DIGITAL MANUFACTURING PLATFORMS FOR CONNECTED SMART FACTORIES

D8.1 Market platform and Virtualized Digital Innovation Hub

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Organization name of lead contractor for this deliverable :	**Jožef Stefan Institute**
Author(s):	**(see list of contributors)**
Partner(s) contributing :	**JSI, EIT, ENG, ATOS, NXT, POLIMI, UNP, VTT, ATLAS, SQS, INNO, FhG, AIT, TTS**

Abstract: This deliverable describes the concept of the QU4LITY virtualized platform and specifies/describes its stakeholders and services it will provide to its users. It also provides some groundwork for other tasks in WP8 and WP9.

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Contents

HISTORY

Version	Date	Modification reason	Modified by
0.1	29/08/2019	Initial ToC	JSI
0.2	30/08/2019	ToC second draft	EIT
0.3	16/09/2019	First draft of the deliverable and partner contribution integration	ALL
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0.7	29/10/2019	Deliverable finalization	JSI and EIT
1.0	31/10/2019	Final version for submission	JSI

Table 1: Document version history

Executive Summary

This document is the first deliverable of the T8.1 Multi-sided Market Platform Architecture and Virtualized DIH Specifications in scope of WP8 European Digital Innovation Market Platform for ZDM. D8.1 Market Platform and Virtualized Digital Innovation Hub Specifications is a report on the QU4LITY virtualized platform concept, detailing the concept of the two entities structuring a common market platform.

ZDM solutions and services based on the AQ concept will be typically associated with complex value chains and production processes, which are not adequately supported by established innovation management structures. To tackle this challenge, QU4LITY will provide a one-shop-stop marketplace for autonomous quality ZDM solutions, which will provide a single-entry point to the project's intellectual property (IP) and results. The project's marketplace will support the AQ services development processes end-to-end, through access to digital technologies, ZDM equipment and other related IP, but also through access to required complementary assets, such as training, technical support and consulting. The QU4LITY marketplace will be empowered by a unique multi-side market platform that will enable the participation of both supply-side and demand-side stakeholders.

This report describes the concept of the virtualized market platform consisting of the virtualized DIH and the Multi-sided marketplace. It describes the platforms' stakeholders and their requirements, foreseen roles needed for the running and curation of the platform, provides a portfolio of possible services to be offered along with the solution providers and projects own IP, which is to be marketed through the marketplace, thus outlining the basic architecture of each. It describes how the two "entities" will be contributing in the goal of providing a holistic solution for the ZDM ecosystem of suppliers and demanders.

As the first deliverable of WP8, the report mainly serves to present the overall concept and ideas on what can be offered and integrated in the virtualized platform's structure. It provides groundwork for the second deliverable D8.2, further discussions with partners and the actual implementation of the platform, which is starting along with the submission of D8.1.

1. Introduction

Scope of the deliverable

The main purpose of WP8 "Virtualized Innovation Hub & Multi-sided Market Platform for Autonomous Quality" is the deployment of a one-stop-shop platform through the establishment of a marketplace along with a DIH for AQ/ZDM. Both of these facilities will empower a holistic end-to-end approach in autonomous and cognitive ZDM, while at the same time consolidate services from multiple national and regional DIHs. QU4LITY will be positioned in the European digital manufacturing ecosystems as a unique virtualized platform, which will be able to integrate services from existing DIHs and offer all services and products supporting the ZDM paradigm through a singular marketplace. The project comes to complement and add-value to existing DIH initiatives rather than competing with them and also add direct access to ZDM components and IP through its multi-sided marketplace. QU4LITY will network with the already identified on-going initiatives for the purpose of exchanging experiences, knowhow and services. QU4LITY comes to reduce fragmentation in ZDM-related networking and innovation management efforts, by providing the means for integrating innovation services and technical services from virtually any number of existing platforms.

According to WP8 overall objective, the purpose of this deliverable is to address the first iteration process of the specification of the requirements intended to guide the design of the QU4LITYs Virtualized Platform.

The collection of the requirements' specification feeding the first instantiations of the QU4LITY DIH and Marketplace will provide the input for D8.2 "QU4LITY Multi-sided Marketplace and Digital Innovation Hub", whose main objective is to model and develop the services as reference workflows guaranteeing the DIHs stakeholders and also define the technical components and specifications of the Multi-sided Marketplace. In this regard, D8.1 will also describe possibilities on strategies for collaborative service provision and so create a channel for further actions in regard to the QU4LITY platform.

2. QU4LITY Virtualized Platform

The Zero-Defect Manufacturing (ZDM) concept has been articulated more than forty years ago as an element of quality management and has been gradually adopted as a quality optimization discipline in the manufacturing chain. Manufacturers have been deploying various ZDM solutions targeting different aspects of quality control and production processes, such as factory automation, condition monitoring, supply chain optimization, and predictive maintenance. Despite these deployments, ZDM adoption is still painful, as it is directly associated with a complex and time-consuming engineering ramp-up phase, while involving multi-stage processes that span multiple production systems. Hence, large enterprises have to deal with many complex ZDM processes at scale, while SMEs lack the knowledge, skills and equity capital to invest in sophisticated digital manufacturing solutions in general and holistic ZDM solutions in particular.

The ultimate aim of the entire QU4LITY platform is to leverage the paradigm of Autonomous Quality (AQ), as a means to address the ZDM challenges above and ensure that both product and process engineering, manufacturing operations and product experience are part of a trusted digital data continuum that leads to products with optimal performance at the hands of the customer. In this regard, the virtualized QU4LITY platform will bridge the gap between SMEs seeking to tackle the challenge of ZDM and enabling technologies, expertise and equipment. It will provide the SMEs with a single-entry point to reach a set of innovation management services and will also make its results accessible through a multi-sided marketplace, which will facilitate SMEs to access QU4LITY's enhanced manufacturing platforms and related digital enablers.

The project will, therefore, establish a virtualized platform for AQ/ZDM, based on the federation, enhancement and virtualization of already available services in the digital innovation hubs of the consortium. The QU4LITY platform will be distributed and fully virtualized, as it will be based on the pooling of resources from the DIHs of the consortium. The consortium brings together some of Europe's leading DIH structures in manufacturing and ICT, which will pool resources and expertise to the QU4LITY virtualized platform. The innovation management services to be offered will be streamlined with the project's developments in other objectives, including the project's experimental platforms and testbeds.

Platform concept

Digitization is essentially an innovation issue and companies will approach it with the usual wide variety of attitudes, approaches and expectations encountered in managing innovation. These range from 'early adopters' keen to climb the technology ladder, to the 'early majority' and 'late majority', who wait for teething troubles to be ironed out before adopting an innovation, to 'laggards', who may need some convincing about the benefits of new digital technology (Figure 1). Thus, the client

base spans a wide spectrum, from the digitally 'mature' to 'immature'. Services will need to be equally broad and accessible to companies through multiple entry points.

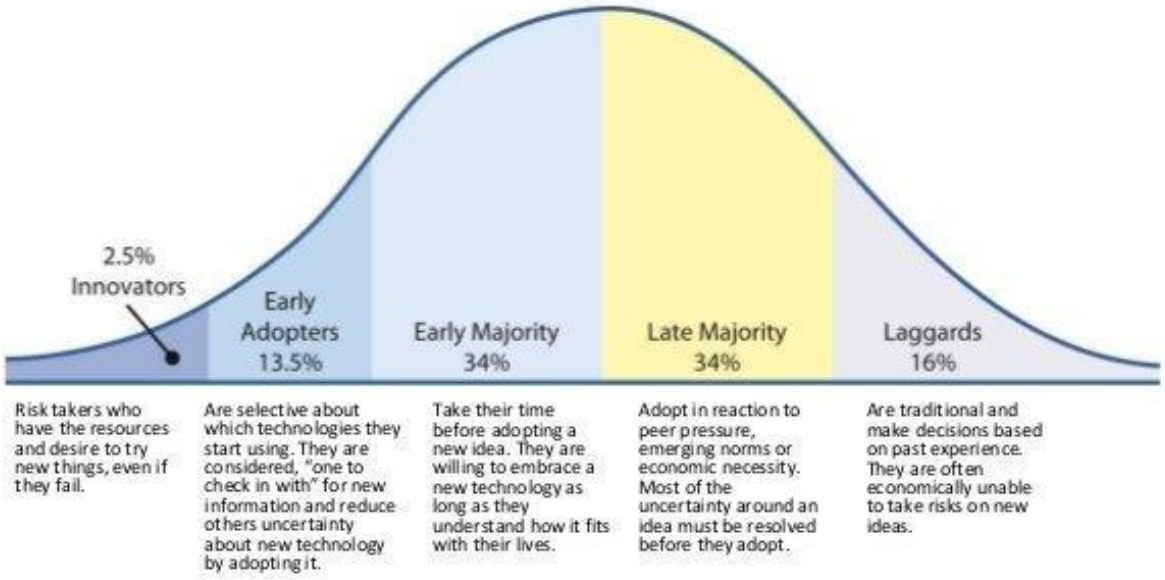

Figure 1: Technology adoption lifecycle[1]

More specifically, in digital enterprises and SMEs are seeking:

- Process optimization based on ICT leading to more efficiency;
- Improvement and development of ICT-based products, services and business models leading to more innovation

However, ICT is changing so fast and there are so many different technologies available that companies do not know what is the best choice for investments. They are therefore seeking 'honest brokers', able to facilitate the exchange of information, help them to make a decision in a trusted way. Companies need help in building the business case for their digital transformation, covering the production processes and the commercial processes, which is best achieved by having the opportunity to engage in pilots and testing activities of the new digital technologies, within their own daily business operation.[1]

The QU4LITY platform is intended to pull together and support all services available in the DIHs in the consortium. The services available through the Platform will enable any business to access the latest knowledge, expertise and technology for testing and experimenting with digital innovations relevant to its products, processes or business models. Services will also provide connections with investors, facilitate access to financing for digital transformations, and help connecting users and suppliers of digital innovations across the value chain. These services are of particular

[1]https://ec.europa.eu/futurium/en/system/files/ged/dei_working_group1_report_june2017_0.pdf

relevance to companies, which currently have a relatively low level of digitization and which do not have the resources or personnel to address the digitization challenge (for instance SMEs).

Figure 2 represents how the platform will connect both supply and demand side stakeholders in a collaborative space. Its presence will be asserted by the implementation of the QU4LITY DIH and the Multi-sided marketplace, providing a wide array of services and also access to a rich set of solutions inside the three side marketplaces. It will be empowered by a collaborative effort from the QU4LITY partners in the consortium and will leverage resources from other DIHs in the consortium.

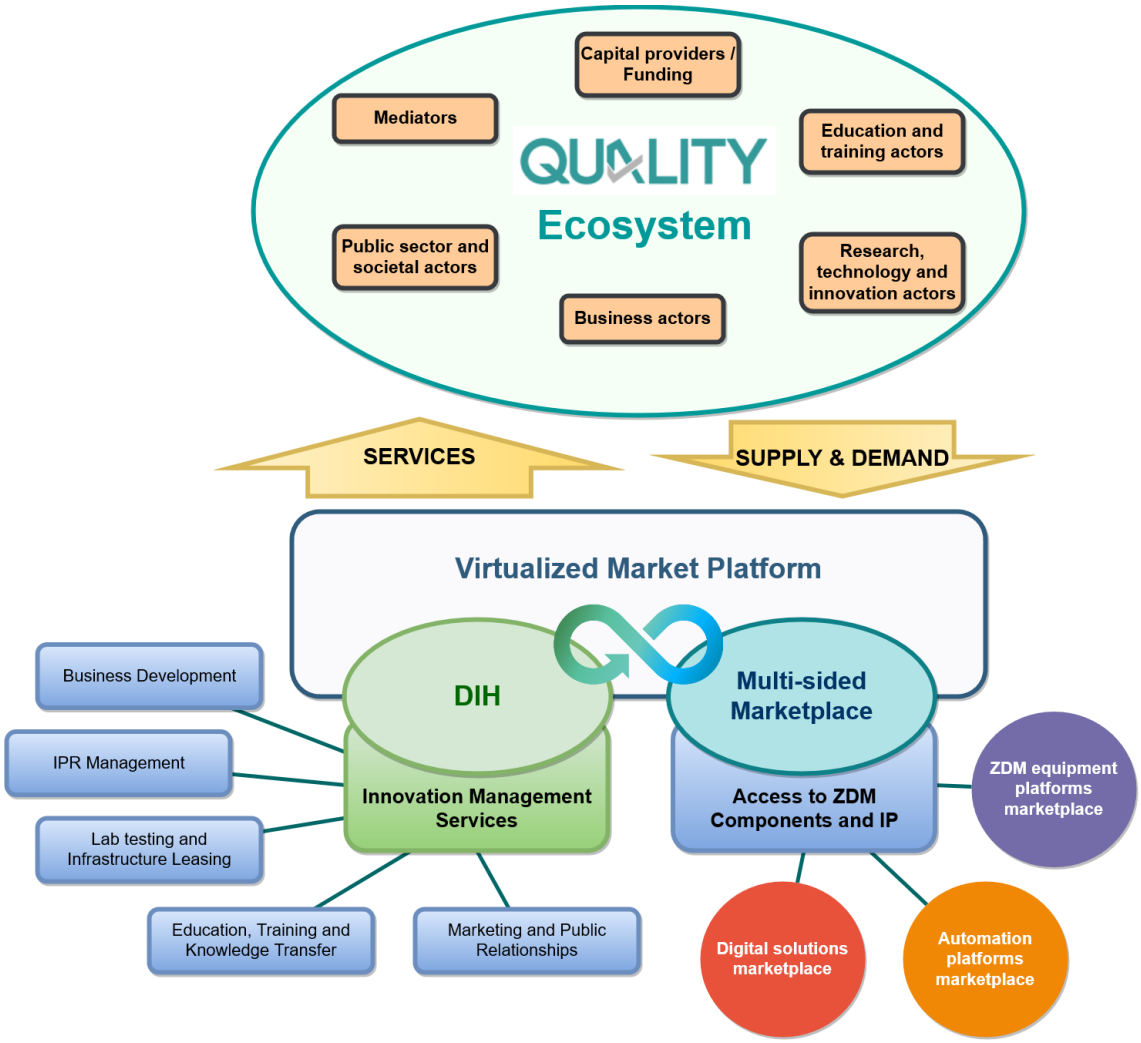

Figure 2: QU4LITY platform concept

As the QU4LITY platform will provide a unique way to tackle ZDM implementation, its structure is defined by the two already known entities with a well-established role in the innovation support ecosystem.

In order for the virtualized platform to provide the desired impact and effectively insert itself in the ecosystem of AQ suppliers and demanders, both the DIH and the Multi-sided Marketplace will be structured in a complementary way, where they each provide the platform users with a holistic offer of ZDM related solutions and services. As the marketplace will mainly serve as a self-service store for products in scope of manufacturing within AQ, the DIH will offer the platform users with a set of business and innovation management services, that support a large spectre of stakeholders within the QU4LITY ecosystem, thus creating a platform for both the technology suppliers and demanders.

The platform will in that regard support collaboration among DIHs in the consortium on a basis of set collaboration rules. These rules will be disclosed in the scope of WP9 and will define the collaboration strategy, governance structure for each service provider and the conditions under which services can be offered.

Users and stakeholders

This section shows initial approach to the stakeholder analysis. This analysis starts with the description of the methodology and the process of identifying general stakeholders relevant for QU4LITY for both the multi-sided marketplace and the DIH.

At this initial stage we can group three main stakeholders' groups:

- Active stakeholders involved actively in the QU4LITY environment (they either use QU4LITY services (project outcomes) or provide QU4LITY services (development, maintenance, consultancy, etc.).
- Enabling stakeholders, they can provide to the expansion and use of QU4LITY outcomes (who would be a part of the dissemination of this technology, regulations makers that would promote or recommend this technology, investors, etc).
- Internal stakeholders, involved in the development and establishment of QU4LITY (consortium partners).

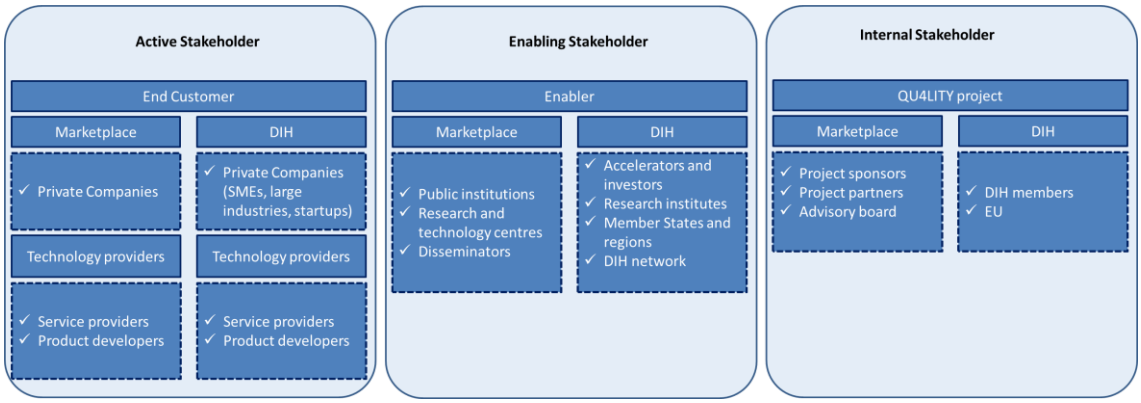

Figure 3: Stakeholder groups

For this analysis, the proposed methodology is the Mendelow matrix also known as Power/Interest matrix. It assists in prioritizing, mapping and grouping the stakeholders in order to identify how to efficiently deal with the relevant QU4LITY stakeholders to maximize the project's efficiency during its transfer to the market.

The Power/Interest matrix, as depicted in Figure 4, maps the stakeholders based in two axes "power" and "interest":

- The **Power**-axis indicates how much impact the respective stakeholder has over the success or failure of the project.
- The **Interest**-axis indicates how much a particular stakeholder cares about the outcome of the project.

The matrix is then divided into the four quadrants (A to D). These 4 stakeholders groups have to be managed differently:

1. **Players** These are the most relevant stakeholder-asset for the project's success. (identified to have high power and high interest). A close management is suggested.
2. **Context Settlers**. They are the second most relevant group (high power but lower interest in the project). It is important to keep this group of stakeholders satisfied (if their interest can be captured their high power can boost the project success).
3. **Subjects** Third relevant group. With high interest but low power. The project is advised to keep the subjects informed.
4. **The Crowd** group of stakeholders not relevant (initially) for the success of the project (low both power and interest). Monitoring of this group can identify any change that could make them relevant.

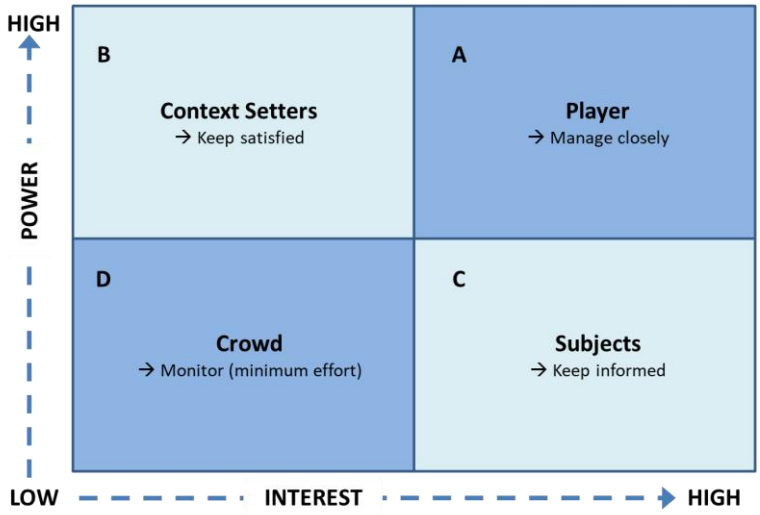

Figure 4: Mendelow matrix

As a preliminary analysis, as depicted in Figure 5, the identified stakeholders can be placed in the following quadrant for a later engagement:

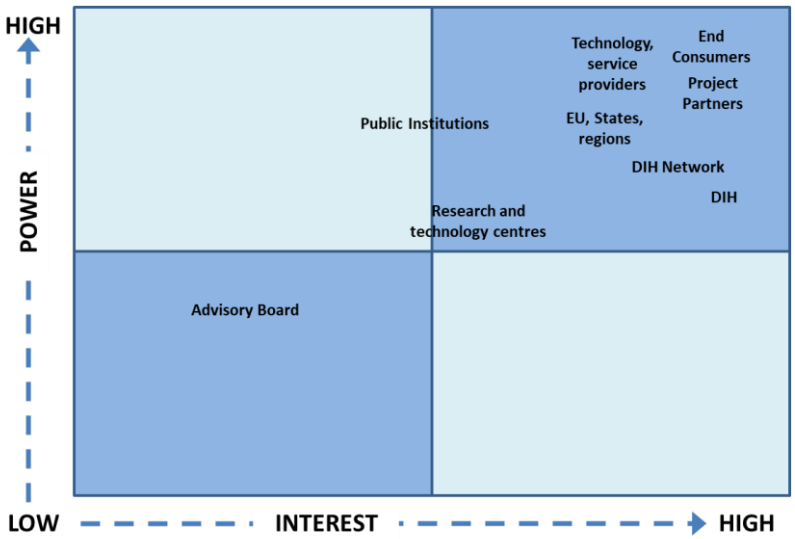

Figure 5: Stakeholder distribution

Requirements from the stakeholders

An understanding of stakeholders' needs is functional for the design and instantiation of the QU4LITY platform. In order to define them, a categorization of the stakeholders based on their organization type was done and the following tables (**¡Error! No se encuentra el origen de la referencia.**, **¡Error! No se encuentra el origen de la referencia.**) present the types of stakeholders and their foreseen business requirements:

Stakeholder	Potential Role(s)	Motivation for working QU4LITY	Direct/Indirect
Business			
Large companies	Client for your clients, service user, service provider	Access to expertise, market insights, human capital, new product development	Direct or Indirect
SMEs	Service user	Access to funding/expertise	Direct or Indirect
Start-ups	Service user	Access to funding/expertise	Direct or Indirect
Research and innovation actors			

Stakeholder	Potential Role(s)	Motivation for working QU4LITY	Direct/Indirect
Research organizations	Partner, service user, product development	Market insights, technology transfer, funding streams	Direct or Indirect
Societal			
Entrepreneurs	Partner, service user, product development	Access to funding/expertise	Direct or Indirect
Incubators	Partner, service user	Develop successful entities	Direct or Indirect
Consumers	Service user	Access to products and services	Direct or Indirect
Public Sector			
Government	Finance provider, policies	Increase innovation and competitiveness levels, employment	Indirect
Capital Provider/funding			
Investors	Finance provider	Investment opportunities	Indirect

Table 2: Organizational types of stakeholders

Req	Business requirement	Business Requirement Description	Category and type of stakeholder				
			Business	Research and Innovation Actors	Societal	Public Sector	Capital Provider/Funding
BR01	Awareness Creation	To create awareness of the opportunities and benefits of digitalization	X	X	X		
BR02	Visioning and Strategy Development for Businesses	To envision its digital future and develop a strategy for delivering this vision	X		X		
BR03	Brokering/ matchmaking	To be a part of a network in order to access information, share experiences, and/or tackle innovation-related problems.	X	X	X		
BR04	Access to Specialist	Access to a Best Practices Catalogue	X		X		

Req	Business requirement	Business Requirement Description	Category and type of stakeholder				
			Business	Research and Innovation Actors	Societal	Public Sector	Capital Provider/Funding
	Expertise and Infrastructure						
BR05	Mentoring	Access to market assessments, trends analysis, business expertise	X	X	X		
BR06	Access to Funding	Access regional, national and/or EU funding to make use of new technologies	X	X	X		
BR07	Collaboration	To stay in a place where it is possible to collaborate and interacts with different Hub members	X		X		
BR08	Access to Expertise	Provide/access expertise, facilities and living labs	X	X	X		
BR09	Training	Provide/access training both technical and management	X	X			
BR10	Collaborative Research	Collaborative Research in areas of common interest	X	X			
BR11	Awareness and Governance	Spread the knowledge, potential and applications of Industry 4.0 technologies and ensure public-private governance for achieving the goals set.				X	
BR12	Innovative Investments	Stimulate private investment in adopting industry-enabled technologies 4.0 and increase spending on research, development and innovation				X	
BR13	Enabling Infrastructures	Ensure adequate network infrastructure, ensure data security and protection, collaborate in defining international interoperability standards;	X	X	X	X	X
BR14	Finance Providing	Create Investment opportunities					X

Table 3: Requirements from the stakeholders

Accessibility and enrollment process

QU4LITY Virtualized platform will be composed by a multi-sided marketplace platform and the virtualized DIH. The shared authentication and authorization technologies will be implemented to support a Single Sign-On (SSO) mechanism over all the websites that compose the virtualized platform. Such mechanism will allow having a single user profile across all the websites, which greatly simplifies the management of users and their authorizations and simplifies the process of authentication, since the user only needs to authenticate once to have access to every site. Moreover, user information will be the same over all the websites, removing the possibility of having incoherent user information across the websites.

In Figure 6 the typical steps for a Single Sign-On authentication are presented. When a user accesses a website, she/he is redirected to the Authentication server where she/he is invited to process with the login. After successful authentication the user receives an authentication token, a cookie is generated and stored on the user's browser to track the status of the authentication against the authentication server and is redirected back to the first website. The new authentication token is used as proof of successful authentication and identifies the user.

When the user accesses another website that redirects to the previous authentication server, the authentication server reads the information in the cookie stored in the internet browser and understands that the user already did a successful login, redirecting it back the previous site with the corresponding authentication token.

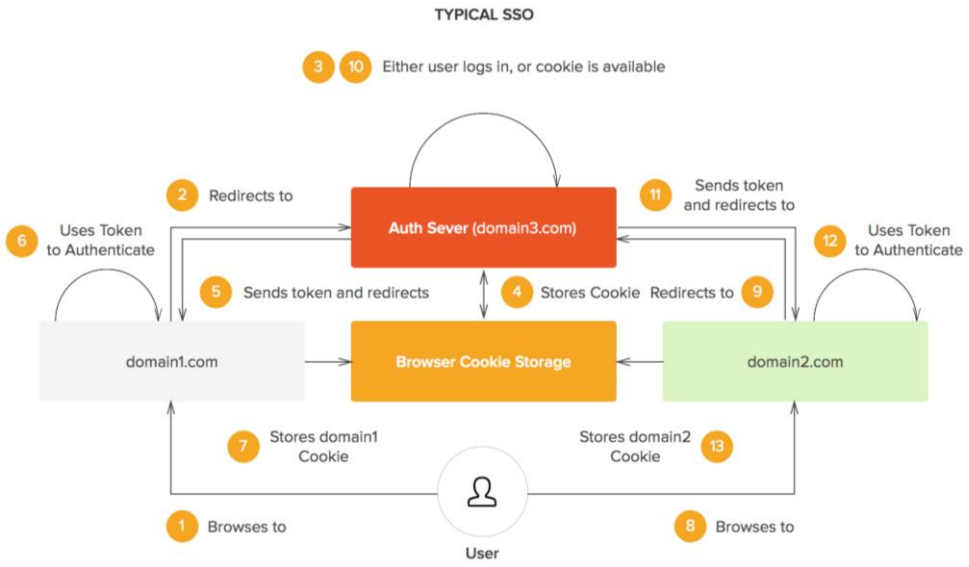

Figure 6: Typical Single Sign-On process

The information required by each website can depend on its purpose and on the role assumed by the user on that website. For instance, the same user can assume the role of a supplier in one website and of a demander in another. As such there should

be a registering mechanism on the authentication server that will collect generic information about the name, contact information, etc. This information will then be automatically provided to all the websites of the QU4LITY virtualized platform. The specific information required by each website will be added to the user profile on that website.

The data collected through the virtualized platform will be stored and processed in accordance with the EU GDPR principles and legal grounds for data processing.

Platform roles

With the goal of seamless provision of services through the QU4LITY marketplaces in mind, several roles can be identified as essential for a functioning virtualized platform, where products and services are being transferred to its users and also between its users. The main foreseen individual or team roles related to the virtualized platform functioning and curation are:

System Administrator (DIH and MSM): The system administrator is the person who is responsible for the upkeep, configuration, and reliable operation of the QU4LITY marketplace platform, seeking to ensure that the uptime, performance, resources, and security of the system he/she manages, and meeting the needs of the users. System administrator responsibilities are, fundamentally, about the care of the general system and also cover the specific applications. He/she is responsible for effective provisioning, installation/configuration, operation, and maintenance of systems hardware and software and related infrastructure.

Content/Category Manager (DIH and MSM): The role regarding the content curation on the entire platform falls to the content manager. He/she oversees the social media presence and news regarding the ecosystem and works closely with the Organization Content Manager in checking the platform for the proper categorization of the IP providers and in identifying success stories.

Organization Content Manager (MSM): This manager represents a specific role dedicated for detailing organization characteristics for every organization registered in the MSM as an IP provider/seller. This role is responsible for providing each organization with a development of their online presence.

Service Provision Teams (DIH): Their role of providing community members with a level of support, that matches the organizations maturity, is essential for the functioning of the DIH and its service provision ability. The number of individual roles needed and their responsibilities are depending on the service provision strategy, indicated in this deliverable, or rather its options.

Customer Service Team (MSM): Following the rules of e-commerce, customer service is essential in providing community members accessing the marketplace with technical support. They also inform the marketplaces' System Administrator of any

platform function issues the community members may come across. The team also has to be familiar with the terms and conditions on use of the platform. Alternatively, an automated technical support can be provided through an AI virtual assistance.

Community Member (DIH and MSM): This role represents every single user accessing the Platform and using its functionalities; as an individual or as a member of an organization. Following the initial SSO (depending on the membership level), the member gains access to all the tools and functionalities the platform has to offer, in regards to their requirements.

3. Multi-sided Market Platform

The project will develop and make available a wide range of novel technologies, which will provide a basis for creating an AQ (ZDM) ecosystem for European manufacturers, digital manufacturing solution providers, vendors of smart manufacturing solutions and other stakeholders (including SMEs). This ecosystem will enable stakeholders from both sides to benefit from the cognitive manufacturing technologies services of the project, through the use of the QU4LITY Multi-sided Marketplace (MSM).

The QU4LITY platform will be empowered by a unique multi-sided marketplace, that will enable the participation of both supply-side and demand-side stakeholders, which will directly benefit from the platform, through the intellectual property and services it will provide.

The marketplace will complement the DIH in providing access to the ZDM equipment and IP. It will consist of three marketplaces in the general scope of AQ paradigm: Digital solutions marketplace, automation platforms marketplace and ZDM equipment platforms marketplace. Together they will construct a common marketplace, enhanced by the IoT Catalogue, which will provide information related to ZDM related technologies and also use cases coming from the QU4LITY pilots.

These market segments will provide an array of AQ based solutions from each of the market's different branches, which together will offer a wide range of solutions in scope of autonomous and cognitive ZDM. In this regard, the IoT Catalogue could be leveraged to help provide information and help in the process of identifying relevant solutions to a demanding user. It is a very useful tool for the QU4LITY marketplace, but the method of leveraging and implementation of it is still to be defined. More detailed information about the IoT Catalogue can be found in Deliverable D2.5.

Concept

The virtualized multi-sided marketplace consisting of three marketplaces, which together offer businesses a holistic approach to ZDM and AQ, will operate alongside the QU4LITY Virtualized DIH. The Marketplace will complement the existing innovation management services, with providing the platforms users with access to ZDM components and IP property provided by service providers of the marketplace. It will offer its potential demand-side stakeholders with self-service platforms, where they can freely browse and buy services or products related to ZDM. In this regard, it will serve as a tool for the demanding companies to leverage the equipment and IP available. The supply-side stakeholders a.k.a. service providers will be able to use the marketplace to market their products/services and also use it as a direct channel to their targeted potential customers.

This Business to Business marketplace model enables a wide variety of commercial offers on a single platform. Hence one-stop-shop. The properties of such a model suggest a complex buying process, long length sale process, a higher number of

decision-makers involved, but also high value of sales. As the majority of businesses, with a low level of digitization and in greater demand of ZDM/AQ solutions, are mostly SMEs, the goal in designing such a marketplace would be to simplify buying/selling processes.

The marketplace will provide its users with a specialized and tailored market in each of the three sectors. Therefore, the marketplace will only offer solutions in the scope of the ZDM and AQ paradigm, implementation of which will be possible in every aspect of manufacturing processes of the demanding companies.

The main focus in the structure specification should be an effective and impactful presentation and promotion of the main service the platform provides, as well as a design that provides the platform visitor with a holistic image of the platform's goals and offerings. It should also enable the user with a practical, direct and quick way to access the solutions in demand. That being said, the platform structure will be designed with these goals in mind.

Alongside the necessary graphical design and architecture of the platform, the technical components of such a marketplace are defined by its service model and usually consist of: searching mechanism, order management system, exchange and customer tracking, rating and feedback, customer service, marketing etc. The definition of such components and specifications will, in this case, need more in-depth discussions and disclosure with partners, but most importantly with the team responsible for implementation, therefore they will be defined in the second iteration of this deliverable, D8.2.

Digital Enablers Marketplace

This part of the multi-sided market platform will provide access to digital enablers, including fog/edge devices, Big Data analytics and AI algorithms, HPC and Cloud environments/infrastructures, blockchain-based services and cybersecurity solutions. This side marketplace will provide assets and services of interest to manufacturers and solution integrators who are looking to enable safe, real-time monitoring and control of their production processes. This chapter provides an insight how the selected groups of digital enablers work within the manufacturing processes and a quick insight into the global market and its trends.

- ***Fog/Edge devices***

Fog and edge are enabling technologies and standards that give IoT users and technology providers more options. Removing the limits of centralized cloud servers means IoT is much more distributed and flexible in the services providers can offer. In essence, fog is the standard, and edge is the concept. Fog enables repeatable

structure in the edge computing concept, so enterprises can push compute out of centralized systems or clouds for better and more scalable performance.[2]

The ongoing developments of 5G networks and its evolution is expected to provide major opportunities for the edge computing market. The number of connected devices is anticipated to exhibit substantial increase with the launch of 5G network. In addition, the connected device and 5G networks are expected to create huge data burden on physical data centers and result into higher demand for bandwidth and lower latency. Hence, all these factors are projected to create major growth opportunities for the market.

The edge computing market size was valued at $ 1,734.8 million in 2017, and is projected to reach $ 16,556.6 million by 2025, growing at a CAGR of 32.8% from 2018 to 2025. Enterprises are employing edge computing to optimize their cloud computing systems, but its complex infrastructure remains a major hurdle for many to overcome.[3]

- ***Big Data analytics and AI algorithms***

Big Data analytics about uncovering critical information to enable smart operations and drive the business. Whether you look at your shop floor, your supply chain or procurement, advanced analytics helps you identify patterns and dependencies within your systems. By doing that you can make right decisions or optimize the whole process. Typical use cases for manufacturing are: Predictive maintenance, Automatic quality testing, Product optimization, Supply chain optimization, …[4]

Many more use cases are out there. How manufacturers will benefit from data analysis really depends on their capabilities, the available data and their ideas.

The Big Data analytics in manufacturing industry market is expected to register a CAGR of over 30.9% during the forecast period, 2019 - 2024. With the high rate of adoption of sensors and connected devices and the enabling of M2M communication, there has been a massive increase in the data points that are generated in the manufacturing industry. These data points could be of various types, ranging from a metric detailing the time taken for a material to pass through one process cycle or a more complex one, such as the calculation of the material stress capability in the automotive industry.[5]

- ***HPC and cloud environments/infrastructures***

With the growth of technologies like the Internet of Things (IoT), artificial intelligence (AI), and 3-D imaging, the size and amount of data that organizations have to work with is growing exponentially. Therefore, fueled by the growth of AI and IoT, high-

[2] https://www.cisco.com/c/en/us/solutions/enterprise-networks/edge-computing.html
[3] https://www.alliedmarketresearch.com/edge-computing-market
[4] https://thrive.dxc.technology/eur/2019/01/14/big-data-analytics-in-manufacturing-how-do-we-leverage-existing-data/
[5] https://www.mordorintelligence.com/industry-reports/big-data-analytics-in-retail-marketing-industry

performance computing is increasingly used to drive commercial, industrial and personal usage.

The new worldwide forecast projects that HPC server revenues alone will grow to $19.9 billion (€17.7 billion) in 2023, compared with a record $13.7 billion (€12.2 billion) in 2018. According to research, the 2023 projection includes $1.4 billion (€1.2 billion) for exascale supercomputers, $2.7 billion (€2.4 billion) for AI-dedicated HPC servers, and about $5.5 billion (€4.9 billion) in cloud usage fees. AI is set to be the fastest-growing HPC segment for HPC, with a projected 30% CAGR during the 2018-23 period.[6]

- ***Blockchain-based services***

Blockchain is a digital ledger technology (DLT) that uses cryptography and timestamps to build stable and secure records. In the manufacturing industry, blockchain capabilities make it all set to disrupt the adoption in the near future. It has the potential to reduce cost substantially, decrease lead times so that manufacturers can focus on other core competence areas to enhance profitability. Whether it is suppliers, procurement, strategic sourcing, shop floor operations or anything pertaining to manufacturing blockchain triggers a completely new way of doing the manufacturing business. Right from sourcing, procurement and dealer quality to operations such as machine-level monitoring, blockchain can pave the way for a new business model and has the potential to emerge as a disruptive solution to these functions in manufacturing.[7]

The business value-add of blockchain is projected to grow to slightly more than $176B by 2025, then exceed $3.1T by 2030. By 2023, 30% of manufacturing companies with more than $5B in revenue will have implemented Industry 4.0 pilot projects using blockchain, up from less than 5% today.[8]

- ***Cybersecurity solutions***

Manufacturing is one of the most targeted industries by cyber attackers, owing to the presence of vital data related to company and government. According to EEF (formerly the Engineering Employers' Federation), over 45% of the manufacturers have been subjected to a cybersecurity incident. With the increasing integration of technological advancements in the manufacturing industry, the security concerns are also increasing at a significant pace.

The EEF's 2018 Cybersecurity Report found that while 91% of manufacturers are investing in digital technology, 35% said they are inhibited from fully investing due to cybersecurity concerns. And it's a legitimate concern – cybersecurity is a real risk for manufacturers. The EEF report found that 24% of manufacturers admitted they

[6] https://insidehpc.com/2019/06/hpc-market-five-year-forecast-bumps-up-to-44-billion-worldwide/
[7] https://www.mordorintelligence.com/industry-reports/blockchain-in-manufacturing-market
[8] https://www.forbes.com/sites/louiscolumbus/2018/10/28/how-blockchain-can-improve-manufacturing-in-2019/#631d5afa5db6

have already sustained financial or other business losses as a result of a cyberattack. But with the fast-moving advancements and opportunities Industry 4.0 is delivering to manufacturers willing to invest, organisations cannot afford to fall behind their competitors.

The global cyber security market size was valued at $104.60 billion in 2017 and is projected to reach $258.99 billion by 2025, growing at a CAGR of 11.9% from 2018 to 2025.[9]

The QU4LITY project is developing a range of digital enablers that will enable the implementation of ZDM systems. An initial mapping of digital enablers has been done with relation to the QU4LITY reference architecture functional domains. More detailed information can be found in deliverable D2.11, in particular in chapter 5.3, and is not replicated here for avoidance of duplication.

These groups were identified as enabling the empowerment of QU4LITY systems' functionalities and are applicable to all functional domains of the projects reference architecture. As the term "Digital Enabler" implies that each of the components will be reusable and accessible via an Open API, they will be offered through the Digital Enabler Marketplace, a side market of the multi-sided Market Platform. The deliverables about the work performed within WP3 are set to provide more detailed information on such digital enablers and their required customization for deployment and use within digital manufacturing platforms.

Digital Automation and ZDM Platforms Marketplace

The factory automation market is worth 270 Billion € (2020), coming from 150 Billion € in 2013, with a compound annual growth rate of 8.53%. The revenues are generated mainly in automotive (35%), packaging (19%), textile (12%) and food processing (6%) applications.

The automation supplier market can be segmented in:

- Automation specialists: focus on few customer segments; competency for complete automation systems for segments. < 5%.
- Solutions providers: differentiation through industry/solution competence; focus on process industry. 15-20%.
- Full-liner: broad range of services; broad range of customers; typically, history in the control segment; completion of portfolio upwards (MES) and downwards. 35-45%.
- Component suppliers: focuses product range; relatively broad range of customers; distinction between volume and niche providers. 30-40%.

[9] https://www.alliedmarketresearch.com/cyber-security-market

- Services providers: mainly provision of auxiliary services. ca. 5%.

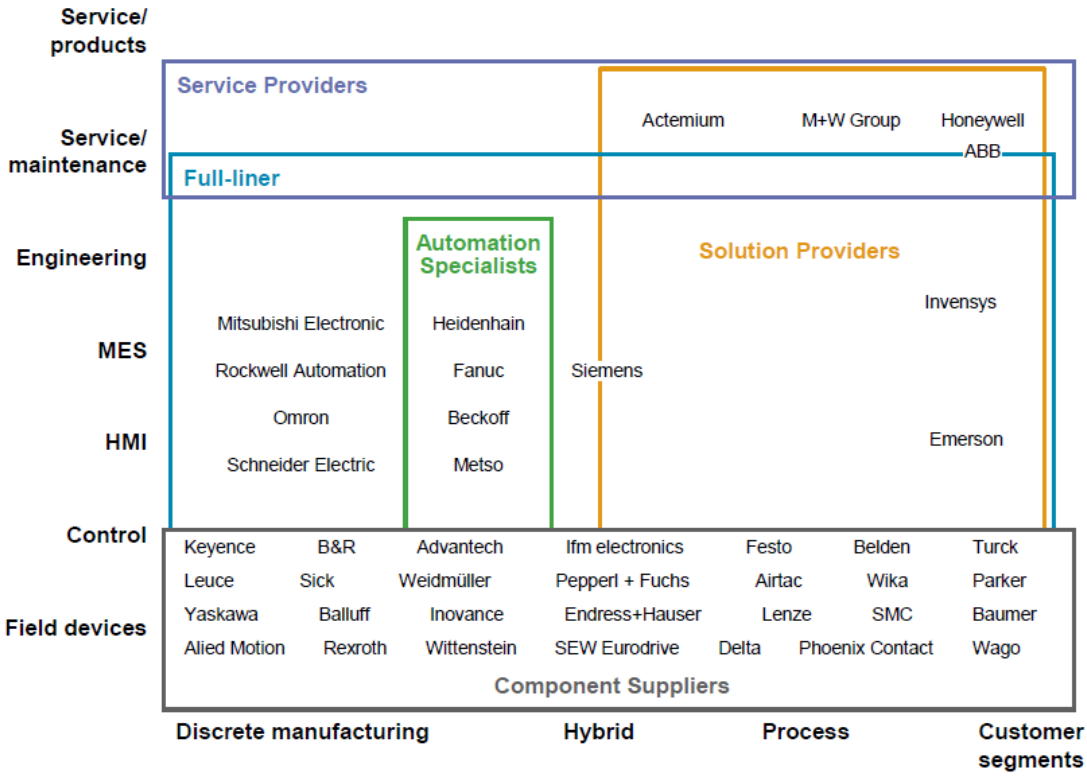

Figure 7: Industrial automation market (Source: Oliver Wyman)

In general, the automated system requires integration by (very often) a third-party systems integrator. This integrator can be a machine builder, the end-user (currently less common), or a systems integrator working for the end-user (most common in mature markets). Third-party integrators typically focus on a particular end market in which they have expertise.

Industrial Automation is key to achieve benefits promised by Industry 4.0 and IoT concepts. The availability of low-cost computational systems is triggering the transition towards decentralization and by that towards autonomous intelligence at the Edge. The requirements are quite clear, but technical development and innovation are needed to make available technologies which help to achieve the necessary flexibility in manufacturing, to provide efficient engineering and to master the increasing complexity.

Today, the engineering of automation systems means creating special-purpose systems and thus creating a unique control system for virtually every installation. Furthermore, current engineering methods lead to the principle of separation of aspects to manage the complexity. Most current tools are vendor-specific and support largely closed control environments. The main improvement can be achieved by increasing the efficiency in automation engineering. Even more so, as engineering

accounts for 70% of the overall automation project costs. Engineering tools need to master the increasing complexity in engineering.

Industry 4.0/IoT's core idea is to distribute embedded, autonomous intelligence throughout the factory, to enable vertical networking with the business process at management level, and horizontal connection among dispersed value networks. This vision is limited by the current PLC technology, a legacy of the eighties, unsuited for sustaining complex "system of intelligent systems" functional architectures. New technologies, such as the IEC 61499, for distributed control systems and others are necessary to support the ease of engineering systems with distributed intelligence, going beyond the limitations of current PLCs means, establishing a new generation of embedded computational devices for control, that could be physically and functionally aggregated in hierarchical system of systems, in order to achieve real-time coordination of their operations within the shop floor.

ZDM Equipment Solutions Marketplace

In this chapter, we deal with the part of the multi-sided market platform that will comprise digitally enhanced ZDM equipment solutions, including robotics, laser solutions, 3D printing solutions, hot stamping solutions and more. This part of the market platform will provide assets of interest to manufacturers and solution integrators. We will first have a look at the target market comprised of manufacturing companies in the EU and globally. We will look at the size of the industry and how it uses and invests in advanced manufacturing equipment, especially on, but not restricted to, ZDM equipment solutions. Secondly, we will have a look at the equipment provider market, its size and supply of solutions.

The ***target market*** for ZDM equipment solutions is the manufacturing industry - a key driving force of the European economy. It provides about 20% of all jobs in Europe and generates a turnover of about €7 000 billion in 25 industrial sectors and over 2 million companies, dominated by SMEs[10]. In terms of value added, the two largest sectors of the manufacturing industry in the EU is manufacturing of motor vehicles, trailers and semi-trailers, and manufacturing of machinery and equipment. Central segments are also manufacturing of food products, fabricated metal products, manufacture of chemicals and chemical products, pharmaceutical products and preparations, rubber and plastics products, electrical equipment, other non-metallic mineral products and repair and installation of machinery and equipment[11].

[10] Kroll&all. An analysis of drivers, barriers and readiness factors of EU companies for adopting advanced manufacturing products and technologies. EU publications. https://publications.europa.eu/en/publication-detail/-/publication/29e4d66e-dd4a-11e6-ad7c-01aa75ed71a1

[11] https://ec.europa.eu/eurostat/statistics-explained/images/e/eb/F1_Sectoral_analysis_of_Manufacturing_%28NACE_Section_C%29%2C_EU-28%2C_2016_%28%25_share_of_sectoral_total%29.png

The European manufacturing industry is a global leader in the use of automation technology. Data from the International Federation of Robotics reveals that globally in 2016 there were 74 installed industrial robots per 10 000 employees and a year later the number of robots was 85. In Europe the corresponding figure is 106 industrial robots per 10 000 workers[12]. The leading industry segment in the use of industrial robots is the automotive industry, but also industries like the electrical /electronics industry and the rubber and plastics industry are increasingly investing in automation. In Europe, Germany is the leading country when it comes to the use of robots. In addition, European countries like France, Austria, Slovenia and Spain have a high robot density[13].

According to a study by PwC, the automation of work is only starting. By the mid-2030s up to 30 % of our present jobs can be automated. In manufacturing, the portion of job to be automated can be even up to 45%[14]. According to an EU study on the implementation of advanced manufacturing technology, key obstacles for companies to investments in advanced manufacturing technology, are made up by a mix of internal and external factors. For nearly three quarters of the firms, especially for SME companies, the most important barrier is the high cost of investments and the lack of financial resources. Moreover, about half of all firms indicate difficulties in assessing the performance and the potential business return of such technologies

Table 4 shows the realized market volumes of central market segments globally and European. The markets for many ZDM equipment technologies is growing rapidly. This can be demonstrated by a 19% yearly growth on robot sales between 2012 and 2017[15].

Technology/industry	Turnover globally	Turnover in Europe
Manufacturing industry	na.	€7.4 trillion (2016)[16]
Machinery and equipment	€2.6 trillion (2017)[17]	€777 billion (2017)[18]
Artificial intelligence	$500 - $700 billion (est.)[19]	na.

[12] https://www.weforum.org/agenda/2019/05/infographic-the-countries-with-the-highest-density-of-robot-workers/
[13] https://www.eu-nited.net/robotics/market/industrial-robotics/index.html
[14] https://bbj.hu/analysis/pwc-predicts-three-waves-of-automation-by-2030_145353
[15] https://www.vdma.org/en/v2viewer/-/v2article/render/25828323
[16] https://ec.europa.eu/eurostat/statistics-explained/index.php/Manufacturing_statistics_-_NACE_Rev._2#Structural_profile
[17] https://www.vdma.org/en/v2viewer/-/v2article/render/25828323
[18] https://www.vdma.org/en/v2viewer/-/v2article/render/25828323
[19] https://pr.euractiv.com/pr/cecimo-announces-35-market-share-global-machine-tool-production-2018-191238

Technology/industry	Turnover globally	Turnover in Europe
Internet of Things	$164 billion (2018)[20]	na.
Factory automation and industrial control	na.	$65.88 billion (2015)[21]
Machine tool production	€79.7 billion (2018)[22]	€27.5 billion (2018)[23]
Automation solutions	€55.2 billion (20xx)[24]	€9.4 billion (20xx)[25]
Industrial robot systems	$48 billion (2017)[26]	na.
Industrial robots	$16.2 billion (2017)[27]	na.
3D printing	$10.6 billion (2018)[28]	na.
Hot stamping equipment	na.	na.

Table 4: Market volume for ZDM equipment

Europe is also a global leader in the ***supply*** of advanced manufacturing technology. For instance, the 15 nations forming the CECIMO -the European Association of the Machine Tool Industries and related Manufacturing Technologies - "cover 98 % of the total machine tool production in Europe and about 35 % worldwide"[29]. Europe also has a strong position in the global robotics market, having 32% of current world markets. In industrial robotics, the European share of the market is about one third and in smaller professional service robots, European manufacturers produce 63% of the non-military robots[30].

In regards to leveraging results from other WPs, the D4.1 focuses on specification of the ways various types of ZDM equipment will be enhanced and thus provides a list

[20] https://www.statista.com/statistics/976313/global-iot-market-size/
[21] https://www.mordorintelligence.com/industry-reports/europe-factory-automation-and-industrial-controls-market
[22] https://pr.euractiv.com/pr/cecimo-announces-35-market-share-global-machine-tool-production-2018-191238
[23] https://pr.euractiv.com/pr/cecimo-announces-35-market-share-global-machine-tool-production-2018-191238
[24] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20190121-1
[25] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20190121-1
[26] https://www.vdma.org/en/v2viewer/-/v2article/render/25828323
[27] https://www.vdma.org/en/v2viewer/-/v2article/render/25828323
[28] https://www.mordorintelligence.com/industry-reports/3d-printing-market
[29] https://pr.euractiv.com/pr/cecimo-announces-35-market-share-global-machine-tool-production-2018-191238
[30] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20190121-1

of machine equipment entailed in the pilot projects (chapter 3). The selection of technologies and equipment to be offered in this marketplace, will be done on the basis of the results that are to be expected by implementing such equipment.

4. Virtualized Digital Innovation Hub

Concept

A Digital Innovation Hub is a support facility that helps companies to become more competitive by improving their business/production processes, as well as products and services by means of digital technology. DIHs act as a one-stop-shop, serving companies within their local region and beyond to digitalise their business. They help customers address their challenges in a business-focused way and with a common service model, offering services that would not be readily accessible elsewhere.

DIHs are the preferred European instrument to support companies in their digital transformation. The implementation of ZDM strategies and ultimately the associated quality control loops, demand the integration of multiple technologies (big data, robotics, laser, 3D, IIoT/CPPS, HPC, cloud, etc). Companies in demand need effective means and services to deal with such technology integration and the supplying companies need IPR and marketing services for their solutions. The QU4LITY virtualized DIH is intended to provide all businesses with a single-entry point to its innovation management, technological, knowledge and business services and so enable implementation of ZDM based solutions.

Service portfolio

The services available through the Platform will enable businesses to access the latest knowledge, expertise and technology for testing and experimenting with digital innovations relevant to their products, processes or business models. The services offered include provision of connections with investors, facilitating access to financing for digital transformations, and helping connecting users and suppliers of digital innovations across the value chain. These services are of particular relevance to companies, which are either looking to improve their production processes or establishing production. On the other side, these services will help companies that offer solutions to protect their IP and market their products or services.

The QU4LITY DIH tries to reflect industry needs, by providing an array of services, under the following innovation management service categories.

- **Business development services**

Business Development Services are a key facilitator of Private Sector Development in EU partner countries. They are important within a development context because they can help small and medium-sized enterprises (SMEs) in Europe to run their business more profitably, allowing the private sector to become a more effective driver of socially inclusive development.

Business Development Services are used to increase MSMEs operating efficiency and grow their businesses. Business Development Services cover a wide range of services such as:

- Facilitation and support for the implementation of proven, highly effective models of corporate development.
- Facilitation and support for forging strategic partnerships and cooperative agreements.
- Support for the attraction of grants and streamlining of effective commercialization practices.
- Promoting business linkages and support for technology and product development.
- Training and technical assistance.
- Technology transfer, training, incubation and awareness construction capitalizing on the consortium competences.
- ICT infrastructure services.
- IT Cloud platforms.
- Services in CPS/IOT enabling technologies.
- Concept validation and prototyping.
- Direct purchasing and operation of cloud-based modelling and simulation solutions.

- **Lab testing and infrastructure leasing services**

Test labs provide help in verifying that the features that are requested to a device and/or system are met. The most important is to guarantee the reliability of the system considering the regulations that apply.

After all, a Digital Innovation Hub (DIH) is a help for companies, that need to implement a new service or new functionality, that they cannot test elsewhere, and that is why it is necessary to ensure that the DIH meets certain standards and the business needs of the MSMEs.

In order to ensure that the technological components to be offered in our virtualized DIH comply with the necessary functionalities, some of the points that arouse a main interest are:

- The compatibility of our quality system with others,
- Certifications that apply to us,
- And the confidentiality of the information…among others.

For this purpose, a test laboratory will be designed, offering the following services:

Tools as a service: Means that all the necessary validation tools will be available as a service for customers.

Verification of compliance with different standards: It will be checked, which other standards apply and, in case it is necessary, it will be evaluated our compliance level against them.

Infrastructure as a Service (IAAS): Access to an infrastructure that allows us to manage the validation strategy efficiently and quickly, will be granted.

Testing Services: Design and run functional and vulnerability test and, in case it is required, unit test will be also executed.

Access to certified components: Information about the components that have been already certified.

Current validation status: Information about the status of the certification.

In the end, the goal is to facilitate to the local industry the access to new technologies products and platforms, and to simplify the access to these resources for their experimentation, validation and verification.

- **IPR management services**

Intellectual property rights are essential for enterprises to protect their innovational achievements and thus generate a competitive advantage. Therefore, the management of IPR should be an integral part of each ZDM company, aiming to create superior and exclusive customer value.

Regarding the multi-sided market platform and the virtualized DIH in QU4LITY, the services for IPR management affects both shop service provider and marketplace customers. While the DIH represents an ideal opportunity for the technology owner to distribute their solutions, it is at the same time necessary to protect their innovations. On the other side, the IP protected deployment of marketplace services to the mainly consuming SMEs interferes with their commercialization strategies.

To this end, IPR management services may consists of the following non-exhaustive list of measures like:

- **Support for patented product generation:**
  A consulting service helps solution providers in the process of patenting their innovation.
- **General informative material about IPR management explaining basics of IPR for interested but inexperienced entrepreneurs.**
- **Regulation of IPR in the scope of joint projects/products:**
  The combination of intellectual property easily results in contradicting situations which has to be properly taken care of. In urgent cases, services for settlement of disputes might be needed.

- **Creation and maintenance of an IPR Directory:**
  A transparent repository of IPR serves as an information source and thus helps in avoiding conflicts in the first place.
- **Guidance and implementation of licensing models** serves as a mediate tool to protect intellectual properties. Especially the clarification of license compatibilities is important, when marketplace customers integrate platform services in their commercialization strategies.
- **Administration of access rights** is the most common way to protect intellectual property.

- **Marketing and public relationships services**

QU4LITY will offer an array of marketing tools and services in order to support an efficient commercialization of ZDM-related products and services. The marketing services will target both supply-side stakeholders, such as CPPS-manufacturing companies, as well as demand-side stakeholders including manufacturers with an interest in adopting or improving ZDM.

Promotion of corporate products and services will be carried out through participation in trade fairs and international exhibitions. Appropriate stands and promotional material such as flyers, posters and banners will be used when attending these exhibitions.

Marketing activities will also be done through social media. Mainly Twitter and LinkedIn will be used to promote various corporate products and services. Moreover, QU4LITY hosts a website with the intended use to promote and spread awareness about ZDM-related products and services. Website content will be published with a SEO-driven approach. The website will also give the possibility for visitors to subscribe to the online newsletter. The online newsletter functions as an additional marketing tool for promoting various corporate services.

In order to assure awareness about ZDM-related products and services, online training sessions will be held for relevant stakeholders. These sessions will specifically target non-IT savvy people, to show them the characteristics of the new services. Additionally, manufacturers´ workshops will be attended on a regular basis.

QU4LITY will also have a scientific approach as a part of the promotional services. This will include participation in conferences and publications in scientific journals. Press and media releases will occur on a regular basis aiming at announcing project outcomes and dissemination of best practices around ZDM-related products and services,

The marketing and communication activities will have an objective of creating and engaging a community of stakeholders around the QU4LITY ecosystem, consisting both of supply and demand-side companies.

Joint effort towards a joint work with Digital Manufacturing Platforms (DMP) in the ZDM area is also been performed. Within this cluster a joint image of the projects working in ZDM has been created (flyer …). It is foreseen to promote joint dissemination activities and work in other relevant areas such as pilots, standards, platform, etc.Interaction and dissemination of QU4LITY within EU associations such as EFFRA, BDVA, etc.are also part of the marketing strategy of our project since M1.

- **Education, training and knowledge transfer services**

The successful adoption and implementation of digital innovations in manufacturing companies and the full realization of the benefits of enhancing manufacturing processes with ZDM solutions in scope of QU4LITY, bring an associated need for new knowledge and skills.

Education 4.0 is expected to respond to the needs of various stakeholders through collaborative skill development strategies:

- *Learner* looks for tailored training services for individual aspirations;
- *Education/Training Providers* aim to dominate the scene in the education 4.0;
- *Industry* looks out for industry-ready personnel and innovation-oriented competencies;
- *Society* expects the ecosystem to create individuals with high emotional quotient (EQ), who work toward solving community challenges in a 'humanly interconnected' way (i.e. collaborative problem solving)[31].

In that light, both educational content and formats are relevant and **formal education**, **hands-on learning** and **on-the-job training**[32] should be combined to upskill and/or re-skill the Industry 4.0 workers with the opportunities offered by the digital technologies of melting physical reality with virtuality to achieve:

- *Personalized and more effective learning experiences.*
- Trainees' engagement in *training reinforcement.*
- *Measurement Effectiveness and ROI* by correlating on-the-job activity in different existing systems with training programs.

The following education and training methods must be part of the service portfolio offer of an ecosystem of DIHs, to support the digitalization of the manufacturing and the exploitation of Autonomous Quality and ZDM knowledge and practices.

Massive open online courses (MOOCs), each student can learn at his own speed:

[31] The World Economic Forum declared that emotional intelligence will be one of the Top-10 most required skills by 2020

[32] https://www.festo.com/net/SupportPortal/Files/551591/Festo_Inudstry%204.0%20User's%20Guide_Educator%20Edition_White%20Paper.PDF

- *Computer-based training* vary from the simplest text-only programs to highly sophisticated multimedia programs (CD-ROM, Multimedia) to virtual reality;
- *E-learning* such as Web Based training, videoconferencing, web meeting or webinars;
- *Mobile learning* to learn anywhere, anytime and on the move with educational content made available over mobile networks to devices such as tablets, smart phones and feature phones.

Serious games are digital applications that use the theme of entertainment to support a learning process, in a less traditional way, by supporting the learning motivation through entertainment. They can be deployed also for training on the field (inside the factory).

Augmented Reality (AR), **Virtual Reality (VR).** Like traditional eLearning, **VR**[33] creates a safe environment for learners to try new things and practice using skills. The big difference is that VR gives the feeling of "really being there" in a way eLearning does not. **AR** is probably a better fit for performance support, as it adds to something that's already there.

Virtual learning platforms like Moodle can systematically be linked to virtual or tele-operative laboratories. Every worker gets the opportunity to experiment with physically real equipment, without the necessity to be physically present at the location of the machine.

Learning/teaching factories can take different forms, being labs or representations of manufacturing processes including integrated physical Industry4.0 components[34]. They support hands-on training and the learning process is closer to industrial practice.

AI (Artificial Intelligence) Learning. It allows on-the-field learning that takes place within the company.

Collaboration rules

The QU4LITY ecosystem is a construct of SAE Silicon Europe and I4MS DIH networks and will leverage resources from different DIHs in the consortium. The platform will support communication and collaboration among DIHs by considering every DIH's specialisation, through their networking. QU4LITY will base its virtualized platform on the pulling of resources under the collaboration rules, which will be fully disclosed in the WP9. Until then, the discussion on how to implement such sort of collaboration is

[33] Bridging the Skills Gap of Workers in Industry 4.0 by Human Performance Augmentation Tools: Challenges and Roadmap - DOI: 10.1145/3056540.3076192
[34] SEPT Learning Factories for Industry 4.0, Education and Applied Research – Mo Elbestawi and others 8th Conference on Learning Factories 2018

active and this deliverable will present some foreseen possibilities on how such collaboration could be implemented.

As the already established DIHs in the consortium are offering innovation management services in their own regional or Pan-European ecosystems, a strategy to leverage them would be to have collaboration partnerships established inside the QU4LITY ecosystem with the DIHs directly. The project would identify the DIHs in the consortium which offer at least one of the services disclosed in the QU4LITY DoA. The mapped DIHs would be assigned to each of the services to be offered on the QU4LITY DIH, based on their competencies, their regional coverage, relatedness to the ZDM and AQ paradigms and the service demander specifications. Whenever a request for service provision would be made, the QU4LITY DIH team would choose the DIH that best suits to the service demander and contracts it to provide the service. The QU4LITY DIH team would consist of partners, which are involved in other DIHs in the consortium and have the competencies and experience in service provision category they are assigned for. Each service would therefore have a small team of partners, who would collectively be responsible for contracting appropriate DIHs.

A more passive approach to the option above, would be to catalogue the providers of each service offered through other DIHs in the consortium and just provide information on them. In this case, the QU4LITY partners will have to identify the service providers, collect information and categorize them appropriately. This represents a more self-service approach, where the platform users can freely browse the catalogued service providers.

Another approach would be to create teams for service provision within the QU4LITY consortium partners. The project would identify the partners who are involved in other DIHs within the ecosystem and have the competencies to contribute to the provision of innovation management service to be offered. Teams of partners would be delegated to each of the services to be provided, where every team is governed by a team leader. The partners would be chosen based on their involvement in other DIHs in the consortium and individual competencies and experience in the service category they would be considered for. Whenever a user of the platform requests a service, the platform governance team deploys the team of partners responsible for the provision of said service.

Depending on the strategy chosen for service provision, some additional roles involved in the platform management, foreseen in chapter 2may be additionally needed.

As the rules are essential for the service provision ability and method, they present a critical factor in drawing up the specifications for such a collaborative platform and will be fully disclosed in the T9.4. This deliverable D8.1 only serves to present possibilities and provide ideas for further discussions regarding the strategy of providing innovation management services to the demanding stakeholders.

5. Collaboration in the QU4LITY Virtualized Platform

The joint exploitation of the QU4LITY services will be based on their structuring around a multi-sided virtualized platform. It will provide a generic cloud-based entry point to all the digital manufacturing and innovation management services of the project. Through forming the QU4LITY ecosystem, on the basis of the to be established DIH and the multi-sided marketplace, the project will build an extensive multi-stakeholder community around it. In a common goal of providing a holistic solution for the demanding market of providers and integrators of digital manufacturing solutions, wishing to evolve their products towards autonomous quality and cognitive manufacturing, and also the supply market of technology and solution providers, looking to market and sell their products, both virtualized entities complement each other in providing sets of services. The complete portfolio of services that needs to be offered in order to provide both-side stakeholders support on all maturity levels and thus offering a holistic approach towards ZDM, is conditioned by enabling the collaborative existence of both the DIH and the multi-sided marketplace. This collaboration is essential in order for the proper functioning in the scope of the project and the delivery of the project's set goals.

Under this aspect the project is looking from different angles to the creation of this platform, taking in particular into consideration the architectural approach, but also the user's/customer's journeys that different stakeholders might take when accessing the platform. The latter one is of particular importance for the attraction of users/providers on both sides, demand and supply.

Architecture initial approach

Along the common goals of the two entities constructing the QU4LITY virtualized platform, they will also share their space under a single domain. A registration of a domain name is a prerequisite to online platform implementation along with a hosting and scalability plan. The foreseen next steps involve SSL certification for data encryption and a monetization plan of the platform, which would mainly involve a membership fee and a pay-as-you-go scheme for innovation management services provision, which is conditioned by an establishment of a payment gateway.

Given the overall platform concept and what it offers, a basic architecture or rather the first layer of the platform can be drawn up (Figure 8).

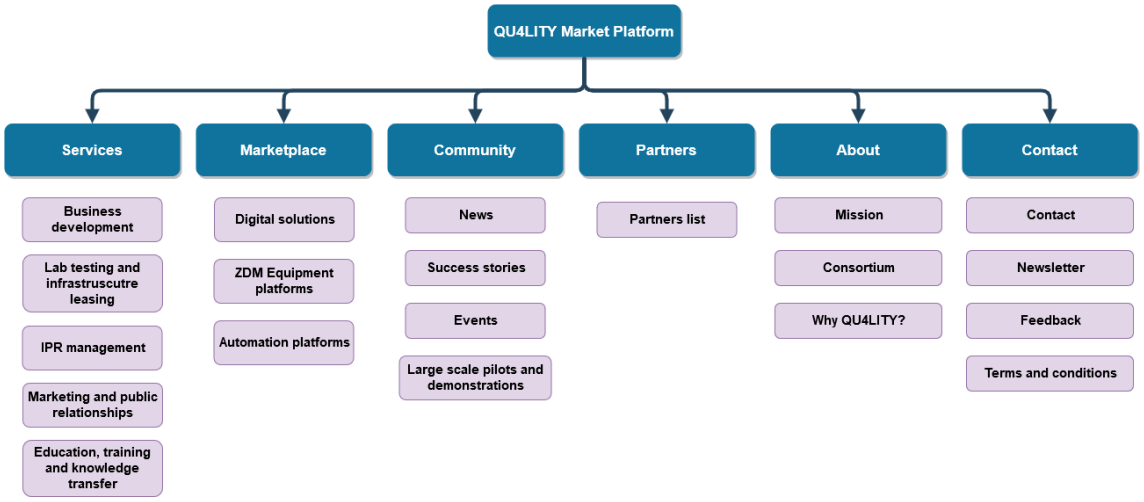

Figure 8: Initial platform architecture

The structure reflects the platform's goal of providing a holistic support in form of a virtualized entity, thus offering access to a marketplace of novel technologies, services and products, along with direct access to the innovation management services it will offer. Mainly focusing on access to services and the marketplace, the platform will also provide some general information regarding the QU4LITY project, ecosystem and the platform, tools for direct contact, newsletter subscription, customer feedback, etc. The community nurturing will be done by providing related news, success stories and information about relevant events.

The platforms content that provides added value, will be locked under a membership check and a registration requirement.

The platform mixes a B2B model of the marketplace with a B2C model of the DIH and as such needs a wide variety of technical components and tools to support everything it should feature. Next to a well-developed back-end of the platform, which will enable proper processing and categorization of the user data, some of the tools needed include forms, filters, search engines, interactive maps, web sniffers, etc. The goal is to make as much of the transaction process and platform curation as automated as possible.

The marketplace platform is planned to also leverage third party tools such as the IoT Catalogue, which can provide the platform users with a source of information regarding relevant solutions and technologies.

This architecture is very fundamental and offers a starting point for structuring the platform. A final version and a more in detail definition of its substructures and gateways will therefore be defined after additional discussion with other partners in the second iteration of this deliverable, D8.2.

User journeys

A good way to demonstrate the vision of the project's virtualized platform, understand user behavior, identify possible high-level functionality and define its taxonomy and interface is by creating user journeys. Each journey depicts the users' goals, their motivations, current pain points, their overall character and what they want to achieve.

As it is of particular importance to create the necessary "mass" for the platform by relying on the network effects, we have already identified some customer/user journeys for the different users of the platform, both on the supply and demand side. The QU4LITY project can already provide with its numerous results a vast number of services, products, uses cases, while the demand side still has to be created and reinforced to attract then as many as possible users to the QU4LITY platform.

The initial set of identified user journeys is mainly targeting the demand side for the reasons indicated above but we have identified an example as well for a user journey on the supply side, who is also a demander of a service offered on the platform. More user journeys will be detailed also as a support for the architecture and creation of the QU4LITY multi-sided platform and will be reported in the next iteration of this deliverable, D8.2.

User Journey #1 (Researcher)

Persona Definition
Researcher • Georg is a senior researcher in industrial engineering with emphasis on manufacturing. • He has a BSc. in mechanical engineering and an MSc. In operations research. • During the last two years he is has a strong interest on Industrial Internet of Things and Industry4.0. • Last month his (Industrial Engineering) group has started a new research project on Digital Twins for Zero Defect Manufacturing (ZDM).
Goals & Objectives of the Persona
Objectives Georg was to gain knowledge and skills that will ensure his successful engagement in the ZDM project. Therefore, he would like to: • Understand the basics of Zero Defect Manufacturing in general and of digital twins for ZDM in particular. • Gain insights on the use of data-driven approach (such as Artificial Intelligence) for ZDM and quality management in production lines.

- See some practical examples of Digital Twins for ZDM i.e. how a real-life system would work in terms of simulating production and identifying causes of defects ahead of time.

Touchpoints in the QU4LITY Market Platform

Touchpoints and Dissemination Channels

Georg is aware of the QU4LITY market platform as a single entry point for accessing ZDM and Quality Management resources in Europe. This awareness is a result of one or more of the following:

- Georg was informed about QU4LITY market platform during a conference, as part of his discussions with a colleague.
- Georg read information about QU4LITY in a widely spread LinkedIn post, written by an influencer of the Industry4.0 community.
- George saw QU4LITY listed in a public catalogue of Industy4.0 resources.

QU4LITY Functionalities in the Persona's Journey

Journey

- Georg visits the home page of the platform.
- He reads about QU4LITY and then selects to access the "Training" and "Knowledge Base" menus.
- Under the "Training" menu George accesses a 15' tutorial webinar about ZDM in the Industry4.0 era. He is asked to register with the QU4LITY platform in order to access the webinar.
- Under the "Knowledge Base" George reads a 700 words blog post explaining the role of Digital Twins in Quality Management and ZDM. Moreover, he is able to find pointers to scientific papers presenting practical case studies of digital simulations and digital twins for ZDM.
- Georg visits the QU4LITY platform two days later. This time he accesses the "Case Studies" section, where he reads about the use of the QU4LITY platform for digital simulation of quality processes towards making predictions and gaining more knowledge about the processes. He is also offered with the opportunity to see a video of a practical deployment and use in the QU4LITY pilot production lines. The video depicts a case that falls directly in the scope of his new project. He has now some very good ideas about how the final deliverable of his new research project could be.

User Journey #2 (SME Chief Technical Officer)

Persona Definition

CTO of SME

- Petra is CTO in an SME manufacturer that produces paper & packaging products.

- Quality management and control in Petra's company is very important, as the produced packaging products are produced based on complex production pipelines involving many processes (e.g., cutting, dying) that may introduce errors and quality problems.
- Petra has read many articles about how digital manufacturing will enable predictive quality and Quality4.0. In collaboration with her colleagues she has started the implementation of some Industry4.0 functionalities in the factory, such as collection of digital data.

Goals & Objectives of the Persona

Objectives

Petra want to access practical information on how to deploy Machine Learning algorithms and systems over the data that her company collects. In particular, she is interested on:

- Machine Learning algorithms that she could use for quality inspection, along with information on the data management infrastructure they run upon.
- Demonstrations of automated predictive analytics on quality data towards Quality4.0 use cases.
- Best practices and lessons learnt about ML deployments for quality management.

Touchpoints in the QU4LITY Market Platform

Touchpoints and Dissemination Channels

Petra is aware of QU4LITY market platform through one or more of the following channels:

- Petra saw a presentation about QU4LITY in a trade fair.
- Petra visit the EFFRA web page and found a banner of QU4LITY.
- Members of Petra's team googled "ML for Quality Management Industry4.0" and the QU4LITY market platform page was among the top results.

QU4LITY Functionalities in the Persona's Journey

Journey

- Petra visits the QU4LITY market platform and notices the Machine Learning Library (ML-Library for ZDM) under the "Solutions" section of the web site.
- Petra see a set of ML algorithms for Quality Management, along with instructions about how to access them and run them in a sandbox environment based on proper API. She also realizes that some of the algorithms are also available in the popular Open ML site.
- Petra is also able to access sample datasets for running the algorithms. She is able to access a demo in the sandbox environment, based on a dataset that comprises sensor data and product quality data.
- Petra can also access documentation for some of the ML algorithms, including sample applications.

- Using the information available in the market platform, Petra is able in a few days to set up some ML examples on the production data of her company.

User Journey #3 (Solution provider Chief Technical Officer) – Demand side.

Persona Definition
CTO of solution provider • Alex is CTO in a SME providing digital twin technology for ZDM in assembly industries. • This SME provides customized solutions to address the different needs of its customers interested in improving the efficiency of their assembly processes. • This SME aims at improving the efficiency of its solution to increase its market share. • Alex has a good experience in deploying solutions for ZDM, but sometimes customers' needs are very challenging and it's not easy to address them.
Goals & Objectives of the Persona
Objectives Alex is interested on: • Checking solutions from other solution providers acting in the same market sector. • Getting news on digital twin technology for ZDM. • Finding best practices on the deployment of this technology. • Getting out real case studies to check for the deployed solution and the lesson learnt.
Touchpoints in the QU4LITY Market Platform
Touchpoints and Dissemination Channels Alex is aware of QU4LITY market platform through one or more of the following channels: • Alex saw a presentation about QU4LITY in a trade fair. • Alex visit the EFFRA web page and found a banner of QU4LITY. • Members of Alex's team googled "Digital twin for ZDM" and the QU4LITY. market platform page was among the top results.
QU4LITY Functionalities in the Persona's Journey
Journey • Alex visits the QU4LITY market platform and searches for "Digital twin solutions for ZDM". • A list of solutions along with their providers is listed. Clicking on each item, a short description with a list of features is shown. A PDF document is also available to be downloaded.

- A hyperlink connects to the web page of the provider where more details will be available.
- Under the NEWS Alex can read some interesting papers on innovative aspects in deploying digital solution for ZDM, and he can find a list of workshops, seminars on this topic.
- Then Alex searches for real case studies on ZDM in small manufacturing companies and he can find 10 interesting applications.
- Alex can also read the lesson learnt from the company where a ZDM solution has been installed.

User journey #4 (Solution provider CTO) – Supply side

Persona Definition
CTO of solution provider • Frank is a CTO in a company providing laser-based solutions for ZDM in manufacturing industries. • This SME company provides machines that allow their customers to manufacture smaller and higher-precision components and is growing rapidly. • SME aims to launch a new laser scriber and expand its business. • Frank has a good experience in deploying solutions, but does not know how and where to market their business.
Goals & Objectives of the Persona
Objectives Frank is interested on: • Checking solutions from other solution providers acting in the same market sector. • Getting news on laser technology for ZDM. • Finding support services for marketing. • Having a platform where he can market their products. • Gaining information on incoming conferences and fairs.
Touchpoints in the QU4LITY Market Platform
Touchpoints and Dissemination Channels Frank is aware of QU4LITY market platform through one or more of the following channels: • Frank saw a presentation about QU4LITY in a trade fair. • Frank visited the EFFRA web page and found a banner of QU4LITY. • Frank heard of QU4LITY as part of a discussion with a colleague in a manufacturing fair. • Members of Frank's team googled "Photonics marketplace" and the QU4LITY market platform page was among the top results.

QU4LITY Functionalities in the Persona's Journey
Journey • Frank visits the QU4LITY market platform and checks the photonics marketplace. • A list of solutions along with their providers is listed. Clicking on each item, a short description with a list of features is shown. Documentation on the solution along with a short video is available. • Frank checks the community link and sees information on how big the ecosystem is. • Frank wants to register on the platform. • Frank looks for marketing services provided on the platform. • He gets in contact with a marketing person who provides information on how to write the presentation of their company and which events to target for marketing.

6. Conclusion of the deliverable and future work

This deliverable is a result of the prerequisite work needed for the defining of architecture, specifications and implementation of the Virtualized QU4LITY platform. It describes the platforms concept, provides the initial definition of its stakeholders and their requirements, foreseen roles needed for the running and curation of the platform, defines platforms accessibility and provides a portfolio of possible services to be offered in the DIH and in the marketplace. Through providing the said information and along with some initially identified user journeys, it outlines the high-level structure of the platform.

This deliverable is the first of the two outputs from QU4LITY Task 8.1 ″Multi-sided Market Platform Architecture and Virtualized DIH Specifications″. The second and final iteration of this deliverable will be focused on providing further and more detailled information regarding the potential platform users, defining the low-level architecture of the platform and describing the technical components to be implemented and by that providing the necessary basis for the creation of the QU4LITY platform.

Based on the current results reported in this deliverable, we will focus in the second iteration on:

- Further analysis of the platforms' stakeholders
- Identification of more user journeys
- Definition of the low-level architecture
- Identification of the needed technical components
- Definition of the platforms' monetization scheme

These actions were defined according to the results of work done thus far and the identified planned work according to the tasks' targets defined in the project plan. The work progress covering all points above will be reported in Del. 8.2 due at M24.

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List of Abbreviations

AQ – Autonomous Quality
AR – Augmented Reality
CPS – Cyber Physical System
DIH – Digital Innovation Hub
EC – European Commission
EQ – Emotional Quotient
ICT – Information and Communication Technologies
IEC – International Electrotechnical Commission
IPR – Intellectual Property Rights
MOOCs - Massive open online courses
MSM – Multi-sided Marketplace
MSME – Micro, Small or Medium Enterprise
PLC – Programmable Logic Controller
RA – Reference Architecture
SAE – Smart Anything Everywhere
SME – Small or Medium Enterprise
SSO - Single Sign-On
VR – Virtual Reality
ZDM – Zero Defect Manufacturing

Annex 1: IoT Catalogue

The 'IoT Catalogue' is an already available web-based catalogue and decision-support tool for solutions of the Internet-of-Things (IoT). The 'IoT Catalogue' targets especially developers/integrators of IoT systems addressing questions such as: What IoT solutions exist for a given problem? What components compose a given IoT solution? What is their cost? Where to buy them from? Etc.

The 'IoT Catalogue' helps in the process of identifying and selecting a group of suitable components that combined work as an IoT solution (able to process, store and transmit data) to a problem defined by the user. The solutions can present different costs and complexity levels ranging from integrated elements to compositions of components.

All the components used in a solution are represented with detailed information such as manufacturer, product page and its vendors and allow the user to choose where to buy based on the store location, price, etc. The components are categorised in different types being type-specific information added to each component. In this tool, several solutions can be considered when taking into account different environments and their specific requirements.

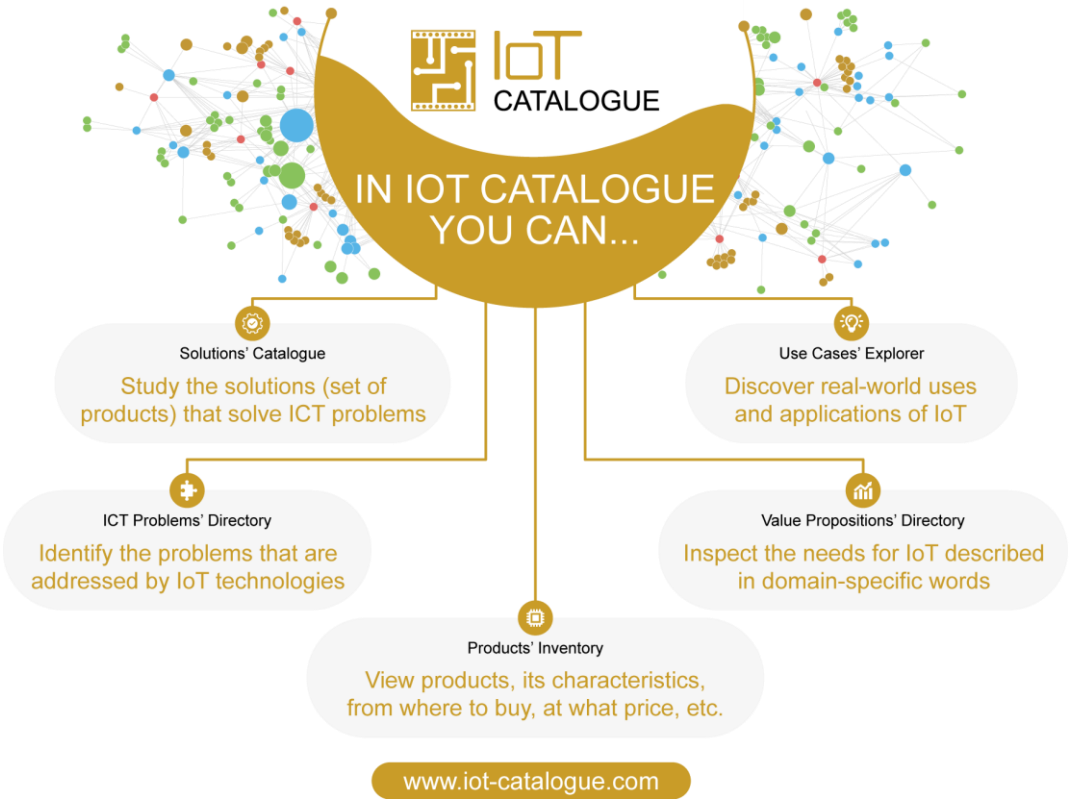

Figure 9: The IoT-Catalogue added value

One of the purposes of the 'IoT Catalogue' is to propose solutions based on problems described by case studies which are defined in this tool along with other details. The problems described by the use cases are grouped into several applications domains (e.g. Agriculture, Environment, etc.). Each use case provides information about a specific problem along with the application domain, the target and the parameters which are required to measure according to the context of a problem.

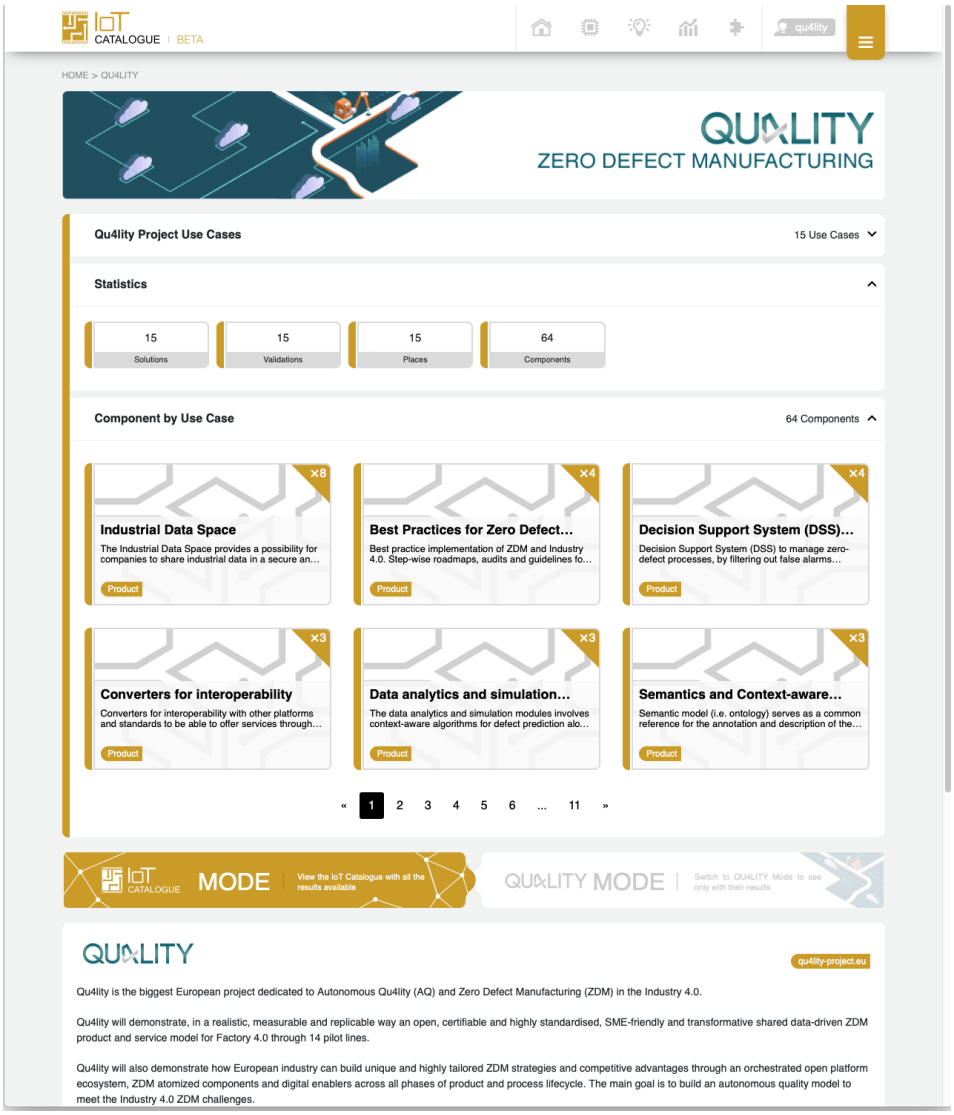

Figure 10: QU4LITY Landing page

The QU4LITY Multi-sided platform will take advantage of this IoT-Catalogue to provide to stakeholders, information related to ZDM related technologies and also Use cases coming from the QU4LITY pilots. However, as part of the IoT-Catalogue roadmap, there are also plans to enhance the IoT-Catalogue with tools to provide

additional functionalities that are not yet supported by the existing version of the web-based tool. These new enhancements are related to software licenses, which are increasingly important in a domain such as Zero-defect manufacturing, and standardization support which is one of the key topics of Industry 4.0. Also, in the roadmap, is the support of services from stakeholders.

- Software License

As part of the planned enhancements, the IoT-Catalogue will provide information regarding the license scheme of each component or product detailed within the catalogue. Figure 11 shows an initial mock-up of a license page (in this case AGPL v3 license), with a summary of the licenses, an overview of the license's permissions, conditions and limitations and the license full text.

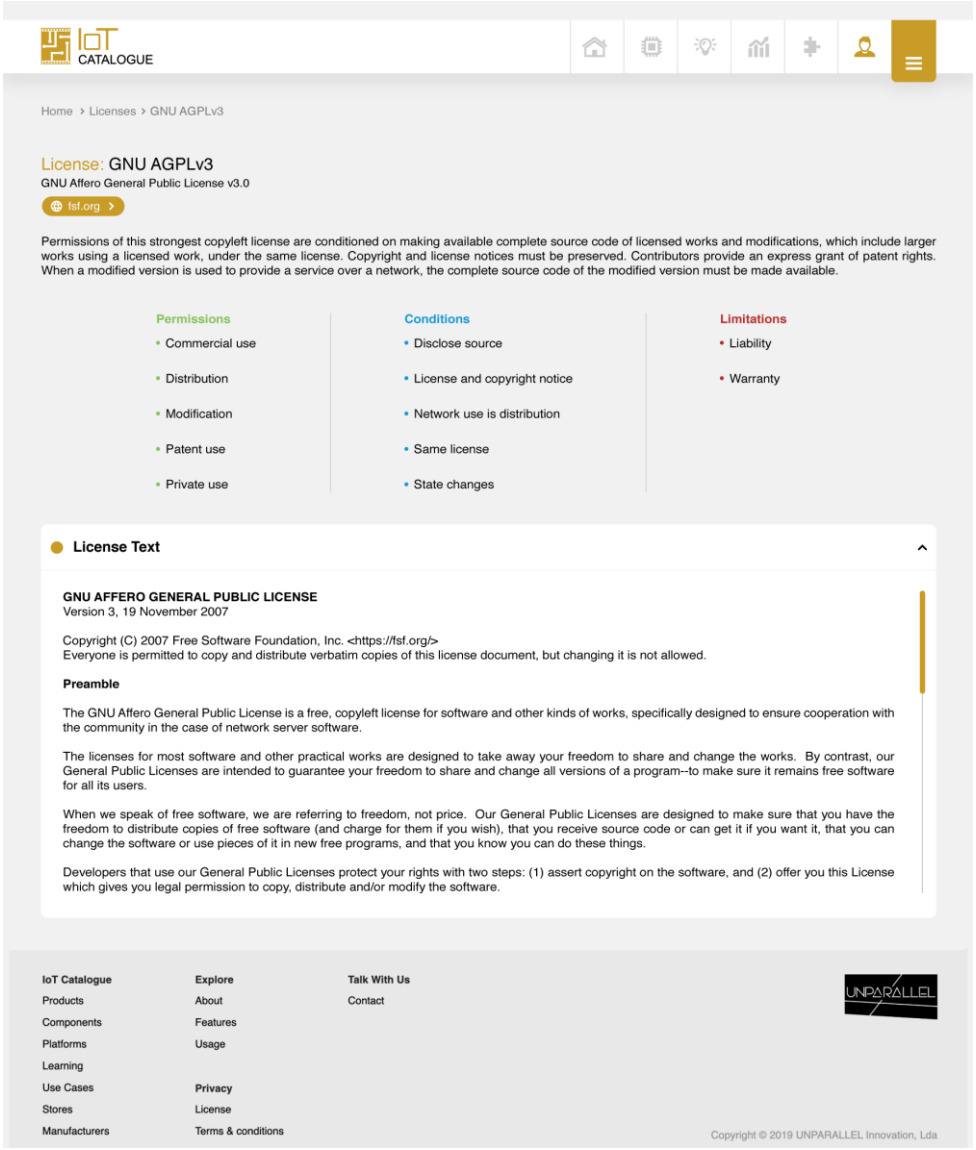

Figure 11: Mock-up of a license page in the IoT-Catalogue

- Standards supported

In order for the QU4LITY stakeholders to analyse ZDM technologies for their own possible uses, it is important that information regarding standards is available. Taking an example from Industry4.0, factories usually use some specific standards within their plants. Information about these used standards can help on the integration of new tools in the factories by understanding which standards can be used on the integration efforts. A mock-up of the supported standards on a QU4LITY technology can be seen in Figure 12**¡Error! No se encuentra el origen de la referencia.**.

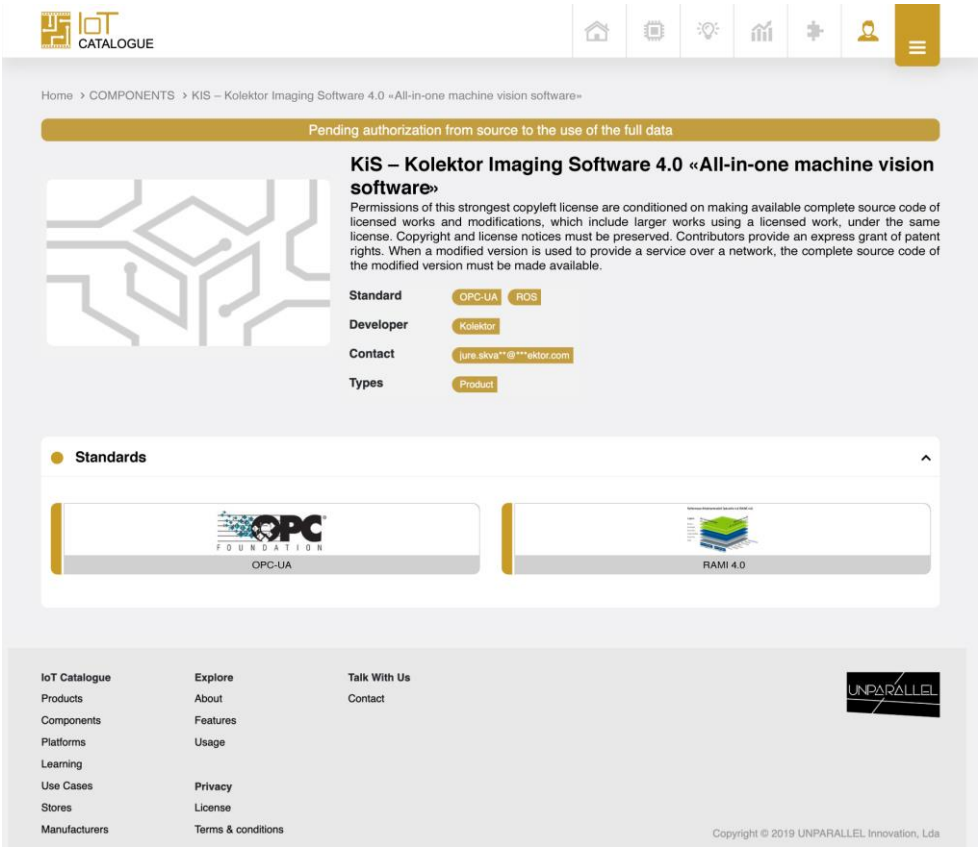

Figure 12: Mock-up of a ZDM technology with supported standards

- Services descriptions

As part of the IoT-Catalogue roadmap is also a new functionality dedicated to supporting services. Currently the IoT-Catalogue already provides information regarding components, products and use cases, but no information exists with respect to services that can provided that can help in deployment or use of solutions. Figure 13shows a mock-up of a service provider page in the IoT-Catalogue, with information related to contacts, descriptions of expertise and a set of services available form this specific provider.

Figure 13: Mock-up of a service provider page

Partners:

INTELLIMECH CONSORZIO PER LA MECCATRONICA
SIEMENS
Atos
AIRBUS
MONDRAGON
NXT CONTROL
AIB Institut für angewandte Systemtechnik Bremen GmbH
Continental
RIA STONE
UNIMETRIK METROLOGY AND CALIBRATION
Technology Transfer System
EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
SQS
FAGOR FAGOR ARRASATE
TTTech Ensuring Reliable Networks
technische universität dortmund
thyssenkrupp
Jožef Stefan Institute Ljubljana, Slovenia
PRIMA INDUSTRIE
eit Digital
ENGINEERING
PACE a TXT company
innovalia ASSOCIATION
Telefónica
Synesis sustainable automation
ghi SMART FARMING
UNPARALLEL
DANOBAT
POLITECNICO MILANO 1863
Whirlpool
VTT
VISUAL COMPONENTS
ASTI
Fraunhofer
cea
INTERNATIONAL DATA SPACES ASSOCIATION
PHILIPS
ATLANTIS
aic AUTOMOTIVE INTELLIGENCE CENTER
KOLEKTOR
AIT
SINTEF
+GF+
Technische Universität Braunschweig
TNO innovation for life