Project Acronym: STAR
Grant Agreement number: 956573 (H2020-ICT-2020-1 – Research and Innovation Action)
Project Full Title: Safe and Trusted Human Centric Artificial Intelligence in Future Manufacturing Lines
Project Coordinator: INTRASOFT International

Funded by the Horizon 2020 Framework Programme of the European Union

DELIVERABLE

D6.2 – Report on Pilot Sites Preparation

Final Version

Dissemination level	PU -Public
Type of Document	Report
Contractual date of delivery	31/12/2022
Deliverable Leader	DFKI
Status - version, date	Final – v1.0, 28/01/2023
WP / Task responsible	WP6
Keywords:	Pilots, Deliverables, Testbeds, Management

Executive Summary

This document as the final version of the deliverable related to task 6.1 "*Pilot Sites Preparation and Pre-Pilot Testing",* which supersedes the previous versions, reports on the activities that have been undertaken in the first two years of the life cycle of the STAR project.

AI systems become more demanding in all domains of research and industries. AI approaches need to be safe and reliable even more in industries with a dynamic and unpredictable environment, and especially when there are humans involved. In the STAR project, the goal is to make the AI systems safe, trusted, and secure in unpredicted and complex environments.

In the STAR project, WP6 "Integration, Validation, and Evaluation" as one of its main objectives focus on the preparation of the three pilot sites of the project for testbeds and their operations of real-life scenarios involving agile manufacturing, quality management, and human-robot collaboration

Task 6.3 which is dedicated to the Philips testbed is focusing on the customization and deployment of the STAR platform, with a focus on human-centric AI technologies for quality inspection in the production line. Task 6.4 focuses more on human action prediction, mobile robot route planning, as well as providing a safe zone for human-robot interaction in the industrial environment. Finally, task 6.5 is handled by IBER-OLIFF and the goal of this pilot is to develop manufacturing processes that are agile, sustainable, and efficient economically. The aim here in this pilot is to manufacture customized products in agile production systems to extend efficiency, speed, operation, and maintenance monitoring. This pilot is human-centered and will be supported at the production management decision-making level by the STAR artificial intelligence platform, connected to the existing digital factory. These three pilots from a wide range of applications in the industrial environment, drive us to test the STAR platform in the avenue of digitalization of the industrial environment using the AI approaches to have a safe and more reliable environment confronting human presence.

Hence, task 6.1 targets to monitor and track the setup of the three pilots as the testbeds for the STAR project. Moreover, during the execution of the activities, possible technical issues and difficulties in the installation were discussed in the regular meetings between all WP6 partners. Furthermore, any deviation in the scenarios and testbeds have been tracked, discussed, and reported. Finally, the collaborations between the testbeds and other partners from other WPs, mainly with the technology providers, were being tracked.

Furthermore, in the STAR project, to make the synergies between different partners more effective and manageable, separate workshops for each pilot partner have been conducted. These workshops were extensively documented and reported under D2.9 "Report on Co-Design Workshops and Focus Groups-Initial version" which allowed the pilot partners to communicate with each other about their specific use cases, and correspondingly with other partners, especially technology providers. Moreover, to make the synergies more productive and effective, some pieces of documentation have been prepared regarding different use cases and the relevant modules, and are shared between all partners in this project, which can enhance the cooperation between all the pilot partners in task 6.1, technology providers as well as other parties in this project. The list of components used in each use case for each testbed, the list of data sharing platforms and local datasets, and the sample of the datasets utilized in each use case are to name but a few of these reported documents.

Finally, in the forthcoming months of the project, we will validate each pilot for their use cases, and evaluate their results in the last step of their studies.

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Document History			
Version	**Date**	**Contributor(s)**	**Description**
0.1	24/11/2022	DFKI	Initial Table of Contents
0.2	02/01/2023	GFT	Review of the first version
0.3	23/01/2023	DFKI	Revised version based on the Comments.
1.0	27/01/2023	INTRA	QA and creation of the submitted version

Table of Contents

EXECUTIVE SUMMARY 2
TABLE OF CONTENTS....... 5
LIST OF FIGURES 6
DEFINITIONS, ACRONYMS AND ABBREVIATIONS 6
1 INTRODUCTION....... 8
1.1 PURPOSE AND OBJECTIVES 8
1.2 DOCUMENT STRUCTURE 9
2 STAR PILOT PARTNERS PRESENTATION....... 10
2.1 PHILIPS (PCL) 10
2.2 IBER-OLEFF (IBER) 11
2.3 GERMAN RESEARCH CENTER FOR ARTIFICIAL INTELLIGENCE (DEUTSCHES FORSCHUNGSZENTRUM FÜR KÜNSTLICHE INTELLIGENZ) -DFKI 12
3 PILOT SITES PREPARATION....... 15
3.1 CHANGES IN THE PILOT SITE PREPARATION SINCE THE PREVIOUS VERSION OF THE DELIVERABLE....... 15
3.2 PILOT PARTNERS AND USE CASES 15
3.2.1 Human-AI Collaboration for Robust Quality Inspections....... 15
3.2.2 Human-centred AI for Agile Manufacturing 4.0....... 17
3.2.3 Human behaviour prediction and safe zone detection....... 19
3.3 WORKSHOPS 22
3.3.1 First workshop....... 22
3.3.2 Second workshop 23
3.4 IDENTIFICATION OF THE RELEVANT COMPONENTS 24
3.5 DATASET SAMPLE AND LOCAL SHARE-POINT PREPARATION 25
3.6 ETHICAL MANAGEMENT AND LEGAL ANALYSIS 27
3.7 SYNERGY BETWEEN TECHNOLOGY PROVIDERS AND IBER PILOT PARTNER FOR THEIR DATASET PREPARATION 27
3.8 STAR DEPLOYMENT FOR SOLUTION 27
4 MAIN USE CASE RELATED ACTIVITIES PERFORMED DURING THE PERIOD OF TWO YEARS....... 28
5 CONCLUSION 29

Table of Figures

FIGURE 1: PHILIPS LOGO 10
FIGURE 2: IBER LOGO 11
FIGURE 3: DFKI LOGO 12
FIGURE 4: SMARTFACTORY LOGO 13
FIGURE 5: SMARTFACTORY TESTBED 14
FIGURE 6: PRODUCTION SYSTEMS SCHEMA, AND FOUR USE CASES FOR IBER TESTBED. 18
FIGURE 7: AS-IS SCENARIO FOR SMARTFACTORY TESTBED 19
FIGURE 8: AS-IS SCENARIO FOR SMARTFACTORY TESTBED. 20
FIGURE 9: TO-BE SCENARIO FOR SMARTFACTORY TESTBED 21
FIGURE 10: SMARTFACTORY TO-BE SCENARIO, ALL USE CASES COMBINED. 21
FIGURE 11: SECOND WORKSHOP FOR PHILIPS TESTBED (ATHENS, GREECE). 24
FIGURE 12: LEFT: ROBOTINO'S LASER SCANNER USED FOR AS-IS LAYOUT GENERATION FOR SMARTFACTORY TESTBED. RIGHT: SCANNED LAYOUT AFTER MANUAL MOVEMENT THROUGH THE PLANT FOR SMARTFACTORY TESTBED. IN THE TO-BE SCENARIO, WE JUST USE THE SCANNED LAYOUT ONE TIME AS THE INITIAL POINT FOR THE LAYOUT WHICH WILL BE USED FOR THALES ALGORITHM FOR CALIBRATION. AFTERWARD ANY CHANGE TO THE LAYOUT CAN BE MEASURED BY THALES ALGORITHM. 26

Definitions, Acronyms and Abbreviations

Acronym/ Abbreviation	Title
AI	Artificial Intelligence
AMR	Automatic Mobile Robot
HAR	Human Action Recognition
HCI	Human Computer Interaction
WP	Work Package

1 Introduction

1.1 Purpose and Objectives

With the recent development of AI-based approaches in a wide range of applications, industries are not exempt from this levelling up. The digital transformation of the production lines is considered the major conversion to Industry 4.0 relying on a wide range of innovative tools and approaches. These shifts in technologies need to be safe and reliable to be implemented in unpredictable, dynamic, and complex environments, where robots and humans are working together. Hence it is crucial to apply and test these AI technologies in industrial environments. The STAR project plans to address these aspects by researching, implementing, validating, and demonstrating AI technologies.

The STAR project's objectives need to be applied and tested in industrial environments and to be proved in different scales in a wide range of manufactories' testbeds. Hence, the STAR project aims to apply and test its AI approaches in the three testbeds with a wide range of functionality and broad industrial applications with different scenarios from manufacturing products in agile production systems to human-robot interaction scenarios, and quality inspection in the production line. WP6 focuses on the integration, validation, and evaluation of the purposes of the STAR project in these manufactories' testbeds.

The main objectives of the WP6 are:

- Preparation of three pilot sites as the testbeds for applying the STAR goals in miscellaneous real-life scenarios consisting of a wide range of agile manufacturing, quality management, and human-robot collaboration. Three pilot sites that collaborate in the STAR project are SmartFactoryKL Pilot Lab in Germany, Philips's factory in the Netherlands, and IBER's factory in Portugal. These pilots with their wide range of functionalities and use cases are the proper testbeds for testing, validating, and evaluating the STAR approaches in dynamic and unpredictable environments, since on one hand the human presence which is the aim of the SmartFactoryKL and IBER pilot scenarios is the main aspect that brings the complexity into the use cases and environments, and on other hand, their wide range of nature gives us the reliable perspective on how broadly apply the STAR project in different industrial environments.
- Integration of the project technical development and prototyping in the STAR platform for secure and safe AI in the manufacturing area.
- Customization and deployment of the STAR platform for the three pilot partner scenarios, agile manufacturing, quality management, and human-robot collaboration.
- Validation of the STAR platform in pilot partners' real-life scenarios.
- Evaluation of the STAR platform in the pilot scenarios from technical, techno-economic, and socio-economic perspectives. The evaluation consists of the users' feedbacks on the easiness of use, and workers' satisfaction.

In the WP6, T6.1 "Pilot Sites Preparation and Pre-Pilot Testing" has started in the first month of the STAR project, and its life cycle is twenty-four months. This task's focus is the preparation of three pilot sites for applying the AI manufacturing systems relying on the STAR platform at the appropriate time. Some of the main activities to be undertaken in this task are: the mobilization of appropriate stockholders in the pilot sites; the training of workers and other actors; pre-deployment, testing, and resolution of the ethical management processes.

Task 6.1, in collaboration with the pilot's coordination task in WP1, focuses on establishing a common/uniform methodology for coordinating and monitoring the preparation of all three pilot partners. The main objectives of the STAR project which need to be addressed in this task are monitoring and synergies regarding different scenarios with other pilot partners and technology providers, the preparation and testing of the testbeds for the AI technologies and evaluate the STAR approach in these three pilots.

1.2 Document structure

In the chapters of this deliverable, the following information are reported:

- Introduction of pilot partners in WP6. We introduce and provide a brief description of the pilot partners on which the AI approaches of the STAR project will be applied. These pilot partners are from a wide range of research institutes and industries with a broad field of studies and diverse scenarios.
- Pilot activities during these twenty-four months period and use cases definitions.
- Documentation for the synchronization and monitoring of the pilot partners' scenarios and the summary of the first and second workshop organized for each of them.
- The targets and activities have been accomplished in the second year of the project.
- Finally, the conclusion of this report.

2 STAR pilot partners presentation

The three different pilots in the STAR project are presented in this section, as a global introduction of the activities carried out in T6.1.

2.1 Philips (PCL)

Figure 1: Philips Logo

Royal Philips is a diversified health and well-being company, focused on improving people's lives through meaningful innovation in the areas of Healthcare and Consumer Lifestyle. The company is a leader in cardiac care, acute care, and home healthcare, including male shaving, grooming, and oral healthcare. Headquartered in the Netherlands, Philips posted 2018 sales of EUR 18.1 billion and employs approximately 77,000 employees with sales and services in more than 100 countries.

Philips Drachten is one of the biggest production and development centers in Europe within Philips. Philips Drachten is a globally oriented center where employees from all over the world collaborate enthusiastically on the development and production of products that improve people's lives. In the factory, which is at the forefront of the latest production techniques, the industry works 24/7 to create a wide range of innovative produces like the OneBlade shavers, Philips Avent baby bottles, teats & parts of Sonicare parts.

The Philips site in Drachten employs over 2100 people, amongst which 600 developers with 40 different nationalities. For more than 60 years the site in Drachten has been manufacturing shaving systems. In 2016 PHILIPS launched the Philips OneBlade, the biggest innovation in male grooming since the razor. PHILIPS Drachten is the manufacturer of the shaving element of this revolutionary device.

As a mass manufacturer of consumer goods, Philips Drachten has many different specialistic competencies developed under which metal cold forming, electrochemical machining, electrochemical grinding, injection molding, lacquering, printing decoration, micro-assembly, and micro-welding.

2.2 IBER-OLEFF (IBER)

Figure 2: IBER Logo

IBER-OLEFF is a private company, founded in 1993, part of IBEROMOLDES Holding, headquartered in Pombal, Portugal. IBER-OLEFF Pombal is the biggest manufacturing site of the holding and is focusing on designing, engineering, and producing the systems and different components for the automotive and electronic industries. Specifically, the focus of the company is in producing the interior plastic components for vehicles like Ford, Bosch, BMW, Delphi, Continental, Volkswagen, Seat, McLaren, Ferrari, and Mitsubishi Trucks Europe, to name a few. The range of the components produced by IBER-OLEFF Pombal is wide namely air vents, ashtrays, grills, radio bezels, multimedia systems. IBER-OLEFF Pombal strategic development gives particular emphasis on agility and flexibility of its layouts and team training, allowing competitive management of small series (niche models) or large series production (vehicles and products of high consumer market models).

IBER-OLEFF Pombal created a full-service-supplier methodology that applies to the whole product cycle from the concept phase to the delivery of the final product to the customers. Their methodology is complete and integrated service, ranging from concept and design, engineering, developing, and prototyping, to industrialization through production. Preceding the massive production, in their product development phase, in which a small series of the production is needed to be produced, the prototype modules are the fastest and more economic process for the pilot-series production. IBER-OLEFF Pombal benefits the advanced technologies providing cutting-edge rapid prototyping and rapid manufacturing solution for a broad array of applications for a wide range of materials.

IBER-OLEFF Pombal intends to implement an agile production unit with vertical and horizontal integration, namely, to incorporate in a production cell of polymeric components an integrated set of equipment and accessories that should add new functions to the usual ones. One of the challenges has to do with full quality control of parts right after the injection process or before entering the assembly process. Another challenge relates to the industrialization of plastic components for automotive interior air vents, including parts with appearance requirements, in ONE-SHOT and ZERO-DEFECT typology, creating a highly customizable product, considering a production unit where several production processes coexist simultaneously, such as injection, decoration, and assembly.

The main IBER-OLEFF Pombal tasks and activities in the STAR project are to present the testbed and apply the AI algorithms from the project in their pilot considering their use case, "human-centered AI for Agile Manufacturing". Considering the pilot unit implemented for the STAR project to achieve the determined goals, IBER-OLEFF Pombal intends to extend this concept to the entire production unit in Pombal (Portugal) as well as the other units in Marinha Grande (Portugal), Martinganca (Portugal), and Salto (Brazil).

2.3 German Research Center for Artificial Intelligence (Deutsches Forschungszentrum für Künstliche Intelligenz) - DFKI

Figure 3: DFKI logo

The German Research Center for Artificial Intelligence (DFKI) was founded in 1988 as a non-profit public-private partnership and now has around 40 million annual turnover and 1000 full-time employees. It has research facilities in Kaiserslautern, Saarbrücken, Bremen, and project office in Berlin. It is the largest European research center devoted solely to Artificial Intelligence and its applications. Research and development projects are conducted in seventeen research departments and research groups, which cover a broad range of AI-related areas: from Deep Learning fundamentals through Robotics, Internet of Things, Industry 4.0, and autonomous driving to Human-Computer Interaction.

In this research center, funding is received from government agencies like the European Union, the Federal Ministry of Education and Research (BMBF), the Federal Ministry for Economic Affairs and Energy (BMWi), the German Federal States, and the German Research Foundation (DFG), as well as from direct cooperation with industrial partners. Beyond academic excellence, DFKI sees its mission in making a real-world impact and facilitating the effective transfer of cutting-edge technology to European industry. Since its founding 30 years ago 60-spin-off companies have resulted from DFKI projects.

Figure 4: SmartFactory logo

Embedded Intelligence group and SmartFactoryKL (SmartFactory) test lab (Figure 5) participate and cooperate in the STAR project. Embedded Intelligence group implements software components that will be used to detect human activities as well as to assist the autonomous mobile robot during its path planning. SmartFactory test laboratory is used to realize three different use cases to define safety zones for an autonomous robot in production.

Figure 5: SmartFactory testbed

In the STAR project, DFKI leads WP6, related to the integration, validation, and evaluation of the AI technologies from the STAR platform in different pilots with a wide range of use cases. In addition, the SmartFactory will be used as a testbed located in the DFKI, in this laboratory DFKI will apply and test its scenarios as well as technologies. Thanks to the flexible and modular demonstrator in the SmartFactory, it is reflected as Industry 4.0 factory in the test environment. Besides several powerful computers, which are available for developing and testing algorithms, DFKI is also the first institution in Europe that receives an NVIDIA DGX-2, which is the world’s most powerful AI supercomputer which can be utilized for the most complex AI challenges.

3 Pilot sites preparation

3.1 Changes in the pilot site preparation since the previous version of the deliverable

During the last year of the project's lifespan, (from the 12th month to the 24th month of the project life), several activities to prepare the three pilot sites have been conducted. In this section, for each part, we provide some updates to the initial version of this deliverable by completing the subsection with the whole activities performed until month 24th. Hence, every subsection consists of several assignments and activities performed by the pilot partners in the first two years of the project. Here, we report on the main activities regarding the use case initialization and pilot site preparation.

3.2 Pilot partners and Use Cases

Testbeds are employed to deploy, validate and evaluate different technologies and aspects of the STAR project in real-world production lines in different environments. The three pilot partners focus on different production areas and research areas:

(i) PCL's pilot focuses on the secure, safe, reliable ad human-centered operations of robots used for visual quality inspection.

(ii) DFKI brings the prediction of human behavior toward initializing safety zone in dynamic and complex production environments and involves optimal configuration for AMR.

(iii) IBER's pilot focuses on secure and human-centered AI systems for agile production operations for the manufacturing of high-quality injected parts and integrated systems for the automotive industries.

In the following, we elaborate on the use cases corresponding to each pilot partner.

3.2.1 Human-AI Collaboration for Robust Quality Inspections

One of the challenges currently faced in the Philips factory in Drachten revolves around the introduction of flexible manufacturing.

Within the current production of shavers, there is a strong emphasis on standardization, automation, and minimization of cycle times within the production lines. These production lines are often specifically tailored for the mass production of one product or product series in the most efficient way. However, due to a shift in customer demand, smaller batch production and customized products are more often requested. To comply with this shift in customer demand, production lines need to be reconfigured more often to be able to produce different products with the same assets. These reconfigurations are expensive and time-consuming. To be able to comply with the market demand and fulfil customer demand in an effective manner, innovative solutions that enable flexibility are investigated, developed, and implemented during the STAR project.

As a global leader in the manufacturing of mass-produced consumer products, Philips is working on use cases revolving around this topic of flexibility and safe human-machine collaboration which is not limited to hardware and the physical world. Philips aims to deliver a pilot demonstrator of the developed technologies in a relevant production environment. By doing this the technology solutions investigated and developed during the STAR project can be demonstrated while providing valuable insights into how these results can be leveraged to improve the flexibility and safety of today's as well as future production systems.

During the STAR project, Philips has defined three use cases regarding the creation of such flexible and safe production systems.

1. Human supervised learning for visual quality inspections.
2. Effective collaboration between humans and artificial intelligence.
3. Safe collaboration between humans and artificial intelligence.

With the first use-case the aim is to introduce flexibility into production revolving around quality inspection for both high and low volume production. In this use case, we aim to investigate and implement solutions that can help setup quality inspection systems in an easy and flexible manner. Normally visual quality inspection systems are trained based on extensive datasets which always require optimization during the production phase. At the start of production ramp-up the performance of the traditional inspection system is not good enough to rely on. Another issue is that in production we aim to produce only good products, so it takes time to gather the specific failure mode learning examples. With low volume production we simply don't produce the number of parts required to train a traditional inspection system. To setup an automated visual quality inspection with fewer examples, alternative solutions are needed since the data volumes are not available at the right time. Therefore, the aim of this use case is to setup an automated quality inspection in a quick and easy way by employing active learning to the quality inspection algorithms. Active learning is a training method for machine learning algorithms where the algorithm asks supervision from a human where it is uncertain. This would enable the setup of such an automated quality system with a relatively small dataset after which the system can continue learning based on operator input to cases in which the algorithm is not sure about its quality assessment. By doing this, we are aiming to utilize the best of both machines and humans to create a dynamic and efficient production environment.

The second use case aims to investigate the interaction of humans and the quality inspection AI. PCL is shifting more and more towards fully automated production lines with limited but increasingly crucial interaction with humans. Regardless of the level of advancement of the AI, a human will always be needed to give some form of instructions. The aim is to develop a system which allows operators to efficiently train the AI for its task.

The last use case will investigate the interaction on an even deeper level. Because of the reduced interaction with the production process, the human role becomes smaller which may lead to problems on a cognitive level. Operators might become distracted, bored, etc., in this new role. Because of the importance of the human role this might lead failure of effective application of AI in quality inspection. The aim is to ease the cognitive load of work activities like data labelling which is necessary to train the AI.

3.2.2 Human-centred AI for Agile Manufacturing 4.0

The future of IBER depends on its ability to develop new knowledge-based manufacturing processes that are agile, efficient, and sustainable environmentally and economically. A key aspect is the manufacture of customized products in agile production systems that allow for greater efficiency, speed, operation, and maintenance monitoring, and greater freedom for engineering design, including the incorporation of smarter components & parts.

The IBER market products are influenced by the end customer, their tastes, and their degree of satisfaction, that's why OEMs today have prioritized cockpit customization. The automotive industry is increasingly faced with the paradigm of the need to reduce costs, while at the same time increasing perceived quality and greater product functionality. The paradigm of product development in the automotive sector is changing, where OEMs are increasingly looking for industrial partners with the ability and competence to fulfil product design, industrialization, production, and distribution responsibilities.

All these dynamics have led to substantial changes in the plastic parts and components market, which requires rethinking molding tools, injected materials, and all the parameterization of transformation processes. In particular, the IBER company already have a high degree of automation, however, do not have the agility, at least in the size required by the challenges of the new industrial reality, which requires faster reconfiguration of the production process in order to respond to small series production, or large series production that may contain several versions with different characteristics or minor aesthetic or functional changes, depending on end-customer preferences, quality level, country, region, etc. (customized mass production).

Product complexity and variability may imply the use of different manufacturing and monitoring processes, which can be developed with tools that themselves combine these processes into a single workstation and/or multiple tools/workstations generating the multifunction production cells. It is critical that the production processes are vertically and horizontally integrated, that means the levels of production management, high-level planning, and management need to have detailed access to the production line with detailed real-time information, but also the entire production line, and other manufacturing cells need to know the general state of any cell for effective real-time optimization and management. The management of this complex process network must be achieved flexibly and responsibly, responding to scheduled production changes as needed to maintain process competitiveness.

The IBER's final goal within the STAR project is to develop a solution for intelligent integration of processes and products to achieve solutions and systems that will allow the production of complex parts with the highest quality and minimal resources. In order to achieve that, IBER has defined four use cases:

1. Production processes simulations for accelerated decisions and safe processes.
2. Production planning optimization.
3. Employ training for reduction of human errors.
4. Agile production management system data integrity and reliability.

In the following figure, the production system is schematically represented and the four use cases planned to be developed in the STAR project are highlighted.

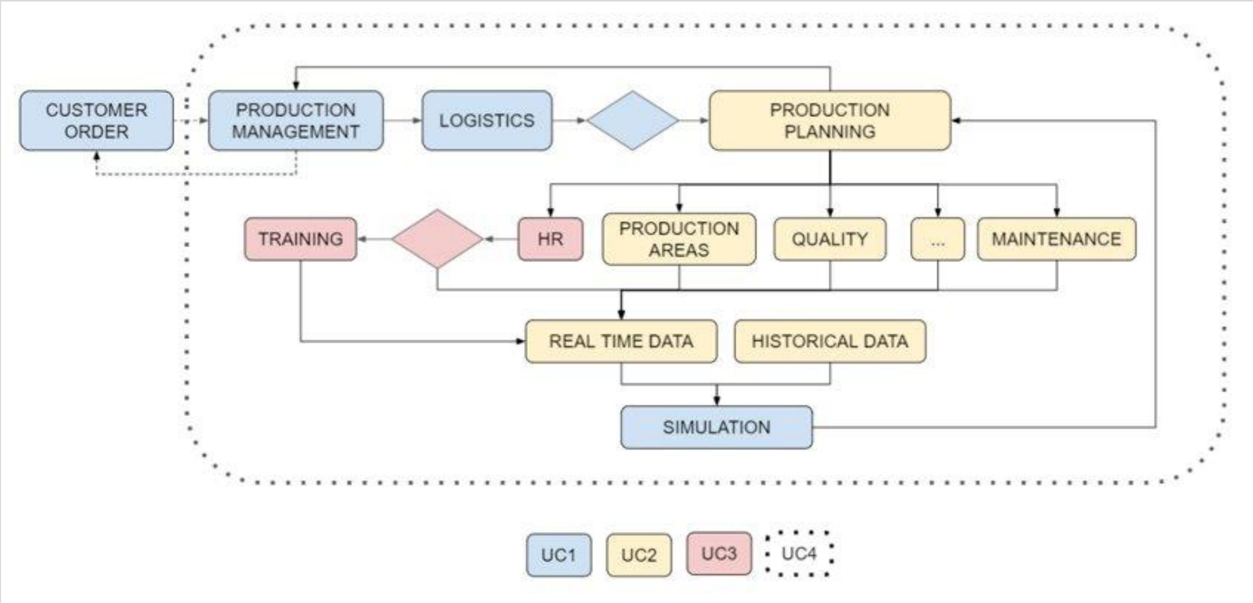

Figure 6: Production systems schema, and four use cases for IBER testbed.

Briefly, the first use case assumes the development of an IT solution that will help production management in making high-level decisions. This solution will be based on real-time simulation of the production process and will benefit from instant production data as well as their history (a specific database will be created). Access to existing data on the production management platforms of the various production areas will be guaranteed. It is to be expected that this solution will be able to present the necessary alternatives to streamline the production process.

The second use case has as its main objective the reduction to a minimum of unfinished product stocks. Practically, there will always be a certain stock of the unfinished product, i.e., injected components and purchase elements that will be assembled according to the customer's monthly or weekly orders. The logistical management and storage of this unfinished product has a relevant cost and therefore the objective will be to reduce it.

The third use case is intended to identify and quantify human errors associated with the assembly process. With the help of the right tools, it is expected to achieve better-operating methods and better management of human resources on the assembly line.

Finally, in the fourth and last use case, it is planned to identify external and internal threats to information systems affecting the production system, mitigate them, and reduce as much as possible the harmful effects.

3.2.3 Human behaviour prediction and safe zone detection

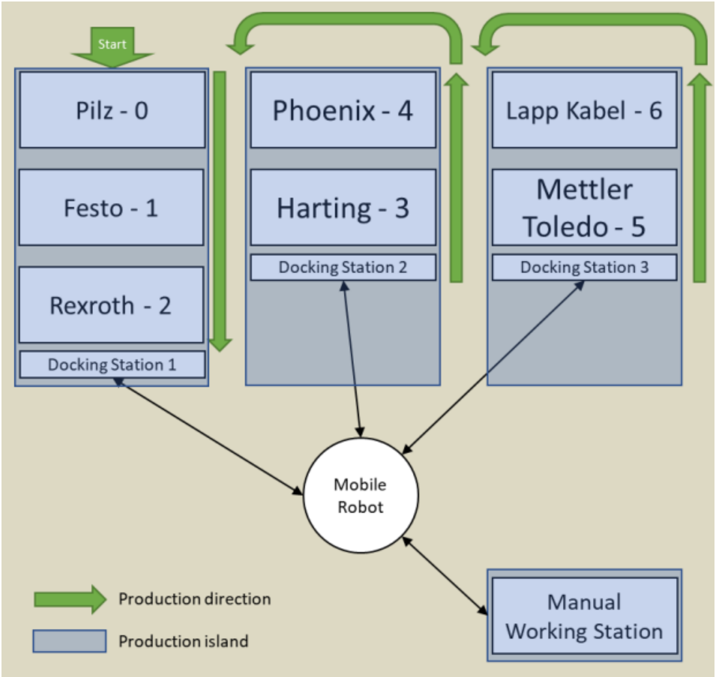

Figure 7: As-is scenario for SmartFactory testbed

SmartFactory lab demonstrates the latest technologies from the industry domain building industry-standard demonstrators. One new addition to our demonstrators (Figure 7) would be adding safety considerations during working with an autonomous robot while combining AI technologies. In this context, DFKI aims to improve its demonstrator to have a high production rate while keeping workers and the hardware equipment safe using AI technologies. To achieve this, three use cases were derived in the STAR project:

1. Human intention recognition.
2. Robot reconfiguration based on the dynamic layout.
3. Dynamic path planning using both first and second use cases.

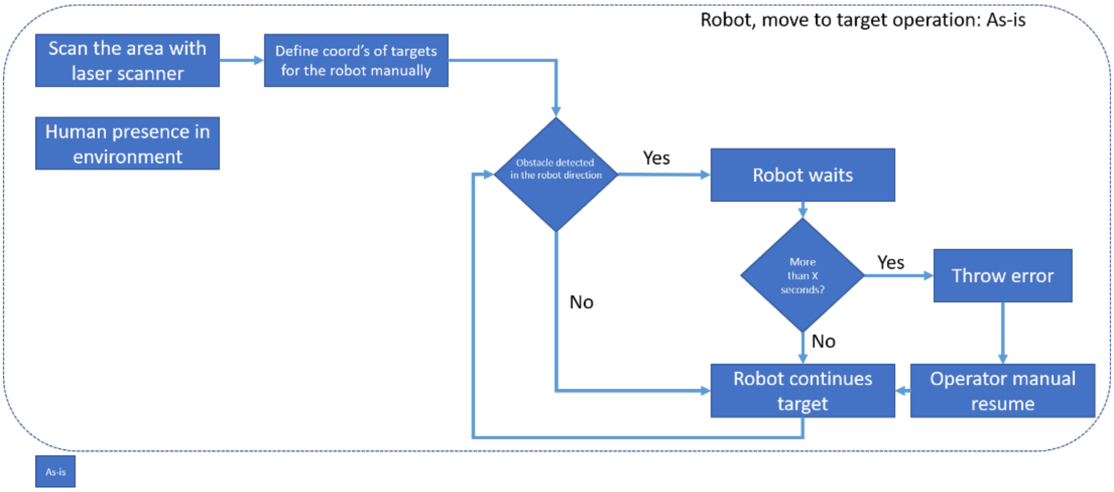

Figure 8: As-is scenario for SmartFactory testbed.

Currently, the robot uses its built-in laser scanner to create a map of the current environment as well as the objects (Figure 7). After the map is created, the stations are manually defined, and their coordinates are stored by the robot. Later, the robot is programmed to deliver the product between the defined coordinates. If an object is detected in the direction of moving, it waits for a specific amount of time and then continues to its target. However, if the object does not move within this time span, the robot must be manually resumed (Figure 9).

However, this scenario is not optimal. The as-is scenario does not consider the human presence. In addition, it does not reach the dynamic layout changes. This as-is scenario is depicted in Figure 7 and Figure 8. The STAR project is planned to improve the situation and the intelligence of the robot.

The First use case plans to detect the human activities and predict their next actions, which then will be combined with robot navigation to create a safer environment. For this matter, DFKI created typical worker scenarios, happening during normal daily work. The behavior of more than 10 participants was recorded, who were supposed to follow the same or similar flow. The recordings were made using wrist sensors which are then analyzed in detail to detect the activity they are currently performing.

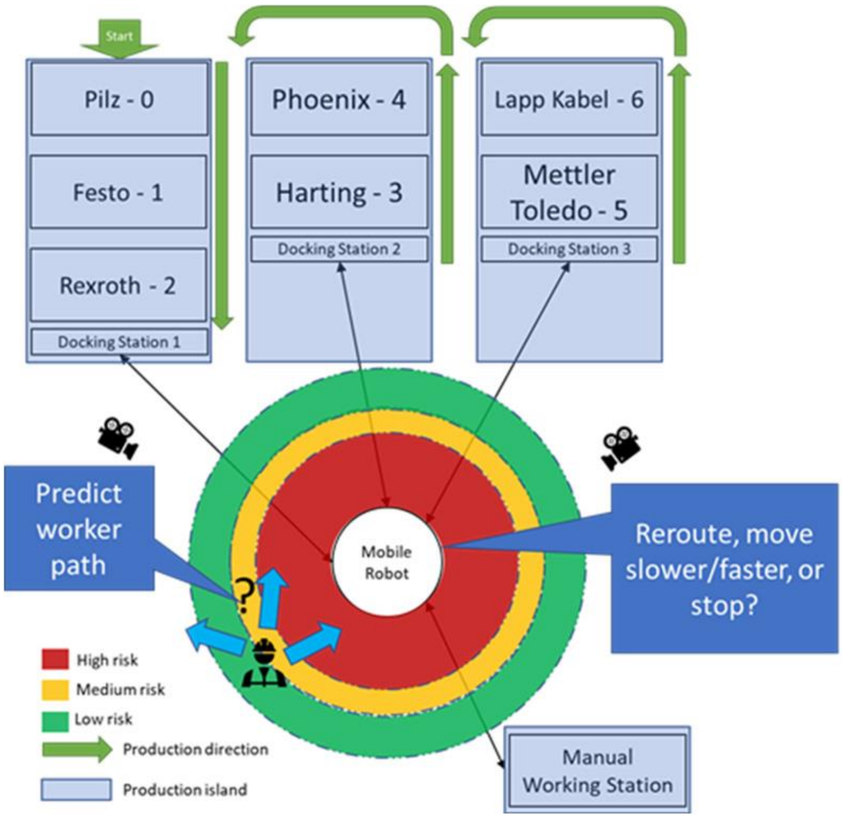

Figure 9: To-be scenario for SmartFactory testbed

The second use case is to dynamically update the navigation route of the mobile robot, by considering human and/or other (non-)moving objects in the environment. This use case will also enable easier reconfiguration of the robot in case the layout of the environment (including the production stations) changes. The layout is actively monitored by the cameras, and humans, as well as the objects in the layout, are detected. In case of any change, the new coordinates of the stations, where the robot should navigate to, are updated. (Figure 9)

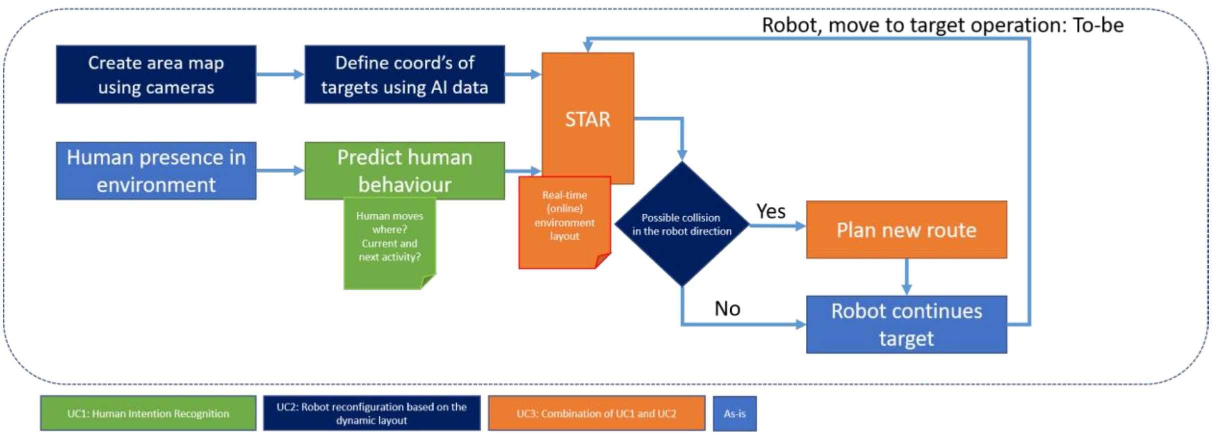

Figure 10: SmartFactory to-be scenario, all use cases combined.

Finally, as the third use case, these two use cases are going to be combined to have a safe environment for the workers and the hardware equipment. The newly received coordinates of the stations will be used to set the robot's destinations. The speed of the robot and the objects in the layout will also be considered to create a collision-free navigation path for the robot. The human's current and next activity is also one of the important aspects to be taken into account during the decision. The points of interest for the robot will be sent as separate data to achieve the original goals of the use case. To-be use cases can be seen in Figure 9, and Figure 10. In Figure 10, light blue blocks belong to the as-is scenario, the green boxes are new additions with the first use case, dark blue boxes are new features introduced by the second use case, and finally, the orange boxes are the functionalities that combine both first and the second use case.

SmartFactory-DFKI prepared its demonstrator and acquired the required hardware to collaborate with THALES and DFKI-EI. At the time of writing this deliverable, DFKI and THALES group are working together to create the first prototype software. This prototype will enable both partners to evaluate the current success rate and/or take the actions to make it more stable. In the ongoing months of the project first version of the technologies in the pilot will be the deployed.

3.3 Workshops

Since the STAR project aims to develop, deploy and validate trusted and safe human-centered AI systems for manufacturing applications, The STAR approach is planned to be validated and tested in the field of user-driven applications in realistic settings such as production lines in the pilot plant. Hence, there is a close relation between Task 6.1 and the validation of the project systems in the production lines. As stated in D2.8–"User Studies and Co-Design for Human–Centered AI", two different workshops have been organized by the University of Groningen (RUG). The first one, a webinar organized on the very first months of the project (Months 3 and 4 of the project lifespan), helped in updating the use cases and receiving new perspectives on the pilots' scenarios. The second one which was conducted in the month 19th of the project lifespan, organized as an in-presence event, allowed the early development of the test cases to be tested. Here the content of the workshops organized so far is magnified.

3.3.1 First workshop

For each of the pilot partners, a separate online workshop took place. Every workshop is coordinated by RUG. Each workshop was conducted as a collaboration between one pilot partner and other parties in the STAR project and it was managed in the online collaboration tool Miro. The workshop was structured in four stages:

1. **Review, refine, and initial user stories:** The pilot partner in the workshop presented the use cases. This part consists of the as-is and to-be scenarios and the initial user stories that the pilot partner defined and provided in the workshop. The other participants collaborated in defining the new user stories if needed as complimentary. These user stories were related to the initial scenarios from the pilot partner.
2. **Define components and functionality for user stories:** In this stage regarding the updates from the previous stage on the user stories, the list of components and

functionalities were reviewed and if needed the new components were defined.

3. **Synthesis for all use cases:** In this stage, all components and functionalities from the previous stage were linked to the use cases from the first stage. In this step, the participants and the pilot partner evaluated, validated, or edited the functional or non-functional requirements that were expressed in the user stories.
4. **Link user stories and components to identify aspects of AI-human collaboration, and anticipated outcomes/success criteria:** In the last stage participants initialized the wide range of collaboration scenarios relying on the relevant success criteria. These scenarios were provided for addressing: (1) How humans can help or augment the AI systems. (2) Where AI technologies can help or augment humans. (3) The optimal interaction between human and AI systems. (4) How AI systems can substitute the human. (5) What can be the other success criteria.

All the pilot partners benefited from their workshop in collaboration with others with the acquisition of new perspectives and ideas toward their scenarios. All three testbeds updated their user stories, components, and functionalities related to their use cases regarding the workshop output. More detailed information in each stage is reported and documented in D2.6- "Report on Co-Design Workshops and Focus Groups", and will also be finalized and documented in D2.10 –"Report on Co-Design Workshops and Focus Groups –Final Version" which is expected to be submitted in M27.

3.3.2 Second workshop

Thanks to the restraint of the pandemic for CoVID-19, all the STAR project's partners found the chance to visit the whole project members in Athens, Greece for the first time. One major reason to have the face-to-face meeting was to conduct the second workshop which was also moderated by the university of Groningen (RUG). This workshop focused on the defined use cases of the pilot sites and the collaboration of the other partners in the STAR project on these three pilots. In this workshop, every pilot partner presented the use cases, the activities have done till that time, and the challenges and barriers they had confronted in the middle of the way.

In other words, this workshop aimed to follow the co-creation and evaluation activities focused on the functionalities of the first version of each pilot system and testing phase. Moreover, the workshop focused on presenting the use cases and pilots to other partners, who were asked to give their viewpoints and system testing scenarios based on the progress of the pilots (Figure 11). More details on this workshop correspondingly will be found in D2.10 -" Report on Co-Design Workshops and Focus Groups – Final Version".

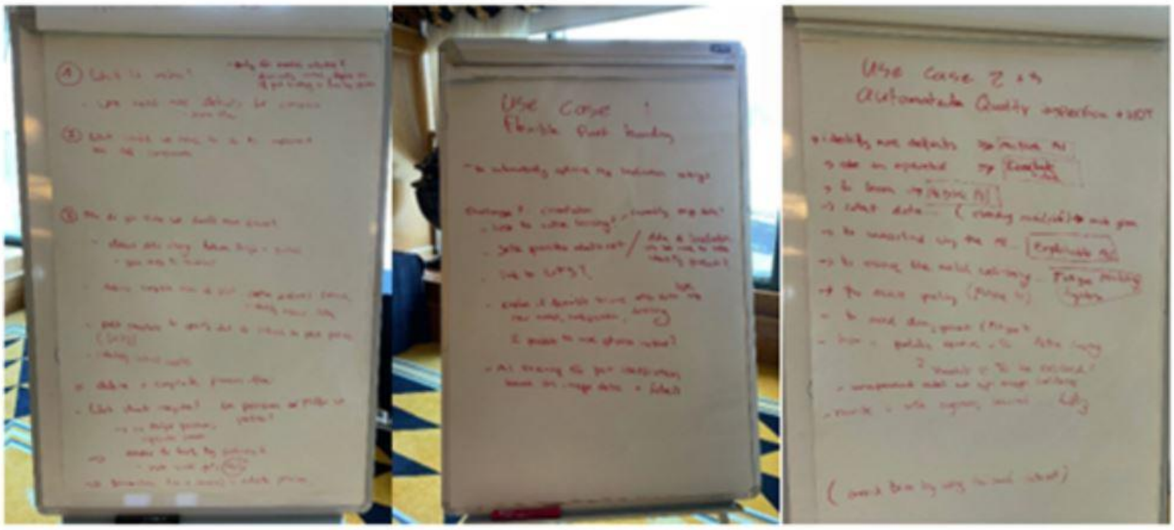

Figure 11: Second Workshop for Philips Testbed (Athens, Greece).

3.4 Identification of the relevant components

In task 6.1, we aggregate the list of use cases' components for all the pilot partners. The list includes all the components, such as hardware and software, which are utilized and developed in the testbed's use cases and all the essential information related to the components that each pilot partners exploit in their scenarios. The detailed information about the usable components enables not only the testbeds but also all other research and industrial partners to have the overall prospect toward the use cases' technologies. Moreover, the list of components makes the technology providers and pilot partners collaborate fluently during the project with a general perspective toward the defined use cases.

In other words, this valuable information is the essential reference and bond between testbeds and other partners, especially technology providers. The excel file is named "*General Asset List" and* contains vital information for the deployment of technologies in the testbeds. This list is initiated from scratch and is being developed by adding more relevant columns of data to it by passing through the project lifespan. Hence, until the 24th month of the STAR project, the list contains the whole information for 15 different components of the project. The *General Asset List* contains information as:

Component: Name of the component.

Component Owner: The component provider(s).

Related Task: The related task in the STAR project.

Pilots to be applied: The pilot(s) and use-case(s) in which the component will be utilized.

Dependency with other components (Input from/ Output to): Any dependency with other technologies.

Component Version: The current available version of the component.

Communication protocol: Related to the transferring/communication protocol.

Availability (Code, Artifact): Whether the code or artifact is available.

Dockerization: Whether the component is dockerized.

Hardware requirements: The HW requirement for each component to be deployed on.

Possible Lab deployment date: The date of the deployment in the service platform.

Status of the Components: Whether the component is developed or not.

Current TRL and Final TRL (at least 5 or 6): Technology readiness level of each component.

API Documentation: If there is any documentation available for the API or each component.

Test Availability (Yes/No): Whether there is any test available for the component.

Bottom-up Requirement mapping: The bottom-up requirements of each component gathered from WP2.

Status of the Requirement: Status of the bottom-up requirements.

Contact Persons: Information of the developer of any person/organization in charge of the component.

This list of components is shared and documented, and it is accessible to the partners in the WP6's SharePoint of the STAR project. More details of the *General Asset List* can be found in the deliverables related to task 6.2.

3.5 Dataset sample and local share-point preparation

Another contribution of the pilot partners in task 6.1 was the preparation of a sample of their datasets. As T6.1 is focusing on the pilot site preparation and pre-pilot testing, all the pilot partners were asked to provide detailed information about their datasets. They provided and documented concrete information about the datasets and data models they plan to utilize. This information consists of the type of data generated in the scenarios with the description of the data, the components and technologies which generate and provide these data, the possible interaction with other components, technology providers, or parties, and a small sample of the dataset and data schemas. This information was documented and reported in detail in the T2.4-*" Data Model and Data Collection"* deliverable. In their contribution with D2.4, pilot partners presented and interpreted their as-is scenarios' data (e.g., Figure 12), and the data which is planned to be utilized in their to-be scenarios. In addition, they presented and clarified the reason why they plan to apply a new source of data in their to-be scenarios by explaining the difficulties and issues they confront in their as-is scenarios.

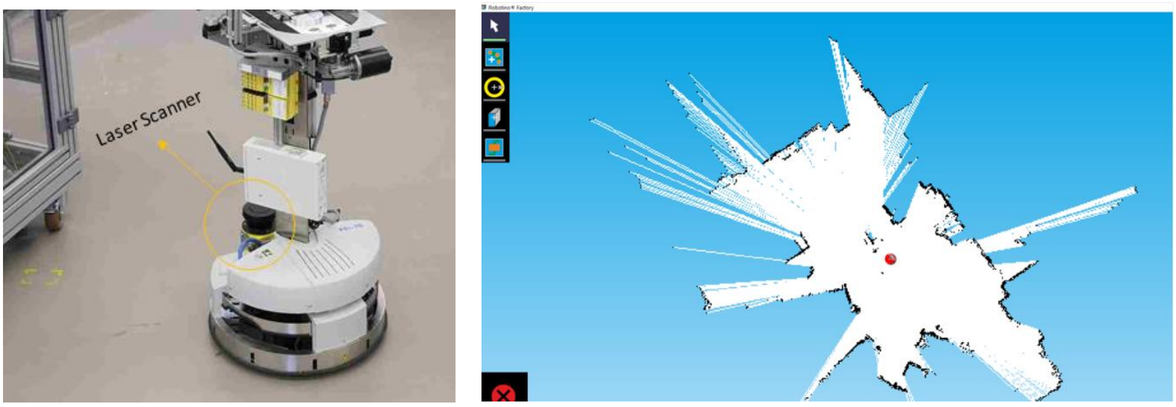

Figure 12: Left: Robotino's laser scanner used for as-is layout generation for SmartFactory testbed. Right: Scanned layout after manual movement through the plant for SmartFactory testbed. In the to-be scenario, we just use the scanned layout one time as the initial point for the layout which will be used for THALES algorithm for calibration. Afterward any change to the layout can be measured by THALES algorithm.

Furthermore, we prepared the list of local sharing repositories that each pilot partner utilizes to save and share their datasets with other project parties. These data can be originated from any source of data from different modules and components that are employed in their to-be scenarios. These repositories are the commonplace that technology providers and other parties in the STAR project utilize to access the provided data from testbeds.

The list of datasets which is documented and shared in the STAR project's repository provides information about:

- **WP:** The WP(s) in which the testbeds and other parties share and utilize the data.
- **Contact point(s):** The source of the data. For instance, it can be the sensor data from IMU sensors, videos or images from cameras, or the LiDAR data from Robots.
- **Pilot partner and use case(s):** The pilot partner which is utilizing the data and provides the dataset. Moreover, the specific use case(s) in which the data is utilized.
- **Accessibility:** The name of any possible partner that needs access to the data. This can be the list of the technology provider(s) for specific pilot partners' use cases.
- **Data format and size of the data:** The format of the data and the size of the batch of the data which is shared. It can be any format and vary in size from KBs to hundreds of GBs.
- **Share point(s) and infrastructure:** The SharePoint in which the data is shared between different parties, and the infrastructure to access the SharePoint. The data can be accessed through any public, shared, or private infrastructure relying on the state of the confidential.
- **Credential or permission:** It represents the sensitivity of the data. Permission is needed for sensitive or private datasets.

3.6 Ethical management and legal analysis

The STAR project and its tools ensure compliance with EU legislation and safeguard human rights and ethical principles through a wide range of precautions and countermeasures to preserve privacy. To ensure ethical principles are used and covered by pilot partners, the project oversight activities and societal impact assessment will be conducted in WP6. For this reason, pilot partners contributed to D1.5-"*Ethical Management & Legal Analysis Activities*". The pilots answered questions addressed separately to each of them, which were tailored to the specific scope of each Pilot.

3.7 Synergy between technology providers and IBER pilot partner for their dataset preparation

In WP6 one of the main focuses of T6.1 is the preparation of the testbeds. This can be either installing the whole pilot for specific scenarios for the STAR project or adapting and improving the testbeds' setups to their priors. For this project, IBER installed its dedicated pilot from scratch. The setting up of the pilot was monitored and tracked in T6.1. Moreover, after setting up the IBER testbed, synchronizations regarding the dataset preparation and acquisition from the testbed were organized. These synchronizations were organized between different pilot partners and technology providers, which brought the outlook for the IBER group on the different possibilities to apply the STAR technologies in their scenarios.

3.8 STAR deployment for solution

Another target achieved for pilot site preparation was the initialization of the GitLab group to host the STAR platform codes. INTRASOFT initialized the common repository for the software components and a common CI/CD platform for development. The INTRASOFT group provided STAR's GitLab repository to host the codes for all pilots and other partners which contribute to their scenarios. It was conducted as a subtask of T6.2 under the supervision of DFKI. For every pilot partner, one or more subgroups in the STAR's GitLab repository are initialized and the state of the privacy for every subgroup is defined. Each subgroup features a different STAR platform module. In addition, each subgroup shall host one or more repositories for software components to construct each module.

In addition, a server, accessible via the internet, is at the project partner's disposal for usage. It contains disk space of 100 GB, 8 CPUs, 64 GB RAM, a docker service package installed, and runs on an Ubuntu 20.04 machine.

4 Main use case related activities performed during the period of two years.

In the sequent, a summary of the main actions taken during the aforementioned period is provided. For a detailed description, one can refer to the above parts of this document.

During the first and second years, many significant activities took place. A portion of the proceedings was to follow the pilots and technology providers during communications. Furthermore, the preparation and pre-pilot testing of each pilot was closely observed, which resulted in use-case finalization and definition of technologies to be deployed for the corresponding pilot. This led to improved coordination, synchronization, and monitoring for all pilots.

Next, an initial version of the integrated STAR platform was provided. Moreover, a General Asset List containing all the details of components such as integration use cases, requirements, and dependencies, Alongside, a service platform (server) was made available.

A portion of the Philips pilot preparation involved data collection, mainly images, from the pad printing machine. Equipment was installed to collect the images. Unfortunately, this equipment is no longer available in the factory due to the changing of the production line in the factory. Hence, they updated their scenarios for their testbeds based on the new production line. In consequence, a new pilot use case is introduced, and a new type of product is evaluated. This strengthens the evaluation of the algorithm and gives more focus on collaboration between humans and artificial intelligence.

A supplementary work for DFKI pilot preparation came in the form of surrogate data collection. For the first use case, time series data were collected from ten different participants, carrying wearable sensors and apple watches. For the second use case, two cameras were mounted on the ceiling of SmartFactory. Utilizing the Cameras, videos captured the environment of the factory together with Robotino and the workers. Further, a 3D mesh and a point cloud representation of the SmartFactory were provided upon request of the technology provider partner THALES group as the initial setup of the layout for their module calibration. Lastly, a list containing the physical properties of the factory entities (e.g. work station dimensions, location, entrance location, reference frame) is provided.

Finally, the next work should come in the form of evaluation and validation of the developed approaches. An auxiliary outcome of the future work should highlight the measurable indicators to assess the impact of the technologies on the testbed and/or equipment.

5 Conclusion

This document is the final report of the work, activity, and participation which have been undertaken in task 6.1 in the STAR project during the first twenty-four months of the project lifespan and also in the end of the task activity period.

The STAR project attempt to make the AI approaches safe, trusted, and secure for the industrial environments. The main purpose of WP6 in this project is the preparation, integration, validation, and evaluation of the STAR project's goals in the testbeds. Task 6.1" *Pilot Site Preparation and Pre-Pilot Testing*" is focusing on the monitoring synchronization and communication between different pilot partners for the preparation of their testbeds. During this period, as the leader of this task, we managed and monitored the preparation of the three pilot partners, PHILIPS, IBER-OLEFF, and DFKI for their scenarios in the STAR projects, "*Human-CoBot Collaboration for Robust Quality Inspections*", "*Human-Centered AI for Agile Manufacturing 4.0*", and "*Human Behavior Prediction and Safe Zone Detection*", respectively. In this document, we mainly report our goals achieved in the T6.1 as below:

- Introduction and explanation of the pilot partners in this project and their fields of study and research.
- Monitoring for preparation and setting up their testbeds for the STAR project.
- Initiation of the three pilots' use cases and their activities to define and finalize their use cases as well as the workshops managed to ease the progress of the initialization of the use cases and collaboration between pilot partners and other partners specifically technology providers.
- Identification and documentation of the requirements for every pilot partner namely the list of components, the list and sample of datasets, and local share points for their use cases that are utilized for their communication with other parties like technology providers in the STAR project.
- Supporting the pilots for their deviation from their plan to define their use cases and overcome to any difficulties.
- Ethical assessment of the project and deployment of the technologies in the pilots as the crucial parts of this task.
- Finally, dominant action points performed, and which are needed to be addressed in the following year of the project.