Project Deliverable 1.1

Captured and structured practices of workers and contexts of organisations

www.facts4workers.eu

FACTS4WORKERS

Factories of the Future
Public Private Partnership

Bibliographic Details

Series: Public Deliverable

Published by: FACTS4WORKERS: Worker-Centric Workplaces in Smart Factories. FoF 2014/636778.

Date: 31.8.2015

Volume 1: Captured and structured practices of workers and contexts of organisations

Reference / Citation

Heinrich, P.; Richter, A. (2015): "Captured and structured practices of workers and contexts of organizations". Project Report - FACTS4WORKERS: Worker-Centric Workplaces in Smart Factories.

Layout and Setting: Florian Ott, Cooperation Systems Center Munich

FACTS4WORKERS: Worker-Centric Workplaces in Smart Factories

E-Mail: facts4workers@v2c2.at
Internet: www.facts4workers.eu

About this document

Executive Summary

This document represents Deliverable 1.1 ("Captured and structured practices of workers and contexts of organisations") of the H2020 project "FACTS4WORKERS - Worker-Centric Workplaces in Smart Factories" (FoF 2014/636778).

At the core of this deliverable, we initially explore the practices of workers and the contexts of organisations at six industrial partners with more than 100,000 employees in more than 50 countries. A deep understanding of workers' individual practices will help us deliver suggestions (in the form of requirements) for sociotechnical solutions that support smarter work. We structure the captured practices in the form of eight contexts-of- use, i.e. four industrial partners have one context-of-use and two industrial partners have two contexts-of-use.

This document also provides a detailed illustration of our methodical approach in order to provide a high level of transparency to all readers. Our general approach is human-centric, iterative and agile by nature, and has been inspired by well-known and widely accepted frameworks and models from the Design Research and Scenario-based Development domains.

In addition, having presented the practices in detail, we then present a first evaluation of the anticipated impacts of the planned interventions on the previously identified contexts-of-use. To do so, we develop a framework with seven impact dimensions and take a closer look at each context-of-use as well as the intended impacts on individuals (autonomy, variety, competence, relatedness, protection) and organisations (quality, time efficiency).

Document authors and reviewers

The following persons have contributed directly to the document. Please note that many other people have supported our work and we thank them sincerely.

Lead Authors

Name	Organisation	Role
Dr. Peter Heinrich	University of Zurich	WP 1
Dr. Alexander Richter	University of Zurich	WP 1 Lead

Featuring Authors

Name	Organisation	Role
Jonathan Denner	University of Zurich	WP 1
Andreas Engelmann	University of Zurich	WP 1
Andreas Häring	University of Zurich	WP 1
Ann-Kathrin Lang	ThyssenKrupp Steel Europe	Industrial Partner
Martin Wifling	Virtual Vehicle Research Center	WP 8 Lead, Project Coordinator

Reviewers

Name	Organisation	Role
Dr. Peter Brandl	Evolaris next level	WP 2 Lead
Dr. Gianni Campatelli	Università degli Studi di Firenze	WP 3 Lead
Dr. Detlef Gerhard	TU Vienna	WP 5 Lead, Scientific Coordinator
Sergio Mayo, Francisco José Lacueva Pérez	Instituto Tecnológico de Aragón	WP 6 Lead
Samanta Krapež	SiEVA	WP 7 Lead
Dr. Lea Hannola	Lappeenranta University of Technology	WP 1, Task 1.2 Lead
Dr. Gerhard Schwabe	University of Zurich	WP 1
Dr. Michael Leyer	University of Rostock	WP 1 (External Expert)
Matjaz Milfelner	EMO-Orodjarna	Industrial Partner
Aleš Bizjak	Hidria Technology Centre	Industrial Partner
Tobija Kovač	Hidria Rotomatika	Industrial Partner
Christian Buchberger Christoph Broese	Schaeffler Technologies	Industrial Partner
Sergio Muñoz Pedro Amoraga	Thermolympic	Industrial Partner

Contents

Table of Figures

Index of Abbreviations

BPMN.... .... Business Process Modelling and Notation

CNC.................... Computerized Numerical Control

EMO................... EMO Orodjarna d.o.o

HID..................... Hidria TC d.o.o

HIR..................... Hidria Rotomatika

HVAC................. Heating, Ventilation and Air-Conditioning

ICT...................... Information communication technology

IP…..................... Industrial Partner

MES…................ Manufacturing Execution System

OEE .... Overall Equipment Efficiency

OEM................... Original Equipment Manufacturer

QA… .... Quality Assurance

Tab. .... Table

SCA..................... Schaeffler AG

SBD .... Scenario-based Development

SME.................... small and medium enterprise

THO.................... Thermolympic S.L.

TKSE.................. ThyssenKrupp Steel Europe AG

1 Introduction

The **mission** of the HORIZON 2020[1] project FACTS4WORKERS is to develop and demonstrate solutions that support including an increasing number of knowledge work elements into the work done on the factory floor. We see a great potential in the use of information and communication technology (ICT) to provide production employees with the information they need to perform their daily work at the right time and in an appropriate manner. These smart ICT solutions should, inter alia, improve decision making, support the search for problem solutions, and ultimately strengthen employees' position on the factory floor.

With FACTS4WORKERS, we want to contribute to the **vision** of a "smart factory" in which smart workers play a central role in the production process and ICT solutions support them in the best possible way. As the most flexible element, smart workers are the focus of attention, and their role is extended far beyond factory work's conventional automated storage routine activities. An autonomous work environment will help them continuously improve knowledge sharing and effective knowledge acquirement in the workplace.

FACTS4WORKERS thus raises the **questions** of how people work and learn, how they interact with new technologies and how we can create attractive and challenging work environments, which will increase their satisfaction and motivation. The answers to these questions are the key to successful sociotechnical solutions for production processes.

As the **result** of an iterative process, we will design and refine an infrastructure that enables (better decision-making ability, increased participation, increased autonomy) and protects (reduced stress levels, reduced cognitive overload, reduced monotonous, error-prone work) production workers. Although our guideline is to increase workers' job satisfaction sustainably, our infrastructure will also increase production quality and time efficiency.

This deliverable (D 1.1) reports on the first step of working package 1 (WP 1): The identification of workers' practices and the contexts of organisations at our six industrial partners in three countries with more than 100,000 employees in more than 50 countries. **The focus of this study** are the **individual practices** that emerge when workers carry out their daily routines, as opposed to previously top-down specified processes as a way to optimise business. A deep understanding of workers' individual practices will help us deliver suggestions (in the form of re-

1 Please cf. http://ec.europa.eu/programmes/horizon2020/

quirements) for an ICT solution that supports smarter work. This approach also implies continuous improvement rather than disruptive changes.

Our primary mandate and **envisaged contribution** are to **empower the workers** and to elicit their needs. The available solutions' implementation feasibility is subordinate to the project's innovative potential. We acknowledge that there might also be quick wins by merely adjusting already existing (and accepted) company solutions. In doing so, our goal is, of course, to consider **individual and organisational constraints** and to align both points of view.

The project's philosophy is that **empowering the worker** pays off, especially in the long term, and is the most sustainable form of improvement. However, a company's efficiency should never be compromised, which implies pareto-efficient solutions. User acceptance is the minimum viability criterion.

Content of this document:

Next, we will explain our general approach in WP 1, which comprises the data-collection and the development of a number of artefacts as the outcome of an iterative, co-evolutionary process which has not yet ended (Chapter 2).

After that, we will present our six industrial partners and the contexts-of-use where we want to implement the envisaged smart ICT solutions. The description of the contexts-of-use and the therein contained practices should allow first insights into the special conditions at our partners (Chapter 3).

An analysis across the contexts-of-use allows the reader to compare these and understand their communalities and differences (Chapter 4).

Please bear in mind that the focus of this deliverable is on identifying the current practices and not on defining the requirements. This will follow in a further deliverable (D 1.2, project month 12).

2 Method and Solution Design

The primary goal of work package one (WP 1) is to establish a shared understanding of the use contexts and work practices across all the involved partners and the stakeholders as well as to identify requirements based on that understanding. Thus, the applied methods and created artefacts have to serve two purposes:

1. They provide the necessary instruments to elicit and capture the required information.
2. They serve as boundary objects and facilitate communication between the partners (Levina and Vaast 2005). The resulting artefacts must be understandable in order to help build a "common ground" for further investigation.

In the context of our project, we use the term artefact whenever we refer to all kinds of digital and non-digital products that we create to support our development process. An overview of the artefacts created and their relations (in WP1 so far) can be found in Figure 12.

Consequently, the method set applied in the project had to be negotiated between the collaborating partners and further refined to accommodate everyone's needs.

The following sub-sections cover the general approach taken (2.1), the approach and outcome of the data collection (2.2 and 2.3) and an overview of the artefacts ultimately created with this process (2.4).

2.1 General approach

Iterative and agile approach

Our general approach was inspired by well-known and widely accepted process models, such as the ISO9241-210 standard for the human-centred design of interactive systems and Design Research's process model (Peffers et al. 2007). Both processes build on the assumption that "wicked problems" (Pries-Heje and Baskerville 2008) cannot be solved in a linear process. Instead, an iterative and agile form of the subsequent (re)-development and evaluation of the requirement is needed. This approach accounts for the normally up-front, loosely specified goals and use contexts. Further, it assumes that the solution success depends heavily on complex interactions between the stakeholders and that proper solutions can only be arrived at through a critical dependence on human cognitive and social abilities (Hevner et al. 2004).

Diverse backgrounds & the demand for co-design

However, the above-mentioned process models are generic and lack concrete procedures for specific situations. FACTS4WORKERS includes more than sixty collaborating persons from six industrial and nine academic partners from eight different countries as well as experts from various domains, like software engineering, production management, knowledge management and engineering, with a broad scope of working contexts. To consider these diverse backgrounds and allow the highest possible degree of collaboration and interaction between the partners, we did not specify the detailed methodological design up front, but developed it as we went along. The constant feedback from the partners regarding the information (formats) they would need, allowed us to ground the project progress in the knowledge gained with each step.

Consequently. we developed and applied a refined (and less abstract) approach in FACTS4WORKERS. One could also say that the method and the solution had to be co-designed to lead to successful solutions.

Figure 1 depicts our starting point, the applied requirement identification process, on an abstract level.

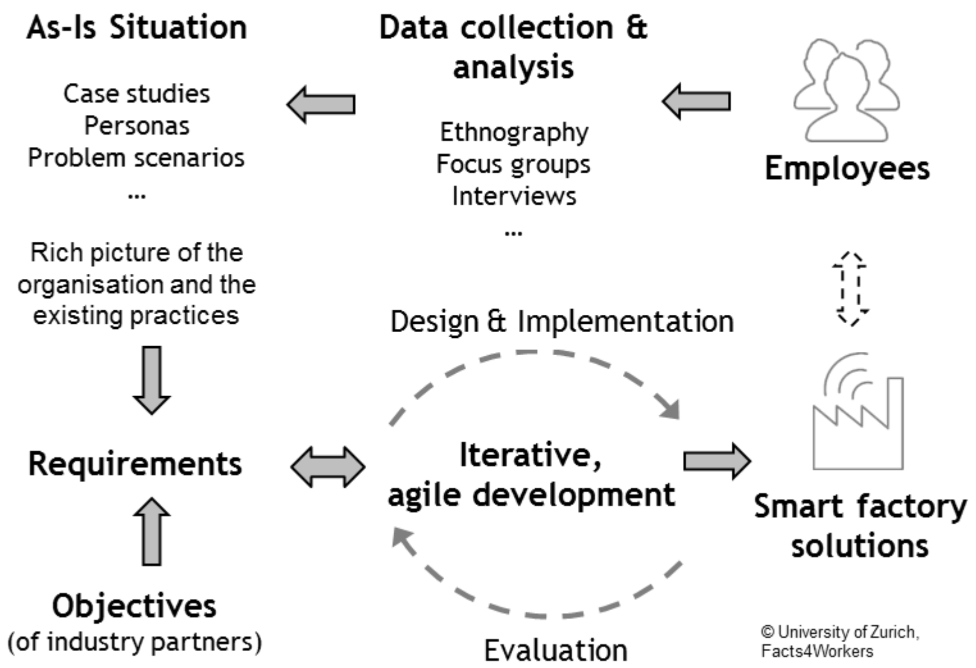

Figure 1: General requirement identification process in FACTS4WORKERS.

Figure 2 illustrates the relationship between the iterative solution and method design phases, which can be explained as follows:

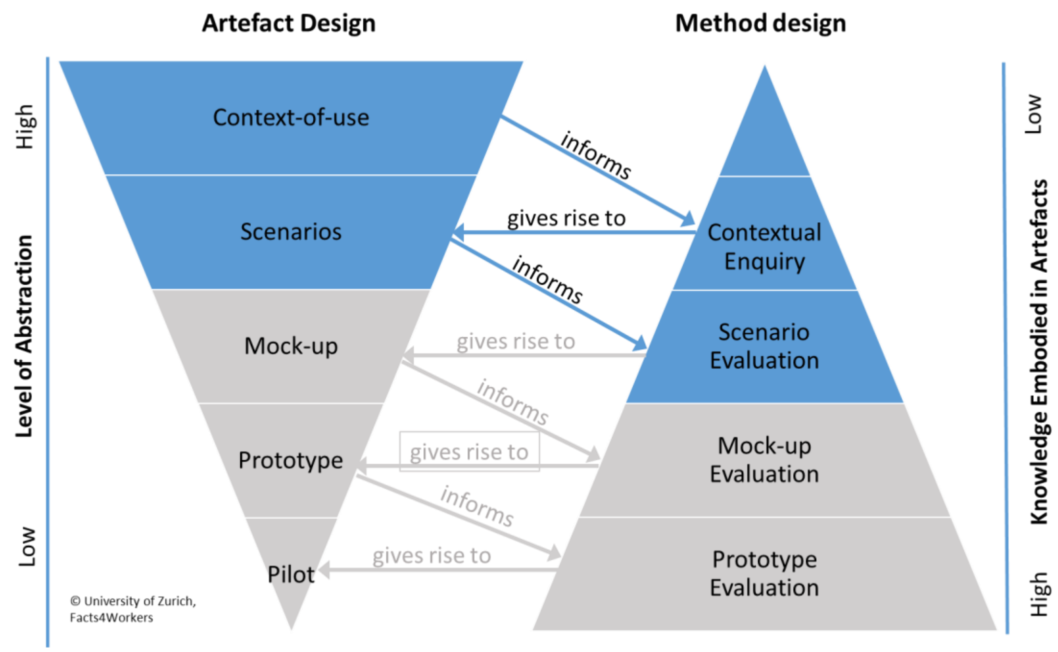

Figure 2: Our approach of an artefact method co-design

Co-Design Process

On the highest level of abstraction (with the least knowledge available at the beginning of the project), we used textual descriptions of the rough context and vague solution ideas that we shared and discussed within the project and with the industrial partners. The resulting document was then used as a boundary object to communicate the identified contexts within the project teams; validating the text with the industrial partners also ensured that a common understanding had been established. Based on this context-of-use information, we planned the specific procedure of the contextual enquiry (see section 2.3.1 for details). This planning step could not be done previously, as both quantitative (i.e. how many subjects from each stakeholder group had to be included) and qualitative (i.e. specific methods of inquiry, i.e. semi-structured interviews, video-recording of work procedures) reasoning would not have been possible. Further, some companies may have restricted certain types of data-collecting methods, like video-recordings or taking photos, to protect intellectual property.

Scenario-based Development

The gained information from the contextual enquiry was then aggregated into problem scenarios and into process models, which made the identified problems and technological solutions better comprehensible. Creating these scenarios is part of the scenario-based development (SDB) methodology (Rosson and Carroll 2002). Instead of describing a future system only in terms of its pragmatic dimensions (i.e. functions) SDB focuses on the perspective regarding how the system **is** and **should be** used by the relevant stakeholders (Rosson and Carroll 2002). Problem scenarios are types of stories that describe how the relevant stakeholders act in the current situation. Later, activity scenarios are created that describe how the envisioned system is used in the specific context. This enabled us to communicate and validate the vision of the solution in the project’s very early stages. Once evaluated, these scenarios formed the bases for the upcoming design of the first mock-ups (i.e. clickable screen mocks). This procedure of alternating building/evaluating cycles was repeated in the next steps.

We applied the co-design method in parallel in all six industrial partners. Using the same representation of the information (boundary objects) also provided the opportunity to compare and evaluate specific contexts, or to identify the similarities between the different contexts (to identify common solutions and problems). Further, this approach enabled us to reflect on the fitness of the methods applied.

In the next sections, we will provide detailed information on the first two phases of the design (see Figure 3).

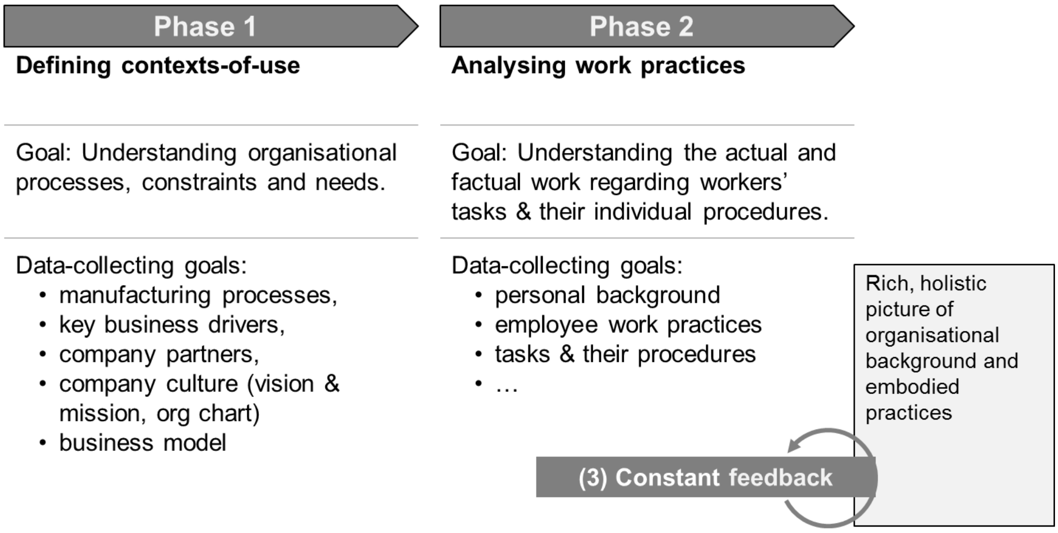

Figure 3: Two-step approach to collecting data from the industry partners.

2.2 Data collection Phase I

2.2.1 Defining context-of-use

The goal of this phase was to get to know the industrial partners and to identify the possible contexts-of-use. Visits to the relevant workplaces' shop floor helped establish a basic understanding of the production environment. These first visits all took place in February and March 2015.

Figure 4: Impression of the first visits

Together with the industrial partner, we sketched the rough idea. The context-of-use would comprise the following items:

Definition *"Context-of-Use"*

1) A short description of the company and the environment in which the solution will be applied.
2) A short description of the problems in that area on an abstract level
3) A first idea of how a potential smart ICT solution could help diminish the problem.

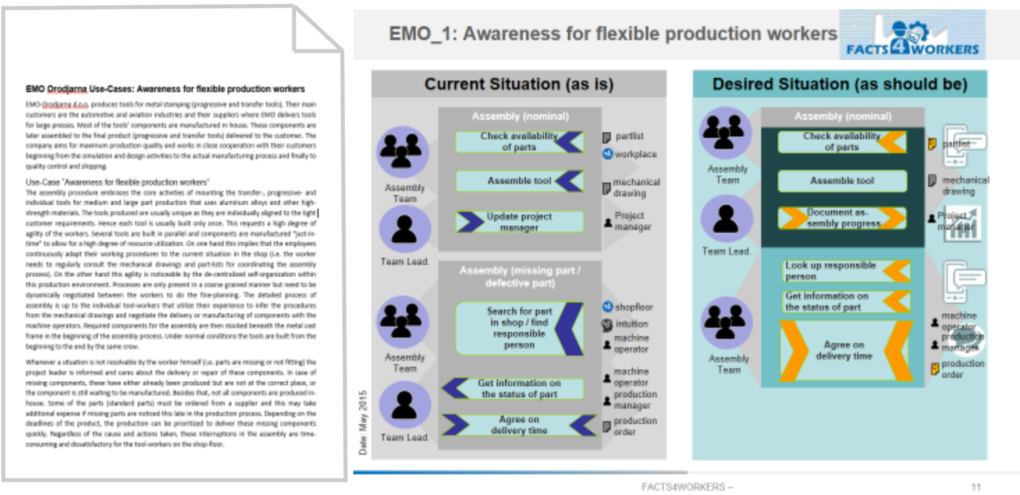

Figure 5: Context-of-use in textual representation (left) and in PowerPoint format.

The prime artefact generated in the first step was a coarse-grained description of the context-of-use in textual form, accompanied by a simple PowerPoint template that had been used in similar projects and which was further refined (see Figure 5).

By validating both documents with the industrial partners, we ensured a mutual understanding of the application context and the rough organisational goals at this level. We used the information gained to inform the methodological design in the second step.

2.2.2 Impact analysis

Next, we deduced the dimensions of the impact on the workers and organisations. We started with the initial project objectives and specified those further.

Initial project objectives

As initially explained, the mission of FACTS4WORKERS is to develop and demonstrate solutions that provide production employees with the information they need to perform their daily work at the right time and in an appropriate manner. These smart ICT solutions should, inter alia, improve decision making, support the search for problem solutions and ultimately strengthen employees' position on the factory floor.

In the project proposal, we specified that we would develop smart ICT solutions for four industrial challenges: personalised augmented operator (IC1), worked-centric rich-media knowledge sharing/management (IC2), self-learning manufacturing workplaces (IC3) and in-situ mobile learning in the production (IC4).

In addition, we specified the following measureable indicators in the proposal:

- Increasing the problem-solving and innovation skills of the workers;
- Increasing the cognitive job satisfaction of the workers participating in the pilots;
- Increasing the average worker productivity of the workers participating in the pilots by 10%;
- Achieving TRL 5-7 in a number of worker-centric solutions through which workers will become the smart element in smart factories.

Specifying the impact further

During our analysis, we additionally structured the impact on the individuals and the organisation into seven major dimensions, five for impacts on the workers and two for on the organisations.[2] These will later help us analyse the impact of the identified contexts-of-use.

[2] We have deduced these dimensions from well-known scientific studies (see below).

The workers' impact dimensions are:

1. **Autonomy** - the freedom of choice regarding what to do when and the possibility to drive their own decisions without consulting various superiors or colleagues.
2. **Competence-** subsumes three sub-dimensions:
    a. The ability to make *informed decisions.* These decisions are often also relevant in a problem-solving context.
    b. The ability to *solve problems individually or collaboratively* form another sub-category.
    c. The competence to produce innovations has been subsumed here. However, successful innovation needs organisational frame conditions that allow for changes and workers' individual abilities to persuade other people to adopt their ideas.
3. **Relatedness** -subsumes two sub-dimensions:
    a. A worker's general *participation* and *involvement*
    b. *A worker's awareness*
4. **Variety** - the diversity of the tasks during the employees' daily work.
5. **Protection** - subsumes two sub-dimensions:
    a. The reduction in stress levels.
    b. The reduction in cognitive overload, resulting in less worker frustration during their daily tasks.

We have deduced these dimensions from well-known scientific studies: The first three dimensions can be aggregated into the psychological empowerment concept as expressed in the self-determination theory, which uses the exact same three dimensions (Spreitzer 1995; Deci, Connell, and Ryan 1989). In the empowerment realm, the fourth category, variety, plays an especially important role in work contexts (Turner and Lawrence 1965). Hence, the core directions of the impact are the workers' empowerment and protection.

The impact dimensions for organisation are[3] (Neely, Gregory, and Platts 2005):

6. **Quality -** aggregates all impacts which are relevant for quality monitoring and traceability as well as for fault or deviation prediction and fault prevention.

[3] Literature also differentiates two further dimensions: flexibility and costs (Neely, Gregory, and Platts 2005). We do not consider **flexibility** further, since it is an emergent property and requires workers to be empowered in the autonomy and variety dimensions. Flexibility cannot exist without these dimensions. A prime example of flexibility is the first EMO context of use. EMO produces lot sizes of around one. Each product is therefore fully tailored to the customer's requirements. At EMO, this is due to the nature of the product. However, this way of production is being increasingly adopted in other industries. For example, in the car industry, the customers have increasing configuration possibilities and options, which make these cars largely unique. Consequently, in industries that focussed on mass production, this flexibility is currently also becoming very important, which it will also be in future. We do not further consider **costs** at this time, since we do not have realistic estimates of the impacts as yet. However, we will again discuss the impacts on costs later in the project.

7. **Time efficiency** – subsumes improvements regarding decreased downtimes, higher throughput and faster decision making as well as faster reaction time

The following figure visualises the dimensions of impact[4]:

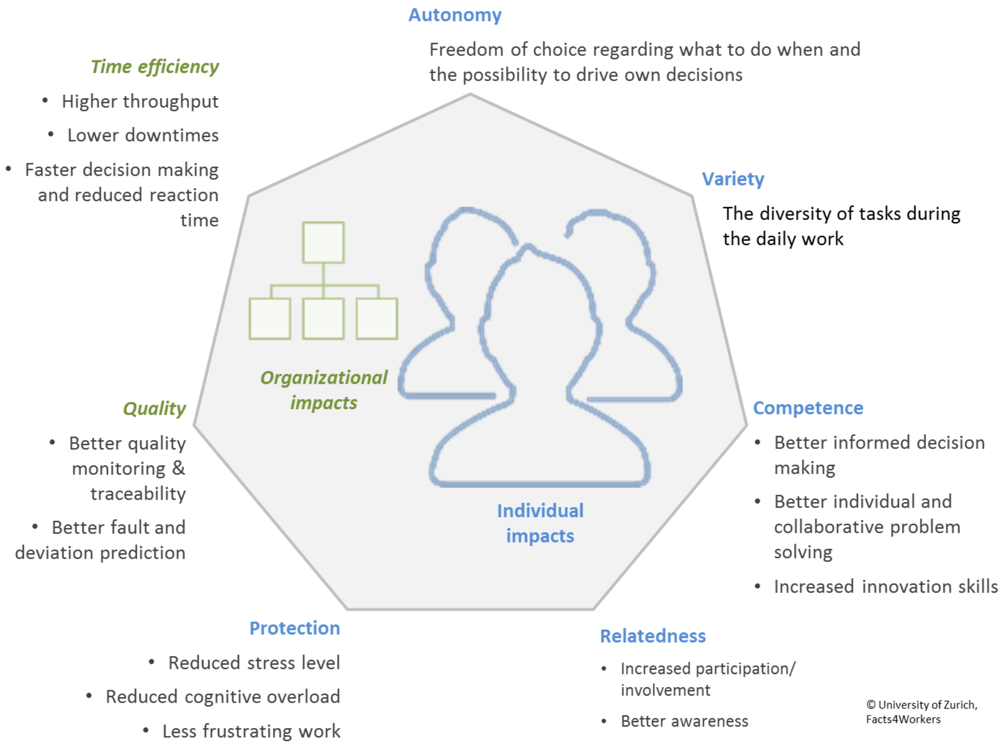

Figure 6: Framework of impact dimensions and terms

Please note that, in this phase, the identified impacts are independent of the specific technology used for the implementation in later phases. Further, there are only rough sketches of the human-machine interfaces.

Technology not yet in focus!

2.3 Data collection Phase II

2.3.1 Analysing work practices

Based on the knowledge gained in the first step, we prepared the work practice analysis. We selected problem scenarios as a representation of the current work practices in order to simultaneously show the current situation, problems and shortcomings. We selected process models (in BPMN - Business Process Model and

[4] This framework may also be used in later project phases for the evaluation of the smart factory solutions.

notation[5]) to capture the coarse processes in order to embed the problem scenarios in the organisational context. Both representations were used to disseminate the knowledge within the project consortium.

"A problem scenario is a narrative of current practice that synthesizes actors, themes, relationships, and artifacts discovered in the field work." (Rosson and Carroll 2002)

Definition "Problem Scenario"

In the project, personas achieved this synthesis of actors. "Personas are user models that are represented as specific individual humans. They are not actual people but are synthesized directly from observations of real people" (Cooper, Reimann, and Cronin 2007)

Definition "Persona"

We selected a multi-methods approach to capture the knowledge necessary to create the scenarios and personas. The main instruments used to elicit the actual work practices from the workers' perspectives were semi-structured interviews, observations and additional documentation, such as photographs and video recordings. When appropriate, a specially developed point-of-view (POV) camera was used to directly capture the working environment from the worker perspective.

A word on privacy

FACTS4WORKERS sets very high standards regarding guaranteeing privacy and all the related personal rights of the involved individuals.

Before we started a data collection, all responsible stakeholders (like working council) were involved and we keep them continuously informed.

Whenever we introduced the project to individuals and started talking about the project details, we informed them that their participation in any data collection was part of research activities carried out within the context of the EU-funded project "Facts4Workers - Worker-Centric Workplaces in Smart Factories". We further informed them that their data would be stored and used anonymously for the project and that the raw data would remain confidential and would not be disclosed to third parties, including their factory. In addition, we informed them that reports and publications based on these data would not contain any personal data. Most importantly, we made very clear that their participation was voluntary; consent could be refused and withdrawn at any time.

At the end of this briefing, every individual involved in the data collection (no matter whether for interviews, photos or workshops) has signed an "informed consent".

[5] BPMN is a graphical modelling notation standardized by the Object Management Group http://www.omg.org/spec/BPMN/2.0/

Semi-structured Interviews

1	**Short briefing about Facts4Workers** Short introduction to interviewer and Facts4Workers Informed consent	**Objective** Ice breaking Understanding of context
2	**Personal background** Getting to know the interviewee: Where do you work (department), for how long have you done so (what did you do before), your role (job description), (others' roles), colleagues?	**Objective** Personal and organisational context
3	**Actual (factual!) work & procedure of each task** What are your daily tasks? Did you perform that task today? Did something special happen today? Variations? Examples and why, why, why!	**Objective** Understanding of daily work and work around practices, not ISO work.

Figure 7: Rough structure of the interviews

We designed semi-structured interviews, which ensured that certain aspects were captured in a comparable way and depth across all the interview partners, while also allowing us to do "deep dives" into interesting topics that arose during the interviews. The coarse structure included questions on individual work practices, group work practices, the worker's perspectives on an envisioned situation and on the current situation's potentials. The personal practices encompassed general questions on the daily tasks, the difference between good and bad days, reasons for being prevented from working and, specific, in-depth questions on the tasks identified. These specific questions included information on the tools, information needed for the tasks and the social network required to complete tasks (i.e. the colleagues involved). Questions on the group practices comprised asking who participates in tasks in which ways and how the work in the team is coordinated. In addition, information was elicited regarding the communication behaviour and the tools. Figure 7 displays the interview structure.

Figure 8 below matches the interview structure and the artefacts we created from them.

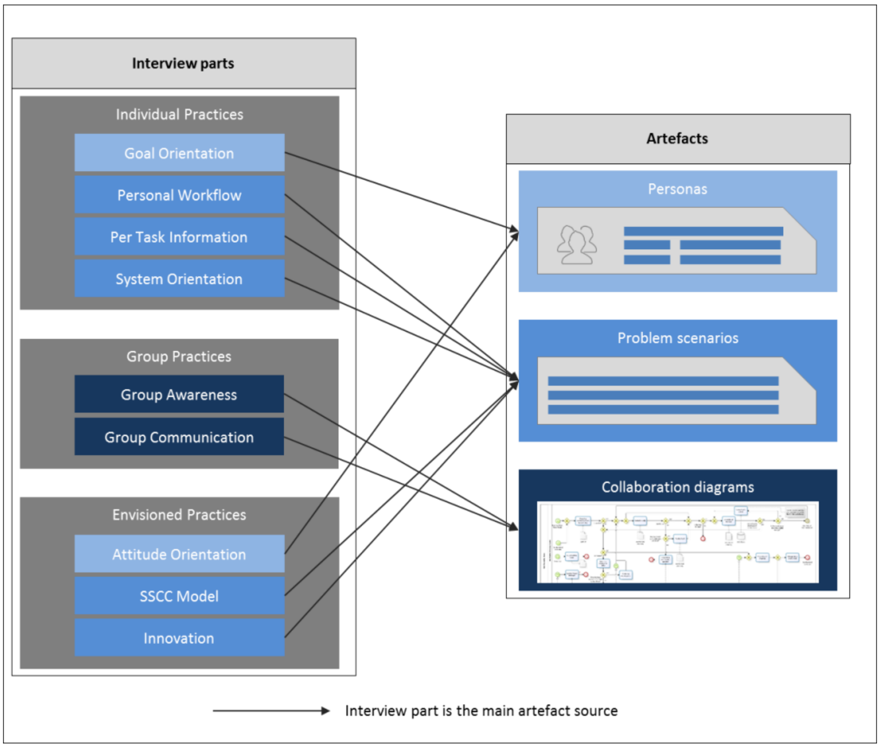

Figure 8: Mapping of interview modules and artefacts

Focus Groups

Focus groups were selected to capture the organisational context in more depth. Here, we focussed specifically on the problems from the management perspective and on their ideas regarding how to assess and control these issues in this project's domain. The focus group was planned to take approx. 120 minutes and used an electronic meeting support system called Group Systems[6]. The standard functionalities of such systems encompass discussion, brainstorming, categorisation and voting support (Nunamaker et al. 1991). In three cases (Hidria TC, Thermoloympics, ThyssenKrupp Steel Europe) we could not use Group System and used a structured approach that was very similar, but did not include software support.

[6] The product was originally developed by the Ventana Corporation. Currently the product is sold by ThinkTank. http://thinktank.net/

Figure 9: Focus group supported by the Group Systems (tm) GSS

The agenda was designed around the identified contexts-of-use in order to identify the intended changes (start-stop-continue-change) and the criteria regarding how and when to measure success (Project KPI) as well as the threats and weaknesses of a smart factory solution from the management perspective.

Focus Group Agenda with approximate net time for the task (90' Agenda + 30' buffer)

Time		Agenda Topics
5'		Why is XY the right partner for the project? (Electronic brainstorming)
10'		**Expectations of the project** (Topic commenter)
15'		**Start-Stop-Continue-Change** (Topic commenter)
	5'	Prioritise items from SSCC (per context-of-use) (Vote)
10		**Project KPIs** (Electronic brainstorming)
	5'	Categories of KPIs (Categorizer)
	5'	Prioritise KPI (Vote)
15'		**How and when to measure the KPIs** (Topic commenter)
10'		**Threats and Weaknesses** (Electronic brainstorming)
	5'	Threat categories (Categorizer)
	5'	Prioritise threats (Vote)

Topic Commenter, *Categorizer*, *Vote* and *Electronic Brainstorming* are functions provided by the GroupSystems software product.

Figure 10: Our Focus group agenda

Job shadowing

The third method applied in the data-collecting process was the contextual inquiry technique. With this technique, people are observed while carrying out their tasks in their normal work environment. During the observation, notes are taken on anything special (as perceived by the observer) and whenever problems arise, or if the performed action is unclear and needs further explanation. Questions can be asked directly during the observation if something remains unclear. This technique also allows for identifying people's behaviour by commenting directly on the actors whose actions are reflected in real time. Another positive aspect is that the observed practices can still be reflected in a later data-collecting, analysis and knowledge-disseminating phase.

A job-shadowing prototype was developed to support the process of obtaining data from the workers. A Raspberry Pi credit-card–sized, single-board computer forms the basis, a camera module was added to this to provide a video feed. A USB headset was added to allow for two-way audio communication. The system was fitted into the smallest possible casing to ensure safe and pleasant wearing. A chest strap allowed hands-free operation. A continuous wireless uplink allowed remote observation. In parallel, a two-way audio link enabled communication with the worker without interrupting his practices. Everything was recorded at a remote site (in this case a laptop) for later investigation.

Figure 11: Job shadowing with point of view camera

A job-shadowing session could not take place at every company, mostly due to business-privacy issues. Figure 11, shows the job-shadowing operation at EMO Orodjarna d.o.o in Slovenia.

2.3.2 Instantiation of the methods at the industrial partners

The following table shows how our approach was instantiated. During our visits to our industrial partners (from February until June 2015), we carried out one focus group session at each IP. Moreover, to date, we have conducted 44 interviews in four languages (English, German, Slovenian and Spanish), have taken more than 100 photos and 20 (about 10 POV) videos. In addition, we had the opportunity to observe many working steps in detail (even when no videos were allowed).

All interviews were conducted by the research partners (in five cases UZH, in Spain together with ITA). In most cases the workers were interviewed in absence of any industrial partners' representatives that could influence them. In Slovenia we had interpreting support from the companies.

Table 1: Overview of exploration

	Focus groups	Interviews	Other	Dates of Visit (2015)
EMO	4 persons GS supported	6	Observ., Photo, POV	1: February 2: April
HID	6 persons	1 (TC) + 4 (Dieseltek)	Observ., Photo	1: February 2: April
HIR	4 persons GS supported	2	Observ., Photo	1: February 2: April
SCA	4 persons GS supported	11	Observ., Photo	1: March 2: May & June
THO	4 persons	10	Observ., Photo, Video, POV	1: March 2: April
TKSE	6 persons	10	Observ. (on site, mobile), Photo	1: March 2: May & June
	10h of focus group sessions	44 Interviews	> 100 Photos 20 videos	

2.4 Created Artefacts

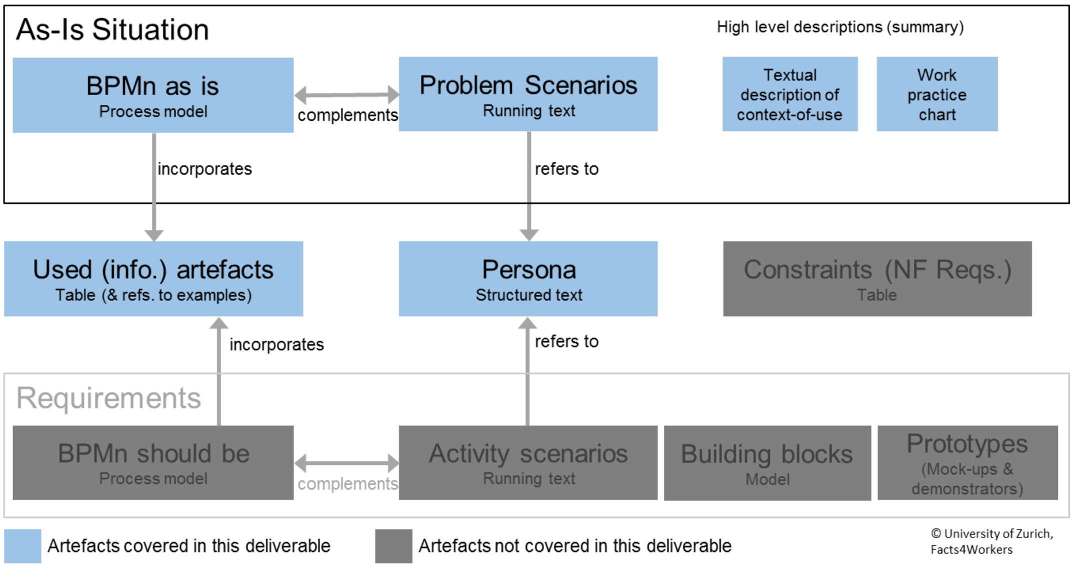

Figure 12: Overview of the artefacts created and their relations ("artefact ontology")

Based on the data collection and analysis, we created several artefacts which serve as documentation and boundary objects for the communication within the project. As explained above, the descriptions of the context-of-use in the form of texts and process diagrams were the primary instruments for the communication of practices. Figure 14 shows how the various documents relate to each other. The description of the practices in the representation of problem scenarios always refers to specific personas and focuses on the individual level of work. The collaboration diagrams in BPMn notation represent a group perspective on the work practices. Here, the various sources of information and artefacts used are also taken into account. In the future project phases, the requirements will also utilise the same notations with a focus on future individual work practices and collaboration (activity scenarios and "should-be" collaboration process models).

In the following three sections, the created artefacts are described in more detail.

2.4.1 Personas

As already mentioned, personas are user models that represent a fictional aggregated character based on the information gathered during the contextual inquiry. These characters' thinking, goals and reasons for striving to achieve them were mapped to the persona (Cooper, Reimann, and Cronin 2007).

Name: Ivan Novak		
Demographic Information	Age	
	Gender	
	Job Title	
	Status	
	Location	
	Tier	
	Quote	
Goals for using F4W Solution	Experience Goals	How a user wants to feel using the F4W solution.
	End Goals	What a user wants to achieve by using the F4W solution.
	Life Goals	The user's drivers and motivations why he wants to accomplish this goals.
	Motivation	Incentive (e.g. money)
		Fear (e.g. losing job)
		Growth (e.g. personal growth)
		Power (e.g. own boss, lead other)
		Social (e.g. respected by family & friends)
Behavioral variables	Activities	What the user does. Define frequency and volume if possible.
	Attitudes	What the user thinks of the working domain and technology.
	Aptitudes	What education and training the user had; What his capability to learn are.
	Motivations	Why the user engages in the working domain
	Skills	What the user's capabilities regarding the working domain and technology are.

General	Typical working day (or other relevant context)	The user's typical working day described chronologically.			
	Frustrations	The main pain points of the user during his current work day.			
	Current solutions	The user's works (around) his current frustrations.			
	Desired solution	The user's desired solution for a specific problem.			
	Relationships with others during work	The user's main interaction partners during the working day.			
Tools, way of working and technology	Tools	Tools used for gathering or documenting information (offline, online, software, hardware).			
	Way of working	How the user gathers information. Example:			
		Practical			Creative
		How the user makes decisions.			
		Analytical			Beliefs-based
		How the user organizes himself or other.			
		Structured			Flexible
		How the user appears to other.			
		Extroverted			Introverted
	Technology	Information sources the user consults regularly.			
			Low	Moderate	High
		IT and Internet			
		Software			
		Mobile Apps			
		Social Network			

Figure 13: Persona template used in F4W (based on Cooper, Reimann, and Cronin (2007))

The observed behaviour patterns were evaluated, which was then formalised in the modelling phase. Four to five interviews can therefore be reflected in one to five personas, as this always depends on whether the observed patterns can be aggregated in one composite archetype (one persona). Figure 15 displays the template used to capture this information.

2.4.2 Problem scenarios

A problem scenario describes how the actors perform their work in a described context and the activities in which they are engaged (Rosson and Carroll 2002). The scenarios are represented as textual stories, whose characters are based on the personas, as described in the previous subsection.

The following box shows two examples of such a problem scenario. It describes a worker in the context of assembling a product. Not only the factual knowledge is described (such as the decisions that are made), but the individual's intention and considerations are also shown. In later steps, this can help derive statements (Rosson and Carroll 2002) regarding the positive and the negative features of this context, which can in turn inform the later list of requirements.

Two example excerpts of a problem scenario:

After his walk across the shop floor, Ivan realises that a part required for the assembly procedure was missing. Ivan now has to decide whether to work on another product, or to resolve the missing part problem. There are normally four lines of production in which he can decide to engage. Before switching to another line, he has to inform the group leader, who then has to solve the problem if Ivan does not (or cannot) resolve it himself, or he can talk to the relevant machine operator. Ivan is not the type of person who likes changing between the lines, as frequent switching between the lines wastes a lot of time.

Another excerpt of a problem scenario:

[…] With the help of the BOM, Martha checks the status of the assembly process and ensures that material and machines are available for the upcoming tasks. This takes half an hour to an hour each day. If Martha identifies missing parts that should have been produced in-house, she speaks directly to Marjan, the production manager. He rearranges the production order for the next day to deliver the parts. This agility helps the company react very quickly if there are mistakes. But if some externally produced parts are missing, or even raw material is missing, it is probably due to a delay in delivery, or to communication problems with the procurement department. It is impossible for Martha to check all parts and stock in advance, because each project requires very many pieces, the schedule changed recently and the parts also change from product to product […]

2.4.3 Collaboration Diagrams

In addition to the creation of personas or problem scenarios, it is important to understand the interpersonal and organisational workflows. These diagrams offer a holistic view of the interaction of the workers, the used artefacts and the flow of information.

As the commonly known BPMN syntax was used to depict and document the processes, it was used as a prime artefact to communicate the processes within the project and to communicate with the industrial partners. These process models also offer a clear way of describing the change in the processes that future solutions will produce in terms of as-is and should-be models in the later project phases. This direct comparison allows a fast-forward view of what the imagined solution will change and helps anticipate the implications for the specific industrial partner.

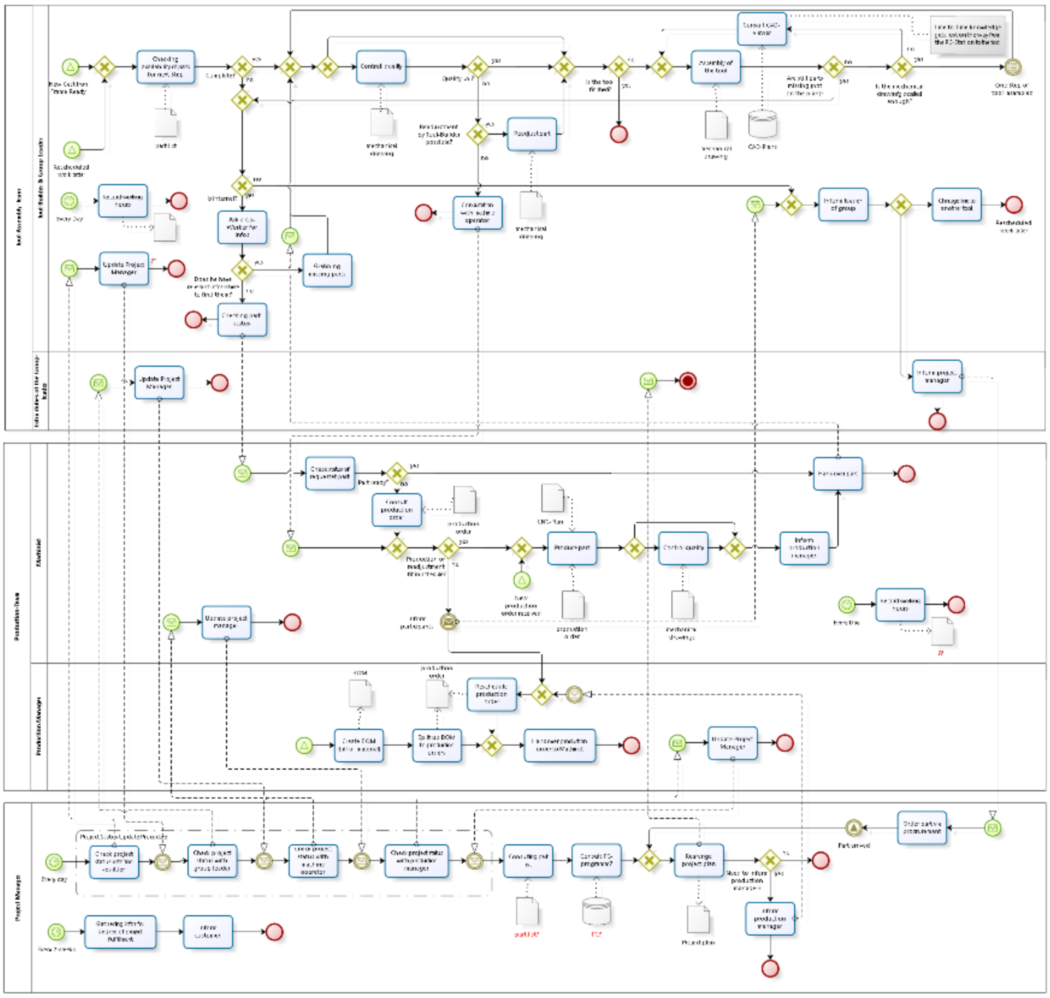

Figure 14: **Example BPMN of one context-of-use showing the complex communication and interaction practices between the relevant employees**

3 Contexts-of-use at the industrial partners

We describe the workers' practices and the organisations' contexts at six industrial partners (IP). As initially explained, this in-depth understanding of workers' individual practices will help us provide suggestions (in the form of requirements) for an ICT solution that supports smarter work. We structure the captured practices in the form of eight use contexts, i.e. four IPs have one use contexts, two IPs have two use contexts. These contexts have been validated with the industrial partners. During the creation of these contexts, we received constant feedback from the IPs during regular phone calls, as mark-up and comments in the text documents and in face to face meetings at the industrial partners' sites.

The contexts-of-use of Hidria Rotomatika, EMO Orodjarna and Schaeffler have also already been published in a scientific journal (Richter et al. 2015).

Please bear in mind that the focus of this deliverable is on identifying the current practices and not on defining requirements. Consequently, the main part of the textual description describes the situation at the start of the project. Nevertheless, we end each description with a short outlook. In some cases, this outlook might cover the next few months, in others there might already be a clear vision.

Please note that these textual descriptions are high-level descriptions of the practices (as can be seen in the overview of the artefacts created and their relations (artefact ontology). We cannot disclose detailed knowledge due to privacy concerns and as such knowledge may include company secrets.

3.1 EMO Orodjarna

EMO Orodjarna d.o.o. (EMO) produces tools for metal stamping (progressive and transfer tools). The company's main customers are the automotive and aviation industries and their suppliers to which EMO delivers tools for large presses. Most of the tools' components are manufactured in-house. These components are later assembled into the final product (progressive and transfer tools) that is delivered to the customer. The company aims for maximum production quality and works in close cooperation with its customers from the simulation and design activities to the actual manufacturing process and, finally, to the quality control and shipping.

Figure 15: Typical stamping tool for sheet metal transformation produced at EMO

3.1.1 Awareness for flexible production workers

The assembly procedure embraces the core activities of mounting the transfer, progressive and individual tools for medium and large part production that uses aluminium alloys and other high-strength materials. The tools produced are usually unique, as they are individually aligned to the precise customer requirements. Hence, even if the structure and the modules of tools are similar, each tool is usually built only once. This requires a high degree of worker agility. Several tools are built in parallel and the components are manufactured just-in-time to allow for a high degree of resource utilisation. On one hand, this implies that the employees need to continuously adapt their working procedures to the current situation in the shop (i.e. the worker needs to regularly consult the mechanical drawings and part lists to coordinate the assembly process). On the other hand, the de-centralised self-organisation within this production environment does not notice this agility. Processes are only present in a coarse-grained manner, but need to be dynamically negotiated between the workers for the fine planning. The detailed assembly process depends on the individual tool workers who utilise their experience to infer the procedures from the mechanical drawings, and negotiate the delivery or manufacturing of components with the machine operators. Components required for the assembly are then stocked below the metal cast frame at the beginning of the assembly process. Under normal conditions, one crew builds the tools from the beginning to the end.

Whenever a worker cannot resolve a situation himself (i.e. parts are missing or do not fit), the project leader is informed and ensures the delivery, or repair, of these components. In the case of missing components, these have either already been produced, but are not at the correct place, or they still need to be manufactured. Furthermore, not all components are produced in-house. Some of the parts (standard parts) must be ordered from suppliers and this may require additional expenditure if the missing parts are noticed this late in the production process. Depending on the product's deadlines, the production can be prioritised to deliver such missing components quickly. Regardless of the cause and actions taken, these interruptions in the assembly are time-consuming and dissatisfactory for the tool-workers on the shop floor.

Figure 16: Large CNC 3axis milling machine workplace (left), large progressive transfer tool built at EMO (right)

The mentioned high demand for agility should also be reflected in a supportive ICT environment that aims to retain the benefits of self-organising assembly teams, while diminishing the negative effects. Mobile ICT solutions could, for example, potentially strengthen the workers' networking and interconnection capabilities, thus providing them with more transparency and awareness. The workers' perceived frustration is currently primarily caused by lacking or insufficient information about other workers' current work status, and about the parts they produce. Here, an ICT tool could offer simple means of communicating the current work status to other workers, for example, regarding what employees are currently working on, or what they are waiting for that prevents them from continuing. Such a system would fully retain the self-organising character of the shop floor, but would simultaneously reduce the communication effort drastically. In addition, such a solution would help plan the individual schedule and would provide all interested stakeholders with a coherent picture of the tool production's current project status.

3.1.2 Machine maintenance skills for operators

Highly skilled workers utilize a large machine park to produce parts according to specifications. CAD drawings and CNC programs guide the production steps. The workers are assigned to a specific machines that they operate. They have detailed and specific knowledge of these machines and are generally the first ones to realise that there are problems or deviations. Currently, a special maintenance team, which periodically checks the machines and does repairs whenever necessary, does the maintenance. The worker just does smaller maintenance jobs, such as topping up the cooling liquid, or changing an air filter. The aim of this context-of-use is to upskill the workers so that they can also perform preventive maintenance tasks on their machine in order to prevent damage and can thus increase the overall machine utilisation by making the machine more durable.

Figure 17: Typical CNC machining operation of press part

Figure 18: Lubrication, a typical maintenance operation on a CNC machine

Possible future improvements could be to guide the workers through the maintenance process by offering them the right amount of information when they need it to undertake an activity. This can be done by means of IT solutions tailored to this environment and to the worker's knowledge demands. This could include a mobile device that helps during maintenance activities by providing specific instructions and guidelines.

3.2 Hidria Technology Centre: Problem-solving support for production workers

Figure 19: View of the assembly line production workshop. A complex assembly line has been built and is ready for shipment

Hidria Technology Centre d.o.o (HID) designs and manufactures a wide spectrum of partly or fully automated assembly lines, ranging from simple conveyer belt designs that support manual assembly to fully automated lines equipped with state-of-the-art instruments that ensure products will meet their specifications. These sophisticated machines are tailor-made, i.e. they are designed from scratch for specific customer needs (built-to-order).

Since the machines are equipped with programmable devices to control the process, the development is a co-design effort by mechanical, electrical and software engineers. However, once installed at the customer's site, these assembly lines show a typical efficiency[7] of just 65%. The loss in efficiency is either due to time-consuming set-up and maintenance activities, or to lacking supplies. In such cases, the line comes to a halt, or produces parts that have not been specified. The reduction of set-up and maintenance time is the focus of this context-of-use.

We assessed the practices of the set-up and maintenance activities at Hidria Dieseltek, a division of the Hydria company and an internal customer of the assembly lines. At this site, assembly lines support the final assembly steps and quality checks of glow plugs for diesel engines[8]. To achieve a high quality and time efficiency, oper-

[7] This is called the overall equipment efficiency (OEE). ISO 22400-2:2014 Automation systems and integration -- Key performance indicators (KPIs) for manufacturing operations management - Part 2: Definitions and descriptions

[8] These lines are up to 24 m long and house numerous apparatus to incrementally manufacture and check the glow plugs. The typical capacity of such a line is tens of thousands of parts per week.

ators have to react quickly to problems during the production. If the glow plugs lose their tight tolerances, the line is halted and the source of the problem needs to be found, evaluated and fixed. Line operators and line owners (supervisors of the operators) work together to quickly resolve the issue. This team directly fixes small problems like the replacement of defective parts, such as simple pneumatic (or electrical) actuators or sensors. With larger faults or more complex problems, the internal maintenance crew helps bring the production up to speed again as quickly as possible. However, switching to another product that has to be assembled and tested at these lines is the most typical and time-consuming event. In today's environment, which demands ever smaller lot sizes and fast delivery, this flexibility is key for competitive production. Further, a reduction in in-house stock requires the capability to engage in just-in-time production, which in turn requires a rapid shift to other products. Here, the essential goal is to adjust and calibrate the machine so that the new parts will be produced according to their specification. These set-up procedures often require several hours of labour until all the problems have been resolved and mass production can start. These set-up times certainly play a significant role in the OEE of the assembly lines.

Figure 20: Production line during construction

At HID, these demands are well understood and novel approaches in assembly-line control help the operators resolve issues quicker and more autonomously. However, owing to these machines' complexity (assembly lines), it seems futile to identify every possible problem or fault condition as well as a relevant procedure for resolving them. The customers of these machines also update and change them constantly throughout their lifetime to support new product designs.

Consequently, HID aims to manufacture a new assembly line generation that applies self-learning techniques in order to continuously adapt its support for the crew that operates such a line. This support is twofold: (1) The line helps the operators document new problems. The procedures applied to resolve the issues are also documented. Hence, the knowledge adapts dynamically to the occurring faults and problems and is externalised so that it can be shared with new or less experienced operators. In respect of known or recurring problems, the system helps by troubleshooting. (2) By applying machine learning and big-data analytics, the machine can predict fault conditions and inform its operators timely. The problems are therefore addressed even before they manifest in an unexpected line standstill, or in deviations from the product's specifications.

Figure 21: Typical production cell, demonstrating the complexity of each apparatus

In summary, in this context, the vision is to transform the currently isolated realms of machine control and worker duties into a socio-technical entity that allows flexible production and continuous improvement. The knowledge management capabilities will also offer the flexible allocation of additional staff to these lines. In addition, the increasing problem-solving competencies of such a human-machine system would also mean that the line supervisors and maintenance team members no longer have to deal with recurring issues.

3.3 Hidria Rotomatika: Augmented decision making for production workers

Hidria Rotomatica d.o.o. (HIR) produces electrical steel laminations and die-cast rotors for automotive and other industrial applications. The company produces parts in the desired quantity according to its customers' designs and specifications. One stream of products are die-cast rotors with shafts that are used in electric motors. These die-cast rotors are compound components consisting of electrical steel laminates and aluminium that form the basis of these squirrel-cage rotors of electric motors. In a later processing step, a precision machined steel shaft is inserted into the rotor to complete the assembly. The process from the raw material to the completed product is spread out over the plant, as it involves numerous processing steps at the factory's different workplaces (i.e. steel stamping, laminating, die-casting of aluminium and the final assembly). The practices that the workers apply are manifold and involve various forms of human-machine interactions, ranging from manual tooling to robot collaborations. The production activities are fully managed and controlled.

Figure 22: CNC machining of the rotor shafts

The workplace of the final rotor assembly is the locus of our investigation, i.e. the context-of-use in this company[9]. The main activities in this specific part of the production involves pressing a shaft into a rotor, machining that compound component and assessing the dimensional properties of the finished good. It is the operators' responsibility to ensure that the produced parts meet the specification. To ensure this, they assesse all critical dimensions of each piece produced, using hand-operated measuring devices, such as gauges, callipers and dial indicators. If the parts are no longer as specified, they are thrown away or re-machined if possible. However, in such cases the cause of the deviation has to be identified and resolved. This

[9] This gives the project the possibility to focus intensely on a single worker's perspective and to explore how to further support him by providing appropriate information. In later phases, this knowledge can be multiplied to other workplaces in the company.

mainly involves a correction of the program parameters in the CNC machine controller. Based on his experience, the operator estimates the parameters for the next machine run. Cycling through subsequent measure-adjusted activities leads to the desired result of parts machined to fully comply with their specifications.

This can be a tedious process, ranging from 30 minutes to several hours. This happens especially when the production switches to different parts, as many dimensions will be affected simultaneously. The operator's only source of estimates of the parameter correction is his experience at this workplace and the specific machines involved. Hence, the efficiency of the production depends on his ability to quickly resolve these dimensional deviations in order to minimise the parts wasted during this process.

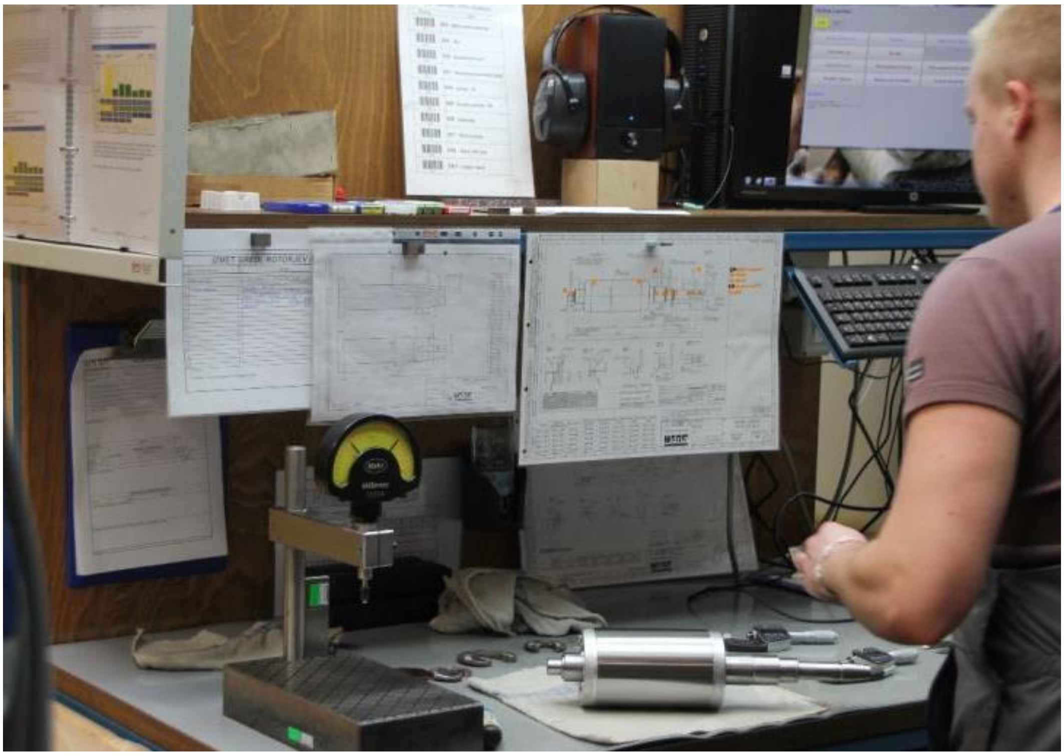

Figure 23: Worker's desk for manual quality control

The vision of this context-of-use is to support the highly skilled workers with helpful information while they perform their tasks. The operator's monotonous and labour-intensive tasks could be improved by automated electronic measurements. Further, big data analytics could process this information, which is more accurate than pass/fail testing, together with the information from the CNC machine. The outcome could be fed back to the workers to provide them with parameter estimations or fault predictions so that they can take appropriate action.

Overall, this context provides the potential to provide a skilled worker with appropriate and helpful information, while keeping him an integral and non-substitutable part of this delicate control loop.

3.4 Schaeffler AG

Schaeffler AG (SCA) is an automotive supplier with a world-wide network of manufacturing locations, research & development facilities as well as sales offices. With more than 82,000 employees at approximately 170 locations in 50 countries, SCA is one of the world's largest family-owned technology companies. At the plant that we examined, SCA produces various engine components. Recently, the plant has changed its production process paradigm from "workshop series production" (i.e. production is separated into several workshop areas) to a modern "value stream production" (i.e. the production of one part is organised in one integrated process).

3.4.1 Quality control expertise for workers

The change to value stream production led to a redesign of the existing quality management processes, specifically of the operational quality assurance. We next discuss these changes in detail:

First of all, an operational quality assurance (QA) employee is no longer only responsible for a subfield of the production process, but for all of the manufacturing steps of a value stream and all of the related technologies. This means greater demands on a QA employee's already comprehensive qualification profile: A QA employee currently requires additional expertise on a larger number of production machine types and the associated measuring devices. Furthermore, the change to value streams means that the production area is responsible for the QA. Thus, a QA employee is organisationally subordinate to the production value stream and acts as a service provider within this stream. As such, the QA staff supports the production staff with daily problem solving, for example, troubleshooting a malfunctioning measuring station.

In addition, QA employees support new product type launches by, for example, testing and approving new machine settings in a timely manner. Further, they have other regular tasks, such as reviewing and archiving all the relevant inspection documents, creating action plans (including shutdown measures) for defective equipment as well as doing measurements to re-evaluate possibly incorrect measurement devices. Integrating QA and production employees as well as the associated employees who are jointly responsible for QA and production, leads to a closer and better cooperation, but the trade-off between the greatest possible number of pieces produced and the quality remains the primary tenet.

The changed situation has not only increased the standards of QA employees' qualifications, but also the standards of production employees' QA qualifications. The QA's increased task range and the generally prevailing demand for efficiency challenge both sides to acquire the needed skills besides doing their daily work. If the production staff is not sufficiently trained, this rebounds on QA employees, who will receive additional support requests. In addition, as a service provider, QA has a strong interest in helping the production staff to execute their quality-related tasks as best and as quickly as possible. A high level of targeted coordination is needed between the production and the QA employees to achieve this while minimising their number of unplanned support tasks (e.g. approval of settings during restarts).

Figure 24: Two of several quality control test sites

As shown above, there is a high demand for skills acquisition and for a close exchange between QA staff and production staff. The variety of necessary processes and tasks as well as the related document types should be jointly collected.

It would be helpful to provide both sides with improved access to action-related knowledge. In addition, the centralised documentation of shift handovers and problem-solving processes may be supported, while simultaneously reducing the paper-based documents. Improving the problem-solving skills should contribute to a reduced number of support requests and, ultimately, to QA employees experiencing reduced stress. Moreover, the time saved can be invested in preventive and strategic measures to further improve the production quality. The time saved could, for instance, be used to analyse defective manufacturing parts. The insights gained from such an analysis could contribute to an even better calibration of the equipment and reduce the proportion of scrap material even further. In addition, there will be more time for processing the actually planned principal activities, such as creating process maps and capability maps.

3.4.2 Paperless information management for assembly workers

The second SCA context-of-use focuses on the value stream of chain spanner production processes. The production is divided into several groups, each of which produces items for the final product and is part of the value stream. One of the main challenges is the just-in-time production, thus establishing compliance with the quantities and timelines without creating large stocks.

Figure 25: Automated production line

The production runs 24 hours in a three-shift operation. The operator, (tool) setter and team leader roles basically describe the task within a shift. Operators work directly on the machines and maintain the production process. Setters monitor the quantities and quality of the multiple machines, set up and retool the machines if necessary and support the operator when required. Team leaders coordinate the operators and the tool setters in each production area and report to the product managers.

A typical day begins with the shift handover, which involves operators, setters and team leaders. During the handover, they orally and in writing exchange important information for the subsequent shift. Owing to the large number of documents and their decentralised storage, information management is a major challenge - especially across multiple shifts or over longer time periods. For example, there are several physical and digital shift logs that document any occurrences during the shifts.

After the shift handover, the setters carry out the necessary maintenance procedures and document them. In addition, the machines are calibrated and retooled to meet the requirements of the current orders. Subsequently, the setters measure whether the parts currently being produced are within the value ranges a priori specified.

During the production, the operation of the machine is monitored continuously and, if necessary, materials are replenished. In addition, as part of a regular series production monitoring, the operators constantly check each semi-manufactured product for the defined quality. If shortcomings are detected the setters recalibrate the machine. The team leader records the product quantities several times a day and compares these with the nominal number of production orders. Counting pieces is partially redundant, very time-consuming and prone to errors due to media breaks.

If the required product quantities are reached, the machines must be retooled for the following order. At the end of the shift, the handover to the next shift takes place.

The requirements regarding parts' quantities are very high. Deviations from the budgeted number of individual components have far-reaching impact on the value chain. This requires a smooth and efficient operation of the internal processes. Nevertheless, there will always be unpredictable material and machine problems that threaten the well-timed production operations. In addition, the documentation processes are usually not digitised and are partially inefficient. The exchange of information between employees mostly occurs orally and is not well structured, which means the sharing and traceability of important information over longer periods cannot be guaranteed. Furthermore, it is not possible to access relevant information centrally and efficiently.

Potential solutions will contribute to improvement in the current situation, support the employees in their daily communication and provide easy access to information. Thus, each employee's competencies can be increased significantly, which will in turn have a positive effect on the efficiency and attractiveness of the workplace.

.

3.5 Thermolympic: Paperless information management for production workers

Thermolympic S.L. (THO) is a specialist in the field of thermoplastic injection moulding as well as in the design and construction of the moulds used in this process. THO's customer base extends from original equipment manufacturers (OEM) in the automotive industry (e.g. fittings for cars) to suppliers of end consumer products for supermarkets (e.g. thermos flasks). Most of the injection moulds are produced in-house. These components are assembled into an intermediate or final product and shipped to the customer. THO works closely with its customers from the design activities to the actual manufacture of the moulds, their quality control and shipping.

In the following, we briefly summarise the various challenges that THO employees face in the current production process: Operators either manufacture work pieces, or process prefabricated work pieces. Depending on the work, this process requires part-specific knowledge. Colleagues and paper-based documents provide this knowledge directly to the workbench. If the employees have specific questions, they have to contact the appropriate team leader. If the employees have ideas for improving the manufacturing process, they have to rely on face-to-face communication with colleagues or superiors.

In addition to their manufacturing activities, the employees are also tasked with fulfilling the handling of data on the work pieces' continuous quality assessment. Even before they execute their own production step, the operators have to check that the incoming work pieces meet their specification. Quality managers, in close cooperation with the customer, define the quality requirements. During the production run, the employees manually record the throughput per hour, the number of errors and the types of errors on a flip chart, sometimes communicating the information directly to the team leader. If there is a serious error, the entire production line has to be stopped and re-adjusted. In order to undertake the quality control of the produced parts, the operator relies on a variety of manual checking procedures, for example, visual inspection of the forms and comparison with the specification. This quality control step is particularly error prone, because it is a rather monotonous task. If a deviation requires a readjustment of the production line, the team leader consults paper-based configuration instructions and also documents the changes on paper. Currently, this documentation is only rarely processed in the later process.

The quality management data are noted on a flip chart, which quality managers transfer to an Excel document for further processing. In this process, a hierarchical folder structure and a variety of Excel spreadsheets are used, but these are additional sources of errors and have to be maintained with a great deal of manual effort. The preparation of the tables also requires a high level of background knowledge about the production, about the file itself as well as requiring previous experience with the folder structures and tables. The data are made available to decision-makers with a delay that may extend to a day, which means that the planning and decision making are based on non-current data.

On the one hand, the current process is monotonous, as the operators have to perform the same steps repeatedly. These steps could easily be automated and carried out by machines (i.e. automated quality control and documentation). However, the operators cannot solve problems autonomously. Hence, they only carry out prescribed work steps and have no decision competency. On the other hand, the current process results in a high work load with very limited time for strategic actions (like suggesting innovations) and also comprises long delays, which means the decision-makers have to rely on outdated information.

Figure 26: Tool set-up

As a first step in this context, it seems viable to help the operators by automating at least the reporting procedures and by bundling the information required for the context. This can be achieved in the short term by installing and implementing a company-wide manufacturing execution system (MES). With the help of such a MES, all quantitative data created during production are recorded automatically. These data are then available to all the employees, quality managers and decision-makers in real time. This eliminates much of the manual reporting and allows communication on the basis of real-time figures. In addition, the creation of standard reports is automated and is therefore less susceptible to errors, is less time-consuming and less monotonous.

In a next step, the partially automated system should help production workers with the quality control. The result of the quality assessment of the individual parts should be maintained in the MES database to enable further (big data) analysis to identify trends and patterns. This information can help predict defects, proactively control production parameters and prevent errors.

This information could also be used as a basis for the decision-makers' strategic planning of the production on medium-term time scales. Furthermore, the distribution of work-piece requirements within the company should also be automated and supported with smart ICT solutions. Here, a solutions is envisioned that allows them to work without paper-based documents (i.e. specification). This also facilitates operators' feedback to project and quality managers. The system should present the intended information tailored to the specific needs of the different functions associated with the quality control process. This human-machine interface could be implemented by using tablet PCs, or larger touch screens mounted in close proximity to the workbench, to ease data entry and perception. Besides speeding up the processes and reducing errors, one of the most powerful use cases for these digital tools would be to set up an automatic training program. This would allow the operators to develop their level of background knowledge. This would also develop their autonomy to further enhance the processes.

3.6 ThyssenKrupp Steel Europe: Problem solving support for mobile maintenance workers

ThyssenKrupp Steel Europe AG (TKSE) is one of the world's leading suppliers of carbon steel flat products. With approximately 19,500 employees, it manufactures high-quality steel products for innovative and demanding applications in various industries. Customised steel material solutions and services complement the business activities. TKSE values the knowledge of skilled workers as a crucial factor in meeting constantly increasing demands for quality and efficiency. Simultaneously, these demands also increase the work complexity. A decreasing number of employees and shorter familiarisation phases require continuous operational and extra-occupational development of the employee knowledge and competencies. In this context, we focus on maintenance in the fields of HVAC (Heating, Ventilation and Air-Conditioning) and electricity. In this maintenance division at TKSE, employees service and repair electricity systems and air conditioning equipment at the 9.5 square kilometre factory premises in Duisburg, Germany.

Figure 27: Electrical substation (left) and furnace (right) at TKSE in Duisburg

While troubleshooting, these employees face a number of challenges: Initially, faults are reported via telephone, e-mail or fax. Subsequently, this coarse-grained information on the type of fault and system is handed to the mobile maintenance staff in the form of a paper document. Frequently, neither the direct route to the fault's location is known, nor is a map available on the fault's surroundings. Depending on the location of the faulty part, personal protective equipment might be necessary and/or special entry and exit procedures have to be executed. New employees need an average of two years' experience before (1) they know their way around in this environment, (2) they are familiar with the conditions in most of the factory buildings and (3) they can troubleshoot autonomously. Despite a structured knowledge transfer, the necessary knowledge also has to be acquired through experience. Usually, this happens through mutual assistance that experienced colleagues provide, or through systematic trial and error iterations over time.

With over 3000 units to be serviced and possibly repaired, maintenance employees rarely have all the relevant information at hand to solve a specific problem. This results in a significant effort to gather more information. Similarly, when spare parts are needed, the workshop has to be contacted, or personally visited, as information on the availability of these parts and the status of order transactions are unavailable to the maintenance personnel when they are mobile.

Feature phones (not smartphones) without access to mobile data services currently support the whole troubleshooting process. As the rest of the fault management process is strongly paper based, the information exchange is hampered and problems can thus occur. For example, employees may engage in repair processes that other employees have already started. Additionally, specific knowledge is often lacking, but the employee with that knowledge is not available, or not present at the fault's location. Here, a communication infrastructure that connects two or more colleagues would be helpful, but has not yet been deployed. These obstacles hamper the maintenance process, which means individual employees have to invest unnecessary time, driving to certain areas multiple times and develop frustration and stress.

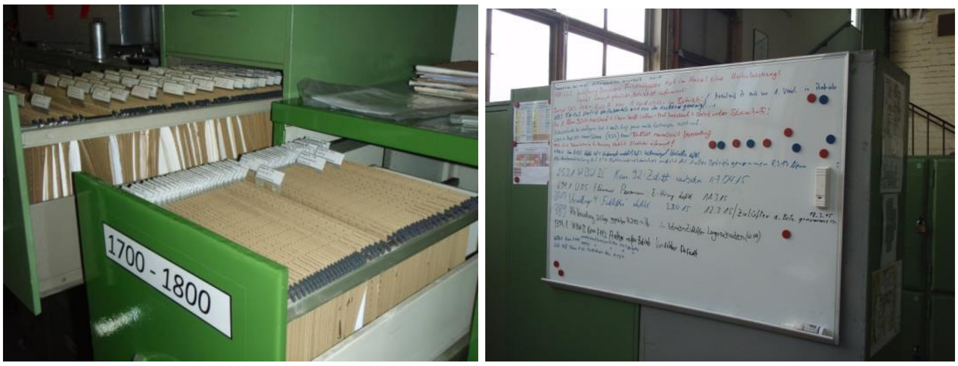

Figure 28: Paper-based (left) and witheboard-based (right) documentation

Owing to the above-mentioned mobility and the wide range of challenges that the maintenance staff face, it is important that the information they require can be provided anywhere and at any time. Context-specific information (i.e. documentation covering the failed system) should also be available in these situations. This could potentially be realised by implementing a mobile knowledge management platform with the maintenance worker (as a mobile knowledge worker) at the centre of attention. Furthermore, as we have pointed out, the maintenance staff needs to access collaborative knowledge and their colleagues' experience. Through these solution elements, the maintenance engineers become *smart workers*. With this form of knowledge work, the communication between the colleagues can be increased, experience and knowledge can easily be exchanged and the fault elimination process can be made more efficient and more satisfactory.

4 Analysis across the contexts of use

This section presents a first analysis of the anticipated impacts of the planned actions on the previously identified contexts-of-use. In Chapter 2, we already deduced the dimensions of the impact on the workers and organisations that we want to use. In the following subsections, we take a closer look at each context-of-use and the intended impact (4.1) and draw an interim conclusion (4.2) with an aggregated view on all contexts-of-use. The following impact analysis is a forecast of the envisioned enhancements' impact.

4.1 Impact analysis per context of use

In the following, we analyse every context-of-use along dimensions developed in Chapter 2. We present them in the form of a spider web diagram to provide a visualisation of each context's characteristics along these dimensions. To aid visualisation, we used the following codes for each dimension[10]:

No or no distinct change: 1

Distinct change: 2

Major change: 3

Based on this scale, the figures in the following subsections represent the envisioned changes relative to the current situation in the contexts-of-use.

10 A value below 1 would express a negative effect on the dimension. We do not expect such an outcome. However, all evaluations will be non-biased in respect of this assumption. Lower values could therefore potentially appear in the later project phases.

4.1.1 EMO 1: Awareness for flexible production workers

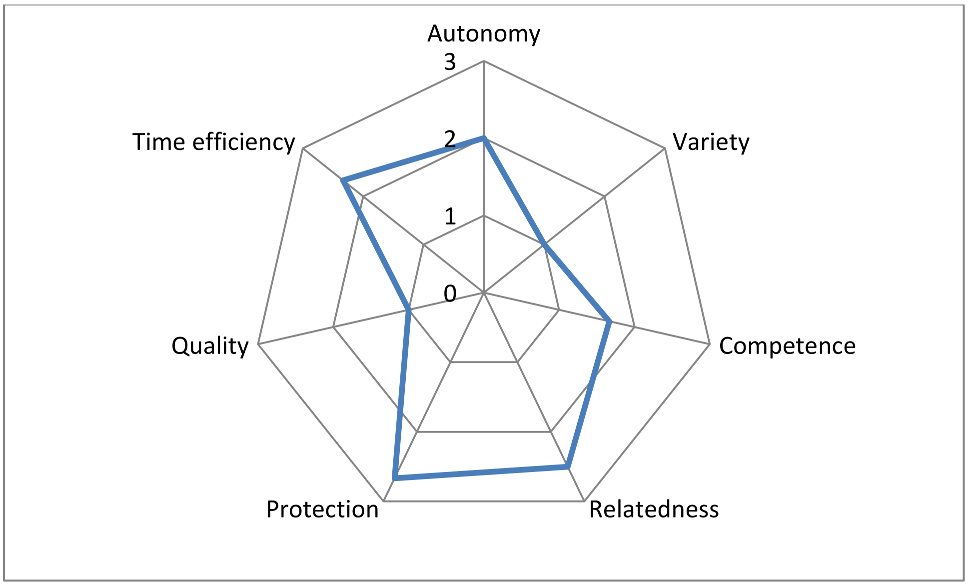

Figure 29: Dimensions of the impact on the "awareness for flexible production workers" context-of-use

In the first EMO context-of-use, the autonomy of the assembly workers will be improved, not because they gain new skills, but rather because they can plan their daily work in a more self-directed way. Basically, changing the current practice of event-driven work planning (i.e. a worker detects a lacking part) to the tactical planning of activities provides improved autonomy. A better supply of tailored information will enable new forms of decision making and thus increase the workers' competencies in this respect. The envisioned solution will also support a better understanding of the individual process steps' contribution to the greater whole. This would be due to the planning of the activities then being directly derived from higher-level organisational goals instead of from events caused by failures or direct production orders without any visible semantic connection. We thus expect an increased relatedness between the activities. All these measures would contribute to reducing individual workers' levels of frustration and cognitive load. In this new environment, the workers should be better protected from such strains. Efficiency will be increased by bundling the multitude of scattered, event-driven task assignment into condensed and well planned activities.

4.1.2 EMO 2: Machine maintenance skills of operators

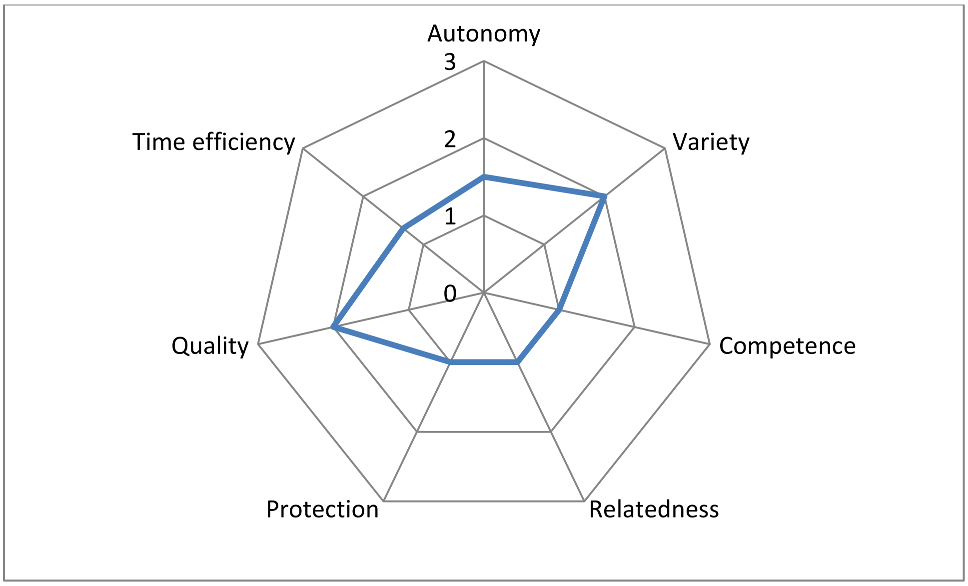

Figure 30: Dimensions of the impact on the "machine maintenance skills of operators" context-of-use

In this rather small context-of-use, only the variety of the work is expected to be significantly increased from the workers' perspective. This is due to the envisioned situation in which the machine operators participate in smaller, proactive maintenance activities. From an organisational perspective, efficiency would increase due to fewer machine downtimes. This is very common in SMEs, which are in the same situation as EMO. Solving these problems is, consequently, a FACTS4WORKERS goal.

4.1.3 HID: Problem solving support for production workers

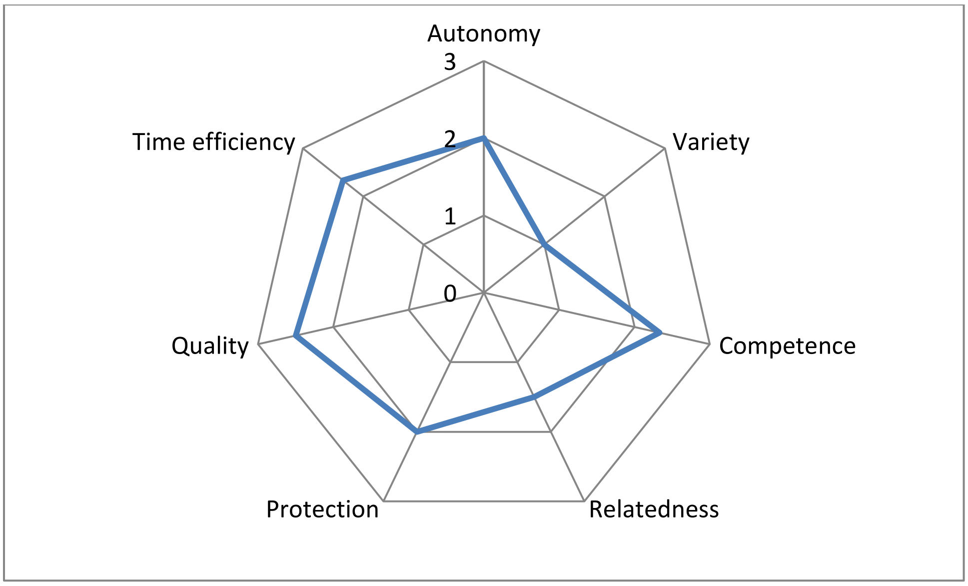

Figure 31: Dimensions of the impact on the "'problem solving support for production workers" context-of-use

In this context-of-use, the key dimension to be improved is the assembly-line workers' competence. The envisioned solution should empower them to solve more problems on their own and faster. This requires an extended autonomy from the currently fixed production procedures to a self-directed engagement in problem-solving activities. Sharing the knowledge with other colleagues supports the sense of relatedness and helps spread the competencies as new problems arise and are solved over time. The production lines' efficiency should increase as downtimes and set-up times are reduced.

4.1.4 HIR: Augmented decision making for production workers

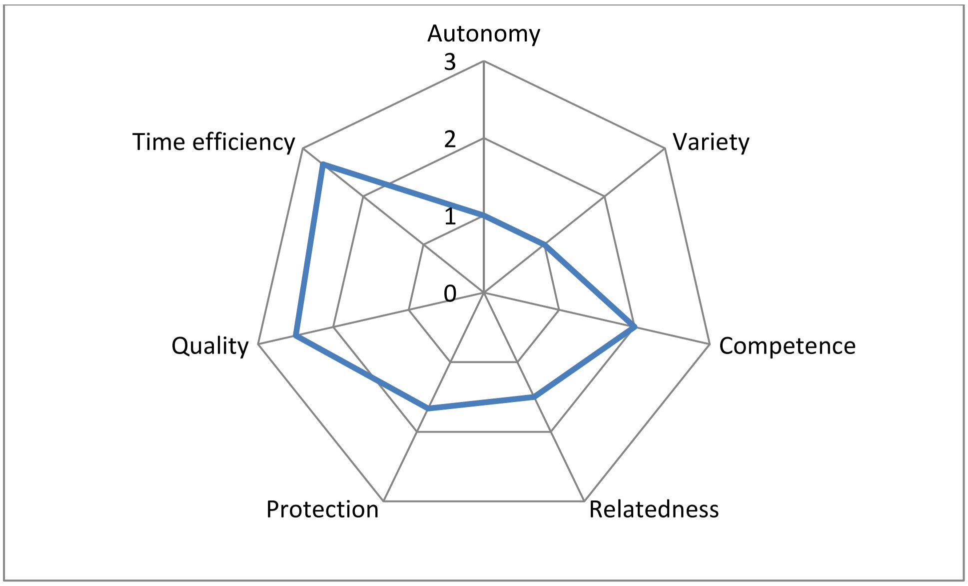

Figure 32: Dimensions of the impact on the "augmented decision making for production workers" context-of-use

The aim in this context-of-use is to minimise the production time while retaining the quality assessment of each part. However, today's pass/fail quality assessment does not offer the possibilities that modern data analytics do. The envisioned workplace would therefore automatically record and store all the measured dimensions, which will enable continuous monitoring of the parts' quality and enable predictions regarding deviations. This will allow the operators to respond to problems faster and before they manifest in faulty or rejected parts. This will also strongly influence the workplace efficiency. In addition, the envisioned solution would help the workers set up the machines for a new part or batch by supporting their decision-making competencies, which will in turn result in an increase in efficiency when the set-up time is significantly reduced.

4.1.5 SCA 1: Quality control expertise for workers

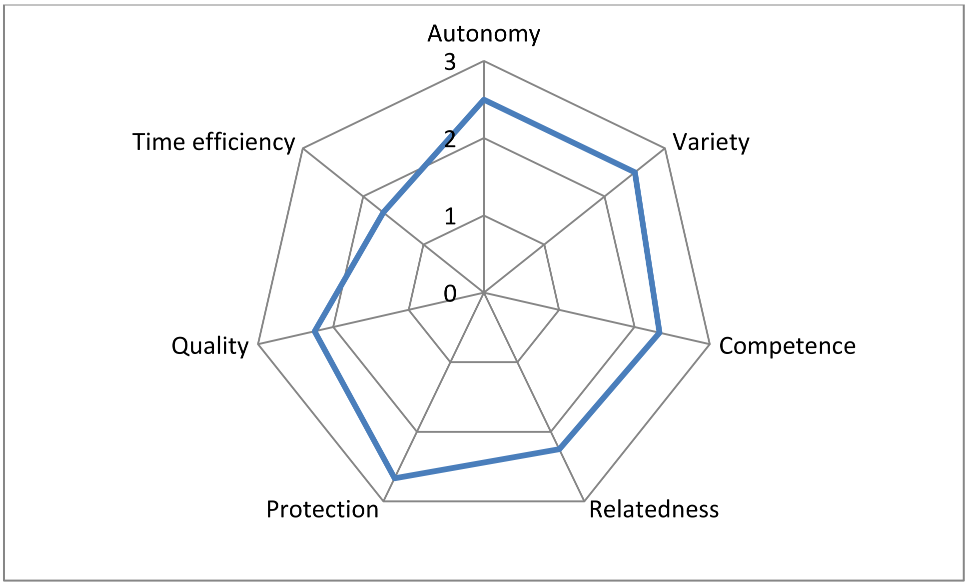

Figure 33: Dimensions of the impact on the "Quality control expertise for workers" context-of-use

In this context-of-use, the employees' autonomy increases directly and indirectly. On the one hand, it increases the production staff's capacity building, which extends their scope for maneuver. On the other hand, the fewer interruptive support requests give QA employees the freedom to autonomously plan long-term activities, such as the analysis of quality defects. Moreover, the capacity building also contributes to higher quality and efficiency. This case further shows how smart ICT can lead to a greater wealth in the variety in employees' daily work. Owing to the reduced number of support requests, they can enlarge the scope of their practices with activities like preventive and strategic measures, which improve the production quality even further.

On the whole, this context-of-use is a good example of the close relationship between the individual needs. Simultaneously, the above-mentioned increase in competence leads to the production staff being more autonomous and increases the employees' active relatedness and knowledge sharing.

4.1.6 SCA 2: Paperless information management for assembly workers

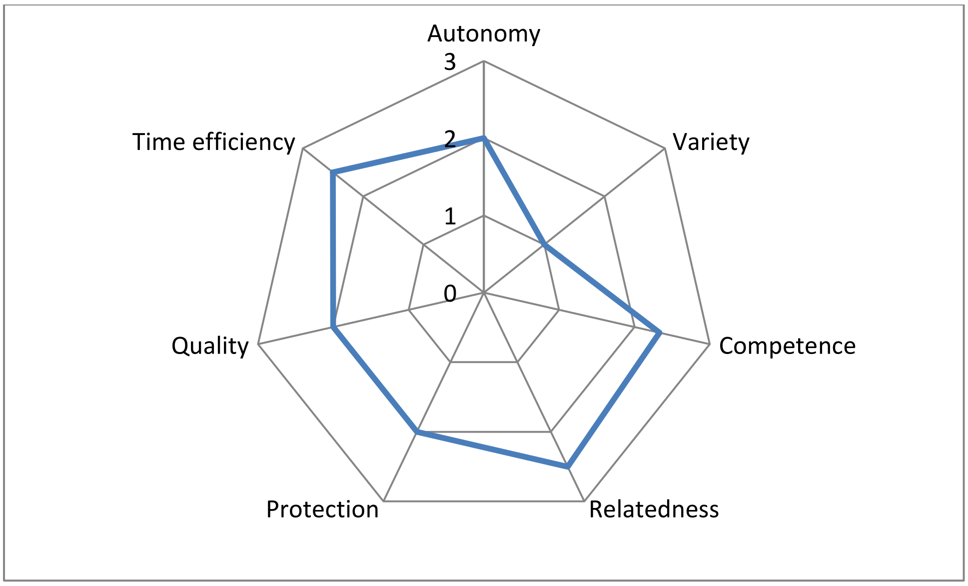

Figure 34: Dimensions of the impact on the "Paperless information management for assembly workers" context-of-use

The second SCA context-of-use is characterised by a distinct growth in competence and relatedness. As the described problems show, the workers need a sociotechnical solution to help them communicate more efficiently and reduce the huge number of paper-based documents, but still provide them with the information they need. This solution might specially focus on mutual awareness, which is illustrated in the shift handover example. Improved awareness will not only enable closer collaboration, but will also reduce redundant task operations. All this will reduce the workers' perceived level of stress, will help them work more efficiently and contribute to a better work quality. Since the assembly practices as such will not change significantly, we anticipate the task variety to remain on more or less the same level.

4.1.7 THO: Paperless information management for production workers

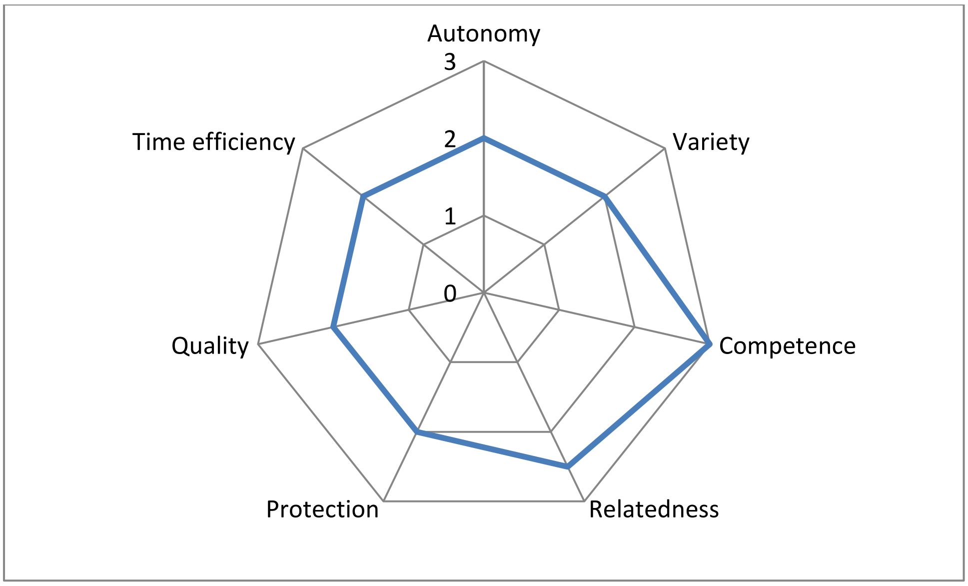

Figure 35: Dimensions of the impact on the "paperless information management for production workers" context-of-use

The THO context-of-use has a clear focus on the employees concerning their competence and the relatedness of their activities as well as also driving the second line of protection, variety and autonomy. The most desired impact is for the workers to learn the needed knowledge during work and to use this competence autonomously in their daily work tasks. Further, the management should accept the need for a related work style and will therefore want to offer their workers an infrastructure.

As THO is a classical family-owned, small-sized company, the owner also has his organisation in mind with this use case, which should drive the quality and efficiency aspects further.

4.1.8 TKSE: Problem-solving support for mobile maintenance workers

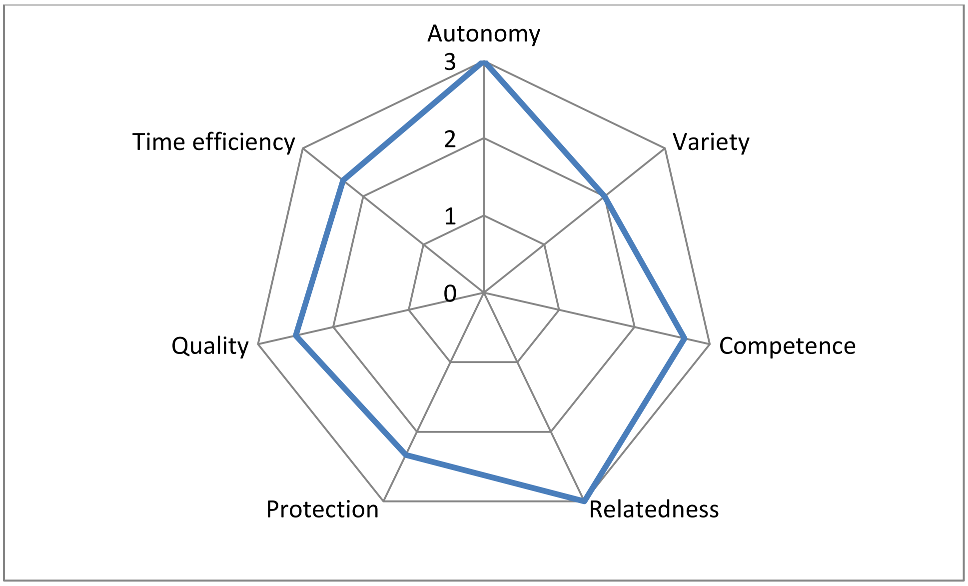

Figure 36: Dimensions of the impact on the "problem-solving support for mobile maintenance workers" context-of-use

The context-of-use has been set up with a clear mandate to improve the situation for the workers by means of four dimensions that add great value for these workers. An interesting aspect is that, after defining the use case with a clear focus on the workers, it has become clear that the organisation itself will also profit in terms of the added value to the quality and efficiency dimensions.

In sum, this use case drives a high-level impact on nearly every dimension with a focus on the workers having freedom of choice regarding what to do when, the possibility to drive their own decisions, their increased awareness of their colleagues with whom they work and the machine for which they are responsible.

4.2 Overall view

The chart below shows that the selected contexts-of-use cover all relevant aspects in a balanced way. Nevertheless, as the companies and their goals differ, the envisaged technical infrastructure has to support all of these scenarios in a similar and balanced way, and should not focus too much on certain aspects.

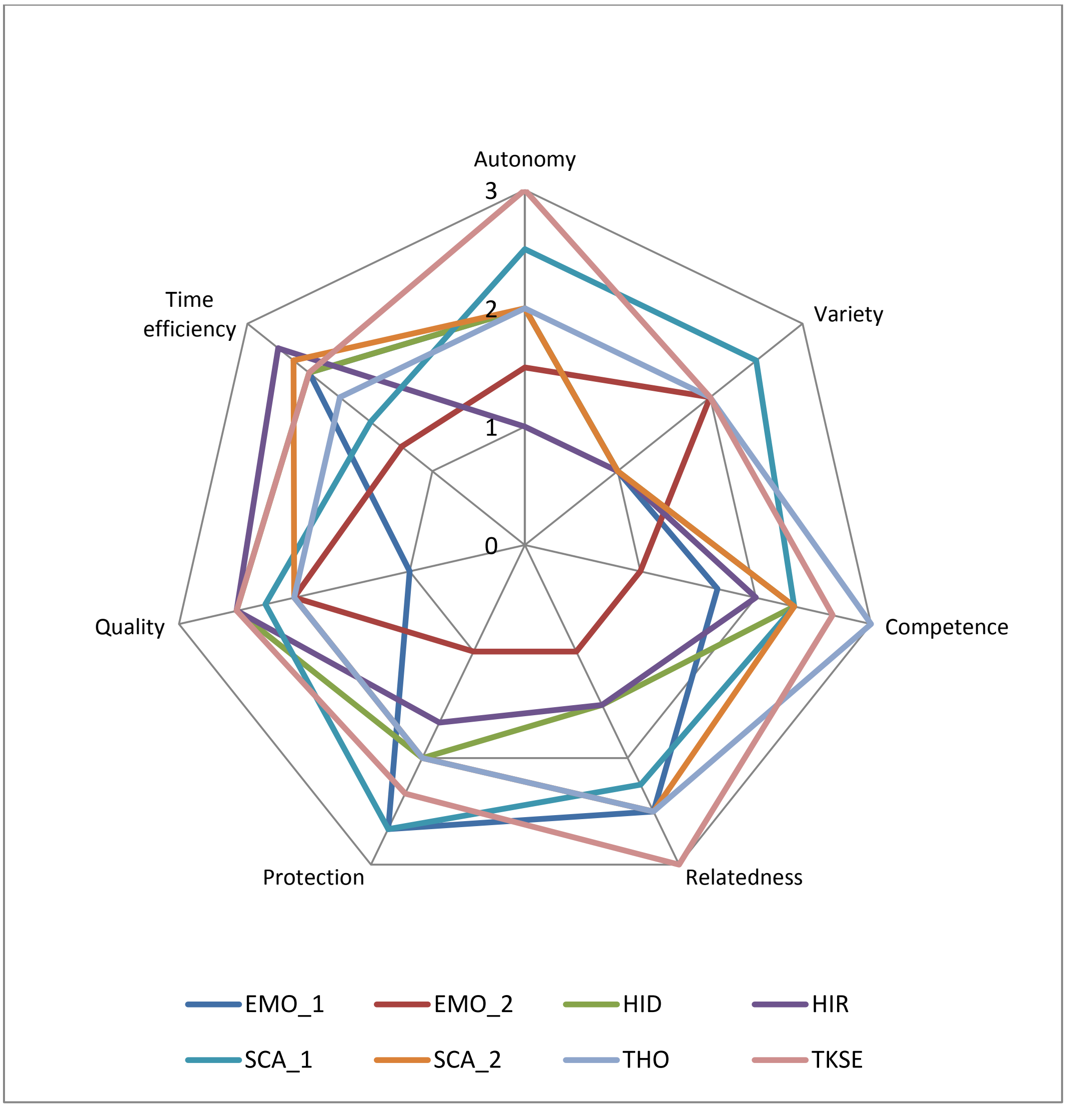

Figure 37: Overall view of the context-of-use analyses

5 Summary and Outlook

Based on a brief introduction to the FACTS4WORKERS project's context, we have illustrated three entities in this document:

- Our **human-centric, iterative and agile methodical approach**, which includes knowledge from Design Research and Scenario-based Development and has been co-designed to accommodate all of the project stakeholders' needs.
- The **practices of workers and the contexts of organisations** at six industrial partners (IP), which we have structured in the form of eight contexts-of-use.
- An **evaluation framework**, which allows — in terms of each of the previously identified contexts-of-use — an understanding of the anticipated impacts of the planned interventions on the individual (autonomy, variety, competence, relatedness, protection) and the organisational (quality, time efficiency) levels. This framework may also be used in later project phases for the evaluation of the smart factory solutions.

This document is the first step towards achieving our project aim of developing and demonstrating sociotechnical solutions that support smarter work, i.e. providing employees with the information they need to perform their daily work at the right time and in an appropriate manner in order to improve decision making, support the search for problem solutions and ultimately strengthen employees' position on the factory floor.

In this document, we have also briefly outlined our next steps (see especially 2.1 and 2.4): Based on our roughly drafted description of the current situation at the companies, we are currently developing concrete requirements to address the identified issues. We believe that we have sufficiently shown why these requirements cannot be collected in a decoupled form (like a table), but should always be kept in the context-of-use. We are therefore collecting the specific requirements for each context-of-use in the form of activity scenarios, should-be processes, mock-ups and demonstrators. We will illustrate all this in the next deliverable (D 1.2).

During our current progress, constant feedback from the industrial partners, especially the workers, will be essential. Over the last months and during at least two meetings at the partner sites, we have developed strong bonds with the scientific and industrial partners. These bonds will form one of the core foundations of our project's future success. At the time of writing this outlook, we have already presented and discussed the first scenarios, the should-be processes and mock-ups.

Simultaneously, we are collecting possible processual and IT constraints that we have to consider when later piloting the sociotechnical solutions and are learning how the companies want to further develop their production processes. Whereas we are still in the middle of the project's first year, the feedback we have received from the industrial partners so far (during regular phone calls, as mark-ups and comments in documents as well as in face-to-face meetings at the industrial sites) shows that we have not only built a solid trust basis, but have also found ways to communicate on a level the enables effective feedback and progress.

References

Cooper, Alan, Robert Reimann, and David Cronin. 2007. *About Face 3: The Essentials of Interaction Design*. Indianapolis, John Wiley & Sons.

Deci, Edward L., James P. Connell, and Richard M. Ryan. 1989. "Self-Determination in a Work Organization." *Journal of Applied Psychology* 74 (4): 580.

Hevner, Alan R., Salvatore T. March, Jinsoo Park, and Sudha Ram. 2004. "Design Science in Information Systems Research." *MIS Quarterly* 28 (1): 75–105.

Levina, Natalia, and Emmanuelle Vaast. 2005. "The Emergence of Boundary Spanning Competence in Practice: Implications for Implementation and Use of Information Systems." *MIS Quarterly*, 335–63.

Neely, Andy, Mike Gregory, and Ken Platts. 2005. "Performance Measurement System Design: A Literature Review and Research Agenda." *International Journal of Operations & Production Management* 25 (12): 1228–63.

Nunamaker, J. F, A. R Dennis, J. S Valacich, D. Vogel, and J. F George. 1991. "Electronic Meeting Systems." *Communications of the ACM* 34 (7): 40–61.

Peffers, Ken, Tuure Tuunanen, Marcus A. Rothenberger, and Samir Chatterjee. 2007. "A Design Science Research Methodology for Information Systems Research." *Journal of Management Information Systems* 24 (3): 45–77.

Pries-Heje, Jan, and Richard Baskerville. 2008. "The Design Theory Nexus." *Mis Quarterly*, 731–55.

Richter, Alexander, Peter Heinrich, Alexander Stocker, and Wolfgang Unzeitig. 2015. "Der Mensch im Mittelpunkt der Fabrik von morgen." *HMD Praxis der Wirtschaftsinformatik*, August, 1–23.

Rosson, M.B., and J.M. Carroll. 2002. *Usability Engineering: Scenario-Based Development of Human-Computer Interaction*. Morgan Kaufmann.

Spreitzer, G.M. 1995. "Psychological Empowerment in the Workplace: Dimensions, Measurement, and Validation." *Academy of Management Journal*, 1442–65.

Turner, Arthur Nicholson, and Paul Roger Lawrence. 1965. *Industrial Jobs and the Workers: An Investigation of Response to Task Attributes*. Harvard University, Division of Research, Graduate School of Business Administration.

6 Appendix

6.1 Informed Consent (in the languages of the industrial partners: German, Slowenian, Spanish)

FACTS4WORKERS

Zustimmungserklärung

Ihre Teilnahme an dieser Datenerhebung ist Teil unserer Recherche im Rahmen des von der EU unterstützten Projekts "Facts4Workers - Worker-Centric Workplaces in Smart Factories".

Über das Projekt: *Facts4Workers ist ein groß angelegtes Forschungsprojekt, dass Sie, den Arbeiter, in den Mittelpunkt der zukünftigen Produktionskonzepte stellt, um die Arbeitsplätze in der Produktion attraktiver und Europa kompetitiver zu machen. Arbeitskräfte der „Smart factories" werden idealerweise durch Informations- und Kommunikationstechnologien unterstützt um ihren Arbeitsalltag zu verbessern. Das wird hoffentlich zu einer erhöhten Arbeitszufriedenheit Ihrerseits führen (unser primäres Ziel) und die Produktionsprozesse hinsichtlich Flexibilität, Effizienz und Zuverlässigkeit verbessern. Die vier Jahre lange Forschungsinitiative wird durch Horizon 2020 unterstützt. Horizon 2020 ist ein Forschungsprogramm für Innovation der Europäischen Kommission, das von 2014 bis 2020 läuft.*

Ihre Daten werden anonym gespeichert und ausgewertet. Sie werden nur für das Projekt Facts4Workers verwendet. Ihre Rohdaten werden auf anonymer Basis genutzt und gespeichert. Sie werden keinem Dritten und nicht innerhalb des Unternehmens weitergegeben. Publikationen und Berichte, die auf diesen Daten basieren werden keine persönlichen Daten enthalten. Die Daten werden außerdem so anonymisiert gesammelt, dass es unmöglich wird spezifische Daten zu identifizieren.

Ihre Teilnahme ist freiwillig, die Zustimmungserklärung kann abgelehnt werden und sie können das Interview jederzeit beenden.

Zustimmungserklärung: Hiermit erkläre ich mich damit einverstanden, dass meine Daten für den oben genannten Zweck genutzt werden. Ich bestätige, dass meine Teilnahme freiwillig ist. Mir ist bewusst, dass ich meine Zustimmung jederzeit zurückziehen kann.

Name:

Ort, Datum: Unterschrift:

Unterschrift Projekt-Vertreter:

Bitte hinterlassen Sie ihre Kontaktinformationen, damit wir sie bezüglich Ihrer Daten kontaktieren dürfen:

Für mehr Informationen über dieses Forschungsprojekt, besuchen sie bitte: http://facts4workers.eu/

Izjava o privolitvi

Vaše sodelovanje v postopku zbiranja podatkov je del raziskovalnih aktivnosti, ki so izvedene v okviru evropskega projekta podprtega s strani EU »"Facts4Workers - Worker-Centric Workplaces in Smart Factories".

O projektu: *Projekt Facts4Workers je obsežen raziskovalni projekt, ki postavi delavca, Vas, v središče proizvodnih konceptov prihodnosti, katerih namen je povrniti privlačnost delovnim mestom v proizvodnji ter tako pomagati Evropi v iskanju njene industrijske konkurenčnosti. Namen projekta je omogočati podporo t.i. pametnim delavcem, zaposlenim, ki preko informacijskih ter komunikacijskih tehnologij prejmejo informacije, ki jim omogočajo izboljšanje njihovih dnevnih delovnih aktivnosti. Upamo, da bo to vodilo k večjem zadovoljstvu delavcev na delovnem mestu (kar je tudi primarni cilj projekta) ter, da bo tudi izboljšalo sam proizvodni proces, tako iz vidika fleksibilnosti, učinkovitosti ter zanesljivosti. Projekt v obliki štiri leta trajajoče razvojne iniciative je financiran v okviru evropske razvojne perspektive Obzorje 2020. Obzorje 2020 je vseevropski razvojni investicijski program za razvoj in inovacije, pod vodstvom Evropske komisije, ki se odvija v obdobju 2014-2020.*

Vaše podatke bomo pridobili ter uporabili izključno na bazi anonimnosti ter izključno za potrebe projekta Facts4Workers. Vsi tako pridobljeni podatki bodo ostali tajni ter ne bodo razkriti nobeni tretji stranki v postopku, niti znotraj Vaše lastne tovarne. Poročila ter publikacije, izdelane na osnovi teh podatkov ne bodo vsebovali nobenih osebnih podatkov. Podatki so dodatno anonimizirani ter združeni, da se nadalje še dodatno prepreči kakršnekoli možnosti identifikacije subjektov raziskave.

Vaše sodelovanje v raziskavi temelji na prostovoljni osnovi, soglasje in Vaše sodelovanje v njej lahko umaknete kadarkoli.

Izjava o privolitvi: Izjavljam, da se moje podatke lahko uporabi ter dokumentira v zgoraj opisane namene. Potrjujem, da moje sodelovanje temelji na prostovoljni osnovi. Zavedam se, da lahko kadarkoli umaknem soglasje k sodelovanju.

Ime in priimek:

Kraj, Datum: Podpis:

Podpis predstavnika projekta Facts4Workers:

Prosimo za navedbo kontaktnih podatkov v primeru Vaše privolitve za nadaljnje kontaktiranje za potrebo obdelave podatkov:

Za vse nadaljnje informacije o projektu obiščite spletno stran: http://facts4workers.eu/

Declaración de Consentimiento.

Su participación en esta toma de datos es parte de las actividades de investigación llevadas a cabo en el contexto del Proyecto Europeo "***Facts4Workers****: Centric Workplaces in Smart Factories"(**Facts4Workers**: Puestos de trabajo centrados en el Trabajador en Factorías Inteligentes).*

Acerca del Proyecto: *Facts4Workes es un proyecto de investigación que considera al trabajador, a usted, como el concepto central de la producción orientada al futuro, para hacer más atractivos los trabajos de manufactura y, así, ayudar a que Europa sea más competitiva. Los Smart-Workers ("trabajadores inteligentes") de estos centros de producción estarán, idealmente, ayudados por las tecnologías de la información y de la comunicación en su trabajo diario. De manera deseable esto contribuirá a incrementar su satisfacción laboral (objetivo principal del proyecto) pero, también, mejorará los procesos de manufactura buscando fiabilidad, flexibilidad y eficiencia. El proyecto, con una duración de 4 años, está financiado por Horizonte 2020, un programa de la Unión Europea que financia la Investigación, Desarrollo e Innovación de la Comisión Europea entre los años 2014 y 2020.*

Sus datos se almacenarán y usarán de manera anónima en el contexto del proyecto Facts4Workers. Sus datos serán mantenidos de manera confidencial y no serán cedidos a terceras partes, incluyendo la empresa para la que trabaja. Los informes y publicaciones basados en estos datos no contendrán en ningún caso ningún dato personal. Los datos serán lo suficientemente anónimos y agregados para prevenir cualquier posibilidad de identificar a cualquiera de las personas que originalmente los generaron.

Su participación es voluntaria, su consentimiento puede ser declinado y retirado en cualquier momento.

Declaración de Consentimiento: Por la presente declaro mi consentimiento para que mis datos puedas ser utilizados para los propósitos expuestos arriba. Confirmo que mi participación es voluntaria. Soy consciente de que mi consentimiento puede ser retirado en cualquier momento.

Nombre:

Lugar, Fecha: Firma:

Firma del Representante Facts4Workers:

Por favor, indique sus datos de contacto (email, teléfono, etc.), si nos permite contactar con usted en referencia a sus datos:

Para más información sobre el proyecto de investigación, por favor, visite: http://facts4workers.eu/

6.2 Interview guideline for the semi structured interviews (in German language)

FACTS4WORKERS

Teil A – Individuelle Praxis (Ist-Zustand)

Teil A – Individuelle Praxis (Ist-Zustand)

Persönlicher Hintergrund

Person (Personas)

Stellen Sie sich kurz vor: Wie alt sind Sie? Wo arbeiten Sie (Abteilung), wie lange (Was haben Sie davor gemacht) ihre Rolle (Job Beschreibung), (andere Aufgaben)?

Zielorientierung (Ziele, Potential, Prioritäten, Informationen)

- **Was macht einen guten/schlechten Tag aus?**
- Welche Aufgaben würden Sie als Zeitverschwendung betrachten?
- Was ist Ihnen am wichtigsten?
- Was hilft Ihnen beim Treffen von Entscheidungen?
- Was mögen Sie am liebsten an Ihrem Job (Oder Lebensstil)? Womit fangen Sie immer an?

Persönlicher Workflow (Prozess/Ereignis/Ausnahme)

- Was haben Sie heute als erstes getan? Was kam danach?
- Wie oft machen Sie das?
- **Was sind Ihre sonstigen täglichen Aufgaben?**
- **Was machen sie wöchentlich, monatlich, aber nicht täglich?**
- **Tauschen Sie Ort/Aufgaben mit Ihren Arbeitskollegen?** Wie oft? Gefällt es Ihnen? Warum? Warum nicht?
- Was geschieht während Ihrer täglichen Routine? Was hilft Ihnen?
- Was macht einen typischen Tag aus? Was wäre unüblich? Ist heute etwas Besonderes passiert?
- Wie teilen Sie sich ihre tägliche Arbeit ein? Gibt es einen klaren Stundenplan?
- Haben Sie Weiterbildungen für neue Prozesse ausgebildet?
- **Was sind die häufigsten Gründe die Sie an Ihrer Arbeit hindern?**
- Haben Sie bestimmte Aufgaben, die Ihnen unnötig erscheinen?

1

Aufgabe & System Hintergrund

Personen und Ihr Werkzeug (User Stories)

Informationen pro Aufgabe

Gehen Sie die folgenden Fragen für jede vom Interviewpartner genannte Aufgabe innerhalb des spezifischen Anwendungsfalls durch.

- **Welches Werkzeug benötigen Sie für diese Aufgaben?** Nennen Sie bitte „physikalische " und IT-Werkzeug(i.e. Zeichnungen, informations-server, …)
- **Was sind die attraktivsten Aufgaben oder Schritte, der beschriebenen Aufgaben/ Schritte?**
- **Was sind die unattraktivsten Aufgaben oder Schritte, der beschriebenen Aufgaben/ Schritte?**
- **Welche Kollegen kontaktieren Sie für diese Aufgabe?**
- Welche Informationen benötigen Sie für die Aufgabe (Was müssen Sie wissen)?
- Welche Informations- und Kommunikationstechnik benötigen Sie hierfür?
- Ist es einfach mehr Informationen zu finden, wenn Sie diese benötigen? Müssen Sie jemanden fragen oder recherchieren mithilfe eines IT-tools?
- Stehen Ihnen alle Informationen für diese Aufgabe zum richtigen Zeitpunkt zur Verfügung?
- Benötigen Sie alle für die Aufgabe angegebenen Informationen? Sind bestimmte Informationen unnötig? Welche?
- Was müssen Sie dokumentieren? Warum? Welche Vorteile haben Sie durch die Dokumentation? Wie müssen Sie es dokumentieren?
- Wie gehen Sie aufkommende Probleme an? Wie verfolgen Sie das Problem zurück?
- Welche Probleme entstehen (sind in der Vergangenheit entstanden), wie gehen Sie damit um und wie lange brauchen Sie um die Probleme zu lösen?
- Ist ihnen der Problemlösungsprozess klar?
- Wie viele Prozesse basieren auf Ihren eigenen Erfahrungen vs. Objektiven Richtlinien (z.B. geschriebene Informationen, Dokumentationen im Allgemeinen)?

System Orientierung

Falls der Arbeiter bestimmte Werkzeuge für Seine Aufgaben nutzt
– Funktion, Häufigkeit, Präferenzen, Scheitern, Expertise

- **Was sind die häufigsten Dinge die Sie mit den aktuellen Lösungen machen?**
- **Was sind Ihre Lieblingsaspekte der aktuellen Lösung?**
- **Was hält Sie ab effizient zu arbeiten?**
- **Wie gehen Sie mit Problemen um?**
- Was ist der Sinn der Lösung? Melden? Kommunizieren? Bei der Arbeit helfen?
- Hilft Ihnen die aktuelle Lösung weiter?
- Von welchen Aspekten der Lösungen machen Sie am meisten gebrauch?
- Welche Abkürzungen/ Shortcuts nutzen Sie?

2

Teil B – Gruppenarbeit (Ist-Zustand)

Teil B – Gruppenarbeit (Ist-Zustand)

Gruppenbewusstsein

Awareness Graph (Struktur)	Swim Lane

- **Wer beteiligt sich an Ihrer Aufgabe?**
- **Wer macht was?**
- Welche Entscheidungen können Sie selber treffen? Welche Entscheidungen müssen vom Teamleiter/ Management getroffen werden?
- An welchen Aufgaben arbeiten sie mit?
- Wie lösen Sie Aufgaben in der Gruppe? Wer dokumentiert das (Buchung, Beschreibung, Status, Fortschritt, Lösung etc. …)?
- Ergreifen Sie die Initiative um zu verhindern, dass sich Probleme wiederholen?
- Wer erkennt Probleme als erstes?
- Machen sie Verbesserungsvorschläge? Neue Ideen? Werden Sie innerhalb des Unternehmens behandelt/ thematisiert? Inwiefern?

Kommunikation in der Gruppe

Awareness Graph (Kanäle)

- **Wann kommunizieren Sie am meisten mit anderen?**
- **Über welchen Kanal kommunizieren Sie? (Welche Hilfsmittel nutzen Sie? / Nutzen Sie E-Mail/ Intranet für die Kommunikation?)**
- Sind die Informationen immer auf dem neusten Stand der Dinge? Ist es möglich nicht aktualisierte Prozeduren o.ä. zu finden?

Teil C – Angestrebte Situation (Vision) & Potential

Teil C – Angestrebte Situation (Vision) & Potential

Der Arbeitsplatz der Zukunft Angebote/Zitate und seine Eigenschaften

Einstellung (Aspiration, Vermeidung, Motivation)

- **Was sehen Sie sich selbst in fünf Jahren tun?**
- Was würden Sie am liebsten machen?

Jetzt haben wir viel über Ihre alltägliche Arbeit gesprochen – Vielen Dank für diesen sehr interessanten Einblick in Ihre Welt! Eine letzte Frage:

- **Können Sie mir Ihre persönliche Vision schildern, wie Ihr Arbeitsplatz in 5 Jahren aussehen sollte, damit Ihr Job Sie und Ihre Kollegen mehr Erfüllt?**
- **Können Sie Ihre Beschreibung in drei bis fünf Adjektiven zusammenfassen?**

SSCC-Modell

SSCC-Blatt

- **Anfang – Was sollte eingeführt werden und warum? (d.h. Zusatznutzen /Fähigkeiten würden Ihnen helfen)**
- **Stopp – Was sollte vermieden werden und warum? (Verschwendete Zeit/Was macht mich unglücklich?)**
- **Fortfahren – Was sollte fortgeführt werden und warum? (d.h. Was hat uns die Erfahrung gelehrt?)**
- **Wandel – Was sollte geändert werden und warum? Wollen Sie es verändern? (d.h. Was hat uns die Erfahrung gelehrt?/ Nutzung neuer Technologien? / Nutzung neuer Möglichkeiten?**
- Sollten neue Indikatoren eingeführt werden um das System unter Kontrolle zu haben?

Innovationen

Innovationsblatt

- **Im Allgemeinen: Wie häufig kommunizieren Sie Verbesserungsvorschläge? Wie häufig werden diese Verbesserungsvorschläge angegangen?**
- **Wurden Sie ermutigt neue Ideen für Verbesserungen anzubringen?**
- **Bekommen Sie für Ihre Ideen Feedback?**
- Haben sich Ihre Aufgaben kürzlich verändert? Wie können Sie zu Veränderungen beitragen?
- Haben sie Werkzeug um Innovationen zu unterstützen? z.B. Ideen Box, Wettbewerbe, Preise?
- Sollten neue Indikatoren eingeführt werden um das System unter Kontrolle zu haben?

Abschluss

So, das war unsere letzte Frage. Vielen Dank für Ihre Unterstützung. Jetzt sind Sie an der Reihe – Haben Sie Fragen zu unserem Projekt oder die gegenwärtigen Prozesse?

About the project

PROJECT PARTNERS

The FACTS4WORKERS project is composed of 15 partners from 8 different European countries:

Virtual Vehicle Research Center	Austria
Hidria TC Tehnološki center d.o.o.	Slovenia
Universita degli Studi di Firenze, Department of industrial Engineering	Italy
Technische Universität Wien	Austria
ThyssenKrupp Steel Europe AG	Germany
Hidria Rotomatika d.o.o., Industrija Rotacijskih Sistemov	Slovenia
iMinds VZW	Belgium
Sieva d.o.o.	Slovenia
University of Zurich, Department of Informatics	Switzerland
Thermolympic S.L.	Spain
EMO-Orodjarna d.o.o.	Slovenia
Evolaris Next Level GmbH	Austria
Itainnova - Instituto Technologico de Aragon	Spain
Schaeffler Technologies AG & Co. KG	Germany
Lappeenranta University of Technology	Finland

PROJECT COORDINATOR / CONTACT:

VIRTUAL VEHICLE Research Center
Inffeldgasse 21A
8010 Graz, AUSTRIA

Tel.: +43-316-873-9077
Fax: +43-316-873-9002
E-Mail: facts4workers@v2c2.at

FOLLOW US AT:

FACTS4WORKERS
@FACTS4WORKERS
facts4workers-project

Captured and structured practices of workers and contexts of organizations

This document represents Deliverable 1.1 ("Captured and structured practices of workers and contexts of organisations") of the H2020 project "FACTS4WORKERS - Worker-Centric Workplaces in Smart Factories" (FoF 2014/636778).

At the core of this deliverable, we initially explore the practices of workers and the contexts of organisations at six industrial partners with more than 100,000 employees in more than 50 countries. A deep understanding of workers' individual practices will help us deliver suggestions (in the form of requirements) for sociotechnical solutions that support smarter work. We structure the captured practices in the form of eight contexts-of- use, i.e. four industrial partners have one context-of-use and two industrial partners have two contexts-of-use.

This document also provides a detailed illustration of our methodical approach in order to provide a high level of transparency to all readers. Our general approach is human-centric, iterative and agile by nature, and has been inspired by well-known and widely accepted frameworks and models from the Design Research and Scenario-based Development domains.

In addition, having presented the practices in detail, we then present a first evaluation of the anticipated impacts of the planned interventions on the previously identified contexts-of-use. To do so, we develop a framework with seven impact dimensions and take a closer look at each context-of-use as well as the intended impacts on individuals (autonomy, variety, competence, relatedness, protection) and organisations (quality, time efficiency).

FACTS4WORKERS