary for implementation after REMODEL Project – should be estimated.

• Possible cost of lack of required infrastructure - should be estimated.

Main KPI to be considered (and achieved in REMODEL):

• Reconfigurability and flexibility to manage a wide range of different switchgear

  - In REMODEL a single switchgear has been considered, the cabling solution will be verified on different switchgear after the end of REMODEL

• Quality of the wiring (compatible with human cabling)

5.4.3 Return of investment

IEMA expect to increase productivity, and based in test during REMODEL this is possible with ER5. However, the system needs to be tested in industrial operative conditions. Then, IEMA will compare the cell work with the productivity and quality achieved by one or two person (between 40k and 80k per year at least). The following table reports the for the pilot implementation in IEMA:

Cost of the UC1 pilot		
Table for robots	€	10,800.00
Protection barriers	€	3,400.00
Rent for nr. 2 UR10e	€	14,400.00
Rent for nr. 2 grippers Robotiq Hand-e	€	4,002.00
Luxonis UB Camera	€	141.28
EPLAN EPL0UC571 License	€	16,670.00
Notebook Hp Zbook Fury	€	2,590.00
Safety equipments	€	1,000.00
OS32C-CBL-10M cable 10m for laser scanner OS32C supply	€	46.00
OS32C-SP1 VER2 Omron Laser Scanner	€	1,200.00
Total	**€**	**54,249.28**

In order to define ROI, we try to simulate a viability plan in a period of few years:

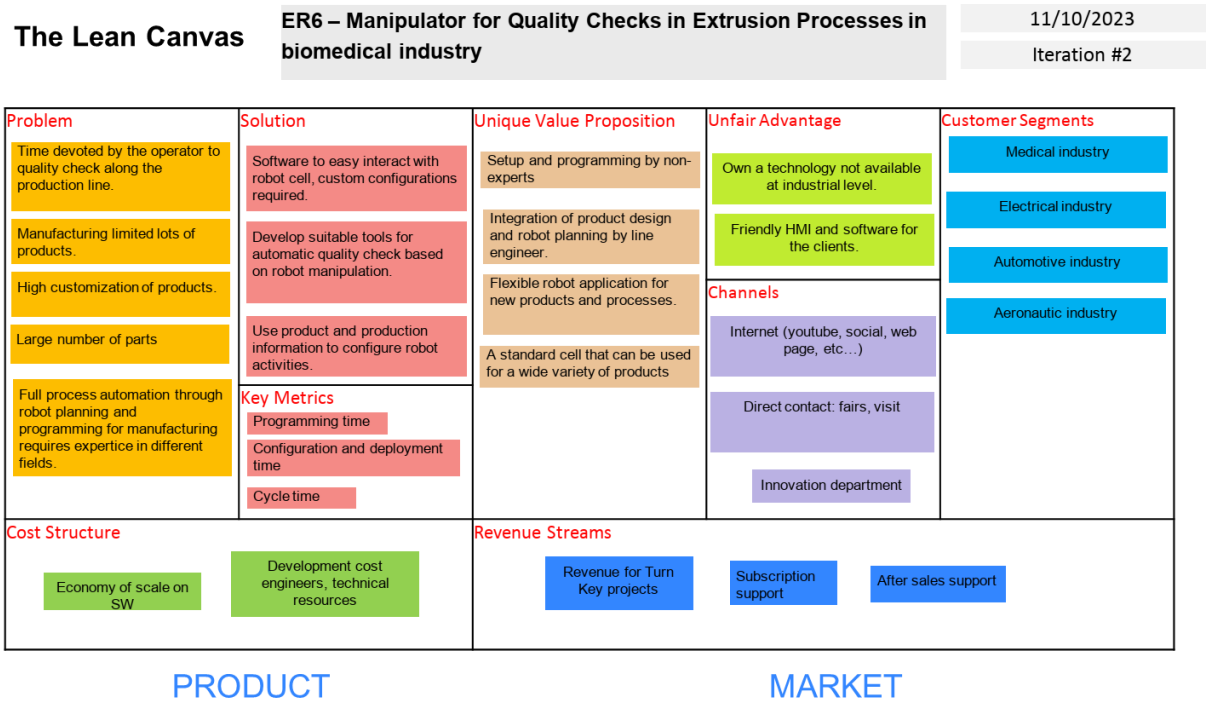
Concept	Subconcept	Detail	2024	2025	2026	2027	2028	2029
Total Incomes	Sales	Sales	77040.00	94296.96	100992.04	108162.48	115842.02	124066.80
Total Incomes	Other Incomes	Royalties & Licenses	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Initial Investment	Initial Investment	-200000.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Manufacturing costs	Materials	-56249.28	-3250.00	-3480.75	-3727.88	-3992.56	-4276.03
Total Costs	Manufacturing costs	Manufacturing Personnel	-28290.00	-32871.96	-33270.98	-33500.01	-33526.64	-33314.10
Total Costs	Marketing costs	Marketing Personnel	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Marketing costs	Promotional Material	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Marketing costs	Advertising	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Marketing costs	Others	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	General costs	General costs	-1570.00	-1601.40	-1633.43	-1666.10	-1699.42	-1733.41
Total Costs	Financial costs	Interests and Financial costs	-1794.94	-1884.69	-1978.92	-2077.87	-2181.76	-2290.85
Cashflow	Cashflow	Cashflow	-10864.22	54688.91	60627.96	67190.62	74441.63	82452.41
ROI	ROI	Return of Investment	-210864.22	-156175.31	-95547.34	-28356.72	46084.91	128537.32
ROI	ROI %	Return of Investment	-5.43%	27.34%	30.31%	33.60%	37.22%	41.23%

ROI	Continous ROI %	Return of Investment	-5.43%	21.91%	52.23%	85.82%	123.04%	164.27%
Net Income			-210864.22	54688.91	60627.96	67190.62	74441.63	82452.41

We define the concept “Sales” such as the group of the sales related directly and indirectly with the project REMODEL. This table shows that considering an investment of 200k€ to finalize the development of the platform, the ROI is about 4 year even considering a very low production (20 switchgears per year on average).

5.5 ER6- Manipulator for Quality Checks in Extrusion Processes in biomedical industry (ENKI)

5.5.1 Business model



Manipulator for Quality Checks in Extrusion Processes in biomedical industry reached TRL6 at the end of the project. ENKI will evaluate the possibility to commercialize this hardware and software solutions. By the end of REMODEL, ENKI will get in contact with other companies producing extruded products to investigate the possibility of establishing commercial partnerships.

5.5.2 Cost structure and KPIs

Current state (25.07.2023) for ENKI Pilot – waiting for software modifications to the extrusion line to cut the sample to check, purchase of robots and grippers, mechanical parts for the robot station and extrusion line modifications, preparation of materials for the test; between 50k and 60k will be spent for hardware. Development of robotic programming is ongoing by UNIBO, UCLV and ENKI

The following costs should be took into account to a cost structure:

- Hardware – robots, grippers, cameras, safety fencing and devices, any other tools or devices previously not defined.
- Software programming of robots and safety

- Software integration with the extrusion line
- Integration of robotic station – with all rules and regulation, in accordance with the Machinery Directive (CE sign).
- Possible costs of licenses – to be defined till the end of REMODEL Project.
- Cost of reorganization, necessary for implementation after REMODEL Project – should be estimated.
- Possible cost of lack of required infrastructure - should be estimated.

Main KPI to be considered (and achieved in REMODEL):

- Reconfigurability and flexibility to manage a wide range of different hoses (100%).
- Quality of the cut samples (80%).
- Success rate in sample preparation for visual inspection (90%).
- Success rate in dimension gauge insertion (90%).

5.5.3 Return of investment

Return of Investment (ROI) is difficult to calculate: ENKI expect to increase productivity and as far as the system will be in operation, ENKI could compare the cell work with the productivity and quality achieved by one or two person (between 40k and 80k per year at least). The following table reports the for the pilot implementation in ENKI:

Cost of the UC4 pilot		
Setup of extrusion line	€	15,000.00
3D printing of hose supports	€	1,000.00
Cost of nr. 1 Robots UR5e	€	28,000.00
Cost of nr. 1 grippers Robotiq Hand-e	€	5,000.00
Extrosion line software integration	€	10,000.00
Laptops for control system	€	4,000.00
Safety PLC	€	5,000.00
Total	**€**	**68,000.00**

In order to define ROI, we try to simulate a viability plan in a period of few years:

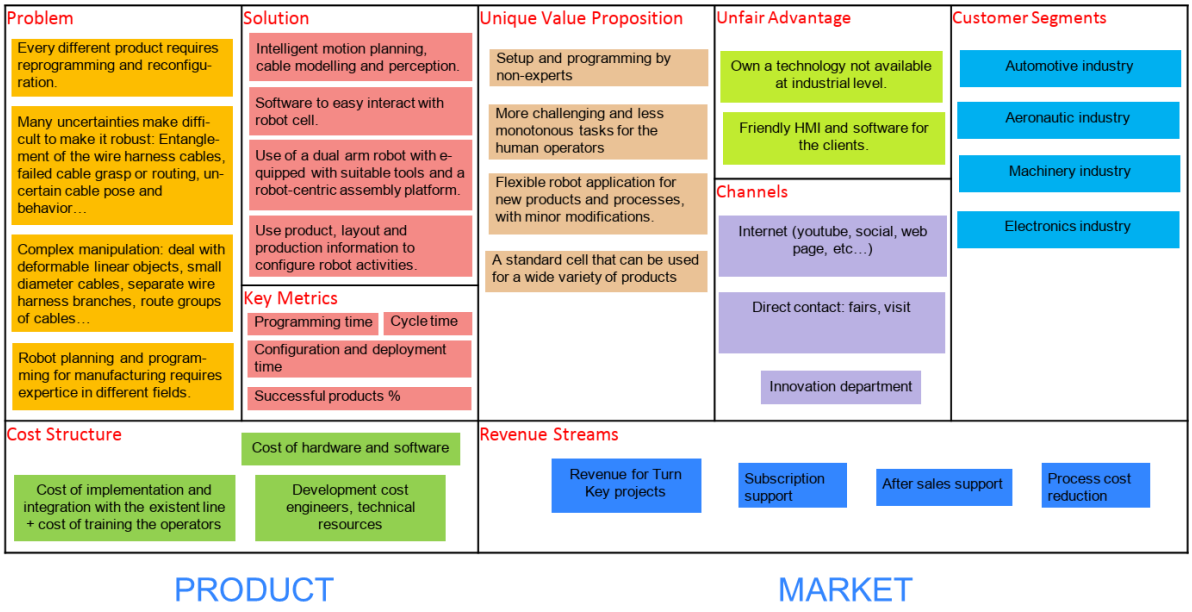
Concept	Subconcept	Detail	2024	2025	2026	2027	2028	2029
Total Incomes	Sales	Sales	192000.00	205632.00	213939.53	222582.69	231575.03	240930.66
Total Incomes	Other Incomes	Royalties & Licenses	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Initial Investment	Initial Investment	-200000.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Manufacturing costs	Materials	-68000.00	-3250.00	-3381.30	-3517.90	-3660.03	-3807.89
Total Costs	Manufacturing costs	Manufacturing Personnel	-96000.00	-102816.00	-106969.77	-111291.34	-115787.52	-120465.33
Total Costs	Marketing costs	Marketing Personnel	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Marketing costs	Promotional Material	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Marketing costs	Advertising	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Marketing costs	Others	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	General costs	General costs	-1570.00	-1601.40	-1633.43	-1666.10	-1699.42	-1733.41
Total Costs	Financial costs	Interests and Financial costs	-1794.94	-1830.84	-1867.46	-1904.80	-1942.90	-1981.76
Cashflow	Cashflow	Cashflow	24635.06	96133.76	100087.58	104202.54	108485.17	112942.27
ROI	ROI	Return of Investment	-175364.94	-79231.18	20856.40	125058.94	233544.11	346486.38
ROI	ROI %	Return of Investment	12.32%	48.07%	50.04%	52.10%	54.24%	56.47%
ROI	Continous ROI %	Return of Investment	12.32%	60.38%	110.43%	162.53%	216.77%	273.24%
Net Income			**-175364.94**	**96133.76**	**100087.58**	**104202.54**	**108485.17**	**112942.27**

We define the concept “Sales” such as the group of the sales related directly and indirectly with the project REMODEL. This table shows that considering an investment of 200k€ to finalize the development of the platform, the ROI is about 2 year considering the cost of the personnel devoted to quality check that can be allocated to other activities.

5.6 ER7- Dual arm robotic platform for Automotive Industry (ELVEZ)

5.6.1 Business model

The Lean Canvas — **ER7 – Dual arm robotic platform for Automotive Industry** — 9/10/2023 — Iteration #2



As analysed from the beginning of REMODEL, the current production process of wire harness assemblies is completely manual. Targeted customers for the developed dual arm robotic platform are all automotive manufacturers and suppliers who produce equipment on a large scale, such as ELVEZ. The main objective is the capability to program the robotic platform for complex manipulation tasks with DLOs, by combining simpler primitive cabling actions by means of intuitive interface, in order to compose a complex cabling task. The use of a strategy based on the combination of simpler sub-action allows an easy adaptation of the system to a new wiring harness production.

5.6.2 Cost structure and KPIs

The developed dual arm robotic system is constituted by two standard robots: the first with a commercial parallel gripper equipped with a couple of sensorized fingers developed by UCLV used for the cabling; the second equipped with a taping gun suitably developed by UNIBO, for the taping operations. An external vision system is used to verify the correctness of the wiring harness produced. An User Interface, developed by TAU, allow to start/pause/interrupt the whole task or only a subtask from different devices. The hardware requested about 60k for the robots and commercial gripper, and about 20k for the sensorized fingers, taping gun and vision system, Additional work needs to make the hardware compliant with CE regulations. The software, which is a fundamental contribution for this system, has been developed in ROS and a porting work is needed for a future commercialization. The costs will depend on the programming environment selected for the porting.

Main KPI to be considered (and achieved in REMODEL):

- Time needed to execute a complete task (3 min).
- Success rate for the routing of a single cable (89% to 97% depending on the type of cable).
- Success rate for the routing of all cables (80%).
- Time needed for the routing (35 sec).
- Time needed for a taping operation (15 sec).
- Success rate for the execution of all taping operations (98%).

5.6.3 Return of investment

Assuming an overall cost of the robotic platform around 60K, the ROI can be calculated considering the number of wiring harness the platform is able to assemble and the return for each wiring harness.

The following table reports the for the pilot implementation in ELVEZ:

Cost of the UC2.2 pilot		
Table for robots	€	8,000.00
3D printing of cable supports	€	1,000.00
Cost of nr. 2 Robots (UR5e and Doosan)	€	40,000.00
Cost of nr. 1 grippers Robotiq Hand-e	€	5,000.00
Zivid 3D camera	€	15,000.00
Laptops for control system	€	4,000.00
Safety PLC	€	8,000.00
Total	**€**	**81,000.00**

In order to define ROI, we try to simulate a viability plan in a period of few years:

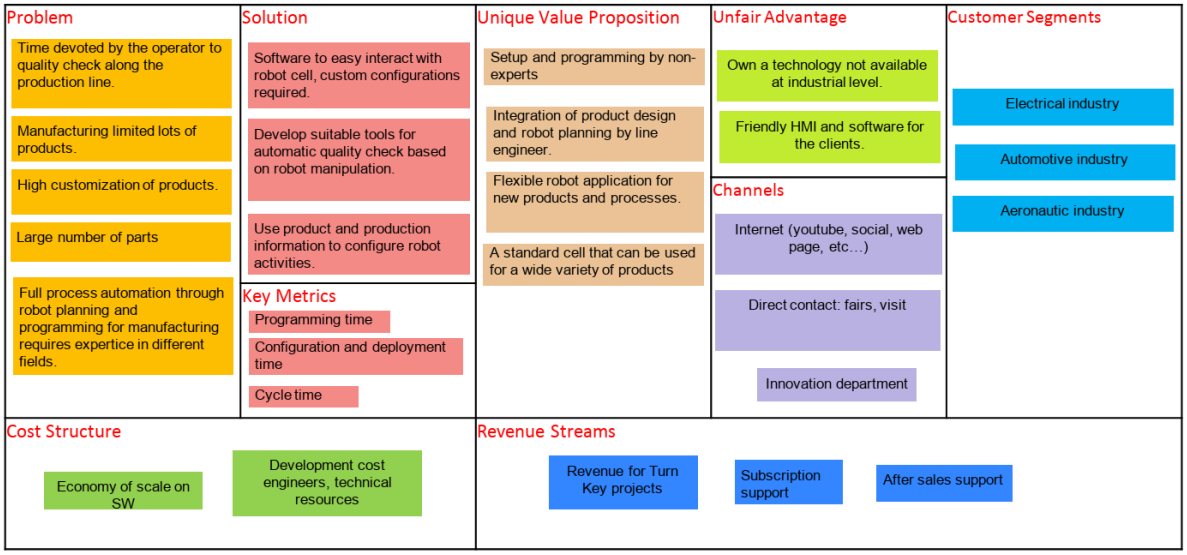
Concept	Subconcept	Detail	2024	2025	2026	2027	2028	2029
Total Incomes	Sales	Sales	192000.00	205632.00	213939.53	222582.69	231575.03	240930.66
Total Incomes	Other Incomes	Royalties & Licenses	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Initial Investment	Initial Investment	-200000.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Manufacturing costs	Materials	-81000.00	-3250.00	-3381.30	-3517.90	-3660.03	-3807.89
Total Costs	Manufacturing costs	Manufacturing Personnel	-144000.00	-154224.00	-160454.65	-166937.02	-173681.27	-180698.00
Total Costs	Marketing costs	Marketing Personnel	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Marketing costs	Promotional Material	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Marketing costs	Advertising	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	Marketing costs	Others	0.00	0.00	0.00	0.00	0.00	0.00
Total Costs	General costs	General costs	-1570.00	-1601.40	-1633.43	-1666.10	-1699.42	-1733.41
Total Costs	Financial costs	Interests and Financial costs	-1794.94	-1830.84	-1867.46	-1904.80	-1942.90	-1981.76
Cashflow	Cashflow	Cashflow	-36364.94	44725.76	46602.70	48556.87	50591.41	52709.61
ROI	ROI	Return of Investment	-236364.94	-191639.18	-145036.48	-96479.61	-45888.20	6821.40
ROI	ROI %	Return of Investment	-18.18%	22.36%	23.30%	24.28%	25.30%	26.35%
ROI	Continous ROI %	Return of Investment	-18.18%	4.18%	27.48%	51.76%	77.06%	103.41%
Net Income			**-236364.94**	**44725.76**	**46602.70**	**48556.87**	**50591.41**	**52709.61**

We define the concept “Sales” such as the group of the sales related directly and indirectly with the project REMODEL. In this simulation a return of 0.5€ per wiring harness and an average assembly time in the order of 1 minute (including stops for maintenance and replacement of materials) over 8 hour shift is assumed. This leads to a ROI of about 5 years. This time can be even reduced in case of longer robotic platform time shift. Anyway, academic partners are exploiting these results in new Horizon Europe Projects and for preparation of new projects’ proposals.

5.7 ER8- CAD Platform Interface to provide the system planner, the layout and product inputs (UNIBO)

5.7.1 Business model

The Lean Canvas | **ER8 – CAD Platform Interface to provide the system planner, the layout and product inputs** | 12/09/2023 | Iteration #2



As analyzed from the beginning of REMODEL, the current manufacturing process in the sectors involving handling of cables is strongly based on manual activity. REMODEL developed solutions to automatize these processes and, in particular, to directly link the design of products to the manufacturing automation. Targeted customers for the developed dual software platform are all manufacturers and suppliers in which production the handling of cables has a significant role, such as for the REMODEL use cases. The main objective is the capability to program the robotic platform for complex manipulation tasks with DLOs, by combining simpler primitive cabling actions by means of direct connection with the product design, in order to compose a complex cabling task. The use of a strategy based on the combination of simpler sub-action and their usage to accomplish the production allows an easy adaptation of the system to a new product manufacturing.

The output of the system will be a set of tasks to be executed by a set of robots for the switchgear wiring process and wiring harness assembly, but also for other process like quality check, pin to pin test, etc.

5.7.2 Cost structure and KPIs

- Hardware: cost of design workstation and robots.
- Software: cost of licenses for the design tools.
- Possible costs of licenses – to be defined till the end of REMODEL Project.
- Cost of reorganization, necessary for implementation after REMODEL Project – should be estimated.
- Possible cost of lack of required infrastructure - should be estimated.

Main KPI to be considered (and achieved in REMODEL):

- Flexibility to manage different products (100%)
    - The software has been tested on both UC1 and UC2 with different products

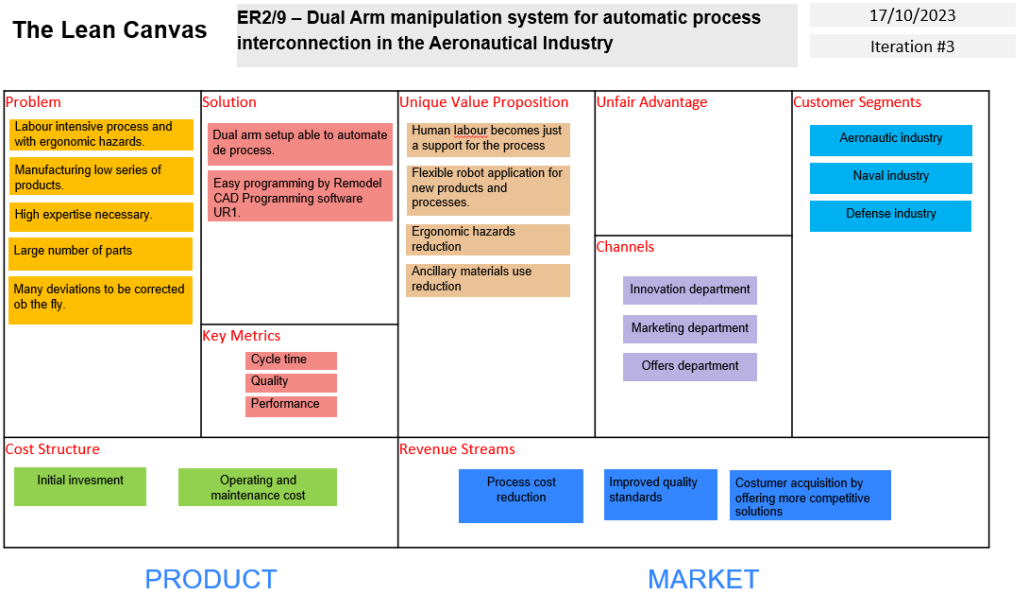
- Percentage of manufacturing operation affordable by the robots (90%)
- Human-labor saving (14 man hours per shift)
- Increase in production (to be evaluated after REMODEL)
- Lead time reduction (to be evaluated after REMODEL)

5.7.3 Return of investment

Return of Investment (ROI) can be estimated considering the time saved during manufacturing and the lead time reduction. The estimation made considering the IEMA production in 2022 shows that the ROI can be less than 3 years.

5.8 ER9- Integrated dual arm manipulation system for interconnection systems automatic manufacturing process (ELIMCO)

5.8.1 Business model



ELIMCO is the end user and targeted customer. In this ER is used with an intuitive and graphical user interface that can be used by non-experts, based on HTML page web, this software allows ELIMCO to create trajectories to be executed by robot arms to manufacture various kind of harnesses.

5.8.2 Cost structure and KPIs

The current state for ELIMCO Pilot, about 60.000 € have been spent in the structure. Programs for both robots is being developed by colleagues from TECNALIA.

ROBOTS IIWA 7	52.000 €
TABLE SET	2.000 €
TABLE SET IMPROVEMENT	1.300 €

SCHUNK GRIPPER	9.000 €

Other costs are not registered, because they are a set of little costs.

The main KPI's which are used by ELIMCO are (and achieved in REMODEL):

- Quantity of harnesses are given on time. (98.9% of them)
- Manufacture time of different type of process in various harnesses model. (20% to 40% reduction depending on the harness size and process)
- Mean production time. (linked to the previous one)
- Mean cost of wiring. (35% reduction)

5.8.3 Return of investment

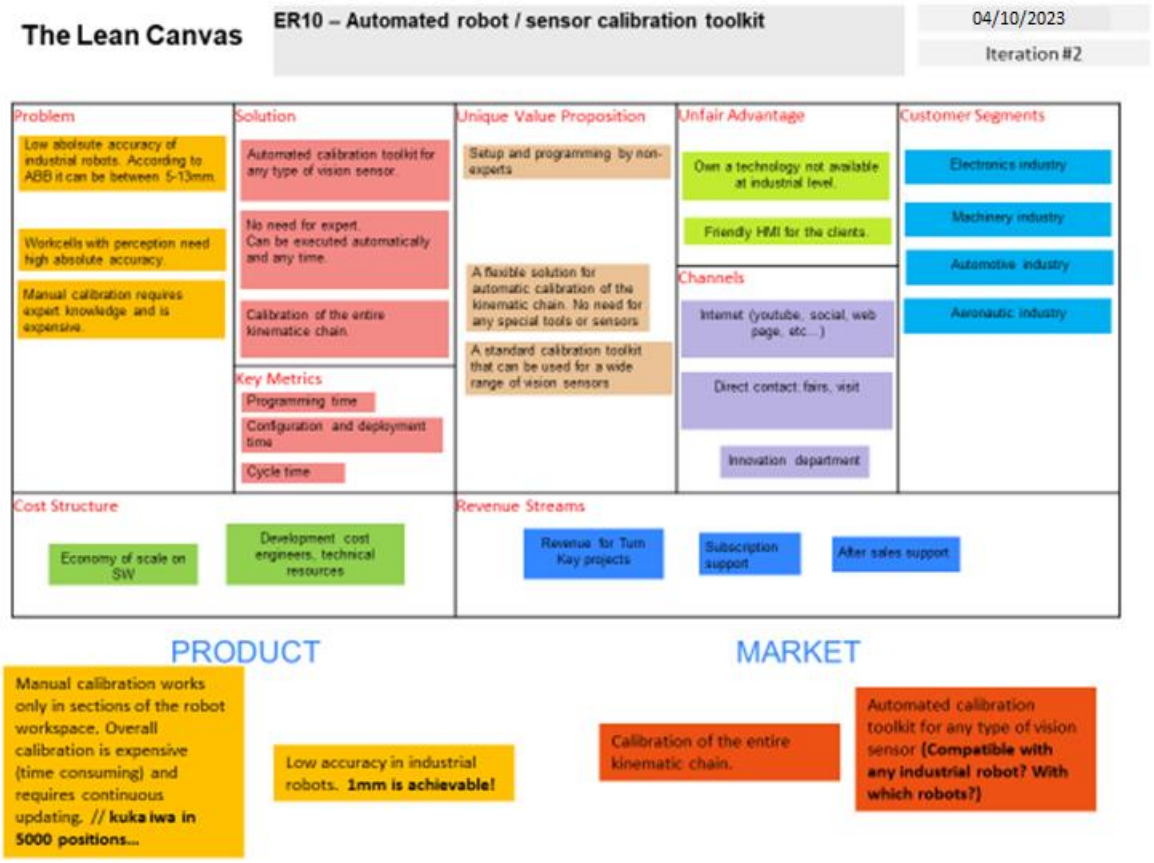
Regarding to Return of Investment (ROI) is difficult to estimate without getting all data. In order to define ROI, we try to simulate a viability plan in a period of few years.

VIABILITY PLAN								
CONCEPT	SUBCONCEPT	DETAIL	2024	2025	2026	2027	2028	2029
TOTAL INCOMES	SALES	Sales	89.746,88 €	91.294,24 €	92.841,60 €	94.388,96 €	95.936,32 €	97.483,68 €
TOTAL INCOMES	OTHERS INCOMES	Royalties & Licenses	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
TOTAL COSTS	INITIAL INVESTMENT	Initial Investment	-386.840,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
TOTAL COSTS	MANUFACTURING COSTS	Materials	-4.487,34 €	-4.564,71 €	-4.642,08 €	-4.719,45 €	-4.796,82 €	-4.874,18 €
TOTAL COSTS	MANUFACTURING COSTS	Manufacturing Personnel	-15.705,70 €	-15.976,49 €	-16.247,28 €	-16.518,07 €	-16.788,86 €	-17.059,64 €
TOTAL COSTS	MARKETING COSTS	Marketing Personnel	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
TOTAL COSTS	MARKETING COSTS	Promotional Material	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
TOTAL COSTS	MARKETING COSTS	Advertising	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
TOTAL COSTS	MARKETING COSTS	Others	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
TOTAL COSTS	GENERAL COSTS	General Costs	-2.243,67 €	-2.282,36 €	-2.321,04 €	-2.359,72 €	-2.398,41 €	-2.437,09 €
TOTAL COSTS	FINANCIAL COSTS	Interest and Financing Costs	-1.794,94 €	-1.825,88 €	-1.856,83 €	-1.887,78 €	-1.918,73 €	-1.949,67 €
CASHFLOW	CASHFLOW	CashFlow	65.515,22 €	66.644,80 €	67.774,37 €	68.903,94 €	70.033,51 €	71.163,09 €
ROI	ROI	Return of Investment	-321.324,78 €	-254.679,98 €	-186.905,61 €	-118.001,67 €	-47.968,16 €	23.194,93 €
ROI	ROI (%)	Return of Investment	16,94%	17,23%	17,52%	17,81%	18,10%	18,40%
ROI	CONTINOUS ROI (%)	Return of Investment	16,94%	34,16%	51,68%	69,50%	87,60%	106,00%
NET MARGIN			**-321.324,78 €**	**66.644,80 €**	**67.774,37 €**	**68.903,94 €**	**70.033,51 €**	**71.163,09 €**

We define the concept "Sales" such as the group of the sales related directly and indirectly with the project REMODEL.

5.9 ER10- Automated robot / sensor calibration toolkit (TUM)

5.9.1 Business model



The targeted customers are end-users of all the manufacturing industries that rely on robotic manipulators. The main aim is to replace specialized expert knowledge to achieve high accuracy and to reduce down-time.

5.9.2 Cost structure and KPIs

- Software: development and scalability
- Possible costs of licenses – to be defined till the end of REMODEL Project.
- Cost of reorganization, necessary for implementation after REMODEL Project – should be estimated.
- Possible cost of lack of required infrastructure - should be estimated

Main KPI to be considered:

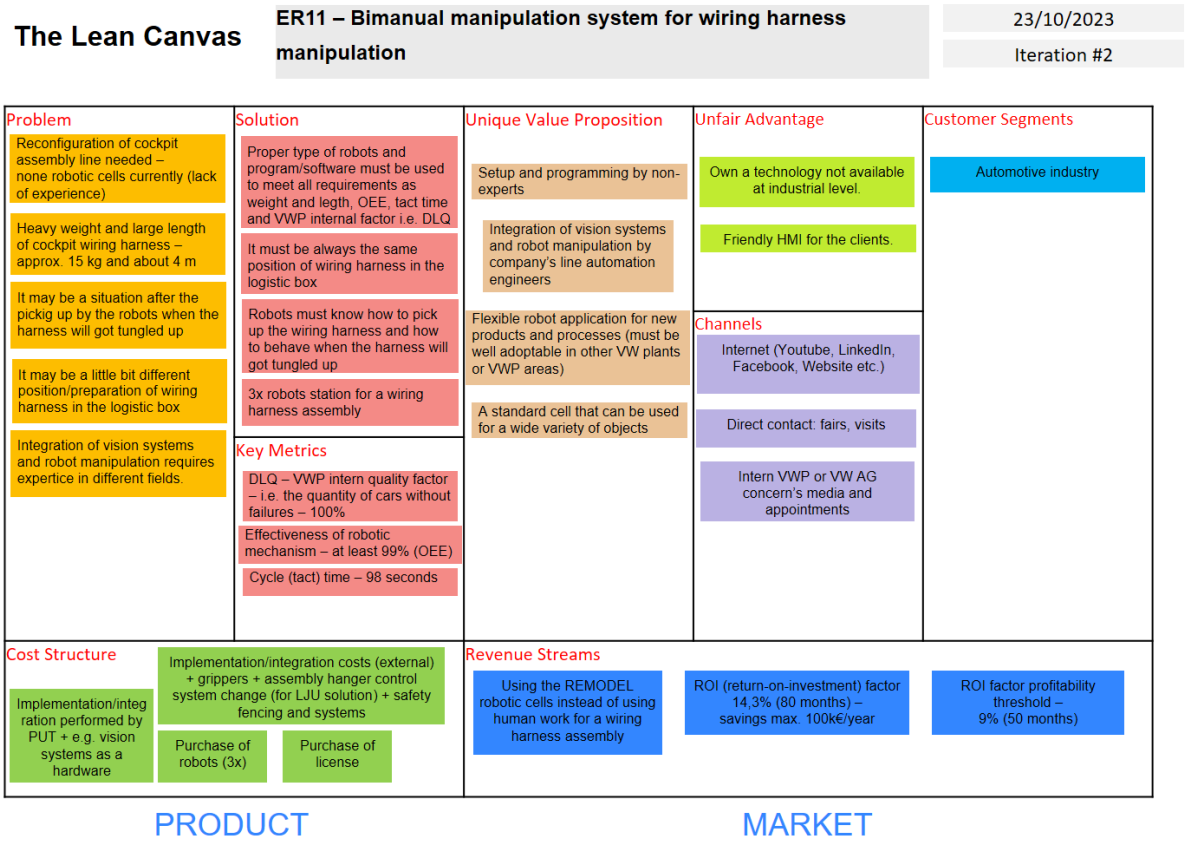
- Programming time
- Configuration and deployment time
- Cycle time

5.9.3 Return of investment

Return of Investment (ROI) is difficult to calculate since more data is required.

5.10 ER11- Bimanual manipulation system for wiring harness manipulation (VWP)

5.10.1 Business model



As analyzed at the beginning of REMODEL Project, the targeted customers are end-users which are mostly or partly involved in wiring harness assembly use case. Main aim is to replace human work by robotic station. Human resources may be implemented to other tasks or developed with new skills e.g. maintenance and automation.

If a robotic station will work, then other VW AG facilities may be interested in implementation of VWP Pilot in their production lines. Such solution might be also successfully implemented in other automotive factories worldwide (with possible adjustments if needed).

5.10.2 Cost structure and KPIs

State as of 14.07.2023: for VWP Pilot – just for an assembly of hardware, preparation of safety fencing, renting of robots – about 150k € have been spent. Programme for both robots is being developed internally by colleagues from PUT.

The following costs should be took into account to a cost structure:

- Hardware – robots, grippers, cameras, logistic racks, safety fencing and devices, any other tools or devices previously not defined.
- Software – programming of robots and safety – safety Profinet, SafeMove etc.
- Integration of robotic station – with all rules and regulation, in accordance with the Machinery Directive (CE sign).
- Possible costs of licenses – to be defined till the end of REMODEL Project.

- Cost of reorganization, necessary for implementation after REMODEL Project – should be estimated by an integrator.
- Possible cost of lack of required infrastructure - should be estimated by an integrator.
- Start-Of-Production (SOP) Support and possible training courses for maintenance staff.

Main KPIs which are strictly important at VWP:

- DLQ – VWP intern quality factor – i.e. the quantity of cars without failures.
- Effectiveness of robotic station – at least 99% (OEE).
- Tact time – about 65 seconds for a robot. Current human work – about 98 seconds.

Status as of 20th of October 2023:

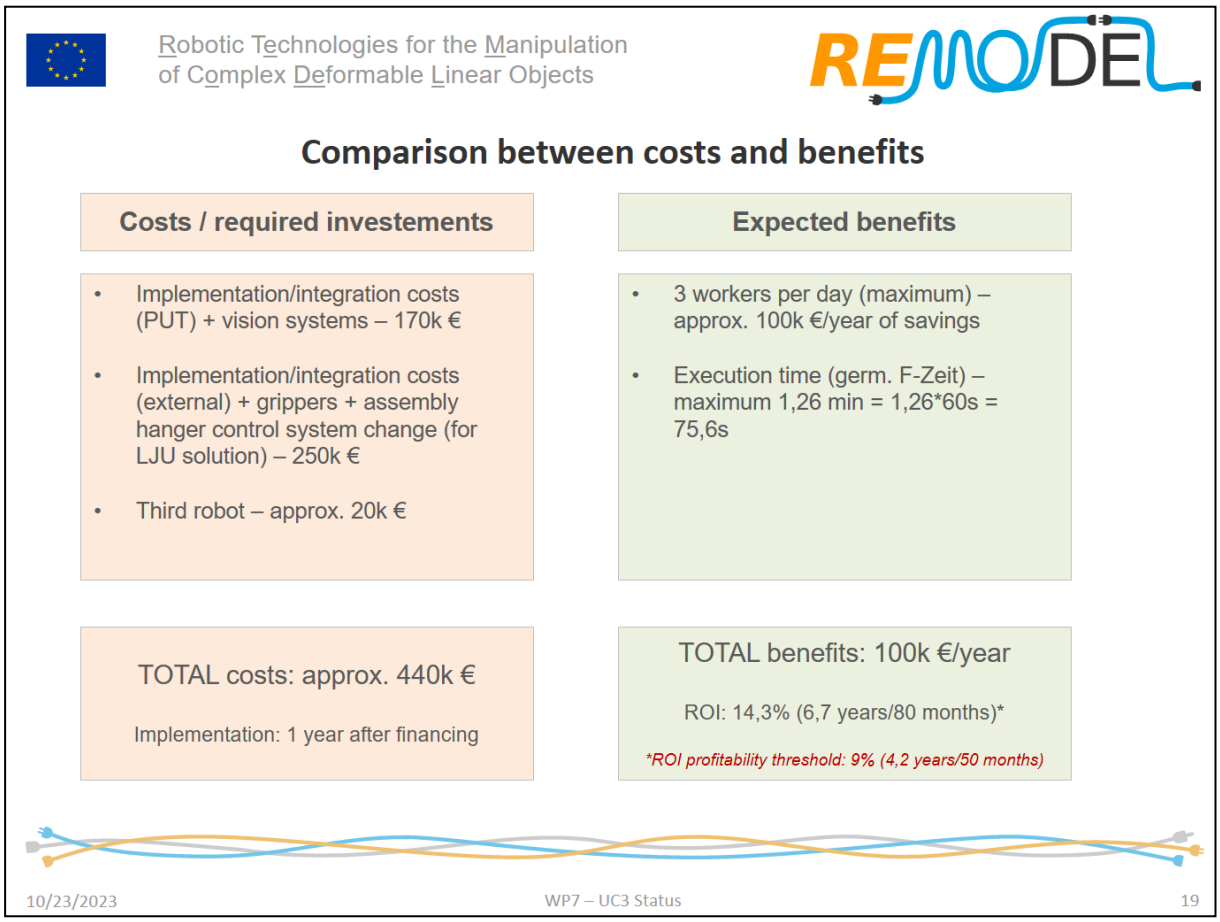
Based on above listed KPIs, the percentage achieved (success rate) is as follows:

- DLQ – based on performed tests during demonstration, there was no failures/damages on a wiring harness, so 100% of DLQ is attainable.
- Effectiveness of robotic station – based on tests performed before last Project Meeting (8 times), there was no failure during execution. If that situation would be possible also by repeating tasks e.g. 750 times without failure, then such factor would be satisfactory.
- Tact time – last update of robotic station is about 3 minutes and 30 seconds (210 seconds in total). So still about 110 seconds left to optimization. Detailed table for time-optimization to TRL9 has been worked out. Based on that prediction, expected tact time is attainable. Current KPI is on a level of about 40% achieved.

5.10.3 Return of investment

Regarding to return on investment (further written as ROI) is difficult to estimate without all required data. In order to define ROI, first a demo of VWP Pilot has been done and it has to work properly within assumed tact time. Then all costs should be estimated, starting from hardware, though software, integration in accordance with the Machinery Directive (CE sign) and meeting all rules and regulation for implementation permit, ending on possible costs of licenses (after the end of REMODEL Project). Having all abovementioned factors may estimate if the project is viable and implementation-worthy.

Update from 23th of October 2023:



Regarding to abovementioned costs:

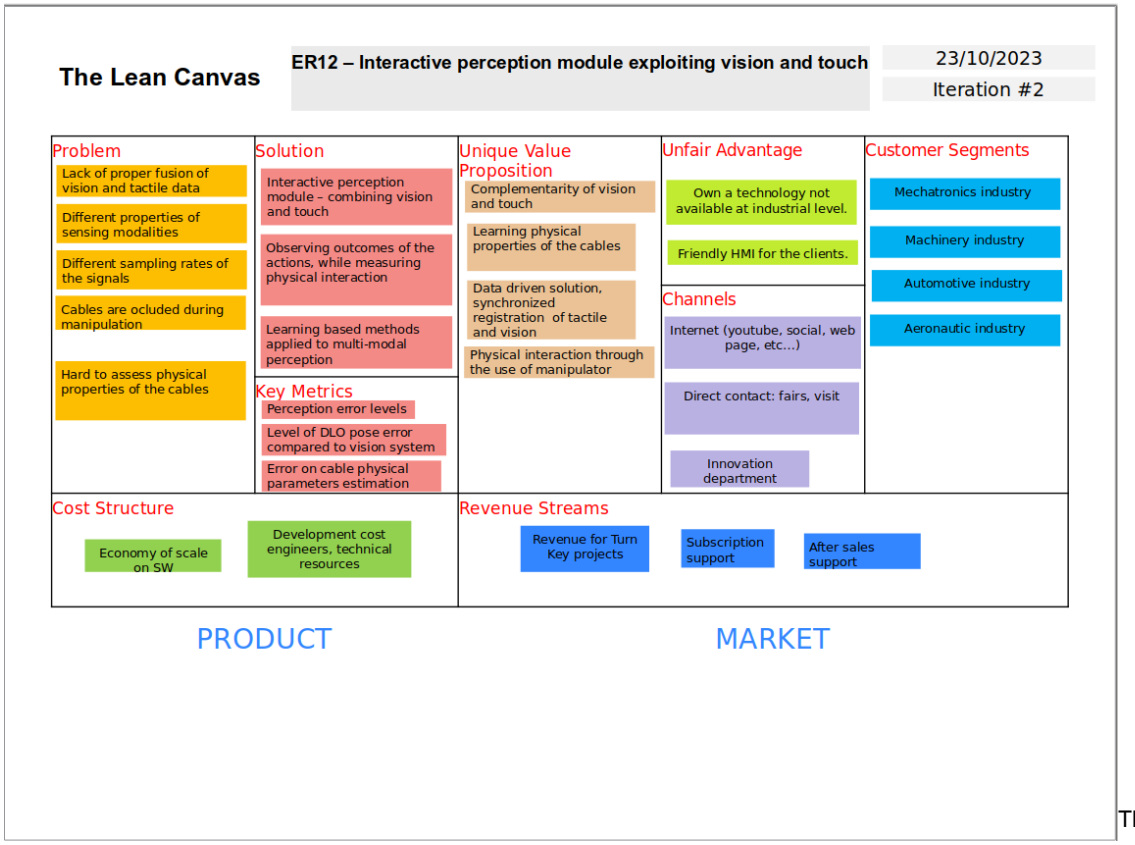
- Implementation/integration performed by PUT + e.g. vision systems as a hardware – cost at least 170k €. It is crucial to mention that these costs are only the estimated ones. Minimum cost contain service part i.e. about 18 months of PUT work at VWP facilities in implementation and integration activities and also license part. That second part must be calculated precisely. Till now there is only an estimated cost of about 20k € license just for this one robotic station or limitless license for further free usage about 300k €. Additionally PUT mentioned (within limitless license) about a percentage of revenues from the use of the license – approx. 20%, negotiable – that is unacceptable by VWP. These numbers are not confirmed and must be calculated by an extern company.
- Implementation/integration costs (external) + grippers + assembly hanger control system change (for LJU solution) – cost about 250k €. These costs contain: modernization of assembly hanger control system (LJU), splitting of control system for three independent zones, purchase of grippers (3x), adding of PN/PN Coupler between PLC groups, modernization of safety zones, new safety fencing, new safety curtains, 1x roller conveyor, positioning of control box by a robot, electrical cabinet in VASS standard, safety mats (entry and exit) modernization of HMI panel in VW standard. These numbers are not confirmed and must be calculated during a purchase process.
- Purchase of third robot – estimated cost of 20k €.

Comparing these costs to benefits:

- REMODEL station may have impact for time-optimization of about 76 seconds at TRL9. It is crucial to point that currently human performs not only a wiring harness assembly (approx. 75 seconds), but is responsible for a car heater assembly and leather cover placing on a cockpit hanger. Therefore still about 20 seconds left as a work to do. There is no potential for full optimization of that work station.
- If assume that human would perform only a wiring harness assembly (75 seconds), then it would be a potential for full robotization of a work station. Then a savings would be on a level 100k€/year, including 3 shifts work. These costs are calculated and confirmed by VWP internal controlling department.
- Based on these savings and required costs, the ROI factor would be equal to 14,3%, so after about 6,7 years (80 months) an investment should be returned. Minimum threshold of profitability of ROI factor for an innovative projects in VW Group is equal to 9% (4,2 years = 50 months).

5.11 ER12- Interactive perception module exploiting vision and touch (PUT)

5.11.1 Business model



The current state of ER is at the TRL 5; the potential customers are car manufacturers and wiring harness producers for different industries. The planned final objective is to develop the system and license it.

5.11.2 Cost structure and KPIs

Providing the system at TRL 9 would require investment in Person Months equal to 90 000 EUR.

KPI is the precision of cable routing 10% higher than with pure vision.

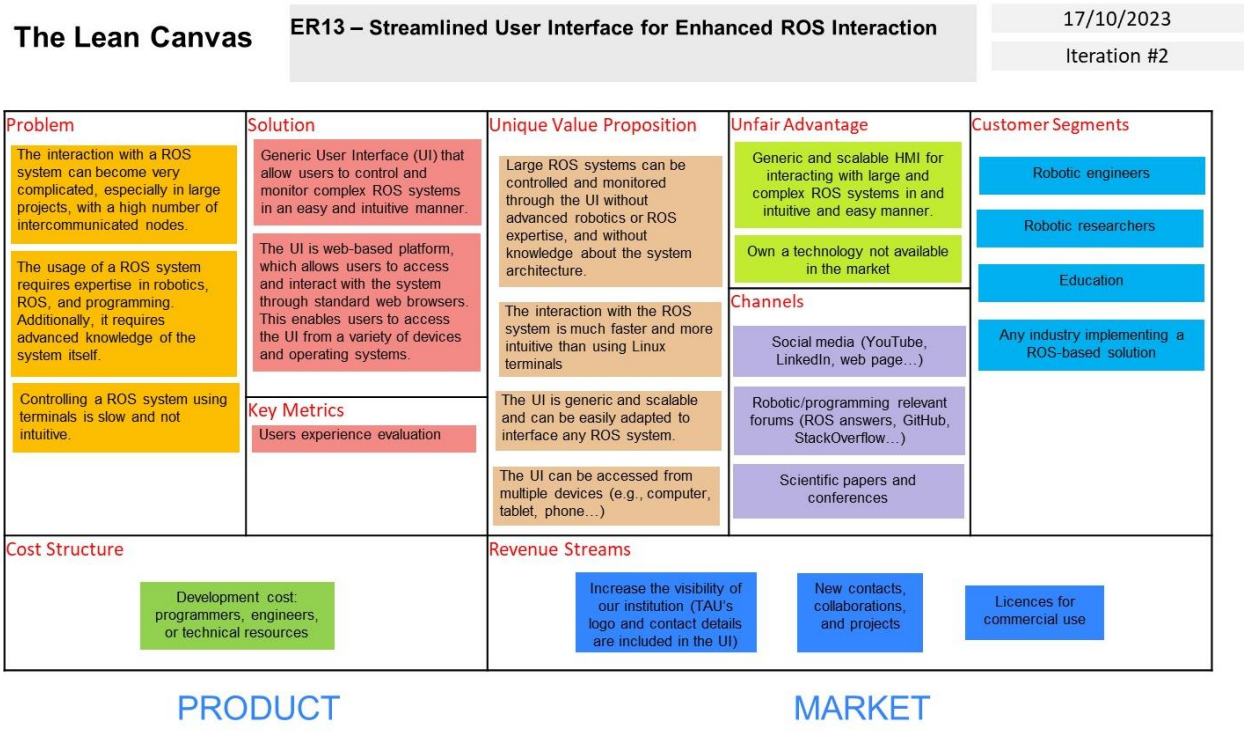
KPI selling 3 systems in first year at a cost 30 000 EUR.

5.11.3 Return of investment

For the companies who buy our system. Taking into account the cost of work at the company in industry in Poland. The mean gross salary in Poland for the industry for 2023 is 1650 EUR/month, hence the employer cost is 2000 EUR. Taking into account 3 shifts the cost is 6000 EUR per month. Return on investment if we provide support on a manufacturing cell would be 30 000 EUR/6 000 EUR/month = 5 months

5.12 ER13 - Streamlined User Interface for Enhanced ROS Interaction (TAU)

5.12.1 Business model

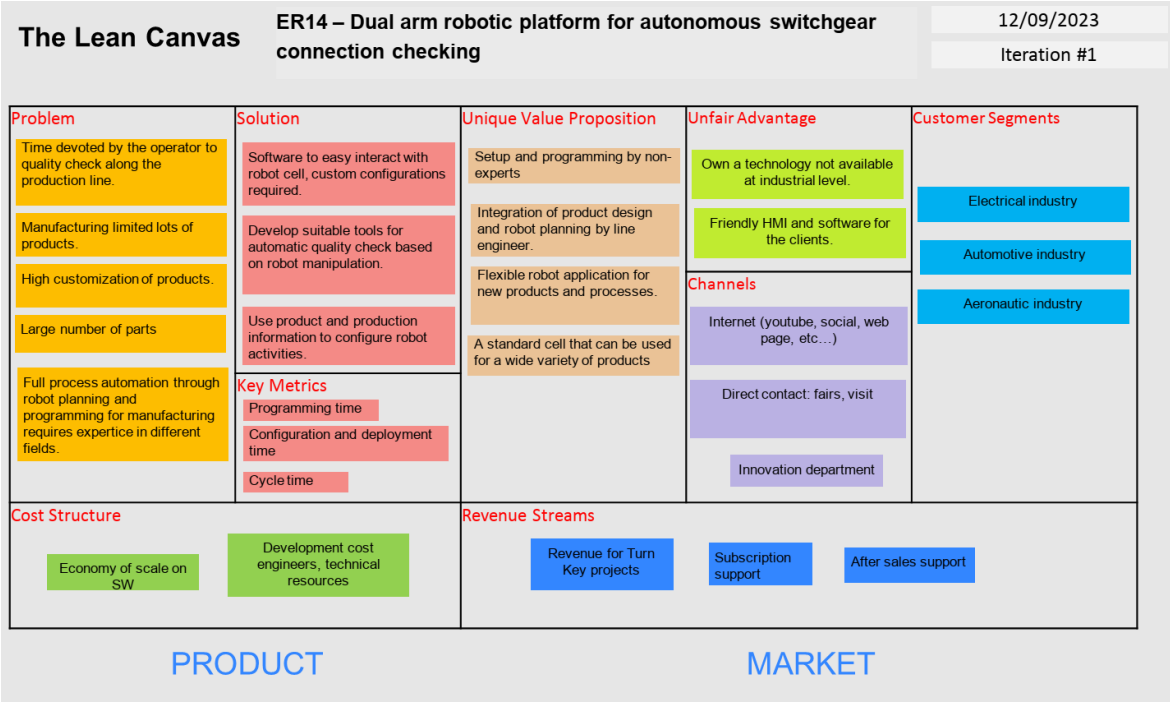


The targeted customers are robotic engineers and researchers. In recent years, ROS is experiencing significant growth in popularity within the robotic community due to its numerous advantages, such as its modularity, flexibility, compatibility and easy integration with different robotic system and components, and its increasing number of tools and libraries. However, the interaction with a ROS system can become very complicated, especially in large projects, with a high number of intercommunicated nodes. Currently, there are not many solutions available for this problem, and the existing ones are either basic or tailored to a specific application. The UI developed for the REMODEL problem fills this gap offering a generic and advanced application to interact with complex ROS systems in an easy and intuitive manner. Due to this, we expect this ER to have a high demand within the robotic community, disseminating the project and our institution (TAU). With this, we aim to increase the visibility of our institution, which can be translated into new projects and collaborations.

The UI will be made available as an open-source solution, allowing its use by educational institutions, researchers, and individual users. However, for commercial purposes, a license will be required to utilize the interface. To disseminate this ER and reach our targeted customers, we will use present the UI solution in scientific publications, conferences, social media (youtube videos, LinkedIn posts…), and robotic/software relevant forums (ROS answers, StackOverflow…).

5.13 ER14 - Dual arm robotic platform for autonomous switchgear connection checking (UNIBO)

5.13.1 Business model



The current state of ER is at TRL 6; the potential customers are manufacturers of switchgears for any field of application. A spin-off called RoboSECT has been created on the base of this result, for the further development and the commercialization. At the current state, the platform is successfully capable to execute the connection testing of variable switchgear in a laboratory setup.

The spin-off project has also been awarded in different context winning the third place at the Emilia-Romagna StartCup2023 competition and Top3 startup in the Italian 'Premio Nazionale Innovazione 2023' in the category for industrial projects.

5.13.2 Cost structure and KPIs.

The variable cost associated to the production of a platform depends on the cost of the two robotic arms chosen for the platform. UNIBO consider the adoption of two collaborative robots, in particular two UR5s from the universal robot. The robot satisfies most of the safety constraint and the payload requirements of the application. The robot cost is estimated to be around 40k, that summed with the cost of production of the tool used by the robot bring the price of the overall production platform to 45K€.

The final business model is structured as a B2B, where the software license will be directly sold to the user while the platform installation will be subcontracted to a third company for the installation. This will enable us to reduce the cost and the number of personnel required and a to focus on the software development part.

A more detail representation of the cost is included in the table, where are also reported the cost associated to the general cost such as the equipment (e.g. workstation, furniture, materials),

Variable Costs							
Transport Variable Costs	0,00	0,00	0,00	1.000,00	1.500,00	4.000,00	***6.500,00***
Production Variable Costs	0,00	0,00	1.500,00	15.000,00	75.000,00	240.000,00	***331.500,00***
Total Variable Costs	**0,00**	**0,00**	**1.500,00**	**16.000,00**	**76.500,00**	**244.000,00**	***338.000,00***
Business Cost							
Marketing	0,00	0,00	500,00	10.000,00	500,00	500,00	***11.500,00***
Totale	**0,00**	**0,00**	**500,00**	**10.000,00**	**500,00**	**500,00**	***11.500,00***
General Costs							
Cleaning Services	0,00	0,00	3.600,00	3.600,00	3.600,00	3.600,00	***14.400,00***
Utilitites	0,00	0,00	3.000,00	3.000,00	3.000,00	3.000,00	***12.000,00***
Costi IT	525,00	700,00	1.325,00	1.325,00	1.500,00	1.501,00	***6.876,00***
Office Supplies	150,00	450,00	600,00	1.050,00	1.050,00	1.200,00	***4.500,00***
Insurance	180,00	540,00	720,00	1.260,00	1.260,00	1.440,00	***5.400,00***
Web Platform	0,00	0,00	300,00	300,00	300,00	300,00	***1.200,00***
Commercial Consulting	500,00	500,00	1.000,00	2.000,00	2.000,00	2.000,00	***8.000,00***
Legal Consulting	1.000,00	3.000,00	5.000,00	10.000,00	12.000,00	12.000,00	***43.000,00***
Total	**2.355,00**	**5.190,00**	**15.545,00**	**22.535,00**	**24.710,00**	**25.041,00**	***95.376,00***
Staff costs	**7.506,00**	**55.974,00**	**80.994,00**	**161.565,00**	**217.255,00**	**221.455,00**	***744.749,00***
Amortisation							
Amort. Intagible Assets	1.000,00	1.250,00	2.250,00	2.250,00	3.000,00	2.000,00	***11.750,00***
Amort. Tangible Assets	3.920,00	13.460,00	13.696,00	23.676,00	23.756,00	21.892,00	***100.400,00***
Total	**4.920,00**	**14.710,00**	**15.946,00**	**25.926,00**	**26.756,00**	**23.892,00**	***112.150,00***

The main KPI's of the ROBOsect platform are (and achieved in REMODEL):

- Automatization of the switchgear connection testing for single unit switchgear (90%)
- Reduce of testing time (30 min per item).
- Improved control over the production (100% testing and automatic reporting).
- Reduced of stressful and repeating task for human-operator (14 man hours reduction per shift)

5.13.3 Return of investment

The return of investment is obtained by considering a time horizon of 6 years. We consider the first two year of development required to bring the platform to TRL 9. The first unit sold is planned to be at the third year.

During the period we consider an overall adoption of the platform of 70 units. Based on the estimation obtained from the earlier results, we estimate that a company like IEMA will requires an approximately 12 platform to cover his entire annual production.

Each software license has a price of 30k€ with a yearly renewable cost of 10K€. We also consider offering an additional on-site assistance package of 8K€, since is optional, we consider an acceptance rate of 20% for platform sold.

Finally, we also consider the direct installation of the platform without the use of third-party contractor for it., since is not the primary business, we consider installing directly only about the 7% of the platforms.

Sales	***Y1***	***Y2***	***Y3***	***Y4***	***Y5***	***Y6***	***Total***	***Unitary Price***
Licence Renew al	0	0	0	1	11	32	**44**	**10.000,00**
On-Site Assistance	0	0	0	0	2	6	**8**	**8.000,00**

Sales	***Y1***	***Y2***	***Y3***	***Y4***	***Y5***	***Y6***	***Total***	***Unitary Price***
Softw are License	0	0	1	10	20	40	**71**	**30.000,00**
Robot Tool	0	0	1	10	20	40	**71**	**6.000,00**
Direct Installation	0	0	0	0	1	4	**5**	**120.000,00**

Given the previous consideration we proceed to obtain the overall performance of the business. The results estimate the first year in negative with the reaching of the financial break-even points by the end of the fourth year. We also estimate the amount of initial cash required to cover the startup costs. We plan to partially meet this requirements through the possible financial opportunity offered by tech incubator, which typically can offer 150K for about 10% of the shares of the company.

	Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Total*
Net Income	-14.781,00	-75.874,00	-78.582,85	116.017,23	453.618,81	1.269.777,01	***1.670.175,19***
Amortisation	4.920,00	14.710,00	15.946,00	25.926,00	26.756,00	23.892,00	112.150,00
Investment	-27.000,00	-53.100,00	-6.900,00	-50.100,00	-600,00	-3.400,00	-141.100,00
Lend/Mortage	0,00						
Cash Flow	**-36.861,00**	**-114.264,00**	**-69.536,85**	**91.843,23**	**479.774,81**	**1.290.269,01**	***1.641.225,19***

	Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	
Break even point (BEF)	**-36.861,00 €**	**-151.125,00 €**	**-220.661,85 €**	**-128.818,62 €**	**350.956,18 €**	**1.641.225,19 €**	

6 Conclusions

REMODEL focuses on tackling crucial challenges related to the deployment of robotic systems capable of handling wires, cables, and wiring harnesses. The results of REMODEL have broad applications across various industrial manufacturing processes currently performed manually, including tasks like switchgear wiring, the manufacturing and assembly of wiring harnesses, and the manipulation of hoses for medical devices, among others.

This document reports a summary of the exploitable results developed in the REMODEL project and of the way how they will be exploited by the industrial and academic partners. Moreover, the document includes a more general overview of the business plan and return of investment for the future exploitation of the project outcome by third parties.

These results will for sure in the future generate new business possibilities for the project partners and increase the competitiveness of the industrial partners.

7 Annex

Background – ER1 – TECNALIA	
ID	CATIA Application for flexible robot programming
Owner(s)	TECNALIA
Nature	Software
Registration / Protection	Confidential Information
Description	A software application developed by TECNALIA during different projects to generate robotic programs using information from CAD(3D) models and a skill-based system. This application was made through an easy programming framework in which the user creates the robot program using the developed skills.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER3 – UNIBO	
ID	Generation of robot planning from product CAD files for switchgear wiring
Owner(s)	UNIBO
Nature	Software
Registration / Protection	Confidential Information
Description	A software package has been developed by UNIBO during the WIRES project to generate the robot plan for the switchgear wiring starting from the information provided by the product design. This software package have been provided to the partners for the integration in the REMODEL demonstrators.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER3 – IEMA	
ID	Generation of robot planning from product CAD files for switchgear wiring
Owner(s)	IEMA
Nature	Software
Registration / Protection	Confidential Information
Description	During the Wires project and since the start of REMODEL IEMA provides CAD file which are used by UNIBO software for extrapolation of datas and all the information used by robot planning for the switchgear wiring.

Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER4 – UNIBO	
ID	Multi-sensorized modular and reconfigurable manipulation tools.
Owner(s)	UNIBO
Nature	Hardware and Software
Registration / Protection	Confidential Information
Description	A first multi-sensorized device has been developed by UNIBO during the WIRES Experiment within the ECHORD++ project. In REMODEL UNIBO is developing the actuation system for the manipulation of Deformable Linear Objects. Also the integration of a vision system is under evaluation in T6.3. Separate ROS nodes are under development for each component.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes.

Background – ER4 – UCLV	
ID	Multi-sensorized modular and reconfigurable manipulation tools.
Owner(s)	UCLV
Nature	Hardware and Software
Registration / Protection	Tactile sensor patented (n° 0001400420, 2010) / Confidential Information
Description	A first multi-sensorized device has been developed together during the WIRES Experiment within the ECHORD++ project. It exploited UCLV patented tactile sensor. In REMODEL a new version of sensorized finger is under development in T6.2 by UCLV: it includes tactile sensor (patented) and proximity sensor. Separate ROS nodes are under development for each sensor.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes.

Background – ER5 – UNIBO	
ID	Dual arm robotic platform for switchgear wiring
Owner(s)	UNIBO
Nature	Hardware and Software

Registration / Protection	Confidential Information
Description	UNIBO implemented a single arm solution for switchgear wiring during the WIRES project. The platform is provided with a software package for collision checking that can be adapted to different robot models. Collision capabilities are exploited to verify the robot plan and adjust it accordingly. The ARIADNE software developed by UNIBO during the WIRES project can be used to detect from images deformable linear objects in the scene retrieving spline models of the objects. This software is a basic component of the dual-arm robotic platform for switchgear wiring. These hardware and software will be exploited for the development of the REMODEL demonstrators.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER5 – UCLV	
ID	Dual arm robotic platform for switchgear wiring
Owner(s)	UCLV
Nature	Hardware and Software
Registration / Protection	Tactile sensor patented (n° 0001400420, 2010) / Confidential Information
Description	Two sensorized fingers with tactile sensors developed by UCLV have been produced to be integrated into the PANDA Robot parallel gripper available in UNIBO laboratory for the REMODEL demonstrator. The fingers have been shipped to UNIBO and correctly integrated both from a mechanical and software point of view. Two ROS nodes have been provided for the acquisition of tactile map and for the reconstruction of the shape of grasped wires.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	The fingers can be used only for project activities. No available use for commercial purposes. They can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER5 – IEMA	
ID	Dual arm robotic platform for switchgear wiring
Owner(s)	IEMA
Nature	REMODEL PILOT
Registration / Protection	Confidential Information
Description	During the WIRES project, IEMA collaborated with UNIBO for the development of the project for the wiring of electrical panels by a robotic arm. IEMA formalized and introduced a series of mechanisms for the generation of a CAD that are interfaced and processed by UNIBO software packages, and produced some switchgears for test purpose.

Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER6 – ENKI	
ID	Manipulator for Quality Checks in Extrusion Processes in biomedical industry
Owner(s)	ENKI
Nature	Knowledge
Registration / Protection	Confidential Information
Description	ENKI has long experience in the design and production of medical hoses. ENKI knows which are the procedure for their internal quality check, including the methods, procedures, hardware and software tools to be adopted for that purpose. Specific strategies and solutions have been designed and implemented in ENKI to perform the quality check of their extruded hoses. This knowledge will be exploited for the development of the REMODEL demonstrators.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER6 – UNIBO	
ID	Manipulator for Quality Checks in Extrusion Processes in biomedical industry
Owner(s)	UNIBO
Nature	Hardware and Software
Registration / Protection	Confidential Information
Description	UNIBO implemented a single arm solution for switchgear wiring during the WIRES project. The platform is provided with a software package for collision checking that can be adapted to different robot models. Collision capabilities are exploited to verify the robot plan and adjust it accordingly. The ARIADNE software developed by UNIBO during the WIRES project can be used to detect from images deformable linear objects in the scene retrieving spline models of the objects. This software is a basic component for the manipulation and quality check in extrusion processes for biomedical industry. This hardware and software will be exploited for the development of the REMODEL demonstrators.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.

Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER6 – UCLV	
ID	Manipulator for Quality Checks in Extrusion Processes in biomedical industry
Owner(s)	UCLV
Nature	Hardware and Software
Registration / Protection	Tactile sensor patented (n° 0001400420, 2010) / Confidential Information
Description	Two sensorized fingers with tactile sensors developed by UCLV have been produced to be integrated into the PANDA Robot parallel gripper available in UNIBO laboratory for the REMODEL demonstrator. The fingers have been shipped to UNIBO and correctly integrated both from a mechanical and software point of view. Two ROS nodes have been provided for the acquisition of tactile map and for the reconstruction of the shape of grasped tubes.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	The fingers can be used only for project activities. No available use for commercial purposes. They can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER7 – UNIBO	
ID	Dual arm robotic platform for Automotive Industry
Owner(s)	UNIBO
Nature	Hardware and Software
Registration / Protection	Confidential Information
Description	UNIBO implemented a single arm solution for switchgear wiring during the WIRES project. The platform is provided with a software package for collision checking that can be adapted to different robot models. Collision capabilities are exploited to verify the robot plan and adjust it accordingly. The ARIADNE software developed by UNIBO during the WIRES project can be used to detect from images deformable linear objects in the scene retrieving spline models of the objects. This software is a basic component of the dual-arm robotic platform for Automotive Industry. This hardware and software will be exploited for the development of the REMODEL demonstrators.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER8 – UNIBO

ID	CAD Platform Interface to provide the system planner, the layout and product inputs
Owner(s)	UNIBO
Nature	Software
Registration / Protection	Confidential Information
Description	A software package has been developed by UNIBO during the WIRES project to extract the information required to generate the robot plan for the product design files provided by the EPLAN/ProPanel CAD platform. This software provides the basic interface the system planner for the robotic activities. This software package have been provided to the partners for the integration in the REMODEL demonstrators.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER8 – IEMA	
ID	CAD Platform Interface to provide the system planner, the layout and product inputs
Owner(s)	IEMA
Nature	Software
Registration / Protection	Confidential Information
Description	IEMA helped UNIBO in building a software to extract the information of the product design files provided by the EPLAN/ProPanel CAD platform. These information will be used by the robot to generate the plan.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER8 – ELIMCO	
ID	CAD Platform Interface to provide the system planner, the layout and product inputs.
Owner(s)	ELIMCO
Nature	Software
Registration / Protection	Industrial secret / Confidential Information
Description	Elimco provided its manufacturing knowledge about the CAD/CAM process of the aeronautical wiring harnesses production.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.

Licensees for use	Can be used only for project activities. No available use for commercial purposes.

Background – ER9 – ELIMCO	
ID	Integrated Dual arm manipulation system for interconnection systems automatic manufacturing process.
Owner(s)	ELIMCO
Nature	REMODEL PILOT
Registration / Protection	Industrial secret / Confidential Information
Description	The company background within this exploitable result is related to the use case itself. Elimco has provided the manufacturing knowledge about this particular type of harnesses in order to advance towards its automation.
Access conditions for research in the project / Limitations	Free to be used inside the project.
	Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	Details about the manufacturing process can be used within the project framework.
Licensees for use	Can be used only for project activities. No available use for commercial purposes.

Background – ER9 – TECNALIA	
ID	Integrated Dual arm manipulation system for interconnection systems automatic manufacturing process.
Owner(s)	TECNALIA
Nature	Hardware and Software
Registration / Protection	Confidential Information
Description	TECNALIA implemented a dual-arm robotic solution manipulation during the VERSATILE project. The solution allows the easy development of new applications by non-expert users while ensuring the correct execution of the new robot trajectories. Therefore, this solution will be used as the basis for the REMODEL solution for wire-harness manufacturing. This hardware and software will be exploited and enhanced to adapt them to the requirements of the manipulation of deformable linear objects.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER10 – ELIMCO	
ID	Automated robot / sensor calibration toolkit
Owner(s)	ELIMCO

Nature	Software
Registration / Protection	Industrial secret / Confidential Information
Description	Elimco provided manufacturing knowledge that helps for the ER development. Also, an industrial perspective has been shared with the consortium.
Access conditions for research in the project / Limitations	Free to be used inside the project.
	Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes.

Background – ER10 – TUM	
ID	Automated robot / sensor calibration toolkit
Owner(s)	TUM
Nature	Software
Registration / Protection	Copyright / Confidential Information
Description	This software performs automated hand-eye of a robot with a 3D sensor. The development of this toolkit was started by TUM in the HORSE project (TRL 1-3). The prototype demonstrated the markerless, extrinsic calibration of an eye-in-hand LiDAR sensor (e.g. Hokuyo UTM or Sick TIM series) on a KUKA LBR iiwa. The software works with any industrial robot and LiDAR scanner supported by ROS. It is further recommended that both devices are intrinsically calibrated themselves first.
Access conditions for research in the project / Limitations	Free to be used inside the project.
	Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes.

Background – ER10 – VWP	
ID	Automated robot / sensor calibration toolkit
Owner(s)	TUM / VWP as Intellectual Property Rights Partner
Nature	Software (tool)
Registration / Protection	Copyright / Confidential Information
Description	This software enables an automated calibration of robots and 3D sensors. The development of this toolkit was started by TUM in the HORSE project (TRL 1-3) and further developed on the basis of each use case (know-how, experience and knowledge belonging to industrial partner). In VWP case it means UC3 – wiring harness assembly.
Access conditions for research in the project / Limitations	Free to be used inside the project.
	Confidential.
Access conditions for use / Limitations	Access for use is enabled for whole VW AG concern regarding to Consortium Agreement, where whole concern was reported as a third parties for simplified transfer of results (see attachment 3 of

	the CA).
Licensees in the project	To be treated confidential, by the rules and regulations of project CA.
Licensees for use	VWP and concern VW AG are interested in using of together performed results in order to manufacture the car cockpits (commercial purposes) – free of charge or on very concessional terms.

Background – ER10 –IEMA	
ID	Automated robot / sensor calibration toolkit
Owner(s)	IEMA
Nature	Software
Registration / Protection	Copyright / Confidential Information
Description	During the WIRES project IEMA helped in the analysis and recognition of electronic component by the vision system and produced CAD model of the objects to detect.
Access conditions for research in the project / Limitations	Free to be used inside the project.
	Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER11 – VWP	
ID	Bimanual manipulation system for wiring harness manipulation
Owner(s)	VWP
Nature	REMODEL Pilot
Registration / Protection	Copyright / Confidential Information
Description	The REMODEL Pilot is combined of equipment and software (results) developed in others WPs. Pilot is based on know-how, experience and knowledge belonging to industrial partner. Then is further developed at VW plant by the cooperation of all involved partners in order to finish the REMODEL Pilot. In VWP case it means UC3 – wiring harness assembly. To assure the real production conditions, test station must be adjusted properly.
Access conditions for research in the project / Limitations	Free to be used inside the project.
	Confidential.
Access conditions for use / Limitations	Access for use is enabled for whole VW AG concern regarding to Consortium Agreement, where whole concern was reported as a third parties for simplified transfer of results (see attachment 3 of the CA). Free to be used only for the partners inside the project (for project purposes).
Licensees in the project	To be treated confidential, by the rules and regulations of project CA.
Licensees for use	Licensees for use is enabled for whole VW AG concern regarding to Consortium Agreement, where whole concern was reported as a third parties for simplified transfer of results (see attachment 3 of the CA). VWP and concern VW AG are interested in using of together performed results in order to manufacture the car cockpits (commercial purposes) – free of charge or on very concessional terms. It strictly forbidden to share individually all drawings, data and other company's information (know-how, knowledge) to the third parties – both during the project and after finishing of him. These data should be authorized by VWP.

Background – ER11 – UNIBO	
ID	Bimanual manipulation system for wiring harness manipulation.
Owner(s)	UNIBO
Nature	Hardware and Software
Registration / Protection	Confidential Information
Description	UNIBO implemented a single arm solution for switchgear wiring during the WIRES project. The platform is provided with a software package for collision checking that can be adapted to different robot models. Collision capabilities are exploited to verify the robot plan and adjust it accordingly. The ARIADNE software developed by UNIBO during the WIRES project can be used to detect from images deformable linear objects in the scene retrieving spline models of the objects. This software is a basic component of the bimanual manipulation system for wiring harness manipulation. These hardware and software have been provided to the partners for the integration in the REMODEL demonstrator.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	The ARIADNE software can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER11 – UCLV	
ID	Bimanual manipulation system for wiring harness manipulation.
Owner(s)	UCLV
Nature	Hardware and Software
Registration / Protection	Tactile sensor patented (n° 0001400420, 2010) / Confidential Information
Description	Two sensorized fingers with tactile sensors developed by UCLV have been produced to be integrated into the OnRobot RG2 parallel gripper available in PUT laboratory for the REMODEL demonstrator. The fingers have been shipped to PUT and correctly integrated both from a mechanical and software point of view. A ROS node have been provided for the acquisition of tactile map.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	The fingers can be used only for project activities. No available use for commercial purposes. They can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER11 – PUT

ID	**Bimanual manipulation system for wiring harness manipulation**
Owner(s)	**PUT**
Nature	**REMODEL Pilot**
Registration / Protection	**Copyright / Confidential Information**
Description	**The REMODEL Pilot is combined of equipment and software (results) developed in other WPs. Pilot is based on know-how gathered during integration of TRL4 solution at PUT premises using own hardware and software.**
Access conditions for research in the project / Limitations	**Free to be used inside the project.**
	Confidential.
Access conditions for use / Limitations	**Free to be used only for the partners inside the project (for project purposes).**
Licensees in the project	**To be treated confidential, by the rules and regulations of project CA.**
Licensees for use	**PUT is interested in using obtained results if there are opportunities to commercialize the outcomes together with involved project partners.**

Background – ER12 – UNIBO	
ID	Interactive perception module exploiting vision and touch
Owner(s)	UNIBO
Nature	Software
Registration / Protection	Confidential Information
Description	UNIBO developed software packages to exploit vision and tactile sensors for cable grasping and manipulation during the WIRES project. This software can be used to correct the pose of cables for cable terminal connection starting from initial guess provided by the tactile sensors and using a camera to detect the cable tip orientation. Tactile feedback is also used in the control of the insertion phase to detect failures and to verify the correct connection after insertion. This software will be exploited for the development of the REMODEL demonstrators.
Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER12 – UCLV	
ID	Interactive perception module exploiting vision and touch
Owner(s)	UCLV
Nature	Software
Registration / Protection	Tactile sensor patented (n° 0001400420, 2010) / Confidential Information
Description	Sensorized fingers with tactile sensors developed by UCLV have been produced to be integrated into different commercial parallel grippers available in partners' laboratories. Two ROS nodes have been provided for the acquisition of tactile map and the reconstruction of shape for grasped DLOs. These data will be combined with vision data.

Access conditions for research in the project / Limitations	Free to be used inside the project. Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	The fingers can be used only for project activities. No available use for commercial purposes. They can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER12 – TUM	
ID	Interactive perception module exploiting vision and touch
Owner(s)	TUM
Nature	Software
Registration / Protection	Copyright / Confidential Information
Description	The development of the of REMODEL ER12 will be supported by TUM's general knowledge in object detection and perception. Moreover, TUM has developed the iiwa_stack ROS driver supporting the KUKA LBR iiwa robot and extensions for a number of grippers available in the iiwa_stack tools package. Both software components have been released as open source under BSD license: • https://github.com/exo-core/iiwa_stack • https://github.com/exo-core/iiwa_stack_tools
Access conditions for research in the project / Limitations	Free to be used inside the project.
	Confidential / Open Source.
Access conditions for use / Limitations	
Licensees in the project	BSD
Licensees for use	BSD

Background – ER12 – PUT	
ID	Interactive perception module exploiting vision and touch
Owner(s)	PUT
Nature	Software (complete solution)
Registration / Protection	Copyright / Confidential Information
Description	The interactive perception module is combining the previous outcomes of UNIBO, UCLV, TUM, PUT. In particular PUT has previous results of using touch and vision in materials recognition task. The outcomes are available to the consortium through publications and the code.
Access conditions for research in the project / Limitations	Free to be used inside the project.
	Confidential.
Access conditions for use / Limitations	Free to be used only for the partners inside the project (for project purposes).
Licensees in the project	To be treated confidential, by the rules and regulations of project CA.
Licensees for use	PUT is interested in using obtained results if there are opportunities to commercialize the outcomes together with involved project partners.

Background – ER13 – TAU	
ID	Streamlined User Interface for Enhanced ROS Interaction
Owner(s)	TAU
Nature	Software
Registration / Protection	Copyright / Confidential Information
Description	TAU has experience in creating web-based user interfaces (UI). In particular, TAU has developed: • A UI to control and monitor an entire robotic assembly line. • A UI to assist the user in a robot teaching by demonstration software. • A UI to assist the user in a virtual reality software. This web-based development experience will be exploited to create the REMODEL UI, whose aim is to ease the interaction of the user with the REMODEL ROS system.
Access conditions for research in the project / Limitations	Free to be used inside the project.
	Confidential.
Access conditions for use / Limitations	Free to be used only for the partners inside the project (for project purposes).
Licensees in the project	To be treated confidential, by the rules and regulations of project CA.
Licensees for use	Can be used only for project activities. No available use for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document

Background – ER14 – UNIBO	
ID	Dual arm robotic platform for autonomous switchgear connection checking
Owner(s)	UNIBO
Nature	Software
Registration / Protection	Confidential Information, patent pending
Description	During the WIRES project and in REMODEL, UNIBO developed a software for extrapolation of data and all the information used by robot planning for connection testing from the switchgear CAD file. In this software, UNIBO also implemented a methodology for the precise localization of components like the ones used in switchgear manufacturing based on geometric features instead of visual ones.
Access conditions for research in the project / Limitations	Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.

Background – ER14 – IEMA	
ID	Dual arm robotic platform for autonomous switchgear connection checking
Owner(s)	IEMA
Nature	Software

Registration / Protection	Confidential Information, patent pending
Description	IEMA provided the data about the switchgear design and the used components. The data are generated by the EPLAN/ProPanel software IEMA customized to provide all the information required for the interpretation of the design by the robotic platform. .
Access conditions for research in the project / Limitations	Confidential.
Access conditions for use / Limitations	Not transferable.
Licensees in the project	To be treated confidential, by the rules of project CA.
Licensees for use	Can be used only for project activities. No available for commercial purposes. It can be used for other activities after the definition of a Non-Disclosure Agreement (NDA) document.