PROJECT NO

101120731

PROJECT ACRONYM

MAGICIAN

PROJECT TITLE:

IMMERSIVE LEARNING FOR IMPERFECTION DETECTION AND REPAIR THROUGH HUMAN-ROBOT INTERACTION

CALL/TOPIC:

HORIZON-CL4-2022-DIGITAL-EMERGING-02-07

START DATE OF PROJECT:

01.10.2023

DURATION:

48 MONTHS

DELIVERABLE D1.2

First coordination report

DUE DATE OF DELIVERABLE:

30.09.2024

ACTUAL SUBMISSION DATE:

30.09.2024

Work Package	**WP1 - Project management**
Associated Task	**Task 1.1 Management and coordination of the project**
Deliverable Lead Partner	**UNITN**
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Version	**1.0**

DISSEMINATION LEVEL		
PU	Public	X
SEN	Sensitive - limited under GA conditions	

CHANGE CONTROL

DOCUMENT HISTORY

VERSION	DATE	CHANGE HISTORY	AUTHOR(S)	ORGANISATION
0.1	31.08.2024	First Draft	Daniele Fontanelli, Rita Martini	UNITN
0.2	15.09.2024	Second Draft	Daniele Fontanelli, Rita Martini	UNITN
0.3	26.09.2024	Third Draft with Use of Resources	E. Chiarani	UNITN
0.4	30.09.2024	Internal Review	E. Chiarani	UNITN
1.0	30.09.2024	Final Version	Daniele Fontanelli	UNITN

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting authority can be held responsible for them.

This deliverable is part of a project that has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement no. 101120731.

EXECUTIVE SUMMARY

This document contains the coordination activities and an overview of the progress of MAGICIAN. The document contains the description of the work carried out during the first year of the project, detailed for the different work packages, and a description of the exploitation activities.

The document reports also the estimated use of resources incurred by the partners, at least those that can be exposed to the public without restrictions, and a description on the open science management of the project.

This document will be updated in D1.3 (M24), in D1.5 (M36) and, at the end of the project, in D1.6 (M48).

DEVIATIONS

No deviation is foreseen from the planned path.

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LIST OF ABBREVATIONS

ACRONYM	DESCRIPTION
ANN	Artificial Neural Networks
CA	Consortium Agreement
D	Deliverable
DMP	Data Management Plan
DoA	Description of Action
EC	European Commission
GA	Grant Agreement

KPI	Key Performance Indicator
LfD	Learning from Demonstrations
QP	Quality Plan
ROL	Results Owner List
CR	Cleaning Robot
SR	Sensing Robot
WP	Work Package
WT	Work Task

1 INTRODUCTION

This deliverable is the first coordination report of MAGICIAN, detailing the work carried out in the first year, the developments towards the objectives listed in the Description of Action (DoA) and the activities breakdown par partner per work package (WP). The estimated use of resources is also reported. Finally, we will discuss the first impact results and the revision of the exploitation plan.

From the management viewpoint, all the activities have been carried out with the foreseen cooperation among the partners, with monthly meetings among WP leaders and per WP, with a monthly basis or whenever the work requested. It has to be noted that from this point on, the different technical developments will be orchestrated in tighter manner, in order to facilitate the integration of all the components in the first robotic solutions to be tested in the final environment.

We finally remark that two work packages, namely WP5 and WP6, did not start yet and will kick in in the second year of the project that is about to start.

2 EXPLANATION OF THE WORK CARRIED OUT AND OVERVIEW OF THE PROGRESS

In this first reporting period, the work followed the agenda depicted in the MAGICIAN DoA, in line with the reported project Gannt chart. At M4 the two main technical work packages, WP3 and WP4, started and the first version of the solutions have been provided. The MAGICIAN partners have already implemented some of the components of the final solution, which are currently under test, while others have been identified and some adaptations are currently ongoing: this was due by the peculiarities of the **TOFAS** use case that helped in reshaping the actual needs towards the project objectives.

In what follows, an overview of the project results towards the objectives of the action, including a summary of the deliverables and milestones, is reported. In the technical description below, please avoid repeating information that is already present in part A of the report (in continuous reporting). Since the project has the need to integrate social sciences and humanities, a detailed description of their role is given in the corresponding work package, i.e., WP2.

2.1 OBJECTIVES

The MAGICIAN's objectives and their descriptions are listed below, with a brief summary of their progress in this first year of the project towards their achievements.

Table 1 Objectives of the project

N°	DESCRIPTION	LEVEL OF ACHIEVEMENT
O1	A robotic perception module integrating visual and tactile sensors. The module will be embedded in a robotic sensor module (the SR, hereafter) and will be used for defects analysis and classification. The SR will replicate the skills of human workers through a learning scheme.	**KPI-SR1: Smallest size of defect that can be sensed/detected by the perception module (Target: ≤ 0.3mm).** *Status:* In the first year we have explored several alternative input modalities with the goal of detecting such small defects. Currently we're converging on visual input, specifically using a polarized camera that can accentuate such details. Tactile data are used as a complementary source of information. Preliminary results show that a sufficiently trained classifier based on Artificial Neural Networks (ANN) will be able to detect such defects. **KPI-SR2: Detection success rate vs humans: false positives (Target: ≤ 120%), skipped defects: (Target: ≤ 110%).** *Status:* The detection success rate is tied to the input modality chosen to accommodate the previous KPI, **KPI-SR1**. Preliminary experiments using ANN classifiers are on track, but there are no concrete estimations of this rate so far. **KPI-SR3: Car-body scan time compared vs humans on a benchmark set (Target: ≤ 110%).** *Status:* Similarly to the previous KPI, the choice in **KPI-SR1** affects this scan time. Care was taken to choose input modalities that will allow this scan time to be within the specified limits. It is estimated that the chosen modalities can allow the SR to cover the scan surface within the time limits and within

		its own kinematic constraints. **KPI-LRN-SR1: Misclassification rate w.r.t. human (Target: ≤ 10%).** *Status:* Similarly to **KPI-SR2**, this rate depends on the chosen input modalities and the training of an ANN system. Preliminary results are on track, but there is no concrete estimation yet. **KPI-LRN-SR2: Time to convergence (Target: observation time ≤ 15h to achieve KPI-LRN-SR1).** *Status:* Information on this KPI will become available at later stages of the project.
O2	A robotic cleaning module attached to a robotic platform (the CR hereafter) equipped with a specialised end-effector to rework defects. The system will learn the necessary skills by observing humans.	**KPI-CR-1: Percentage of defects removed w.r.t. humans (Target: ≥ 98%).** *Status:* At the time of writing, the CR robot is under development. The cleaning module has been designed, while a second alternative is currently under development. The control architecture and algorithms to carry out the defect removal are underway, but the end-effector is yet to be mounted on the robot. As such, no such figures are available now. **KPI-CR-2: Time to remove the defect (Target: ≤ 110% of the time required by the human).** *Status:* As for **KPI-CR-1**, the end-effector need mounting and testing before these figures are available. **KPI-CR-3: Residual level of vibration (for grinding it is about 8.5m/s^2;**

		Target: ≤ 1 m/s^2). *Status:* As for **KPI-CR-1**, the end-effector need mounting and testing before these figures are available. However, the end-effector passive elements needed for the objective achievement has been tested in isolation. **KPI-LRN-CR1: Reduction of measurement uncertainty (Target: RMSE ≤ 5%).** *Status:* The fusion of force, visual and tactile sensing data has been tackled for a learning perspective and, since the end-effector need mounting and testing before these figures are available, at the moment the possible fusion algorithm for this multimodal approach has been defined algorithmically. **KPI-LRN-CR2: Time synchronisation error among data coming from different sources (Target: ≤ 0.1 ms).** *Status:* As for **KPI-LRN-CR1**, the end-effector need mounting and testing before these figures are available. **KPI-LRN-CR3: Number of samples to converge to a satisfactory policy. (Target: ≤ 10h of observations).** *Status:* As for **KPI-CR-1**, the end-effector need mounting and testing before these figures are available. Nevertheless, the control strategies and the underlying learning algorithms for the planning and execution of the tasks has been defined. **KPI-LRN-CR4: Similarity measures between the learnt and the human policies. (Target: position error ≤ 1mm,**

		orientation error ≤1°, force error ≤ 5N, moment error ≤ 2Nm). *Status:* As for **KPI-LRN-CR3**, the control strategies and the underlying learning algorithms for the human motion models has been defined and currently under first tests.
O3	A software robotic platform including: a) the basic services needed to implement the SR (O1) and the CR (O2), b) a modular infrastructure to integrate external services and components, c) a toolset to support quick system deployment and configuration.	**KPI-TP-1: Time needed to scan the whole surface of the vehicle w.r.t human operators. (Target: ≤ 80%).** *Status:* As for **KPI-TP-1**, information on this KPI will become available at later stages of the project. The work focused on this first part of the project on effective planning strategies that stochastically show promising vehicle scanning efficiency. **KPI-TP-2: Probability of missing major defects during the scanning phase. (Target: ≤5%).** *Status:* As for **KPI-TP-1**, information on this KPI will become available at later stages of the project. The work mainly focused on strategies that stochastically establish the scanning time per type of defect and will build upon the results from the perception system of the SR. **KPI-MP-1: Probability to have an accident, evaluated in simulation. (Target: less ≤ 10^{-6}).** *Status:* As for **KPI-TP-1**, information on this KPI will become available at later stages of the project. The work focused on the design of effective human motion detection and prediction relying on the available sensing system of the robotic

		cell. **KPI-MP-2: Average time to execute a sensing or defect reworking task w.r.t. humans. (Target: ≤60%).** *Status:* I As for **KPI-TP-1**, information on this KPI will become available at later stages of the project. **KPI-MP-3: With respect to the KPI for O1, active sensing error reduction. (Target: ≥10% reduction).** *Status:* As for **KPI-TP-1**, information on this KPI will become available at later stages of the project. In this first part of the project, the active sensing algorithms, which will be based on classic and ergodic control laws, have been identified. **KPI-PP-1: Reduce the learning time to adapt to new use cases of the 20% using knowledge transfer.** *Status:* As for **KPI-TP-1**, information on this KPI will become available at later stages of the project. **KPI-PP-2: Successful integration of at least 3 third party COTS found through the FSTP.** *Status:* As for **KPI-TP-1**, information on this KPI will become available at later stages of the project. **KPI-PP-3: Successful application of the approach to at least three new use-cases found through the FSTP.** *Status:* As for **KPI-TP-1**, information on this KPI will become available at later

		stages of the project.
O4	A closed-loop defect detection and avoidance system for robot and welding processes.	**KPI-CL-1: Probability of faulty classification of a defect. (Target: ≤8%).** *Status:* Information on this KPI will become available at later stages of the project. **KPI-CL-2: Time needed for inline defect identification and classification. (Target: < process cycle time).** *Status:* As for **KPI-CL-1**, information on this KPI will become available at later stages of the project. **KPI-CL-3: Success rate of closed-loop process optimization. (Target: ≥ 90%).** *Status:* As for **KPI-CL-1**, information on this KPI will become available at later stages of the project.
O5	Two TRL 7 integrated prototypes: one for defect analysis and one for defect reworking.	**KPI-INTEGRATED-1: The two prototypes will be deployed in two distinct workstations and will successfully carry out defect analysis and reworking in sequence.** *Status:* Information on this KPI will become available at later stages of the project. Towards the integration, the consortium converged on the most promising robotic platform, that has been acquired and shipped to all the partners involved in the robotic technical development and integration, namely **UNITN**, **IIT** and **ALT**. Requirements analysis has been performed.

O6	A human-centred approach to human-robot collaboration.	**Project Achievements in Relation to SSH Objectives:** **KPI-SSH-1: Number of Stakeholder Workshops (Target: > 8 by the end of the project)** *Status:* In the first year, we have conducted several key presentations and discussions involving a broad spectrum of stakeholders in various forums. These presentations have served as valuable interactive platforms for gathering feedback and initiating collaborative discussions. While these activities contribute towards the KPI-SSH-1, formal stakeholder workshops, as defined by the project criteria, will be organised in the coming years to meet the target of eight workshops by the project's conclusion. **KPI-SSH-2: Number of Testing (Feasibility/Demo) Activities (Target: > 8 by the end of the project)** *Status:* During this initial year, we have commenced feasibility activities through observations and interviews. As the project progresses, more comprehensive evaluations and testing activities will be conducted during the implementation of demonstrators. **KPI-SSH-3: Number of Stakeholders Involved (Target: > 40 by the end of the project)** *Status:* To date, 39 stakeholders have been directly engaged in the project. This reflects strong early progress in stakeholder involvement. As we continue over the next three years, we anticipate surpassing this target as more stakeholders become involved in various

		phases of the project. **KPI-SSH-4: Number of Presentations at Non-Academic Conferences (Target: > 6 by the end of the project)** *Status:* In this first year, we have delivered several presentations in relevant non-academic settings. While this is a positive start, we recognise that additional presentations will be necessary in the coming years to meet and exceed the target of six presentations at non-academic conferences by the end of the project.
O7	To demonstrate the two prototypes (see O5) in an operational scenario.	**KPI-DEMO-1: Realism: the demonstrator will satisfy the production constraints.** *Status:* Requirements analysis has been performed. A cobot model that meets the defined requirements has been selected. The work area is currently under preparation. **KPI-DEMO-2: Accessibility. (Target: 2 months of physical accessibility and 4 months for remote accessibility).** *Status:* Information on this KPI will become available at later stages of the project. **KPI-DEMO-3: Number of business-oriented visits. (Target: at least 100 business-oriented visits).** *Status:* Information on this KPI will become available at later stages of the project.

O8	To expand scope and applicability of MAGICIAN via Financial Support to Third Parties (FSTP).	**KPI-DEMO-4: min 40 application proposals received within the 2 OCs.** *Status:* The WP related to this objective and KPIs has not started, yet. Nonetheless, preliminary meetings have been setup to start digging into the matter. **KPI-DEMO-5: min 12-month implementation period per selected experiment/application.** *Status:* The WP related to this objective and KPIs has not started, yet. **KPI-DEMO-6: 2 Mln/EUR distributed via FSTP.** *Status:* The WP related to this objective and KPIs has not started, yet. **KPI-DEMO-7: >3 possible exploitation opportunities identified based on the selected applications/experiments.** *Status:* The WP related to this objective and KPIs has not started, yet.

2.2 EXPLANATION OF THE WORK CARRIED OUT PER WP

2.2.1 WP1 – PROJECT MANAGEMENT (UNITN, M1-M48)

The main role of WP1 is to keep the project on track in terms of results, time and budget and to maintain the research data coming from the project.

In the first year of the project, the project management structure and procedures, the Quality Plan (QP), the Data Management Plan, the governing boards and the responsibilities of each partner of the project have been set in place and communicated to the partners in to-the-point meetings, as well as reported in D1.1.

Moreover, templates, schedule, timeline and quality assurance procedures for deliverables and reports have been defined, together with the rules for internal documents storing and for the internal communications.

Monitoring procedures for project progress activities and use of resources were defined on a 6-months basis.

Pre-financing was distributed according to the GA and CA provisions.

Following the lines defined in D1.1, the Coordinator ensured a smooth cooperation among the partners towards the project goals. What follows is a description of the activities carried in the different WP tasks.

Submitted deliverables:

D1.1 Data and Quality Management Plan (M6)

D1.2 First coordination report (M12)

Milestones

Ms1 Project start-up: deliverables, DMP.

Details of the activities by Task and by Beneficiary

Task 1.1: Management and coordination of the project (M1-M48; Lead: UNITN; Part: All)

The work carried out by **UNITN** in this task was project coordination, management of the consortium, meetings set-up, reports and deliverables writings coordination, and consortium-level issues handling. **UNITN** Project Manager supporting the Coordinator in the Day-by-Day work has resigned at beginning of September, so a new call has been set-up, and the consortium will have a new Project Manager in a couple of months. Despite this issue, the coordination has been carried out smoothly.

A first General Assembly has been organised online at M6, while a second will be in person in Crete at M13. Web meetings for the different WPs and fort the WP leaders has been organised every 2-6 weeks.

UNITN set-up an internal monitoring of project progress in terms of activities and use of resources on a 6-months basis that is used also to prepare the foreseen Management Deliverables. **UNITN** distributed the pre-financing to the beneficiaries according to the GA and CA provisions.

All the partners contributed to the T1.1 activities by supporting **UNITN** in the management duties, including the participation to meetings and telcos, the provision of contents for the periodic reporting, the submission of deliverables and the reaching of the project's milestones and objectives.

ZAB provided TEAMS as the project repository and management tool.

The list of the PIs per partner has been defined in D1.1 as the participant to the General Assembly meetings.

Task 1.2: Data Management (M1-M48; Lead: UNITN; Part: All)

In this task, the data handling was outlined in the Data Management Plan, while the consortium data was shared via a **UNITN** shared platform that was then changed to account for some of the partners' company rules. Data from scientific publications adhered to open access rules and was stored in publicly accessible repositories, as outlined in the DMP.

All the partners contributed to D1.1 - "Data and Quality Management Plan" and adhere to the rules set-up in the DMP.

Moreover, **CRF** and **TOFAS** contributed to the definition of the specification of data and metadata for the different datasets present in the MAGICIAN repository (full details in the D1.1).

In close collaboration with **UNITN** and collected partner inputs, SIG drafted the Data and Quality Management Plan (D1.1).

ALT contributed to D1.1 by defining data collection methods and rules within its facilities. The data will be sourced from our demonstration system and will include records of visitors to the **ALT** facilities, including their names, companies, and visit dates. All collected data will be stored securely and accessed only according to the rules defined in the DMP. Personal information will be processed in compliance with GDPR regulations.

Task 1.3: Risk and quality management (M1-M48; Lead: SIG; Part: All)

The main work carried out in this task was the definition of the QP, which defines the team organization, the quality standards, the procedures for deliverables and reporting preparation, the risk management strategies and the policies for managing collected data. The plan also outlined the Consortium's open access policy, in coordination with data management activities from T1.2. Risk analysis was monitored and updated as needed.

Templates to be used in the project were prepared by SIG in collaboration with **UNITN**.

All the partners contributed to T1.3 by complying with the quality planning and standards defined in the D1.1 - "Data and Quality Management Plan", and by internally defining the policies and procedures for the management of the data collected during the project's activities.

SIG additionally contributed to T1.3 by setting up a methodological framework for data collection and gathering partner input on data generated in MAGICIAN. These inputs are part of overall quality management as presented in D1.1.

2.2.2 WP2 - USE CASE DEFINITION AND PLATFORM DESIGN (LU, M1-M48)

WP2 focuses on the integration of user-centred design methodologies in the development of the MAGICIAN automation systems. The primary objectives include engaging key stakeholders such as workers, managers and union representatives, fostering multidisciplinary teamwork, and establishing ethical and social requirements. Significant progress has already been made towards these goals. A baseline study at **TOFAS** involved direct collaboration with workers, developers and managers, offering crucial insights into workplace dynamics and the effects of automation. Furthermore, interviews have been conducted in Sweden with union representatives and workers to deepen the understanding of the automotive industry, particularly regarding what makes work meaningful for employees and their perspectives on automation and robotics.

Submitted deliverables:

D2.1 Use case definition (M6)

Milestones

Ms1 Project start-up: deliverable.

Details of the activities by Task and by Beneficiary

Task 2.1: Use case definition (M1-M39; Lead: CRF; Part: All, except SIG)

A comprehensive description of two use cases and their corresponding needs within the MAGICIAN project has been provided as deliverable D2.1. Specifically, we have outlined two distinct Use Cases involving the **TOFAS** automotive manufacturer in its Body In White (BIW) and Stamping processes. Additionally, a third Use Case focusing on the Circular Economy, particularly the refurbishing of alloy rims, has been examined within MAGICIAN. While these industrial Use Cases share several technical commonalities that enable MAGICIAN to apply a unified approach, they are also sufficiently complementary to address a broad range of sensing and actuation manufacturing topics, as well as the associated control mechanisms.

Moreover, a thorough description of the manufacturing systems under examination within the MAGICIAN project, along with the production tasks linked to these systems, has been documented. This includes the specific needs of the manufacturers identified through an assessment conducted at the **TOFAS** production site in Bursa, Turkey, in January 2024 by the involved partners.

We have described the roles of humans in human-robot collaboration, the production modules such as machines and robots utilised in the respective production environments, and the systems currently in use, including their purposes and connection types. Furthermore, we have included a description of the social science and humanities (SSH) perspective, outlining how the project will integrate this perspective by detailing the methods to be employed throughout the project. This approach will assess how work can remain meaningful while utilising MAGICIAN systems and technologies. This perspective considers both social and technical factors to ensure a holistic understanding and implementation of the system, ultimately aiming to safeguard human well-being.

During the reporting period, the deliverable D2.1 - “Use Case Definition” was prepared and submitted on time at M6, based on the coordination and harmonization of contents from CRF, the use case provision from **TOFAS** and the active contributions from the other involved partners. This document gives a comprehensive description of the MAGICIAN Use Cases from the user perspective, as they stem from the business practice of its industrial pilots, along with the corresponding objectives, priorities and KPIs that will be used to evaluate how the MAGICIAN project will facilitate and improve their operations and meet their needs.

LU was the main driving force for all the activities carried out in this task, thus they have been deeply involved in what reported above.

TOFAS hosted a technical assessment meeting in their production plant with the participation of all the MAGICAIN technical partners, with particular emphasis on the stamping and body in white production lines. General process flow and operator working standards were examined by the project partners. Defect types on the stamped parts and automobile body explained and physically presented to the partners. All related layout, process standards, quality standards, expected functionalities and related information is compiled and shared with CRF to prepare the D2.1.

UNITN participated to all the activities of the use case definition, from the **TOFAS** onsite visit to the definition of all the requirements during the online meetings, hence providing inputs to D2.1. Moreover, data and software requirements were identified. Further contributions to this task with regards to software will be made when the integration between the different robotic modules becomes clearer.

FORTH contributed to the use case definition by evaluating various visual sensing modalities tailored for each separate use case. Factors such as minimum size to be detected, total scan time, and other relevant constraints were considered for each scenario. The findings of this investigation were documented in D2.1.

ALT contributed by defining the demonstrator setup for testing and evaluating the collaborative robot system performance. The process design and virtual analysis of the collaborative robots, as well as the possible mobile mechanisms, in relation to the two process stations and the physical sensing were discussed for the user perspective. In particular, the equipment, the robot and the safety integration requirements were analysed.

IIT contributed to defining the use case by evaluating state-of-the-art methodologies that exploit commercial force and vibration sensors for defect detection. In addition, assessments were made on the design of the tactile perception module in relation to various surface topologies that need to be scanned, along with considerations regarding scanning time and other operational constraints. These evaluations were documented in D2.1.

PIP identified and described the requirements and needs for the Configuration Optimization Tool from a use case perspective. These needs were separated into project needs, use case needs and technical needs within D2.1. Moreover, in collaboration with

HWH main involvement was on the draft concept of the hardware setup and system requirements.

Task 2.2: User-centred design (M1-M48; Lead: LU; Part: UNITN, IIT, CRF, TOFAS, ALT, HWH)

During the first year of the MAGICIAN project, the initial phase of the human-centred approach to human-robot collaboration was initiated. We conducted desktop research, resulting in literature review and the submission of a manuscript to a peer-reviewed scientific journal. Additionally, we delivered two presentations to practitioners and researchers: the first in March 2025 at the Human Factors Network, a national network of authorities, research departments, and manufacturing companies with an interest in Human Factors, and the second in June 2025 at the conference on Sustainable Human Resource Management and Working-Life Practices. Furthermore, we presented the project to the Digital Justice group at the Pufendorf Institute, Lund University, which includes both Swedish and international researchers exploring the intersection of technology, human rights, and social justice. We have also integrated the MAGICIAN project as a case study into one of **LU**'s courses on Leadership, Organisation and Management, as well as in a course on Interaction Design. The visibility and acknowledgement of the project in academic courses and presentations in both non-academic and academic settings, have enabled us to explore and gain insights into the fears and hopes surrounding human-robot collaboration from a wide range of perspectives, including those of students in industrial economics, engineering and interaction design, as well as researchers, developers, workers, managers and union representatives.

Moreover, we have applied for and received ethical approval for conducting user-related studies in Turkey and Sweden. Following the receipt of ethical approval, we conducted interviews with workers and managers at **TOFAS** in Turkey, as well as developers, and completed three full days of observations at **TOFAS** for the baseline study. These observations will be followed by further evaluations during the implementation of demonstrators. Currently, we are analysing all the data collected from the baseline study.

To gain a better understanding of the organisational context and how well automation and cobots align with existing structures and practices in car manufacturing, we also conducted interviews with union representatives, engineers and line managers at VOLVO in Sweden. This is aimed at comparing the organisation of work in Northern Europe with that in Turkey. The process of conducting Interviews is ongoing.

We are also in the process of developing a quantitative questionnaire based on job characteristic theory, which will be distributed to line workers at **TOFAS** before the introduction of the demonstrators. This will be followed up after the demonstrators are introduced.

The partners primarily involved in this work were **LU**, which conducted the studies, and **TOFAS**, which collaborated by providing access to the sites and involving workers and management. Additionally, **ALT** participated and assisted in recruiting developers for interviews, while **CRF** contributed to the task activities, in collaboration with **TOFAS**, by bringing the end-users perspective and needs into account for the analysis carried out, and in general, participating to meetings and general activities of the task. More precisely, **TOFAS** experts analysed the questionaries prepared by **LU** for the operators, developers and decision makers for the necessary adjustments to the **TOFAS** HR policies. After some iterations, final forms were prepared by **LU**. Three full days of observation and interview schedule was prepared by **TOFAS**. Mr. Günter Alce from **LU** and a related **TOFAS** expert spent time near the operators to observe the work and after the observation, an interview was done in a meeting room. Several operators from stamping and body in white shop participated in this activity. In addition to operators, the shift supervisors, production and engineering managers, also participated in interviews as decision makers. The manufacturing engineering and maintenance experts and managers participated in the interviews as developers and gave insights about the current practice and the necessities of the process.

Both **UNITN** and **IIT** participated to the **TOFAS** visit in January 2024 to observe workers conducting surface exploration for defect detection. This observation was crucial in informing the development of the initial prototypes for the tactile perception module as well as for the safety requirements on the robots that should be enforced.

HWH supported in filling-in the required templates and tables to describe the use case scenario for the user centred design, its discussion and formalisation, together with the involved partners.

Task 2.3: Interface definition and robotic platform design (M1-M42; Lead: UNITN; Part: IIT, LU, FORTH, CRF, TOFAS, ALT, PIP, HWH)

The work carried out and the main achievement of this task are related to the preliminary results of T2.1 and T2.2, for the perspective of the robotic platform design and the related safety constraints. Also, a first design of the deployment of the external cameras in the robotic cell, considering possible occlusions and software requirements, has been conceived.

UNITN coordinated the activities of this task considering the robot requirements in terms of both performance and safety constraints. This activity was crucial to identify the control approaches to be employed for MAGICIAN.

Similarly, **HWH** participated in shaping the robotic platform requirements in light of their main activity that is to the design of inline defect detection of welding processes and on the automatic adjustment of the respective process execution parameters in an optimal way.

CRF actively participated in the evaluations accounting for workers' needs and requirements, and in the analysis regarding costs, payload and DoFs constraints of the identified collaborative robotic arms.

FORTH's contribution to T2.3 is currently in the initial stages, focusing on the evaluation of the interface requirements between the visual sensing modalities and the robotic platform. Work is ongoing to ensure that the polarized camera setup and associated lighting configurations are compatible with the overall robotic design, with emphasis on maintaining modularity and ease of integration. Further detailed contributions will develop as the interface design progresses.

IIT work focused on assessing the design requirements for the tactile sensing interfaces. The goal is to create a system that is user-friendly for operators and can be easily mounted on the robotic platform. Ongoing efforts are focused on ensuring that the perception module setup aligns with the robotic platform, with particular attention to maintaining modularity and ease of integration. As the interface design advances, more detailed contributions will follow.

LU contribution to this task first requires more development on the back-end defect detection and cleaning module and has therefore been minimal thus far. These modules require adequate computational speed and explainability for human usage. The design requirements will depend on the hardware modules, developed by other partners.

ALT played a role in the selection of the collaborative robot and the design of the demonstrator setup. In collaboration with project partners, **ALT** actively participated in evaluating potential robotic arms based on factors such as requirements, costs, payload, ROS compatibility and industrial communication capabilities.

PIP's contribution to this task first requires more development on the back-end defect detection and cleaning module and has therefore been minimal thus far. These modules require adequate computational speed and explainability for human usage. The design requirements will depend on the hardware modules, developed by other partners.

2.2.3 WP3 - DATA ACQUISITION AND SKILLS LEARNING (FORTH, M4-M45)

The goal of WP3 is the development of perception systems and learning techniques for defect detection and reworking skills, emphasizing visual and tactile solutions to address both extended and small defects. During the first year, the primary efforts were directed towards establishing a multi-modal perception framework to detect and categorize defects, integrating visual and tactile data for comprehensive analysis. Key achievements include the initial selection and setup of appropriate sensing technologies, the development of algorithms for defect detection, and the creation of datasets for validation and testing. Overall, WP3 has laid the foundation for integrating human-like perception and skill acquisition in cobots, aiming for robust defect detection and reworking capabilities in manufacturing environments.

Submitted deliverables:

D3.1 First delivery of perception systems (M12)

Milestones:

Ms2 First Release of the robot components

Details of the activities by Task and by Beneficiary

Task 3.1: Perception system, data acquisition and processing (M4-M45; Lead: FORTH; Part: UNITN, IIT, LU, CRF, TOFAS, ALT, PIP, HWH)

The task focused on setting up perception systems with visual and tactile sensors for defect detection, incorporating data fusion techniques. Key achievements include acquiring annotated datasets of defects and developing algorithms for multi-modal perception, for robust defect detection and human-robot interaction.

TOFAS provided samples of metal surfaces with annotated defects to several partners. The parts include sub-assemblies like engine hood, doors and body sides and sheet metals cut-off from the stamped parts in A4 sizes. The defects include positive and negative dents, weld spatters and seal residuals which are real examples from production line.

FORTH contributed by acquiring polarized images of defects. Special care was taken to properly record the provided labelling of defects, such as positive or negative dent, or welding defect.

PIP contributed by looking at the acquired tactile sensing test data and investigate the different approaches to (pre)process and use this data to prepare it for the classification tasks, focusing on making it possible to combine different tactile signals together in one classification model.

UNITN studied the integration of the sensing system with the CAD model of the vehicle and started the metrological analysis of the perception system, firstly applied to low cost, low resolution off-the-shelf components. **UNITN** also worked on the development of algorithms for human motion prediction to be used for human aware motion planning (T4.3).

IIT contributed to the acquisition and processing of tactile data for detecting defects in car body parts. By leveraging force sensors and accelerometers, **IIT** developed a tactile perception system that replicates human touch in identifying surface imperfections.

CRF provided a general support to the task activities, by participating in the technical developments and bringing the end user's needs and perspective into the analysis and developments carried out by the technical partners.

ALT has actively participated in project meetings, contributing to the definition of engineering requirements necessary for the developed systems to adapt to the harsh conditions of the industrial environment. In particular, **ALT** has provided suggestions related with critical points such as safety, performance, and flexibility for robot integration.

LU participated to all the meetings and gave their feedback from a user centred perspective.

Task 3.2: Learning defect classification skills from humans (M4-M45; Lead: FORTH; Part:

UNITN, IIT, LU, CRF, TOFAS, ALT, PIP, HWH)

Efforts centred on developing automatic classification strategies for defect identification using the available data. Achievements include the creation of a defect classification framework and the initial exploration of semi-supervised learning techniques for robust, generalized classification models.

FORTH contributed by designing and developing an initial image classifier based on a Convolutional Neural Network (CNN) for defect detection and characterization. Preliminary datasets with annotated defects were utilized to train and validate the model.

UNITN focused on the robotic arm control and planning of the trajectories to ensure the best sensor to defect relative position and orientation, thus enabling active sensing algorithms and simplifying the sensory data acquisition.

IIT contributed by creating an initial dataset containing labelled data on defects. The data were collected using the tactile perception module with different end-effectors and multiple subjects performing surface exploration. The defects were intentionally designed to replicate those described by **TOFAS**.

PIP then utilized this dataset and contributed by looking into possible classification models and multiple approaches for the tactile sensing data. At first, a combination of Long Short Term Memory networks (LSTM) and Convolutional Neural Networks (CNN). Secondly, ensemble methods such as random forest, bagging and gradient boosting were tested.

CRF provided a general support to the task activities, by participating in the technical developments and bringing the end user's needs and perspective into the analysis and developments carried out by the technical partners.

The sample parts provided by **TOFAS** constituted the core components, directly coming from the production lines, and enabling the development of suitable classification strategies for the classification of the defects. Furthermore, **TOFAS** ensured its participation in the meetings as an end user and providing the Status of human practices.

ALT contributed to the task by attending meetings and sharing insights on the industrial practices.

HWH drafted a control algorithm to detect weld spatters from sensor signals and predict their severity. Moreover, gathered real welding data to run and train statistical and physical process models

Task 3.3: Learning defect working skills from humans (M4-M45; Lead: IIT; Part: UNITN, FORTH, CRF, TOFAS, ALT)

Work in this task has focused on transferring defect reworking skills from humans to robots using Learning from Demonstrations (LfD), with initial efforts directed at capturing and modelling human motions for defect inspection and reworking.

The main activities carried out by **IIT** was related to the defect inspection and, in particular, to the dynamic comparison between signals of components with defects and non-damaged parts so as to understand how the human working skills can be captured and apprehended by the tactile sensing system.

UNITN designed the first promising version of the LfD algorithm considering information from different sources (pose of the tool, interaction forces/acceleration, and visual data). The integration into the MAGICIAN project solution is under way.

FORTH continued its work on improving MoCapNets for enhanced human pose estimation, contributing to the accurate capture and modelling of human motion data required for skill transfer to robotic systems.

CRF provided its contribution to the task activities, by bringing its expertise on human skills and best practices, as performed in the Stellantis production environments.

TOFAS provided general support to the activities by participating in the meetings as an end user and providing the Status of the human practices. This contribution, based on the real behaviours and conduct of the workers in the **TOFAS** production lines, constitutes the key enabler of the initial efforts directed at capturing and modelling human motions for defect inspection and reworking, also based on videos and technical the visits from technical partners, that were hosted in the **TOFAS** production lines, to show and demonstrate the actual production processes.

ALT contributed to the task by attending meetings and collaborated with the team to integrate the technology into the demonstrator setup.

2.2.4 WP4 - ROBOTIC PLATFORM AND INTERFACES (IIT, M4-M45)

WP4 aims to develop a robotic platform and its associated interfaces, along with the control, planning, and scheduling algorithms required for grinding operations and the defect detection station. In the first year, efforts were centred on designing intuitive human-robot interfaces that integrate tactile perception systems for defect detection and reworking tasks. Notable achievements include the creation of wearable and handheld tactile devices equipped with force sensors and accelerometers for surface inspection and defect identification, as well as the development of motion control algorithms utilizing impedance control to ensure safe and adaptive interactions.

Submitted deliverables:

D4.1 Human-Robot interfaces and intelligence (M12)

Milestones

Ms2 First Release of the robot components

Details of the activities by Task and by Beneficiary

Task 4.1: Human-Robot Interfaces (M4-M45; Lead: IIT; Part: UNITN, LU, CRF, TOFAS, ALT)

The task focused on developing human-robot interfaces that integrate tactile perception systems for enhanced defect detection. Key achievements include the design of intuitive interfaces, enabling accurate and efficient detection of surface defects.

IIT led the design of the tactile perception modules. Specifically, two types of tactile devices were developed: a wearable tactile device and a handheld tactile device. Both devices integrate tactile sensors to mimic human touch in industrial defect detection.

UNITN analysed the proposed sensing solution and the implication it has on the robotic arm motion control to enhance the sensing capabilities of the system as a whole.

CRF provided a general support to the task activities, by participating in the technical developments and bringing the end user's needs and perspective into the analysis and developments carried out by the technical partners.

Through project meetings and workshops, **LU** with expertise in SSH have shared critical insights on user experience.

TOFAS provided the current layout and process flow, dimensions and models of the parts and body in white to be inspected. The sample parts which were provided to the related partners are also used for development in this task.

ALT examined the current layout and process flow to effectively integrate the basic concept into the demonstrator setup.

Task 4.2: End-effector design and interaction control co-design (M4-M45; Lead: IIT; Part: UNITN, LU, FORTH, CRF, TOFAS, ALT)

The main activities carried out for this task concerned the study and first development of the impedance control with hybrid motion-force control. Moreover, the first design of a teaching-by-showing solution has been implemented and currently under test on the MAGICIAN robot: this will enable the workers to directly operate the CR in kinaesthetic teaching mode. Finally, a first study and implementation of the mounting mechanism of the robot end-effector has been provided by **IIT**.

IIT also provided and implemented the first version of the impedance control module, endowing the gravity compensated teaching/interaction mode.

UNITN studied an alternative design of the end-effector, which is in the preliminary stages, to maximise the adaptability of the MAGICIAN solution to the new use cases. The main results are related to the robot-grinder interface co-design, that is the simultaneous optimization of hardware and control parameters.

CRF provided a general support to the task activities, by participating in the technical developments and bringing the end user's needs and perspective into the analysis and developments carried out by the technical partners.

LU have primarily been involved by participating in Magician team meetings, providing the SSH perspective.

FORTH has contributed by supporting the integration of visual sensing with end-effector design, ensuring that the chosen sensing modalities are compatible with the robotic interaction control strategies.

TOFAS provided the current manual tools with technical specifications and current manual practices for the development.

ALT supervised the planning and the design of the robot interfaces to operate successfully in the challenging industrial environments, as highlighted in meetings regarding the initial delivery of the system.

Task 4.3: Planning and scheduling (M4-M45; Lead: UNITN; Part: CRF, TOFAS, ALT)

The main activities of this task concentrated on the visual-tactile inspection and defect reworking were scheduling of operations to optimize efficiency and timing. The sequence of tasks, statistically determined based on past executions and on the gathered sensory data, consider parallel execution by multiple robots. The final motion plan will be generated through graph optimization algorithm.

UNITN and **PIP** started formalizing the problem of optimizing the path for the cleaning robot based on the inputs from the defect detection. Using locations, severity and defect types, the distances need to be calculated, and the optimal path needs to be computed. This problem and its constraints are formulated as a multi-agent orienteering problem. Moreover, **UNITN** started working on the scheduling of the sensing operations of the SR, to ensure an effective use of the resources, to respect the operations time constraints, and to guarantee the desired level of defect detection and classification performance.

CRF provided a general support to the task activities, by participating in the technical developments and bringing the end user's needs and perspective into the analysis and developments carried out by the technical partners.

TOFAS provided the current defect control and rework procedure in body and stamping shop. The cycle times, defect ratios, number of operators in each stage and process videos were shared with technical partners. These data are curial inputs for the MAGICIAN's solution development studies.

ALT participated in the meetings and worked to formalize the integration of analyses conducted by the technical partners to the upcoming demonstrator setup.

Task 4.4: Motion control and active sensing (M4-M45; Lead: UNITN; Part: IIT, FORTH, CRF, ALT, HWH)

The work carried out in this task concerns the design of the motion controller strategy to execute the planned path, taking into account safety and ergonomics of the human workers and efficiency. The other main activity was the selection of the promising approach to active sensing for the SR, which was defined based on the requirements that came from the **TOFAS** plant visit.

UNITN formalised the motion control and active sensing strategy as an ergodic control problem, provided a first overview of the solution, with potential benefits for the MAGICIAN project. Furthermore, **UNITN** developed a novel classifier for the human motion model, which return effective predictions and constitute a promising solution for the safe motion control algorithm.

FORTH's contribution so far has involved initial discussions on potential active sensing approaches, such as the use of ergodic control, to optimize the robot's motion for defect inspection, and on the perception system needed to identify the human posture and motion in the robotic cell.

IIT prepared the technology for active sensing by studying the optimal combination of sensors.

CRF provided a general support to the task activities, by participating in the technical developments and bringing the end user's needs and perspective into the analysis and developments carried out by the technical partners.

ALT actively participated in the meetings, focusing on formalizing the integration of active sensing into the demonstrator setup. Their efforts involved collaborating with team members to identify key requirements, ensuring that the active sensing components seamlessly enhanced the overall functionality and performance of the demonstrator setup.

HWH supported the discussion about motion controller strategies and how to perceive human motions in the area, but no tangible results have been produced at the moment.

Task 4.5: Closed-loop defect analysis (M4-M45; Lead: HWH; Part: UNITN)

Inline defect detection in welding processes and automatic optimization of process parameters was the main focus of the work done for this task.

HWH main activities related to the first draft of a discrete event associated algorithm that finds correlations between weld spatter of different types and severity and applied it to historical data. A first collection of real welding data to run and train statistical and physical process models is currently ongoing. In this respect, the work of **UNITN** has focused on a first study of the statistical tools that can be used to support the closed-loop control of the welding process.

Task 4.6: Configuration optimisation tool (M4-M45; Lead: PIP; Part: UNITN, IIT, FORTH, ALT, HWH)

Since the objective of this task is to determine the optimal configuration settings for new use-cases to accelerate MAGICIAN's deployment, the main activities concerned the first organization and the requirements definition of the model to be used to facilitate this task.

PIP started creating a framework for the configuration optimization tool (COT), which should act as a facilitation tool for creating plug-and-play solutions for new use cases. A first setup was created where the requirements are specified and the model architecture is explained. This will become clearer as other modules are created, as the COT heavily relies on the other project components.

UNITN and **FORTH** participated in initial meetings with **PIP** to discuss the configuration of the optimization tool. We provided preliminary data to outline the data format standards we are using, facilitating alignment on data integration requirements for future collaboration.

Similarly, **IIT** participated in several meetings organized by **PIP** to discuss potential requirements for new use cases, specifically concerning the development areas for which **IIT** is responsible.

Since the main activity of **HWH** in this task include the basic development of configuration tools to optimize welding parameters and the support in the infrastructure discussion, including data generation, integration, and storage, in this first year no specific results are reported. Indeed, the evidence from the data is crucial for the work **HWH** is carrying out.

2.2.5 WP7 - DISSEMINATION AND EXPLOITATION (SIG, M1-M48)

The main objectives of this WP are to create a communication channel with the potential MAGICIAN stakeholders (industries, scientific communities, consumers associations, solution providers, regulatory bodies and the general public) to promote and disseminate the project results, the rest of this section is devoted in detailing the activities carried out in the first period for this goal, highlighting also the exploitation strategies put forward and the IPR management.

Submitted deliverables:

D7.1 – D&C and exploitation plan

Milestones

MS1 Project start-up: deliverable, D&C and Exploitation plans

Details of the activities by Task and by Beneficiary

Task 7.1: Dissemination and Communication (M4-M45; Lead: SIG; Part: All)

In this task, **SIG**, with feedback from all project partners, developed the Project Visual identity together with a professional design agency, including the Project Logo, the Concept Graphic, and a Styleguide which served as a basis for the development of further communication materials.

A *MAGICIAN LinkedIn account* was set up in M4 and continuously updated with posts on project activities and topical posts in close exchange with all project partners. As main communication and information platform, the website was designed based on the defined CI and the structure and content discussed with project partners, notably the coordinator **UNITN**, and **ZAB** for the Open Calls Sections.

The website https://www.magician-project.eu/ was launched in M6 and has been updated regularly with news, events, and resources material. In addition, several templates (PPT, Word, General Project Presentation) have been shared with partners for internal and external promotional purposes which complemented promotional material designed for use at events, i.e. a project roll-up, flyer, and updated poster.

Communication efforts in these first project months focused on generating project awareness and raising interest in MAGICIAN solutions, partners, and Open Calls. Apart from an active Social Media presence and website updates, a first press release (EN) was drafted and shared with partners, and the first newsletter published via LinkedIn at M11 which summed up the first project activities and highlighted project objectives and partners. MAGICIAN partners have supported communication efforts by introducing MAGICIAN through various media (own websites, TV etc,).

In terms of dissemination, MAGICIAN partners have presented MAGICIAN at e.g. scientific conferences, educational events, regional networking events and EC Online events. For research outputs in MAGICIAN, a dedicated project community has been set up on Zenodo where scientific results will be published Open Access.

First project collaborations were realized with the EU Projects INVERSE (mutual Social Media support, joint Steinbeis newsletter feature, events) and EARASHI (joint application for workshop at ADRA event).

For internal organization and coordination, **SIG** has developed a monitoring table for communication and dissemination activities as well as scientific publications which has been updated by **SIG** and project partners continuously. To ensure smooth coordination of the communication, dissemination and exploitation activities and maintain an ongoing exchange with partners, **SIG** has organized bi-monthly WP7 meetings starting from M8.

An updated PCDE was elaborated on in D7.1 based on input from project partners offering a refined communication, dissemination, and exploitation strategy and preliminary planning on events/conferences, scientific journals for publishing MAGICIAN research developments,

All project partners contributed to this task upon request by **SIG**. Furthermore, **SIG** exchanged frequently with **UNITN** for feedback and **ZAB** regarding the project communication on Open Calls.

With Communication and Dissemination activities implemented until M12, **Error! Reference source not found.** and **Error! Reference source not found.** below shows and updated list of associated KPIs:

Table 2 Communication KPIs status

COMMUNICATION MEASURE	KPI	STATUS
Website	1 Website > 10,000 page visits	1 Website launched at M06 ✓ 219 page visits (M11)

	by M48	
Corporate Image	1 updated logo Documents templ. PPT templ.	1 logo ✓ Deliverable Template (Word) ✓ PPT template ✓ General PPT Presentation ✓
Social Media Presence	> 500 overall followers (M48)	85 followers (M11)
Promotional Material	4 posters 1 roll-up 4 project brochures	1 poster 1 roll-up ✓ 1 project flyer
Newsletters	8 newsletters	1 newsletter (M11)
Video	2 videos	1st video planned for M15

Table 3 Dissemination KPIs status

DISSEMINATION MEASURE	KPI	STATUS
Workshops	2 demonstration workshops 2 educational workshops	To be organized
Web seminars	6 web seminars • 1 focusing on human-centred approach • 2 demonstrator seminars • 1 market uptake seminar • 2 Open Calls	To be organized

	seminars	
Activities with other projects/init.	Min. 1 joint activity with related projects/init.	**EU Project INVERSE** • Social Media • Joint newsletter feature • Joint conference publication (IEEE CASE 2024, see below) **EU Projects INVERSE & EARASHI** • Joint application for workshop at ADRF 24
Events/Conferences participation	> 30 active participations in various events, workshops etc.	6 event participations (e.g. CASE, ICRA, 2024)
Scientific Publications	> 10 conferences/workshop papers (Open Access) > 5 peer-reviewed scientific publications (Open Access)	IEEE CASE 2024 conference publication / upcoming
Industry and EU publications	> 2 articles in industrial magazines or EU publications	1 article on MAGICIAN Kick-off and general project information in the industrial publication "Schweißzeit" (01_24) published by **HWH**
Contributions in policies/ standardisation	1 jointly developed policy brief	Not initiated yet, HS Booster has been considered

Task 7.2: Ecosystem Mapping and Development (M1-M48; Lead: SIG; Part: All)

SIG organized a First ecosystem Mapping Workshop with partners on 29th January 2024 using the online whiteboard tool Mural, gathering 18 participants from 9 partners. Results were used to refine the target groups defined in Section 2.2 of the GA, identify individual stakeholder in each of these target groups, and develop an individualized engagement strategy for each stakeholder based on the "Power" of each stakeholder, i.e. their ability to facilitate or block the progress of MAGICIAN, and their "Interest", i.e. how much influence does the project exerts over the corresponding stakeholder. Responsibilities for each stakeholder were identified and the engagement strategy is to be further refined and consolidated in future stages of the process. Further discussions of the results are taking place in bi-monthly WP meetings, among others in the context of identifying and planning potential collaborations with related initiatives and projects. Figure 1 shows how individual stakeholders identified by partners in a first step are ranked in terms of their potential role for the project and resulting engagement strategy.

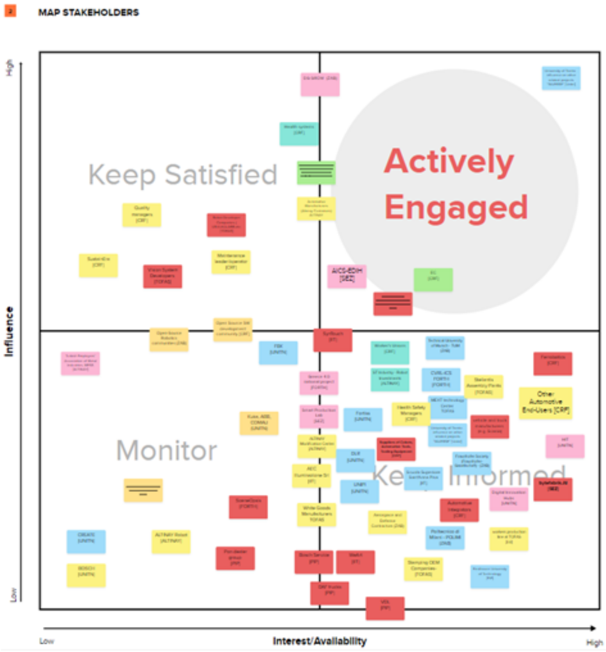

Figure 1 Defining stakeholder engagement strategies

Task 7.3: Path toward Exploitation (M1-M48; Lead: SIG; Part: All)

SIG plans to have a first exploitation workshop divided into two parts, an online workshop on 1st October 2024, and an on-site workshop at the General Assembly meeting in Crete on 14th October 2024. The First Exploitation Workshop constitutes the first exploitation activity of the MAGICIAN project, dedicated to protecting the intellectual assets generated by the project, converting these assets into commercial products, refining its proposed business cases, and developing a market uptake strategy for selected results. A critical step in this phase is connecting the Background IP brought by the partners, as outlined in the CA, to the intellectual assets, i.e. Foreground IP, produced by MAGICIAN. Thus, the specific objectives of the workshop are:

- Refine the Background IP detailed in the CA.
- Integrate additional Background IP identified during the first 12 months of MAGICIAN.
- Consolidate the Background IP of each partner.

- Monitor the status of the KERs.
- Strengthen the Foreground IP and link it to the Background IP.
- Establish the groundwork for agreements on the commercialization strategy of the MAGICIAN-manufacturing platform.

Upon concluding the First Exploitation Workshop, we will have strategically connected Background and Foreground IP, ensuring a robust foundation for developing a market uptake strategy and commercializing the products resulting from MAGICIAN activities. Individual Exploitation Meetings have been organized and focus on refining the Background IP reported in the CA in preparation for the First Exploitation Workshop. For this, a first draft of the Results Owner List (ROL) will be utilized, in which the reported Background IP will be updated and additional Background IP that is under use but has not been reported will also be integrated. This updated Background IP will be later integrated into the MURAL board to be used in the workshop itself.

Once the First Exploitation Workshop is executed, an internal report will be produced with the results of the workshop, including a first update of the ROL and an outline of the future steps. This report will be socialized with the consortium and will have to be approved by the coordinator once the whole consortium has commented on any correction.

To guide partners through exploitation activities, **SIG** has developed guidelines explaining the rationale of exploitation under Horizon Europe, objectives, and next steps. In addition, **SIG** has organized individual exploitation interviews with each partner to introduce the overall process, refine the background IP as stated in the CA, and discuss the foreground to be developed within the project.

2.3 IMPACT

During the first RP (M1-M12), MAGICIAN is confirming its ambitious vision with clear and measurable parameters. Specifically, it has defined a credible pathway for achieving the planned outcomes by creating a significant impact on the robots' cognition in the automotive production industry. Credibility of the pathway is ensured by means of the direct involvement in the partnership of the Stellantis automotive group (throughout the **TOFAS** and **CRF** support), which is aimed at the demonstration and early adoption of the three major MAGICIAN achievements, as reported as unique contributions provided by the project:

i. **Outcome 1:** Demonstrators able to show the added value of robotics in addressing challenges in major application sectors, or in dangerous, dull, dirty tasks or those strenuous for humans or in extreme environments.
ii. **Outcome 2:** Systems able to demonstrate beyond human performance in complex tasks, with high impact in key sectors, that show extended levels of adaptation and flexibility.
iii. **Outcome 3:** Systems able to show high levels of reactivity and responsiveness

and intelligibility when performing human-robot and robot-robot interactions in major application sectors.

MAGICIAN is contributing to the above outcomes by pushing the limits of robotics cognition, by means if its two principal modules: the SR (Sensing Robot) and the CR (Cleaning Robot). These platforms, currently into their design and specification stage, constitute a new generation of AI-Powered Robotics: Enabling collaborative robots to have more profound impacts than they currently have, in powering them with a deeper kind of AI, endowing them with better perception and understanding of the world (up to semantic and explainable representations). Accordingly, MAGICIAN is progressing, as planned, in the development of its technical achievements, that will be showcased in its sensing and cleaning demonstrative solutions. Specific contributions towards the above outlined outcomes are described as follows:

a. *A deeper kind of AI empowered collaborative robot generation*. MAGICIAN is developing AI empowered platforms with fully integrated novel sensors (SR) and actuators (CR), with an unprecedented integration of artificial intelligence in control systems, leading to a new generation of HRC solutions, whose operation and early adoption (as demonstrative systems) will be showcased in the production premises of **TOFAS**. Furthermore, the SR and CR platforms provide the target for the development of the MAGICIAN solutions, implementing deep AI further to maximize the exploitation of cobots' usage in human-centric applications.
b. *A better perception and understanding of the world*. This requirement implies a better and selective perception of relevant information from the bulk of data collected from the SR. However, filtering helpful information from the general world is not simple. MAGICIAN has proposed a systematic approach that employs sophisticated sensing solutions and learning capabilities to gather world information such as gaze, body motion, fatigue, and then feature extraction systems that employ deep learning and statistical models for mapping world information and desired features to develop reasoning and knowledge base that the SR is presumed to retrieve during collaboration. This is empowered with realistic human motion behaviour models and knowledge. Moreover, the better perception and world understanding will allow MAGICIAN to impact broader applications, not limited to the automotive industry.
c. *The capability to work without/with limited supervision*. MAGICIAN, with its CR solution, aspires to create a human-centred AI-enabled robot that operates with limited supervision to complement human workers, e.g., by mimicking its activities and sharing autonomy to handle tools, such as industrial grinders, collaboratively. In the MAGICIAN Use Cases, reported in the deliverable D2.1 .- "Use Case Definition", have been proposed and are meant to showcase in a primary industrial automotive settlement (the one of the **TOFAS** premises) on how the capabilities of robots can be enhanced up to the level of working for the cleaning of defects, in the Stamping or in the Body In White (BIW) processes, without/with limited human supervision.

d. *Capability to physically interact with or assist humans*. According to the preliminary works published in the field (Finn, C., Yu, T., Zhang, T., Abbeel, P., and Levine, S. One-Shot Visual Imitation Learning via Meta-Learning. In Proceedings of Machine Learning Research, 78:357-359, 2017), human activity recognition may enable robots to understand how their counterpart behaves. However, it requires a constraint concept to generate plausible and natural human motions to simulate human motion behaviours and their interaction with the world. A robot that understands how human behaves is likely to acquire knowledge and reasoning for doing things right and reliably. Furthermore, it is necessary to transfer human collaboration skills to understand further shared autonomy from workers and cobots operating together. In this aspect, it is essential to employ AI-based high-level task planning approaches that apply semantic descriptions. In general, a human is not a machine that can operate for a prolonged duration with constant efficacy. It is natural to have micro-interruptions or to reorder the body joints to feel refreshed. In contrast, a robot may continue working as long as the order is in place. It is necessary to fill the limitations of human physical capabilities by constantly monitoring human emotions, fatigue, and intention while empowering robots' cognition to understand human feelings. Further, it is necessary to build mutual understanding in human and robot partnership. In this aspect, MAGICIAN will have a specific impact on enhancing the capabilities to physically interact with or assist humans for the grinding operations.

e. *Intuitive, safe and efficient cognition capability*. Explainable representation of the world and process knowledge that MAGICIAN envisioned allows intuitive interaction between humans and robots through the SR and CR platforms. The AI-based models are further explained to create transparency and trust during collaboration. Furthermore, the robot complies with safety requirements that make the robot more acceptable and reliable to share human workspace.

Impact on scientific community.

As reported in the D7.1 – "D&C and Exploitation Plan", MAGICIAN has presented its results in different scientific conferences and symposia to share the work-in-progress and research results. In addition, quality-assured scientific journals e.g., IEEE TPAMI, IMAVIS, Autonomous Robots, and others are some of the targets. Nevertheless, MAGICIAN will also trigger contributions for the next research direction and dimension, potentially playing a significant role in shaping the future of robotic system requirements, human behaviour characterization and explainability of AI models together with renowned researchers and practitioners in the field.

Impact on industrial community

Improving European Industries competitiveness ever and ever mainly depends on research and innovation that goes beyond the state of the art and technology. In this aspect, MAGICIAN proposes robot cognition and handling capability that allows physical interaction between human and worker in a shared workplace. Furthermore, enabling robots with AI will maximize its applicability in various application scenarios. Within

MAGICIAN, this impact will be showcased in the demonstrative areas of a primary industrial player of the Automotive Market (the Stellantis group) in the premises of **TOFAS** in Bursa (Turkey).

Contribution to EU Green Deal initiative

MAGICIAN enhances sovereignty for Europe in AI, data and robotics in developing world-class technologies serving the needs of the automotive manufacturing, by providing top-performing solutions that industries will trust and adopt to maintain their competitiveness and maximize their contribution to environmental sustainability, thus contributing to EU Green Deal Initiative. Optimized HRC through AI enhances decision making process for efficient production, leading to less pressure on climate.

2.4 UPDATE OF THE PLAN FOR EXPLOITATION AND DISSEMINATION OF RESULTS

Work progress regarding Communication, Dissemination, and Exploitation activities including the Status has been detailed in section WP7 - Dissemination and Exploitation (SIG, M1-M48), of this report and summarizes T7.1 until T7.3. Both communication and dissemination activities have also been reported in the frame of continuous reporting in the project portal. Regarding exploitation, an updated list of key exploitable results has likewise been added to D7.1 and will be further updated during the first exploitation workshop (Part I and Part II) in M13.

As such, no update on the exploitation and dissemination of results in this first year of the project.

3 FOLLOW-UP OF RECOMMENDATIONS AND COMMENTS FROM PREVIOUS REVIEW(S)

Not applicable.

4 EXPLOITATION PRIMARILY IN NON-ASSOCIATED THIRD COUNTRIES

Not applicable.

5 OPEN SCIENCE

MAGICIAN follows the Open Science guidelines set by the Grant Agreement which states that immediate Open Access must be ensured for all project-related publications including data sets. To that end, **SIG** has established a MAGICIAN community on Zenodo, a trusted open repository developed under the EU OpenAIRE program, to make project results easily findable, accessible, interoperable, and reusable (FAIR principles) in Open Access.

To guide partners through Open Access obligations under Horizon Europe and give the general topic of Open Science emphasis during the project, WP7 meetings are used to inform partners in detail on the role of Open Science in the project implementation. In addition, **UNITN** has organized a webinar on 7th May 2024 for partners in the context of Data Management which has likewise included a presentation on Open Science under Horizon Europe.

6 DEVIATION FROM ANNEX 1 AND ANNEX 2

There are not deviations from the DoA, apart from a slight delay in the CR development, as reported in the following Section 6.1. Nonetheless, any corrective action is currently needed.

6.1 TASKS / OBJECTIVES

Regarding the objective O2 - *A robotic cleaning module attached to a robotic platform (the CR hereafter) equipped with a specialized end-effector to rework defects*, at the time of writing, the CR is under development. The cleaning module to be attached on the CR has been designed, while a second alternative is currently under development. The control architecture is ready, but the end-effector is yet to be mounted on the robot. The road towards the first integrated version of the solution at M21 does not present any serious risk.

6.2 USE OF RESOURCES

For this deliverable covering the progress of the MAGICIAN project during the first 12 months, we collected from all the partners the information related to the effort and costs spent. As the deliverable is due at M12, the information collected is provisional and this will be fixed at M18 with the official reporting.

In any case this gives a good idea of the project progress. In the next Sections we will provide an overview of the effort and the costs.

6.2.1 EFFORT

The estimated effort spent in total during the first 12 months amounts to 149,68 Person Months.

Tables 4 and 5 show the details of the Person Months claimed by the partners on the Work Packages for the Period M1-12 with respect to a *linear* planned effort (164,45 PMs), calculated on the Tasks durations, and with respect to the total planned effort M1-48 (977 PMs).

The project is slightly under consuming in terms of human resources (91,02%). As we will see in the rest of this section, there are some differences if we consider the single WPs and partners.

Table 4 Estimated effort M1-12 vs Planned Linear effort M1-12

		Duration	UNITN		IIT		LU		FORTH		CRF		TOFAS	
			Planned PMs M1-12	Estimated actual PMs M1-12	Planned PMs M1-12	Estimated actual PMs M1-12	Planned PMs M1-12	Estimated actual PMs M1-12	Planned PMs M1-12	Estimated actual PMs M1-12	Planned PMs M1-12	Estimated actual PMs M1-12	Planned PMs M1-12	Estimated actual PMs M1-12
WP1	Project management	M1-48	8,50	6,35	0,50	0,20	0,50	0,76	0,75	0,75	0,75	0,68	0,50	0,48
WP2	Use case definition and platform design	M1-48	6,07	3,49	4,45	2,44	8,11	12,12	0,79	0,79	7,39	7,17	5,32	8,00
WP3	Data acquisition and skills learning	M4-45	8,36	2,91	10,50	5,00	0,43	0,11	13,07	22,34	2,57	2,26	2,14	2,00
WP4	Robotic platform and interfaces	M4-45	16,50	9,28	13,93	11,00	0,86	0,10	0,50	0,50	2,79	2,46	1,07	0,20
WP5	Integration and performance analysis	M16-48		0,00		0,00		0,00		0,00		0,00		0,00
WP6	Cascaded funding management	M13-48		0,00		0,00		0,00		0,00		0,00		0,00
WP7	Dissemination and exploitation	M1-48	1,50	0,77	0,50	0,00	0,50	0,35	0,38	0,38	2,50	2,27	1,00	0,85
Total			40,93	22,80	29,87	18,64	10,39	13,44	15,48	24,75	16,00	14,84	10,04	11,53

		Duration	ALT		SIG		ZAB		PIP		HWH		TOTAL	
			Planned PMs M1-12	Estimated actual PMs M1-12	Planned PMs M1-12	Estimated actual PMs M1-12	Planned PMs M1-12	Estimated actual PMs M1-12	Planned PMs M1-12	Estimated actual PMs M1-12	Planned PMs M1-12	Estimated actual PMs M1-12	Planned PMs M1-48	Estimated actual PMs M1-12
WP1	Project management	M1-48	0,50	0,50	1,50	1,64	2,00	3,60	1,00	0,88	0,50	0,52	17,00	16,36
WP2	Use case definition and platform design	M1-48	3,79	3,23		0,00	1,00	0,89	1,57	0,47	3,36	3,88	41,84	42,48
WP3	Data acquisition and skills learning	M4-45	0,64	0,64		0,00		0,00	1,36	2,63	0,86	0,80	39,93	38,69
WP4	Robotic platform and interfaces	M4-45	1,07	1,07		0,00		0,00	1,57	0,97	5,14	5,49	43,43	31,07
WP5	Integration and performance analysis	M16-48		0,00		0,00		0,00		0,00		0,00	0	0,00
WP6	Cascaded funding management	M13-48		0,00		0,00		0,00		0,00		0,00	0	0,00
WP7	Dissemination and exploitation	M1-48	1,00	1,00	11,25	12,50	2,00	2,00	0,38	0,10	1,25	0,87	22,25	21,09
Total			7,00	6,44	12,75	14,14	5,00	6,49	5,88	5,05	11,11	11,56	164,45	149,68

Table 5 Estimated effort M1-12 vs Planned effort M1-48

		Duration	UNITN		IIT		LU		FORTH		CRF		TOFAS	
			Planned PMs M1-48	Estimated actual PMs M1-12	Planned PMs M1-48	Estimated actual PMs M1-12	Planned PMs M1-48	Estimated actual PMs M1-12	Planned PMs M1-48	Estimated actual PMs M1-12	Planned PMs M1-48	Estimated actual PMs M1-12	Planned PMs M1-48	Estimated actual PMs M1-12
WP1	Project management	M1-48	34	6,35	2	0,20	2	0,76	3	0,75	3	0,68	2	0,48
WP2	Use case definition and platform design	M1-48	16	3,49	16	2,44	29	12,12	2	0,79	19	7,17	13	8,00
WP3	Data acquisition and skills learning	M4-45	39	2,91	49	5,00	2	0,11	61	22,34	12	2,26	10	2,00
WP4	Robotic platform and interfaces	M4-45	77	9,28	65	11,00	4	0,10	7	0,50	13	2,46	5	0,20
WP5	Integration and performance analysis	M16-48	28	0,00	12	0,00	3	0,00	8	0,00	11	0,00	30	0,00
WP6	Cascaded funding management	M13-48	20	0,00	6	0,00	1	0,00	4	0,00	3	0,00	6	0,00
WP7	Dissemination and exploitation	M1-48	6	0,77	2	0,00	2	0,35	3	0,38	10	2,27	4	0,85
Total			220	22,80	152	18,64	43	13,44	88	24,75	71	14,84	70	11,53

		Duration	ALT		SIG		ZAB		PIP		HWH		TOTAL	
			Planned PMs M1-48	Estimated actual PMs M1-12	Planned PMs M1-48	Estimated actual PMs M1-12	Planned PMs M1-48	Estimated actual PMs M1-12	Planned PMs M1-48	Estimated actual PMs M1-12	Planned PMs M1-48	Estimated actual PMs M1-12	Planned PMs M1-48	Estimated actual PMs M1-12
WP1	Project management	M1-48	2	0,50	6	1,64	8,00	3,60	4,00	0,88	2,00	0,52	68,00	16,36
WP2	Use case definition and platform design	M1-48	12	3,23		0,00	2,00	0,89	4,00	0,47	9,00	3,88	122,00	42,48
WP3	Data acquisition and skills learning	M4-45	3	0,64		0,00		0,00	19,00	2,63	4,00	0,80	199,00	38,69
WP4	Robotic platform and interfaces	M4-45	5	1,07		0,00		0,00	22,00	0,97	24,00	5,49	222,00	31,07
WP5	Integration and performance analysis	M16-48	50	0,00		0,00		0,00	7,00	0,00	24,00	0,00	173,00	0,00
WP6	Cascaded funding management	M13-48	12	0,00	1	0,00	40,00	0,00	4,00	0,00	4,00	0,00	101,00	0,00
WP7	Dissemination and exploitation	M1-48	4	1,00	45	12,50	8,00	2,00	3,00	0,10	5,00	0,87	92,00	21,09
Total			88	6,44	52	14,14	58	6,49	63	5,05	72	11,56	977,00	149,68

If we consider the WPs in Table 6, we can see that **WP4** is the only one under consuming. This is essentially due to the underspending of **UNITN** (difficulties in the recruitment process of the post-doc, and time constraints imposed by the Italian regulations for PhDs that will be finalised between the end of September and November 2024 and the arrival of the robot in May 2024, M8). Furthermore, the work to be carried out in WP4 highly depends on the platform and embeds the findings and requirements of WP2 and WP3.

The other active WPs (**WP1**, **WP2**, **WP3** and **WP7**) are more or less in line, although there are some differences between the beneficiaries contributing to these WPs that will be analysed in the next paragraphs.

Notice that WP5 and WP6 will start during the second year of the project.

Table 6 Estimated Person Months M1-12 by WP

WP	WP1	WP2	WP3	WP4	WP5	WP6	WP7	Total
Planned Effort M1-48	68	122	199	222	173	101,00	92,00	977
Planned Effort M1-12	17,00	41,84	39,93	43,43			22,25	164,45
Actual Effort M1-12	16,36	42,48	38,69	31,07			21,09	149,68
% M1-12	96,24%	101,52%	96,90%	71,54%			94,76%	91,02%
% M1-48	24,06%	34,82%	19,44%	14,00%			22,92%	15,3%

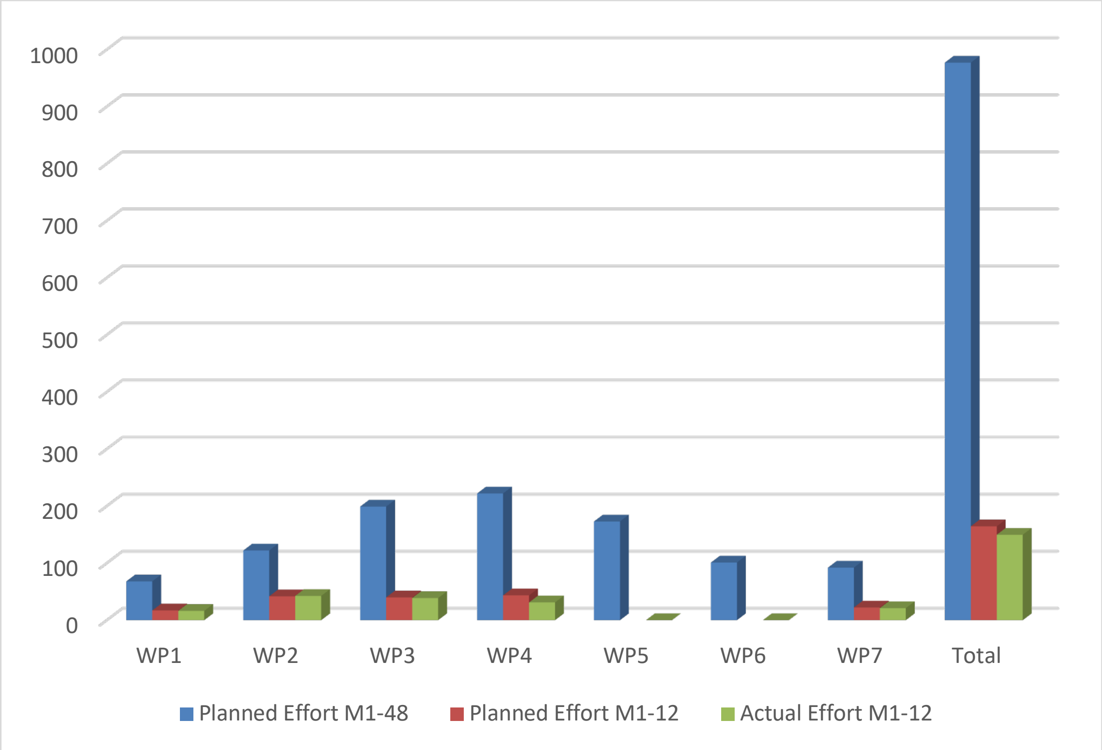

Figure 2 Estimated Person Months M1-12 by WP

Regarding the effort claimed by the partners, most of them are in line or overspending.

UNITN is underspending (55,71% of the linear planned effort) and the reasons are mainly related to the aforementioned long process of recruitment. One post-doc researcher has just been recruited and started at the end of September, while the team will be completed only in November 2024, when 3 PhD students will start their careers. Notice that November 2024 is the official starting date for all the PhD programs in Italy. During this first year, the work has been implemented mainly by the senior researchers involved in the project. This is reflected by the higher average PM cost. As an additional remark, the tasks related to WP3 and WP4 suffered a delayed implementation start induced by the robotics platform selection its availability, that was available at M8 (May 2024).

IIT is under consuming in terms of PMs. Similarly to Trento, the work during the first year has been performed mainly by senior researchers. While the work of **IIT** follows two main paths, namely the design and implementation of the haptic sensing system and the development of the grinding end-effector, with the associated control algorithms, the late arrival of the robot has an impact for this partner as well.

CRF, **TOFAS**, **ALT**, **SIG**, **PIP**, **HWH** are more or less in line with the linear planned effort.

LU is slightly overspending in terms of person month, and this is explained by the higher effort spent on WP2 at the beginning of the project. Moreover, the team comprises PhD students and one post-doc, who have been working on the related MAGICIAN tasks: since these young researchers generally require more time to complete the activities than the senior researchers, hence the higher number of PMs reported.

Similarly, **FORTH** claimed a higher effort, in WP3, because of the involvement of junior researchers at a lower cost.

ZAB claimed 1,5 PM more in WP1 for the collaboration given to **UNITN** for the setup of the project repository, involving more junior profiles.

Table 7 Estimated Person Months M1-12 by Beneficiary

Partner	UNITN	IIT	LU	FORTH	CRF	TOFAS	ALT	SIG	ZAB	PIP	HWH	Total
Planned Effort M1-48	220	152	43	88	71	70	88	52	58	63	72	977
Planned effort M1-12	40,93	29,87	10,39	15,48	16	10,04	7	12,75	5	5,88	11,11	164,45
Actual Effort M1-12	22,80	18,64	13,44	24,75	14,84	11,53	6,44	14,14	6,49	5,05	11,56	149,68
% M1-12	55,71%	62,40%	129,32%	159,87%	92,75%	114,89%	92,00%	110,90%	129,80%	85,96%	104,08%	91,02%
% M1-48	10,36%	12,26%	31,26%	28,13%	20,90%	16,47%	7,32%	27,19%	11,19%	8,02%	16,06%	15,3%

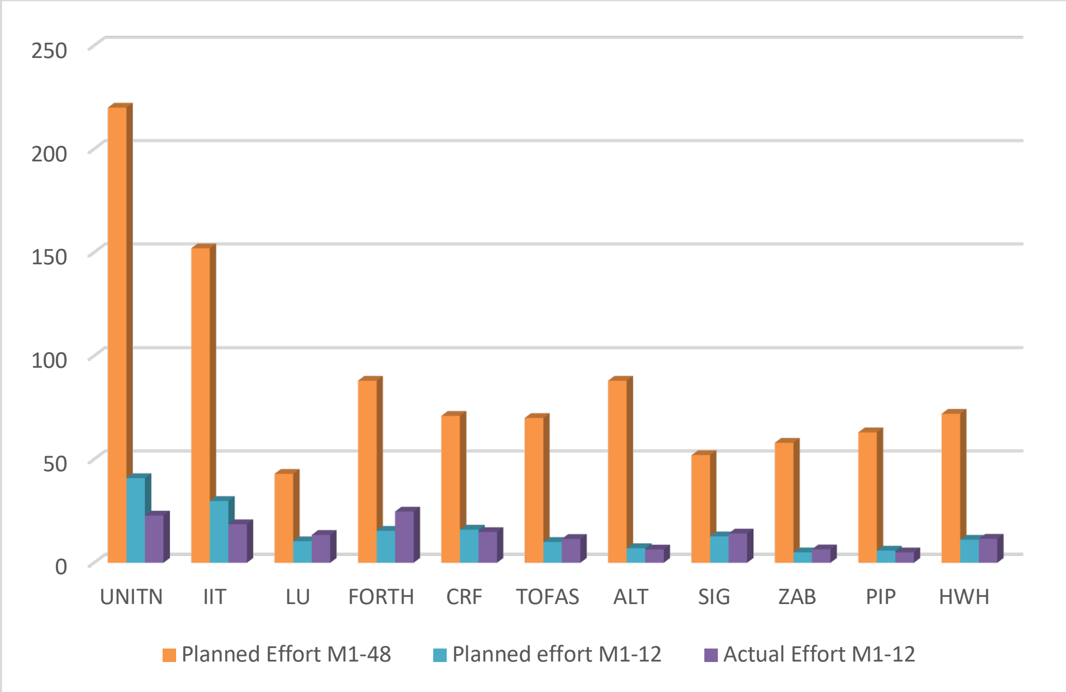

Figure 3 Estimated Person Months M1-12 by Beneficiary

6.2.2 COSTS

Concerning the estimated costs for the Period M1-12, we have to specify that, as the effort, the figures are partial and provisional due to the difficulties for the administrative and financial units to have complete information until the end of September.

All the partners collaborated providing the latest information available and this allows us to draft an analysis of the costs. This is part of an internal monitoring of the use of resources that is planned to be done every 6 months.

As we can see in Table 8, the main cost category is, of course, Personnel that absorbed 16% of the planned budget. This is quite in line with the claimed effort (15% considering the total planned effort M1-48).

Table 8 Estimated costs M1-12

	PLANNED TOTAL COSTS M1-48	ACTUAL ESTIMATED COSTS M1-12	REMAINING BUDGET	% delta
Personnel	**4.786.940,00**	**784.221,89**	4.002.718,11	16,38%
Subcontract		**-**	-	
Travels	**311.000,00**	**25.600,55**	285.399,45	8,23%
Equipment	**282.700,00**	**78.010,85**	204.689,15	27,59%
Other goods and services	**350.585,00**	**20.584,79**	330.000,21	5,87%
Financial support to third parties	**2.000.000,00**	**-**	2.000.000,00	0,00%
Internally invoiced goods and services	**10.000,00**	**-**	10.000,00	0,00%
Indirect costs	**1.432.806,25**	**227.104,52**	1.205.701,73	15,85%
Total	**9.174.031,25**	**1.135.522,59**	**8.038.508,66**	**12,38%**

Most of the partners involved researchers with junior profile as we can see in Tale 9. In this table we didn't report the amounts because of the deliverable D1.2 is marked as Public and some partners had concerns about sensitive information. So, we decided to show only the percentage of the ratio between the actual personnel cost and the planned personnel cost. Complete tables will be included in the official Periodic Report.

UNITN and **IIT** involved senior researchers due to the recruitment issues, hence the higher percentage. Since the situation of **LU** and **FORTH** is symmetrical, as stated previously, the cost reduced.

TOFAS delta is explained by Turkish lira-Euro currency change versus inflation and resulting salary increases discrepancy between the proposal and reporting period.

Table 9 Actual/Planned average PM cost (delta in %)

Partner	UNITN	IIT	LU	FORTH	CRF	TOFAS	ALT	SIG	ZAB	PIP	HWH
% delta Actual/Planned PM average cost	147,25%	148,43%	78,54%	77,66%	100,48%	138,10%	57,27%	81,99%	84,40%	76,19%	100,00%

Travels and Other Goods and Services categories are in underspending at M12, but these will increase in the next months with the intensification of the project tasks and also of the dissemination and communication activities.

Other goods and services include organisation costs related to project meetings, conferences fees, consumables needed for technical activities, costs related to website, templates, flyers & rollup design.

Equipment is in line, thanks to the purchase of the robots.

Table 10 Estimated Purchase costs M1-12

	ESTIMATED TOTAL COSTS M1-12
Travels	25.600,55
Equipment	78.010,85
Other goods and services	20.584,79
Internally invoiced goods and services	-

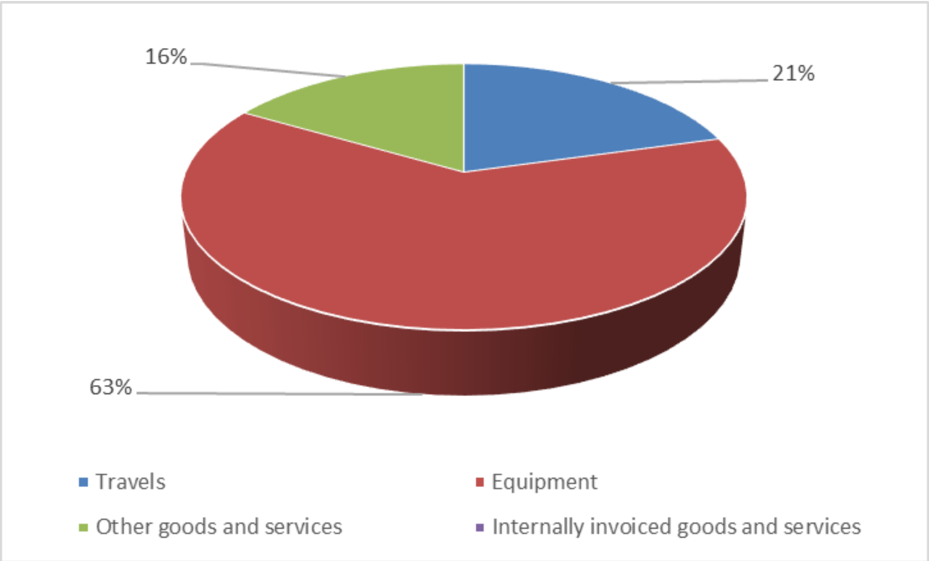

Figure 4 Estimated Purchase costs M1-12

6.2.3 UNFORESEEN SUBCONTRACTING

Not applicable.

6.2.4 UNFORESEEN USE OF IN KIND CONTRIBUTIONS

Not applicable.