OPEN_NEXT

Deliverable 3.1

User stories of collaborative engineering needs

This project is funded by the European Union's Horizon 2020 Research and Innovation Programme under the Grand Agreement no. 869984.

OPEN_NEXT – Transforming collaborative product creation

Consortium:

#	Participant Legal Name	Short Name	Country
1	TECHNISCHE UNIVERSITAT BERLIN	TUB	DE
2	INSTITUT POLYTECHNIQUE DE GRENOBLE	GINP	FR
3	ALEXANDER VON HUMBOLDT-INSTITUT FURINTERNET UND GESELLSCHAFT GGMBH	HIIG	DE
4	UNIVERSITY OF BATH	UBA	UK
5	ZENTRUM FUR SOZIALE INNOVATION GMBH	ZSI	AT
6	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	FHG	DE
7	DANSK DESIGN CENTER APS	DDC	DK
8	WIKIMEDIA DEUTSCHLAND - GESELLSCHAFT ZUR FÖRDERUNG FREIEN WISSENS EV	WMDE	DE
9	WIKIFACTORY EUROPE SL	WIF	ES
10	STICHTING WAAG SOCIETY	WAAG	NL
11	MAKER	MAK	DK
12	AGILE HEAP EV	FLB	DE
13	SONO MOTORS GMBH	SOM	DE
14	OPNTEC GMBH	OPT	DE
15	STYKKA APS	STY	DK
16	TILL WOLFER	XYZC	DE
17	FICTION FACTORY	FIF	NL
18	M2M4ALL	SOD	NL
19	INNOC OSTERREICHISCHE GESELLSCHAFT FUR INNOVATIVE COMPUTERWISSENSCHAFTEN	HAL	AT

Duration: 09/2019-08/2022

Grant: H2020-869984

Contact (coordinator): Prof Dr-Ing Roland JOCHEM
Address: Technische Universität Berlin, Sekretariat PTZ 3, Pascalstr. 8-9, 10587 Berlin
E-mail: roland.jochem@tu-berlin.de

D3.1 - User stories of collaborative engineering needs

Review and approval status:

	Name and Surname	Role in the Project	Partner
Author(s)	Sonika Gogineni	Research associate	FHG
Reviewed by	Robert Mies	Project manager	TUB
	Dr-Ing Kai Lindow	Project manager	FHG
Approved by	Prof Dr-Ing Roland Jochem	Project coordinator	TUB

History of changes

Version	Date	Description of changes	By
0.1	17.02.2020	Initial draft	Sonika Gogineni
0.2	24.02.2020	Manuscript for review	Sonika Gogineni
0.3	28.02.2020	Publish-ready deliverable	Sonika Gogineni

Details

Dissemination level	Open Access
Due date	01.03.2020
Issue date	01.03.2020
Contract No.	869984
Responsible Partner	FHG
File name	D3.1_User stories of collaborative engineering needs_GoS

Abstract:

This document is a deliverable (3.1) of project OPEN_NEXT. This deliverable report describes and summarizes the activities carried out and their results in Task 3.1: Assessing the needs, which belongs to work package (WP) 3. The work package aims at developing information and communication technology (ICT) infrastructure to support open source hardware (OSH) and collaborative engineering in company-community collaboration (C3). Hence, the activities mentioned in this deliverable report is the first step to find and understand the needs for developing the required ICT infrastructure. This deliverable document delivers the following results, which are further detailed in later sections:

- Collecting and accessing needs: An outline of twenty in-depth interviews conducted to assess community needs.
- Development of user stories: A summary of the user stories generated from the interviews. The user stories act as the first step to translate the needs into solutions for filling the current ICT infrastructure gaps.
- Data flow architecture development: Analysis and development of data flow architecture to understand the activities and processes of OSH development in C3.

Table of Contents

List of abbreviations and terms

C3	Company-community collaboration
EU	European Union
ICT	Information and communication Technology
MFP	Minimum functional prototype
CFP	Complete functional prototype
DFM	Design for manufacturing
ODM	Open distributed manufacturing
OSH	Open source hardware
SME	Small and medium enterprises
WP	Work package

List of figures

List of tables

1 Introduction

The work package 3 aims at delivering ICT infrastructure solutions to the OSH community in order to support OSH development and collaboration by carrying out the following enhancements:

1) Extension of Wikifactory[1] platform with features for
   a) Product and service data management
   b) Tools for open production engineering
2) Development of a dedicated Wikibase[2] instance to focus on
   a) Data discoverability and structuration

In order to gain insights into the different opportunities available for development of solutions mentioned above there was a need to collect requirements in the field of OSH and company collaboration. Partial insights on requirements for development platforms have been conveyed by Abhari et al. (2016, 2017) with a conceptual model of social product development. In addition, the project OPEN (Mies et al., 2020) also delivered requirements for such platforms based on inter-organisational collaborative development framework by Lünnenmann et al. (2016). These works provided a start to look into relevant technical features to enable co-development, however they are not an exhaustive set of requirements for OSH and C3. Hence, this report aims to deliver an exhaustive set of requirements from the activities of task 3.1 in WP3.

The methodological approach of the activities in Task 3.1 is shown in Figure 1. The method used to collect the requirements was semi-structured interviews. This method was chosen because the OSH community has different stakeholders who have diverse characteristics in terms of goals, size of operation, way of operations, business models and the customers they focus on. Hence, it was first important to understand their goals and steer the interview to obtain the relevant needs for the project. In total, twenty interviews were conducted among various stakeholders in the community.

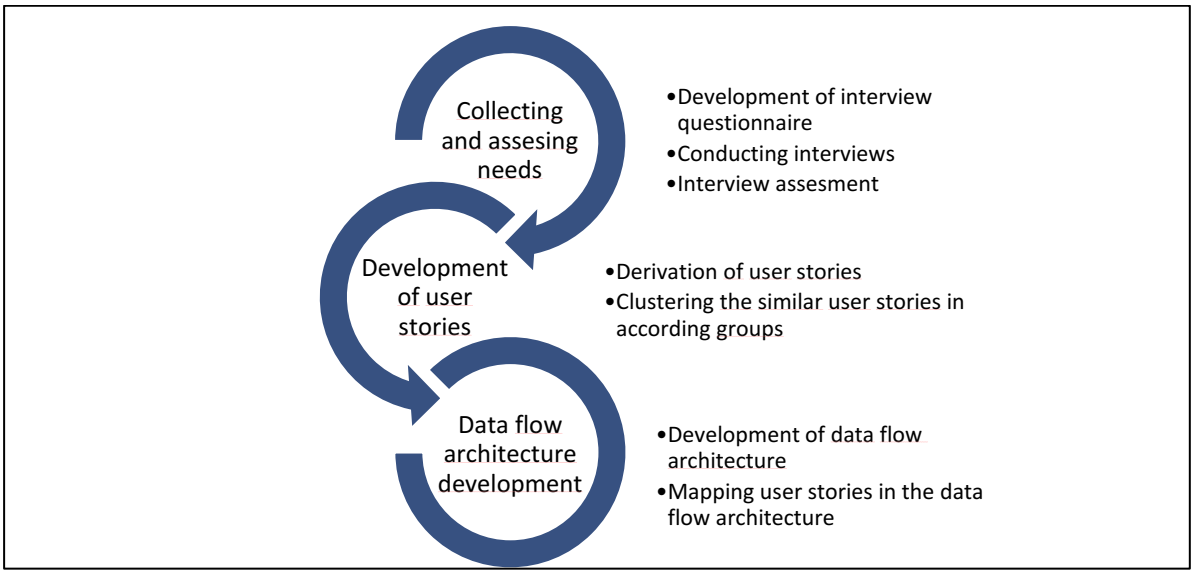

Figure 1: Systematic approach followed in Task 3.1 and in this report

[1] https://wikifactory.com/

[2] https://www.wikimedia.de/projects/wikibase/

This deliverable reports the summary of the interviews followed by the derived user stories. Development of use stories were chosen as the suitable method here because they are effective in initially defining the ICT features required by translating the user's requirements (Gilson & Irwin, 2018). In addition, it was important to understand the various activities in OSH development and C3, therefore a data flow architecture analysis was considered to be a suitable method to map the activities and their connections (Riedelsheimer et al., 2017). This helps in understanding and improving the efficiency of activities and corresponding processes. Mapping the user stories onto the data flow architecture further points out the activities which are connected to them. This is important as the activities influence the ICT features which have to be developed and incorporated into the demonstrators. The demonstrators are the prototypical implementations of ICT solutions, which will be developed in WP3 in the following tasks (Task 3.2 and Task 3.3).

2 Definitions

In this report, the terms **company and organisation** are used interchangeably. They refer to a company which designs/manufactures/produces products or manages projects or a research institute or foundation or non-governmental organisation.

Small and medium enterprises (SME) are defined as organisations who have a particular headcount and amount of turnover (European Commission). In addition, in this report SMEs are considered as organisations who are developing or have already developed products for OSH, or those who have already been involved or are planning to be involved in C3.

Fab labs and makerspaces or any organisation, which provides space for people to come together and work in groups or to work on technical equipment, are handled synonymously in this report. This is because it is difficult to distinguish them from each other owing to of their many facets. Fab labs have signed up to a Charter defining a core set of capabilities and tools allowing sharing of projects between different labs. In contrast to makerspaces, the ideas of knowledge sharing and public access are specifically anchored in the Charter, officially giving fab labs an educational character rather than "just" working at the same place and using common tools like in makerspaces (García Sáez, 2016; Klemichen et al., 2018). Since makerspace communities often share the same mindset on sharing as fab labs communities, differentiation is – in real life settings – often only of descriptive nature (Colegrove, 2013; van Holm, 2015).

3 Collecting and accessing needs

The needs or requirements from the OSH community is an important starting point for the development of infrastructure to support OSH development. Hence, it was important to obtain various perspectives from different stakeholders in the OSH community. The targeted community consisted of SMEs who have worked/are working on OSH projects, fab labs or makerspaces who have worked/are working on OSH projects, institutes which support OSH projects, or any of the above organisations who are planning to work on OSH projects.

The request to participate in the interview was sent out to twenty eight organisations who are not part of the OPEN_NEXT consortium, they were recommended from internal project partners. These organisations are active participants in OSH fields or were interested in being actively involved with OSH. Ten of them participated in the interviews. In addition, ten interviews were also conducted with the internal project partners (SMEs and fab labs of the project). Hence, in total twenty in-depth interviews were conducted. The following sub-sections provides a detailed report on the procedure used to conduct the interviews and a brief summary of the interviews.

3.1 Development of interview questionnaire

The aim of the interviews was to collect needs for ICT infrastructure from the community. Hence, the structure shown in Figure 2 was adopted. The structure was developed by discussing with internal WP partners Wikifactory and Wikimedia in an independent workshop and web conference respectively. In addition, the inspiration was also taken from literature research sources (Johnsen & Ford, 2000; Lock, 2013). As the focus of the project lies in OSH, C3, product

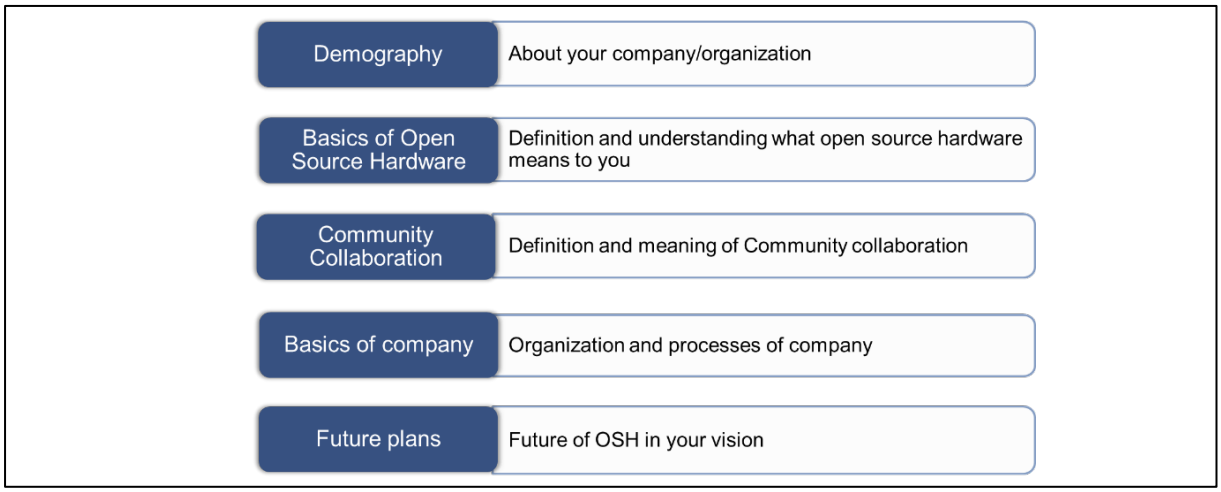

Figure 2: Structure of interview

development and design to production, the questionnaire was structured to address these topics. The questions of the interview was divided into five sections. The first section, called demography, aimed at capturing a brief overview of the interview participants experience and about the organisation they are a part of. In the next section, basics of open source hardware, the interview participants were asked about their perspective of OSH and about their experience with OSH projects (if they had any). In community collaboration section, the questions focused on how the company/organisation collaborated with the community and their positive and negative experiences. In the fourth section, the working of the company was discussed to question and analyse the pain points or challenges faced. We also recommended the use of a familiar example to the participant to explain their processes. In the last section, future plans of organisations with respect to OSH was questioned.

The complete list of questions can be found in the Annex A and B. Annex A has the interview questions for the SMEs and the Annex B is similar to Annex A with a few additional or modified questions for fab labs and makerspaces. The interview questionnaire was assisted with a set of slides, which was presented to the user during the interview. The purpose of the slides was to guide the user during the interview. The slides used during the interviews for the SMEs and the fab labs are attached separately and are called: Interview_Concept_Slides_SMEs.pdf and Interview_Concept_Slides_Fablabs.pdf respectively.

3.2 Conducting interviews

The interviews were conducted in consent with the interview participants, this was done by agreement and signing of the consent forms. The consent form was prepared following the format mentioned in the Deliverable 7.1 (H- Requirement No. 1). The duration of the interview was one hour and thirty minutes. The medium of interview was web conference.

3.3 Interview assessment

During the interviews, the responses were manually recorded. In addition, the interviews were recorded and saved. This was done to make sure that the written responses were correct and

complete. The interview responses were then digitally transcribed using Microsoft Excel after evaluating the recordings and the handwritten transcripts. A brief summary of all the interviews is detailed in the following sub-sections ordered by the sections in the interview as shown in Figure 2.

3.3.1 Demography

This section contained questions to obtain a clear picture about the interview participant and the organisation they are a part of. The Figure 3 shows the diversity of the business classifications of interview participants. The majority of the participants with a count of nine were SMEs, followed by five fab lab/makerspace organisations. Foundations, institutes and associations were divided equally with two participants each.

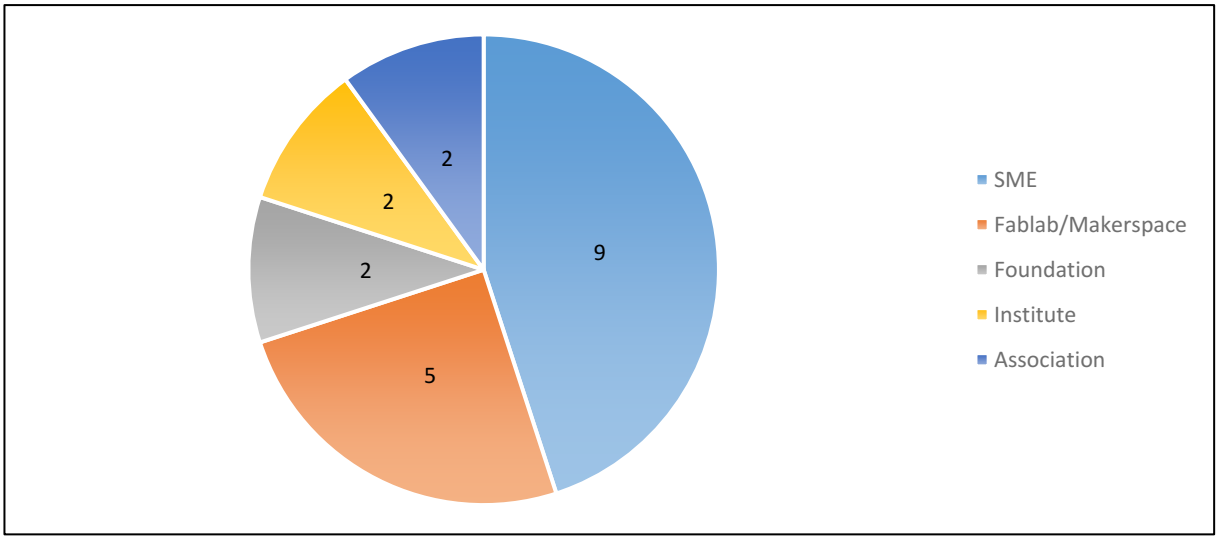

Figure 3: The categories of business classifications of interview participants

3.3.2 Basics of OSH

In this section, the definition of OSH was discussed to establish a common understanding. Followed by discussions about the experiences of the participants in OSH related activities. The definition of OSH by OSHWA was used (Open Source Hardware Association), which states: "*open source hardware as a term for tangible artifacts — machines, devices, or other physical things — whose design has been released to the public in such a way that anyone can make, modify, distribute, and use those things*". Most of the participants agreed to the definition and stated that it was a board definition hence accommodating various scenarios. Some additional considerations were inclusion of credits to the original idea and allowing the contributing community to determine the path of further licensing of their ideas.

Seventeen interview participants already have experience of working with OSH projects, three participants have no experience of working on OSH projects yet, but are planning to work on OSH. This is visualised in Figure 4.

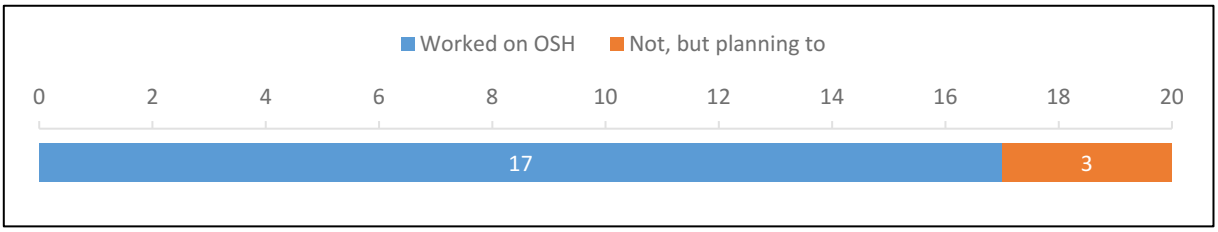

Figure 4: Distribution of participants' experience of working with OSH

The participants were also questioned about the general advantages and disadvantages of OSH from their experience and knowledge. The advantages are synonymous to potentials of OSH and the disadvantages highlight the challenges of OSH. The most stated general points are summarized in Figure 5.

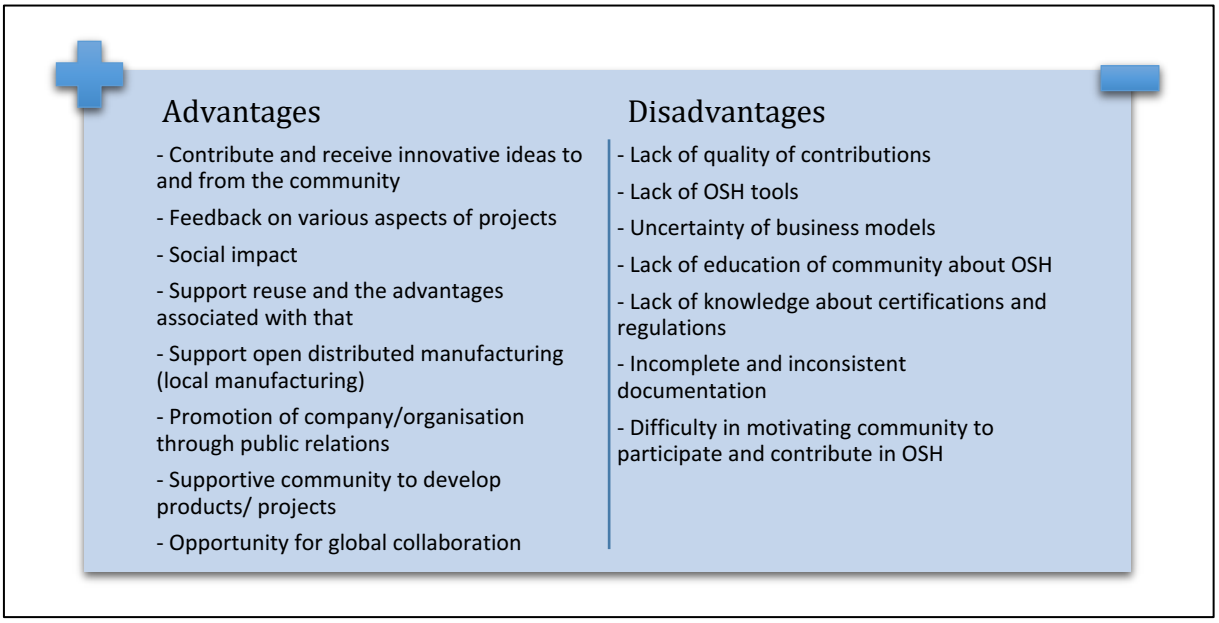

Figure 5: General advantages and disadvantages of OSH

3.3.3 Community collaboration

Following the aims of the OPEN_NEXT project, community collaboration here was focused on highlighting the collaboration between an organization and the community. Hence, it was defined as: Company-community collaboration (C3) refers to collaboration between companies and an undefined crowd undefined crowd as per open innovation practices (Heitmann, 2012). On the definition, most of them disagreed with the words "undefined crowd". The clarification was that they do know who the crowd is when they are collaborating. A participant suggested to define the undefined crowd as "experts, specified group or interested people" instead, which is similar to what the other participants expressed. Figure 6 shows that seventeen of interview participants were involved in C3 related activities and three participants had no experience in C3.

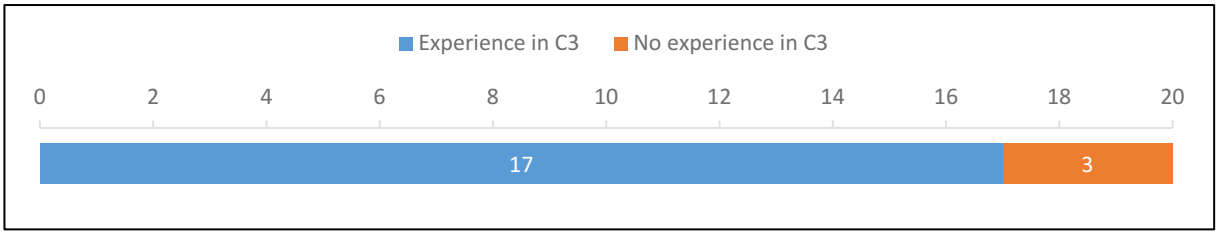

Figure 6: Distribution of participants' experience in C3 in OSH

The interaction channels used to interact with the community depended on the organisation. The statistics of the channels used is shown in Figure 7. The collaborating organisations use one or more channels to communicate. Direct communication with community and communication through physical events or workshops had a tie of being used by seven participants organisations' each. Usage of external platforms and through own platform/website are mentioned five times each. Communication through social media is followed by two interview participants' organisations.

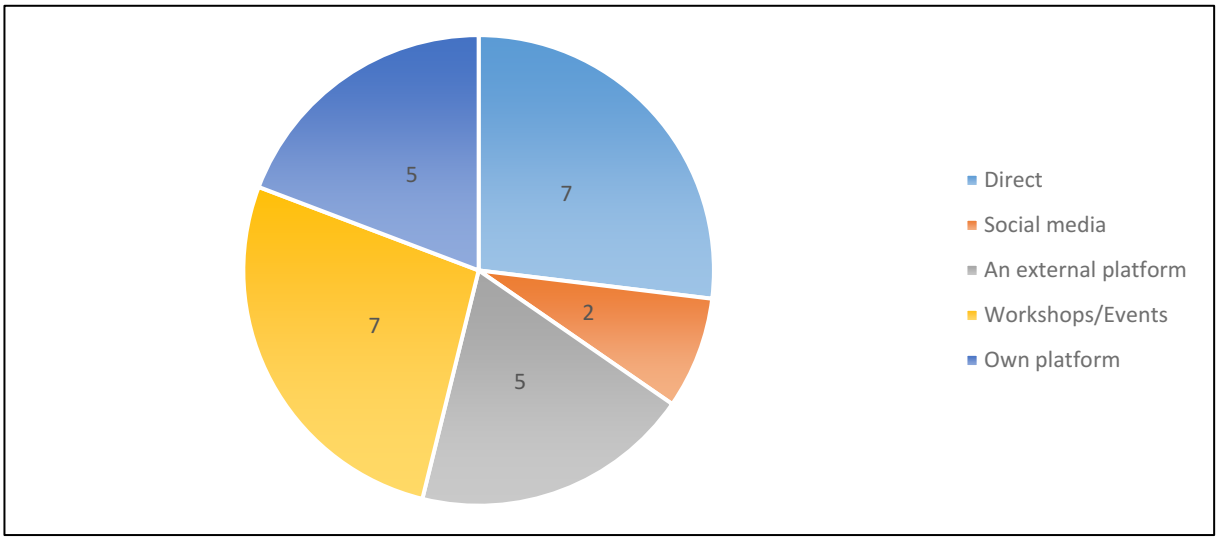

Figure 7: Communication channels used for community collaboration in OSH

The interview participants were also asked about what the advantages of disadvantages of company-community collaboration in OSH from their perspective and the most stated points are summarized in Figure 8.

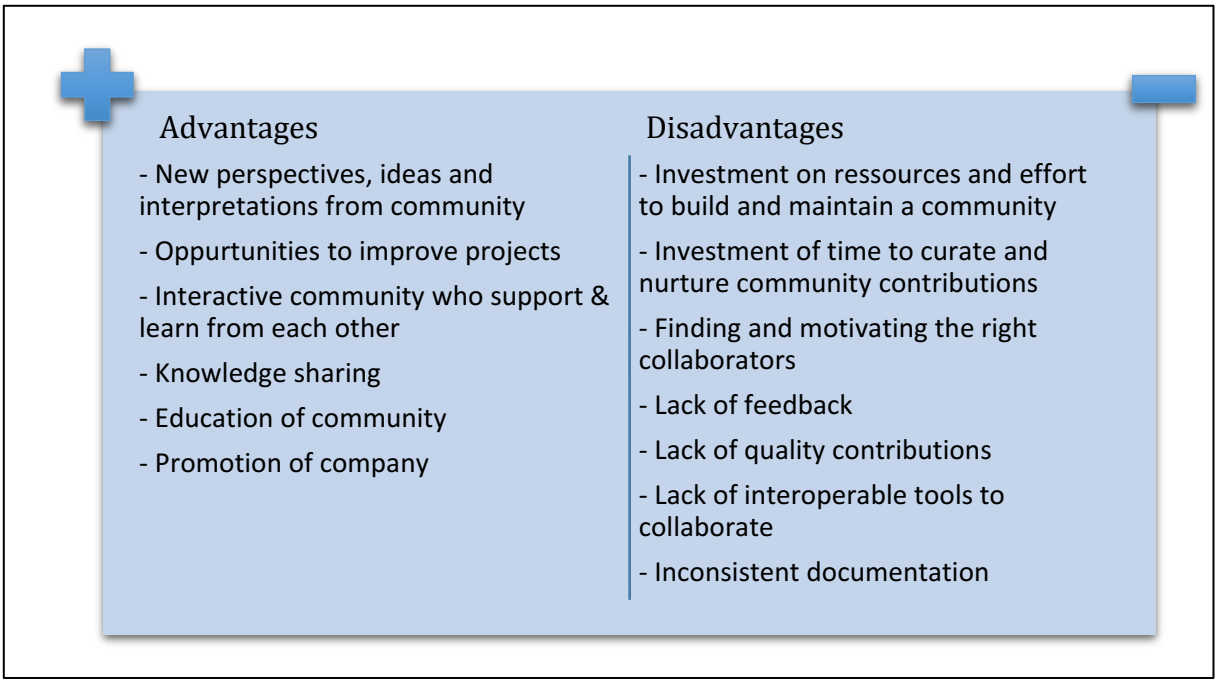

Figure 8: General advantages and disadvantages of C3 in OSH

3.3.4 Basic operations

The processes and activities in the organizations related to OSH or in general was questioned examined in this section. This was spread across five generic phases namely: concept development, concept validation, design & development, prototyping and production. These phases were derived from literature analysis (Boujut et al., 2019, p. 2309; Stark & Müller, 2009; The Department of Justice, 2003). To guide the questions a high-level representation of processes as shown in Figure 9 was used. The procedure starts with the development of the concept, where the idea generation followed by concept development takes place to solve a problem. This is succeeded by concept validation where questions about validation through community were asked. The next phase called design and development consisted of questions related to the further design and development of the validated concept. After the designing phase, the prototyping phase was discussed. The last phase is the production with considerations such as certifications, regulations testing, etc. It was also explained that the processes are not linear as show in Figure 9, but iterative in nature. This was agreed upon by all the participants.

Figure 9: General processes for product development and launch in an organisation

All of them accepted the phases and activities mentioned were familiar to them and their organisations working. However, there were just a few who carry out concept validation and that was mostly done through talking to experts they knew. Just one participant mentioned the use of community to validate the concept. In addition, most of them expressed that there is often a quick and direct jump from the concept development or ideation phase to the prototyping phase. This is often followed by rethinking, redesigning and iterative prototyping. There were a few requests to include additional phases such as problem identification and description, and service, maintenance and repair. The summary of responses to the questions in the individual phases is described below.

Concept development. In concept development, how the SMEs go about the generation of a concept to solve a problem was investigated. In the case of fab labs/makerspaces how they support concept development was investigated. The problem they try to solve is often an internal company problem and seldom a problem directly received from a community. The process of concept development is mostly offline in the early phase; hence, there is less to no feedback received from the online community in concept development. A challenge to develop concepts with a community was that there is no standardized structure/documentation, which acts as a guide. This results in unorganized community collaboration, which is hard to manage and maintain. Some IT-Tools the participants use in this phase are office tools, LibreOffice, GitHub, their own platform/website, WebEx, Zoom and Slack.

Concept validation. The main questions in this phase are targeted at understanding how concept validation was carried out and if the opportunity of validating with the community was being used. In general, the concept validation in the organisations is usually carried out through direct communication with experts known to the organisation or the customers they are developing for. The online community is rarely involved in the validation phase, only one SME interacts with a community to obtain validation on aesthetic factors. However, some of the organisations are planning to involve the community in the future. They also see a potential in using the community for market research of the concept developed.

Design and development. In this phase, the processes, tools and community collaboration methods used to design and develop the concepts were questioned and assessed. The design and development focus among the interview partners was spread across various domains such as electronic, mechanical and software, which in turn was across sectors such as automobile, electronics, furniture, health and humanitarian aid. The most used information technology (IT) tools in design & development phase can be divided into design tools and collaboration tools. The design tools used are a mix of open source tools (such as KiCad and FreeCAD) and closed source tools (such as SolidWorks and Fusion 360). For collaboration tools used are also a mix of open source (such as Github and Wikifactory) and closed source tools (such as Trello, Slack and MS project).

As IT tools were mostly used in this section, it was further investigated if there was a need for additional features in existing tools or if there was a need for new tools. The following points were often mentioned in the interviews:

- Improvements in built-in visualizations of models on development platforms
- Version management to collaborate and track changes
- Connected project elements on a metadata level to enable traceability
- Design quality management measures

Prototype. Prototyping phase was spread across four phases as shown in Figure 10 supported by testing across the phases. Most of the participants agreed with the shown figure, but there were differences in the actual implementation. Experience with designing of processes and products for manufacturing which belong to the process of Design for Manufacturing (DFM), was sparse. Similarly, the experience with collaborative prototyping was also sparse. The reason being that the community has to have access to the education, resources and support to actively participate in collaborative prototyping. Some suggested possibilities were integration of fab labs/makerspaces and use of new ICT tools to enable this in OSH. The challenges that have to be addressed here are to handle complex products, to produce and test small quantities of prototypes without high investment, to improve quality and to enable less-qualified community to collaborate.

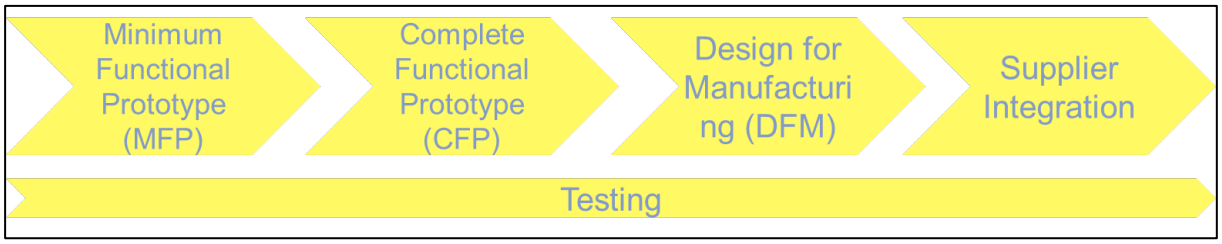

Figure 10: Phases of prototyping

Production. In production phase, general questions were asked about production, certifications, regulations and testing. In this section open distributed manufacturing (ODM) was also defined and the participants were asked if they see any potential for ODM.

ODM defines a small, scalable and flexible manufacturing with a decentralized production (Matt et al., 2015, p. 185). This enables lower logistic costs, shorter delivery time and higher flexibility. It reflects local customer needs with better accuracy and quickly responds to the increasing competition and market globalization of companies (Fjeldsted et al., 2012). Most of them saw a potential in ODM, but had little to no experience in the field. Those who did have the experience face some challenges which are summarized as disadvantages in Figure 11. Additionally the potentials in terms of advantages are also summarized in Figure 11.

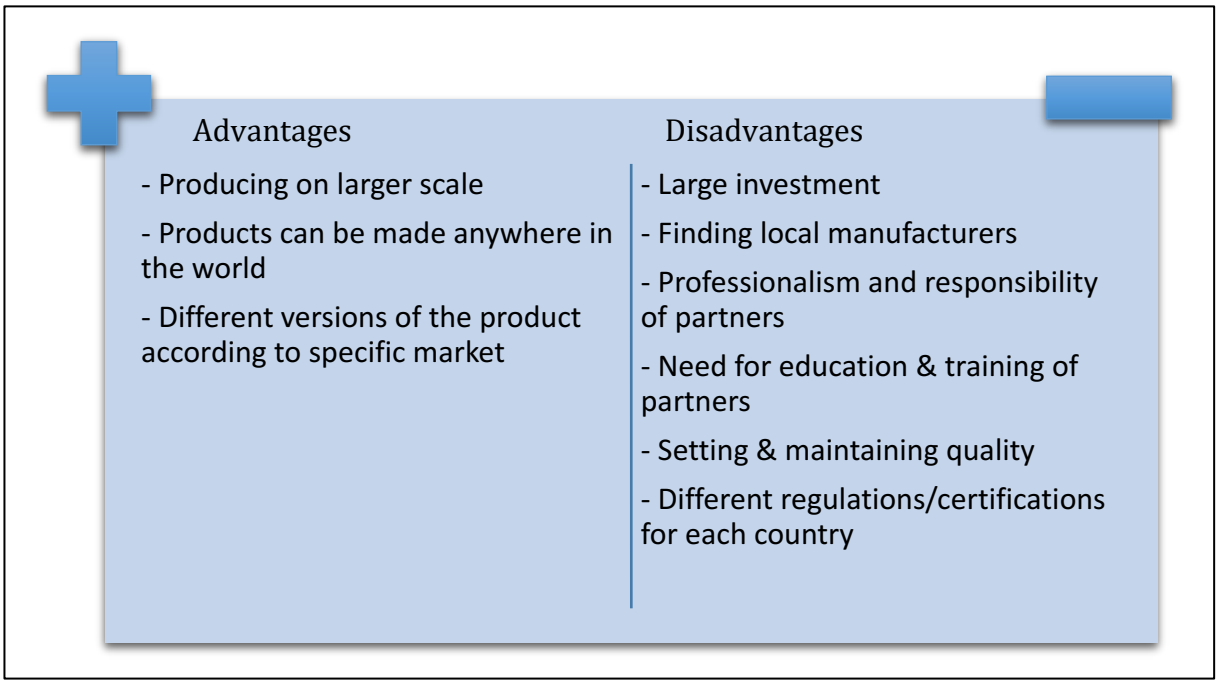

Figure 11: General advantages and disadvantages in ODM

3.3.5 Future plans

All the participants see potentials of OSH in the future. Hence, they are already working on it or planning to integrate it in their plan. However, there is lack of clarity on how OSH would develop and mature in the future.

4 Development of user stories

The interviews resulted in the derivation of two hundred and sixty user stories. The user stories consist of elements such as its name and description, the role of the user it refers to as well as the goal of the user and what purpose it should fulfil (Zeaaraoui et al., 2013 - 2013, p. 3).

The roles/perspectives of the user stories were categorized into the following roles:

- Project owner: Anyone who contributes and shares their own design files, making and testing process and documents this is called a project owner (Li & Seering, 2019)
- Company: An organisation or entity
- Community: According to Fjeldsted et al. (2012) community consists of "users who wish to participate in the development of the product and administration which usually is provided by the initiating company" or by an individual as well.

The user stories were then clustered based on their similarities and connections. When grouping user stories there were some user stories that were very similar but did not consider certain aspects, this was then noted in the column additional considerations. Some user stories do belong to one or more groups and this information is mentioned in the column additional groups. From

the complete set of interviews the frequency of user stories are also indicated to highlight how many of the participants mentioned the requirement. The complete list of clustered user stories are attached separately as a file called Userstories.pdf. In addition, Table 1 shows an excerpt of the clustered user stories under community collaboration. As an example, the user story U1/2 belongs to the cluster community management and is from the perspective of the project owner. Here the project owner, that has uploaded a project and its files, wants to find and attract the right collaborators for the project. The purpose here is to grow and sustain the project with a community with the aim of receiving effective contributions from the community. Some additional considerations here are to bring together various stakeholders such as other companies and building heterogeneous teams to support various aspects of the project. This user story was mentioned by fifteen of the interview participants.

Table 1: Excerpt of derived user stories for community management group

Number	Group name	Perspective	User story	Aim	Purpose	Additional considerations	Addition-al Group/s	Freq-uency
U1/1	Community management	Community collaboration platform manager	Managing community service needs	Provide relevant services	Engage community			3
U1/2		Project owner	Finding and attracting the right collaborators	Growth and effective contribution	Growth & sustenance of community collaboration	- Including companies - Build heterogeneous teams (to encourage development of all aspects of a project) - Skill based categorization		15
U1/3		Project owner	Motivating community to contribute	Healthy & innovative collaborative environment	Growth & sustenance of community collaboration	- Promote out of the box thinking - Avoid feeding influential ideas/concepts to the community - Keep community on board for a longer term - Provide triggers to encourage community to collaborate		15
U1/4		Project owner: Company/org anization	Determine business viability of community collaboration through online channels	to successfully collaborate/not collaborate with a community on the long run	Avoid risks	-Select processes which are of interest to the community		5
U1/5		Project owner	Curation of community content	Effective community collaboration	To ensure the users are not overwhelmed with irrelevant data			3
U1/6		Project owner	Community collaboration tool	Use IT tools to collaborate with community	reduce efforts and improve effectivity of working with a community	- Stand-alone tool for community collaboration - Connect with internal platform with community collaboration tool - Scheduling		9
U1/7		Project owner	Improve quality of contributions	To receive contributions which are of good quality	To ensure good quality open source hardware development	- Educate community about how to contribute	Quality, Guidelin-es	8

In conclusion, these extensive set of user stories form the basic requirements list to start the development of the demonstrators. To further analyse the connection of the user stories with the activities and processes carried out in OSH and C3 a data flow architecture was developed. This is discussed in the next section.

5 Data flow architecture development

Data flow architecture analysis, is an original method developed by Fraunhofer (FHG) to trace data paths in product development processes (Riedelsheimer et al., 2017). Data flow architecture analysis aims at tracing elements of activities such as data source, data destination, tools used, stakeholder roles and data artefacts generated or modified.

The data flow architecture for OSH development and collaboration derived in Task 3.1 is based on literature research and from the data collected in the interviews. The literature research is further explained in the next paragraph. The interview participants were asked about the basic operations of their organizations as mentioned in sub section 3.3.4. Most of them found the phases shown in Figure 9 to be similar to what they go through. However, the most important difference is that much thought or time is not spent on activities such as concept development and concept validation. There was often a direct and quick jump from concept to prototype, with few working on designing the prototype before building it.

The data flow architecture is spread over ideation, concept development and validation, design and development, prototyping, testing (for certifications, for personal use) and production. It is important here to highlight that the derived data flow architecture is based on hypothetical activities. These assumptions grow from general procedures which – consciously or subconsciously – take place in the individual phases. The ideation process is based on the procedures in VDI2220 - product planning, but this is enhanced with several feedback loops considering the OSH and C3 practices to map the community influence (VDI, 1980). The phases concept development and design and development take VDI2221 into account, but - as described above –it is not very detailed, since the interviews showed a more general approach in the OSH community (VDI, 1993). The validation part of the concept development and validation phase and the prototyping share the same ideas as VDI2206 in having a validation loop for every development step, similar to the V-model for software development (VDI, 2004). The certification process is shown on an abstract and general level (Berndt & Scholz, 2012) and depends of course on the specific certification bodies and processes. For personal use of OSH products in the testing phase priority is provided to the basic requirements for safety. For the production process, the data flow has been followed until ordering of production with the manufacturer is concluded.

The hypothetical activities are also enhanced with roles, tools, data artefacts, data sources and destinations, which are also general and hypothetical. This was done to determine the various activities involved in OSH and C3 processes and to associate them with the interviews partners. An excerpt of the data flow architecture can be seen in Figure 12. The phase here is Ideation and the activities across the ideation phases are mapped. In addition, the user stories derived in section 4 are mapped onto respective actives in the data flow architecture. The round bubbles below the activity boxes represent the user stories. In Figure 13 two additional columns namely documentation & guidelines and business considerations are shown. This highlights the fact that these aspects have to be taken into consideration in parallel with the activities across phases. Similar to in Figure 12, the round bubbles with the user stories are also included in the two columns and categorized based on the phases. The complete data flow architecture document called Dataflow_with_Userstories.pdf is separately attached to this report.

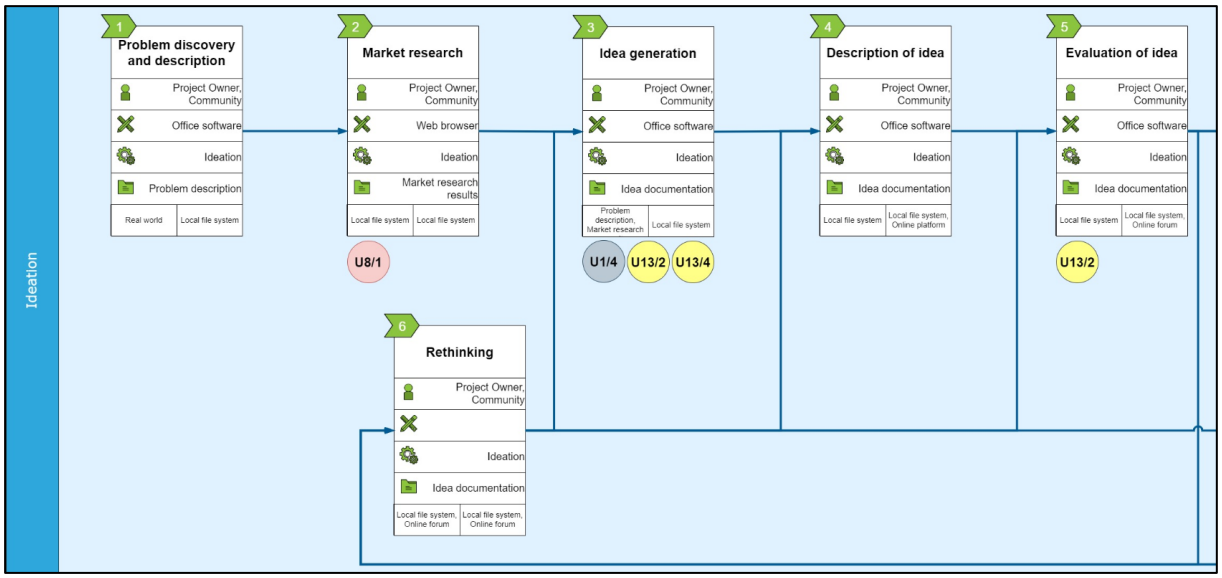

Figure 12: Excerpt of the ideation process in the data flow

User stories in association with their mapping in the data flow architecure provide the location and aim of the need to be addressed. With this information ICT infrastructure solutions can be generated to be implemented in both the demonstrators. This ensures the consideration of the relevant activities, roles, data artefacts, tools and the origin and destination of the data artefacts associated with the user story.

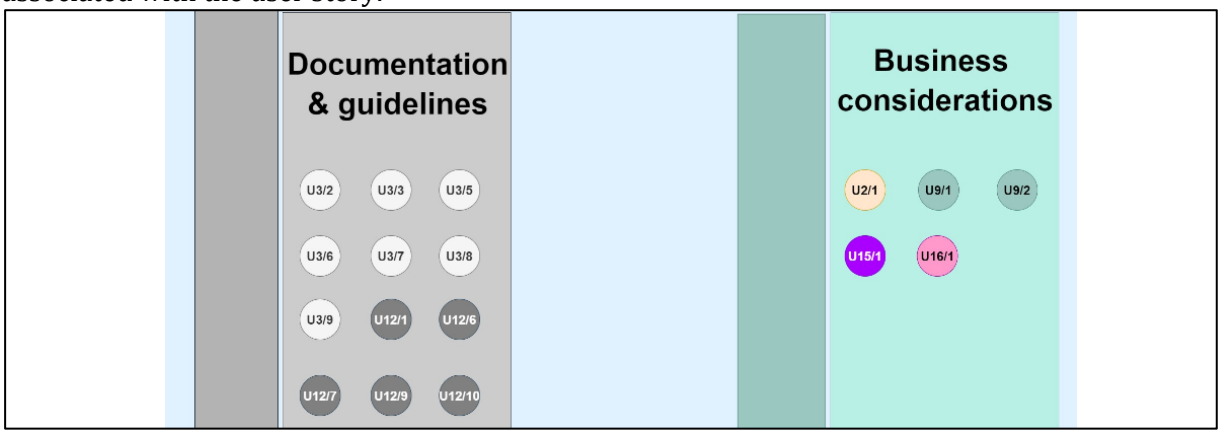

Figure 13: Excerpt of documentation, guidelines and business considerations for the ideation process in the data flow

In addition to the general data flow analysis, there was a workshop conducted with our partner Wikifactory. The aim of the workshop was to understand the Wikifactory platform and to generate user journeys. This was important to understand as the future demonstrators have to be developed based on the Wikifactory platform. The user journeys enabled identifying the different interactions a user of the platform can have. We then mapped the user stories onto the user journey to identify the areas for future improvement. An excerpt of this can be seen in Figure 14. The excerpt for example highlights the journey of starting a project which is for public use and then a list of possible activities which can be carried out on the right side of the image. These activities include inviting collaborators, commenting, uploading files or creating issues. The complete user journey mapping is attached separately in a document called User_journey_Wikifactory.pdf.

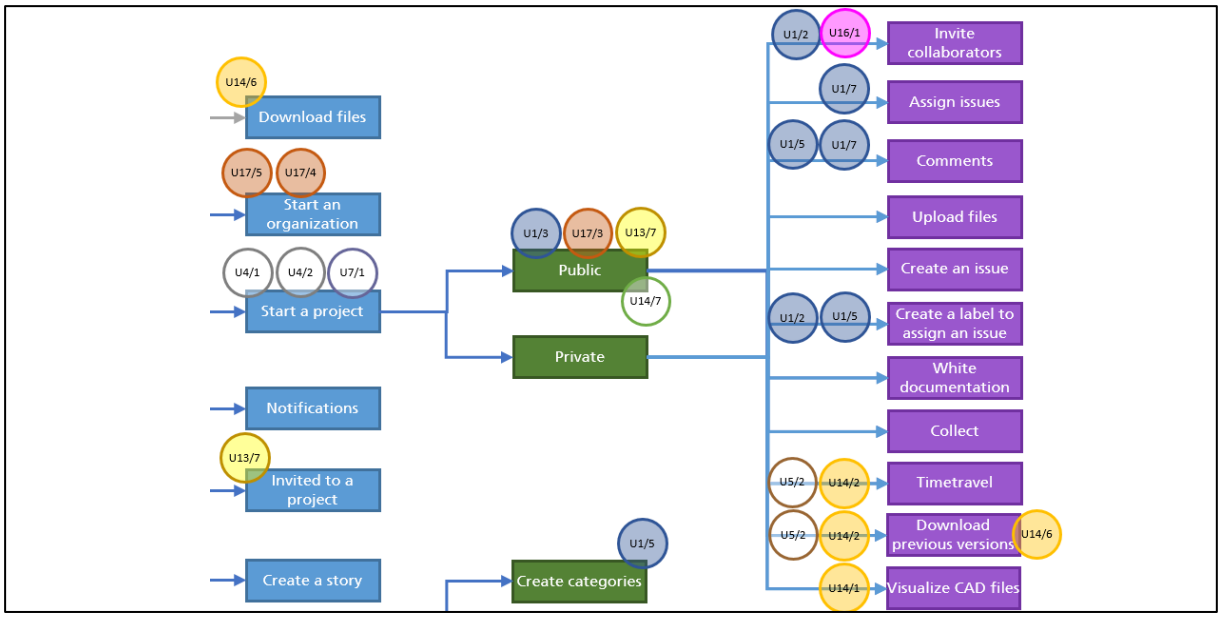

Figure 14: Excerpt of user journey on Wikifactory platform and the mapped user stories

The data flow analysis was not conducted with our other partner Wikimedia, which is involved in the project to provide and integrate an open software for knowledge databases called Wikibase with other platforms. Therefore, Wikibase is not an OSH product development platform unlike the Wikifactory platform. However, the data flow analysis developed and shown as an excerpt in Figure 12 takes into consideration of the aspects that would be integrated into the Wikibase instance demonstrator as well.

6 Conclusion and outlook

In this report the results of the task 3.1 in WP3 are detailed and discussed. The results were divided into three main sections namely: collecting and accessing needs, data flow architecture development and development of user stories. The results of each of these sections were aimed at deriving requirements and then generating user stories to be used for developing demonstrators in the next tasks of the project. This in turn is aimed at aiding the OSH community at large with ICT infrastructure in cooperation with Wikifactory and Wikimedia. The derivation of two hundred and sixty user stories from the interviews provides an extensive list of requirements for future development. The frequency of the user stories helps in prioritizing the implementation of next steps. In addition, it also highlights the fact that multiple participants pointed out similar pain points. However, there is still plenty of room for additional requirements and user stories from those experiences of other organisations taking part in OSH and C3 activities. In a similar way there is also an opportunity to expand and continuously enhance the data flow architecture along the project period to reflect the changing conditions and best practices for OSH and C3. At the end of the project, the demonstrators are also validated, which also helps in validating the data flow architecture.

References

Abhari, K., Davidson, E. J., & Xiao, B. S. (2016). Taking Open Innovation to the Next Level: A Conceptual Model of Social Product Development (SPD). In *AMCIS 2016.* https://www.semanticscholar.org/paper/Taking-Open-Innovation-to-the-Next-Level%3A-A-Model-Abhari-Davidson/5e9d99ef41385c79dfd4432b09171d7531ac1778

Abhari, K., Davidson, E. J., & Xiao, B. (2017). Co-innovation platform affordances. *Industrial Management & Data Systems*, *117* (5), 873–895. https://doi.org/10.1108/IMDS-05-2016-0156

Boujut, J.-F., Pourroy, F., Marin, P., Dai, J., & Richardot, G. (2019). Open Source Hardware Communities: Investigating Participation in Design Activities. *Proceedings of the Design Society: International Conference on Engineering Design*, *1* (1), 2307–2316. https://doi.org/10.1017/dsi.2019.237

Colegrove, T. (2013). Editorial Board Thoughts: Libraries as Makerspace?

The Department of Justice. (2003). *Systems Development Life Cycle Guidance: Chapter 1*. https://www.justice.gov/archive/jmd/irm/lifecycle/ch1.htm

European Commission. *What is an SME?* https://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en

Fjeldsted, A. S., Adalsteinsdottir, G., Howard, T. J., & McAloone, T. (2012). Open Source Development of Tangible Products. *NordDesign 2012*.

García Sáez, C. (2016). We need to make (almost) everything. A social and educational look at Fab Labs and the maker movement. http://www.fundacionorange.es/wp-content/uploads/2016/08/Estudio_Fablabs_Casi_Todo_por_hacer_en.pdf

Gilson, F., & Irwin, C. (2018). From User Stories to Use Case Scenarios towards a Generative Approach. In *2018 25th Australasian Software Engineering Conference (ASWEC)* (pp. 61–65). IEEE. https://doi.org/10.1109/ASWEC.2018.00016

Heitmann, M. (2012). *Open source development and company-community collaboration: Impact factors on the process of entering the open source market*. Zugl.: Berlin, Techn. Univ., Diss., 2012. *Schriftenreihe innovative betriebswirtschaftliche Forschung und Praxis: Vol. 348*. Kovač.

Johnsen, T., & Ford, D. (2000). Managing Collaborative Innovation in Complex Networks: Findings from Exploratory Interviews.

Klemichen, A., Roeder, I., Ringhof, J., & Stark, R. (2018). Needs and Requirements for Environmental-friendly Product Development in Makerspaces - A Survey of German Makerspaces.

Li, Z., & Seering, W. (2019). Does Open Source Hardware Have a Sustainable Business Model? An Analysis of Value Creation and Capture Mechanisms in Open Source Hardware Companies. *Proceedings of the Design Society: International Conference on Engineering Design*, *1* (1), 2239–2248. https://doi.org/10.1017/dsi.2019.230

Lock, J. (2013). *Open Source Hardware: Can embedded electronics companies thrive through the use and/or development of open source hardware?*

Lünnemann, P., Müller, P., Neumeyer, S., Wang, W. M., Hayka, H., & Kirsch, L. (2016). *Zukunft der unternehmensübergreifenden Kollaboration: Expertenmeinungen zu aktuellen Herausforderungen und zukunftsweisenden Trends in der kollaborativen Produktentwicklung* (1st ed.). Fraunhofer IPK. 978-3-945406-07-6

Matt, D. T., Rauch, E., & Dallasega, P. (2015). Trends towards Distributed Manufacturing Systems and Modern Forms for their Design. *Procedia CIRP*, *33*, 185–190. https://doi.org/10.1016/j.procir.2015.06.034

Mies, R., Bonvoisin, J., & Stark, R. (2020). Development of open source hardware in online Communities: investigating requirements for groupware. In *Design 2020.*

Open Source Hardware Association. *Definition*. https://www.oshwa.org/definition/

Riedelsheimer, T., Lünnemann, P., Lindow, K., & Stark, R. (2017). Betrachtung des Entwicklungsumfeldes durch die methodische Datenflussanalyse. *ProduktDaten Journal* (2), 52–56.

Stark, R., & Müller, P. (2009). Product-service system methodologies in research and industry. In H. Meier (Ed.), *Industrial product service systems // Seminar proceedings / 2nd International Seminar on IPS2, 23 - 24 March 2009, Berlin, Germany ; paper and presentations volume: Dynamic interdependency of products and services in the production area ; seminar proceedings, paper and presentations volume* (pp. 5–11). Shaker.

Van Holm, E. J. (2015). What are Makerspaces, Hackerspaces, and Fab Labs?

Zeaaraoui, A., Bougroun, Z., Belkasmi, M. G., & Bouchentouf, T. (2013, August - 2013, August). User stories template for object-oriented applications. In *Third International Conference on Innovative Computing Technology (INTECH 2013)* (pp. 407–410). IEEE. https://doi.org/10.1109/INTECH.2013.6653681

Appendix A: Questionnaire for SMEs

Subject area	Question
	Identification of the respondent / respondents
	Date of interview
	Company name
	Name of the interview protocoler
Introduction	Thank the participant -Reference to privacy information and consent form (must be signed): Emphasize confidentiality of data, data will be treated anonymously and used only to prepare the maturity level and in the study. The data will then be deleted. -First about FHG and what we do -Then about OpenNext goals in general
Demography	What does your company/organization do? What are your core business competencies?
Demography	Which business classification can your company be categorized into?
Demography	How many employees does your company employ?
Demography	In which specialist area are you active in?
Basics of open source hardware	We want to know how you perceive and define Open source hardware: We define Open source hardware as: Open Source Hardware (OSHW) is a term for tangible artifacts — machines, devices, or other physical things — whose design has been released to the public in such a way that anyone can make, modify, distribute, and use those things. This definition is intended to help provide guidelines for the development and evaluation of licenses for Open Source Hardware.
Basics of open source hardware	How would you define Open source hardware?
Basics of open source hardware	Have you worked on Open source hardware projects or applications?
Basics of open source hardware	If you worked with Open source hardware projects, can you explain them.
Basics of open source hardware	What were the advantages and disadvantages you observed?
Community collaboration	We want to know about your involvement in community collaboration What we mean by Company-community collaboration is: Company-community collaboration (C3) refers to collaboration between companies and an undefined crowd undefined crowd as per open innovation practices.
Community collaboration	Do you participate in community collaboration?
Community collaboration	Have you ever worked on a community collaboration project or application?
Community collaboration	How do you collaborate with the community? What were the advantages & disadvantages of Community collaboration?
Community collaboration	What are the challenges you observed?
Community collaboration	Do you reuse information or knowledge from the community/ If yes, how?
Community collaboration	Have you worked with supporting partners (e.g. Fablabs / SMEs)? If yes, how did you collaborate and what were advantages & disadvantages?
Basic operation of company	We want to know in brief how your company is organized We have a few general categories here which can help you define the processes in the organization
Basic operation of company	So lets take an example and go through the operations in your organization over the following phases
Concept Development	This phase concentrates on generating a concept from an idea/problem
Concept Development	How do you go about concept development?
Concept Development	Are you facing any challenges here or would you like to change or improve anything here?
Concept Development	Do you see a need for ICT tools to be integrated in this process to address the challenges?
Concept Validation	Validation of concept, community engagement & market research
Concept Validation	How did/do you validate your concept?
Concept Validation	Do you involve/plan to involve a community in validating your concept and/ market research?
Concept Validation	How do you get feedback from the community on concepts?
Design & Development	Generating the design
Design & Development	How do you design and develop your product/ project?
Design & Development	Is a community involved in this process or are you participating in a community?
Design & Development	Do you use any supporting IT tools?
Design & Development	Do you currently face any challenges or would you like to change or improve anything here?
Design & Development	Do you see a need for new IT tools to be integrated in this process?
Prototyping	MFP -> CFP -> DFM -> Supplier Integration
Prototyping	Is this how your prototyping process looks like?
Prototyping	What are the challenges you face here or would you like to improve anything here?
Prototyping	Is a community involved in this process or are you participating in a community?
Produce	Turning DFM into many identical products
Produce	Do/Did you currently produce products for sale on the market?
Produce	Do you see potential to integrate a community for open distributed manufacturing?
Produce	How did you go about testing?
Produce	How did you go about certifications and regulations?
Produce	How about supplier arrangements/integration?
Future plans or thoughts	Finally, we would like to talk about the future of OSH?
Future plans or thoughts	What is your future plans about your company? What do you want to accomplish ?
Future plans or thoughts	if you can make a wish: What does the future of the OSH look like for you in 20 years?
Future plans or thoughts	How do you assess the potential in your company to use OSH in the future to assess innovation and community collaboration?
Future plans or thoughts	How large w+A1:B53ould you rate this potential on the following scale: 0 = no potential; 1 = little potential; 2 = large potential?

Appendix B: Questionnaire for Fab labs/Makerspaces

Subject area	Question
	Identification of the respondent / respondents
	Date of interview
	Makerspace (Company) name
	Name of the interview participant
	Name of the interview protocoler
Introduction	Thank the participant -Reference to privacy information and consent form (must be signed): Emphasize confidentiality of data, data will be treated anonymously and used only to prepare the maturity level and in the study. The data will then be deleted. -First about FHG and what we do -Then about Open!Next goals in general
Demography	So let's start by getting to know you and your company/organization.
Demography	What does your company/organization do? What are your core business competencies?
Demography	Which business classification can your company be categorized into?
Demography	What USP do you have in comparison to other FabLabs? (or how do you differentiate your Fablab from the others?)
Demography	How many employees does your company employ?
Demography	In which specialist area are you active in?
Basics of open source hardware	We want to know how you perceive and define Open source hardware We define Open source hardware as: Open Source Hardware (OSHW) is a term for tangible artifacts — machines, devices, or other physical things — whose design has been released to the public in such a way that anyone can make, modify, distribute, and use those things. This definition is intended to help provide guidelines for the development and evaluation of licenses for Open Source Hardware.
Basics of open source hardware	How would you define Open source hardware?
Basics of open source hardware	Have you worked on Open source hardware projects or applications?
Basics of open source hardware	If you worked with Open source hardware projects, can you explain them.
Basics of open source hardware	What were the advantages and disadvantages you observed?
Community collaboration	We want to know about your involvement in community collaboration what we mean by Company-community collaboration is: Company-community collaboration (C3) refers to collaboration between companies and an undefined crowd undefined crowd as per open innovation practices.
Community collaboration	Do you participate in community collaboration?
Community collaboration	Have you ever worked on a community collaboration project or application?
Community collaboration	How do you collaborate with the community? What were the advantages & disadvantages of Community collaboration?
Community collaboration	What are the challenges you observed?
Community collaboration	Do you reuse information or knowledge from the community/ If yes,why and how do you reuse it?
Community collaboration	Have you worked with other companies/Fablabs/Makerspaces? If yes, how did you collaborate and what were advantages & disadvantages?
Basic operation of company	We want to know in brief how your company is organized We have a few general categories here which can help you define the processes in the organization
Basic operation of company	So lets take an example and go through the operations in your organisation over the following phases
Basic operation of company	Are these processes similar to what you do? or services in?
Basic operation	How does your business model work?
Basic operation	What is the starting point of interaction with makers (in person, platform)?
Concept Development	This phase conceptrates on generating a concept from an idea/problem
Concept Development	How do you go about concept development?
Concept Development	Are you facing any challanges here or would you like to change or improve anything here?
Concept Development	Do you see a need for ICT tools to be integrated in this process to address the challenges?
Concept Development	Do you support makers with a broad concept to further develop?
Concept Validation	
Concept Validation	How did/do you validate your concept?
Concept Validation	Do you involve/plan to involve a community in validating your concept and/ market research?
Concept Validation	How do you get feedback from the community on concepts?
Concept Validation Fablabs	Can you already at this stage suggest if or how you can "produce" according to customer requirements?
Concept Validation Fablabs	Can provide suggestions from similar project experiences based on the congruency of requirements? Is that in your eyes useful/practicable?
Design & Development	
Design & Development	How do you design and develop your product/ project?
Design & Development	Do you reuse existing designs? If yes, do you face any challanges? If no, what are the main barriers?
Design & Development	Is a community involved in this process or are you praticipating in a community?
Design & Development	Do you use any supporting IT tools?
Design & Development	Do you currently face any challenges or would you like to change or improve anything here?
Design & Development	Do you see a need for new IT tools to be integrated in this process?
Prototyping	
Prototyping	Is this how your prototyping process looks like? (Show presentation)
Prototyping	What are the challenges you face here or would you like to improve anything here?
Prototyping	Is a community involved in this process or are you praticipating in a community?
Prototyping	According to your experience, what are here significant differences of Fablabs compared with private makers and SMEs?
Prototyping	What evaluations/testing do you provide for prototypes (When is my protoype ready for production?)
Produce	
Produce	Do/Did you currently produce products for sale on the market?
Produce	Do you see potential to participate with companies and community for open distributed manufacturing?
Produce	How did you go about testing?
Produce	How did you go about certifications and regulations?
Produce	How about supplier arragements/integration?
Produce	Do you have collaborations to manufacture? How is the communication and contact with customer here managed? (separat contact, collaborator can access directly data...)
Future plans or thoughts	Finally, we would like to talk about the future of OSH?
Future plans or thoughts	What is your future plans about your company? What do you want to accomplish ?
Future plans or thoughts	if you can make a wish: What does the future of the OSH look like for you in 20 years?
Future plans or thoughts	How do you assess the potential in your company to use OSH in the future to assess innovation and community collaboration?
Future plans or thoughts	How large would you rate this potential on the following scale: 0 = no potential; 1 = little potential; 2 = large potential?
Future plans or thoughts	What advantages/disadvantages would you see for your business?