

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

D2.9 - Report on Co-Design Workshops and Focus Groups-Initial version

Dissemination level	PU -Public
Type of Document	Report
Contractual date of delivery	30/09/2021
Deliverable Leader	University of Groningen (RuG)
Status - version, date	Final - v1.0, 30/09/2021
WP / Task responsible	WP2 / RuG – University of Groningen
Keywords:	co-creation, user studies, human-centric AI

This document is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 956573. It is the property of the STAR consortium and shall not be distributed or reproduced without the formal approval of the STAR Management Committee. The content of this report reflects only the authors' view. The European Commission is not responsible for any use that may be made of the information it contains.

Deliverable Leader:	RuG (University of Groningen)
Contributors:	PCL, DFKI, IBER
Reviewers:	PCL
Approved by:	Charalampos Ipektsidis, John Soldatos (INTRASOFT)

Document History			
Version	Date	Contributor(s)	Description
V0.1	21/06/2021	RuG	Initial structure
V0.2	07/07/2021	PCL	Content from PCL workshop
V0.3	16/07/2021	DFKI	Content from DFKI workshop
V0.4	02/09/2021	IBER	Content from IBER workshop
V0.7	27/09/2021	RuG	Final draft synthesis
V0.8	28/09/2021	RuG	Addressed review comments
V0.9	29/09/2021	RuG	Final editing and revision
V1.0	30/09/2021	INTRASOFT	QA and final submitted version.

Executive Summary

This deliverable provides an overview of the Co-Design Workshops which have been specified, organised, and conducted during the Design phase of the project (Design Workshops). The objective of the Design stage workshops was to steer the STAR project design towards Human-Centricity by involving multi-stakeholder's viewpoints in co-creation sessions. In preparation for the workshops, a survey was designed, launched, and its outcomes were analysed, aimed at seeding the workshops with initial concepts and ideas to seed into the workshops. These targeted user requirements, as well as an initial pool of concepts regarding the envisaged Human-AI synergies for each use case and for each pilot of the project. The survey was designed accordingly to identify user-centred viewpoints, expressed via user stories, along with identifying components and functionality appropriate for meeting the requirements of the user stories, alongside their envisaged outcomes, in terms of work design and human factors, as well as operational performance targets. The survey also sought to identify the starting points for the foreseen human-AI synergies to meet the production requirements for the pilot use cases. The outcomes of the survey were analysed and were fed as seeds for the participatory co-creation workshops that followed. Due to the pandemic restrictions, the workshops were held employing virtual collaboration board tools. The collaboration boards were designed to contain an appropriate structure for facilitating the co-creation activities. All co-creation workshops involved an introductory session to established a shared context about the workshop objectives, the pilot use cases aims, and the aims of the workshop activities. The workshops then involved representatives of different functions and roles in which would be relevant to designing an AI-enabled solution for manufacturing lines, as expressed within the consortium partnership, including different roles within the manufacturing stakeholders, technology providers, research organisations, as well as legal and ethics experts. The workshop outcomes were analysed to offer a synthesis of what constitutes the collective creation of the multi-stakeholders view of user requirements, expressed as user stories, components and functionality needed to meet these requirements, alongside with proposed scenarios of human AI synergies, and the prospective outcomes and impact of that synergy in terms of both human factors and work design, as well as operational performance, including the key elements of trust, safety, and security. The deliverable will inform the development of STAR components, contributing to the overall platform needs and will also feed into shaping the evaluation methodology of the STAR results.

Table of Contents

EXECUTIVE SUMMARY	3
TABLE OF FIGURES.....	6
LIST OF TABLES.....	7
DEFINITIONS, ACRONYMS AND ABBREVIATIONS	8
1 INTRODUCTION.....	9
2 SURVEY IN PREPARATION OF WORKSHOPS.....	10
2.1 INTRODUCTION SURVEY	10
2.2 STRUCTURE OF THE SURVEY	13
2.3 SURVEY RESULTS.....	14
2.3.1 <i>Part 1 Task scenarios between AI and humans.....</i>	<i>14</i>
2.3.2 <i>Human and job effects</i>	<i>16</i>
2.3.3 <i>Operational effects.....</i>	<i>20</i>
2.3.4 <i>Generic success criteria</i>	<i>21</i>
2.4 ANALYSIS OF SURVEY RESULTS AND CONCLUSION.....	23
3 CO-CREATION WORKSHOPS – DESIGN STAGE	25
3.1 INTRODUCTION.....	25
3.2 WORKSHOP INPUTS AND STRUCTURE	25
4 PCL WORKSHOP	29
4.1 PREPARATORY PHASE.....	29
4.1.1 <i>Workshop agenda.....</i>	<i>29</i>
4.1.2 <i>Virtual collaboration board setup</i>	<i>29</i>
4.2 WORKSHOP EXECUTION	30
4.3 WORKSHOP OUTCOMES	33
4.3.1 <i>Use Case 1.....</i>	<i>34</i>
4.3.2 <i>Use Case 2.....</i>	<i>37</i>
4.3.3 <i>Use Case 3.....</i>	<i>39</i>
4.4 PROPOSED HUMAN-AI SYNERGY OUTCOMES.....	42
4.4.1 <i>Categorisation of Human-AI collaboration activities.....</i>	<i>42</i>
4.5 WORKSHOP EVALUATION	45
5 DFKI WORKSHOP	47
5.1 PREPARATORY PHASE.....	47
5.1.1 <i>Workshop Agenda.....</i>	<i>47</i>
5.1.2 <i>Virtual collaboration board setup</i>	<i>47</i>
5.2 WORKSHOP EXECUTION	47
5.3 WORKSHOP OUTCOMES	49
5.3.1 <i>Use Case 1.....</i>	<i>50</i>
5.3.2 <i>Use Case 2.....</i>	<i>51</i>
5.4 PROPOSED HUMAN-AI SYNERGY OUTCOMES.....	54
5.4.1 <i>Categorisation of Human-AI collaboration activities.....</i>	<i>54</i>
5.5 WORKSHOP EVALUATION	55
6 IBER-OLEFF WORKSHOP	57
6.1 PREPARATORY PHASE.....	57
6.1.1 <i>Workshop Agenda.....</i>	<i>57</i>
6.1.2 <i>Virtual collaboration board setup</i>	<i>57</i>

6.2	WORKSHOP EXECUTION	57
6.3	WORKSHOP OUTCOMES	58
6.3.1	<i>Use Case 1 – Process Simulations for Accelerated Decisions and Safe Processes</i>	<i>60</i>
6.3.2	<i>Use Case 2 - Production Planning Optimisation.....</i>	<i>62</i>
6.3.3	<i>Use Case 3 - Training.....</i>	<i>63</i>
6.4	PROPOSED HUMAN-AI SYNERGY OUTCOMES.....	64
6.4.1	<i>Categorisation of Human-AI collaboration activities.....</i>	<i>64</i>
6.5	WORKSHOP EVALUATION	66
7	CONCLUSION.....	68
8	APPENDIX – PREPARATORY SURVEY FOR WORKSHOPS.....	70
	<i>Part 0</i>	<i>70</i>
	<i>Part 1: Task scenarios between AI and humans.....</i>	<i>70</i>
	<i>Part 2 Human and job effects</i>	<i>70</i>
	<i>Part 3 Operational effects of AI.....</i>	<i>71</i>
	<i>Part 4 Success criteria to guide the design, development and deployment</i>	<i>72</i>

Table of Figures

FIGURE 1. INFLUENCING FACTORS OF AI-ENABLED SOCIOTECHNICAL SYSTEM PERFORMANCE.....	12
FIGURE 2. DESIGN PROCESS (ADAPTED FROM NEUMANN ET AL., 2021)	13
FIGURE 3. THE DIFFERENT STAGES OF EACH PILOT CASE WORKSHOP	26
FIGURE 4. WORKSHOP ACTIVITIES, INPUTS AND OUTPUTS.....	27
FIGURE 5. EXAMPLES OF HUMAN-AI SYNERGIES.....	27
FIGURE 6. EXAMPLES OF HUMAN-AI SYNERGY IMPACT CRITERIA	28
FIGURE 7. EXAMPLE OF VIRTUAL COLLABORATION BOARD SETUP	30
FIGURE 8. EXAMPLE OF CO-CREATION ACTIVITIES DURING THE WORKSHOP.....	31
FIGURE 9. EXAMPLE OF LINKING USER STORIES WITH USER CATEGORIES AND COMPONENTS.....	32
FIGURE 10. FINAL COLLABORATION BOARD OF PCLCO-CREATION WORKSHOP	33
FIGURE 11. DFKI PRESENTING THE PILOT CASE AND ITS USE CASES.....	48
FIGURE 12. DFKI PILOT CO-CREATION OUTCOMES ON FINAL COLLABORATION BOARD.....	49
FIGURE 13. IBER-OLEFF PRESENTING THE PILOT CASE AND ITS USE CASES.....	58
FIGURE 14. FINAL COLLABORATION BOARD FROM THE IBER-OLEFF CO-CREATION WORKSHOPS	59

List of Tables

TABLE 1. PCL TASK SCENARIOS	14
TABLE 2. IBER-OLEFF TASK SCENARIOS	15
TABLE 3. DFKI TASK SCENARIOS.....	15
TABLE 4. 'AI IN GENERAL' TASK SCENARIOS	16
TABLE 5. OVERVIEW OF EXPECTED HUMAN AND JOB EFFECTS PER PILOT	16
TABLE 6. OVERVIEW IMPORTANCE OF CONSIDERATION OF OPERATIONAL EFFECTS PER PILOT SITE	20
TABLE 7. GENERAL SUCCESS CRITERIA	22
TABLE 8. ADDITIONAL SUCCESS CRITERIA	22
TABLE 9. CO-CREATION ACTIVITY PRODUCES NEW AND UPDATED USER STORIES CONTENT	34
TABLE 10. PCL PILOT CO-CREATION WORKSHOP EVALUATION	45
TABLE 11. DFKI PILOT PCL PILOT CO-CREATION WORKSHOP EVALUATION.....	56
TABLE 12. EVALUATION OF IBER-OLEFF PILOT CO-CREATION WORKSHOP	66

Definitions, Acronyms and Abbreviations

Acronym/ Abbreviation	Title
AI	Artificial Intelligence
IT	Information Technology
OT	Operational Technology
SOP	Specific to OPERations
SR	Simulated Reality
VR	Virtual Reality
W1	Definition and Design Workshops (project Design phase)
xAI	Explainable Artificial Intelligence

1 Introduction

The user studies and co-design sessions of the project have been identified as driving the development of the project's technologies and pilots based on human-centricity, trust and safety. Therefore, a number of user-studies and co-design sessions have been defined as part of D2.8 (User Studies and Co-Design for Human – Centred AI), pertaining to a number of consecutive workshops held for both the definition and design, as well as the two development and testing phases at each pilot throughout M1 to M27.

This report summarizes the content and output of the **'Definition and Design Phase Workshops' (W1)**, which were held for each one of the three pilot sites. It also includes the output of a survey distributed among project participants with the aim to collect preparatory information to prepare content for the online workshop executed via MIRO online visual collaboration platform. During the workshop, participants co-created content on different sub-boards containing 'seeding' information from the survey and earlier deliverables containing placeholders for user stories, components/functionality that can be used or is required to implement the user requirements as expressed in the user stories, and a structure to host the contributing participants view on the involved AI-Human Interaction, and anticipated outcomes/success criteria. Each workshop followed a pre-set process. To validate and edit the functional requirement as defined in the use cases, participants first worked on the user stories, followed by defining and linking required components and functionality to the user stories. Then, participants co-created different collaboration scenarios based on relevant success criteria, addressing how (1) humans can help/augment the AI, (2) where AI technology can help/augment humans, and (3) the optimal interaction. Participants were able to propose, represent, interrogate and reflect on the different scenarios, while proposing ideas and visions which are based on the actual use context, and different criteria and anticipated outcomes. Overall, the workshops were positively evaluated, and respondents found the online collaboration via MIRO collaboration tool very useful.

This report summarizes the preparation (Section 2-3) and the outcome of the three workshops executed for PCL (section 4), DFKI (section 5), and IBER-OLEFF (section 6), reporting the resulting user stories, system components linked to the user stories, proposed human-AI synergy outcomes in terms of task distribution and collaboration, and the expected outcomes for human and work design effects and operational effects, and finally the success criteria for every pilot. The contents contained in this report constitute input that needs to be taken into account in Deliverables D2.5 (final version of Data Models and Data collection), D2.10 (final version of Report on Co-Design and workshops and Focus Groups), D6.3 and D6.4 (STAR platform), the D6.5-D6.10 demonstrator deliverables, and the D6.11-12 evaluation deliverables. It can also be consulted during the development of STAR components, contributing to the overall platform needs and success criteria.

2 Survey in preparation of workshops

The content of the survey will address the following three use cases:

- PCL: Human-Robot collaboration for quality inspection
- IBER-Oleff: Human-centred AI for agile manufacturing of automotive parts
- DFKI: Human-behavior prediction and safe zone detection

To prepare for the definition and design workshop (W1), project participants were asked to fill in the survey for every specific use case they are involved in to obtain the specific requirements for each individual use case. It was also possible to fill in the survey for AI technology in general. The survey recorded 19 usable responses from the different project participants. Before the start of the questions, respondents were asked to indicate the use case addressed in the survey. This allowed them to tailor their responses to a specific use case. Respondents were able to provide answers for multiple pilot sites. 5 responses were collected for Phillips, 1 for DFKI, and 1 for IBER. 11 responses indicated no specific use case, but AI in general.

2.1 Introduction survey

The survey is designed to aid the design of human-centric, safe and trusted AI system as defined in the STAR project. To steer AI-based systems development in this project towards meeting stated aims (e.g., human-centric, trusted, safe), it is necessary to jointly consider human, technical, and operational factors as early in the design process as possible. The interaction between human and non-human actors (i.e. technological, including AI,) will aim at a positive impact on technical, operational and human performance, and ultimately determine the overall system performance. By identifying envisioned human, as well as technical and operational effects, success criteria can be identified that ultimately guide the system designers to jointly pay attention to different contributing factors early on in the design process. The main aim of this survey is to identify the desired effects of the deployment of human-centric, safe, and trusted AI systems in specifically the pilot cases of the STAR project. The outcome is intended will provide input for the definition and design workshop (W1) (D2.9). Moreover, it is aimed at providing valuable input for the development of the design targets for the AI deployment. The terms “success criteria”, “performance targets” and “effects” are considered to carry similar semantics and will be employed to set targets for the AI-deployment and the overall system evaluation.

Background survey

Modern and future manufacturing environments are not simply technical systems but complex socio-technical ones. While physical technical systems include components (e.g. hardware, software) and have implications for procedures and processes, the procedures and processes themselves are not part of their definition but change depending on the organisational context. Conversely, socio-technical systems include both technical systems and people. People are expected to understand the purpose of the system (which technical systems do not) and are integral part of organisational operational processes, which are often governed by regulations and rules. To steer AI-based systems development in this project towards meeting stated aims (e.g., human-centric, trusted, safe), it is necessary to

jointly consider human, technical, and operational factors as early in the design process as possible. The interaction between human and non-human (i.e. technological, including AI, actors) will aim at a positive impact on technical, operational and human performance, and ultimately determine the overall system performance. By identifying envisioned human, as well as technical and operational effects, success criteria can be identified that ultimately guide the system designers to jointly pay attention to different contributing factors early on in the design process. Modern manufacturing systems are complex sociotechnical systems. Such systems are developed to tackle problems that are so complex and involve so many entities that there is no single specification uniformly suitable for all cases (Sommerville, 2015). **Therefore, the aim of this survey is to:**

- identify desired effects of the deployment of human-centric, safe and trusted AI systems in specifically the pilot cases of the STAR project
- to steer STAR direct design and development activities for the pilot cases in a way that takes into account the aforementioned factors (i.e. desired human, technical and operational effect)

Both the above targets are served by utilising the survey outcomes as initial “seeding” ideas for the co-creation workshops to follow. Considering the diversity of the application cases in the manufacturing sector, as evidenced also in the STAR project cases, there can be no single definition of success criteria which would be generally applicable (Sommerville, 2015). Instead, success criteria are linked to whether or not the system is effective when deployed, when assessed against organisational objectives. This implies that although goals and success criteria can be broadly derived from the survey outcomes, these will be put into test and further processing during the co-creation workshops. The stakeholders involved in the workshops will be able to revisit them, bearing in mind organisational and business goals. Modern manufacturing environments are not simply technical systems but complex sociotechnical ones. In sociotechnical systems, human actors hold a key role with implications for system performance, alongside the physical technical systems. This is illustrated in Figure 1, where a sociotechnical cyber physical production system is seen to be composed of human and non-human actors, with technical actors falling under operational and information technology (OT/IT). The caveat is that the boundaries between these are increasingly blurred: IT and OT are converging, and human operators are increasingly enabled by IT and OT, with the latest additional being AI-enablement of human and non-human actors. The overall achieved functional system performance (e.g. production throughout, product quality, etc) is deeply influenced by non-functional system performance and organisational evolving objectives, as well as work on environment, job characteristics, and effects of the overall work design on humans, as conceptually shown in Figure 1.

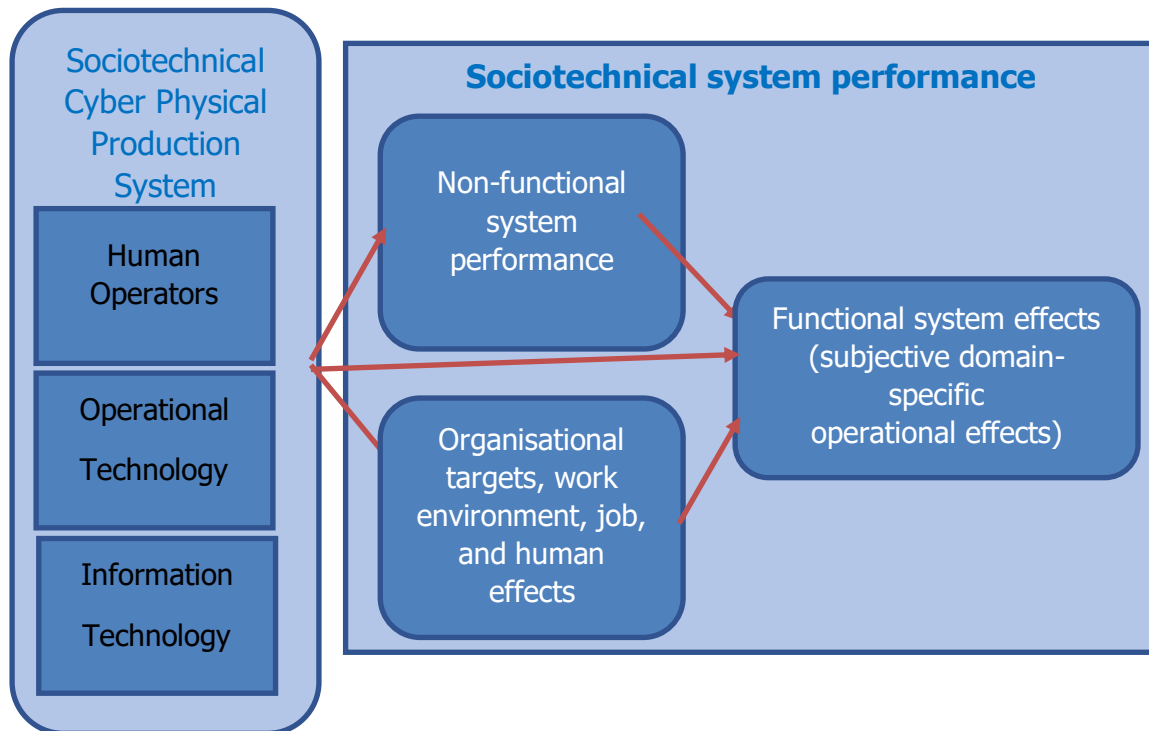


Figure 1. Influencing factors of AI-enabled sociotechnical system performance

Non-functional performance can be considered to include (Sommerville, 2015) Reliability; Usability; Volume/Throughput; Repairability; Security/Safety.

Human factors effects (performance) as specified in D2.8, will include: engagement; trust; intrusiveness; likeability; cognitive overhead; physical overhead; safety; ease of use; explainability; security; and enriched jobs. Note that security and safety are of direct relevance to human factors, but they are also considered as overall system non-functional performance targets, as they are also relevant to the physical/cyber-physical assets of the production environment.

The functional system effects are broadly considered to fall under process quality, efficiency, flexibility and costs (D2.8) but need to be specified in the context of the specific targeted application domain. Therefore, these are subjective, rather than objective, and are linked to organisational goals.

It is worth noting that the individual actors (human and non-human) have a joint influence on the sociotechnical system performance. For example, system reliability is linked to hardware, software, and operator reliability. Ease of use refers to the interface between a human and a non-human actor: it is perceived by the human actor in relation to the use of the non-human production asset that it refers to.

The above can be considered to motivate a design process for AI-enabled systems. Specifically, the design process needs to consider the impact of design choices in terms of human effects, changes to the environment and work design, and overall operational effects, all of which make a contribution towards the performance targets (Figure 2).

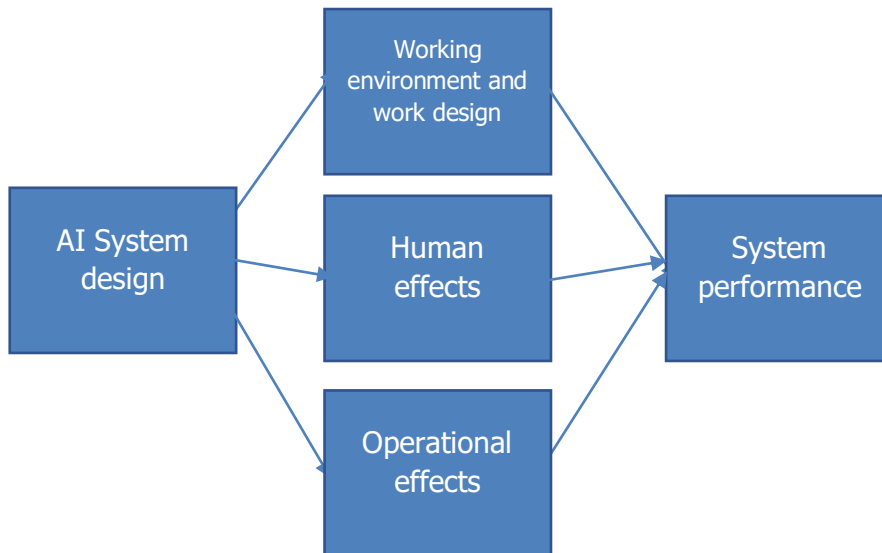


Figure 2. Design process (adapted from Neumann et al., 2021)

2.2 Structure of the survey

The survey addresses different categories of questions. To tailor the questions to a specific pilot site, respondents are first asked to select the pilot site, or to answer the questions for AI technology in general. The survey questions can be found in the Appendix.

The different categories of questions include:

Part 0: Background survey respondent

Part 1: Task scenarios between AI and humans

We identify four different task scenarios that are relevant in the context of AI and which are important to consider during the design and development phase. Per scenario, please provide concrete and relevant examples of future tasks at the selected pilot site that fall within these categories.

Part 2 Human and job effects

The questions focus on rating the importance of considering a number of human and job effects during the design, development and deployment of the selected pilot site with the corresponding AI solution.

Part 3 Operational effects of AI

The questions focus on rating the importance of considering a number of operational factors during the design, development and deployment of an AI system in manufacturing.

Part 4 Success criteria to guide the design, development and deployment

In this section, respondents are asked to rate the importance of success criteria to guide successful design, development and deployment of the AI technology.

Success criteria are generic and can guide the system designers to jointly pay attention to different contributing factors (human, technical and operational) early on in the design process. They are derived from the envisioned human, technical and operational effects examined in parts 3 and 4 of the survey.

2.3 Survey results

The survey recorded 19 usable responses from the different project participants. Before the start of the questions, respondents were asked to indicate the pilot site addressed in the survey. This allowed them to tailor their responses to a specific use case. Respondents were able to provide answers for multiple use cases. Five responses were collected for PCL Phillips, one for DFKI, and one for IBER. Eleven responses indicated no specific pilot site, but addressed AI deployment in manufacturing in general.

2.3.1 Part 1 Task scenarios between AI and humans

The respondents identified the following task scenarios per pilot site. (Table 1-Table 4).

Table 1. PCL task scenarios

AI substitutes humans	AI augments humans in tasks	Human augments AI in tasks	Integrated AI & human perform task collaboratively
In clerical tasks	For decision making in strategic decisions		
- Part detection & automated part handling (partly AI / partly robotics)	- Safety risk detection and reaction - Mental health monitoring	- Human input for low confidence decisions / sampling by AI Quality inspection	- Quality control systems
1) Visual inspection of very common defect/non-defect cases 2) Repetitive Pick and Place of objects on the QA line	AI can be more consistent and detect smaller defects the human might miss	1) Human points out correct solution when AI is uncertain about a certain inspection 2) Human provides initial input to help AI adjust more quickly to a new environment (e.g. pick and place in a different production line) 3) Human can take part in identification and correction of cases where the AI is highly confident but wrong	AI can make use of intelligent methods to make the most of the human input provided. The human can help the AI with corner cases and high-risk decisions. Both the above happen in a continuous bi-directional feedback loop.
Vision systems and Artificial intelligence (e.g. CNN) can be applied to inspect items and to verify items	AI supports humans in the decision making system. Decisions can be: Item in vs out of quality Tasks scheduling & and planning (e.g. cobot handles the part and human performs	Humans instruct AI based system on which items are in and out of quality. Humans instruct AI based system on which is his/her current status (e.g. activities, fatigue level, emotion) to	AI detects possible non-conformities. Human evaluates if items are out or in quality.

conformity.	quality check vs vice versa) Cobot parameters definition (e.g. movement speed, pose estimation, safety zone)	train or improve accuracy.	
-------------	---	----------------------------	--

Table 2. IBER-OLEFF task scenarios

AI substitutes humans	AI augments humans in tasks	Human augments AI in tasks	Integrated AI & human perform task collaboratively
-	Nowadays the training of HRs in the various production processes is planned and carried out in advance, in accordance with appropriate operational methods. The flexibility of human resources training, to accommodate an agile production, can be achieved with the help of artificial intelligence platforms. These platforms can contribute, on the one hand, to the improvement of operative methods and consequently the reduction of human errors associated with learning and assimilation, and, on the other hand, due to continuous monitoring of production processes, in reducing human errors associated with overspecialization, which usually occurs when an operator is performing the same functions in the same workplaces over a given period of time. Practically the phenomenon can be described as the loss of operator concentration due to overconfidence, with consequences on productivity and quality of work performed.	-	-

Table 3. DFKI task scenarios

AI substitutes humans	AI augments humans in tasks	Human augments AI in tasks	Integrated AI & human perform task collaboratively
			The use case deals with this category. AI does not substitute the human, but acts as a complementary actor.

Table 4. 'AI in general' task scenarios

AI substitutes humans	AI augments humans in tasks	Human augments AI in tasks	Integrated AI & human perform task collaboratively
- moving and storing goods in logistic (using AI and Robots)	- AI-controlled semi autonomous robotic arm performs drilling, screwing, etc, simplifying the job of the operator	- Human revision of AI based quality inspections	- Scheduling of works and workers, management of the operations, planning..
- XAI system could give good introspection into behaviour of ML models and could therefore replace or help a data scientist	- human planners often take fixed, pre-calculated normatives and other values within the production unit; AI can help human planners provide better plans by checking the schedules, assessing the personnel skills, predicting collisions regarding human resources and so on.	- by obtaining reasoning, why a particular model would give certain predictions (e. g. by explanations or by relevant data instances), one might detect a flaw in the reasoning (e. g. taking irrelevant data, unfair data etc.); models might be fixed based on this input	- in maintenance tasks an operator often fixes the problem and notes the intervention down into a legacy system (sometimes even a piece of paper); an AI system, that would keep and collect this knowledge in an automated manner, could assist for faster and better future interventions
Robotic cell does a quality inspection for a part or product.	AI system suggests maintenance schedule for an asset.	Robotic cell doing quality inspection and consulting a human worker when not sure.	A repetitive part of a task (e.g., polishing, grinding) is done by robots. Humans coordinate the robots.

2.3.2 Human and job effects

Respondents were asked to rate the expected positive or negative impact of the adoption of the AI solution on a number of jobs and human related factors, as well as rating the importance of their consideration in the design of the technology. Table 5 summarizes the expected human and job effects per pilot site, and for AI in general. A 5-point Likert scale was selected to answer this question, 1 being the lowest, and 5 being the highest.

Table 5. Overview of expected human and job effects per pilot

Effects	Pilot Case	Expected impact	Negative or positive outcome	Importance of consideration during design of AI
	Phillips:5 IBER: 1 DFKI: 1 AI in general: 11	1 (significantly lower) to 5 (significantly higher)	1 (negative) to 5 (positive)	1 (unimportant) to 5 (important)
Job autonomy	Phillips	3.2	4.5	3.33
	IBER	3	5	4

	DFKI	4	5	4
	AI in general	3.72	4.45	4.45
Task variety	Phillips	4	4.6	3.4
	IBER	4	5	4
	DFKI	3	3	3
	AI in general	4.36	4.36	4.54
Feedback from the job	Phillips	3.6	3.8	3.2
	IBER	4	5	4
	DFKI	5	5	4
	AI in general	4.63	4.9	4.5
Job complexity	Phillips	3.4	3.8	3.6
	IBER	3	5	4
	DFKI	2	5	4
	AI in general	3.90	-	4.63
Specialization	Phillips	3.5	4	3.2
	IBER	4	5	4
	DFKI	2	2	3
	AI in general	4.54	4.81	4.72
Problem solving req.	Phillips	4	3.8	3.6
	IBER	5	5	5
	DFKI	2	2	2
	AI in general	4.45	5	4.63
Information processing req.	Phillips	3.6	4.4	3.2
	IBER	3	3	n/a
	DFKI	2	5	3
	AI in general	4.09	5	4.63
Skills variety	Phillips	3.8	3.4	3.4
	IBER	4	5	4

	DFKI	2	4	4
	AI in general	4.54	4.72	4.45
Interdependence	Phillips	3.25	2.8	3.8
	IBER	3	5	3
	DFKI	4	4	4
	AI in general	4.09	4.54	4.27
Social support	Phillips	2.4	2.8	2.5
	IBER	3	5	4
	DFKI	1	1	4
	AI in general	4	3.09	4.18
Feedback from others	Phillips	2.5	3.25	3.2
	IBER	3	4	3
	DFKI	4	4	2
	AI in general	4.18	4.54	4.09
Physical demands	Phillips	2	4.2	3.4
	IBER	3	3	n/a
	DFKI	2	5	3
	AI in general	3.90	4.09	4.27
Well-being	Phillips	4	-	3.4
	IBER	3	-	n/a
	DFKI	3	-	2
	AI in general	4.54	-	4.36
Safety	Phillips	4.2	-	3.8
	IBER	4	-	3
	DFKI	5	-	4
	AI in general	4.81	-	4.54
Fatigue	Phillips	2.2	-	3.8
	IBER	4	-	4
	DFKI	4	-	4

	AI in general	4.18	-	4.45
Mental workload	Phillips	3	4.2	3.2
	IBER	3	3	n/a
	DFKI	2	3	3
	AI in general	4.18	4.90	4.36
Trust	Phillips	3	3	3.8
	IBER	3	3	n/a
	DFKI	4	4	3
	AI in general	4	4.18	4.72
Usability	Phillips	4	3.8	3.8
	IBER	3	3	n/a
	DFKI	4	4	3
	AI in general	5.09	4.90	4.36
Situation awareness	Phillips	3.4	4	3.4
	IBER	4	3	n/a
	DFKI	3	5	4
	AI in general	4.72	4.81	4.09
Explainability	Phillips	3.6	3.6	3.8
	IBER	3	3	n/a
	DFKI	5	5	4
	AI in general	4.18	4.18	4.09
Motivation	Phillips	3.6	3.8	3.2
	IBER	3	3	n/a
	DFKI	4	4	3
	AI in general	4.63	4.90	4.27
Intrusiveness perceived by user	Phillips	3.74	2.25	3.25
	IBER	5	1	4
	DFKI	2	3	2
	AI in general	4.09	4.36	4.27

Ergonomics	Phillips	4.25	4.25	3.75
	IBER	3	3	n/a
	DFKI	3	3	2
	AI in general	5	5.09	4.54
Job satisfaction	Phillips	4	-	3.6
	IBER	3	-	n/a
	DFKI	4	-	4
	AI in general	4.81	-	4.73
Additional human- or job related factors not previously mentioned?	Phillips	Participation of worker in the continuous improvement of the AI system, opportunities to share/enhance his/her expertise, make suggestions etc.	/	/
	IBER	/		/
	DFKI	/	/	/
	AI in general	Privacy (e.g: In environments involving cameras)	Transparency of the System to the End-Users will be a key for adoption and acceptance of the AI despite other properties.	- Accountability for accidents caused by robots - Accountability for decisions made by AI - Job replacement (possibly more among lower-skilled workers which may increase social inequality)

2.3.3 Operational effects

Respondents were asked to rate the importance of considering a number of operational factors during the design, development and deployment of the AI solution (Table 6). summarizes the importance of considering the impact on the indicated operational effect during the design and adoption of the AI solution.

Table 6. Overview importance of consideration of operational effects per pilot site

Effects	Pilot Case	Importance of consideration
---------	------------	-----------------------------

		(1 (unimportant) to 5 (very important))
Productivity	Phillips	4
	IBER	3
	DFKI	4
	AI in general	4.82
Process quality	Phillips	4
	IBER	3
	DFKI	4
	AI in general	5
Process efficiency	Phillips	4
	IBER	3
	DFKI	4
	AI in general	4.9
Process flexibility	Phillips	4
	IBER	3
	DFKI	4
	AI in general	4.63
Operational costs	Phillips	4.4
	IBER	4
	DFKI	3
	AI in general	4.90
Process time/speed	Phillips	3.6
	IBER	4
	DFKI	4
	AI in general	4.72

2.3.4 Generic success criteria

Respondents were asked to rate the importance of **generic success criteria** to guide the successful design, development and deployment of an AI solution. The responses are independent of the use cases.

Table 7. General success criteria

	Importance of consideration
Reliability	4.64
Performance	4.35
Human safety	4.86
Technical safety	4.57
Environmental safety	4.35
Security	4.35
Usability	4.29
Job enrichment	3.93
Physical support	4.07
Cognitive support	3.79
Social support	3.79

The following additional generic success criteria not mentioned in the survey were identified by respondents (Table 8).

Table 8. Additional success criteria

Respondents	Additional generic success criteria
1	Acceptance and Trust
2	<p>Explanatory comments on the above:</p> <ul style="list-style-type: none"> - Environmental safety is a top priority because given that it is a long-term project and that AI (production and training) and digital data (processing and storage) can have negative effects on the environment, it is essential to align the project with the sustainability objectives of Europe. - Security is a top priority, since security is a prerequisite to all others; marking security as 'moderately important' would have an impact on all other factors. - Usability is a top priority because it includes safety in the explanation. - Job enrichment is a top priority, given that this project is human-centric, and that we have to think of the role we want AI to play in our lives. Human agency has priority. <p>It is also suggested to consider the recently launched proposed regulation of AI ('Artificial Intelligence Act'). https://digital-strategy.ec.europa.eu/en/library/proposal-regulation-european-approach-artificial-intelligence</p>
3	<p>Important criteria for success are accountability, trust and transparency.</p> <p>Moreover, it is suggested to consider the newly proposed regulation on AI in the project</p>

https://digital-strategy.ec.europa.eu/en/library/proposal-regulation-european-approach-artificial-intelligence

2.4 Analysis of survey results and conclusion

The survey served to identify the desired effects of the deployment of human-centric, safe, and trusted AI systems in specifically the pilot cases of the STAR project. It thereby addressed a number of job characteristics and human factors, specifically the effect of AI and the importance of considering it in the design of the AI systems. The survey did not have a sufficient number of responses to allow statistical inference, yet primarily provided input for the definition and design workshop (W1) (D2.9). It provided the following insight:

- The survey provided content for the workshops in the form of starting placeholders for user stories, functionality, and AI-Human interaction, as well as outcomes (human, operational) and success criteria
- Respondents expect AI to have a positive impact on all included job characteristics and human factors, suggesting an overall job enrichment and positive individual outcomes for human workers due to the AI adoption. Respondents expect positive effects on:
 - Job autonomy
 - Task variety
 - Feedback from the job
 - Job complexity
 - Specialization
 - Problem solving requirements
 - Information processing requirements
 - Skills variety
 - Interdependence
 - Social support
 - Feedback from others
 - Physical demands
 - Well-being
 - Safety
 - Fatigue
 - Mental workload
 - Trist
 - Usability
 - Situation awareness
 - Explainability
 - Motivation
 - Intrusiveness
 - Ergonomics
 - Job satisfaction
- Project participants characterize the consideration of all operational effects included in the survey as important to consider during the design of the AI system (scoring 3 or higher).

- Reliability, human safety and technical safety were found to be the most important success criteria to guide the successful design, development and deployment of an AI solution, whereas job enrichment, cognitive support and social support were found to be the least important.

The responses obtained through this survey enabled an initial understanding of requirements and expectations for each pilot case and were processes as initial “seeding” of ideas for the co-creation workshops, as described next.

3 Co-creation workshops – Design stage

3.1 Introduction

For each pilot site one Design stage (W1) co-creation workshop took place. Due to the COVID-19 restrictions, it was not possible to hold the workshops with physical presence. Therefore, available collaborative working tools were evaluated (see D2.8) and the MIRO on-line visual collaboration platform was selected to facilitate the co-creation collaboration activity.

3.2 Workshop inputs and structure

Each W1 comprised a process wherein:

1. An agenda was agreed among partners, including the time, duration, objectives of the workshop (as specified in D2.8) and participants (see table).
2. Initialisation of a MIRO board with “seeding” information and knowledge, arising from early project deliverables and the STAR partners survey outcomes, which were outlined earlier in this report, and included process workflows for the targeted use cases, draft user stories, and some of the key survey concepts. Each workshop collaboration board consisted of multiple sub-boards, with initialised structure to contain placeholders for user stories, components/functionality that can be used or is required to implement the user requirements as expressed in the user stories, and a structure to host the contributing participants view on the involved AI-Human Interaction, and anticipated outcomes/success criteria. The structure was:
 - a. User stories per Use Case
 - b. Scenarios (AsIs/ToBe) as process workflows
 - c. Initial Components per Use Case
 - d. AI substitutes humans in tasks (placeholder)
 - e. AI augments humans in tasks (placeholder)
 - f. Humans augment AI in tasks (placeholder)
 - g. Integrated AI+humans perform tasks (placeholder)
 - h. Effects (work design +human factors) (placeholder)
 - i. List of operational effects (placeholder)
 - j. List of success criteria (placeholder)
3. Conducting of the workshop with the multiple steps included in the agenda:

- a. at first participants worked on the user stories
- b. then moved on to work towards defining components and functionality needed to satisfy the requirements as expressed in the user stories
- c. the next step was to link the components and functionality with the user stories

In this way, the co-creation workshop evaluated, validated, or edited the functional and non-functional requirements as expressed in the user stories.

4. Work on the linked user stories and components to identify aspects of AI-human collaboration, and anticipated outcomes / success criteria. In this stage, the participants co-created different collaboration scenarios based on the relevant success criteria. Scenarios address approaches regarding how (1) humans can help/augment the AI, (2) where AI technology can help/augment humans, and (3) the optimal interaction. Participants were able to propose, represent, interrogate and reflect on the different scenarios, while proposing ideas and visions which are based on the actual use context, and different criteria and anticipated outcomes.

5. A workshop evaluation activity, using an on-line evaluation survey.

A typical workshop structure is seen in Figure 3.

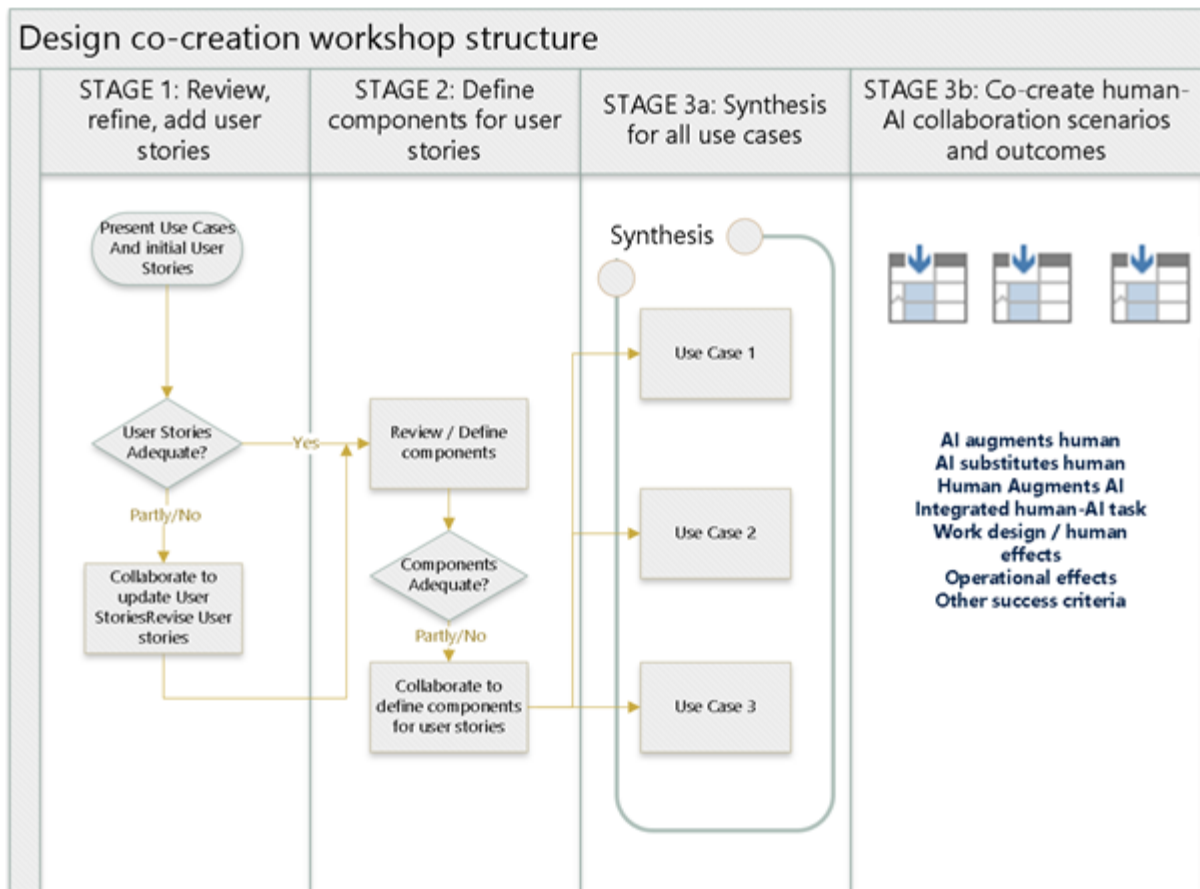


Figure 3. The different stages of each pilot case workshop

At the start of each workshop, the inputs fed into it, the activities planned to take place during the workshop, and the expected outcomes were communicated to the participants, as seen in



Figure 4. Workshop activities, inputs and outputs

The workshop methodology was explained further, providing some examples; for example, for the Human-AI synergies, relevant examples were shown to the participants, as seen in Figure 5.

PLC - AI substitutes humans	AI augments humans in tasks	Human augments AI in tasks	Integrated AI & human perform tasks collaboratively
Vision systems and Artificial intelligence (e.g. CNN) can be applied to inspect items and to verify items conformity.	AI supports human in the decision making system. Decisions can be: Item in vs out of quality Tasks scheduling and planning (e.g. cobot handles the part and human performs quality check vs viceversa) Cobot parameters definition (e.g. movement speed, pose estimation, safety zone)	Human instructs AI based system on which items are in and out of quality. Human instructs AI based system on which is his/her current status (e.g. activities, fatigue level, emotion) to train or improve accuracy.	AI detects possible non-conformities. Human evaluates if items are out or in quality.
	Recommendations to the decision-makers	Active learning tasks for manufacturing/logistics	
1) Visual inspection of very common defect/non-defect cases 2) Repetitive Pick and Place of objects on the QA line	AI can be more consistent and detect smaller defects the human might miss	1) Human points out correct solution when AI is uncertain about a certain inspection 2) Human provides initial input to help AI adjust more quickly to a new environment (e.g. pick and place in a different production line) 3) Human can take part in identification and correction of cases where the AI is highly confident but wrong	AI can make use of intelligent methods to make the most of the human input provided. The human can help the AI with corner cases and high risk decisions. Both the above happen in a continuous bi-directional feedback loop.

Figure 5. Examples of Human-AI synergies

Other examples illustrated the relevance of different outcome expectations, regarding both application domain-specific ones, such as performance, which is only defined taking the scope of the targeted application domain into account; or generic ones, such as security, usability, etc (Figure 6)



Figure 6. Examples of Human-AI synergy impact criteria

Common “semantics” were employed across all workshops, for example employing board collaboration virtual stickers with different colours, indicating the different categories of users expressing requirements in the form of user stories. The starting categories of users were organisational, technical, and operational users. Similarly, coloured stickers were employed for other categories of content, such as Human-AI types of synergies, outcomes/effects of human – AI synergy, etc. Based on the above input for each workshop, the details of the co-creation activities of each pilot workshop are provided next.

4 PCL workshop

4.1 Preparatory phase

The workshop took place on 29/4/2021. In preparation for the workshop PCL and RuG organised bilateral meetings and collaborated to prepare the proposed agenda and an initial setup for the MIRO collaboration boards. Microsoft Teams was employed in parallel for shared presentations and the discussion.

4.1.1 Workshop agenda

Opening	08:30 – 08:40
As-is scenario	08:40 – 08:45
To-be scenario	08:45 – 08:50
STAR Use-cases	08:50 – 08:55
Current pilot idea / overview	08:55 – 09:00
Introduction to the workshop	09:00 – 09:10
Workshop UC1	09:10 – 09:50
Workshop UC2	09:50 – 10:30
Workshop UC3	10:30 – 11:10
Development of collaboration scenarios	11:10 – 11:40
Evaluation	11:40 – 12:00
Closing	12:00

4.1.2 Virtual collaboration board setup

A virtual collaboration board was set up, following the structure described in section 3.2.

An example of the initial setup of the board for the user stories activities is shown in Figure 7.

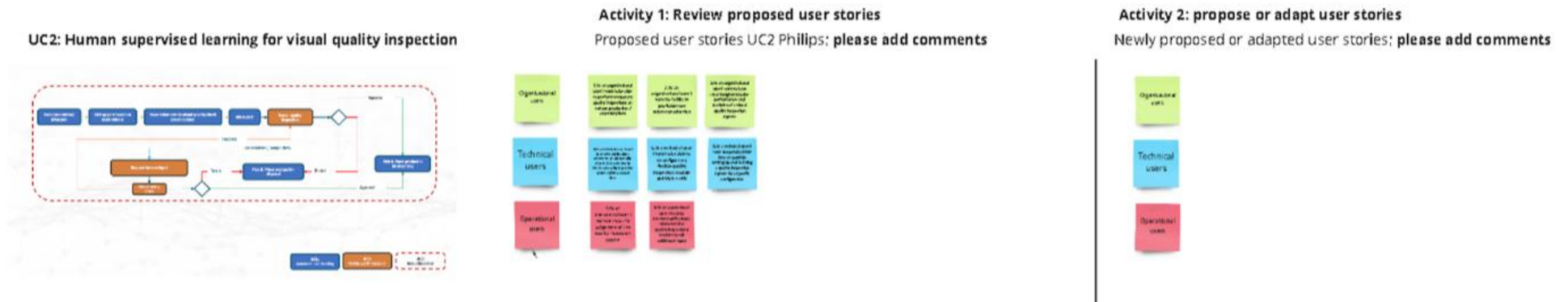


Figure 7. Example of virtual collaboration board setup

The collaboration board contained a process workflow for the targeted application of the use case. It also contained stickers with different colours, indicating the different categories of users expressing requirements in the form of user stories. The starting categories of users were organisational, technical, and operational users.

4.2 Workshop execution

The workshop had a duration of 4.5h and 29 participants from all partners took part. PCL opened the workshop presenting the use cases and their requirements. Starting with the vision and goals of the different use-cases supported by visualization by presenting the current processes (as-is scenario) vs. the expected future processes (to-be scenario) which was used as a basic introduction to all participants to the different PCL use-cases and the vision regarding these specific use-cases.

Then, RuG described the process to be followed during the execution of the workshop, using the MIRO collaboration boards. Following the agenda, the participants engaged in a highly participatory co-creation collaboration activity for the user stories (Figure 8), components and the linkage between components and user stories (Figure 9).



Figure 8. Example of co-creation activities during the workshop

The process was repeated for each use case, contributing to revising the user stories and components and their linkages.

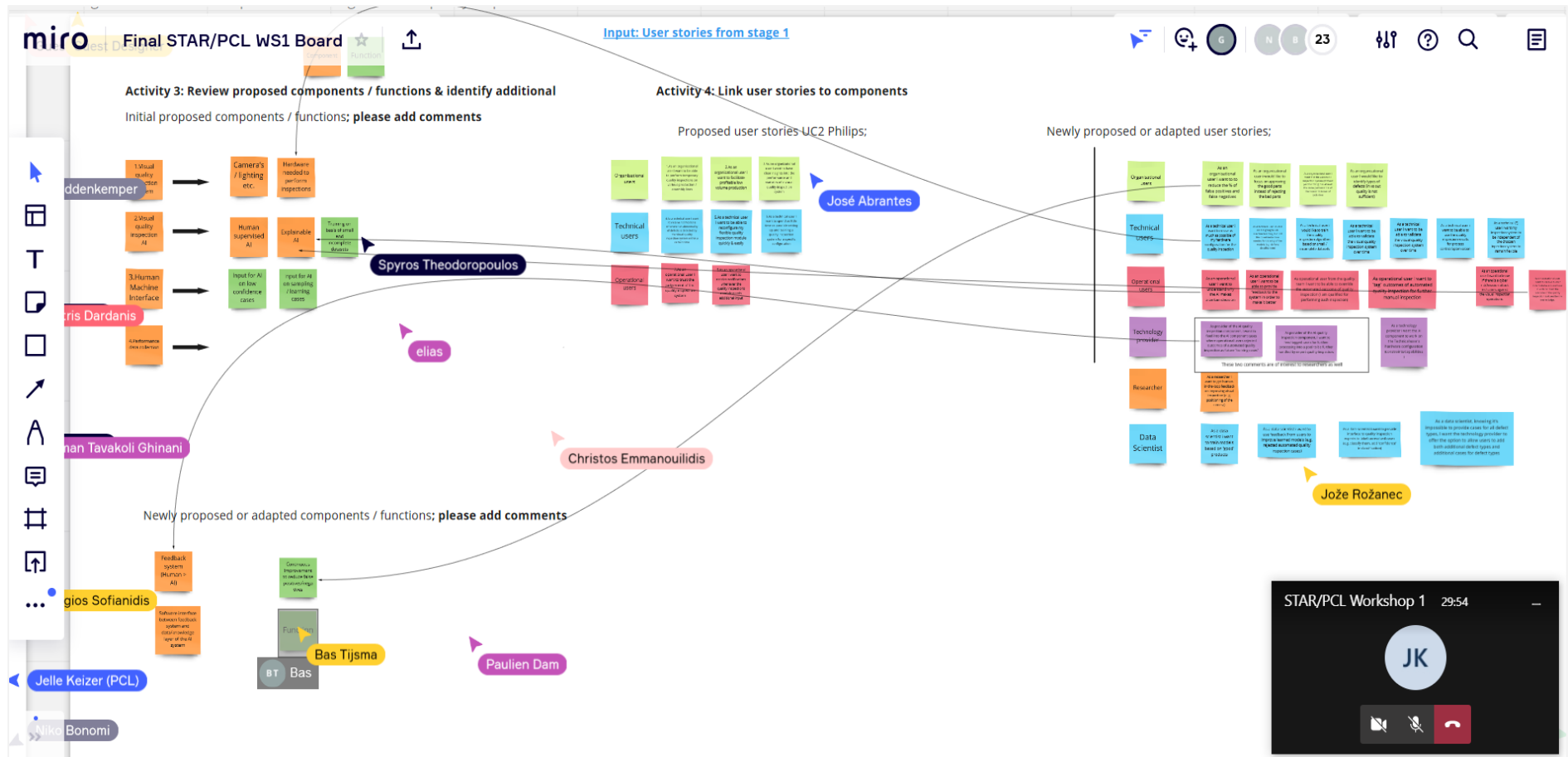


Figure 9. Example of linking user stories with user categories and components

4.3 Workshop outcomes

After all use cases were examined, the final stage brought all use cases together and the participants worked together to define the AI-human collaboration scenarios that were envisaged, alongside targeted outcomes (Figure 10).

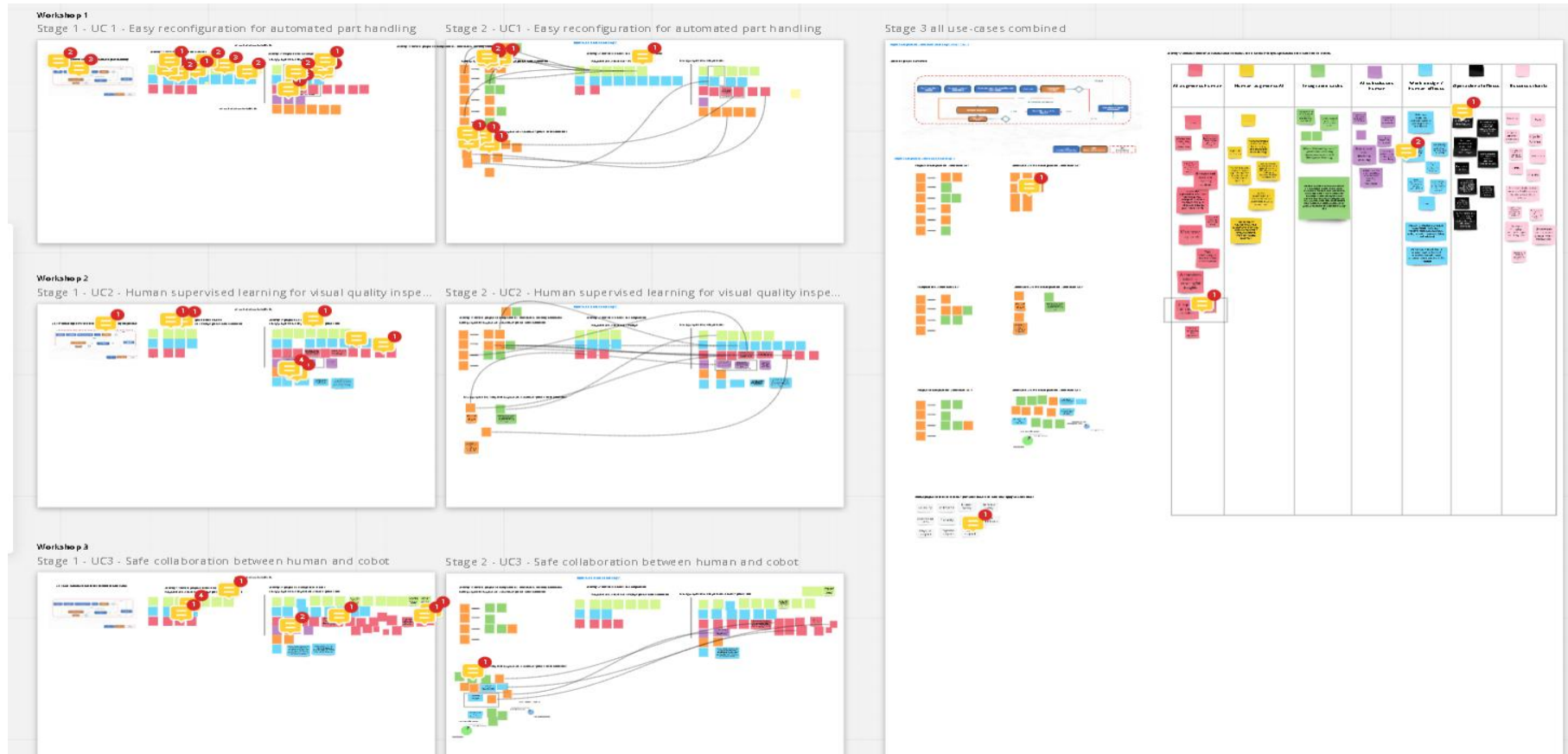


Figure 10. Final collaboration board of PCLco-creation workshop

The motivating effect of the appropriate preparation and sharing of application-relevant insights from the Use Case, as well as the ease of use of the employed collaboration platform, created a highly exciting environment for very effective and engaging collaboration.

While it is of particular interest to analyse the outcomes in qualitative terms, even a quantitative analysis produced impressive results. For example, just for the user stories and components alone, the following quantitative results were produced, as a result of the collaboration activity (Table 9):

Table 9. Co-creation activity produces new and updated user stories content

	UC1	UC2	UC3
User Stories			
Old	14	8	11
Total (inc new/modified)	36	40	45
Components			
Old	14	10	10
Total (inc new/modified)	24	17	26

The achieved outcome confirmed that the mitigation approach to involve online collaboration tools proved to be very effective. This was further confirmed after the workshop evaluation. While the added value contributed during the workshop has been evident, for brevity, in the consequent presentation of the results, the report only concentrates on the finally produced content of the co-creation activity.

4.3.1 Use Case 1

Use case 1 revolved around the topic of easy reconfiguration for automated part handling. As described earlier, during the workshop collaborative input was gathered regarding the user stories, the relevant components of the use-case and the link between these 2. The outcomes of this part of the workshop are shown below.

User Stories

Organisational User

I want to automate complex part handling
I want a part handling module that detects incoming parts
I want to implement this part handling module easily in different production setups
I want to automatically generate robot instructions based on the incoming part detection
I want real-time insight into the performance of the system
I don't want to invest in technical users (engineers) in order to save operational users

I require this solution to be safe
I want to be able to compare different configurations
I want to have alternatives (e.g. manual configuration) in case of breakdowns or downtime (e.g. maintenance/reconfiguration)
I want to have minimal setup times
I want to keep the cycle time for automated part handling low
I want this system to be compatible with existing manufacturing systems & processes
I want to facilitate profitable low volume production

Technical User

I want to be able to reconfigure the flexible part handling system quickly and easily for a new process
I want to be able to setup my new production run during the current production run
I want to be able to prepare reconfiguration of the part handling module in the virtual domain
I want to be able to simulate and validate my next production setup in the virtual domain
I want to be able to monitor the current configuration and performance of the production line / module
I want to be able to save configurations which are/can be used more often and have the best performance
I want to be able to deploy saved configurations easily (maybe even faster than new configurations)
I want to receive notifications if there is a situation the needs immediate attention
I have an interest in explanation of what failed and why
I want the part handling system to be able to handle multiple sides of parts
I would like to avoid complex vision systems for part orientation and I would prefer to use physical systems to reduce orientation variability and a smart end effector (e.g. force sensors)

Operational User

I don't want to be dependent on technical users to run production
I want clear instructions on how to solve problems/malfunctions

I want to be able to setup my next production run during my previous production run
I want to have a dashboard showing key process information and raise my attention when there is something that needs attention
I want to know which task the automated cell is performing and what movements the automated cell is about to make
I want to know if my system is compromised by e.g. a cyber risk/attack on any of the components of the entirety of the system
I want to have access to emergency stops at all time (in general I want to be able to work safely)
I want to reduce the amount of stressful tasks I need to perform

Technology Provider

I want my systems to use reliable and accurate industrial data
--

Researcher

I want to have access to performance data for analyzing and improvements
I want to have the possibility to try new idea's/solutions without stopping production
I want to have access to user feedback easily in order to come up with new solutions/prototyping
I want to have access to the data from manual quality check to improve system in uncertainty estimation
I want to have access to product specifications to be able to apply different techniques/criteria based on product type/specification etc.

Components

Cobots OMRON TM5 - 700 (2x)
Multifunctional gripper for OMRON TM5 - 700
Gripper exchange system
Part detection system
Automated part handling system
Integrated system
Offline programming system

Virtual commissioning module
Performance data collection system
Performance data dashboarding system
Event detection / warning system
Interfaces both digital and physical between elements of the entire module
Safety system
Performance data collection long-term storage system
Testbed for improvements, prototyping etc.
Back-up system
CE certification
Internal handling within the module
Part supply system
Outfeed / part storage system
Orchestrator / software
Human - Machine Interface

4.3.2 Use Case 2

Use case 2 revolved around the topic of human supervised learning for visual quality inspections. As described earlier, during the workshop collaborative input was gathered regarding the user stories, the relevant components of the use-case and the link between these 2. The outcomes of this part of the workshop are shown below.

User stories

Organisational User

I want to reduce the amount of false positives / negatives (%)
I would like to focus on approving good parts instead of rejecting bad parts
I want the automatic visual quality control to reach the same performance as human actors in terms of cycle time
I would like to identify types of defects (other than OK – Not OK)
I would like an objective quality inspection system instead of subjective measurements which vary between human inspectors

Technical User

I want to reuse as much as possible of my hardware configuration for different quality inspections (on different processes)
I want to train the visual quality inspection system algorithm based on small / incomplete datasets
I want to be able to use the quality inspection results for process control / optimization
I want the quality inspection system to be independent of the chosen process to remain flexible
I want that the inspection system does not need part manipulation in order to have a complete inspection (all sides, parts, surfaces)
I want the camera(s) to be able to identify defects with one shot with a high resolution (without a mechatronic system to move the camera around)
I expect the AI system to improve over time as more data becomes available
I want human input for the AI system in order to make it better and secure quality (e.g. in low confidence cases)

Operational User

I want to understand why the AI makes a certain decision
I want to provide feedback to the system in low confidence cases and to make the system better
I want to be able to override the automated outcome of a quality inspection (qualified worker to do this, e.g. Quality Team)
I want to minimize feedback interactions
I want to "tag" outcomes of automated quality inspection for further inspection (e.g. sampling)
I want to know when the system is compromised (e.g. cyber risk/attack against the system)
I want to know how the AI system is working (e.g. create visual representation of taken photo + defect detected)

Technology Provider (Data Scientist)

I want to train models based on good products
I want to use feedback from user to improve learned models (e.g. rejected automated quality inspection cases)
I want to provide an interface to quality inspection experts to label unresolved cases (e.g. classification, and add confidence to classification)

I want to be able to add additional defect types and additional cases for defect types

Researcher

I want to get human-in-the-loop feedback on improving visual inspection (e.g. positioning of the camera)

I want to retrain the system with new observations to improve it

Components

Camera(s)

Lighting for quality inspection

Additional sensors / quality inspection hardware

AI Algorithm for quality inspection

Human Supervised Learning system / feedback system

Human Machine Interface

(Performance) data collection system

Dashboarding

Software interface between feedback system & data/knowledge layer of AI

Safety - AI Cyber defence evaluation and risk awareness system

Interaction system where operator can manually "tag" parts for further inspection (e.g. unresolved cases)

Interface to AI where defect types can be added along with cases for "new" defect types

4.3.3 Use Case 3

Use case 3 revolved around the topic of safe collaboration between human and cobot. As described earlier, during the workshop collaborative input was gathered regarding the user stories, the relevant components of the use-case and the link between these 2. The outcomes of this part of the workshop are shown below.

User Stories

Organisational User

I would like to improve the well-being of my workers in order to reduce turnover and improve

performance
I want user data to be secured and in compliance with GDPR
I would like to have a quick and simple dashboard to supervise the system
I want an overview of statistics / KPI"s regarding mental and physical "stress" of workers in order to improve my processes
I want my employees to be qualified for the tasks they are assigned to / are performing
I want to promote task rotation in order to increase the skills of employees
I would like employees to feel safe and satisfied through their involvement with the cobot
I want cobots to handle tasks with a higher performance than workers alone
I want to assess workers' satisfaction and well-being and have their feedback on it

Technical User

I want to detect the fatigue and stress level of an active operator
I want to have a clear view of the state of the cobot and its operations
I want to be able to assign tasks to multiple entities in order to reduce job assignment constraints
I want to be able to lock and tag out the machine in order to perform maintenance / make changes
I would like to easily setup rules to manage task assignments
I want any new systems to be deployed securely and safely with fair additional technical effort from our side

Operational User

I want to be safe when I'm working close to a cobot
I don't want to wear intrusive wearable sensors
I want support to determine priorities in complex environments
I want to have access to an EM Stop at all times
I want to be able to raise attention / alert level of cobot in a simple way (voice, button, gestures)
I want to be scheduled tasks when my current task is completed / about to be completed
I want to be able to get instructions and support for a problem at hand (e.g. via VR / SR / Digital instructions / SOP)

I want automatic systems that adapt their behaviour based on my personal needs, conditions and behaviours and not the other way around
I want to work together with a cobot where the cobot can step in when I'm busy and vice-versa
I would like to have a natural and friendly interaction with cobots
I would like to have the choice on the level of confidentiality / anonymization of my sensitive data when shared within the company or to other sources
I want the cobot to perform ergonomic part presentation (e.g. if I'm 180cm it should present the part at the appropriate height)
I want to know if there is a cyber risk against decision making algorithms I'm working with
I would like to raise alerts or notifications in case of problems with the system to allow an AI module or other human to intervene and fix the issue
I want to know how data from my activities is used in order to trust the system
I would like the system to detect and suggest my next step in process (e.g. for new employees)

Technology Provider / Data Scientist

I would like all human sensor data to go through the same architecture in a way that it is easy to track and / or extend the system
I want data about the shopfloor context in order to build an effective system
I want to feed into AI learning cases when operators raised alert / safety level, even if AI system OK-ed the case regarding safety
I want to integrate new data and retrain the system to improve performance and accuracy

Researcher

I would like to have a testbed where models can be tested and user feedback can be easily obtained
--

Components

Safety zone detection system
Task scheduling for human/cobot collaboration
Safety system override
Messaging / alert system

Lighting system for cobot (e.g. URING)
Event detection system
Data management system
Safety Dashboarding system
Human Digital Twin Dashboarding system
Human digital twin system
Operator support system
Training platform

4.4 Proposed Human-AI synergy outcomes

4.4.1 Categorisation of Human-AI collaboration activities

AI augments humans

Co-creation workshop addition
Cobot extend the part to human in an ergonomic way (e.g. based on worker position or anthropometric data)
AI supports in planning & scheduling
AI provides on the job instructions to human operator
Recommend decision-making options
AI provides explanations to human users (e.g. you attempted to enter a red zone, the part was rejected due to poor colour match)
Objective decisions (based on data)
Operator support
Task scheduling for human-cobot collaboration
AI translates data into meaningful insights
AI support human skill evolution
On-line training of new operators

Human augments AI

Co-creation workshop addition
Human provides active learning feedback (e.g. labelling cases) for AI learning)

High risk decisions
Human provides implicit feedback (in general, related to UI implementation and how AI forecasts / insights are presented)
Human provides implicit feedback (e.g. raising alert level) for AI reinforcement learning
Human supervision of both robotics operation as well as automated quality inspection
Human expert expands knowledge model of AI actor (e.g. adds more process / component states, which are hard to predefine)

Integrated Human and AI tasks

Co-creation workshop addition
Non-conformity detection by AI, Human to evaluate in or out quality
xAI (unclear)
AI out of knowledge zone (novel case detected); human to examine and label (active learning) (this is actually relevant to human aiding AI)
AI actor alone does not know in advance all knowledge entities. Human actor cannot translate alone observed cases to knowledge entities but can define the knowledge entities. Jointly the human and AI actors allow the overall system to learn more than each actor could achieve alone and the overall learning cannot be performed without the integrated learning task (Not possible to assign this to a simple case of AI aiding humans or humans aiding AI, as it is an evolving process with deep integration of human and AI activities)

AI substitutes human

Co-creation workshop addition
Inspection of items and verification of conformity
Repetitive pick and place tasks
Storing goods
Human task scheduling and support (Not clear substitution case but could be listed as AI supporting humans)
Basic, low-risk decision-making
In tasks where injury or fatigue is more likely
Detect training and up-skilling opportunities based on detected weaknesses (Not clear substitution case but could be listed as AI supporting humans)

Expected outcomes on human and work design effects

Co-creation workshop addition

Shift from repetitive operator tasks to system guidance by operator
Learning curve, operators will need training to learn new ways of working
Operator can support a larger and more complex environment (e.g. multiple cells or lines)
Reduce worker's complacency, boredom and distraction
In the beginning fear of losing out (being replaced) by AI
Automatically choose the correct worker for the correct task/job
Remove wearing tasks assigned to operators (e.g. reduce repetitive tasks, non-ergonomic tasks, tasks that require to follow a defined pace)
Workers can be alerted to support each other with stress/fatigue alerts are issued or when specific skill is needed

Expected outcomes on operational performance

Co-creation workshop addition
Human cycle time vs. cobot cycle time targets
Improved agility in operation, potentially reducing the Idea 2 Market lead time
Human accuracy vs automated inspection system accuracy
Easy & cheaper reconfiguration between different production runs
Increased output
Compliance with quality standards and norms (degree at which a human respect the defined way to accomplish its task)
Consistence in work and quality control (partly removing the subjectiveness of the human)
Reactive automated safety systems instead of human forced safety measures
Human operators focus on high-value tasks, making their work also more enjoyable.

Success criteria

Co-creation workshop addition	Analysis – how to measure?
Acceptance	Part of acceptance testing
Trust	Part of the evaluation methodology, perhaps through survey
Easy to use for everyone	Usability testing / survey
Cycle times	Measurement / recording of cycle times
Quality detection & learning improvement	Measurement / estimation / recording of false

compared to current scenario	quality passes & false rejections
Transparency	Part of the evaluation methodology, perhaps through survey
Safety	Recording of incidents / Survey
Flexibility	Successful reconfiguration cases / survey
Successful education on what AI offers both to company and to worker	To be explored
Pull from the shop floor: operators are asking for the solutions	Recording of pull cases from shop floor
Demonstration of how AI could work in synergy with human	Through the pilot demonstrators
Greater throughput per person per working time	Throughput measurements vs working time
Greater job satisfaction / greater work motivation.	Part of the evaluation methodology, perhaps through survey
Process reliability & potential unsupervised operations on the long term?	Incident recording / Survey

4.5 Workshop evaluation

The workshop was evaluated by means of a survey distributed at the end of the workshop. A total of 12 workshop participants executed the survey. The survey included closed questions (Q2-Q8; Q10), as well as open questions (Q9, Q11). A 5-point Likert scale was adopted ranging from poor to excellent (Q2), and from strongly disagree to strongly agree (Q3-8, Q10). An overview of the questions and the responses are shown in Table 10.

Overall, the workshop was positively evaluated as indicated by a 4.33 overall score of the workshop. The objective, which was clearly stated, was also met. The workshop was well organized and perceived as useful and relevant. Respondents agreed that they had sufficient opportunity to contribute to the workshop. Instructions were clear and finally, the workshop met respondents' expectations. Respondents listed a few aspects which they liked best and found most useful, namely the usage of the MIRO board, which allowed for collaboration and interaction as well as a better understanding of the cases. Recommendations for improvements include the definition of used terminology before co-creation activities, an ice-breaking activity at the start of the workshop, and information on the use cases sent before the meeting to be able to prepare but also to use during the workshop.

Table 10. PCL pilot co-creation workshop evaluation

Question	Mean response 1 strongly disagree -5 strongly agree
Q2 - Overall, how would you rate this workshop?	4.33
Q3 - The objectives of the workshop were clearly stated.	4.50

Q4 - The objectives of the workshop were met.	4.67
Q5 - The workshop was well organized.	4.83
Q6 - The workshop was useful and relevant.	4.75
Q7 - I had sufficient opportunity to contribute to this workshop.	4.75
Q8 - The instructions were clear.	4.50
Q10 - The workshop met my expectations.	4.58
Q9 - What do you like best or find most useful in this workshop?	Using Miro, allowed for quick interactions and a better understanding of the use cases. Allowing partners to add content, comments and questions enabled partners to understand the main motivations.
	The collaboration within miro works great! It brought many new/additional insights from different perspectives which is very useful for the next steps in maturing the pilot use-cases as well as the alignment between STAR partners.
	I really like the Miro Board, a great tool for interactive collaboration, where it's easy for everyone to contribute.
	The collaboration through the Miro board.
	The tool capabilities and the way the boards were set up connecting with each other
	Very productive session, the tool helped to achieve a lot.
Q11 - Do you have any ideas or suggestions for the improvement of future co-creation workshops?	Not really, all went pretty smooth from what I could see. Great preparation. Maybe it could help to provide a description/definition for some of the terminology used. For instance, the different user groups. I believe that people may have anticipated the user categories differently.
	Perhaps a quick introduction round or fun introduction game to 'break the ice' and warm up the meeting.
	Not of any I can think right now. Of course a live meeting would be the best.
	No, it was really good
	Maybe a PowerPoint presentation sent with the Use Case in advance would be good. It is great to have the entry presentation but it could help to be able to go back to it to remember while working with Miro.

5 DFKI workshop

5.1 Preparatory phase

The workshop took place on 11/5/2021. In preparation for the workshop, DFKI and RuG organised a bilateral meeting and collaborated to prepare the proposed agenda and an initial setup for the MIRO collaboration boards. Microsoft Teams was employed in parallel for shared presentations and the discussion.

5.1.1 Workshop Agenda

13:00 – 13:05 – Opening Section

13:05 – 13:20 – Introduction of DFKI Use Case (DFKI)

13:20 – 13:45 – THALES Simulation Software with real-world projects (THALES)

13:45 – 13:55 – Human activity and emotional state recognition with existing projects (DFKI)

13:55 – 14:00 – 5 Minutes Break

14:00 – 14:30 – Workshop UC1 – Human intention recognition

Stage 1 – User Stories

Stage 2 – Components / functions

14:30 – 15:00 – Workshop UC2 – Robot reconfiguration based on the dynamic layout

Stage 1 – User Stories

Stage 2 – Components / functions

Stage 3 – Combination of scenarios and effects

15:00 – 15:20 – Development of collaboration scenarios

15:20 – 15:30 – Evaluation and Close up

5.1.2 Virtual collaboration board setup

A virtual collaboration board was set up, following the structure described in section 3.2, similar to the structure of the PCL workshop.

5.2 Workshop execution

The workshop had a duration of 2.5h and 20 participants from the STAR project partners contributed to it. DFKI opened the workshop by presenting the use cases and their requirements. THALES was then invited to present their simulation environment for joint activity scenarios between humans and robots.

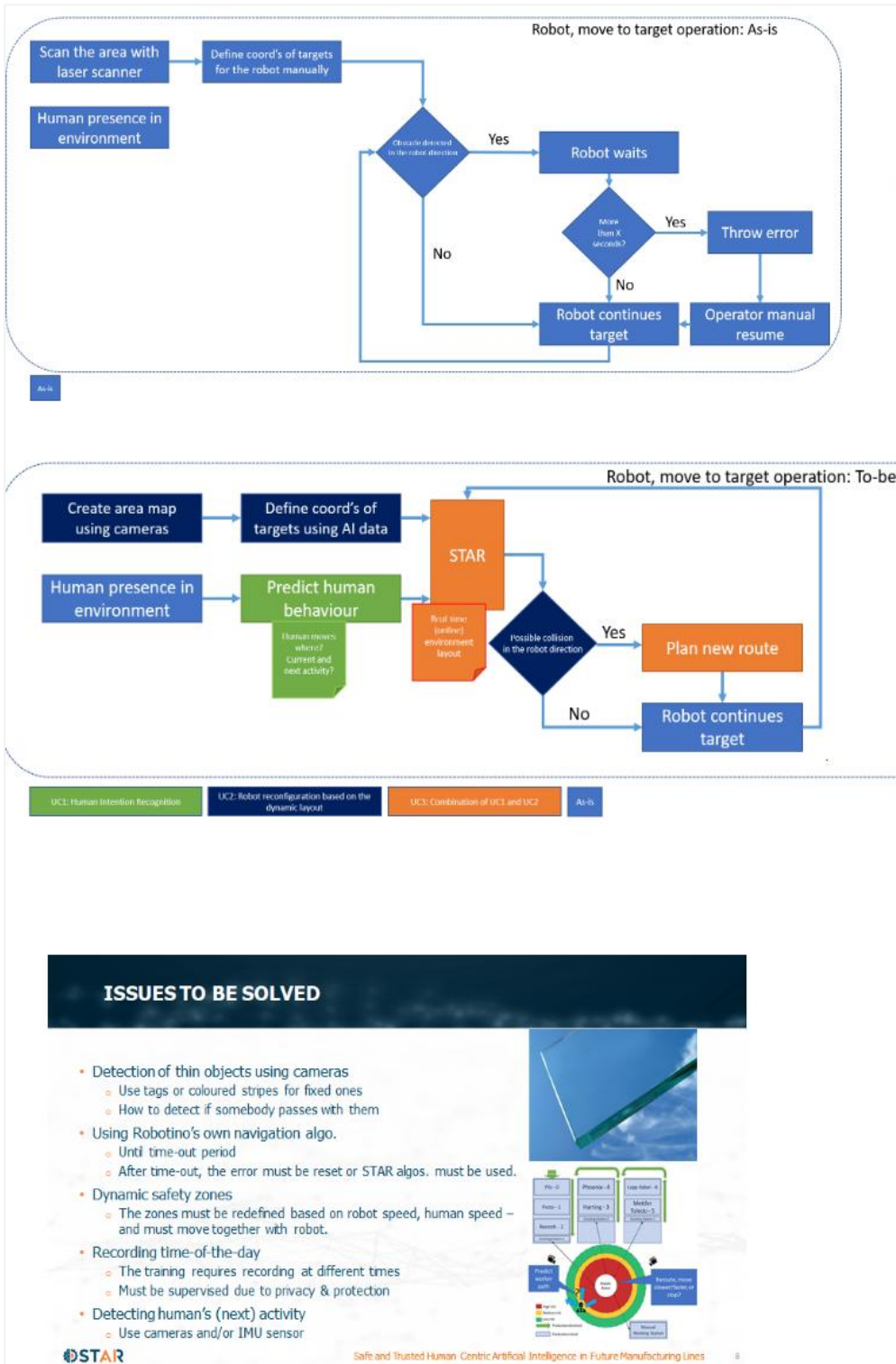


Figure 11. DFKI presenting the pilot case and its use cases

The DFKI co-creation workshop followed a similar pattern with that of the PCL one. RuG described the process to be followed, using the MIRO collaboration boards. Following the agenda, the participants contributed to the co-creation collaboration activity for the user stories, components and the linkage between components and user stories.

5.3 Workshop outcomes

The final MIRO collaboration board after the intense co-creation activity can be seen below.

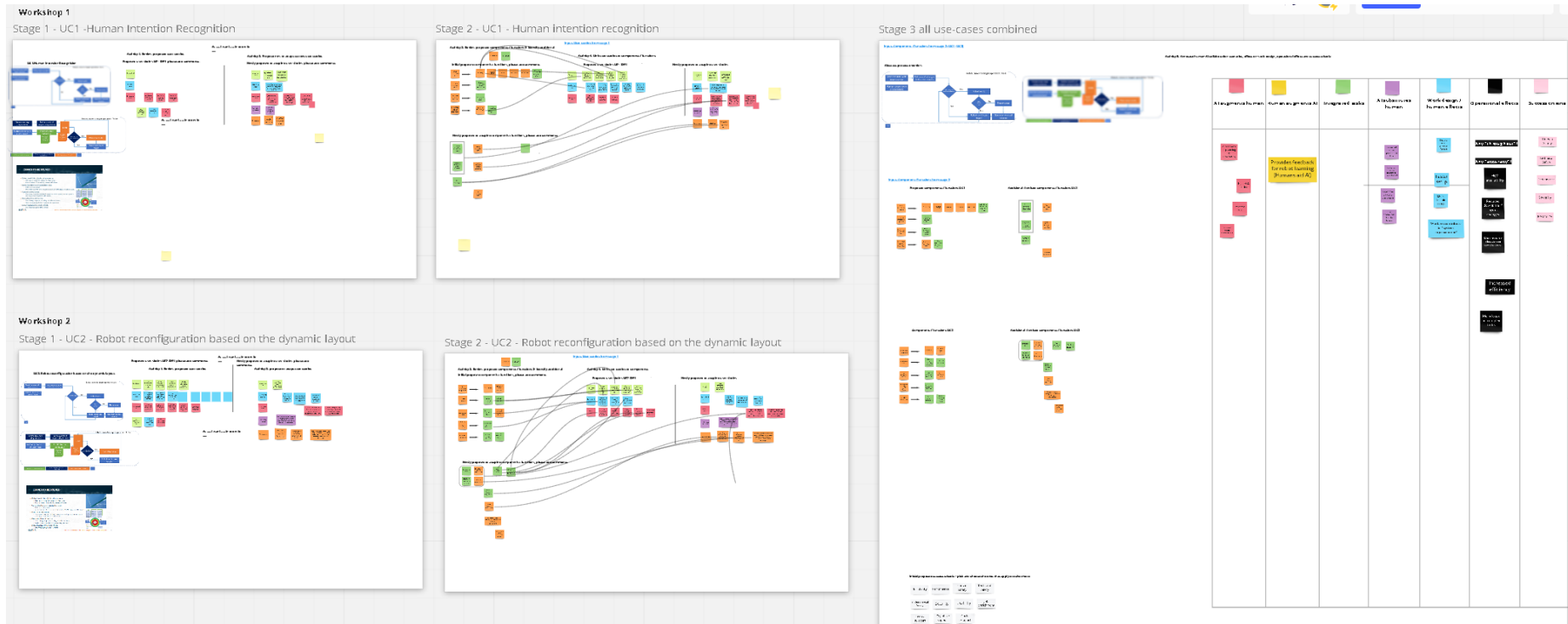


Figure 12. DFKI pilot co-creation outcomes on final collaboration board

The final co-creation activity outcomes are presented next.

5.3.1 Use Case 1

Human intention recognition: the use case is about anticipating human behaviour. This will be of use as part of the human-robot collaboration management, for example in mobile robot re-routing.

User Stories

Organisational User

I want to reduce the re-pathing time for robot
I want to reduce downtime in case of routing error
I want to keep the environment safe for the human
I want to keep the equipment safe
I want to predict human movement intention in order to plan an optimal robot route without collision risk s
I want to be able to set up a new workflow/business process for the human-robot interaction environment to respond to production reconfiguration needs

Technical User

I want to be able to monitor the path of the Robot dynamically.
I want to be able to localize the Robot in the path to the target.
I want to be informed about any collision that happens.
I want to be able to simulate the production line with any permanent changes.
I want to be informed if the re-routing does not happen in a certain period of time.
I want an interface to enable me to create a structure for Business Process / Activities / Tasks so that I can deal with production reconfiguration situations

Operational User

I want to be informed about any delay in the process.
I want to be able to define activities so as to prepare for solution reconfiguration
I want to be able to issue a STOP/ALERT if I feel in danger
I want to trust the system to correctly identify my intention in order to prevent a robot colliding with me

I want clear instructions on how to do routines or solve malfunctions.
I want to access a dashboard to monitor the flow of the process online.

Technology Provider

I want to make sure I provide devices which help the customer
I want to continuously improve the system by comparing the determined intention vs. the actual movement performed
I want an interface to enable me to create a structure for Business Process / Activities / Tasks so that I can deal with production reconfiguration situations

Researcher

I would like all events (e.g. human robot activities) to be recorded as possible contributors to reinforcement learning

Components

Voice interaction component
Component for defining business process and linking to activities tasks
Physical distributed emergency button components
Status monitor
Event detection component

5.3.2 Use Case 2

Robot reconfiguration based on the dynamic layout: this is about managing the robot reconfiguration as part of an overall production process reconfiguration, linked to simulation of the production processes, optimisation of path planning and safe human-robot collaboration.

User Stories

Organisational User

I want to understand the impact of errors
I want to keep the equipment safe

I want to reduce downtime in case of routing error
I want to keep the environment safe for the human
I want to reduce the setup time to reconfigure the robot

Technical User

I want to easily reconfigure the robot
I want to get more feedback in case of an error
I want to have a reliable system
I want to be informed about any collision happens.
I want to be able to simulate the production line with any permanent changes.
I want to be informed if the rerouting does not happen in a certain period of time.
I want to be able to monitor the path of the Robot dynamically.
I want to be able to localize the Robot in the path towards the target.
I want to monitor the current status of all the robots : current position, autonomy left, type (linked ability to perform a task), current task handled (path planned)

Operational User

I want to start production as soon as possible
I want to solve the problems faster, preferably myself
I want to feel safe working with robot
I want to have a reliable system
I want my system to adapt to different conditions (light, crowd)
I want to be able to "instruct" a robot to stop in case of perceived risk to safety
I want the system to detect my intended activity without usage of tags and stripes
Provide a current list of tasks to be performed by the fleet

Technology Provider (Data Scientist)

I want operational, technical, and organisational users to state which are "events of interest"

according to their viewpoints so that these can be recorded
Replanning of the navigation based on obstacles

Researcher

I would like to approximate uncertainty for any unforeseen situation that happens.
I want to enable operational users to indicate when robot action is wrong or right (to feed into reinforcement learning)

Components

Robotino's laser scanner
Visualisation components
Plans a route avoiding obstacles
Collusion detection
Determine the positions of the modules with AI
Creates a online map of the area
Simulates the navigation in digital twin
Initiate robot connection
Send the commands to the Robot
Newly proposed or adapted components / functions; please add comments
Emergency stop
Physical stop button components
Auto-configuration for fast setup
Status monitor
Human feedback to robot
Voice interface
Distribution over obstacle detection instead of single detection.
Event detection component
Business process, activity, task definition / configuration component

Component to link event logs to states

5.4 Proposed Human-AI synergy outcomes

5.4.1 Categorisation of Human-AI collaboration activities

AI augments humans

Co-creation workshop addition

AI supports in planning & scheduling

AI supports human in high risk decisions
--

Support towards risks prevention

Assist human’s awareness of whole environment

Objective decisions (based on data)

Operator support

Human augments AI

Co-creation workshop addition

Human provides feedback for robot learning
--

High risk decisions

Integrated Human and AI tasks

Co-creation workshop addition

None

AI substitutes human

Co-creation workshop addition

Unlimited active production line

Faster and more accurate in repetitive tasks / repetitive pick and place tasks
--

Offers more security and failure free operation on tasks
--

Expected outcomes on human and work design effects

Co-creation workshop addition

Reduces operators physical fatigue
Faster and easier setup
Workers contribute to “system improvement”

Expected outcomes on operational performance

Co-creation workshop addition
High availability
Reduced downtime if layout changes
More secure resource allocation on complex tasks
Easy & cheaper reconfiguration between different production runs
Increased efficiency
More focus on complex tasks

Success criteria

Co-creation workshop addition	Analysis – how to measure?
Human Safety	Recording of incidents / Survey
Technical Safety	Recording of incidents
Performance	Part of the evaluation methodology
Security	Part of the evaluation methodology
Reliability	Part of the evaluation methodology
Transparency	Part of the evaluation methodology, perhaps through survey
Overall Safety	Recording of incidents / Survey
Flexibility	Successful reconfiguration cases / survey

5.5 Workshop evaluation

The workshop was evaluated by means of a survey distributed at the end of the workshop. A total of 12 workshop participants executed the survey. The survey included closed questions (Q2-Q8; Q10), as well as open questions (Q9, Q11). A 5-point Likert scale was adopted ranging from poor to excellent (Q2), and from strongly disagree to strongly agree (Q3-8, Q10). An overview of the questions and the responses are shown in Table 11.

Overall, the workshop was positively evaluated as indicated by a 4.33 overall score of the workshop. The objective, which was clearly stated, was also met. The workshop was well organized and perceived as useful and relevant. Respondents agreed that they had sufficient

opportunity to contribute to the workshop. Instructions were clear and finally, the workshop met respondents’ expectations. Respondents listed a few aspects which they liked best and found most useful, namely the usage of the MIRO board, which allowed for collaboration and interaction as well as a better understanding of the cases. Recommendations for improvements include the definition of used terminology before co-creation activities, an ice-breaking activity at the start of the workshop, and information on the use cases sent before the meeting to be able to prepare but also to use during the workshop.

Table 11. DFKI pilot PCL pilot co-creation workshop evaluation

Question	Mean response 1 strongly disagree -5 strongly agree
Q2 - Overall, how would you rate this workshop?	4.33
Q3 - The objectives of the workshop were clearly stated.	4.67
Q4 - The objectives of the workshop were met.	4.50
Q5 - The workshop was well organized.	4.50
Q6 - The workshop was useful and relevant.	4.50
Q7 - I had sufficient opportunity to contribute to this workshop.	4.50
Q8 - The instructions were clear.	4.33
Q10 - The workshop met my expectations.	4.67
Q9 - What do you like best or find most useful in this workshop?	The board
Q11 - Do you have any ideas or suggestions for the improvement of future co-creation workshops?	.More time

6 IBER-OLEFF workshop

6.1 Preparatory phase

The workshop took place on 5/7/2021. In preparation for the workshop IBER-OLEFF and RuG organised a bilateral meeting and collaborated to prepare the proposed agenda and an initial setup for the MIRO collaboration boards. Microsoft Teams was employed in parallel for shared presentations and the discussion.

6.1.1 Workshop Agenda

Opening - 15h00-15h10

As-Is Scenario - 15h10-15h15

To-Be Scenario - 15h15-15h20

IBER Use Cases - 15h20-15h25

Introduction to Workshop - 15h25-15h30

Workshop UC1 - 15h30-16h00

Break - 16h00-16h10

Workshop UC2 - 16h10-16h40

Workshop UC3 - 16h40-17h10

Break - 17h10-17h20

Collaboration Scenarios - 17h20-17h50

Evaluation - 17:50 – 18:00

6.1.2 Virtual collaboration board setup

A virtual collaboration board was set up, following the structure described in section 3.2, similar to the structure of the PCL workshop.

6.2 Workshop execution

The workshop had a duration of 3h and 18 participants from the STAR project partners contributed to it. IBER-OLEFF opened the workshop presenting the use cases and their requirements.

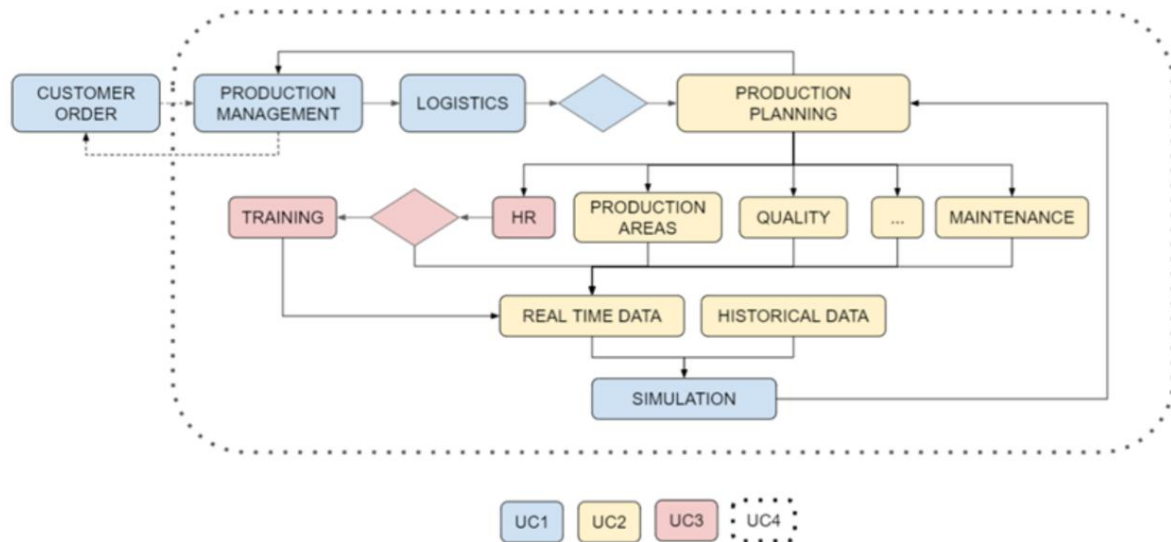


Figure 13. IBER-OLEFF presenting the pilot case and its use cases

RuG described the process to be followed, using the MIRO collaboration boards. Following the agenda, the participants joined the workshop co-creation activities to define user stores, components and the linkage between components and user stories.

6.3 Workshop outcomes

The final MIRO collaboration board after the intense co-creation activity can be seen in Figure 14.

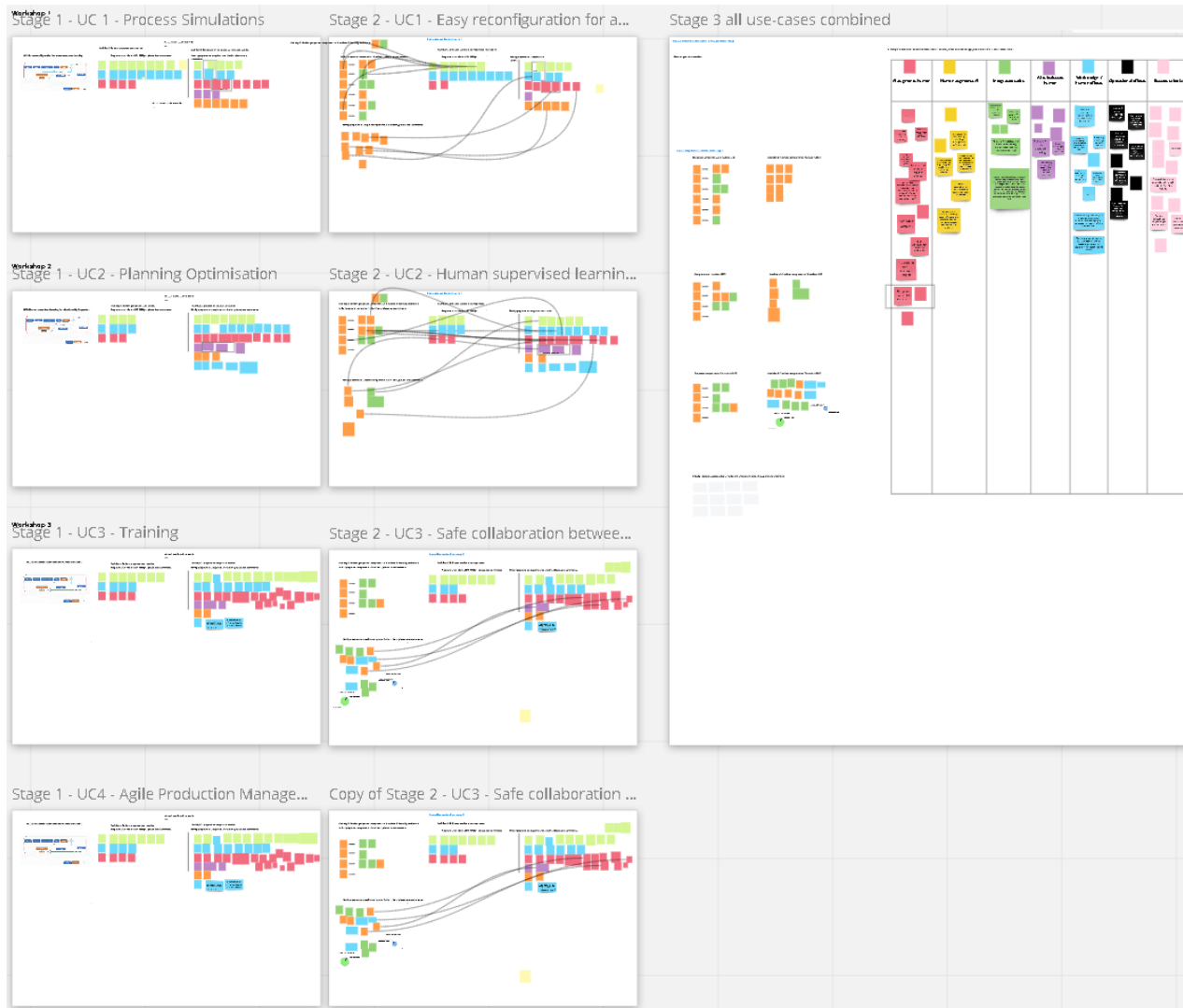


Figure 14. Final collaboration board from the IBER-OLEFF co-creation workshops

The final outcomes are presented next.

6.3.1 Use Case 1 – Process Simulations for Accelerated Decisions and Safe Processes

The use case is relevant to performing production process simulation to drive decisions and reconfigure production as a result.

User Stories

Organisational User

I want to take right decisions regarding production system in order to accommodate customer orders
I want to be able to simulate different scenarios of production system in order to select the adequate one
I want to have real-time insights into the performance of the production system
I want to have access to historical data regarding the performance of the production system

Technical User

I want to be able to fast and easily reconfigure production system in order to be flexible
I want to be able to prepare reconfiguration of the production system in virtual domain in order to not affect the productivity
I want to be able to monitor the current configuration of the production system
I would like the simulation to adapt to real-time changes in the production process (also the operational user)
I want to have tools plug and play and/or with minimal setup
I want to receive notifications if there is something that needs immediate attention
I want to be able to fast and easily reconfigure production system in order to be flexible
I want to define validation criteria and intercomponent hard and soft dependencies
I want to have only validated configurations deployed in operational environment

Operational User

I want to have real-time insights of warehouses stocks (finished products & unfinished parts)
I would like to monitor the whole process and current status.

I would like the simulation to adapt to real-time changes in the production process
I want to have information about when and how simulation is inaccurate
I would like to be aware of new tools in line. (to be safe for example)

Technology Provider

As a technology provider delivering an AI component for resources planning	I need access to the monitored parameters and the production
--	--

Components

Accelerate decisions at production management level

Configuration simulator

Virtual simulation module

Configuration simulator

Validation of developed configuration

Performance data collection system

Dashboarding of real-time information

Various components for the above

Component that feeds real time data to simulator

PLCs and sensors in workcentres for data acquisition

Interface with IBER-OLEFF software (PHC, ProSes, CAQ)

Universal adapters for tools

Database to store datasets

Component to monitor the human activity (IMU, Wearable glass, etc)

Various functionalities for the above

Comparison of simulated outcomes with real ones

Project Information Security (non functional)

6.3.2 Use Case 2 - Production Planning Optimisation

The use case is about producing optimised production planning aiming in parallel at zero-defect production.

Organisational User

I want maximization of productivity
I want to have clear insights into the performance
I want to have a monitoring system of manufacturing processes
I want to consider workers historical performance and skills in order to assign jobs and tasks

Technical User

I want to receive notifications whenever an abnormality of defects is detected by monitoring system
I want to be able to quickly & easily reconfigure production system
I want to spend as little time as possible setting up and training operational users
I want to consider workers historical performance and skills in order to assign jobs and tasks

Operational User

I want to be safe when performing my work
I want to have clear procedures to follow
I want to be assigned to the jobs and tasks that I prefer, that fit my aspirations and that can allow me to increase my skills.
I want to be informed about any problem in the line and the procedure to resolve that.

Technology Provider

Researcher

I want to have access to the data from production line. (Training testing)
--

Components

Monitoring system of production processes (hardware + software)
Visualisation System (software)
HR Training System (software, with access to "knowledge repository")
Human digital twin (software)
Data collecting system (with sensors, cameras etc, feeding into a "Knowledge repository")
AI resource planning and assignment component (with Configuration Validation

6.3.3 Use Case 3 - Training

The use case is about managing appropriate user training for preventing operator errors.

Organisational User

I want to provide a safe and healthy working environment for all employees
I would like that my employees will be trained based on current but also future needs (e.g. technologies, market fluctuations, etc.)
I want to combine the best of both human and machine

Technical User

I want to be safe when I am working close to a robot
I want to spend as little time as possible training operational users
I don't want the digital system to be prone to attacks that might disrupt its functions
I want a recommender system to provide a training path based on current skills and experience, and desired skillset.

Operational User

I want to work in a safe environment
I don't want to be burned out by my work
I would like to receive clear and easy-accessible instructions on tasks if needed
I would like to know clear safety measures
I want to receive alarm/notification to prevent me making an error (or warn me that I made an error) or an unsafe action; and receive appropriate instructions

I want to follow training to improve my job profile, increase my skills and pursue my aspirations.

As an operational user I would like to get trained in a virtual reality to be safe

As an operational user I want to follow training that allows me to improve my job profile, increase my skills and follow my aspirations.

Technology Provider

I need to have training content for operators to include in a content management system

Researcher

I want to have access to user profiles, their skillset, and available training options (short characterization, e.g., course, time required, cost, etc) so that a recommender system for employee training can be developed. Any external information on managers' criteria for employee eligibility is welcome too.

Components

Shared space safety system (for example to deliver prevention of human-machine collisions)

Digital safety system (for example to prevent evasion & poisoning attacks)

Mental health monitoring services system (with fatigue / emotion detection module)

Content management systems for tasks - instructions - required skills - guidelines - common mistakes (Skills matrix management functionality included)

6.4 Proposed Human-AI synergy outcomes

6.4.1 Categorisation of Human-AI collaboration activities

AI augments humans

Co-creation workshop addition

Operator receives task instructions

Human decision makers are supported by AI in production planning and job assignment.

AI recommender system to suggest employee training paths for skills acquisition

Error reduction

Fast and accurate training

AI recommender system for decision making options

Training HR's monitored by AI to identify accuracy of operational methods

Human augments AI

Co-creation workshop addition

Human configurator of AI edits CMS to feed into recommended actions for tasks

Selection of training data cases for human activity / fatigue recognition

Human returns validated or rejected reconfiguration cases (to be used for AI training)
--

Recording of prototype correct actions for AI-delivered human training
--

Integrated Human and AI tasks

Co-creation workshop addition

Human validation of AI derived reconfiguration
--

Joint human-machine tasks for assembly
--

Human validation of AI derived reconfiguration
--

Joint human-machine tasks for assembly
--

AI substitutes human

Co-creation workshop addition

event detection (for alerts etc)

Detect defects

Monitoring and maintenance action recommendation
--

Expected outcomes on human and work design effects

Co-creation workshop addition

Job enrichment and avoidance of over-specialisation

Cognitive support of operators with context-relevant recommendations
--

Safer jobs + workplace

Expected outcomes on operational performance

Co-creation workshop addition

Flattening of resources allocation peaks
Reliability

Success criteria

Co-creation workshop addition	Analysis – how to measure?
Human Safety	Recording of incidents / Survey
Improved performance	Part of the evaluation methodology
Improved flexibility (training and task assignment are performed to increase skills, extending the assignment options)	Successful reconfiguration cases / survey / part of the evaluation methodology
Security	Successful reconfiguration cases / survey
Agility of production system	Successful reconfiguration cases / part of the evaluation methodology
Usability	User survey

6.5 Workshop evaluation

The workshop was evaluated by means of a survey distributed at the end of the workshop. A total of 6 workshop participants executed the survey. The survey included closed questions (Q2-Q8; Q10), as well as open questions (Q9, Q11). A 5-point Likert scale was adopted ranging from poor to excellent (Q2), and from strongly disagree to strongly agree (Q3-8, Q10). An overview of the questions and the responses are shown in Table 12.

Overall, the workshop was positively evaluated as indicated by a x overall score of the workshop. The objective, which was clearly stated, was also met. The workshop was well organized and perceived as useful and relevant. Respondents agreed that they had sufficient opportunity to contribute to the workshop. Instructions were clear and finally, the workshop met respondents expectations. Respondents found most useful that they had the opportunity to add comments to clarify all ideas mentioned, the co-creation and collaboration process, and the Miro board (i.e. digital work). Respondents suggested conducting a physical workshop as soon as this is possible.

Table 12. Evaluation of IBER-OLEFF pilot co-creation workshop

Question	Mean response 1 strongly disagree -5 strongly agree
Q2 - Overall, how would you rate this workshop?	4.22
Q3 - The objectives of the workshop were clearly stated.	4.67
Q4 - The objectives of the workshop were met.	4.44

Q5 - The workshop was well organized.	4.33
Q6 - The workshop was useful and relevant.	4.67
Q7 - I had sufficient opportunity to contribute to this workshop.	4.89
Q8 - The instructions were clear.	4.56
Q10 - The workshop met my expectations.	4.67
Q9 - What do you like best or find most useful in this workshop?	The opportunity to add comments to clarify all ideas mentioned.
	The collaborative digital work
	Co-creation process
	Miro
Q11 - Do you have any ideas or suggestions for the improvement of future co-creation workshops?	It would be nice to have a physical meeting to do this exercise but of course due to the pandemic this was not possible
	Not a particular one. That was a successful workshop for me!
	Keep going
	Add "to-do" for MIRO boards

7 Conclusion

This report outlined the activities that have taken place during the Design Phase co-creation workshops at each pilot case and the key outcomes from these workshops. It also includes output of a survey distributed among project participants with the aim to collect preparatory information to prepare content for the online workshop executed via MIRO online visual collaboration platform.

The key challenge during this project activity was the COVID-19 overall situation, which prevented the project from conducting co-creation workshops with physical presence of participants in a common room for collaboration. Therefore, the mitigation action that was taken opted instead to employ a virtual collaboration tool, namely MIRO.

To better prepare for the co-creation sessions, a STAR project partners survey was designed, distributed, filled-in and analysed, aimed at influencing the structure and the initial “seeding” content of the workshops. This was deemed important, as the lack of physical presence was expected to hamper the collaboration efforts, and therefore initial ‘seeding’ of concepts and ideas acted as sufficient stimulus to initiate a very lively collaborative co-creation activity in each workshop.

During the workshops, the participants, coming from different perspectives, as represented by the different stakeholder roles of the project partners, worked jointly to co-create key concepts and ideas, bringing together design motivation and requirements, system components that could be relevant to them, bringing in perspectives from different categories of users, in the form of user stories. Importantly, the participants worked to link the user stories and the envisaged components and their expected functionality with potential outcomes and effects / success criteria for the human-centric AI solutions to be developed in the STAR project. The workshops were positively evaluated at the end, marking a very successful co-creation activity during the time of the pandemic restrictions. It was further concluded that the project partners would consequently be expected to take stock of the co-creation activities outcomes when designing and implementing their parts within the overall STAR portfolio of solutions. As the co-creation activities outcomes by their nature are of conceptual and rather abstract nature, the next step would be for them to be more concretely taken into account in the STAR components design, development and testing. It is highly relevant that this is done in a way that examines also both the consistency and feasibility of the derived outcomes, given the project aims, targets, and available resources. Furthermore, the co-creation activities outcomes will be taken particularly into account in the evaluation methodology for the project outcomes in deliverables D6.11 and D6.12. The most important outcome arising from the activities reported in this deliverable is that they offered the partners the opportunity to act as a collaborative co-creation team, triggering the composition of ideas and design requirements and concepts, especially at a time that such a collaboration was particularly restricted due to the pandemic.

References

Reference	Name of document
[REF-01]	STAR. D2.8: User Studies and Co-Design for Human-Centred AI. 2021-02-28
[REF-02]	

8 Appendix – Preparatory survey for workshops

Part 0

What is your role in the STAR project?

- Use case representative/employee
 - PCL
 - Iber
 - DFKI
- Scientific institution/researcher
- Technology developer
- Expert _____
- Other _____

Please indicate the targeted AI system addressed in this survey:

- PCL
- Iber
- DFKI
- AI technology in general

Part 1: Task scenarios between AI and humans

We identify four different task scenarios that are relevant in the context of AI and which are important to consider during the design and development phase. Per scenario, please provide concrete and relevant examples of future tasks at the selected use case that fall within these categories.

AI substitutes humans
AI arguments humans
Human augments AI in tasks
Integrated AI & human perform tasks collaboratively

Part 2 Human and job effects

The next questions will focus on rating the importance of considering a number of human and job effects during the design, development and deployment of the selected use case with the corresponding AI solution. Table ? provides an overview of relevant effects.

Questions 2.1.

2.1.1. Please rate what you expect the impact of deploying the AI solution will be on the future _____ of the user?

2.1.2. Would you rate this impact to be a positive or negative outcome?

2.1.3. Please rate the importance of considering the following human and job effects during the design, development and deployment of the AI system.

Work design related effects (Morgeson & Humphrey, 2006)	Human (factor) effects
Job autonomy (work scheduling, decision-making and work methods)	Physical demands
Task variety	Well-being
Feedback from the job	Safety
Job complexity	Fatigue
Specialization	Mental workload
Problem solving	Trust
Information processing	System usability
Variety of skills	Situation awareness
Interdependence (initiated and received)	Explainability
Feedback (from others)	Job satisfaction
Social support	Motivation
Interaction of users outside the organization	Intrusiveness
	Ergonomics

Question 2.2.

Can you identify human or job-related factors not previously mentioned and that you consider important to measure the success of the AI system?

Part 3 Operational effects of AI

In this section, you are asked to rate the importance of considering a number of operational factors during the design, development and deployment of an AI system in manufacturing.

Questions 3.1.

Please rate the importance of considering the following operational effects during the design, development and deployment of the AI system.

Operational effects
Productivity
Process quality
Process efficiency
Process flexibility
Costs
Speed/lead-time

Question 3.2.

Can you identify operational factors not previously mentioned and that you consider important to measure the success of the system?

Part 4 Success criteria to guide the design, development and deployment

In this section, you are asked to rate the importance of success criteria to guide successful design, development and deployment of the AI technology.

Success criteria are generic and can guide the system designers to jointly pay attention to different contributing factors (human, technical and operational) early on in the design process. They are derived from the envisioned human, technical and operational effects examined in part 3 and 4 of the survey.

Please rate the importance of the following criteria for the successful design, development and deployment of the AI system.

(Strongly disagree to strongly agree)

4.1. Reliability

The ability of the socio-technical system to perform as required for a given time period and for given conditions, without failure.

4.2. Performance

The ability of the socio-technical system to deliver specified performance targets.

4.3. Safety

Human Safety: The ability of the socio-technical system to exhibit freedom from risk of harm to persons

Technical Safety: The ability of the socio-technical system to exhibit freedom from risk of damage / loss to technical assets.

Environmental Safety: The ability of the socio-technical system to exhibit freedom from risk of damage to the environment.

4.4. Security

The ability of the socio-technical system to resist an attack.

4.5. Usability

Usability can be described as the capacity of a system to provide conditions for its users to perform the tasks safely, effectively, and efficiently while enjoying the experience.

4.6. Job enrichment

Job enrichment is a type of job 'redesign' (see Job Design). It refers to building into jobs "greater scope for personal achievement and its recognition, more challenging and responsible work, and more opportunity for individual advancement and growth.

4.7. Physical support

Optimal design of the physical elements, interactions and activities

4.8. Cognitive support

Optimal design of the mental requirements, interactions and activities

4.9. Social support

Optimal design which allows for sufficient social interaction.

4.10. Can you identify additional success criteria not previously mentioned and that you consider important to guide successful design, development and deployment of AI technology?