

D6.4 Human-centred adaptive manufacturing - societal and industrial impacts



## Empowering and Participatory Adaptation of Factory Automation to Fit for Workers

### Abstract

Smart factories are characterized by increasing automation and increasing customization. In these dynamic environments, flexible and adaptive work organization is crucial, for both productivity and work satisfaction.

The Factory2Fit project will support this development by developing worker empowering workplace adaptation solutions as well as engaging solutions for participatory design, knowledge sharing and learning. With the Factory2Fit solutions, people with different skills, capabilities and preferences can become motivated and productive members of the work community in manufacturing industries.

This deliverable describes the results of the first impact assessment interviews. The interviews were carried out with the representatives of the industrial pilot partners of the Factory2Fit project (Continental, Prima Power and UTRC-I (United Technologies Research Centre - Ireland) as well as the members of the External Advisory Board (EAB) representing different expertise to support the project.

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## Executive Summary

In the project plan of Factory2Fit project, we have foreseen several industrial and societal impacts. To support the progress of the project towards these impacts, we will carry out an annual study to assess the foreseen impacts based on the current development stage of the project. This first study is based on the Factory2Fit concepts that have been defined during the first project year. To assess the impacts we have interviewed representatives of the industrial pilot partners of the Factory2Fit project (Continental, Prima Power and UTRC-I) and well as the members of the External Advisory Board (EAB), who represent versatile expertise to support the project. The interviews took place from mid August to early September 2017.

Well-being at work consists of many issues such as self-esteem, engagement, commitment, motivation, mood, feeling of confidence and competence as well as development possibilities. Empowering the worker concepts have potential to contribute to work well-being, and the balance between personal and professional life. When work is developed to better take into account the various skills and expertise of people, productivity can be increased. Monitoring workers is however, a new and complex phenomena with several legal, ethical and company policy considerations.

An engaged work community is flexible and prepared for changes. The workers feel responsible not only of the daily performance but also for the future of the company. When people can influence on their work, they will feel their work more meaningful. Being listened to and respected also brings meaning, as well as getting feedback, learning positive things of one's qualifications, and noticing that one can bring benefit to other people at work by teaching and sharing knowledge.

The results show that the industrial partners think that the project is proceeding well towards the industrial impacts expected in the project plan: increased adaptation, work satisfaction and increased quality. When factory management gets an insight of the link between worker well-being and factory performance, this can have many positive impacts, and will boost the adoption of the solutions. A negative impact could be that Factory2Fit solutions could eventually be used for performance management. Data tends to be "greasy" - once created it is difficult to control how it is being used. The whole data life cycle should be designed carefully.

On a societal level, Factory2Fit solutions can be seen as one step towards data-intensive and quantified society. Factory2Fit solutions could support the aim of sustainable and responsible industry by compensating the physical and cognitive capacity of the worker during his/her whole work career. For wide adoption in the manufacturing industry, the benefits of adaptation should be made visible.

The results of this impact assessment will be utilised in the Factory2Fit project to refine the concepts and in designing the industrial pilots. The results also include important issues to guide the exploitation and dissemination activities of the project. The impact assessment will be repeated at the end of the second project year and at the end of the project. The results of this impact assessment will be utilised in the Factory2Fit project to refine the concepts and in designing the industrial pilots. The results also include important issues to guide the exploitation and dissemination activities of the project. The impact assessment will be repeated at the end of the second project year and at the end of the project (the third year).



# 1 Introduction

In the project plan of Factory2Fit project, we have foreseen several industrial and societal impacts. To support the progress of the project towards these impacts, we will carry out an annual study to assess the foreseen impacts based on the current development stage of the project. This first study is based on the Factory2Fit concepts that have been defined during the first project year. The concepts are built on extensive studies on technical enablers and industrial requirements. To assess the impacts we have interviewed the representatives of industrial pilot partners of the Factory2Fit project (Continental, Prima Power and UTRC-I) and well as the members of the External Advisory Board (EAB), who represent versatile expertise to support the project. The interviews took place from late August to early September 2017. The results of the interviews are analysed and reported in this deliverable. In the following, in Section 2 we describe the method and in Section 3 we present an overview of the Factory2Fit concepts. In Section 4 we present the results of the interviews with the industrial partners, in Section 5 the results of the interviews with the EAB members and in Section 6 we describe the results of the questionnaire to assess the productivity and work satisfaction impacts of the concepts. In Section 7 we conclude the results.

## 1.1 Purpose of the Document

In this deliverable, we describe how the project is proceeding towards the targeted impacts, and we suggest measures that would support the progress towards the impacts. Thus, internally, within Factory2Fit, the deliverable supports the work of the project towards the impacts. Externally this public deliverable describes expert views on the impacts of worker-centric adaptive and participatory manufacturing environments.

## 1.2 Intended readership

Deliverable 6.4 is a public document (PU) and is, therefore, intended for the European Commission, the Factory2Fit Project Officer, the members of the Factory2Fit consortium, the members of other national and H2020-funded projects, as well as relevant stakeholders in the field of the research and industry more widely, and even the general public.

## 1.3 Relationship with other Factory2Fit deliverables

The interviews are based on the initial Factory2Fit project plan (Annex 1 of the Factory2Fit Grant Agreement #723277) and the draft version of the deliverable *D1.3 Adaptation concepts*, which includes public descriptions of the Factory2Fit adaptive and participatory concepts for manufacturing environments.



## 1.4 Acronyms and abbreviations

Abbreviation	Description
EAB	External Advisory Board
EFFRA	European Factories of the Future Research Association
EU	European Union
F2Fit	Factory2Fit
IoT	Internet of Things
KPI	Key Performance Indicator
OEE	Overall equipment efficiency
UTC	United Technologies
UTRC-I	United Technologies Research Centre Ireland

Table 1: List of Abbreviations



## 2 Method

The interviews were carried out as semi-structured interviews with predefined themes. The interview themes followed the expected impacts presented in the Factory2Fit project plan (Description of Action, 2016). With the industrial partners, the focus was first on the foreseen impacts on their immediate business in relation to the expected impacts foreseen in the Factories of the Future call FoF-4-2016 in the H2020 work programme (H2020, 2015). Then they assessed the societal impacts of the Factory2Fit solutions, based on goals set in EU 2020 strategy (European Commission, 2016) and the EFFRA roadmap (2013). Even if Factory2Fit solutions will primarily influence individual workers, they may also influence other actors within the factory. That is why we assessed societal influences also on work community and factory management. When widely adopted, the solutions may also influence manufacturing industry as a whole, manufacturing related education and finally society. These viewpoints were also used in the assessment of the societal impacts.

The EAB members focused on assessing the societal impacts of the Factory2Fit solutions similar to the industrial partners. However, the EAB members assessed separately the impacts of the concepts to empower workers and the concepts to engage workers. The EAB members were also asked how the positive impacts could be supported and/or the negative impacts be avoided/minimized. Finally the EAB members assessed the overall impacts of Factory2Fit concepts according to the goals presented in EFFRA roadmap (2013): productivity, meaningful work, attractive workplaces, safety, as well as sustainable and responsible industry.

The different interview themes for the Industrial partners and the EAB members were chosen because with the industrial partners assessing foreseen impacts on their immediate business took large part of the interview, and thus we did not want to include too many additional themes. Both groups had their own interview templates. The interview templates are presented in Appendices 1 and 2.

To get also quantitative results, each interviewee filled in a simple questionnaire. In the questionnaire, the interviewees assessed each of the six Factory2Fit concepts regarding their impact on productivity and work satisfaction. The questionnaire is presented in Appendix 3.

Before the interview, the interviewees from the EAB got a draft version of the Factory2Fit deliverable 1.3 and a slide set based on the deliverable, giving an overview of the adaption concepts proposed by Factory2Fit. The concepts were also described to the interviewees with the slide set in the beginning of the interview. The concepts are briefly described in Section 3.

The interviews were carried out with Factory2Fit industrial partners (one interviewee from Continental and Prima Power and two interviewees from UTRC-I, interviewed together) and with the External Advisory Board (EAB) members (9 individuals).

The interviewees filled in a consent form, where they allowed the use of the results in this public report. They also had the opportunity to check the draft deliverable before publishing.

Five interviews were carried out face-to-face and seven online. Two to three researchers from VTT and Carr participated in each interview, one researcher leading the interviewing and the other(s)



taking notes and asking complementary questions if needed. Each interview took around one and a half hour. The interviews were audio-recorded.

## 2.1 Interviewees

In Table 2, the professional backgrounds of the interviewees are described. The interviews are anonymous, so the identity is revealed only to the extent of whether the interviewee belongs to the industrial partners of Factory2Fit, having the prefix IND, or to the External Advisory Board, having the prefix EAB. The order of the descriptions is random.

IND-1 has worked in industry for 35 years, having experience in many fields, such as the paper industry, warehousing and automation. After having graduated as Master of Science, the interviewee has worked in product development, the last decades in a managerial position.
IND-2 is working as launch manager for new products, and has been working in this position for ten years. The interviewee is mainly responsible for coordinating activities, but needs to know also about issues related to factory floor work.
IND-3 is an industrial engineer with a Master's and PhD in applications of operations, research and artificial intelligence methods to various manufacturing problems, such as production planning and assembly line balancing and scheduling. IND-3 worked as a planning engineer for three years and has now been working as senior research scientist in a system modelling and optimization group in a research centre for the last year.
IND-4 has a background in formal verification and cyber physical systems. The IND-4 has been in this current position for seven years, and has two roles in the research centre; IND-4 primarily acts as the leader of the external partnership and business development strategy. IND-4 also leads projects for new initiatives in fields such as cyber security and advanced manufacturing.
EAB-1 has a background in research at a university and in process development in a company. The interviewee is currently working in a position with an overview on companies in manufacturing industry. The focus is on designing projects with industrial partners in which critical domain related challenges are tackled by new innovative means
EAB-2 is working as university professor in the area of ethical and social aspects of technologies.
EAB-3 is working in a trade union for industrial workers as head of the research unit, with almost 20 years work experience of sociology research at a university.
EAB-4 has been working in the area of marketing and communication, and from the year 2008 on, in an own company, which provides information and solutions for barrier-free and accessible building. The interviewee's work is based on the principle of Design for all - developing and improving environments accessible for everyone.
EAB-5 has worked as a work and organisational psychologist for 25 years. The interviewee first worked in a national training and development institute. In that role, the interviewee helped people who had had either nervous breakdowns or accidents back into workplaces. For the last 19 years, the interviewee has worked as a work and organisational psychologist, bringing health and safety expertise to workplaces. The interviewee has a particular interest in psychoanalysis of organisations, teams and families, and holds a M. Phil in Psychoanalysis and a Health and Safety diploma.
EAB-6 works as a group manager in a national electrotechnical standardisation association. The interviewee is in charge of several national standardisation committees where experts participate in the work of the International Electrotechnical Commission (IEC) and the European Committee for



Electrotechnical Standardization (CENELEC). One of these committees is SK 65 Industrial process measurement, control and automation.

EAB-7 has worked for an organisation in the aerospace industry for over 20 years. The interviewee first joined the organisation as a member of the business development team, and later took on the role of leader of the marketing group and continued in the commercial field. The interviewee then moved on to experimental products. In more recent years, the interviewee has been focusing more on European research programmes, and at the moment the main focus is on REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) requirements.

EAB-8 has been working in the manufacturing field for almost 20 years. The interviewee has been involved largely in the computer integrated manufacturing area, and has worked on projects related to simulation, computer aided design, or computer aided manufacturing. In the past 10-15 years, the involvement has been more at the supply chain level and also the manufacturing operation management systems level.

EAB-9 works as a manufacturing technology manager in aerospace industry. The interviewee has over 10 years of work experience in manufacturing industry. The interviewee holds a master's degree in manufacturing engineering and also a degree of Master of Business Administration (MBA).

*Table 2: The interviewees*



### 3 Overview of Factory2Fit concepts

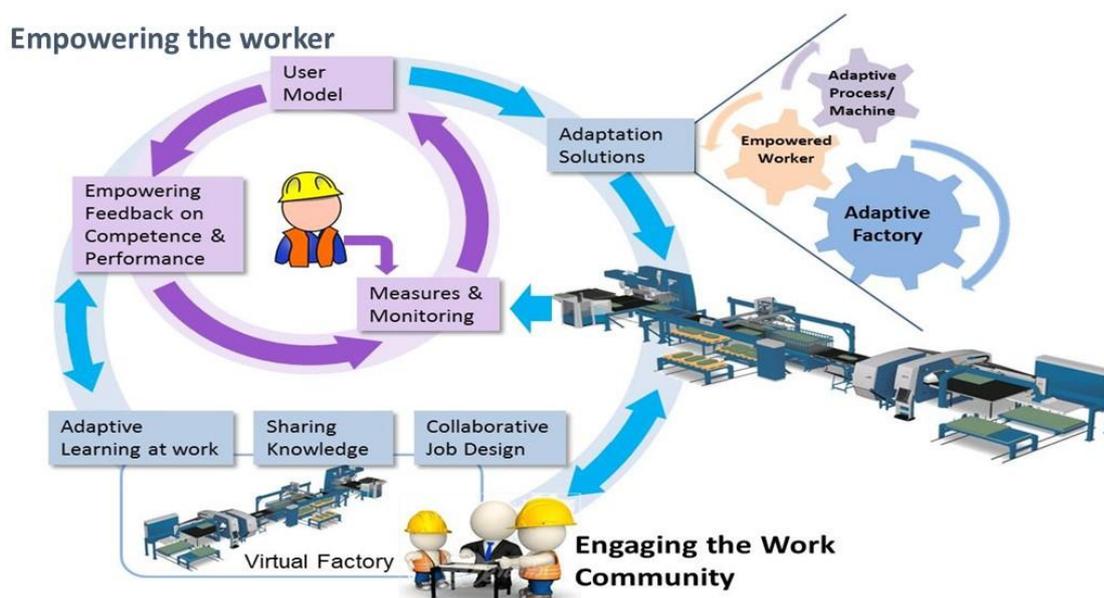


Figure 1: Factory2Fit approach to adaptation

As illustrated in Figure 1, Factory2Fit will develop adaptation solutions with two approaches that can be described as approaches to empower the worker (based on the Quantified worker approach) and approaches to engage the work community. The concepts are described in details in Factory2Fit Deliverable *D1.3 Adaptation concepts*. The concepts are divided into two groups of solutions: empowering the worker and engaging the work community.

Empowering the worker adaptation solutions are based on a dynamic worker model. This group includes the following concepts:

1. Worker Feedback Dashboard to give the worker motivating feedback of his/her well-being and performance, based on the Quantified worker approach
2. Adaptive user-machine interaction for personally and situationally relevant support and functions
3. Adaptive task assignment for personally and situationally relevant and motivating tasks

Engaging the work community solutions encourage and activate workers to active participation at the work place. This group includes the following concepts:

4. Participatory design with motivating tools to encourage workers to contribute to designing their own work environment and related tools and practises
5. Knowledge sharing tools to make tacit knowledge visible and accessible
6. Training solutions that support efficient adoption of new machines and practices, engage workers to contribute to the training materials and support continuous competence development at the worker's own pace

The approaches are partially overlapping, especially regarding learning at work, as the empowering feedback on one's competence and performance supports learning at work and taking responsibility of one's own professional competence.



## 4 Impact assessment with the industrial pilot partners

Based on the ongoing F2Fit concept definition, we returned to the impacts foreseen in the project plan. For each industrial impact category, we had set target KPI values in the plan. The interviewees assessed the progress towards the foreseen impacts. Not all KPIs were applicable to each of the three companies. If a KPI target value had not been defined, we discussed the impact at a general level. After discussing the industrial impacts, we also asked the interviewees to assess societal impacts at the level of the individual worker, the work community, management, the manufacturing industry, training as well as society.

In the UTRC-I interview results, when we quote the interviewees, we refer to them as IND-3 and IND-4 to maintain their anonymity. In the quotes in the Continental and Prima Power interviews, the first person pronoun "I" refers to the interviewee.

### 4.1 Increase in adaptability

Key Performance Indicators (KPIs)	KPI-1: Percentage of human operations that can be adapted KPI-2: Percentage of workers in the pilot cases who are modelled KPI-3: Percentage of workers in the pilot cases who can participate in designing their own work
Target KPI Value	KPI-1=Prima Power 50%, Continental 60%, United Technologies 70%  KPI-2= Continental 60%, United Technologies 70%  KPI-3=Continental 85%, United Technologies 80%

#### Continental (KPI-1, KPI-2, KPI-3)

We are not working on the initially planned use case (the KPI targets are originally set for that) any longer, but we are focusing on the new use case of measurement lab. KPI-1 is still valid, but not as relevant as was expected before. Learning of the operators can be adapted, depending on their role, experience and skills. The main work tasks of operators will stay the same, but the way information is coming, used and distributed will change. KPI-2 will stay high as we are doing this for all the people in the measurement lab, only excluding some people working e.g. on programming and organizational issues. KPI-3 stays also as high. The tasks will be distributed based on the workers' own preferences. Everybody who is within the impact area will be able to participate and have an impact on their work by supporting knowledge sharing and changing their preferences.

#### Prima Power (KPI-1)

A lot depends on how the concept of adaptation is defined. Earlier I considered "adaptation" as relative to the user so that the machine adapts to the user, and in this case, the value (50%) is quite big. However, I suggest that the perspective for adaptation is changed a bit. Presently I would define adaptation as a matter relative to the context or situation at hand when using the machine and in this case I think that this target is valid and reachable.



#### UTRC-I (KPI-1, KPI-2, KPI-3)

IND-3: We expect very high achievements in terms of these three KPIs. Since the human workers are at the heart of the manufacturing process at the assembly stations at our pilot site, we expect the participation of workers to be high. Our KPI target values are quite a lot higher than those of the other industrial partners, since their manufacturing processes are more automated.

IND-4: The KPI values set in the proposal are still applicable and should be achievable. In terms of KPI-2, it is important to note that there are certain aspects of the model that may be challenging. Our approval processes are complex, and restrictions may be imposed on what can be recorded and tracked and what cannot. Therefore it is too early to comment on KPI-2 and to say how far we can go into modelling and tracking user activity.

## 4.2 Increased worker satisfaction

Key Performance Indicators (KPIs)	KPI-4: Work satisfaction rates measured with Factory2Fit framework KPI-5: Retention rate
Target KPI Value	KPI-4=Continental: 15%, United Technologies 40% increase from project start to end of the pilot KPI-5:=Continental: 20%,United Technologies 10% increase

#### Continental (KPI-4, KPI-5)

KPI-4 is ok, but KPI-5 seems to be too high. I do not know the current retention rate, but I feel we are already at a high level in this area. Ten percent or less would be a better target value. The concepts will be influencing these factors, but KPI-5 seems to be overestimated.

#### Prima Power (no KPI target set)

Work satisfaction increases when the machinery is rapidly implemented and the usage of the machine is easy. It surely will decrease the level of stress and, accordingly, raise the customer's work satisfaction. I think we are going towards greater work satisfaction among our customers with these solutions.

#### UTRC-I (KPI-4, KPI-5)

IND-4: We are very confident that the use cases that UTRC-I has defined will increase worker satisfaction. Now, based on this interview, we need to record the baseline (at UTRC-I, we have a baseline based on our internal procedures of tracking work satisfaction, including parameters such as the environment, salary and working conditions). I'm not sure about the level of details we can provide there. Because naturally we cannot include salary, for example. We have to put work satisfaction within a context. This is a very difficult metric, but I am confident that it is feasible. The retention rate [KPI-5] is challenging. I don't know if that is information that we can release or not. We need to talk to the factory's HR unit to determine how to handle it.



### 4.3 Quality increase in total system (human and automation) performance

Key Performance Indicators (KPIs)	KPI-6: Error rate KPI-7: Defect rate KPI-8: OEE (Overall equipment efficiency)
Target KPI Value	<i>KPI-6= Prima Power decrease by at least 15%, Continental 10%, United Technologies 30%</i> <i>KPI-7= Prima Power: decrease by at least 15%, Continental 10%, United Technologies 30%</i> <i>KPI-8= Prima power: increase by at least 15%, Continental 5% (as is already high), United Technologies 10%</i>

#### Continental (KPI-6, KPI-7, KPI-8)

KPI-6 and KPI-7 estimates are good. When we are able to use more information, we can detect, count and analyse errors better. We expect to have a big impact also on KPI-8. KPI-8 is one of our opportunities where we can improve by implementing Factory2Fit solutions and which came more into the focus when the use case was changed. The target value can be even higher, as there is more where we can improve. It is a bit early to estimate but the number could be 10-15%. One potential barrier for the targets is that we need to combine all the information for analysis. The first action is a workshop with the people working in the measurement lab and IT, to start communication between the relevant parties.

#### Prima Power (KPI-6, KPI-7, KPI-8)

Our customers may struggle for a long time with errors when starting to use new machines and this project can improve the situation [KPI-6]. Actually, we already produce machinery, which provides rather flawless results so there is not so much to improve with the defect rate [KPI-7]. And when our machinery becomes easier to use, the error rate decreases and the implementation time becomes shorter, the overall efficiency will naturally improve too [KPI-8]. So, as a whole, we have work to do with error rate and overall equipment efficiency even if the quality is already quite fine. They also depend on each other; reducing error rate improves overall efficiency as well.

#### UTRC-I (KPI-6, KPI-7, KPI-8)

IND-3: We will definitely reduce the ramp-up period for workers by introducing new training solutions and information sharing technologies. This will eventually help us reduce the error rate during the manual assembly operations and the defects that we detect in the products. We think an improvement of around 30% in these KPIs [KPI-6 and KPI-7] is looking realistic. As for overall equipment efficiency [KPI-8], a 10% improvement is also quite reasonable since we are using all manual operations and only manual tools.

IND-4: When it comes to individual concepts, the KPIs set at the proposal stage will change when we start doing things and setting priorities. All three parameters (KPI-6, KPI-7, KPI-8) will be impacted by the activities we carry out, some of them indirectly. KPI-7, the defect rate, we will not be able to measure during the lifetime of the project. Or, at least even if we measure it, we will not be achieving higher rates just because of what we are doing but because of other things. The question is whether



we will hit the 30%. We definitely foresee an improvement but I am (Interviewee 2) not comfortable with specifying a percentage. We will need to follow up on this.

#### 4.4 Higher social acceptance of factory work

##### Continental

Concerning our region, the acceptance of working in a factory is already very high. Of course, it is a matter of taste, if you like to work in a factory or in another profession. Continental is already one of the most attractive employers in the region. However, the acceptance may still increase or stay as good as it is, when we show that we are able to use new technical solutions to improve the factory work and follow the development in the society.

##### Prima Power

Higher social acceptance is hard to accomplish during a project lasting only for some years. It may come true among our customers but to a larger extent, it is hard to reach as a single supplier hardly becomes an opinion leader. Social impact requires a lot of communication. If our results [in the Factory2Fit project] become visible, it can happen. One possibility is to include these aspects in our marketing material. If these results could be seen in fairs and exhibitions and our competitors see them, which could bring some leverage. Our hope is that with WP6 [Dissemination related work package] in Factory2Fit and the strong marketing department in our company, we could really advertise these results. If marketing understands the importance of these results, it will strongly support our business. It is like with the press - if you make a really good story, it will sell itself.

##### UTRC-I

IND-4: I (Interviewee 2) think Factory2Fit plays a role in helping to materialise digitalisation - a factor that attracts young people. Being able to use your own mobile phone or even being given one that you can use to do some work in a factory is definitely a great improvement in attracting young workers to move from paper work to more digital types of platforms. It's therefore definitely something that will increase the social acceptance of factory work. An obvious way of raising the awareness of young people planning their careers is through job ads. They need to be tailored to highlight the new types of work environments. You want to make sure you communicate how great it is to work there, the fact that the factory cares about the satisfaction of its employees, that it offers an easier, or more up-to-date, or state-of-the-art, socially acceptable type of environment. I think that one of the measures would be HR highlighting this in all aspects of the hiring process.

IND-3: I hope that the pilots will create an impact that we encourage workers to participate in decisions made on the factory floor. We have democratised operations management, using digital tools. This will attract more young workers to the factories, which is one of the expected impacts.



## 4.5 Stronger global position of the industry in Europe

Key Performance Indicators (KPIs)	KPI-10: Nr of manufacturing jobs re-shored to Europe KPI-11: Manufacturing machines sold in Europe
Target KPI Value	<i>KPI-10 = Continental is not applicable as work is distributed in manufacturing network.</i> <i>KPI-10 = United Technologies 5%</i> <i>KPI-11= Prima Power: 20% increase in European sales for automated machines</i>

Continental (no KPI target set)

My personal feeling is that compared to Asia or other places outside Germany, others are faster in trying out new technologies. They do not have so much regulation, which makes implementation easier. We need to keep the pace in Europe.

Prima Power (KPI-11)

The 20% is a valid value, the sales regarding systems is strongly growing.

UTRC-I (KPI-10)

IND-4: This is a challenging KPI to validate. We can talk about an increase in the workforce and in worker satisfaction, but I can't formally link it to bringing jobs to Europe from other places. It would be very tough for us to say.

## 4.6 Wide adoption of the developments

Key Performance Indicators (KPIs)	KPI-12: Market increase
Target KPI Value	<i>KPI-12 = Prima Power: at least 20% annual sales increase for automated machines; Continental: Overall capacity of the system to produce and deliver parts can be increased by 10%</i> <i>KPI-12 = United Technologies is expected to increase of 30% its position in the market due the possibility to accept more requests for customizing units.</i>

Continental (KPI-12)

We have possibilities to increase the overall capacity, besides OEE improvement, but this will not end in the increase of produced and delivered parts. The increase in overall productivity will save us money and lead into market increase.

Prima Power (KPI-12)

The question is actually about the same in KPI-11 and KPI-12, the former was about Europe, and this is throughout the world. The value (at least 20%) is fine here too.



## UTRC-I (KPI-12)

IND-4: I think this is a very valid KPI. The challenge is that this is a research and innovation action. The factory produces a lot of things. We have a production line for Air Handling Units and a specific type of handling units with a number of workers that work in it. Talking about the KPIs to cover all the HVAC [the company where the piloting will take place] side of it is not reasonable. But in the context of this particular factory increasing its share, it is achievable.

## 4.7 Impact in industry

### Continental

I think that implementing the solutions will help increasing productivity in the companies. Working with higher motivation, faster and with fewer errors will increase productivity. This does not depend on the type of industry, but is similar to all. To make the results adapted in the industry, we have to do good work in communicating and promoting the results.

### Prima Power

The various fields of industry are actually quite similar. Perhaps the key question is how to trigger the spreading. The best means is to use it in marketing and competitors start to follow. Once somebody started to talk about green technology and another about Industry 4.0 and now everybody talks about them. Presently, people say something is user friendly, but the strength in marketing lies on the efficiency. The talk is about the size of the screen, Windows, multitouch interface, and user friendliness. The fact nobody talks about user empowerment or other themes familiar in Factory2Fit is an opportunity for us. As nobody tells, where user friendliness comes from and how the human user can be taken into account, we can use it to differentiate. It is possible to create a good story with reasonable investments; a good story is different from others.

## UTRC-I

IND-4: UTC is a big organisation, so it is possible to create impact by engaging with other factories. At the end of the day, I think people adopt whatever's successful. If we are successful in capturing user satisfaction and in addressing issues such as privacy, worker participation and acceptability etc., I don't see why there wouldn't be wider acceptance. I think Prima Power would be an excellent vehicle because they provide solutions for factories, so it's easier for them to reach a variety of factories through their machines. And then if they are bringing in Factory2Fit technologies, where it's tied in with whatever tool they provide, that's definitely the best way of impacting the wider industry. It's a challenging task as the issue of monitoring workers is very complicated. I'm not sure how many factories would adopt that. But if we break through and offer successful solutions that address acceptability issues and concerns, people will adopt it.



## 4.8 Societal impacts of the Factory2Fit concepts

### 4.8.1 Individual workers

#### Continental

Today, the workers have to do many organisational tasks. We would like to avoid this and make the people work in the field of their expertise. If I think about me, this would be something that would empower me as this would let me concentrate on doing what I want and what I'm good at. This is a very good solution that can make people more aware what they are doing and how.

The concepts to engage the work community will give more responsibility to the workers: Only if I participate and put my wishes and expertise to the system, it will work and help others. I think it is good motivation, as you cannot complain afterwards. I think most of the people are proactive and they like the work and to work. They will feel that the solutions will help them.

#### Prima Power

Our customer have several roles, they have users of the machines, supervisors, management and others... The problem of a single user is that if a machine does not work, it sets a lot of pressure to the worker. Factory management has pressure if the investment is not as good as expected. Everybody is glad when the machine rocks. The user of the machine wants usability and the management wants predictability. Factory2Fit affects differently on different roles.

#### UTRC-I

IND-4: Adaptation will reduce the level of stress and pressure on workers. This will make workers feel more empowered. At UTC, we already have a solid tradition of trying to get people to participate. The fact that there are no specific tools limits the applicability. Having the appropriate tools will help engaging more people. The concepts will let workers design their own work and offer light ways of engaging workers. As for training solutions, we can definitely adopt these things, training on the job etc.

### 4.8.2 Work community

#### Continental

In general, if we provide a possibility to make communication easier, this will support the community. If it is not misused, it will have a positive impact. If you just think about Facebook, you can like it when you use it the right way, but you can use it for making harm as well. We should also think about misuse and how we can avoid it.

I think especially those people who try to protect their knowledge and position are not motivated to behave this way any longer. If we make them understand that sharing knowledge helps securing their position, we can gain a positive impact.



Prima Power

It depends on the work community in question whether this affects work roles. In Finland, work communities are equalitarian but elsewhere there is more hierarchy involved. If a good tool for knowledge sharing is implemented, it improves communication, providing a platform for it. This can affect work community - even if you can't talk to each other face-to-face, you may still be able to do it via a computer.

UTRC-I

IND-3: The concepts will also empower the relationship between the workers in the community.

IND-4: If you are part of something you become more engaged. If a tool makes you part of something without creating inefficiencies, the whole community can participate, including workers with different functions in the factory.

### 4.8.3 Factory management

Continental

We would like to prove the possibility of managing the people and putting them to the right place in the way that most of their preferences are respected. Today, some workers say what they want. Some don't say anything, but may still complain afterwards if something negative happens. This creates better transparency for the management.

I think that the impact of the concepts to engage the work community is not that big, because we are talking more about the level of factory workers.

Prima Power

Transparency and how production is proceeding are essential. Large transparency, covering both production – thinking about KPIs – and people affect management.

UTRC-I

IND-4: Factory management will benefit significantly, as managers will not make mistakes tasking non-expert workers. The relationship between management and workers will improve. IND-3: Factory management will be able to see the impact of their decisions in the factory. IND-4: For managers, it would be helpful to have a connection with the workers and a positive atmosphere. It is also good to receive feedback from the field. Tools that help managers gather information from the work community are very welcome.



#### 4.8.4 Manufacturing industry as a whole

##### Continental

In general, for other industries the impact will be the same as for us. The main thing is to do the benefits transparent and measure them, then the industry can decide whether adaptation it is worth investing. In Europe, there are many unemployed people and it is easy to replace workers. If it was difficult to find good employees, investing in the system would be worthwhile.

##### Prima Power

If a phenomenon is brought to the market strongly enough and it will become imitated or followed, the phenomenon can affect widely. Consultants invent a story and start to sell it; a celebrity can write a book about it; phenomena are created for some certain need and that is the way inventions begin to renew the industry. It starts from publicity, everybody starts to talk about it and everybody wants to be involved, and somebody starts it.

##### UTRC-I

IND-3 and IND-4: Tools that capture feedback and opinions and help you understand can become accepted as a practice in the industry because they are built bottom-up. An engaged worker does a better job, which applies to the industry as a whole. IND-3: So far, we have spoke about individual factories, but a holistic view of the change process and about workers in different factories can help Europe improve the manufacturing industry as a whole.

#### 4.8.5 Manufacturing related education

##### Continental

Many of the ideas are helping to make education easier, to have shorter ways of information flow and more sources for people to get information of tasks they have to do. This is clearly going to have an impact how we educate people. I think this is one of the biggest impacts.

##### Prima Power

Educational institutes invest in new machines and education is often organized so that companies are involved. However, it must be taken into account how quickly new education is organized. The development of education is slow, it is guided by appropriations and the stand of the Ministry of Education, and the related social and educational policies, whereas industry proceeds according to commercial principles. They are different from each other, in their essence and processes.

##### UTRC-I

IND-3: The concepts would definitely improve workers' on-the-job skills and complement their basic training. I'm also hoping that in the near future we can also have an impact on the way they're being educated in the schools and so on.



#### 4.8.6 Society as a whole

##### Continental

Society is a very wide word; the impact needs to be huge to change the society. One thing, which may become different in the future, is that we want to make people more aware of their physical state, like when they are stressed or when something unhealthy is starting to come up. We are able to avoid people working until they get sick. This is a big problem, and it creates also medical and injury costs. This is still all at work level, but what I take home from work is my feeling, mood and health and thus I believe that this is a field where it is possible to have an impact on wider part of the life.

##### Prima Power

If publicity is massive enough, it affects society. Impact has to be really strong to affect not only industry but also society. For instance, digitality is such a powerful theme that it affects society.

##### UTRC-I

IND-4: Happy workers go back smiling and behave better with their immediate environment, starting with their family. Making working in factories more attractive is a chicken-egg situation. Satisfied workers have a positive influence on the atmosphere and vice versa. A happy worker means a happy environment and vice versa.

#### 4.9 Additional impacts and other comments

##### Continental

No additional comments.

##### Prima Power

I think that the six impacts according to the project plan are important but now that I have more insight I think that there are two themes, which are important for Prima Power and affect these impacts. One is the concept of pre training, that is, efficient training before the machinery is implemented, and the other is the development affecting the usage of the machine, related to increased adaptivity and error control. They make a huge difference to our customers who want to implement the new machinery as rapidly as possible and do not have any more spare capacity for compensating gaps in production.

I do not like about the idea of just drumming some numbers without contemplating what is behind them. In this sense, this interview is good.

##### UTRC-I

IND-4: By continuously improving factories through adaptation, innovation and change, factories (not the workers this time) become empowered. They become able to cope with change, sustainability,



and continuous improvement. This means facilitating factories to get signals from everybody to see what changes are needed.

#### 4.10 Conclusions

Overall, the industrial partners thought that the KPI targets set in the project plan are still valid and reachable. However, as the plans for the industrial use cases in the project had been refined, especially with Continental, the emphasis of the KPIs has changed a bit. The interviewees thought that the KPI targets would be different for different concepts.

All industrial partners agreed that the project is proceeding well towards the targets of increased adaptation, work satisfaction and quality increase. Adaptation possibilities were seen especially high in the UTRC-I use case, where the focus is on manual assembly work. At Prima Power, the adaptation concept was extended towards situational adaptation, rather than just adapting to the worker. All three companies expected quality increase especially in decreasing error rate and in increasing overall efficiency.

All the companies foresaw positive impacts in their business, with well-being of the workers and transparency and predictability for the management. However, current regulation may slow down exploitation. Monitoring workers is a new and complex phenomenon with several legal, ethical and company policy issues.

The interviewees thought that Factory2Fit concepts for adaptation would reduce stress and pressure on workers, improve the work experience and thus increase work well-being. Appropriate tools will help engaging workers to influence more at the work place. The concepts will also give more responsibility to the workers.

Within the work community, the concepts providing a platform for communication will evidently increase collaboration, which is good. However, possible ways to misuse should also be identified and ways to avoid misuse should be developed. Motivation to share knowledge should be studied, as some people may tend to protect their knowledge.

Respecting worker preferences will improve the relationships between the management and the workers. The interviewees thought that the proposed concepts would create better transparency for the management, covering both production process and the workers. Bottom-up created concepts have good potential to be adopted as new practices.

Education institutes are slow at adapting to change but Factory2Fit concepts may have a strong influence on how people are educated. Societal influences were seen in happy workers spreading happiness around them also in civil life.

The interviewees thought that Factory2Fit work has potential to influence on higher social acceptance of factory work but that will require a lot of dissemination efforts. Dissemination can take place on different forums, for instance by job ads. It is important to create a good story to explain how the Factory2Fit concepts create work well-being and how working with higher motivation, faster and with fewer errors will increase productivity.



For wide adoption of the concepts in the manufacturing industry, the benefits should be made visible to show that it is worth investing in adaptation. A holistic view of the change process and the workers in different factories will help improving the European manufacturing industry as a whole. A clear message and strong dissemination activities are needed to create phenomena to influence the industry widely.



## 5 Impact assessment with the External Advisory Board

The EAB members were assessing the industrial and societal impacts of the planned developments based on the presented Factory2Fit concepts. They assessed separately the concepts for empowering the worker and engaging the work community, both groups of concepts at the level of the individual worker, the work community, management, the manufacturing industry, training and society. After that, they assessed overall impacts related to productivity, meaningful work, attractive workplaces, safety as well as sustainable industry.

### 5.1 Impacts of the concepts to empowering workers

#### 5.1.1 Individual workers

##### EAB-1

In Factory2Fit, the concept of an active worker seems to be central, which requires a considerable change in the mindset in the manufacturing factories at the moment. Firstly, part of workers are interested and part not. For instance, recently a worker commented in a development project that what (s)he has been asked to do is not actually his/her work but the work of managers who are just not doing their job. Secondly, the current concept according to which the work is performed does not support an active role for a worker. When a worker is given a more active role, it means that the levels between hierarchies must become lower throughout Europe – the more authoritarian the leadership is currently, the more changes are to be expected. Furthermore, the skill set needed in factory work will change as communication skills and the ability to take initiative will be needed, too.

The change is supported by finding those individuals who are interested in it, and the development processes should be renewed as well. The latter is required as otherwise the new ideas may be rejected without any explanations and the worker easily feels (s)he is not listened to and becomes unmotivated.

Digitalisation supports workers and standardises the output as those performing at a lower level learn to work better. Then, there is the issue with those workers having excellent results - they only support others, receiving nothing in return. This should be tackled somehow.

##### EAB-2

If workers are actually empowered, the workers may enjoy the work more, they may become more productive, the outcomes are positive and the overall work environment is improved. At the same time, individual workers may misuse the system, for example by trying to skip supervision. It is very context-dependent; the solutions might become empowering, but they might also become tools of suppression.

##### EAB-3

When work is digitalised or automated or otherwise supported by the machinery, these new solutions can reduce the share of tasks which are burdensome for a human worker. Work also becomes more meaningful and more safe if it can be made more versatile and flexible, based on the level of personal performance at each time, influenced e.g. by tiredness or head ache. For instance, the physician may



send you on sick leave when having an aching foot, even if you could still be able and willing to work in a lighter way. So as a whole, I see these type of solutions mainly positive from the worker point of view.

On the other hand, we are not changing the society, we are quite vulnerable related to personal data. It is not only that if heart rate would indicate some heart problem, measured by a device sending data to a cloud, you suddenly started to receive advertisements about heart related medication. Once you reveal some personal data, all kinds of commercial applications will attack you. The real problem here is that if the employer knows too much about you, (s)he can use it as a reason for paying you less.

#### EAB-4

The new tools can make workers concerned, and some will be reluctant to change their ways of working. They may end up thinking how I can use the new tools and how will they influence my work. A key question is how the new tools can be adopted as an integrated part of one's work and what kind of communication takes place. For people with disabilities, the new solutions may open new opportunities, if their needs are considered in the design process of the systems. For a worker with limited mobility, vision, hearing or cognitive abilities, this may be a means to offer more adaptive solutions.

#### EAB-5

The positive impact is significant. The main one is that the worker feels empowered, respected and listened to. Perceived influence makes people feel more able and competent. When you make the worker feel like a central part of the system, you raise their capabilities. Part of the reason why we don't do something is that we don't have the confidence in our competence. All the positives feed into each other; feelings of confidence, competence, resilience, feeling listened to and respected.

As for the negatives, this change, just like any change, may be interpreted with fear. This applies not just to the individual workers but to all groups. People are often suspicious of change even if the change actually ends up being good for them. People's fear of newness and mistrust of management might cause them to feel stressed, because newness entails having to adapt, assimilate and learn. Individuals might feel that they are not going to pick up a particular new thing, that they are not familiar with computers and dashboards, that they fear they will be embarrassed and humiliated etc. Some people catastrophise and spread a feeling of catastrophe, mistrust and unrest in a team. This is often a coping mechanism. Change can make both workers and managers feel exposed and vulnerable.

#### EAB-6

The impact depends on how the concepts are used in a workplace. There might be an initial fear that managers use the metrics to put pressure on workers. It is of course possible to use the concepts and introduce metrics in new, positive ways. We just have to make sure they are used in the way they are intended. Managers need to commit to using the concepts correctly in order to gain the trust of the workers.



As for the adaptive user interfaces, some clarification is needed. If a user interface is role-based and looks different to people working in different roles, it could get messy if one worker has several roles. Adaptive task assignment would be very welcome, not only in factories but e.g. in office environments as well. It would be good if the task assigning could adapt to the workload at hand and interlink related tasks instead of randomly assigning a task to a worker just because they seem to have time.

#### EAB-7

The concepts and their effect will depend on workers' skills and motivation to get involved in the process. Some workers may express resistance towards the approach, towards having their performance reviewed in detail and their behaviour monitored. Understanding the results of monitoring versus production metrics is important. It has to be carefully explained to the workers what the data is for, what is personal data, what is shared, and for example that the aim is to improve the balance between personal and professional life. The younger generations that are more eager to share what they do will see the concepts as more positive. More experienced workers may be more difficult to approach with the new solutions. The understanding of the skills and preferences of individual workers will be key for the success of the concepts.

#### EAB-8

If the information can be kept private to the worker, the worker will be happier and more productive. Happiness and health go together, so the health of workers also improve through less stress. This can be achieved if workers are less often asked to do something they don't want to do. At the same time, workers might have concerns about the company tracking their performance and comparing them to other workers. There might have to be some sort of guarantee that the data will not be used for direct benchmarking between the workers. Otherwise it might have an adverse effect on the worker.

#### EAB-9

There are a couple of levels to this. It is quite empowering and motivating for individual workers to be able to design their own work. Being able to design your own work also instills a commitment – 'I've said that I'm going to undertake this task in this amount of time, to these standards, to these performance measures'. The challenge lies in how you control the variation between the entire workforce and that community. Different people may or may not want to undertake work in different ways. That could be a challenge, but that's where the adaptive environment comes into play. How adaptive is adaptive? Can you take into account all the variation of individual workers' needs, but also individual workers' performance? The way you undertake a task could impact performance in that task in a number of different aspects. There therefore needs to be some thinking around how that variation in work still meets the objectives of the business and the management. There's an expectation that work is done to set performance levels in terms of task time, quality performance, cost performance. It would be interesting to find out how adaptive the systems can be and also how much variation in worker methodology and work design can be accounted for in these concepts. We might find constraints within that working environment – that you can adapt your tasks and your work, but it's within certain confines. Those limitations and the impact of those on the individual would also be interesting to understand, especially if there are specific dictated procedures. Engineering requirements guide undertaking tasks in a specific way. How will the workforce feel about having freedom to design work versus tasks that are dictated to them by engineering requirements.



### 5.1.2 Work community

#### EAB-1

The possibility of moving from one working position to another makes it possible to understand the process from a wider perspective. This may improve solidarity and the feeling of togetherness in the work place.

The dashboard may place people in a competitive setting, even if it is meant to be used only personally. Regarding biometrics, the information is surprisingly personal (steps, sleeping, heart rate), whereas work-related measuring is quite traditional. What if the work-related measurements were about training that the worker has participated in, the machines (s)he controls, the number of issues (s)he has solved, the number of videos or posts delivered to knowledge sharing, or safety related matters such as the number of accidents in the workplace?

Person related data is challenging – if the management in a workplace has a different view on the personal than the person him/herself, is it good that the managerial level sees more? It may raise suspicions; the worker may think that something is hidden from him/her. This may become a critical question in labour unions; for instance in Germany, an employer was not allowed to keep a record of what competences the workers have, so the idea of having a database filled with employees' personal information would be impossible there, at least at the moment.

#### EAB-2

The impacts depend on who has access to which data; whether one can see the data of co-workers or the whole factory at any particular time. The solutions might strengthen the community, for example if you see that someone is feeling bad today and help this person. At the same time, the impacts can also go the other way: You see that you are working more than another person, but you know that you do not earn more. This means that the solutions may lead to tension in the community. I think this is dependent on how the system is implemented, who has access to which part of the system and which data and what it is used for.

#### EAB-3

The impact on the work community is hard to evaluate as it depends on the size of the organization. Most work places in the metal industry (in Finland) have less than 20 employees whereas the largest companies can have 4000 people working. We can talk about a relatively compact unit such as a department in a larger company. If not only people but also machines knew that one person in a team is not feeling well, other team members could compensate his/her lowered performance with their own work. This is what currently takes place among employees of a small team, even without these new solutions.

The willingness to share work depends on how the salary is determined. If blue-collar workers get paid based on the work they perform in a team, so that the salary depends on how well the whole team performs, then people are willing to collaborate. The salary is the best motivator in this domain, unfortunately.



Machines can support human work. Media tells us that robotics and digitalization reduce the number of employees but I have seen the situation is quite the opposite; when companies have bought more robots and digitalized services, the number of employees has increased as well.

#### EAB-4

The impacts are dependent on the nature of the work community. The solutions are regarded as positive in an environment where workers are already familiar with digital solutions and user interfaces. If the work community is used to digital solutions, they are likely to find the use of new ones more beneficial. In more traditional manufacturing industries, adopting new solutions may take more time. There are work communities that are early adopters, and work communities that are late adopters. The impacts are dependent on the working culture, worker profiles and age structure of the work community.

#### EAB-5

In a workplace, successful training solutions constitute one factor that can have a positive impact on the entire work community. Letting the members of the work community video their work, giving them an app, making sure that they can easily share their knowledge within the community, e.g. in a WhatsApp group, enabling interactivity and posting of new ideas adds a relational aspect to it.

#### EAB-6

If individual workers find a better balance between their particular situation and their workload, the impact of the concepts is bound to be positive also on the work community. As the concept is centred around the individual, it is challenging to see the effect it would have at community level.

#### EAB-7

The overall impact on the work community should be positive – around 4 on a scale from 1 to 5. It depends on the individual skills, the preferences and the mindset of the group. It is important for the community to understand the importance of the balance between professional and personal life, which could be improved thanks to these concepts.

#### EAB-8

It is not clear how the dashboard will impact on collaboration. It seems like if everybody can choose what they want to work on and the tasks are assigned based on the preferences (including preferences on who to work with), that could be two sides of the same sword. It is not clear whether this will benefit collaboration in the community. Somewhere in this assignment model, both skills and preferences will be taken into account. Perhaps the model has to put more weight on the skills and less on the preference, so that the right set of people are assigned to the tasks so they can collaborate to achieve the goal. This could result in a positive impact in terms of happiness, in the sense that the workers get to work more on what they are skilled with. It is not clear how you capture the preference in terms of the kind of task that workers want to work on.

If workers get to choose what they want to work on, the outcome depends on the characteristics of the individual worker. Some people just want to stay in their own box and select a narrow set of things



that they want do. Others are more adventurous and flexible and would choose something a bit outside the realm of their skills. Sometimes when you collaborate you might want people who can think outside the box and who are not so immersed in a particular area.

#### EAB-9

If you take an approach that you need to reach consensus in how you do a task, that's a very powerful thing that people buy into – undertaking work in a particular way. There may be flexibility at an individual level, but if you talk about work being undertaken in a way that is agreed by consensus, it's very powerful and it would drive team work. It would motivate the team, and people are motivated to deliver the performance measures of the team rather than the individual. The worker community, then, is a really powerful thing. If you reach consensus in how you do things that drive a team mentality and a team methodology to consistently improve and meet performance metrics.

### 5.1.3 Factory management

#### EAB-1

The managing of the work will become different with Factory2Fit type of solutions. The whole process should become managed in a more collaborative and transparent way. One practical question, which should be answered, is how to perform those tasks (noisy, messy etc.) which everybody knows are unappealing.

#### EAB-2

Management could try to use this for beneficial purpose by improving the way the work is organised. As the management has huge incentives to maximize the productivity and the output, there might be a very strong temptation to use the system for performance management, seeing how workers perform and even their attitude. In a factory environment, it might be very tempting for managers to use this as a power tool.

The history of information technology has shown that once data is collected it is going to be very difficult to not use it for something else than its original purpose. If a company knows that the data is collected, it would be very tempting for them to try to get access to it for other purposes. A lot of regulation already exists in terms of data protection, but it may not be sufficient. For example, the system may anonymize data, but still the data may be used for purposes that are not in the interest of the data holders. The question is whether the regulation should take place at the organisational level, at the industry level or at the level of legislation.

#### EAB-3

Some future scenarios claim that managers will vanish from workplaces and workplaces start to manage themselves. This can be one direction of development and can already be seen in the metal industry. In a car reseller company, the mechanics were on strike last week as their tasks had been changed without asking them about it. They were supposed to not only repair cars but also do selling – this means that one worker category was removed and the tasks were transferred to the worker level. On the other hand, if work management could be successfully performed between a machine



and a good work team, that would be fine. The machine could act as a work supervisor when the application the machine runs performs work allocation. We know that human and machine do not always fit perfectly together but if it were an interactive system so that people could vote to accept, it would be good. The smaller the team the more important it is that everybody agrees.

#### EAB-4

In general, it is a positive impact that work can be designed, evaluated and targeted according to worker profiles. In virtual prototyping and digital concepts, a challenge is that there is a growing number of such solutions in the market, which makes it difficult to integrate them into the actual operative actions. In the higher management, managers are likely to welcome the solutions and see the benefits quicker than employees. Some may see the new solutions as a threat, some as an opportunity. An excessive amount of information may hamper decision-making, it gets too specific.

#### EAB-5

The solutions should make the managers' work much less time consuming. There should be no need to micro manage, to set strict rules and boundaries, to constantly monitor the workers or to boss them around. The solutions should instead enable cooperation in a more horizontal, less hierarchical way, more as a team. Any change process requires a lot of resources during the transition phase, and eventually, once it's done, it should make the managers' job easier, i.e. harder at first but easier in the long run.

As among workers, knowledge sharing solutions are important among management as well. Sharing knowledge with each other and having an open system of communication helps managers share insights and understand how other managers feel about certain processes and analyse issues that have arisen for them and their teams.

Fear may be experienced at all levels, including the managerial one. Managers might think that empowerment of the employee automatically leads to disempowerment of the employer. If there is a 'managers vs. workers' culture of competitiveness, managers (no matter how good they are) might think that placing the workers at the centre will give the workers a stick to beat the managers with. They might get defensive and reject change if workers are given the opportunity to point out flaws and inconsistencies. Most managers are inconsistent to some extent, i.e. do things differently depending on the worker, and some may feel that they are observed and monitored, and that there is surveillance on them.

#### EAB-6

It is the managers' responsibility to ensure the measures are used to improve worker wellbeing rather than to exploit the worker. It is of course also possible that individual workers learn strategies to avoid work and to cut their workload excessively. These are, however, probably rare exceptions.

#### EAB-7

The management will understand how personal life and professional life go together. The adaptive approaches in terms of humans vs. machines will be better understood by management. Some



elements of Industry4.0 are pushing forward, and the idea of better alignment of human intervention within the automated production environment is key for managers.

#### EAB-8

The concepts could make the worker happier, but it is not clear whether they will have a positive impact on the organisation long-term. Overall it remains to be seen whether the impact will be positive for the management. We will need data to see which way the pendulum is going to swing. You could have a mix of workers, and if the management let all of them stay in their own box too much it's not good for the organisation either. You have a concept about the training that will perhaps play an important role in terms of how you counter-balance this kind of preference. It may be possible to suggest some training to step up the skills of the worker in line with the company needs, and still keep the workers comfortable and happy. It's good to get the worker to choose what they would like to be trained on. Some of the training will of course be suggested by the management based on the company direction and the skills that will be needed to move the company forward.

#### EAB-9

Factory management have an expectation of performance and will therefore always be driven by performance. But when you get into individuals' adaptability and work design, and the empowerment of doing your work, there will probably be a difference between factory management's expectations and the output of this process. There needs to be a way of levelling up factory management expectation to the work design element. You have a range of performance levels, and all of them are acceptable to the individual. One person does his/her task in a different way, so you get a level of variation. It would be interesting to know how management understands that variation and interprets factory performance. The challenge would be, not necessarily the work design, but the factory management view on how that work performance should be measured and how variation is accounted for. For the team, the work community and the individuals, it is very much focused around a positive ethos: 'I want to do a very good job' or 'I want to do my task well', and wellbeing is a very important thing. At a management level, there may be more a slant towards factory performance, in terms of quality delivery metrics, etc., rather than worker wellbeing.

What the project is proposing is powerful. To link worker wellbeing to factory performance would change management's view, potentially. Worker wellbeing may be the right thing to manage if you're thinking around quality, performance, on-time delivery performance metrics, etc. If workers are engaged in their task they will make sure that they will get the job done, and they will get it done correctly.

### 5.1.4 Manufacturing industry as a whole

#### EAB-1

The manufacturing industry is currently changing as it is already identified that ICT related competences need to be increased. When thinking about how factory work will change in the future, the work environment must be made more attractive and the training needs to be changed too.



## EAB-2

If the solutions turn out to be beneficial, there would be competitive pressure to use them more broadly in the manufacturing industry. That raises a question of what is the level of industry that should be considered: regional, national, or even international. Are we looking at all manufacturing companies in the world? The solutions have the potential to be disruptive if their impact becomes significant.

## EAB-3

Research proves decade after decade that when employees are taken care of, they feel committed and motivated to work. One way to take care of the workers could be to take their working ability, skills and preferences into account. This, of course, requires that the management makes the workers commit. That can be accomplished by providing a permanent job and a proper salary. Many people working on the shop floor are not interested in career development – they live one day at a time, do their work, receive their salary regularly and if there is enough money, that is fine. The other things that they expect about life is going fishing or something else. Their ego is not built through work towards career or some fantastic objective, like the ego of middle-class-people may tend to be.

Many workers drift doing some work because they do not want to move from their home town. Local work is preferred. If acquiring education, it is because your mates have chosen the same profession. Of course people may like their work and may see it as meaningful, but usually they are not aware why they chose such a profession. If you tell a worker that you should develop your competences, he may wonder what is competence and why should he care about that. The ability to evaluate yourself requires tools, which many do not have.

The machinery in metal industry is often really old, due to that fact that most companies are small. The attitude among entrepreneurs is as if they were farm owners - “nobody tells me how I should run these things” – even when doing poorly, they just struggle and try to survive. They do not intend to go abroad or to increase profit – similar to the workers, they just want to survive somehow. Furthermore, few small companies have the possibility to be funded, banks are nowadays not eager to provide risk financing.

## EAB-4

When we think about a basic worker in the manufacturing environment, the question is how they start to utilise the system. The workers may think that even smart phones are not necessary. It may take time until this sort of solutions are regarded as positive. To foster adoption, usability of the solutions is crucial.

## EAB-5

The manufacturing industry is often seen as lagging behind, whereas other industries, such as tech and pharma, as seen as sexy and sharp, on the edge and project management led. In the eyes of many people, the manufacturing field is as a poor relative of the more branded, ‘googley’ industries. The manufacturing industry would therefore benefit from carving out its own high tech in terms of worker wellbeing. It can be difficult to retain staff and to get the right, smart and ambitious people on board.



Introducing and using science and tech to make the world of manufacturing best in class would therefore be good also from a PR perspective. The manufacturing industry would be seen as more appealing, more up to date and more modern.

#### EAB-6

The impact of the concepts on the manufacturing industry will be positive in general.

#### EAB-7

We are moving towards the Internet of Things (IoT), which is the ultimate vision for the production environment. The F2FIT concepts will bring improvements, and it seems that they can be applied to other sectors. At the moment, however, it is very difficult to say how applicable the concepts will be to other fields of production.

#### EAB-8

Overall, the concepts could increase the industry's productivity, and it could help make manufacturing jobs look more favourable. The solutions could show that manufacturing jobs can be satisfying jobs. This could increase the interest in manufacturing industry jobs.

#### EAB-9

The worker model, and wellbeing versus factory performance, will be a very powerful thing for the industry. We are very driven by hard data-driven metrics. We don't necessarily focus so much on the softer side, the people side of the production system. When we talk about the people side, we'll look at skills, capabilities and certifications, but we don't necessarily always ask 'how are you feeling today?' When you walk through an airport you have the 'happy face' or the 'sad face' option where they ask you how your experience was today when going through airport security. We don't generally ask people in a factory when they go out the door 'how was your experience at work today?' It's a very powerful thing to start thinking about focusing on the people side as well as the hard metrics side. Industry as a whole probably needs to start thinking about more of the softer side. We're very reliant on people and skills and they are essentially what make industry happen and factories work. We therefore need to make sure we have a motivated factory. And linking a motivated factory to factory performance would be a very powerful thing for the industry to understand.

### 5.1.5 Manufacturing related education

#### EAB-1

Regarding automation, ICT related training is needed as a whole, both in basic training and also when training those already working in the field. The training needs are such that companies can organise part of training together with other companies and company specific training is needed only partially.

#### EAB-2

As workers are subject to this technology, they have to be told what the new solutions are, how they work and how the workers interact with them.



## EAB-3

Next year, vocational education in Finland will be reformed so that one third of training will be given in workplaces. It is a challenge as it has not been defined how the training will be arranged, who will train, will the trainer be given some compensation (money) for training etc. Workplaces are different, so young people around the country and with different cultural background are not in equal positions. This is so much contrasting to education given at school as schools perform according to some standards and teachers are pedagogically qualified.

These Factory2Fit type of solutions could support learning at work, they could formalise the basic things that at least have to be taken into account and could support in building an individual learning plan. We must also remember that many of the students will have an immigrant background, with weak cultural and linguistic competences. Factory2Fit solutions could function with several languages and bridge the gap between people with different mother tongues. That is actually ingenious, when the same software can be read in different languages; people could communicate among each other.

Regarding learning at the work place from the work introduction point of view, this would be good as in large companies, there can be over 20 nationalities working together, subcontractors are used and workers constantly come and go. Apprenticeship type of learning could be realised with this system as well so that the young person could learn how experienced professionals perform by acquiring this through the machine. People also have different disabilities (deafness for instance), this could support workers to get job irrespective of them.

## EAB-4

These solutions are ideal to be used for education, as customization is important in learning. The solutions would help trainers and foster interaction between trainers and learners. The solutions would enable providing better ways to give feedback of the training and taking different ways of learning (e.g. auditive or visual learning style) into account.

## EAB-5

The solutions would have a significant impact on training as some of the traditional training models still in use today are quite outdated. There is a lot of useless training out there. Some trainers give lessons on a particular skill without having any knowledge of how to embed that skill and make it usable. Training is often unsuitable, not fit for purpose, and does not take the differences in learning styles of individuals into account. It is just presented in a very generic way. The F2FIT solutions on the other hand will be bespoke, worker-designed, worker-led, worker-trusting, workplace-based, upskilling and smoothing the process, so there is potential for the impact to be very positive. For training companies, the solutions may involve some negatives, as they will need to adapt and adjust their training approach.

## EAB-6

Training is a very important factor, and it influences the workers' motivation through an increased understanding of why they do their work and what the impact of it is.



## EAB-7

The concepts may help operators get trained and involved quickly at the beginning of their involvement. This is needed as novices are often not ready to take on all duties when they start. They are not 100% ready on Day 1. The impact is likely to be good when education is extended into the workplace and tailored to the needs of the production system. It is also very useful from the management point of view. Incorporating e-tools and the F2FIT concepts sounds great.

## EAB-8

Manufacturing education needs to be enhanced. Trainees would have to be trained to look out for themselves. There is also a need for some training to teach them to effectively use these kinds of tools to their advantage and their own effectiveness. The current workforce is not familiar with these kinds of tools and ideas where they try to adapt themselves. It would be good for them to learn about these tools as it will make their jobs more comfortable. They could get the support that is needed when they are not feeling well or when they are not performing well.

## EAB-9

It might change the way we look at designing the workspace. If you can find a positive correlation between factory performance and worker wellbeing, you could definitely get people to think about how they would design the workplace differently. Would it change education then? Yes, as long as we can provide a possible correlation between the two. What F2F is doing around the monitoring of worker wellbeing is also a great thing. We're really good at monitoring the performance of manufacturing processes, but we miss out on the human element of it. If we can somehow ingrain the fact that we need to monitor certain metrics around that worker in terms of their wellbeing, that's a different thing to think about when you talk about monitoring factories and driving the performance of the factory. If you had a worker who was educated more in terms of work design, how to do things more efficiently (versus just the man off the street) you would see a difference in the way that they design the task. Is education important for that? Absolutely. If we are going to rely on our workforce to design their own work, we need them to understand the principles behind designing that work. We need to think more about, not just how to do the task, but how to design your own task.

## 5.1.6 Society as a whole

## EAB-1

This will have a positive impact on the automation related conceptions. Presently the talk is quite negative, concentrating on how robots take all work and soon nobody has a place to work. With the Factory2Fit concepts, the perspective can be changed to considerations of how the new technology can support the worker, how the tasks can be made more interesting so that people could concentrate more on problem solving and matters requiring creativity. Research has shown that that digitalisation and automation actually do not replace any group of workers but removes some tasks from several worker groups.



## EAB-2

This is one further step, among many others, towards the more data-intensive and quantified society. Following the quantified self trend, fitness trackers and different sorts of technologies in the private use, the idea is now to move these sort of technologies to the work environment. Depending on what the technologies do in the work environment, they will have influence on technologies that are used throughout the society elsewhere. They have an impact on what is acceptable and what is deemed to be acceptable, and how this changes all the time. This is one part of a much larger development that we observe now.

If the solutions actually work, and if they do help people to work in ways and in environments that are more aligned with their preferences and with their abilities than at the moment, then that would be a positive impact. However, the negative impacts are at least as obvious and much more easy to envision than the positive ones.

## EAB-3

When talking about change in the division of labour, Emile Durkheim stated it is a question of moral change in larger perspective – it is a question of changing mind-set in a profound way. Digitalisation will cause this type of change, it will affect our way of thinking about work, working and work practices. It will not collapse the class society but may produce a new ordering in it.

## EAB-4

When the workers have learned to use the system, and start to observe factors related to productivity and one's wellbeing, reflecting this data on the design of one's work may become meaningful. At its best, a new system may enhance productivity and well-being, but it will require active use of the system. A company can support this with an encouraging company culture and providing training to support using the new solutions. Currently the organizational cultures vary; there may be a box for new ideas in the factory, and it may be used or not. Both the management and the workers need to understand the purpose of the solutions. Then, the solutions may become integrated in the actual work, and do not be left as something extra. It is important to provide training and let workers spend enough time for adopting the solutions. As an example, one company offered its workers fitness tests and a prize for the worker who will improve her fitness test results most during one year. The company showed that it cares about its workers wellbeing and set a long enough period for following the metric.

## EAB-5

There are too many variables to be able to measure the exact impact of the solutions on society, especially during the lifetime of the project. There are plenty of cause and effect factors, plenty of correlations and plenty of mediating variables and interferences. Doing little tiny bits might have a large impact in the end. It would be interesting to introduce a measurement model during or after the project. By comparing manufacturing organisations that F2FIT has and hasn't worked with, you can try to detect potential differences in the work climate, culture, collegiality and emotional resilience of some of the workers. The impact is also likely to have a knock-on effect on workers' private lives.



EAB-6

N/A

EAB-7

Society is changing on a daily basis. We see change all the time and new mindsets and approaches are defining people. New generations are more adapted to new tools. Young people like to be measured in terms of their competence, preferences, skills and internal strengths. All these concepts will be accepted by the young in today's society.

EAB-8

If these solutions can go beyond the manufacturing industry, and apply to office workers, the impact would be positive for the whole society. If we are talking about the manufacturing industry alone, and if we assume that these kinds of concepts will help increase the productivity of manufacturing and also increase the satisfaction on the job, we will have happier people in society, which will also be better. Manufacturing is the backbone of any economy, so if there are more manufacturing jobs in the economy, it is also better for society.

EAB-9

If we can have a positive outcome in terms of the workforce's wellbeing, it's going to have a positive aspect on society. The more we can make people happy, the better. If you have a positive and motivated factory that would definitely rub off on the environment. If you are doing well at work, you are happy at work and potentially happy in your home environment. In general, you don't bring the worries of work home with you and you have a positive home life and therefore society benefits from that.

### 5.1.7 Supporting positive impacts/minimizing negative impacts

EAB-1

It has to be accepted that not everybody will change according to changes at work. Usually, new workers are open for change, and in every work place there is usually also the person who wants to develop – they are the people to participate in designing new ways of working.

As a whole, when presenting these new ideas, openness is important. Workers must be explained why these new solutions are employed and what they are used for, what the target is. As a starting point, monitoring and measuring provoke negative feelings so it is important to highlight the good intention behind these solutions. The discussion should clarify what new can be created with it, such as improving safety and making a machine do such (boring) work, which a machine can perform better than a human. This is also a possibility for the workers to affect this change as now the solutions are developed, now is the time to design them to support workers as well as possible.

EAB-2

Assuming that this kind of technology will be introduced, there will have to be agreements on how the system can be used, and how the data can be accessed and used. That would have to be discussed before the system is implemented and that would need to be reflected on why it is being implemented



and used. For example, the question who gets access to which data, needs to be very clearly defined before the system is adopted at the workplace. If the workers, for example, do not want to share some of the data, the level of agreement would have to be defined prior to the actual implementation of the technology. To protect employees, this sort of technology might call for regulation. In addition, according to data protection principles, everybody should have access to the data that is held about them.

EAB-3

I do not know. I want to see how this works in practice first.

EAB-4

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EAB-5

Positive impacts need to be supported and reinforced in order for them not to extinguish. Factors leading to a stop often include a lack of maintenance. Regular follow-ups are therefore necessary. Positive impacts could also be supported through leader behaviour. It is important not to choose leaders solely based on their level of seniority, but on attitude, motivation, and on a voluntary basis. Also, people tend to fall back on the easiest way, so it is necessary to engineer the system so that the easiest way is the right way.

EAB-6

Managers need to make clear what purpose the measures serve. They need to commit to the aim of increasing worker wellbeing.

As I understand it, there will be a mechanism that reduces the workload of a worker who is stressed or overworked. If a worker pretends to be stressed in order to avoid work, it might be worth considering measures such as medical checks, which might discourage faking and bring balance.

EAB-7

There are always some risks, but at the moment the risk level is hard to judge. There are so many different elements that may create a positive impact of the concepts that the risk of not succeeding is minimal.

It is very important to explain to experienced workers that sharing knowledge is not against them. They might fear that they will be made redundant if they share their knowledge. It needs to be explained that if they share their knowledge, they have an opportunity to get other functions within the company or to get promoted, or better allocated for future tasks. It's a question of how we create other parallel systems so that we convince the experienced workers of the fact that the impact will be positive rather than negative.

EAB-8

There would have to be some sort of formal agreement on paper, a strong promise from the management, that the worker can be sure that somebody would be held accountable if that data is



used in an un-promised way. It could be a contract stating that the data will not be used in a particular way.

#### EAB-9

It is very much down to being able to prove a correlation between worker wellbeing and factory performance. If you are able to correlate that worker wellbeing absolutely gives you a 10% performance improvement under certain criteria, you will be able to prove to industry that if you give workers flexibility in these areas, in these inputs, you get a positive factory outcome. To make sure you are tracking that journey in terms of driver measures, if you monitor or you consider understanding worker wellbeing in these areas, you can correlate worker wellbeing to output. That is a very powerful model to be able to share with industry. That's the important piece – the correlation between worker wellbeing and factory performance and the drive for worker wellbeing.

#### 5.1.8 Summary of the results - societal impacts of the concepts to empowering workers

The solutions were seen empowering as they contribute to the feeling of confidence and competence, and they can improve the balance between personal and professional life. The solutions can make work more versatile and flexible, and ease adapting work to people with disabilities. The amount of variations in work can be limited by business objectives, though. There is a threat that the solutions can become tools of suppression if the information gathered is misused, e.g. to compare workers. It may be tempting to managers to use the solutions as power tools. Commitment of the management to use the solutions only to the agreed purposes is needed to gain the trust of the employees.

The EAB members emphasized the differences between people at the workplace. Not all want to be active, and some prefer staying at their familiar box, without any interest in competence development. On the other hand, the active ones may feel that they are just supporting others and do not get anything to themselves. There may also be people who try to find ways to misuse the systems. An employee that is taken care of, is committed and motivated to work. The Factory2Fit solutions can have impact on this, even if the main caretaking actions are a permanent job and a proper salary.

Having more variety in work tasks can increase understanding of the whole work process, thus improving solidarity and the feeling of togetherness. Already now, team members tend to compensate the momentary lowered performance of teammates. The Factory2Fit solutions would support these existing practices by helping to identify and share with others lowered performance. The feedback dashboard may create a competitive setting and tension, if people start to compare their results even if they are not officially shared. In addition to mere work performance, the feedback dashboard could indicate e.g., activity in training and knowledge sharing or following safety guidance, thus motivating good practices and communicating that successful work consists also of these elements, not only work performance. The competitiveness between individuals could be reduced by keeping the measures on team level, motivating the team to continuously improve their performance metrics in collaboration. The solutions should be integrated in actual work processes, rather than being something extra. Whole work communities can be early or late adopters of new solutions.

Gradually, the solutions could replace managers, and work teams could start leading themselves with the technical tools, which act as supervisors helping in task allocation. However, human management



may still be needed e.g. to tempt people out of their familiar boxes and start developing new skills. When factory management gets an insight of the link of worker well-being and factory performance, and the link of motivated factory and factory performance, that can have many positive impacts in adopting the solutions.

In the future, vocational training will increasingly take place at work places. Factory2Fit solutions can support this, e.g. by adopting training to people's different learning styles. If workers start to design their own work, these design skills should be taught to them.

At the societal level, the empowering worker solutions can be seen as one step towards a data-intensive and quantified society. The EAB members foresaw young people as the early adopters of the solutions.

When presenting the new ideas at workplaces, openness is important. It has to be accepted that not everybody is eager to change according to the changes at work. Before the solutions are implemented, it should be reflected why the system is implemented and for what it will be used. Data access rules should be agreed well before the implementation.



## 5.2 Impacts of the concepts to engaging the workers

### 5.2.1 Individual workers

#### EAB-1

When participating in the development work, work becomes more meaningful. Workers have the best insight about the bottlenecks in the process and when these experiences are utilised, the efficiency of the factory will improve as well.

Presently, when a new employee comes to the site, usually the same, experienced person is dedicated to train the newcomer. Then only his/her best practices (and worst practices!) are transferred to new workers. With knowledge sharing, the expertise of several people is involved and training becomes more versatile. The best incentive is the development of work community and the meaningfulness of work. External incentives tend to lead performance in a wrong direction.

There should be encouraging measurement for delivering information. If knowledge sharing is not supported, it is not self-evident that experts want to share their knowledge. A company should be cautious in delivering information about the output of the factory as shifts easily compare their output with the output of other shifts. This can lead to workers withholding information instead of sharing their expertise with all colleagues.

#### EAB-2

Many people would like to see a bigger ability to influence on the way they work and because of that, the solutions are very likely to be welcomed.

#### EAB-3

Differences among people are relatively large. Manual workers are not necessarily conscious what they can accomplish or what kind of tacit knowledge they are using, so understanding how to help others is even harder. Furthermore, work does not necessarily bring in situations where demanding problem solving would be needed. I already described how this could function in team work at its best, then the capabilities of an individual would be better taken into account perhaps and the distribution, as well supervision, of work could be autonomous. This is hard to answer as so much depends on individuals.

#### EAB-4

There seem to be many positive impacts. As one can foresee the future utilizing a virtual model, it strengthens the individual's feeling of safety. Already now, virtual models are often used in designing new spaces, which helps getting an overall image of a space before it exists. In solutions, where one can give comments or feedback to the system, the accessibility issues are relevant. Often these systems are designed for people who are not visually impaired, and they cannot be used in alternative ways, e.g. with a tactile writing system (braille) or with audio. Virtual solutions may improve accessibility by engaging also people with impaired mobility, as one does not need to go to the actual environment to be able to participate.



The impacts of knowledge sharing solutions seem to be very positive. Already now, people are used to sharing many kinds of things on Facebook, which has e.g. a community for female entrepreneurs or a forum for recycling. The same idea of knowledge sharing can also be applied in the work context; it seems easy to approach and easy to use for anyone.

EAB-5

This question seems to focus more on specifics whereas the previous question was more general. My answers here would therefore be almost the same, because it is all part of what was said before – of empowering and upskilling, of placing the worker at the centre. This applies across the board, so there is no need to go through each one individually. Wearable devices, fitness and well-being seem to be emphasised across the board these days. People see the benefits in getting fitness thinking in during work time. They get steps in and fitness related feedback - apps and different technology that allows them to synthesise or bring together their personal and professional side. People will be interested once they see that there is something in it for them, not just as a worker, but as a person. People often like to get well-being related data (feedback on pulse, heart rate, number of calories burned). The impact can large when the approach is solution-focused.

EAB-6

In terms of work satisfaction and motivation, it is important to make workers feel that they are included in decision-making etc. It is hard to comment on the engagement aspect without seeing the tools.

EAB-7

If we are able to involve workers at an early stage of a process preparation, we get much better results, and systems are optimised at an early stage. The concepts will definitely have a positive impact.

EAB-8

With this kind of approach, the worker can feel more respected and have a better self-esteem, and that would of course lead to greater job satisfaction.

EAB-9

Every individual wants to share their experiences. When people are asked to help share their knowledge, many will positively work towards that (and some may not). The more you can share and standardise that knowledge and understand the way work is undertaken allows you to better design work in the future. It's a very positive thing. And it's really going to be down to the individual in terms of their engagement in that process. In the past, the methods that we used for knowledge sharing can be looked upon at a couple of levels. There is the 1-1 knowledge sharing (training the trainee), which is the traditional method of passing knowledge down the line. When you start to capture it, you start to move away from this 'Chinese Whispers' – this ability to sometimes adapt it. You have passed it down the line two or three generations and you have probably got a different way of doing a task, because people have adapted it over time. When you capture it in a way that knowledge is retained without being changed or adapted, it's more firmly captured. The converse thing to that is if certain individuals have different ways of doing things, so you never know the best way of doing it. But if you



were taking an individual-to-individual approach to training, sometimes things will naturally work towards the best way of doing something.

### 5.2.2 Work community

#### EAB-1

When workers understand better the functioning of the whole factory and the various inputs and outputs involved, it will make the work more flexible and will improve the performance of the work community. Mutual understanding can increase and the development ideas can emerge more efficiently when the focus is wider than the one of one's own location.

#### EAB-2

If the individual workers can contribute to the design of their work, this could change the ways the community interacts. Presuming that the tools allow sharing knowledge and making things visible, the tools already include a community component by nature. The potential outcomes would be more positive working environments, including the work community.

#### EAB-3

This could enhance democracy at work and ease supervision of work. In many Finnish industrial companies, especially in small but why not in large companies as well, work has become project based. Like in a shipbuilding yard in Turku, where there are currently three ships being built. Three simultaneous projects, which are in different phases and workers transfer from one location to another. Materials are no longer stored, it does not pay off. Factory2Fit solutions will support the planning of project based work and will ease transferring people from one project to another. This is also related to the education reform. In the future we will not have car mechanics but maintenance masters who can do everything from repairing cars to serving customers. People can stay at the same workplace as they will possess so many skills, needed in various projects.

Regarding knowledge sharing, there is a challenge as shop-floor workers represent culture, which talks and performs. A lot depends on the abilities of producing and receiving knowledge in written form. Additionally, we have those born in 50's to whom the usage of a computer can be difficult. Not everybody has an e-mail address, even if the state may soon require it. There is stiffness, which takes its time.

#### EAB-4

New ways to share information and one's expertise are likely to have positive impacts. Continuous development and generating new ideas are important targets, and usually, there are not too many channels for that. From the perspective of participatory design, these kinds of tools are a positive matter, and the possibilities to give feedback using several channels is an issue of equality.

#### EAB-5

In a workplace, successful training solutions constitute one factor that can have a positive impact on the entire work community. Letting the members of the work community video their work, giving



them an app, making sure that they can easily share their knowledge within the community, e.g. in a WhatsApp group, enabling interactivity and posting of new ideas adds a relational aspect to it. (same as in 5.1.2)

#### EAB-6

The work community is where the biggest benefit is gained. By getting individual workers to share their knowledge, the entire work community benefits. People are intrinsically keen on sharing knowledge. Communities with a competitive atmosphere may be exceptions, as workers in such places might prefer to keep an efficient work method to themselves in order to beat the others etc.

#### EAB-7

It is important to engage the work community in the production process as early as possible. Even before it starts, at the very early stage of planning. It is important both in terms of maintaining the knowledge within the company and sharing it with the new, unexperienced workers. Gone are the days of having an isolated group of experts preparing the best solutions. Now multi-skilled groups and workers together define optimised production cells with the working environment. Even strange ideas may be developed. The impact will be positive both for worker development and for management that will understand and use the hidden knowledge of workers, by having them brainstormed etc.

#### EAB-8

It would have a great impact on the worker community. When people start sharing knowledge, it always makes it better for the community. If you have provided good tools, and people are not inundated with information, there is no reason to expect negative impacts. Today, paradigms of computing are based on search. You have to have very good search engines for the knowledge sharing tools. If you just let people share and upload information without offering a way to discover the knowledge, it may be useless. That is the only potential risk. There could be a situation where the management needs to provide some sort of incentive for people to share their knowledge, at least to begin with. It could depend on the culture and on whether people would be happy to contribute and satisfied with the fact that their knowledge is getting used or adopted.

#### EAB-9

There needs to be a better way of sharing information and sharing knowledge. An ability to give people an accessible knowledge base of how to undertake tasks would be of benefit. There would also be more of a sense of community in terms of work design. We can look back on history to see what has worked and what hasn't worked. The key point for knowledge retention and knowledge capture is the methods and means of doing that. A lot of the time we will revert to an Excel spreadsheet, which isn't necessarily the best way of capturing knowledge. It would be very interesting to see how the knowledge capturing processes/tools develop in the F2FIT project. That is a really key challenge especially for the manufacturing industry. How do we make knowledge accessible to people? It's a really difficult challenge, because when knowledge is passed down individual-to-individual, it is easy, it is a conversation. When we talk about a community, capturing that knowledge becomes more challenging.



### 5.2.3 Factory management

#### EAB-1

The general change of mind-set, according to which workers are more involved, the “leadership as a service” concept comes along. Then the experts (workers) tell how things should be done and the management of the factory should enable that change and, if it is not possible, explain in a transparent way why that idea is not realisable.

Some control must be exerted over worker-originating procedures and hints. It is possible that some working model is efficient as such but is against safety regulations. If this is the case, the feedback should be given to the worker in a constructive way, explaining the situation in such a way that it does not paralyse the person in question.

#### EAB-2

It would potentially flatten hierarchies. On the one hand it would help managers to create a better working environment and thereby hopefully increase productivity. On the other hand, it would mean that some of the traditional managerial tasks might be delegated to the systems or to the community. For example, the design of training would no longer be done top-down, but bottom-up. That is something that some managers might welcome and lot of them probably would not.

#### EAB-3

The effect on factory management depends on the size of the company. In many small companies, the lead does not have better education than the subordinates. Nowadays, in bigger companies, there tends to be in the managerial level engineers with a university degree, but in many small companies there is the managing director, some people in the supervision of work and about 20 employees. These companies are not comparable with each other. If there is a so called goodie in a small company, that person can see this as an opportunity but even then, there must be both willingness and ability to invest.

#### EAB-4

A challenge from the employer’s perspective is to keep the time used for sharing information reasonable, to define how much time can be used for that and how much time must be left for basic work tasks. Using the tools must not become as important as the actual work. One challenge is how the management can utilise the new ideas and put them into practice.

#### EAB-5

One potential challenge might come up with the management in large organisations that are already up and running. If they already have their premises with systems and the overall design already in place, how much participatory design are they going to be willing to adopt? They might take on board smaller parts, such as co-design related to the seating the colours or the height of something.



## EAB-6

Middle management may resist change to some extent as they may feel that it is their job to come up with better work methods etc. If a worker below them in the hierarchy comes up with an idea, they may feel threatened, like the worker is stepping on their toes.

## EAB-7

Management will give the concepts their full support, because engaging the workers is something they do on a daily basis. Applying the concepts will allow them to get as much as possible from workers. Another important aspect for the management is the knowledge sharing and properly maintaining knowledge in the company. Knowledge that is not written in the process plans but that is hidden/tacit needs to be available to future workers. In today's world where the turnover of workers is fast and people move around to look for new opportunities, it is important for the management that knowledge stays within the company or the production facility and gets passed on to future operators.

## EAB-8

The tools have to be good. They cannot be just be a knowledge taker. They need to be knowledge creators as well. They have to have good support for knowledge discovery. You have to have a good search engine that goes along with it. The better it is, the better it will be at reducing this potential negative impact. Workers should be able to find what they are looking for very easily. It has to be as simple as typing in search words – just like you type in the Google search. It has to be really smart and has to go beyond Google search. Within the same company, everybody is using the same lingo. Different semantics used in the communication is therefore not a big issue. The UI has to be simple. People type in what they are looking for and they get what they need. The UI for sharing the knowledge has to be simple, but behind the scenes it has to be smart at categorising the data. Because at least in the US, factory workers are not very patient or good at using tools to capture information. They tend to just want to capture things in the natural language and use a lot of abbreviations, particularly when it comes to having to type something in. It might be better to have some kind of voice recognition technology instead of people typing in what they want to share, or voice-based search.

Participatory design will have a positive impact, particularly if the management succeeds at resolving the different ideas that the workers may have. This will make the workers happier about their workplace and the things that they do in their jobs. The potential negative impact is that it could take longer before the management can get things going if there is some new thing that needs to be done. Receiving input from one worker and resolving potential differences between other workers may slow things down. People may have different ideas about the design of the work environment.

## EAB-9

It will be seen as a good thing, because factory management absolutely want to know the best way of doing things. It would also be very powerful for them to understand different people's perspectives on how tasks should be done. It's very powerful for engineering management, so it will surely be



looked on as a positive. It is also a means to retain knowledge. Ageing workforces and the challenges we face in manufacturing are quite stark, especially in the UK around the aerospace industry. Capturing the knowledge of the baby boom generation and passing it down to the younger generation will be viewed as a very real issue. F2Fit is a really important project in terms of best practice in the factories, etc. That goes for the manufacturing industry as a whole as well.

People are different when it comes to sharing knowledge; it depends on what motivates the person. E.g. if I'm motivated by money and I'm the only person who knows how to do a task, I'm not going to share my knowledge because I want to be the person who gets overtime payments. But you might have someone who's not motivated by money, but motivated by teamwork instead, and will absolutely help everyone in the business and is motivated by the team doing well. It's very much in terms of the psyche and you might find that it differs from country to country as well. There will be some national biases in terms of culture, etc.

#### 5.2.4 Manufacturing industry as a whole

##### EAB-1

The impact will realise through individual factories and companies. If work profiles change, the whole industry will be involved in discussing e.g., how to organise education. This kind of discussion may not get started but it would be useful. It is possible that other issues will be involved, such as legal matters or data protection. Especially the measuring of personal matters (biometrics) is related to worker acceptance and this discussion should take place in the manufacturing industry as a whole.

##### EAB-2

If the work will actually become more emancipatory and engaging, which would improve the output and the quality of the work, that would lead to competitive pressure on other companies to copy the solutions, which might change the way that the work is done in the industry as a whole. However, this is a very optimistic view of the world. In the past, there have been several attempts to improve work and emancipate workers, but the attempts have not survived. Scandinavia may be an exception, but in the rest of the world, they have not seemed to be successful.

The reason why the engaging solutions have not succeeded may have a lot to do with simple and straightforward considerations of power; people who have power tend to be very reluctant to share it. As an example, in the automotive industry in the 70's, some companies changed the manufacturing processes into small team environments, following the ideas of work enrichment and worker empowerment. Workers got a lot more say on what they did on the assembly line. Then, in the 90's, the assembly lines were made much more straightforward again. As they were simplified, the jobs became more boring, and workers were overqualified. However, as this allowed paying workers a higher wage, they did not resist the change and seemed to be happy with it.

The interesting questions are who drives this sort of development, whether it is purely financial, what are the motivations and where does it end up. Those are big social questions.



## EAB-3

The automotive industry has been across the years the domain in which new ideas have been first realised. The textile industry is the oldest one, starting from spinning jenny, but in Henry Ford's factory, there was even a Dept of sociology. It sounds like the one at the university but in the factory, it meant a unit for social care, workers were taken care of. So I think this cannot be generalised to all industries. In the automotive industry, these solutions could work, they have the need and the money, they export which means a lot, and they could become excited about this.

One thing to remember is that nowadays, big companies do not have their own departments for Human Resources but they have externalised that service. That externalised department provides training for employees. According to a study released this summer, about 51 % of the Finnish industrial companies have used agency workers. Many of medium-size workplaces are using agency workers because work is organised as projects and there are peaks during which temporary labour force is needed. This is a remarkable change – everything possible is externalised and companies focus on their substance capabilities. Companies may not be willing to invest, as it would require the employees were bound to the company. When providing a permanent job, employees would commit themselves to work, and they would be motivated and capable. This is a simple scheme, but it just does not work in practice.

## EAB-4

There is a lot of discussion on the decreasing number of jobs in the manufacturing industry due to the increase of automation and digitalisation. It is important to invest in education, as the contents of jobs are changing. The students should understand what their role can be in the industry in the future, and what kind of expertise is important. There is a lot of talk, but it would be important to be able to connect this to one's own career path.

## EAB-5

Same as in 5.1.4

## EAB-6

All in all, the impact will be positive, even in competitive parts of the industry. The impact will be achieved through the adoption of better, more efficient work methods.

## EAB-7

An engaged community is creating a special opportunity for its members. It is easy to change company, jobs. With this new mindset, the community is more flexible and prepared for changes. The only constant today is change. If we manage to change properly and train ourselves and adapt quickly, we have more freedom to do what we want to do.

## EAB-8

The manufacturing industry could be more stable and have fewer problems with shortages of skills. People might feel better in the sense that they feel like they can move from one company to another



because they can get definitely get trained for joining other companies. If this was to lead to a higher turnover rate of workers, it may involve some degree of adverse impact to individual companies.

The concepts would mean that shortages in skilled workers pose a smaller risk, since the knowledge is captured, there are invaluable training materials available and people can be trained and get up-to-speed quicker. The key is that there has to be some incentive, potentially to encourage workers to make good training material. They may feel like they don't want to share their skills because they don't want to be replaced. It is compensation-based. If a regular factory worker is to do it, it definitely elevates their responsibilities. The company has to be willing to pay them more. The workers are not just responsible for the day-to-day job anymore. They are responsible for the future of the company. A salary increase or profit-sharing solution would work well. One example of such a company environment would be Toyota, where they reward the workers who contribute to the continuous improvement of the factory.

#### EAB-9

As mentioned, it is not just commonplace; it is needed. Industry needs it. Because of the current demographics of industry, there is an absolute need to capture knowledge today of a certain profile of the workforce, to make sure that their competency isn't lost.

### 5.2.5 Manufacturing related education

#### EAB-1

Education should include the possibility to bring new matters in it, such as problem solving skills. It would be good to have cases in which real problems are solved. Learning factory is one possibility; in it, students from various levels of education are solving together some real problems. Usually, many areas of expertise are needed, such as product design or improving a process. This type of training is looked forward to at least in part of the industry.

#### EAB-2

Adopting these solutions successfully requires a cultural change. In a company where people are not empowered, if you want to empower them, they have to change their approach to work, which may be difficult. Getting people to take ownership on what they are doing, putting their ideas forward and putting them to practice, is difficult. Education would have an important role to explain to people what they are expected to do and their role. Change is always difficult to achieve.

#### EAB-3

Vocational education has already been talked about so it will not be repeated here. Then there is also training provided by the employer. Interestingly, people do not consider the training provided at work place as training. If the employer asks the employee to study the usage of some tool, it is considered as a task and not as training. People have versatile opinions about training; some find it fun, others think it is killing. To make training meaningful for employees, it should be rationalised by telling how it is worthwhile, what it means and how it builds the work community.



#### EAB-4

Sharing solutions are a big question. Do the universities in Finland have the latest results and knowledge on the future digitalization and automation? When we are aware of the solutions developed elsewhere, we can utilise this knowledge here as well. See also the previous comments related to education (5.2.4).

#### EAB-5

Same as in 5.1.5

#### EAB-6

Educational videos that workers can create, produce and share are excellent. They are a great tool that workers can use to share their knowledge and train each other.

#### EAB-7

Extended and fast track in-house training for newcomers in the company is important. The concepts should get people involved to understand the culture and production environment. The transfer from the education system to the company life where the work is is positive. We should be able to convert concepts into a system that supports development, education and training through the company on a daily basis.

#### EAB-8

Training is likely to provide a very positive impact. If it is done well, the worker will potentially think about the ways to doing things in a more methodical way, which could lead to a higher quality of the product. The workers on the shop floor are actually often the people who best know the nitty-gritty detail of the technique for doing things. They have a lot of tacit knowledge. This will allow the company to really capture a lot of tacit knowledge if they can get the worker involved in this training material. It will also help the company be able to deal with the turnover of workers. One scenario would be: a worker creates training material. The tacit knowledge gets captured. Something happens and the worker leaves. A new worker takes over, and thanks to the training material, will get up-to-speed better than if using training material developed by outside consultants or by the management.

Workers would need to be trained on how to make good training material, on different ways of creating this training material and on how to use the knowledge sharing tools. They need to be easy to use and very intuitive. Workers need to get training on different software packages that can be used. Introducing VR for the training concept would definitely require special training on the creation of that kind of material.

#### EAB-9

With everything you capture in terms of knowledge, you need to turn that knowledge into realisable outputs. An interesting point that would be good to understand would be 'we've captured this knowledge, and how do we now interpret that knowledge into a useful output?'. There may be conflicting ways of doing something, so how do you take that knowledge and say this is what we think is the best ways of doing something? You want to train people, but if there are two conflicting



suggestions in that knowledge pool, how do you say what the most relevant knowledge is for a specific task? The analysis of that knowledge and the definition of an output would be useful.

## 5.2.6 Society as a whole

### EAB-1

Need for education is the central link to society. Education and re-education are societal matters, society has the role to provide that.

### EAB-2

In the ideal world, this development would be an example of demographic society put into the workplace. If these solutions were adopted, empowering workers to influence their work would be mutually beneficial to the political system and economical system, which would then be more aligned.

### EAB-3

According to research over decades, it has been shown that those who are active in one way are active in all ways, and then there are those who are not interested at all. I think that the connection between an individual and the society is weakened. This is connected, I think, to the current individualized culture. If these Factory2Fit type of solutions would awaken somebody to realise it is possible to affect matters at the workplace, it could be reflected also in the society as an activating factor. That would be great.

### EAB-4

Participation from outside the workplace becomes an opportunity, when the tools are as accessible as possible (cognitive and technical accessibility) and easy to use. This is essential for the older workers in particular, as they have a lot of tacit knowledge and expertise. It is important that they do not become scared of the digital platform.

### EAB-5

Same as in 5.1.6

### EAB-6

The impact will be positive. There are so many things that affect everything in society, however, in here the impact will be confined to a small part of the society.

### EAB-7

It is not clear how overall society may benefit directly. In a sense, we improve society through extending education into companies. For the current generation, it is clear that constant learning and gaining experience is as important as our basic needs, such as a home, food etc. Once we have those



secured, education comes next. Society gets more prepared, more flexible and less dependent on what has been done in the past.

#### EAB-8

Society will be better in the sense that the manufacturing workers will feel better. The division between blue-collar and white collar will become greyer. Overall, people in society will feel that they are more equal. The impact of the concepts will basically be that the blue-collar workers take more responsibility in terms of creating the company's knowledge.

#### EAB-9

A positive workforce is a happy workforce, is a happy society. The more you can engage the workforce, make them feel valued, the better society becomes.

### 5.2.7 Supporting positive impacts/minimizing negative impacts

#### EAB-1

The question of incentives is a tricky one. It should be remembered that training and the change in mind-set are important. The dashboard could be used for rewarding initiative activities; in some companies, initiatives are rewarded already so that some system may exist already for that.

#### EAB-2

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#### EAB-3

Nothing can be induced by force; and activation, as a concept, has got a negative tone. To make people participate in common efforts people will need more carrots, not sticks. One central motivator for shop-floor workers is money. It does not exclude the possibility of finding a job interesting or enjoying the social aspect of having workmates. The social aspect is especially important for male workers who often continue regularly meeting each other even after retirement.

#### EAB-4

The solutions must be easy, possible to integrate as a part of one's work, and such that the management will be committed to them. The more the tools are used, the more positive the impacts will be. The adoption of the tools needs to be given time and the tools must not be changed too frequently (the tools to be used must be carefully selected).

#### EAB-5

Positive impacts need to be supported and reinforced in order for them not to extinguish. Factors leading to a stop often include a lack of maintenance. Regular follow-ups are therefore necessary. Positive impacts could also be supported through leader behaviour. It is important not to choose leaders solely based on their level of seniority, but on attitude, motivation, and on a voluntary basis. Also, people tend to fall back on the easiest way, so it is necessary to engineer the system so that the easiest way is the right way. (Same as in 5.1.7)



## EAB-6

The positive impact of the knowledge sharing solutions could be supported by making the tools as user-friendly as possible. If you don't put down and share your thoughts and ideas immediately when you come up with something, you simply forget or don't get around to doing it. If the tools are made easy, the chances are higher that the knowledge will end up being shared.

## EAB-7

The riskiest part is the potential skepticism towards knowledge sharing solutions. Experienced workers may consider that if there is no parallel system that gives them the opportunity to get promoted or elevated within the company, the worst-case scenario would be: "If I share my experience, I will disappear soon". This leads to resistance to sharing knowledge. To ensure a positive impact, parallel systems need to be considered.

## EAB-8

N/A

## EAB-9

Through tools and methodologies to capture knowledge, to interrogate that knowledge and to disseminate that knowledge into actionable outcomes. Rather than an Excel spreadsheet, we want a knowledge-based system that helps to design work for the future. Whatever those tools and processes are would be very interesting as a positive outcome.

### 5.2.8 Summary of the results - impacts of the concepts to engaging the work community

Knowledge sharing tools will increase reliability of the advice shared, compared to passing knowledge in line worker to worker, where the content tends to distort at each step. Motivation is very important in knowledge sharing. Generally, people are willing to share and help each other but if they start feeling that they are giving and never being rewarded, it may lower the motivation. It is also important to get constructive feedback how the ideas and suggestions are taken care of, and why they are or are not accepted, is important feedback to the employee. The worker feedback dashboard is one opportunity for monitoring activity in knowledge sharing and could be used for rewarding initiatives as well.

It is important to consider how the gathered knowledge will be analysed and shared further, and what kinds of search tools will be needed, to get full benefit of the knowledge for the company. Factory floor workers represent a culture of talking and performing. The transformation to textual knowledge sharing may be challenging.

Many people are motivated to have more possibilities to influence the way they work, so Factory2Fit solutions that introduce new channels for continuous development and generate ideas, should be welcome. Seeing the future with a virtual model will strengthen the individual's feeling of safety. Virtual solutions may increase accessibility e.g. for people with motorical disabilities.

In the past, engaging solutions have not always succeeded because people who have power tend to be reluctant to share it. The solutions may challenge the management as e.g. training would become



increasingly bottom-up and some traditional management tasks might be delegated to machines or the work community. Especially middle management may feel threatened. At its best management could get powerful information to understand different people's perspectives.

There are also agency workers at the factories. For them the targets of engaging may be different and maybe not so tempting if they feel that their role is anyway temporary at the work place.

An engaged work community is flexible and prepared for changes. The workers feel responsible not only of the daily performance but also for the future of the company. However, the workers may be more ready to change jobs even to another company, because they can rely on the possibilities of learning at work.



## 5.3 Overall impacts

In this section we are reporting the foreseen impacts of the overall Factory2Fit solutions on productivity, meaningful work, attractive workplaces, safety, as well as sustainable and responsible industry.

### 5.3.1 Human achievements and productivity in manufacturing industry

#### EAB-1

When better development ideas are acquired through engaging the work community, achievements and productivity improve. Especially small but important renewals can be made. Automation and digitalisation can support in getting rid of unsafe and repetitive human work so that human potential can be used in inventing new solutions.

#### EAB-2

If the project manages to collect the right data on the worker, which would allow understanding how they are working, and how they could be working better, the solutions might lead into increasing productivity. A likely outcome is that the solutions could also be used for performance management, which, from the perspective of the company, might actually increase productivity. It might be something that the company would see positive, whereas the individual worker might not. There can be negative fallout.

#### EAB-3

Productivity increases when employees are committed to their work. It would be good that people got some compensation for raised productivity – the duration of working day could be shortened for instance, without reducing salary. Technological development is a means to reduce working hours without lowering salary as then the competence level required has raised. Calculating and understanding of productivity will then change, when people start to understand that cost/person is not the only way to assess productivity.

#### EAB-4

In the end, the impacts seem to be positive. When one can visualize things in advance, also manufacturing can be planned better. Implementation of actions and sharing knowledge becomes easier, and more people can have an impact on planning. In implementation, considering more issues in advance saves money. Simple tools for monitoring results work, as what is monitored, often starts to improve. An important matter is that the responsibility of productivity is given from the employer or management to the worker.

#### EAB-5

The link between performance and wellbeing is very important. Most of the research shows that there is a real link between people's wellbeing and their performance levels. The link is not direct though, and there are many mediating factors. Productivity can be increased through three means:



1. elevating the workers' mood i.e. mood enhancement through respect, listening etc. (soft side),
2. knowledge sharing, which is not done enough today,
3. upskilling and worker-led training, by giving workers easier methods of working by using technology and communication tools.

Generally speaking, if you increase well-being, you increase performance. Wellbeing hence leads to better productivity on the whole. For some people, increased focus on wellbeing can lead to a slight decrease in productivity (while they are enjoying the wellbeing flush and lifting their feet up), but this is usually temporary. Increased productivity is therefore not achieved by making people work longer hours or through lunch, but by making them feel that they are worth more and by elevating their mood.

#### EAB-6

The objective of participatory design and task planning is presumably to increase worker satisfaction and wellbeing. Increased worker satisfaction and wellbeing tend to lead to increased productivity as well. There are some pitfalls however. If a team under a lot of stress has their workload decreased, this won't automatically lead to an increase in overall productivity. It is important to find the solution to the cause of the stress. The F2FIT solutions are therefore one tool among many, but not the only solution to increase productivity. Stress may be caused by inappropriate task assignment, so adaptive task assignment should help.

#### EAB-7

If the system is able to support people with various skill sets and experience, and is able to share the experience and maintain it in the companies, it will definitely support human achievements. It could be e.g. productivity, it could be measured differently, but the manufacturing industry will benefit from the concepts. It may depend on the sector. The splash effect might be investigated in follow-up projects in the future. In the future, we can try to understand how different sectors, such as the automotive or aerospace sector, or the shipbuilding industry, benefit from certain F2F applications.

#### EAB-8

This is going to be a collective impact from the earlier questions. The solutions will definitely have positive impacts on productivity. They will definitely have a good place in the factory of the future. As mentioned earlier, improving worker satisfaction will elevate their self-esteem; it will reduce the risk of the manufacturing industry having shortages of skills. These aspects will collectively increase the productivity of the manufacturing industry.

#### EAB-9

If you get a happy and motivated workforce, you will probably theoretically see a productivity increase. If we can link worker motivation (and what influences worker motivation) to productivity, that is a key output of the project. An increase in worker wellbeing will influence productivity.



### 5.3.2 Meaningful work

#### EAB-1

When people do not have to do simple, repetitive work but get tasks requiring human initiative and problem solving, the work becomes more meaningful. People will understand better what is the role of their own work in relation to the entity of work at the factory. Everybody should understand the importance of one's own work and usually, it will require the understanding of the entity (in this case, factory-wide processes).

#### EAB-2

This could lead to a positive outcome; by allowing people to influence what they are doing, the activities may become more meaningful. It could also go the other way, and increase pressures. For example, in call centres in the UK, there is a large overview of how successful everyone has been on a particular day, how many calls they have made, how many contracts have people agreed to etc. This sort of technology can be used for very similar things, to compare all your workers, and have immediate feedback to performance measurement. If that is done, it might be the opposite of more meaningful work. The work would be less meaningful, people feel more pressured, put themselves under pressure, and feel pressure from the outside. It would have very detrimental effect.

#### EAB-3

It would be great to hear you possess some qualifications you are not aware of. Likewise, it would be fine to see that you can teach other people, that you can bring benefit to other people. These Factory2Fit type of solutions make it visible.

The concept of shared workplace means a workplace with employees from several companies. It is possible that these people do not even speak the same language. If Factory2Fit solutions can bridge the related gaps, solidarity in the workplace would be increased and cultural frictions decreased. It would also be fine if this enhanced the willingness of the employer to invest on human capital. Then the employer would have understood how important it is to motivate the employees and make them committed to the work.

#### EAB-4

The aim of meaningful work can be supported by listening to people through participative solutions. Adopting these kinds of tools is a statement in itself. Indirectly, it gives an experience that one's own work is meaningful.

#### EAB-5

The solutions could and should be supportive even if they don't alter the actual work or specific tasks very much. Not all work has much meaning intrinsically, but any work can be given more meaning through contexts, situations, teams and projects. Being heard, listened to and respected brings meaning. Work often feels more meaningful when one's ideas are being taken into account, one is being offered goals, feedback and stimulus. The solutions can build meaning through change, through



allowing for self-management and self-development. A workplace where you can build relationships and the social side of work is taken into account is meaningful. Relationships form the main reason for people enjoying their workplace. Reimbursement is often secondary, once the worker is paid enough to do okay. Feedback from other people in the workplace and from others outside the workplace for working there is also important.

#### EAB-6

The sense of meaning comes from understanding one's role within the bigger picture and from feeling part of a community. This is linked to the training aspect, as training supports understanding.

#### EAB-7

All the proposed solutions seem to support the engaging of the work community. By engaging the workers, you allow them to become a central part of the company and the system, and to get a better understanding of what is being done and why. This is also linked to the training aspect. It is important to communicate the overall goal or corporate goal to the factory floor. Work in isolation and pushing buttons is not how people want to spend their daily lives. Therefore, the more we can involve the worker, the better. Improving the health and safety aspects is also very important, and improving the image of the company as a company that cares about well-being. These are factors that support the aim of a meaningful workplace, and this aim will be achieved without a doubt.

#### EAB-8

It is not clear if the solutions will enhance that aim significantly. Factory worker usually already see that their work is meaningful because they produce something tangible. They are usually already proud of the product they create and of the particular skill that they contribute. As for the other aspect of the factory environment – not the design of the product but the aspect where the worker gets to contribute to the designing of how the product should be made – that might help increase the feeling of the work being more meaningful.

#### EAB-9

As you start looking at the work design, you understand what people feel is meaningful work and what people feel is an additional burden of the process. Workers may focus more on the meaningful work and there is less focus on the work they don't believe is important when you consider the work design. If workers put a lot of effort into one area, you will see that they feel that it is meaningful. If there are elements of the work that need to be done but aren't really focused upon, you could probably correlate to a level of meaningfulness to those elements. It could be that the level of effort in terms of work design by work element may give you a correlation between meaningful and un-meaningful work.

### 5.3.3 Attractive workplaces

#### EAB-1

Companies would like to make factory work more attractive for those (young people) not working there yet. Companies like this type of solutions: work is more digital, it is not just winding the screw



and sitting in one position. The new ideas should be outlined, described and piloted so that the new way of thinking is apparent – like in this project.

#### EAB-2

If it turns out that the system does enrich the work and does empower the worker, then the work would be attractive to many people, not to everybody but people who seek to control their own lives. The solutions could be something that a company could use in advertising.

#### EAB-3

The current challenge in the metal industry [in Finland] is that people do not find it as attractive work. The situation could be improved if the employer paid a proper salary and provided permanent jobs. Still, manufacturing work is not a working class dream. At the moment, young people dream of becoming from nobody to a star, like happens in TV shows like Idols. However, if the work is not very hard, it is properly paid and the job is permanent, it would attract people differently.

One affecting factor is the availability of work. Shop-floor employees do not want to move to get work. For instance, last year (2016) there were 105 available student positions in two big industrial towns near each other in Finland and only 33 people were primarily interested in those positions - I don't know how many of them finally participated in the entrance examination. This year, as there is work in this area, all student positions were filled. This also explains why women in metal industry have such a poor salary. Women tend to do women's work, and if hairdressers and waiters end up in the metal industry it is because there is work available in the vicinity, they do not have an education and can only do simple work. There are women in younger generations who have the appropriate education and they can be the prevailing experts in the company. This is not the situation among older women, and there are still a lot of these older women working in the metal industry.

#### EAB-4

The solutions may attract young people in particular, and brain capacity even from abroad. A hype of new technologies may attract young people, but it may drive older people away, if they are afraid that new tools are complex and difficult to use. Usability and ease of use can be means to attract people who are not that used to digital solutions.

#### EAB-5

Young people of today are educated and feel more entitled to be listened to and respected and to have an input than older generations. Older generations are used to entering at the bottom and to only expect respect and progress after many years. For an industrial environment to be attractive as a workplace for young people today, it needs to have a 'brand', be inclusive, have a social element, be fun, up-to-date and progressive, with a focus on tech, fitness and mental health. Young people do not want to be bossed around. These elements need to be promoted as central parts of the culture and climate of the factory. This makes workers feel part of a tech enhanced, wellbeing oriented family and allows for reversing the bad image manufacturing has in the eyes of many young people. One needs to pay attention to the words and language used, not just as an aspirational mission statement.



## EAB-6

As for the attractiveness, young workers might not see the change as they don't have anything to compare to. They don't know how things were before. Companies need to build wellbeing aspects into their company culture and sell them to young people.

## EAB-7

These are all new concepts. For the majority of the community, the concepts would increase the attractiveness of the workplace. There are some risks, however, but it is up to the F2FIT partners to sell the concepts in a way that emphasise the final result and goal of the project rather than steer the focus to the potential risks. The overall attractiveness of workplaces would increase with these concepts. The understanding of how personal life affects professional life should be easy to visualise through the solutions. The young generation is very likely to accept and embrace them.

## EAB-8

Companies that adopt the Factory2Fit solutions will definitely have the benefit of being more attractive workplaces. Any worker would be happy to hear that they can provide meaningful feedback to the company and to the management about their work. The opportunity to provide ideas about how to improve the work environment will have a positive impact in the eyes of the workers. The Factory2Fit solutions (e.g. dashboard and worker participation) will significantly impact the attractiveness of the workplace.

## EAB-9

A motivated workplace and an interesting workplace is an attractive workplace. The more that you can motivate the workforce, the more attractive it becomes. It speaks for itself that if you don't have a motivated workforce, you don't get a buzz in the factory, and people are less inclined to want to work there. You can correlate worker wellbeing to positivity. If you have high levels of wellbeing, you could probably think about correlating that in terms of industry or factory attractiveness to workers.

### 5.3.4 Safety aspects

## EAB-1

It is possible that wrong advice will be given. The challenge is that wrong working practices may get spread. A way should be found to remove certain types of instructions, advice and hints, instead of always removing the ones made by a specific person. The reason why the advice is not feasible should be given, the ways to improve should be described, and the safety aspects should be raised more often. If having dyslexia or colour blindness, the possibility to make an error can be diminished by taking it into account in adaptive systems. Also when a novice is in question, more instructions could be provided for working to increase safety.

## EAB-2

If you give individual workers, who actually understand what is happening at the workplace, a voice, they may highlight safety issues. However, a collaborative activity that allows the community to set their own standards, so that they can design their own work, might also be blind to safety issues.



Overall, in this case, the impacts are more likely to be more positive, as people who actually do the work could highlight safety concerns.

#### EAB-3

I do not want to repeat the importance of privacy matters here [regarding personal measurement], they handle such things that the person in question is not necessarily aware of him/herself, even. Another perspective is that when there is a lot of data, it becomes big data which can be utilised to evaluate risk factors in human work. If there were such work, which is not good for the human, it would be reflected in this data. Such risks could be eliminated, then.

#### EAB-4

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#### EAB-5

There are often safety challenges involved precisely in the process of change. Change makes people have to rethink how they do things, and it leads to people making mistakes at first. It is common for people to over-attend something and under-attend other factors while adapting to something new. This is why it is important to introduce all change gradually, incrementally, bit by bit, including the F2FIT solutions. It is important to highlight safety critical aspects in advance, e.g. if someone is working on a dangerous machine. Engineering aspects need to be factored in and analysed. Ultimately, change will make things safer, but it is tricky at the start. It is important to introduce change in a positive way, and when done correctly, safety improvements have a tendency to pan out (i.e. a partial improvement improves the whole system).

#### EAB-6

New work methods that are found to be better and more efficient than earlier ones are not necessarily safer. If we do something faster than before, there might be safety risks involved. This is something that needs to be taken into account. In terms of risk prevention, the way safety at work is taught usually depends on the company culture. If someone notices that a measure involves a safety risk and comes up with a way of eliminating that risk, the solutions might improve safety aspects.

#### EAB-7

Safety can be supported by allowing the workers to see that 'If I rest well, I will perform much better'. A good rest vs. work balance will improve the safety aspects. It depends on the production environment. We may add some safeguards to production lines with risks. Overall safety challenges will be addressed through the final results of the project. We need to look at specific cases we are dealing with in the project in order to be able to say more about safety.

#### EAB-8

Performance monitoring can enhance the safety of the worker. The increased worker responsibility to create training material and share knowledge could enhance the safety of the worker. The workers are familiar with the potentially hazardous situations in the workplace. As for the knowledge sharing tool, the idea has been discussed in the form of social networking tools in companies. When it comes



to the shop floor, this has to be done correctly and made sure that the tools don't distract the workers while they are on the job. That is perhaps the only potential safety issue. Training material created by a worker has to be reviewed by safety experts. If some knowledge is shared without being complete with a safety precaution, it could be hazardous.

#### EAB-9

It's a level of both. One is in terms of people's knowledge about safety systems and regulatory requirements. They need to be very much fixed, because we can't alter something that's dictated by regulation. Safety restrictions around regulation is absolutely paramount. We can't alter the way we do it without the right authorisations. The other way to look at it, however, is if workers are concerned about a process, it allows them to raise that concern within the work design. There are two sides. One is maybe people feel it's restrictive (because of regulation), but on the other side it allows people to highlight their concerns. It will therefore give people the possibility to raise safety concerns, but also, if they don't properly understand the regulatory requirements, they may feel constrained by those. It can be seen from both sides. Regarding adaptation, for each method of working you need the right level of risk assessment. It may become an administrative burden if you have too many ways of working, because within the workplace you obviously have a requirement to undertake hazard assessment, etc. And if you have lots of ways of doing it, the level of hazard assessment increases. There might, in other words, be some level of administrative burden on the safety assessment process.

### 5.3.5 Sustainable and responsible industry

#### EAB-1

Different people can work and the age or physical limitations can be taken into account by the machine. It will affect the company image. Employees are an important informant in the industry.

Companies have to act in a responsible way. A central challenge is that the company does not use these solutions just for taking advantage of the workers, demanding more work without any benefits. This concept is so easily turned into monitoring and pressing the worker instead of good changes in work. This discussion has to be performed to avoid this bad and unintended type of future.

#### EAB-2

Assuming that the solutions work the way they are intended to work, then the level of responsiveness of the organization towards its workers as a key stakeholder group will be increased. That will lead to sustainability, at least internal economic sustainability in a sense that it is likely to keep the workers happy and it is likely to improve the retention of workers.

#### EAB-3

I would like to raise the issue of work span. It would be good if the Factory2Fit solutions could compensate the physical and psychic capacity of a human being during his/her work career. Much work is performed as pairs – it would be good if people of different age and competences could work together and compensate each other, either temporarily or permanently. The Finnish culture



emphasises individual performance, and the other option seems to be a group. Why not perform in pairs or in a small team; that could even be the most efficient option. When knowledge is shared within the small team, it does not leak outside.

In addition to human capital, there is the ecological aspect as well. When work is performed in a new way, also processes can be renewed so that they become ecologically more sustainable. For instance, in a shipyard, the ultimate cruisers are built to process water so that dirty water goes in and clean water comes out; they are organisms which do not pollute. This tendency exists also elsewhere in the industry. Anything can be developed when communication among people is developed in this [Factory2Fit type of] way.

#### EAB-4

Sustainability is often approached from the environmental perspective, but there is also an aspect of social sustainability. When people can participate more and when their diverse needs are better understood, the design supports equality and thereby socially sustainable development. In addition, when also well-being is measured alongside productivity, it tells about responsibility. In some industries, the responsibility issues have been challenging, considering both the environment and the workers. Utilising virtual solutions is also an environmental issue, as it decreases the need to build and re-build solutions.

#### EAB-5

The proposed solutions need to be kept going, otherwise they won't sustain. For most solutions, sustainability needs to be built into software and other tools, and it is important to develop tools and bridges that can be used by organisations, to introduce e.g. redoing, at different times, and make reinforcing new things easier. Biases need to be disintegrated, as people tend to be dragged to the past (from habit, we will e.g. keep writing 2017 in January 2018).

Sustainability and responsibility in industry are closely linked. Workers need to feel that they matter. They need to be given a broader, deeper vision of what's happening in the company, more input and more responsibility, and they need to be let be in charge of things in their field. At the same time, companies need to be careful not to overpromise.

#### EAB-6

The wellbeing aspect seems to be well represented. What about environmental liability? It feels distant in Factory2Fit. Surely the knowledge sharing tools could be used also for reducing waste (losses).

#### EAB-7

The solutions that aim to maintain the knowledge within the company and extend training solutions to be offered in the workplace support sustainability and demonstrate that the employer is responsible and takes care of all daily aspects of the wellbeing of the workers. The solutions will support an image of a company that looks after the staff and applies certain solutions to get not only improved perceptions of the workplace but also improved worker satisfaction. Transferring the knowledge definitely will support and improve the sustainability of the industry.



## EAB-8

The ability to monitor the workers' health and performance, and provide support to the worker makes the manufacturing industry more responsible. The possibility for workers to also provide feedback in terms of the kind of things they want to do and the kind of workplace they want also increases the view of what the responsibility to the worker should be. The idea of co-designed training material and knowledge-sharing will of course sustain the industry with workers who have skills to produce high quality products when older people retire. All of this definitely contributes to the sustainability and responsibility of the industry.

## EAB-9

The ability to make sure you have a positive workforce and people want to stay is important. If we look back to the past, people used to have a job for life. When people started a job, they would probably retire in the same place. Now we are moving to a time where people are becoming more mobile, they are willing to travel and change jobs more, etc. There are two levels of sustainability. One is the ability to capture knowledge and adapt for the workforces. Those people change and you will be able to capture their knowledge and what they have learned as people move between roles. There is thus a level of sustainability, of adapting to the new way that people work. The other level of sustainability is that if you generate a positive environment, you may find that people move against that trend. If they are happy, engaged, interested and empowered in their work, they may want to stay with that business for longer. One way is retention of people and the other is the ability to manage that retention churn.

### 5.3.6 Additional impacts and comments

## EAB-1

Workplaces will change more meaningful but not everybody perceives work in a similar way. The change that is supported in this project is not a meaningful change to every worker, at least before the change in mind-set is made, and before own work role is transformed bigger and more demanding. The ability to contribute to building a better work place is not self-evident, part of employees are developers and part are not; and the continuous development is a never-ending cycle.

## EAB-2

The systemic side of things is one impact. At this point, the project work is focused on the individual companies and factories. However, the impacts could extend to the relationship between factories, e.g. a company with several factories could start to e.g. benchmark factories against each other, which might bring interesting relationships. Another issue is the big data analytics side of things. If this data is lying around somewhere, it might be used for big data analysis and combined with other data sets, which may be used for many purposes. That might lead to e.g. health benefits; if the data is linked to patient records you may be able to have an early warning system, where you can identify workers that are more likely to get a heart attack in next three weeks. Also e.g. an insurance company might want to have an access to the data, to identify major life insurance risks. Then, on top of all that, there are security considerations, in particular in national security. After the latest terrorist attack, the police might come to the factory and say that give me all your user data on who was asleep at the time of



the attack. This means that limiting the view on the individual factories is not enough; you need to think this in broader way. Somebody has coined the term greasy data; the data is very slippery, difficult to keep in your hands. That is something to be considered here as well.

If you are going to implement your system in a factory, and then the data leaks out, you cannot say 'oh, I didn't see that'. There are no easy solutions, but one of them would be to think, not only about the access control mechanism and about the security of the data, but also deletion of the data. This makes some of the misuses impossible. The whole data life cycle need to be thought as part of the work you are doing.

EAB-3

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EAB-4

These kinds of solutions would also fit to the sector of health care. Health care personnel could benefit from empowering solutions, as the workers are often stressed and working under strict requirements. Also participatory tools, especially for giving feedback and utilizing virtual reality, would suit to the sector of health care. Today, the solutions are not close to personnel, but support management in analysing the fluency of the work. The perspective of the actual workers and experts could be considered more.

EAB-5

I do think there will be additional impacts as there are always unforeseen circumstances. This applies to both work and life in general. You anticipate certain consequences, but things might take a different direction. It is important to be prepared for that. The impact can be studied a quarter of the way through, halfway through etc. The consequences for all parties can be studied, including potential competition among employees. It is always advisable to try to avoid conflict between people, because conflict is not progressive.

EAB-6

Knowledge sharing solutions in combination with thematic information campaigns could have a positive impact. Sharing knowledge about a certain theme, e.g. the importance of turning off lights in the context of energy saving could be encouraging and work also in the manufacturing environment.

EAB-7

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EAB-8

The only potential problems related to the knowledge sharing and training material have to do with the issue of how to make the worker contribute their tacit knowledge. They may be afraid that their job will be automated once their knowledge is documented. That could be a potential issue. At the



same time, if that knowledge is going to be documented, there is an opportunity for the company to automate some of the work that is performed by the worker. It could have a positive impact on the company in the sense that some work can potentially be automated, and with some more analysis, it could also increase the quality of the results. The health impact could also be good in the longer term. The workers may stay in the workforce longer. They will not be overworked and they will be subject to less problems from repetitive working syndrome, because their responsibility is going to be diversified. Workers will be able to do other things, such as producing training material, and perhaps collaborate with the other workers to do some of the workplace design.

#### EAB-9

The key point is linking worker wellbeing to factory management's expectation and helping industry to understand the link between worker wellbeing and factory performance. A lot of industries are metrics-driven (automotive, aerospace, etc.). It's all about the bottom line and about meeting targets. Sometimes the way we drive the business to meet those targets could have a negative impact on worker wellbeing and engagement. A higher-level education process for factory management would be really important. If you can correlate work design adaptability to wellbeing to factory performance it's a very positive thing. I don't think we ask enough 'are you happy with your work and the way you're working?' Getting industry to think slightly differently around the work design side would be important, i.e. how that impacts wellbeing and performance. There might be something around education of management in regards to that. It would however need the evidence to substantiate that proposal.

#### 5.3.7 Summary of the results - overall impacts

The EAB members thought that the Factory2Fit solutions would increase productivity, based on the link between well-being and productivity. Well-being consists of many issues such as self-esteem, engagement, commitment, motivation, mood and development possibilities. Factory2fit could contribute to widen the understanding of the fact that productivity increase will not be achieved by longer working hours but by appreciating workers, and elevating their mood. If a work team is under stress, lowering their workload may not increase productivity. However, identifying the cause of the stress and focusing on better task assignment can both remove the stress and increase productivity. Productivity increase can also be achieved by better understanding people and how they work, and developing work to better take into account the various skills and experience of people. A negative impact could be that Factory2Fit solutions would eventually be used for performance management, which from company point of view might increase productivity, but at the expense of worker well-being.

Already today, factory workers often see the meaningfulness of their work as they are working with concrete things and they can see that their work contributes to brand products that they can be proud of. Seeing the entity better and understanding one's own role in the production process would increase the feeling of community and meaningfulness. When people get rid of unsafe and repetitive work, get tasks requiring human initiative and problem solving, and can influence on their work, they will feel their work more meaningful. Being listened to and respected also brings meaning, as well as getting feedback, learning positive things of one's qualifications, and noticing that one can bring benefit to other people at work by teaching and sharing knowledge. Adapting Factory2Fit solutions at



a workplace will be a statement in itself, it will improve the image of the company as a company that takes care of its employees. This will make the employees feel that their work is meaningful.

A possible negative impact to meaningfulness may be created if management starts to use the systems to compare workers and performance management. This should be avoided. Data tends to be "greasy" - once created it is difficult to keep in hands. This should be kept in mind when developing solutions that are gathering personal data; it should be ensured that the data is only being used for the intended purposes. The whole data life cycle, including deleting the data, should be designed carefully.

The metal industry may not currently feel very attractive as a career option for young people. The EAB members thought that the hype of new technologies may attract young people but it may also drive older people away. That is why the ease of use of the new solutions is crucial. Young people do not like to be bossed around, and they may be the early adopters of well-being measures. So the adaptation solutions might be well accepted by young workers. The workplace has to have a brand, it has to be inclusive, it should have a social element, be fun and up-to-date to attract young people. It has to be kept in mind that a large part of the work force is currently agency workers, and the basic factors for attractiveness: proper salary and permanent job may be missing.

Factory2Fit solutions for knowledge sharing and training may have negative impact on safety, if they spread unsafe working practises. The workers themselves may not realise the safety aspects, so the worker-generated guidance should be moderated for safety issues. All changes may cause people making mistakes in the beginning, so safety aspects should be studied in advance. New tools, e.g. based on augmented reality, should not distract workers from their main tasks. If workers are allowed to introduce various parallel ways to carry out a job, each of those should be studied for safety. On the positive side, personalised instructions will help especially novice workers also in safety issues. The easy possibilities to raise safety concerns would increase safety. The big data gathered can be utilised for evaluating risk factors in human work.

The EAB members thought that the Factory2Fit solutions would support the aim of sustainable and responsible industry by compensating the physical and cognitive capacity of the employee during his/her whole work career. Caring about the well-being of the workers, openness and participation possibilities that support equality will demonstrate that the employer is responsible. The solutions can also support environmental sustainability by using virtual designs instead of physical prototypes, and by letting the employees to contribute to the design of ecologically more sustainable processes.

All developments may also have unintended and unforeseen consequences. It is important to be open to see these kinds of side-effect possibilities early, to be able to react.

The most important thing is to help the industry to see the link between worker well-being and factory performance. The workers should be asked much more often "are you happy with your work?", and the answers should be taken seriously.



## 6 Results of the impact questionnaire

At the end of the interviews, the interviewees filled in a questionnaire to assess the foreseen impacts of Factory2Fit concepts on productivity and work satisfaction. The results are shown in Tables 3 and 4. Most interviewees saw moderate positive effects with all the six concepts, with small variation towards some positive effect and strong positive effect. Only one respondent saw negative impact with one of the concepts (productivity with adaptive manufacturing process). Overall, the expectations seem to be high for all the concepts to be developed in Factory2Fit.

### Productivity increase

Concepts to empower the worker	negative effect	no effect	weak positive effect	some positive effect	moderate positive effect	strong positive effect
Worker dashboard			X	XX OO	XXXXX	X
Adaptive user-machine interaction		O	O	XX	XXXXXX	X O
Adaptive manufacturing process	O			X	XXXXXXXX OO	X
Concepts to engage the work community	negative effect	no effect	weak positive effect	some positive effect	moderate positive effect	strong positive effect
Participatory design			X O	XX OO	XXXX	XX
Knowledge sharing			X	XX	XXX OO	XXX O
Learning at work				XX	XXXX O	XXX OO

Table 3: Foreseen impacts on productivity (x=EAB member, o=Factory2Fit industrial partner)



Concepts to empower the worker	negative effect	no effect	weak positive effect	some positive effect	moderate positive effect	strong positive effect
Worker dashboard		X	X	X OO	XXXX O	XX
Adaptive user-machine interaction		O	O	XXXX	XXX	XX O
Adaptive manufacturing process				XXX	XXXX OO	XX
Concepts to engage the work community	negative effect	no effect	weak positive effect	some positive effect	moderate positive effect	strong positive effect
Participatory design		X	O	X	XXXX OO	XXX
Knowledge sharing				XXX	XXX OO	XXX O
Learning at work				X O	XXXX O	XXXX O

Table 4: Foreseen impacts on work satisfaction (x=EAB member, o=Factory2Fit industrial partner)



## 7 Conclusions

The Factory2Fit project has proceeded to a stage where we have studied thoroughly industrial requirements as well as technical enablers, and based on the studies we have defined two categories of adaptation concepts - concepts to empower the worker and concepts to engage the work community - three sub concepts in both categories. We have assessed the concepts for foreseen impacts by interviewing the industrial project partners who will be piloting the solutions later in the project. We have also interviewed the nine members of the project's External Advisory Board, who represent different expertise to support the project.

The results show that the industrial partners think that the project is proceeding well towards the industrial impacts expected in the project plan: increased adaptation, work satisfaction and increased quality.

Well-being at work consists of many issues such as self-esteem, engagement, commitment, motivation, mood, feeling of confidence and competence as well as development possibilities. Empowering the worker concepts have potential to contribute to work well-being, and they can improve the balance between personal and professional life. When work is developed to better take into account the various skills and expertise of people, productivity can be increased. Monitoring workers is however, a new and complex phenomena with several legal, ethical and company policy considerations. Respecting worker preferences will improve the relationship between the management and the workers. Worker who is taken care of is committed and motivated to work.

An engaged work community is flexible and prepared for changes. The workers feel responsible not only of the daily performance but also for the future of the company. Seeing the work entity better and understanding one's own role in the production process would increase the feeling of community and meaningfulness of the work. Bottom-up created concepts have good potential to be accepted by the work community. However, it is important to make sure that the workers get benefit of the new practices to motivate them to adopt the solutions. Knowledge sharing tools may on one hand increase the reliability of the advice shared as knowledge is not passing in a row from worker to worker. However, worker initiated advice may also be wrong, or the workers may not realise the safety concerns related to their suggestions. That is why moderation of the knowledge sharing is important. Constructive feedback to the workers is important for motivation. In addition to mere work performance, the Worker Feedback Dashboard could indicate activity in knowledge sharing and training as well as following safety guidance, thus encouraging good practices. In the future, vocational training will increasingly take place at the workplaces. Factory 2Fit solutions have good potential to support that.

The workers are different in many ways, including also their willingness to be active and to contribute. There are many agency workers at the factories, and they may feel their role as a temporary one. It should be studied how the Factory2Fit concepts would suit them. When people get rid of unsafe and repetitive work, get tasks requiring human initiative and problem solving, and can influence on their work, they will feel their work more meaningful. Being listened to and respected also brings meaning,



as well as getting feedback, learning positive things of one's qualifications, and noticing that one can bring benefit to other people at work by teaching and sharing knowledge.

When factory management gets an insight of the link between worker well-being and factory performance, and the link of motivated factory and factory performance, this can have many positive impacts, and it will boost the adoption of the solutions. Taking the solutions into use is a statement as such, and improves the image of the company as one that takes care of its employees. However, the solutions can challenge the management, also. The adaptation solutions may gradually start replacing managers, so that work teams supported by task allocation tools could start leading themselves. Training can take increasingly place bottom-up, without management control. These changes may be threats especially for middle management.

There are also threats that should be kept in mind. A negative impact could be that Factory2Fit solutions could eventually be used for performance management, which from company point of view might increase productivity, but on the expense of worker well-being. It should be considered whether work performance should be monitored on the level of individual workers, or would it be more beneficial to monitor only team performance. Data tends to be "greasy" - once created it is difficult to control how it is being used. The whole data life cycle should be designed carefully. There will always be ways to misuse technology to other purposes than was originally intended. All development may have unintended and unforeseen consequences, so it is important to keep eyes open for those.

On a societal level, Factory2Fit solutions can be seen as one step towards data-intensive and quantified society. Factory2Fit solutions could support the aim of sustainable and responsible industry by compensating the physical and cognitive capacity of the worker during his/her whole work career. Caring about the well-being of the workers, openness and participation possibilities that support equality will demonstrate that the employer is responsible.

For wide adoption in the manufacturing industry, the benefits of adaptation should be made visible. It is important to create a good story to explain how Factory2Fit concepts will create work well-being and how working with higher motivation, faster and with fewer errors will increase productivity.

The results of this impact assessment will be utilised in the Factory2Fit project to refine the concepts and in designing the industrial pilots. The results also include important issues to guide the exploitation and dissemination activities of the project. The impact assessment will be repeated at the end of the second project year and at the end of the project.



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## 9 Appendices

### A1: Interview questions for the industrial partners

*Background: Please describe your professional background in manufacturing field. How long have you been working in the field? In what kinds of roles?*

Based on the F2Fit concept definition work by now, we would like to return to the impacts foreseen in the project proposal. In this interview we would like to get your feedback about the progress towards the foreseen impacts.

1. *Increase in adaptability.* We set the following KPI targets in the project proposal. Please estimate how the project has been progressing towards the targets. Can you see any barriers towards the targets? What kinds of measures would support progress towards the targets?

Key Performance Indicators (KPIs)	KPI-1: Percentage of human operations that can be adapted KPI-2: Percentage of workers in the pilot cases who are modelled KPI-3: Percentage of workers in the pilot cases who can participate in designing their own work
Target KPI Value	KPI-1=Prima Power 50%, Continental 60%, United Technology 70%  KPI-2= Continental 60%, United Technology 70%  KPI-3=Continental 85%, United Technology 80%

2. *Increased worker satisfaction.* We set the following KPI targets in the project proposal. Please estimate how the project has been progressing towards the targets. Can you see any barriers towards the targets? What kinds of measures would support progress towards the targets? Prima Power: you did not set KPI targets here but do you foresee progress towards increased worker satisfaction with your machinery? How?

Key Performance Indicators (KPIs)	KPI-4: Work satisfaction rates measured with Factory2Fit framework KPI-5: Retention rate
Target KPI Value	KPI-4=Continental: 15%, United Technology 40% increase from project start to end of the pilot  KPI-5:=Continental: 20%,United Technology 10% increase

3. *Quality increase in total system(human and automation) performance (e.g. quality or productivity).* We set the following KPI targets in the project proposal. Please estimate how the project has been progressing towards the targets. Can you see any barriers towards the targets? What kinds of measures would support progress towards the targets?



Key Performance Indicators (KPIs)	KPI-6: Error rate KPI-7: Defect rate KPI-8: OEE (Overall equipment efficiency)
Target KPI Value	KPI-6= Prima Power decrease by at least 15%, Continental 10%, United Technology 30% KPI-7= Prima Power: decrease by at least 15%, Continental 10%, United Technology 30% KPI-8= Prima power: increase by at least 15%, Continental 5% (as is already high), United Technology 10%

4. *Higher social acceptance of factory work.* Where do you see possibilities of progress towards this? How could the progress be supported?
5. *Stronger global position of the industry in Europe.* We set the following KPI targets in the project proposal. Please estimate how the project has been progressing towards the targets. Can you see any barriers towards the targets? What kinds of measures would support progress towards the targets? Continental: do you foresee any other influence in business?

Key Performance Indicators (KPIs)	KPI-10: Nr of manufacturing jobs re-shored to Europe KPI-11: Manufacturing machines sold in Europe
Target KPI Value	KPI-10 = Continental is not applicable as work is distributed in manufacturing network. KPI-10 = United Technology 5% KPI-11= Prima Power: 20% increase in European sales for automated machines

6. *Wide adoption of the developments.* We set the following KPI targets in the project proposal. Please estimate how the project has been progressing towards the targets. Can you see any barriers towards the targets? What kinds of measures would support progress towards the targets?

Key Performance Indicators (KPIs)	KPI-12: Market increase
Target KPI Value	KPI-12 = Prima Power: at least 20% annual sales increase for automated machines; Continental: Overall capacity of the system to produce and deliver parts can be increased by 10% KPI-12 = United Technology is expected to increase of 30% its position in the market due the possibility to accept more requests for customizing units.

7. *Impact in industry.* What kinds of impacts Factory2Fit could have in industry more widely? What kinds of measures would support the positive impacts?
8. *Societal impacts.* How do you see F2Fit 1) empowering and 2) engaging concepts could impact:



- a. *individual workers*
  - b. *work community*
  - c. *factory management*
  - d. *manufacturing industry as a whole*
  - e. *manufacturing related education*
  - f. *society as a whole*
9. Do you foresee some additional impacts of the proposed concepts? Please describe.



## A2: Interview questions for the External Advisory Board

*Background: Please describe your professional background in manufacturing field. How long have you been working in the field? In what kinds of roles?*

We have defined tentative concepts of Factory2Fit solutions and the concepts are presented as scenarios of future manufacturing work and work environment. We would like you so help us in assessing the industrial and societal impacts of the planned developments.

1. Let us first focus on the concepts to empower workers, the quantified worker approach. If these kinds of solutions become widely adopted, how do you see that they would influence:

- a. *individual workers*
- b. *work community*
- c. *factory management*
- d. *manufacturing industry as a whole*
- e. *manufacturing related education*
- f. *society as a whole*

How could the positive impacts be supported? How could the negative impacts be avoided/minimized?

2. Then let us first focus on the concepts to engage workers, participatory design, training and knowledge sharing solutions that enhance the role of the worker. If these kinds of solutions are widely adopted, how do you see that they would influence:

- a. *individual workers*
- b. *work community*
- c. *factory management*
- d. *manufacturing industry as a whole*
- e. *manufacturing related education*
- f. *society as a whole*

How could the positive impacts be supported? How could the negative impacts be avoided/minimized?



3. How do you see that F2Fit solutions would support increasing human achievements (productivity) in manufacturing industry ?
4. How do you see that F2Fit solutions would support the aim of meaningful work?
5. How do you see that F2Fit solutions would support the aim of attractive workplaces?
6. How would the proposed solutions support safety? Do they introduce safety challenges? Please describe.
7. How do the proposed solutions support the principle of sustainable and responsible industry?
8. Do you foresee some additional impacts of the proposed concepts? Please describe. Any additional comments/questions?



### A3: The impact questionnaire

Based on the presented concepts, please assess how you foresee that they will impact  
productivity and work satisfaction

#### Productivity increase

Concepts to empower the worker	negative effect	no effect	weak positive effect	some positive effect	moderate positive effect	strong positive effect
Worker dashboard						
Adaptive user-machine interaction						
Adaptive manufacturing process						
Concepts to engage the work community	negative effect	no effect	weak positive effect	some positive effect	moderate positive effect	strong positive effect
Participatory design						
Knowledge sharing						
Learning at work						

#### Increase in work satisfaction

Concepts to empower the worker	negative effect	no effect	weak positive effect	some positive effect	moderate positive effect	strong positive effect
Worker dashboard						
Adaptive user-machine interaction						
Adaptive manufacturing process						
Concepts to engage the work community	negative effect	no effect	weak positive effect	some positive effect	moderate positive effect	strong positive effect
Participatory design						
Knowledge sharing						
Learning at work						

