DIGITAL MANUFACTURING PLATFORMS FOR CONNECTED SMART FACTORIES

D9.8 Community Building Report (Version 2)

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Abstract: QU4LITY plays an active role in many I4.0 communities at EU and National/Regional levels. D9.7 (M20) defined an action plan to establish win-win relationships with them. The current D9.8 reports the actions performed and the results achieved in building an ecosystem around Digital Manufacturing Platforms.

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Contents

HISTORY

Version	Date	Modification reason	Modified by
0.1	01/03/2022	Initial template of document	Sergio Gusmeroli
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1 Executive Summary

The QU4LITY Innovation Action is a project belonging to the "Digital Platforms and Pilots" focus area of the H2020 LEIT ICT workprogramme, namely funded under the DT-ICT-07-2018 call "Digital Manufacturing for Connected Smart Factories". Win-win bi-directional relationships have been planned and need to be planned and developed in several communities which are related to the domains of Industry 4.0, Zero Defect Manufacturing and Autonomous Systems. Indeed, thanks to these intense liaisons, on the one side, QU4LITY development, integration and experimentation activities can re-use and exploit results and assets from other initiatives, on the other side, QU4LITY dissemination and exploitation activities can find broader channels and prospects for a capillary and effective impact to the EU industrial landscape, from a technology-business-social viewpoint.

The results developed in the deliverable D9.7 have been here updated. Indeed, in this deliverable, D9.8, it has been performed an analysis investigating the initiatives and additional collaborations set with external actors. Here the nine lines of actions identified since the very beginning are summarised to highlight the key updates:

ACTION1. **QU4LITY** needs to start effective collaborations with the "**Support to Hub**" Community on DT-ICT workprogramme. Moreover, four main axes are needed to be mentioned since they have brought significant SMEs audience to QUALITY: the EDIH call in Digital Europe Program DEP, the DIH4Industry portal, the AI REGIO Didactic Factories initiatives, and the AI TEF for Manufacturing Call in Digital Europe Program.

ACTION2. **QU4LITY** needs to intensify its collaboration with the "**DMP Cluster**" Community in DT-ICT-07. Very strong relationship is already in place with **ZDMP** which has been funded under the same sub-topic. With the other projects (especially **SHOP4CF**, **digiPRIME** and **KYKLOS4.0**), common activities are foreseen for DMP cluster's WG7 WG2 and WG3 regarding Reference Architectures, as well as common Research and Dissemination activities.

ACTION3. **QU4LITY** needs to contribute to the **ConnectedFactories Pathways** by bringing its experience in terms of autonomous quality solutions and pilot cases in the three scenarios of Smart Factory (Autonomous Factory pathway), Smart Value Chain (Hyper-connected Factory pathway) and Smart Product lifecycle (Collaborative Product-Service pathway). Specific AQ views to the three pathways (**zero defect manufacturing and autonomous quality** in our case) have been developed and relevant assets and cases inserted in the EFFRA Innovation Portal.

ACTION4. **QU4LITY** beneficiaries have contributed to the new pathways proposed by **ConnectedFactories2** CSA: Circular Economy and Data Spaces. VTT and POLIMI (QU4LITY beneficiaries) are leading the two pathways. So contributions from QU4LITY have been provided not just in the validation

(identifying industrial and technological cases to be mapped in the 2D space) but also in the development phase.

ACTION5. **QU4LITY** needs to contribute to **OPEN DEI Task Forces** in order to open-up new opportunities for dissemination and exploitation of its assets to other domains, e.g. **Agrifood**, **Healthcare**, and **Energy**. QU4LITY experts contributed to the Manufacturing section of OPEN DEI white paper about "Design Principles for Data Spaces" in TF1, while TF3 (Reference Architectures Interoperability and Standards) just started and during the KOM (February 15th 2022) Olga Meyer from FhG and QU4LITY proposed a cross-domain collaboration originated by DMP Cluster WG1 about Standardisation

ACTION6. **QU4LITY** needs to contribute to **Manufacturing PPPs and Associations** in order to meet the needs of European manufacturing industry and to bridge H2020 towards Made in Europe Partnership. In the EFFRA working group, QU4LITY home is obviously the **4ZDM cluster**. Particular attention will be given to cluster with DT-FOF-11 new projects which address quite similar challenges but from the DG RTD perspective and in the view of the Made in Europe partnership. Moreover, **EIT Manufacturing**, **SPIRE-06** and **ECSEL JU** initiatives do deserve special attention by QU4LITY.

ACTION7. **QU4LITY** needs to contribute to several initiatives in the domain of **Digital Technologies** in order to be able to adopt and uptake in manufacturing pilots (champions) the latest and most innovative Digital Technologies. **EIT DIGITAL**, with its "Digital Industry", has allowed QU4LITY innovations to meet investors and to consider the incubation and acceleration of innovative start-ups. Machine oriented AQ applications and evolutions in **AIOTI** have been monitored through events. The intense relations with **BDVA** facilitate the update of several Big Data Technologies at the basis of several AQ applications. Last, Data Economy and Data Sharing Spaces are also fundamental enablers for Autonomous Quality, especially along the lifecycle of a product and along its full value chain (**IDSA).**

ACTION8. **QU4LITY** needs to contribute to **National and Regional** initiatives in the domain of Industry 4.0. Several Countries and Regions have been analysed. QU4LITY and its Marketplace, EU-level assets and solutions have found a local National / Regional dissemination and exploitation channel in this ACTION8, dramatically improving the potential impact of EU-level ZDM solutions. Indeed, thanks to the contribution of QU4LITY beneficiaries, joint events with National / Regional initiatives have been organised and these have contributed to the QU4LITY impact creation.

ACTION9. Regarding the future programme 2021-27, **QU4LITY** needs to contribute to the elaboration and planning of the **Multiannual Financial Framework** of the European Commission in the domain of Industry 4.0.

The **Made in Europe** Partnership includes several technical challenges which QU4LITY already addressed, in particular Zero-defect and zero-downtime high-precision manufacturing, Artificial intelligence for productive, excellent, robust and agile manufacturing chains, Zero-defect and zero-downtime high-precision manufacturing. The **AI, Data, Robotics Partnership** represents the ICT side of the AQ coin. Joint collaborations with technology driven project have been developed and brought to the recent selection of ADRA projects with a consistent participation of QU4LITY assets and solutions.

2 Community Building results: DIHs (Action1)

ACTION1 QU4LITY needs to start effective collaborations with the "**Support to Hub**" Community on DT-ICT workprogramme and in particular with the I4MS Phase IV CSA (**I4MS4Ts**) and the eight Innovation Actions (**DT-ICT-03**) which have started their activities in Fall 2020. Digital Twins, Additive Manufacturing, AI Applications, Human Robots Interaction are domains where Autonomous Quality principles and solutions could play a very relevant role. Moreover, the Widening DIH topic helps QU4LITY reaching Countries and Regions not included in the Consortium in its dissemination, communication and exploitation strategy implementation.

The H2020 "Support to Hubs" Focus Area

As mentioned in the D9.7, QU4LITY is part of the DMP cluster together with 5 Innovation Actions (IA)s and the CF2 cluster. In the LEIT ICT 2018-2020 H2020 Workprogramme, the Call - **Digitising and transforming European industry and services: digital innovation hubs and platforms** is central for the materialization of the **Digitising European Industry**[1] communication of April 2016 and its principles. The call is composed by two subgroups: (i) "Support to hub" and (ii) "Platforms and Pilots".

Regarding the first subgroup, "**Support to Hubs",** it includes 6 topics (5+1) focusing on the implementation of SME-oriented regional Digital Innovation Hubs (DIHs) in the domains of Smart and Embedded Systems (SAE DT-ICT-01), Robotics (DT-ICT-02), ICT Innovation for Manufacturing SMEs (I4MS Phase IV DT-ICT-03 see below), Photonics (DT-ICT-04) and Big Data (DT-ICT-05). The DT-ICT-06 topic is for the CSA supporting Hubs which is called DIHNET.EU[2]. Among the **DT-ICT-03** winning projects it is worth to mention:

- Create and Harvest Offerings to support Manufacturing SMEs to become Digital Twin Champions, **Change2Twin**, 951956
- Digital twins bringing agility and innovation to manufacturing SMEs, by empowering a network of DIHs with an integrated digital platform that enables Manufacturing as a Service (MaaS), **DIGITbrain**, 952071
- DIH-World - Accelerating deployment and matureness of DIHs for the benefit of Digitisation of European SMEs, **DIH-World**, 952176
- Fostering the PAN-European infrastructure for empowering SMEs' digital competencies in laser-based advance and additive manufacturing, **PULSATE**, 951998
- Grow your manufacturing business, **Better Factory**, 951813
- I4MS Tools and Technologies for Transformation, **I4MS4Ts**, 951848
- platform-enabled KITs of arTificial intelligence FOR an easy uptake by SMEs, **KITT4SME**, 952119

[1] https://ec.europa.eu/digital-single-market/en/news/communication-digitising-european-industry-reaping-full-benefits-digital-single-market
[2] https://dihnet.eu/

- Regions and DIHs alliance for AI-driven digital transformation of European Manufacturing SMEs, **AI REGIO**, 952003
- Value Of Joint EXperimentation in digital Technologies for manufacturing and construction, **VOJEXT**, 952197

The DIHs represent for QU4LITY a twofold perspective being it a Digital Manufacturing Platform project. The two perspectives lay in: (i) dissemination and exploitation towards SMEs, Midcaps and Local Public Administration, (ii) interception, nurturing and scaling-up of local innovation actors.

I. Regarding the first perspective, this can be directly visible in the four pillars characterising DIHs (i.e., "test before invest", "skills and training", "support to find investments" and "innovation ecosystem and networking"). The potentialities of DIHs for disseminations and exploitations are many as described in the future plans of the Digital Europe Programme according to which the network built by the European Digital Innovation Hubs (EDHIs) has to operate as a bridge between technology deployment and final users, more precisely as a "networking Transfer of Expertise"

II. Regarding the second perspective, the local innovation actors can be intercepted, nurtured and scaled-up, and they can be made visible to European R&I landscape and Large Scale Pilots or Innovation Actions. Among all, the highly innovative SMEs and Start-Ups can be founded thanks to the mechanism of FSTP (Financial Support to Third Parties) enabling them to take part to the most advanced R&I programs in H2020 increasing their visibility over a greater audience.

Therefore, QU4LITY has to benefit from DIHs, establishing win-to-win relationships, because of the possibility to use them as dissemination and exploitation channels but also to exploit innovative ideas and solutions to be used in QU4LITY project.

Starting from 2020, QU4LITY had established great collaborations on Digital Twins (DIGITBrain project), AI (AI RAGIO project), and Cognitive Systems (VOJEXT project) related projects won in DT-ICT-03 call and widened the DIHs to new regions and countries through (DIH-World Project). A brief explanation of the topics tackled in these projects is reported below.

- DIGITBrain project aims to extend the Digital Twin solution developed in CloudiFacturing creating an augmented version named "Digital Product Brain" together with a smart business model, "Manufacturing as a Service". Indeed, having access to on-demand data, models, algorithms and resources for industrial products, it will support the customisation for each situation and context. Indeed, it will enable the implementation of "Manufacturing as a Service" which would facilitate especially SMEs in accessing advanced manufacturing resources and facilities. This project aims to address four principles which are: 1) Technology, 2) Feasibility, 3) Sustainability, 4) Network of DIHs.
  QU4LITY is in contact with some key beneficiaries of this project like ATOS, DFKI, IMR, Piacenza, STAM, and START4.0 Competence Center.

- AI RAGIO project aims to fill three open gaps, at policy, business and technology level, limiting digital transformation pathways of SMEs belonging to AI-driven DIHs.
    - Regarding the policy level, SMEs experiment difficulties in scaling up to become pan-EU accessible in global marketplace and quite often are constrained in local environment and contexts.
    - Regarding the business level, there is still a limited attention over Industry 5.0 bounding the research around the AI revolution and the interaction between humans and autonomous systems.
    - Regarding the technology level, initiatives, communities and innovation actions still have a silos perspective creating a gap between Digital Manufacturing Platforms and DIHs whose challenges are not of interest to the others.

  QU4LITY is in contact with some key beneficiaries of this project like POLIMI (the coordinator), ENG, CEA, CARTIF, NISSATECH.
- VOJEXT project aims to facilitate the matchmaking between producers and users of cognitive autonomous systems for human robot interactions, especially cobots, creating a proper business and technological framework. This project started with 5 experimental pilots (and 9 SMEs) in different sectors like plastic, textile, electronics, automotive, construction and creative architecture for urban regeneration. This differentiation enables VOJEXT to cover traditional and non-traditional areas for AI-robotics and cognitive ICT developments.

  QU4LITY is in contact with UPM (the coordinator), and other key beneficiaries like Fortiss, EMC2, and IIT.
- DIH-World project aims to support SMEs in creating their competitive advantage, and in accelerating the usage of digital advanced technologies looking at all the sectors. Indeed, this project aims to provide European SMEs with a wide range of services like harmonised tools, proven technologies, effective methodologies, knowledge, investment sources to create an innovative and dynamic environment linking each SME with the proper DIH.

  QU4LITY is in contact with the coordinator, CARSA, and some key beneficiaries like INNOVALIA, PwC, Effizienz Cluster, Uninova, Chalmers, LMS

QU4LITY and the DIH4INDUSTRY Initiative

The QU4LITY virtual DIHs community

The Virtualized DIH in QU4LITY (T8.5) is following the principle of an (E)DIH by federating the innovation management resources and services from existing DIHs, notably DIHs in the Consortium (CEA, EIT, FhG, JSI and VTT), that are providers of innovation management and business services for digital manufacturing and having a strong presence in the digital manufacturing market worldwide, as well as being part of a network consisting of the main players of the global manufacturing ecosystem / ZDM. It groups virtually the competencies of each of the DIH partners

of the Consortium (DIHs, RTOs, Clusters, etc.), geographically distributed, in a win-win approach providing i) benefits for the service providers that will sell their own services or in collaboration with other partners (collaborative services) and also ii) benefits for all stakeholders that find in a unique platform all what is needed to improve their processes or to enhance their solutions for the industrial market. The QU4LITY Virtualized DIH provides all businesses through a unique entry point access to these innovation management, technological, knowledge and business services, as well as to all support services (e.g., trainings) that might be needed mainly by the SMEs, Startups, etc. for the implementation of ZDM based solutions, covering both sides of the "one-stop-shop" multi-sided market platform, the demand side facilitating the access to services, and the supply side, enabling the DIHs to provide and exploit their business services on a commercial basis.

The scope of the virtualized DIH was clearly defined from the beginning to complement and add value to the existing DIH initiatives, rather than being in competition and to extend the network of DIHs in the area of ZDM/AQ. Therefore, during the lifetime of the project, the initial categorization of services (reported in D8.9) as shown in the figure below needed to be aligned/mapped with the service categories of the most relevant DIH Initiatives in the manufacturing sector, DIH4Industry and the future EDIHs.

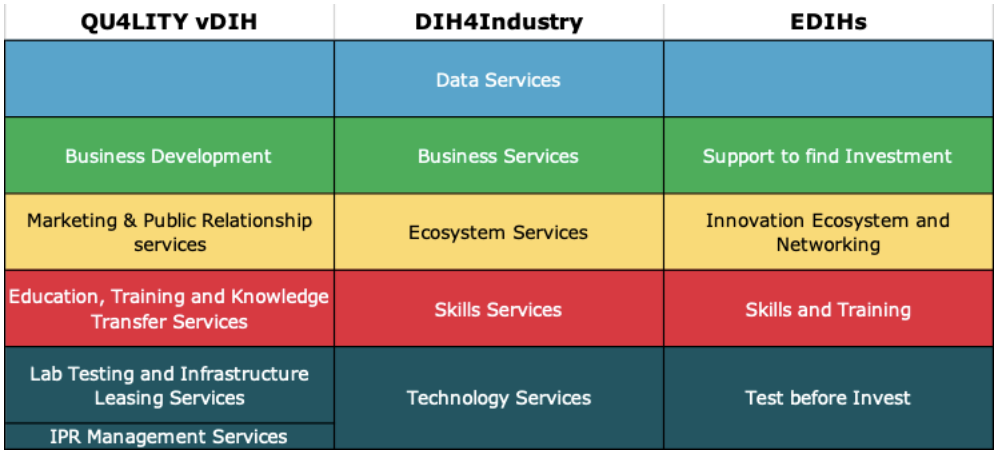


Figure 1 - EDIHs services vs Virtualized DIHs categories

An alignment in the service categories allows other DIHs to integrate their services in the virtualized DIH as well as allows QU4LITY to collaborate with other initiatives.

The DIH4INDUSTRY platform

DIH4INDUSTRY is a new environment for the exchange of services, expertise and knowledge, aiming at creating, nurturing and governing an Ecosystem of Digital Innovation Hubs with a regional Smart Specialization in Manufacturing.
The vision of DIH4INDUSTRY is to boost innovation and digitalization by a platform where opportunities of collaboration between DIHs can arise, sharing assets and needs in an innovative approach driven by knowledge and experience, within a single access point.

The DIH4INDUSTRY platform offers:

- an **Ecosystem**, enabling the creation of hubs for all DIHs focused on Industry 4.0;
- a **Marketplace**, in the form of a showcase of DBEST (Data, Business, Ecosystem, Skills and Technology) digitalization support services made available by the DIHs for the benefit mainly of other DIHs;
- a **Community**: a collaborative environment that DIHs may use to foster innovation by forming new projects and supporting the networking among members.

The present configuration of DIH4INDUSTRY consists of a public area and a private area, with the following contents:
In the public area:

- a **DIHs Community**, where DIHs are shown in a map and in a list, that can be filtered by DIH's Name, Initiative, Project, Country, Sectors, Technologies; 69 DIHs have registered, at present;
- a **DBEST Marketplace**, where services are classified according to the new **DBEST** taxonomy, which is fundamental to facilitate the collaboration among DIHs; services can be filtered by Initiative, Project, DIH and Country; so far, **542 DBEST Services** have been entered;
- a dedicated section for each **Initiative** participating in the platform, by which DIHs are grouped according to the Initiatives in which they participate; the creation of Initiatives within the platform favours the strengthening of relations between DIHs within their group of origin, respecting the identity of each one; at the same time, Initiatives are integrated in a context of other Initiatives, allowing DIHs to widen their experience at European level;
- sharing of the **Experiments** conducted by the DIHs and their constituents; the experiments can be visualized by a map and a list, and can be filtered by Initiative, Project, DIH, Country; **52** experiments descriptions have been entered so far.

In the private area:

- the same contents of the public area, plus
- a **Knowledge space** (publish, organize and access community information in one central location) and resources cataloguing (managing information by the use of powerful metadata, so enabling the cataloguing of resources and their dynamic modelling and visualization).

The public area is accessible to anyone without the need to register; the private area is accessible after registration.
In the private area it is possible to enter and edit content (DIH, DBEST Services, Experiments), according to the prerogatives assigned to users.

At the moment, these 6 Initiatives are participating to the platform, with the relevant Projects:

- **I4MS** – Manufacturing SMEs DIHs (Projects: AI REGIO, MIDIH)

- **SAE** – Smart and Embedded Systems DIHs (Projects: HUBCAP, DIH4CPS)
- **SCoDIHNet** – Internet of Things DIHs
- **RODIN** – Robotics DIHs (Project: TRINITY)
- **BIG DATA DIHs** (Project: EUHUBS4DATA)
- **ARTIFICIAL INTELLIGENCE DIHs** (Project: DIH4AI)

In order to achieve a significant size, new Initiatives will continue to be added. The objective is to offer to Smart Manufacturing DIHs to be part to a large pool of European DIHs with related services, and the broadest possibility to access contacts and collaborations with other DIHs, Services and Experiments.

From a business perspective, the distinctive feature of the DIH4INDUSTRY platform is to offer services classified according to the D BEST taxonomy: this feature perfectly fits the strategy of development of the platform, aimed at offering collaboration opportunities to European Manufacturing DIHs.

The new DBEST cataloguing method was developed in the MIDIH project and continued in the AI REGIO project, and provides that the services offered by the DIHs are classified in five categories: Technology (including online accessible technical and regulatory sandboxes); Business (including go-to-market and fund raising matchmaking events); Ecosystem (including hackathons, awards, wikis and discussion fora) Skills (including MOOCs, webinars and other skills development services); Data (including PoC and pilots on how to manage and share data in a secure way).
The DBEST categories are further divided into sub-categories, or "types", and then down to "services".

This standardisation of services greatly facilitates the exchange of information, communication and collaboration between DIHs and helps enhancing the collaboration among providers and consumers of digital technologies (DIHs, SMEs…).
This structure has been adopted by the DIH4INDUSTRY platform, and can be considered a prerogative of the platform that makes its value proposition unique.

From a technical point of view, DIH4INDUSTRY is an instantiation of DIHIWARE.
DIHIWARE is an integrated solution aiming at supporting both the "Access to" and the "Collaborate with" services, providing access to the latest knowledge, expertise and technology in Digital Transformation pathways toward piloting, testing and experimenting new digital technologies. The Platform leverages on knowledge-driven services in order to maximize awareness, hands-on experience, knowledge and maturity levels of the ecosystem. Moreover, it provides also Innovation and Collaboration capabilities, so that demand and offer in a marketplace could be transformed into partnership and co-innovation. As one-stop-shop where multiple services could be offered, it enables the collaboration of organizations by allowing them to find synergies and providing and finding opportunities and valuable information, and easily connect with other people within the ecosystem.

DIHIWARE Main Subsystems are:

- a **Catalogue Management System**: resources organization and cataloguing; catalogues design and management; taxonomies and metadata use; dynamic information modelling and visualization;
- a **Knowledge Management System**: knowledge management, social activity next to collaboration and innovation capabilities;
- an **Identity Manager:** users management, centralizing user authentication, defining their roles and granting their access while using the other applications.

DIHIWARE capabilities can extend to: interoperability with external systems, interoperability among DIHIWARE instances, exploit potential synergies, alignment with methodologies and standards, match-making to foster engagement and interactions among platform beneficiaries, knowledge increase, demand analysis, strategic product planning, virtual assistance.

As mentioned, DIH4INDUSTRY offers the possibility to register, so as to have prerogatives to enter and edit contents. Users are assigned prerogatives during registration; the user who wishes to register fills in a form, available on the Home Page of the public area, in which he describes his characteristics (if DIH, SME, other...); depending on the profile, the user will be enabled to different functionalities: contents visualization only, or also the possibility to insert, modify and delete.
The users who are allowed to add contents (normally DIHs) remain the owners of the contents, and the only ones allowed to edit them.

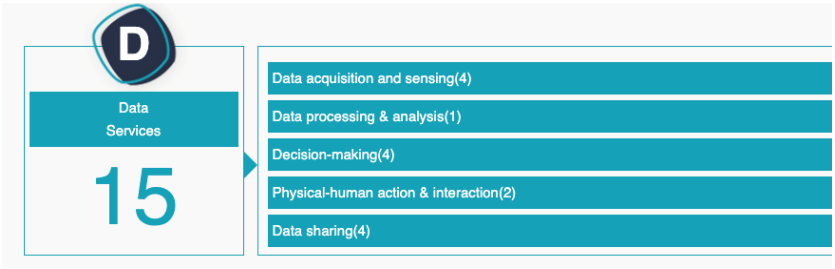
QU4LITY Contribution to DIH4INDUSTRY

QU4LITY is contributing to the DIH4INDUSTRY. The DIH4INDUSTRY is the ecosystem of DIHs operating for the digital transformation of the European Manufacturing Industry. This ecosystem involves all the Manufacturing DIHs as required by the focus areas of the H2020 DT-ICT workprogramme and it also includes all the DIHs which might be specialised in Industrial IoT and Industrial AI, but also which might have a sectorial specialisation like the one in the process industry.

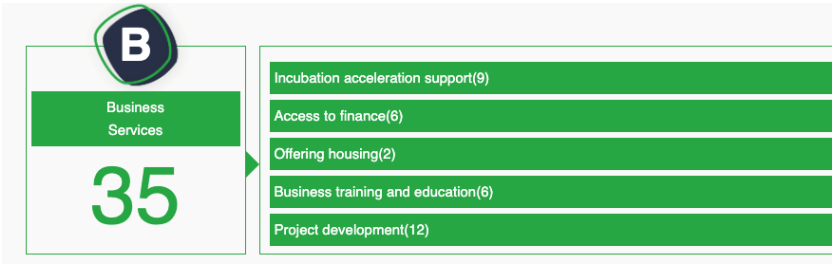
This ecosystem represents the collector of DIHs operating for the smart specialisation of the manufacturing sector by also collaborating with the European Commission Digital Innovation Hubs Tool. Thanks to this ecosystem, it is possible to identify which are the EC DIHs operating for the manufacturing sector, where they are located, which are the experiments they are supporting, and which are the services they are delivering. This ecosystem is based on a community of 69 DIHs, 542 services through the D BEST Marketplace and 52 Experiments.

Regarding the D BEST, thus the marketplace where are visible the services delivered by this community, this is composed by five different types of services:

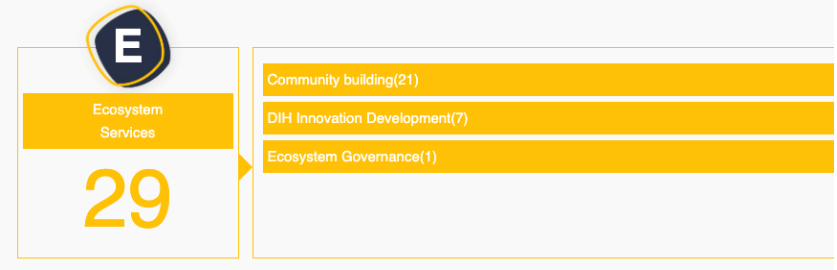
1. Data Services (15) listed in



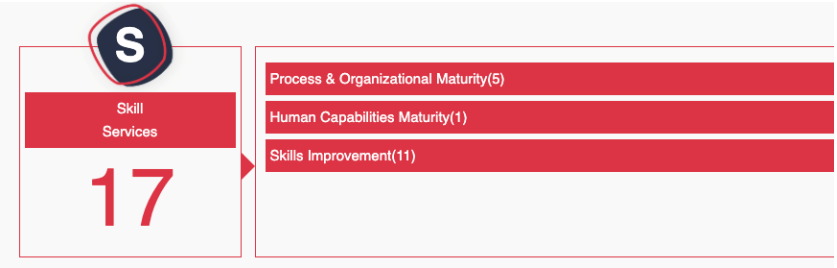
2. Business Services (35) listed in



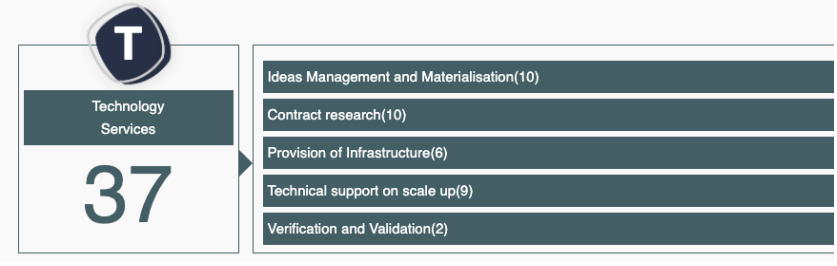
3. Ecosystem Services (29) listed in



4. Skill Services (17) listed in



5. Technology Services (37) listed in



QU4LITY and the AI REGIO Didactic Factories community

The QU4LITY TEF community

Around the world, eight Technical Experimental Facilities (TEF) have taken part to Qu4lity's activities as reported in Figure 2.

Figure 2 QU4LITY TEFs distributions

The shared aim is to enhance the quality of production and to reduce the number of defects generated during production processes by sharing technological enablers, specialized or enhanced equipment and processes. More specifically, the eight TEF that joined the QU4LITY project shared their perspectives and know-how on how to apply AI, digital infrastructures, and other emerging technologies in brownfield scenarios. Below the list of TEFs (see Figure 2) is reported:

- ROSF: The name of this TEF comes from "The Region of Smart Factories" and it has been established in the Northern provinces in the Netherlands as a consortium composed by Philips, Fokker and TenCate and other partners. ROSf has the goal to foster the advancements of the manufacturing industry especially of these countries.

- FFLOR: it has been established by CEA with the intention to give a global view of the Factory of the Future providing access to high added-value technologies. Within QU4LITY project, this TEF aims to integrate IEEE TSN technology to enable use of standard IEEE Ethernet technology. This would facilitate the achievement of deterministic communications in presence of best effort and critical traffics on the same medium.

- SMARTLAB: it is a demonstrative laboratory established by the Intellimech consortium. Here the technological opportunities and machines coming from the consortium partners are connected together. The laboratory has a software room for simulation and testing, and a showroom where the demonstrators are shown.

- ASF: The name comes from "Automotive Smart Factory" and it combines virtual and physical capabilities to analyze the potentialities of the different I4.0 technologies and advanced manufacturing technologies. The TEF aims to support companies in the transformation process by developing personalized strategies and evaluating the impacts generated from the application of these strategies. More specifically, in QU4LITY, this TEF addresses a use case of remote virtualization of the production environment based on the usage of 5G technology.

- SMACC: it has been established thanks to a partnership between Tampere University of Technology) and VTT Technical research center of Finland. The goal of this TEF is to facilitate the efficient integration of SMEs' oriented service culture together with the highest scientific competence in smart machines and manufacturing area.

- ARENA2036: The name comes from "Active Research Environment for Best Generation of Automobiles" and it has been established by the University of Stuttgart together with Fraunhofer IPA and other partners. It aims to include academics and industrial people under the same roof working together addressing the same objectives. This TEF is an integration platform, willing to operate as an experimental field for new methods regarding both the manufacturing and the assembly of lightweight vehicles by continuously transferring the results to other industries.

- JSI: this TEF has been established in the Jozef Stefan Institute and it is based on the Roconcell workcell that is a reconfigurable robotic assembly workcell which relies on flexible reconfigurable concepts allowing to manage the changeable production. In QU4LITY project, this TEF worked on the setting up of a new functionality for adaptive visual quality inspection. This has been done by using robotic arms, camera, and complex algorithms for trajectory estimation with the aim to also facilitate the detection, in the production chain, of defects in the fastest way.

- INDUSTRY4.0: it has been established in Politecnico di Milano as a "real-like" environment to carry out research activities around the I4.0 topics. It aims to have a multidisciplinary vision of production environments being it used also as "teaching factory" for education purposes. Within the QU4LITY project, this facility has extended its infrastructure to enhance the interactions with processes by adding the an Augmented Reality module, new sensors to obtain additional information on vibrations and sounds, and new components to interpret sensors data and predict the behavior of the system.

The major advancements in the last months have been seen in FFLOR, ASF, INDUSTRY4.0 and JSI TEFs are briefly described above.

Among all, to report an example, POLIMI has joined the QU4LITY project putting at disposal its Industry4.0Lab (INDUSTRY4.0 in Figure 2). The semi-automated assembly line which constitutes the core of the laboratory replicates a real manufacturing environment reflecting the challenges and the future trends of manufacturing. The line itself is constituted by several stations (namely seven) whose purpose is to assemble a device similar through remote control.

From the perspective of a Zero Defect Manufacturing, the station which is more subject to losses of quality is a drilling machine (see Figure 3) which drills four holes in the device cover. The wearing of the cutting tool affects indeed the overall quality of the performed operation and can result in rejected goods.

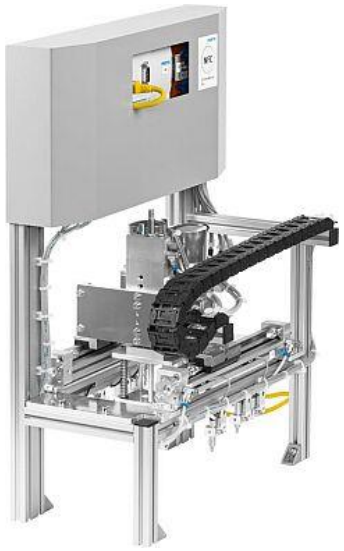


Figure 3. Drilling machine at Industry4.0Lab

In order to prevent the tool to reach a wearing level dramatic enough to wrongly process some pieces, a procedure for the prompt substitution has been set up. This procedure is composed by two main steps:

1. A Machine Learning-based system warns the operator about the health status of the cutting tool.
2. An Augmented Reality-based system guides the operator in the substitution of the worn-out cutting tool.

For what concerns the first part, Figure 4 shows how the station has been equipped with additional sensors (accelerometers, thermometers, and ultrasonic transducers) and the aggregated data has been used to train a software platform including a Machine Learning algorithm able to assess the health status of the cutting tool.

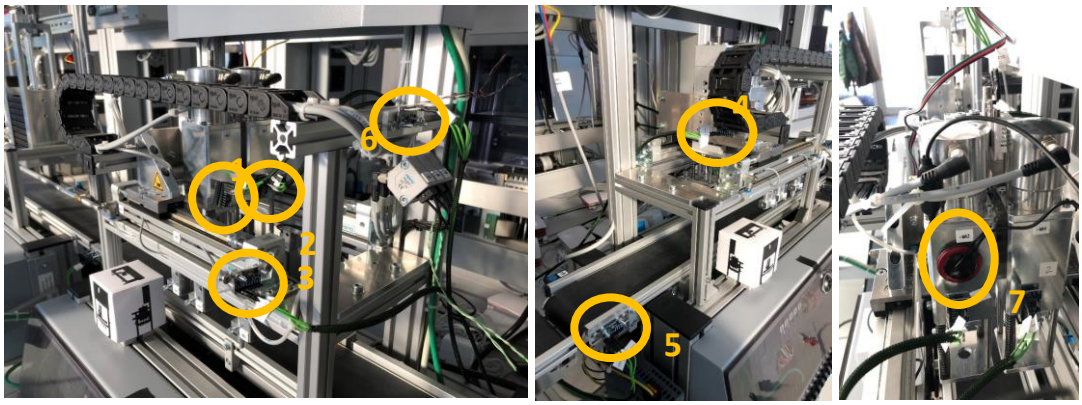


Figure 4. Sensors installed on the drilling station

When the platform detects that the values are leaving the "healthy" region, a computation of the remaining useful life is performed and the operator is warned about the need to change the tool (a graphical explanation of the concept is shown in Figure 5).

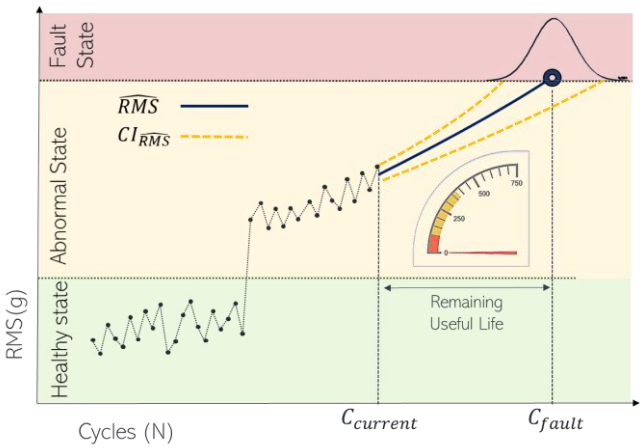


Figure 5. Remaining useful life

After the operator has been warned, the Augmented Reality based system is triggered and through a tree-based procedure guides the operator in the substitution of the tool. The main steps of the procedure are summarized in Figure 6.

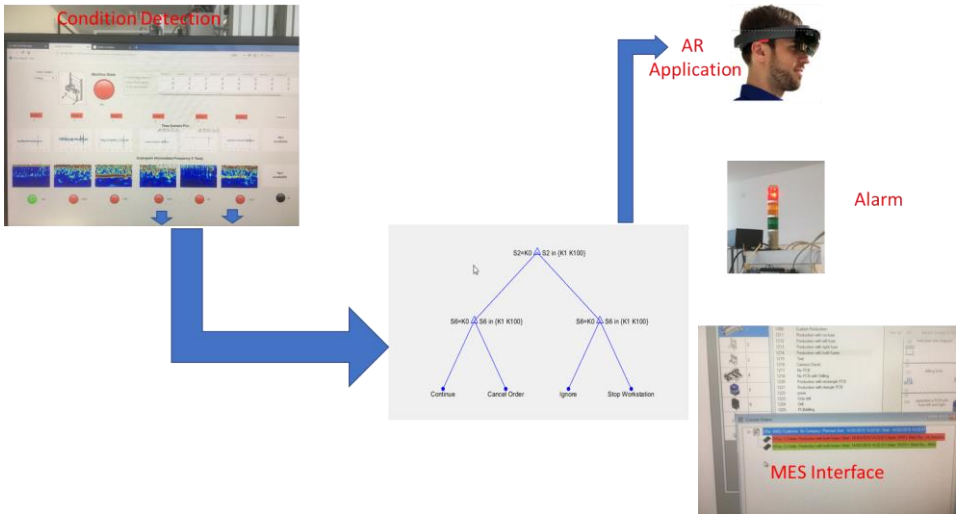


Figure 6. AR assisted cutting tool substitution

The successful results of the experimentations led to some considerations:

- The hardware installation took about one hour, making the intervention not-invasive.
- Taking into account the availability components increment growth and according to the OEE methodology, the energy savings are estimated to assess around 15%.
- Notwithstanding that the experiments have been carried on in a laboratory environment, the effectiveness of conditions bringing to stopping failures has been about 80%, while the punctual recognition of failures has been around 95%, with a 12% of false positives.

The AI REGIO Didactic Factories Community

In the last decade, the concept of Learning Factories or Didactic Factories (DFs) started to arise and spread, especially in Europe, both in industry as well as in academia to support education, training and innovation in manufacturing. A Didactic Factory is an organization that includes both elements of learning and teaching (didactic) as well as a production environment (factory).

AI REGIO project is developing the concept of Didactic Factory, by creating its own network of DFs and expecting to be a precursor of the European AI Testing and Experimentation Facilities (TEFs), boosted in the Digital Europe program[3] to optimize development and deployment of AI. This will include support for full integration, testing and experimentation of latest AI-based technologies to solve issues/improve solutions in a given application sector, including validation and demonstration.

AI REGIO aims to create a network which facilitates cooperation between DFs, allows the exchange of resources, best practices and lessons learned, but also the collection

[3] https://digital-strategy.ec.europa.eu/en/activities/testing-and-experimentation-facilities

and sharing of manufacturing data spaces (metadata, ontologies, datasets) to be used for didactic purposes all over Europe.

The creation of the AI REGIO network consists of two phases. The first phase focused on setting up the network and finding DFs. Activities in this phase are based on the consultation of consortium partners for input, the definition of a state of play about DFs and the development of the service portfolio. This phase ended in February 2022.

The first group of Didactic Factories has been identified inside the project's border, looking at the consortium partners. A set of "10 champions" represent the core of the AI REGIO network of DF, as shown in the Figure below.

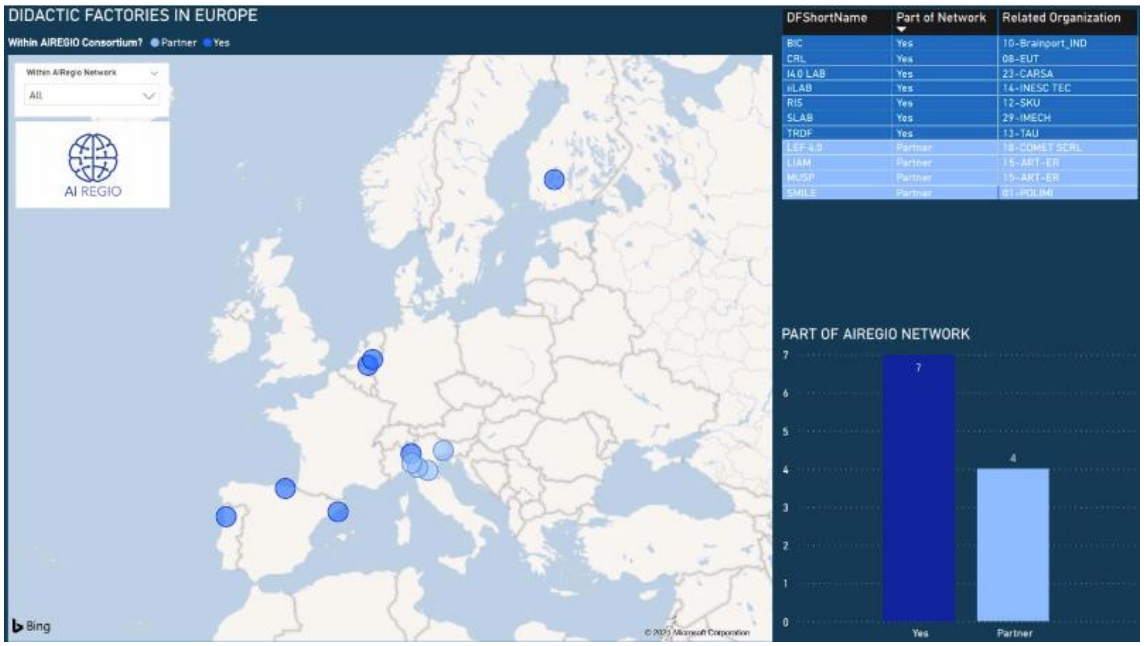


Figure 7 The AI REGIO network of Didactic Factories

The Champions cover different European regions and are specialised in different domain, both from the didactic and technological point of view.

At this stage, the role of the AI REGIO is to stimulate the feeling of being part of a network, boosting knowledge exchange, best practices and lessons learned between the champions. The objective is to create a team of the champions who cooperate one with each other. Important in creating a network is to enhance collaboration with the champions and encourage dialogue across the network.

The second phase is the process of executing the DR BEST taxonomy with the champions. The process of undergoing Portfolio analysis (so called DR BEST analysis) is fundamental since it provides insight in the services the DFs offer. The DR BEST analysis is a structured approach proposed by AI REGIO to Didactic Factories (DFs) in order to define their as-is service portfolio and to identify in their offering the gaps to be filled. Services are classified according to a 3-levels taxonomy and this has a twofold advantage: on one side it shows a full picture of the possible services that a DF could provide and on the other, it guarantees that services are presented in a standard and comprehensible way. The macro-classification (level 1 of the taxonomy)

groups services in six different classes (Data, Remote, Business, Ecosystem, Skills, Technology), from where the name DR BEST comes.

Next steps will be to create an interoperating network of DFs with a pan-EU AI-oriented portfolio and AI REGIO is working to define the strategy and scope for the extended network. Actually, AI REGIO is not the only initiative actively involved with Didactic Factories: currently, at different places in Europe, DFs have started and they are facing new challenges. So, to exploit synergies and to prevent reinventing the wheel and instead learn from each other, it is useful to set-up a European network of Didactic Factories and this is why AI REGIO is trying to extend its network involving even more organisations.

Finally, the AI REGIO ecosystem of Didactic factories can function as a precursor network for AI TEF for Manufacturing, by implementing additional services and assets that can be used to develop AI TEF for Manufacturing

QU4LITY Contribution to Didactic Factories

A preliminary activity that has been run with the Didactic Factories is the definition of their service portfolio, in accordance to the DR BEST taxonomy.

The DR BEST analysis is a structured approach proposed to Didactic Factories (DFs) in order to define their as-is service portfolio and to identify in their offering the gaps to be filled. In AI REGIO, the taxonomy has been originally defined to describe the Digital Innovation Hubs offering and it was called D BEST (without the "R"); later, dealing with Didactic Factory, also the "R" of Remote has been defined.

The DR BEST catalogue contains in total 69 different services: 12 are services related to Data management, 13 to services provided Remotely, 14 to Business activities, 12 to Ecosystem management and communication, 9 to Skill assessment and training and 9 to Technological support.

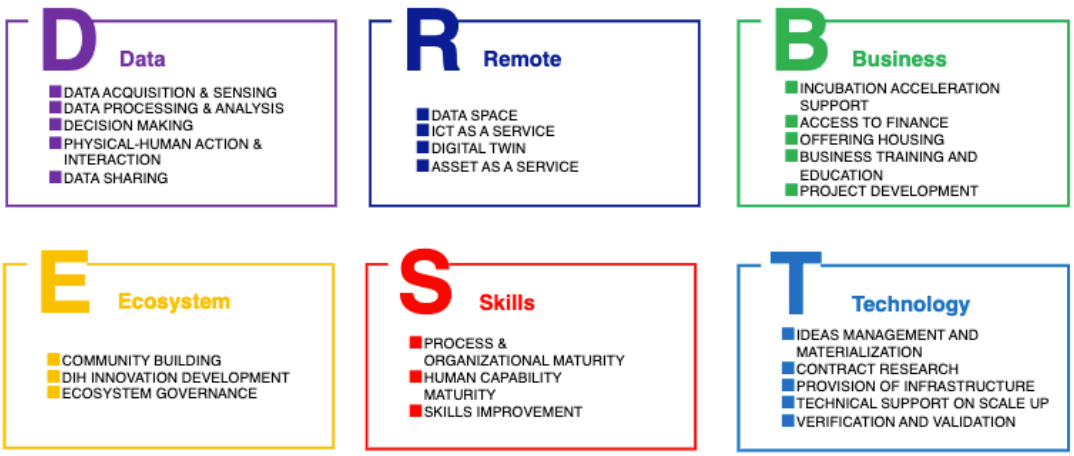


Figure 8 DR BEST taxonomy -level 1 and 2

The provision of "R" services is assuming an increasing importance, mainly due to the covid-19 pandemics, after which it became quite fundamental, since it allows to

have access to data and hardware/software assets without physically going to the DF's facility. The R taxonomy has been conceived to cover four degrees of the remote experimentation, from the remote use of simple datasets (1) to the remote use of software/computational resources (2), including the simulation of physical models thanks to Digital Twins (3) and the use of physical assets thanks to a system of teleoperation and remote control (4).

The AI REGIO Didactic Factories Champions have been required to analyse their current Service Portfolio, applying the DR BEST taxonomy. It means to describe each service provided as an instantiation of one of the 69 activities described in the framework, at level 3. In doing so, the DFs have been invited to reasoning with a structured approach about their offering, evaluating their strengths and weaknesses also in comparison to other Didactic Factories and in a perspective of future collaboration.

The AI REGIO Network of Didactic Factories has currently at disposal a Portfolio of 228 services, as the combination of 8 different organisations. Missing partners will be included in the analysis, as soon as their Portfolios will be available. As the chart below shows, services are quite balanced into the six DR BEST categories.

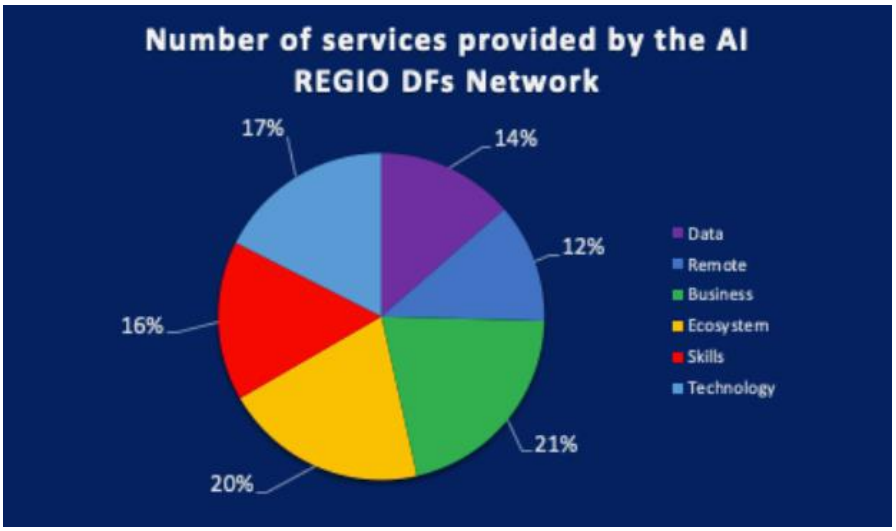


Figure 9 Distribution of the AI REGIO DFsNetwork's portfolio by DR BEST classes

QU4LITY and the AI TEF for Manufacturing DEP Call

The AI TEF for Manufacturing call

The Artificial Intelligence Testing and Experimental Facilities (AI TEF) have been introduced by the European Commission as part of the Digital Europe Programme with the final aim to optimise, develop and deploy AI strategies in Europe. The AI TEFs will operate as a relevant brick required to build an AI-based excellence ecosystem in Europe founded on trust and high experience. On one side, AI TEFs aim to attract founding of investments to improve the facilities, on the other side, they aim to attract innovative players to collaborate with.

The AI TEFs act as relevant bridges to bring technological innovation, related to AI, to market in Europe. Therefore, these AI TEFs will be open to all the technology providers across Europe in order to test and experiment AI-based software and AI-based hardware solutions and products developed in research studies. Indeed, these solutions are aimed to be deployed to market by first testing them into real-world environment and at scale which will enhance and facilitate the uptake and advancing of AI diffusion in Europe. Testing and experiment at large will be based on a combination of physical and virtual facilities which will enable the technology providers to integrate their solutions, validate and demonstrate them also in real environment.

The AI TEFs cover four main areas: 1) manufacturing, 2) healthcare, 3) agri-food and 4) smart cities and communities. Looking at the manufacturing sector, in 2020 there were different workshops in this area. The main takebacks are below reported:

- The main challenge is to improve the quality of both products and processes by integrating AI technologies with advanced manufacturing technologies
- There is the need to guarantee access to TEFs for SMEs and Start-Ups
- There is the need to create collaborations in manufacturing by connecting all the players and actors and by developing common standards.
- There is the need to reinforce the main attracting point of TEFs which is the possibility to empower the existing facilities and expertise in manufacturing.
- The TEFs must be as close as possible to real contexts to ensure the proper testing and experimentation
- The TEFs can have a prominent role in deploying certifications by improving trust.

In manufacturing TEFs, the funding scopes are reported as following:

- Increasing and ensuring the end-users involvement
- Improving the quality and sustainability of production processes relying on AI-driven manufacturing facilities
- Creating a trustable, transferable, and scalable Industrial AI Europe based on the integration between AI and robotics technologies within the manufacturing sector.
- Creating facilities seen as reference for the testing and experimenting of solutions which can be fully integrated, validated, demonstrated and certified.

The key areas in which the manufacturing TEFs operate are reported below:

- Optimization at factory level of production processes, and testing of AI-driven technologies used for the autonomous decision-making solutions
- Development of collaborative robots
- Reduction of resource consumption through circular economy adoption.

QU4LITY Contribution to AI TEF

AI TEF aims at connecting the dots, including enhancement of previous investments and national and European facilities. TEF will focus mainly on technical aspects and

the performance expected by the users. TEFs will address the non-technical aspects only where necessary, such as the business case, compliance with legal and ethical requirements. TEF shall provide the expertise and infrastructure necessary for the design and implementation of AI testing methodologies in real-world environments within TRL 6 to TRL 8. it supports technology providers in validating in real-world environments their state-of-the art AI solutions, to assess the suitability of the solutions to meet the needs of the sector. Furthermore TEF is expected to facilitate compliance with the upcoming regulatory framework for AI, and they may support standardisation activities. They could support regulatory sandboxes supervised by regulators where innovative AI solutions may be tested by innovators in a controlled environment.

TEF is expected to collaborate with the network of European Digital Innovation Hubs (EDIHs), serving as a distribution channel for the innovations tested in the TEFs. They may also help in fostering trust and acceptance by the user community and boosting the roll-out of European AI, data and robotics solutions from the lab to the market, through its validation process, increasing the maturity of the tested solutions.

The TEF is composed of a network of around 4-6 nodes, one per Country, including smaller facilities, so-called satellites, connected to one or more nodes. Satellites will support nodes to achieve the critical mass to each node whether appropriate. Nodes will provide access to technology providers both remotely and in person. Satellites may provide access only digitally, but nodes always have to also provide physical access to their facilities. TEF must ensure strong cooperation between the nodes and ensure economies of scale throughout its network.

Services offered by the TEF should take advantage of the respective strengths and specialisation of the individual nodes, allowing for complementarity. Example of service offering includes (but is not limited to): testing processes, methodologies and metrics, established through the involvement of the necessary expertise (sectorial user expertise, AI/integration/IT-support, end-user representatives, regulatory, etc., as appropriate); professional services support on technical aspects of AI testing (integration of the solution within the testing scenario/environment, running the testing and validation processes, technology maturity assessment, issuing of a validation report); access to the necessary digital infrastructure, as appropriate: high-power-computing, labs, cloud computing, connectivity technologies such as 5G, trusted and secured access to sets of (labelled) high quality data, access to sensor networks, and AI toolkit solutions as needed; support the establishment and operation of regulatory sandboxes may be set up with national authorities.

Examples of TEF manufacturing resources are model factories that combine different technologies such as additive manufacturing, machine tools, intelligent conveyor systems, automated warehousing, trusted and secured access to data, IoT infrastructure and more, covering multiple industrial processes.

The manufacturing TEF will address the manufacturing sector's needs for Industrial AI, taking into account domain-specific requirements in terms of time criticality, safety, security and effective interaction and collaboration between robots, AI solutions, and humans who are in control, as well as resource efficiency and environmental performance. The TEF site will offer support and best practices in AI solution implementation including: full integration, industrial validation and demonstration up to pilot manufacturing in dedicated assembly lines and production cells. The TEF needs to support testing and experimentation of main AI-related

services, which cover areas of machine learning, robotics, planning and scheduling, optimization, self-configuration, computer vision, formal methods, natural language processing, automated reasoning, game theory, multi-agent systems, complex systems, system verification, bioinformatics and others.

Finally, TEF site will define and establish European test and training data sets in cooperation with manufacturing data spaces. The project is encouraged to collaborate with other relevant Digital Europe Programme projects, in particular the edge AI and other sectorial Testing and Experimentation Facilities, to ensure appropriate synergies. When required by the use cases, the manufacturing TEF also needs to cater for edge computing. In manufacturing context, this means that AI tools are brought to sensors and devices, i.e. there where data is produced. These AI tools need to deal with manufacturing requirements related to latency, throughput, stream processing, etc. High-performance computing should be also offered where needed. The manufacturing TEF will address key areas in an agile setup such as the ones listed below:

- **Factory-level optimization** (flexible production in high-throughput and high variety environments, rapid prototyping); testing and assessment of AI technology for autonomous decision making within the real world, i.e. interaction with and decision for humans and other machines;
- **Collaborative robotics** (mobile, intelligent AI-powered robots enabling safe human-robot collaboration, also in teams; also in sectors like textiles, tourism or construction);
- **Circular economy**: minimize resource consumption, optimize supply chains in uncertain environments, use of substitute material, collection, sorting and treatment of products that have become waste (making available secondary raw materials and maximum extraction of value), reverse logistics, remanufacturing.

Other impactful topics in AI enabled manufacturing can be addressed as well. QU4LITY partners are leading the AI MATTERS proposal.

3 Community Building results: DMP Cluster (Action2)

ACTION2 QU4LITY needs to intensify its collaboration with the "**DMP Cluster**" Community in DT-ICT-07. Very strong relationship is already in place with **ZDMP** which has been funded under the same sub-topic. In particular, in the course of WG1 Standardisation, several actions are in place, like for instance the joint development of three CWAs (Terminology in Zero Defect Manufacturing, DMP Manufacturing Marketplace Requirements and DMP Data Exchange), the joint participation to Plattform I4.0 Standardisation Council SCI4.0[4] meetings and to CEN/CENELEC/ETSI Smart Manufacturing Coordination Group SMaCG. With the other projects (especially **SHOP4CF**, **digiPRIME** and **KYKLOS4.0**), common activities are foreseen for WG7 WG2 and WG3 regarding Reference Architectures, as well as common Research and Dissemination activities.

The H2020 "Digital Manufacturing Platform" Focus Area

The H2020 "Digital Manufacturing Platform" is the second focus area in addition to "Support to Hubs". As mentioned in the D9.7, this area includes 7 topics focused on the implementation of European Digital Platforms and their experimentation in real world, but also supporting pilots in the domains of Digital Manufacturing for Connected Smart Factories (DMP DT-ICT-07), the creation of Agricultural digital integration Platforms (DT-ICT-08), Rural Economies and cross-sector service Platforms (DT-ICT-09), Interoperable smart homes and grids (DT-ICT-10), Big Data solutions for Energy (DT-ICT-11) and AI for the Hospital of the Future (DT-ICT-12). The DT-ICT-13 topic is for the CSAs supporting Digital Platforms in the four domain areas of Manufacturing, Energy, Health & Care, Agrifood (OPEN DEI) and in the domain of construction (digiPLACE)

The DMP cluster, to which belongs QU4LITY, was born from the DT-ICT-2018-2019 according to which the challenge to be addressed was to exploit technologies and concepts making manufacturing companies be adaptable in fulfilling external demand by advancing the digital manufacturing platforms in order to exploit and make accessible the data to be gathered from the shopfloor and across the supply chain network.

Among all, in 2018 and 2019 the calls in this domain, enabling to create platforms for the connected smart production facilities in Europe, were the following:

I. **Agile Value Networks: lot-size one** (2018 call)
   - **eFactory[5]. European Connected Factory Platform for Agile Manufacturing**. The eFactory project aims to create a smart factory ecosystem based on the 4 smart factory platforms of FoF-11-2016 cluster. This ecosystem will be ancillary supported by industrial platforms and collaboration tools selected with the aim to support connected factories in

[4] https://www.sci40.de/english/
[5] https://www.efactory-project.eu/

lot-size-one manufacturing. In this way it will enhance access to innovation in the long term.

II. **Excellence in manufacturing: zero-defect processes and products** (2018 call)
   - **ZDMP[6]. Zero Defect Manufacturing Platform.** *The aim of this project is to combine state of art technologies with proven technologies with the goal to increase product and process quality support based on a platform delivering specific services.*
   - ***QU4LITY Digital Reality in Zero Defect Manufacturing****. Our project.*

III. **The human factor: human competencies in synergy with technological progress** (2019 call)
   - **SHOP4CF[7] Smart Human Oriented Platform for Connected Factories**. *The EU-funded SHOP4CF project aims to create a platform based on an open architecture enabling the human support in production that can support humans in production activities and providing open-source solutions.*

IV. **Sustainable Value Networks: manufacturing in a circular economy** (2019 call)
   - **DigiPrime Digital Platform for Circular Economy in Cross-sectorial Sustainable Value Networks**. The aim of the project is to develop a circular economy digital platform to facilitate the creation of circular economy business models based on data-enhanced recovery and reuse of functions and materials for cross sector business.
   - **KYKLOS 4.0[8] An Advanced Circular and Agile Manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences**. This project, as the previous one, operates in the circular economy environment. It aims to find solutions limiting waste creation by recirculating resources relying on cyber physical systems, product life-cycle management, life-cycle assessment, augmented reality, and artificial intelligence technologies.

Under the ZDMP project initiative, in 2019 there was the born of the DMP cluster which is based on 8 working groups (among which WG1 is led by QU4LITY representatives) which are reported below.

- WG1 Standardisation has the goal to identify potential synergies and common interests among participants about the topic of standardisation selecting those standards already used by the participants.
- WG2 Dissemination aims to disseminate the advancements of the cluster in international events.
- WG3 Research aims to perform relevant and innovative research for industry

[6] https://www.zdmp.eu/
[7] https://www.shop4cf.eu/
[8] https://kyklos40project.eu/

- WG4 Performance Management and KPIs aims to create assessment frameworks and a common performance management system and KPIs, usable also by SMEs, to ensure the augment of productivity
- WG5 Market Analysis and Business Models aims to ensure to bring to the market the outcomes from the cluster
- WG6 Open Calls aims to ensure external stakeholders to improve components and develop applications
- WG7 Platforms aims to exploit the synergies among technology-based platforms analysing the existing architecture available.
- WG8 Pilots aims to increase knowledge to pilots

The meetings held in 2020 experienced an active participation from QU4LITY representatives like POLIMI, ENG, ATOS, VTT, FHG IPA and INNOVALIA in particular.

QU4LITY and the DMP Working Groups

The DMP Working Groups

The Working Groups (WG) in the Manufacturing domain are composed by projects financed by the EU through the calls "**H2020-DT-ICT-07"** in 2018 and 2019 under the name of "Digital Manufacturing Platforms for Connected Smart Factories".

The resulting DMP cluster is composed of six Innovation Action projects and a CSA: EFPF, KYKLOS 4.0, DigiPrime, SHOP4CF, ZDMP, QU4LITY and Connected Factories2 (Global-leading smart manufacturing through digital platforms, cross-cutting features and skilled workforce)[9]. The main purposes of this cluster are the organisation of joint activities in areas such as platform interoperability, dissemination, business models or standardisation, to share and discuss the different results or activities resulted from the different projects and the definition of a common cooperation strategy to increase dissemination and outreach of the projects results.

To reach these goals, five working groups have been established by QU4LITY, ZDMP and EFPF (e-Factory) projects, funded in the call H2020-DT-2018-1 and later extended to SHOP4CF, DigiPrime and KYKLOS4, funded in the call H2020-DT-2019-1. WGs will exploit synergies between technology-based platforms and pilot activities and manufacturing platforms and piloting projects of the focus area related to issues such as architecture, interoperability and standards approaches. The involved people in these working groups are listed in Table 1.

[9] https://www.connectedfactories.eu/

Table 1. People involved in DMP working groups

Working Groups	EFPF	ZDMP	QU4LITY	Kyklos 4.0	digiPRIME	SHOP4CF
WG1: Standardization	Martin Lorenz (Austrian Standard)	Christian Grunewald (DIN)	**Olga Meyer (Fraunhofer IPA)**	Kjell Bengtsson (Jotne)	John Soldatos (INTRASOFT)	Jose Saenz (Fraunhofer IFF)
WG2: Dissemination	Ingo Martens (Hanse-Aerospace)	Oscar Salgado (IKER)	**Silvia de la Maza (Innovalia)**	Christos Koidis (EfB)	Marcello Colledani (POLIMI)	Emily Carroll (ISDI)
WG3: Joint Research Activities	Usman Wajid (ICE)	Joao Sarraipa (ZDMP)	**Sergio Gusmeroli (QU4LITY)**	Jason Mansell (TECN)	Luis Usatorre (TECNALIA)	Sladjana Martens (TUM)
WG4: Experimentation	Alexandros Nizamis (EFPF)	Nic Fair (UoS)	**Carmen Polcaro (Innovalia)**	Samuel Almeida (F6S)	Nicoletta Picone (COBAT)	Sladjana Martens (TUM)
WG5: Platforms and architecture	Usman Wajid (Information catalyst)	João Sarraipa (UNINOVA)	**Angelo Margugliio (ENG)**	Jason Mansell (TECNALIA)	Marcello Colledani (POLIMI)	Meri Maghlakelidze (TUM)

Manufacturing WG1: Standardization

This first working group aims to achieve a unified standardisation path, a joint structure including common standardisation areas and contribute to the EFFRA (European Factories of the Future Research Association) Innovation Portal[10]. One of the main activities that are being carried out is the collection of information about the standardization activities of the different projects to establish a common understanding and facilitate the support between the different projects.

Manufacturing WG2: Dissemination

The dissemination WG aims to exchange information with other EU projects, joint appearances at events and fairs, coordinate the activities regarding any new information material to be developed, establish KPIs to measure dissemination activities and perform calls to coordinate activities. The final goal of the WG is to harmonise dissemination activities, attract users, promote the transmission of project

[10] https://www.effra.eu/effra-innovation-portal

information, exchange of experiences on different dissemination activities and dissemination of projects´ open calls.

Manufacturing WG3: Scientific and Socio-Economic Impact

The aim of this working group is to establish joint research challenges through unified publications teams around topics and defined journals to increase the scientific impact, to establish a connection with specific projects to facilitate the adoption of our project results in order to boost the societal impact and finally, to establish a basis for projects to benefit from collaborations, that is, to be able to effectively exploit results that they cannot achieve on their own aiming to achieve a higher economic impact.

Manufacturing WG4: Experimentation

The scope of this working group is to map use cases and analyse several aspects (such as their coverage of the pathways, gaps with the market) in order to scan the common aspects that can be extracted and shared with others the lessons learned. This will be achieved through the creation of a Collaboration and Support channel among the participants of the Cluster, the promotion of the different pilots' experiments and the information sharing and collaboration with new projects that are involved in the DMP meeting and initiatives.

Manufacturing WG5: Platforms and architecture

The main objectives of this working group are to define a common understanding of different reference architectures and platform development approaches being adopted by the participating projects, and to establish a common understanding of the different platform development methodologies and reference architectures that were used in the different ongoing projects. This approach will lead to discussions that will support the development of a digital platform ecosystem.

QU4LITY Contribution to DMP Working Groups

QU4LITY and specifically, the 12 pilots have strongly contributed to the DMP working groups in different activities. Some of them are explained below.

In relation to the WG1, a DMP common matrix has been created compiling the information related to the standards from QU4LITY[11] and other projects. The output document from this activity will be a joint map that represents the current standardisation landscape of the cluster regarding the ZDM standards.

[11] https://portal.effra.eu/project/1864#anchor-7

								RAMI4.0 transfer to EFFRA/WIKI						Factors						QU4LITY		
Committee	ID	under development	Title	Link	Date of Publication	Publisher	License	Asset Layer	Integration Layer	Communication	Information Layer	Functional Layer	Business Layer	(tbd)	Human	Security & safety	Interoperability &	Quality	RA	AI	QU4LITY "in usage"	QU4LITY RA	QU4LITY Details
IEC/TC 65 Industrial-process	IEC 62443 series		Security for industrial	Link	-	ANSI, IEC, ISA	Private									x						Distributed Trustworthiness	Cyber Security in Industrial Environments
DIN German Institute for	DIN SPEC 16592:2016		Combining OPC Unified	Link	2016	DIN	Private										x					Digital models and Vocabularies	Description of industrial plants and components
ISO/TC 199 Safety of machinery	ISO 13849-1:2015		Safety of machinery —	Link	2015	DIN	Private									x						Control Service	Control Service; design and integration of safety-
e@Class e.V.	eCl@ss		eCl@ss	Link	2002-2019	eCl@ss e. V.	Private										x					Digital models and Vocabularies	e@Class: Supports the digital

Figure 10. Standards classification matrix

In addition, some of the partners participated in the event hosted by Connected Factories "Standards for digital manufacturing"[12]. In this webinar the QU4LITY reference architecture was presented as part of the dissemination WG2.

Regarding the WG3, QU4LITY has participated in the definition of pathways for the digitalisation of manufacturing together with CF2. QU4LITY use cases and demonstrators associated with these pathways are gathered and promoted in the "Digital Transformation Use Cases Catalogue"[13], which aims to document the use cases and demonstrators generated by Industry 4.0 related to research and innovation projects.

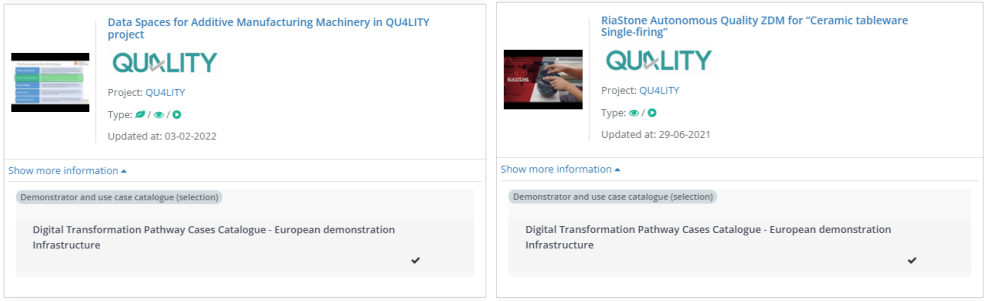


Figure 11. QU4LITY in Digital transformation Use cases Catalogue

The WG4 has participated in a bilateral meeting on the 3rd of February 2022 led by CF covering aspects such as the business models and legal aspects, interoperability and human aspects in QU4LITY pilots.

12 https://www.effra.eu/news/standards-digital-manufacturing-webinar-recordings-and-presentations-are-now-available

13 https://www.connectedfactories.eu/news/digital-transformation-cases-catalogue-now-launched

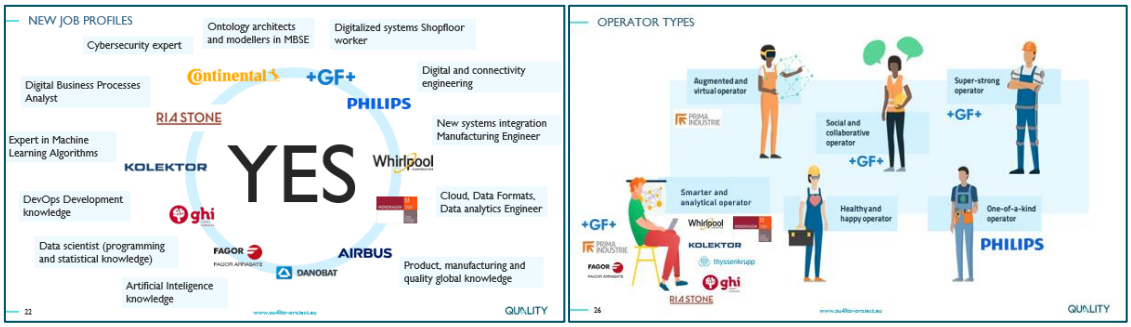


Figure 12. Bilateral meeting CF

Finally, one example of the activities carried out by the WG5 is the completition of a questionnaire in relation to the interoperability aspects in the QU4LITY platform. The information gathered from different projects will be mapped through the EFFRA Innovation portal at three different levels of interoperability: Platform level, application level and integration level.

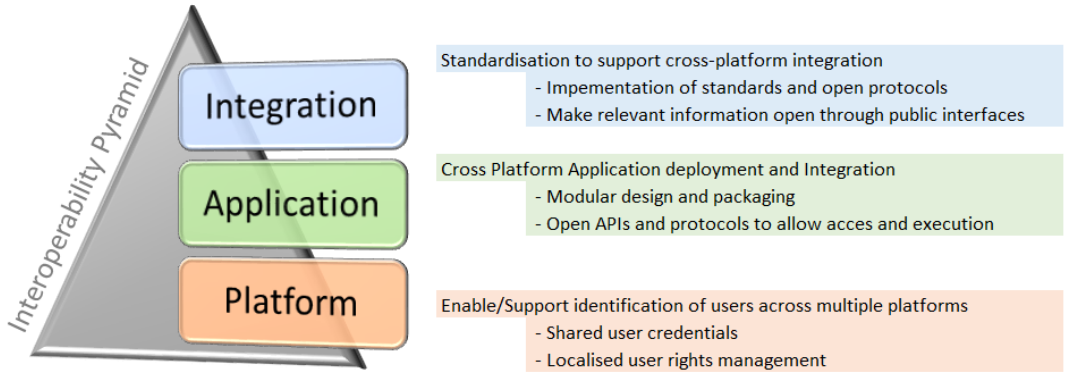


Figure 13. Interoperability pyramid

The activities gathered in this section are only some examples of activities to which QU4LITY has contributed along the project.

4 Community Building results: Connected Factories Pathways (Action3 Action4)

ACTION3. QU4LITY needs to contribute to the **Connected Factories Pathways** by bringing its experience in terms of autonomous quality solutions and pilot cases in the three scenarios of Smart Factory (Autonomous Factory pathway), Smart Value Chain (Hyper-connected Factory pathway) and Smart Product lifecycle (Collaborative Product-Service pathway). CF1 was born to support ICT-11 RIA projects but now need to evolve towards DT-ICT-07 and their new contributions. Specific views from the four topics (**zero defect manufacturing and autonomous quality** in our case) need to be developed. What does it mean ZDM and AQ in the Factory, in the Value Chain and in the Product lifecycle management (including end-of-life)? The presence and impact of QU4LITY in CF pathways evolution and validation need to be improved now that QU4LITY AQ solutions and industrial pilots are available.

ACTION4. QU4LITY needs to contribute to the new pathways proposed by **ConnectedFactories2 CSA: Circular Economy and Data Spaces**. Both pathways are still in their ideation and development phases, while soon a through validation in the DT-ICT-07 community will take place. VTT and POLIMI (QU4LITY beneficiaries) are leading the two pathways, so substantial contributions from QU4LITY are expected not just in the validation (identifying industrial and technological cases to be mapped in the 2D space) but also now in the development phase. Interviews to QU4LITY industrial stakeholders (from the demand and the supply side) are foreseen in the next period.

The Connected Factories I and II CSAs

Two projects, respectively, the ConnectedFactories (2016-2019) and ConnectedFactories2 (2019-2022) https://www.connectedfactories.eu/ were conducted with the goal to create pathways facilitating the digital and sustainable transition of manufacturing companies. In the next two sub-chapters their results and activities are summarised.

ConnectedFactories I objectives and main actions

ConnectedFactories - Industrial scenarios for connected factories 2016-2019, CSA (Cordis https://cordis.europa.eu/project/id/723777) was finalised in October 2019 with VTT as coordinator. Public reports at Cordis and also at https://www.connectedfactories.eu/. The main objectives of Connected Factories Project are summarised by the following concepts: *fast-moving developments around 'digitisation' and 'digital platforms' in manufacturing, structured overview of both available and upcoming technological approaches, develop forward-looking scenarios or pathways, stimulate consensus building, create trust and deepen the links within the community*

As just anticipated, the **'scenarios and pathways'** represent the tools through which **companies can develop their innovative strategy** in the context of digitalization. Each path relies on different levels of maturity which are linked to a set of milestones to be achieved to move to the next level becoming more advanced.

In the first project 2016-2019 the following pathways were originated and the mapping of projects and their results was conducted on these pathways[14].

- The **Autonomous Smart Factories** pathway[15] has a focus on intra-factory manufacturing automation and optimization, including advanced human-in-the-loop workspaces and it is based on five levels of maturity as depicted in Figure 14.

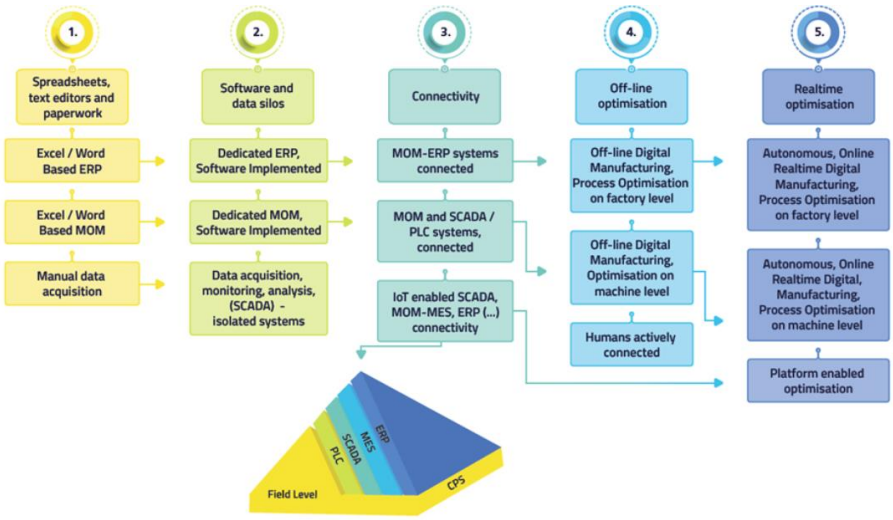


Figure 14 Autonomous & Smart Factories pathway

- The **Hyper-connected Factories** pathway[16] has a focus on networked enterprises in complex, dynamic supply chains and value networks. It relies on 5 levels of maturity as depicted in Figure 15.

[14] https://www.connectedfactories.eu/pathways-digitalisation-manufacturing
[15] https://www.connectedfactories.eu/autonomous-smart-factories-pathway
[16] https://www.connectedfactories.eu/hyperconnected-factories-pathway

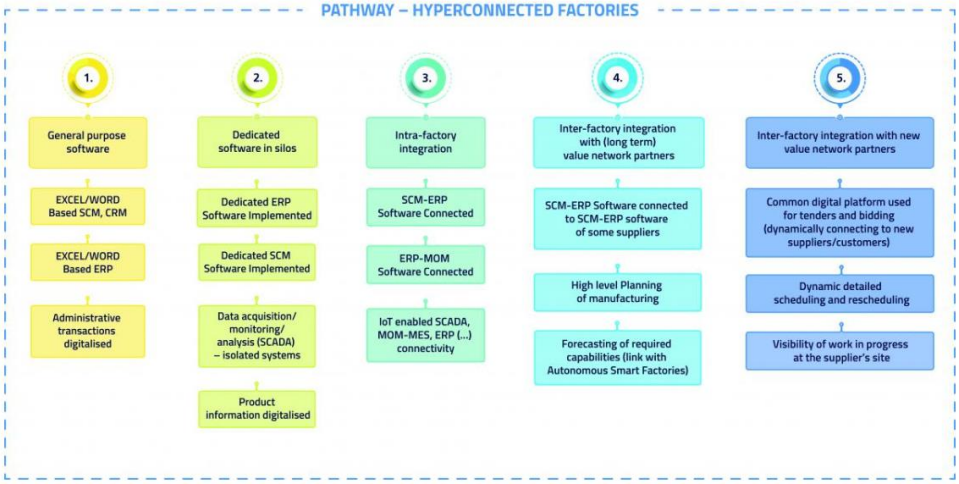


Figure 15 Hyper-connected Factories pathway

- The **Collaborative Product-Service Factories** pathway[17] has a focus on data-driven product-service engineering in knowledge intensive factories and it relies on five levels of maturity as depicted in Figure 16.

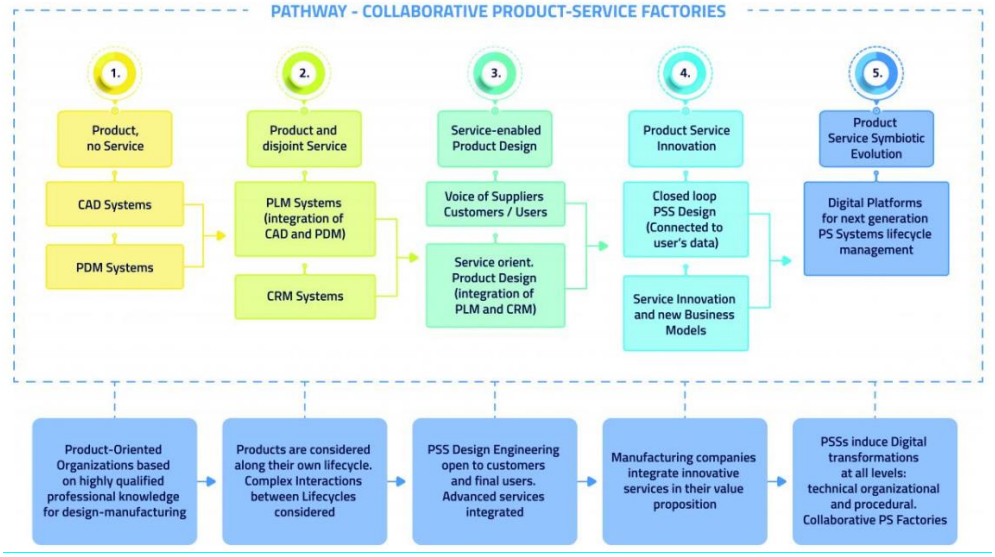


Figure 16 - Collaborative Product-Service Factories pathway

ACTION3 for QU4LITY Community Building (Chapter 7) is dedicated to CF pathway

ConnectedFactories II objectives and main actions

The **ConnectedFactories 2** project provides an overview on advanced technologies and best practices with regard to the digitalization of the manufacturing sector by highlighting present and future needs of manufacturing companies. The project

[17] https://www.connectedfactories.eu/collaborative-product-service-factories-pathway

developed two pathways supporting the data driven and sustainable transition of companies which is highly linked to the Green Deal.

The ConnectedFactories 2 project (started on 1 December 2019) focuses on: *creating a common understanding of key enablers and cross-cutting factors for the development of digital technologies platforms for manufacturing, deepening pathways by considering legacy systems, industrial requirements and challenges, situating inspiring research and industrial state-of-the-art cases, matching of skills, engaging with the research and industrial, creating a broad awareness about the pathways, stimulating visibility and impact of Digital Manufacturing Platforms for Connected Smart Factories projects (call DT-ICT-07-2018-2019)*

The CF2 Data Spaces pathway

The first pathway relied on the diffused need to create a common EU Data Space for Manufacturing Industry. Reading the BDVA publications, like the positioning paper, "**TOWARDS A EUROPEAN DATA SHARING SPACE,** enabling data exchange and unlocking AI potential"[18], it is possible to understand what are the Data Spaces, the Data Platforms and the Data Marketplaces within EU Data Ecosystem and by reading the BDVA "**SRIA Strategic Research and Innovation Agenda** version 4.0"[19] reference model, six main challenges are highlighted: i) Data Management, ii)Data Protection, iii) Data Processing Architectures, iv)Data Analytics, v) Data Visualisation and User Interaction, vi) Ecosystems for Data Sharing.

Based on these results, representing the six main dimensions, it was possible to define the five maturity levels for "Data Space" for a Manufacturing company (SME) through which evaluate the dimensions: 1) No Data Control, 2)Data Silos, 3) Data Bridges, 4) Data Interoperability and 5) Data Valorisation.

Therefore, the DS pathway, based on a 6*5 matrix reported in Figure 17, was filled by QU4LITY participants.

[18] https://www.bdva.eu/sites/default/files/BDVA%20DataSharingSpace%20PositionPaper_April2019_V1.pdf
[19] https://www.bdva.eu/node/874

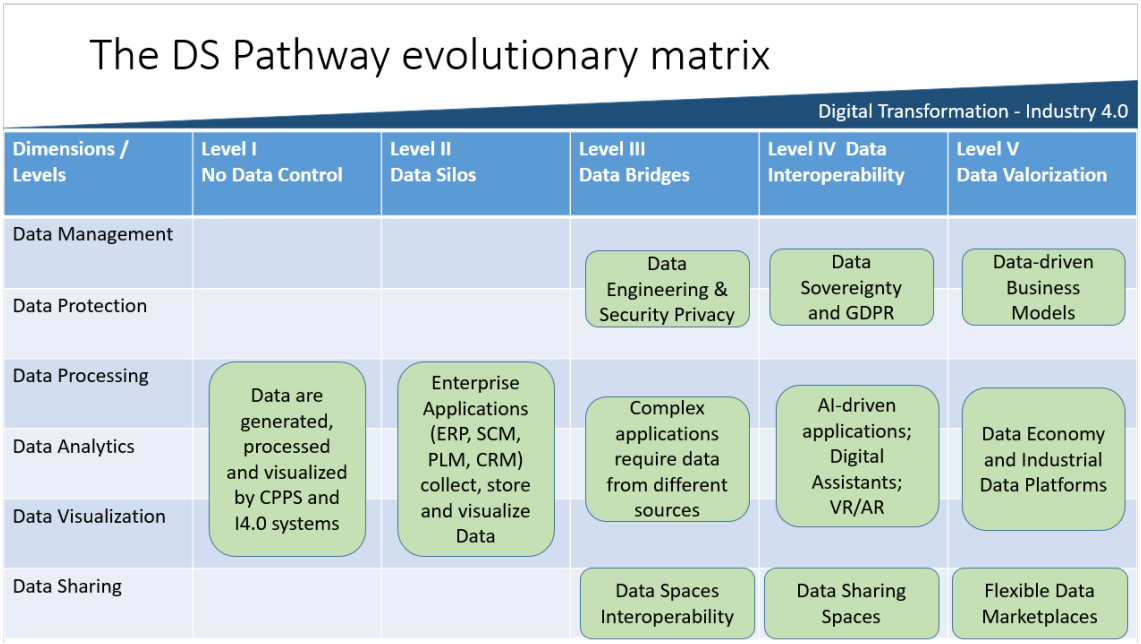


Figure 17 DS Pathway evolutionary matrix

The CF2 Circular Economy pathway

The second pathway developed is the one concerning Circular Economy which has the goal to provide a tool facilitating the reduction of resource consumption by the manufacturing sector in accordance with several initiatives from the European Commission and United Nations. This pathway was built relying on the extant literature and other initiatives and reports among which the Lombardy Roadmap for Research and Innovation on Circular Economy, and the "Advancing Circular Business" publication, which summarizes company and network level approaches towards circularity. The five levels of maturity enable the mapping of a manufacturing company initiatives and the levels are reported below:

***LEVEL_1. LINEARITY**. The manufacturing company does not consider any projects to become circular, it is stuck into the traditional linear concept of make-take-dispose.*

***LEVEL_2. INDUSTRIAL CE PILOTING**. Some cultural modifications have been put in place within company boundaries fostered by managerial and tactical levels of the company*

***LEVEL_3. SYSTEMIC MATERIALS MANAGEMENT**. The "R-cycles" of industrial materials has become a standard practice adopted by the company and external partnerships have been established in order to systematically identify possibilities to reuse, refurbish and remanufacture materials*

***LEVEL_4. CIRCULAR ECONOMY THINKING**. The top management has pushed the experimentation of the adoption of some CE strategies (e.g. new product design and deployment of new services), though internal analysis towards CE.*

LEVEL_5. CIRCULARITY. *Adoption of CE strategies with adequate countermeasures on products, processes, organization and technologies, i.e. sustainability/circularity KPIs are implemented.*

QU4LITY and the Connected Factories Innovation Portal

The Connected Factories Innovation Portal

The European Factories of the Future Research Association (EFFRA) deployed the 'EFFRA Innovation Portal' in cooperation with the European Commission. The aim of this portal is the creation of an online resource that facilitates the information sharing from different research and innovation projects, including the results of the demonstrators associated to them.

The portal counts with several video-tutorial with the main goal of explaining and helping the users, how to contribute and navigate through the huge amount of information that is contained in the portal. The tutorials (see Figure 18) try to explain how to edit projects and results, search projects, import information from the EU Open Data portal and to create reference documents.

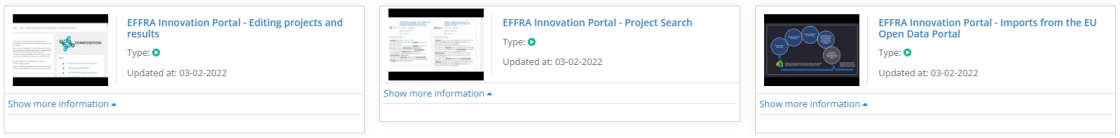


Figure 18. CF Innovation portal tutorials

One of the most successful achievements of this portal is the creation of the Demonstrator and use case Catalogue. This catalogue was launched in June 2021 and it is composed of dynamically evolving collection of inspiring use cases and demonstrators that fit in the context of the digital transformation of manufacturing. More specifically, the CF Innovation Portal includes all Factories of the Future partnerships' projects and also includes projects from other programs and initiatives on manufacturing. One of the included projects is QU4LITY (Figure 19).

Figure 19. QU4LITY in the CF Innovation Portal

This initiative aims to promote and describe the impact of the developed technologies and demonstrators and to show the way forward to their implementation in industry. Some of the information that is included in the portal is the following:

- Short project description including information such as the web resources, start-end dates, budget, calls, twitter name, contact information etc.

- Demonstrators and partners mapping (company name, webpage and location)
- Project standards
- Project technologies and enablers
- Digitalisation pathways
- ICT performance characteristics
- Demonstrators in the project (videos, description, technical partners, developed technologies, results, etc)
- Project videos and presentations
- Results including deliverables and reports related to the project

The cases and pilots included in the portal can be described using structured lists or wiki[20] (Figure 20). This is the backbone of the structured mapping and it also serves as a stand-alone structure wiki about aspects that matter in the context of manufacturing and manufacturing innovation in particular.

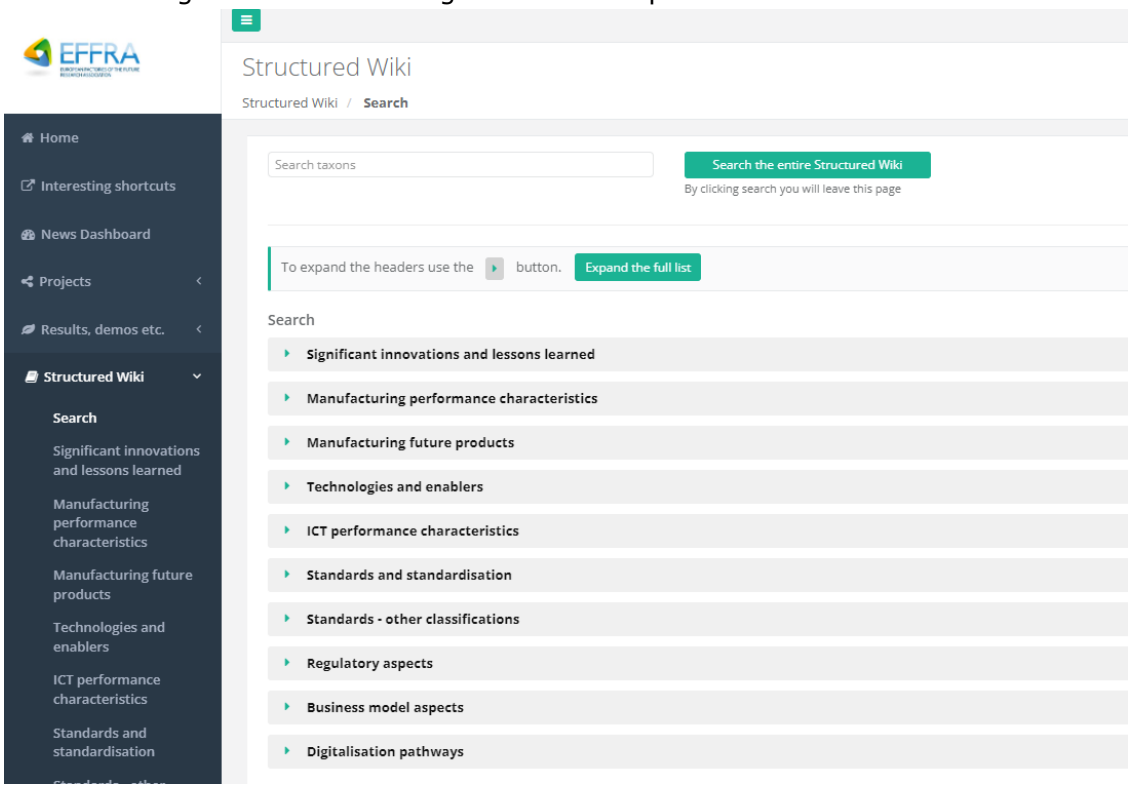


Figure 20. Structured wiki

QU4LITY Contribution to CF Innovation Portal

As explained in the previous subsection, QU4LITY has included the results of the project in the CF Innovation Portal[21]. As part of the contribution from QU4LITY to the CF Innovation Portal, the results and pilots were mapped and included in the

[20] https://portal.effra.eu/wiki

[21] https://portal.effra.eu/project/1864

digitalisation pathways (Figure 21). In Figure 22, an example of the mapping of the pilots related to the Autonomous Smart Factories Pathway is shown.

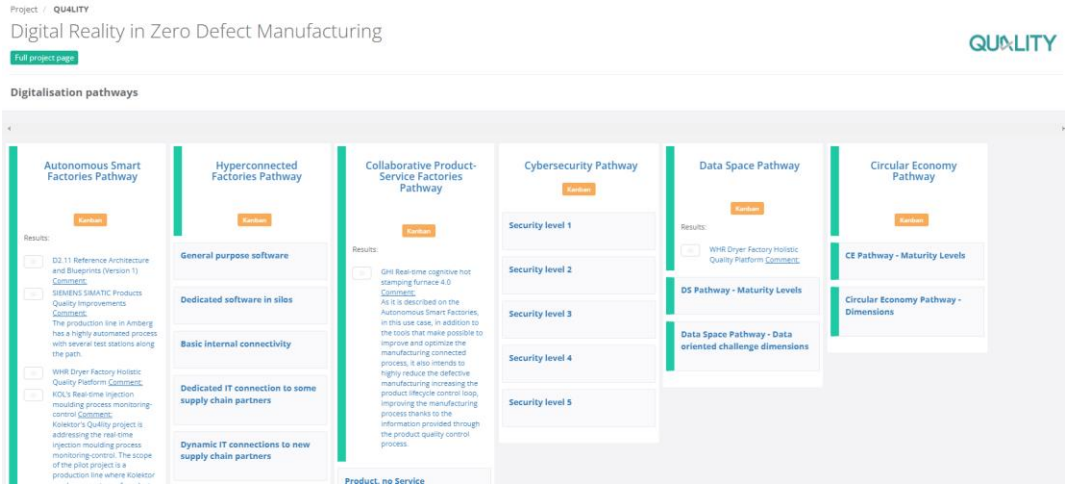


Figure 21. Digitalization pathways

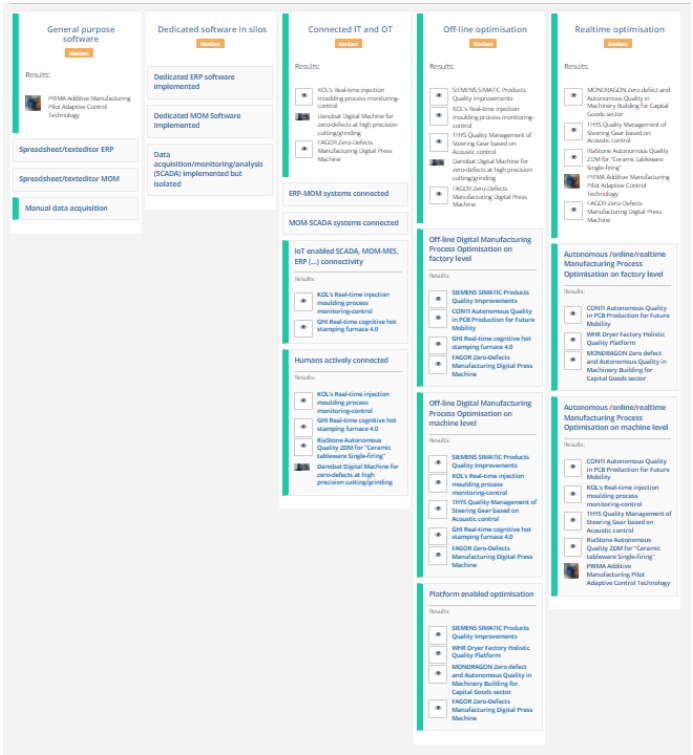


Figure 22. Autonomous Smart Factories Pathway

QU4LITY and the CF2 Circular Economy Pathway

The CF2 Circular Economy Pathway

The CE pathway developed in the Connected Factories 2 (CF2) project raises awareness and highlights the importance of the CE paradigm for the sustainability of the manufacturing sector. The CE maturity levels are i) linearity, ii) industrial CE

piloting, iii) systemic material management, iv) CE thinking and v) full circularity. These maturity levels are mapped to a linear manufacturing value chain: Product design - Sourcing - Production - Logistics - Marketing and sales - Product use - End-of-life (see Figure 23).

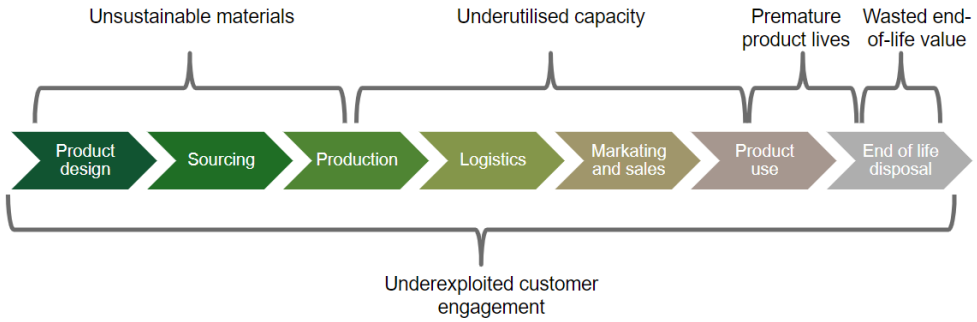


Figure 23 Inefficiencies on the current manufacturing value chain

Thus, the creation on matrix 6x8 reported in Table 2(Saari et al 2021).

Table 2 CE Maturity levels mapped with the linear value chain (Saari et al 2021).

Linear value chain	Linearity	Industrial CE piloting	Systemic material management	CE thinking	Full circularity
Product design	Product design does not consider durability, upgradeability, circularity or sustainability.	Company considers transition from the use of unsustainable and hazardous substances to sustainable raw materials. Company has piloted the repair or reuse of products.	Durability and upgradeability of products is promoted and applied. Personalisation of products is driven by demand and purpose.	Environmental impact assessment is a driving force of product development (eco design). Products are designed to avoid loss and premature end-of-life.	Products are fully circular by design, enhancing purpose-based durability during the life-cycle and enabling multiple reuse, repair, remanufacturing and regenerative recycling at end-of-life.
Sourcing	No actions to reduce the consumption of energy and/or materials are being implemented. Materials are sourced based	Company seeks to minimise inputs of energy and materials. Material sourcing is being shifted from unsustainable	Sourcing is based on code of conduct guidelines for circularity and the sustainability of materials. The amount of waste is	Raw materials are sourced mainly from known and monitored secondary markets and through reverse logistics. Social	Full circularity is enabled by sustainable materials that have less environmental impact (on biodiversity, climate change, acidification,

	on performance and price.	to sustainable raw materials.	minimised and side streams are utilised.	impacts are considered in the sourcing process.	etc.) than traditional counterparts.
Production	Operations of the company meet environmental regulations, but R-cycles are not considered.	The minimisation of virgin raw materials, water and energy has been piloted at machine, process and company levels.	Production-on-demand allows the company to limit inputs and to reduce outputs, avoiding unnecessary use of raw materials, water and energy.	Circular production scheduling considers stocks on different levels.	Production is environmentally sound, which is enabled by close monitoring of the environmental impacts of production processes.
Logistics	Company has no goal to optimise logistics.	L*ogis*tics optimisation pilots are taking place.	In addition to deliveries, logistics covers raw materials and waste.	Linear and reverse logistics are considered with partners. Traceability of products is implemented.	Value chains are localised, and closed loops are implemented. Transparency of products, production and logistics is enabled.
Marketing and sales	Company has not included CE sustainability views in their marketing activities.	Communication of CE piloting activities is planned as part of strengthening the company's image.	Materials origins, work force and locations are communicated transparently.	Proactive demonstrations of sustainability activities on the environmental, social and economic levels are capitalised.	Product-as-a-service and X-as-a-service approaches are implemented.
Product use	Products are not reused or repaired during their life-cycles.	Pilots are undertaken for reuse and for the recovery of materials from used products.	Production plans are based on an analysis of multisource product usage data.	Understanding customer behaviour and needs enables a prolonged life-cycle, upgrades and repairs to products.	Sharing economy business models provide novel alternatives for product usage.
End-of-life	At end-of-life, the product is treated as waste.	Pilots are undertaken that upgrade materials or products for reuse.	Reuse of products, side flows and waste is implemented.	Environmental, social and economic impacts of end-of-life products are known.	The next life-cycle of a product is known, with its environmental, social and economic impacts.

QU4LITY Contribution to CF2 Circular Economy Pathway

QU4LITY and other H2020 projects did contribute to the CF2 Circular Economy Pathway. The preliminary framework was presented and tested in the *Pathways to Digitalisation of Manufacturing and Associated Use Cases* webinar on Wednesday 24th March 2021, organised by the European Factories of the Future Research Association (EFFRA). Information on the pilot projects was also gathered during the workshop, particularly case examples of the different development pilots of companies seeking to solve identified value chain inefficiencies at each CE maturity level.

Instances of collaboration were identified in the solutions implemented in CF2 projects, (Saari et al. 2021) see Table 3.

Table 3 Collaboration in the solutions of CF2 projects (as March 2021)

Level	Instance of collaboration	Projects and solutions
Linearity	No collaboration, prevalence of make–take–dispose paradigm.	No instances among CF2 projects.
Industrial CE piloting	Collaboration and experimentation with external industrial actors, with an emphasis on production and logistics.	QU4LITY: QU4LITY pilots on the reduction of unnecessary scrap material and augmented reality (AR) demos to support the maintenance. European Factory Platform: logistics traceability via blockchain.
Systemic material management	Integrated concerns with opportunities to reuse, refurbish, recycle and remanufacture materials.	Kyklos: automatic product design for a personalised 3D-printed wheelchair with AR manuals. TRICK: tracing 'from sheep to shop' via blockchain. European Factory Platform: digital marketplace with automated B2B matchmaking and new market opportunities. AI.SOV: AI-based solution to forecast and optimise spare parts production.
CE thinking	Commitment to an industrial symbiosis network in which the	Kyklos: in addition to the web-based configuration tool (a digital twin), the

	ultimate goal is to leverage a closed-loop supply chain.	IoT is embedded in the product, enabling predictive maintenance. European Factory Platform: smart waste management with connected factories, real-time data analytics and blockchain.
Full circularity	Aspirational goals reflecting a broad understanding of value flows and the co-creation of new value circles within manufacturing networks.	None to date.

QU4LITY and the CF2 Data Spaces Pathway

The CF2 Data Spaces Pathway

As just mentioned, the **ConnectedFactories 2 - Global-leading smart manufacturing through digital platforms, cross-cutting features and skilled workforce** project developed two pathways (supporting the data driven and sustainable transition of companies) and it is validating a third one, not yet published on the website.

The **Data Spaces pathway** relies on the increasing need to create a common EU Data Space for Manufacturing Industry. The pathway is the result of a detailed analysis of many relevant European publications on the topics, that allow to understand the EC's value and position: the BDVA positioning paper, "Toward a European-Governed Data Sharing Space"[22], to understand what Data Spaces, Data Platforms and Data Marketplaces are within EU Data Ecosystem and the BDVA "SRIA Strategic Research and Innovation Agenda version 4.0"[23] reference model where five plus one data-oriented challenges have been identified and materialized.

The final result is a 6x5 evolutionary matrix, having

- **six dimensions** on the rows, that is, six different processes related to data exploitation.
- **five maturity levels** for a Manufacturing company, to be crossed with the data dimensions.

[22] https://www.bdva.eu/sites/default/files/BDVA%20DataSharingSpaces%20PositionPaper%20V2_2020_Final.pdf
[23] https://www.bdva.eu/node/874

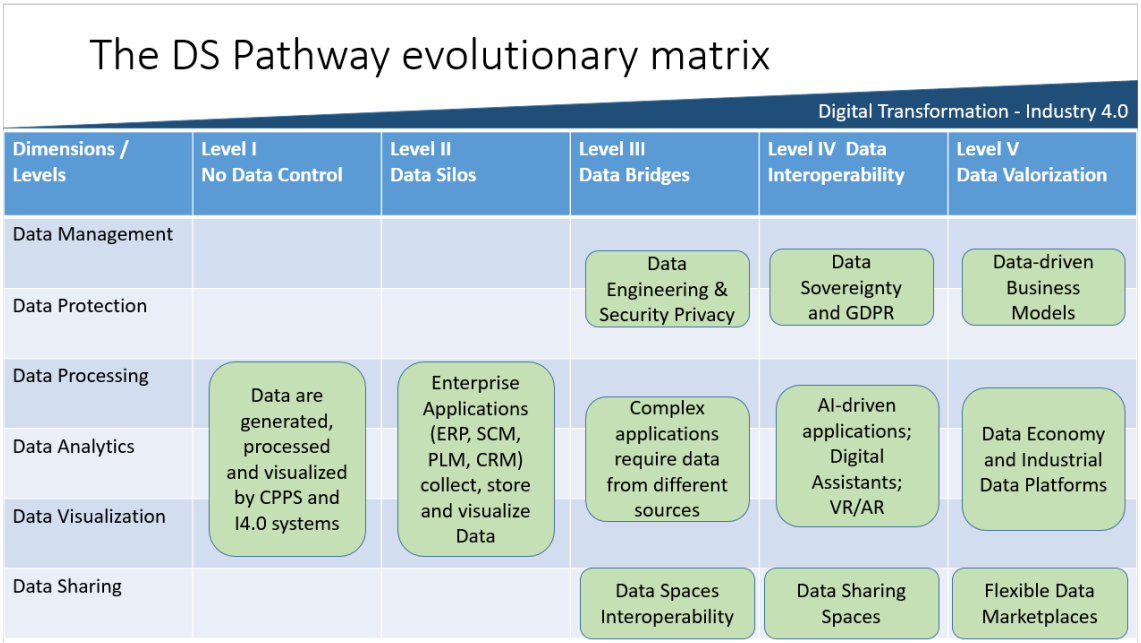


Figure 24 Data Space Evolutionary Matrix

The six dimensions are:

- **Data Management**: Principles and techniques for data lifecycle management including quality, integrity, provenance and liability
- **Data Protection**: Privacy and anonymisation mechanisms to facilitate data protection. This is shown related to data management and processing as there is a strong link here, but it can also be associated with the area of cybersecurity.
- **Data Processing Architectures**: Optimised and scalable architectures for analytics of both data-at-rest and data-in-motion, with low latency delivering real-time analytics
- **Data Analytics**: Data analytics to improve data understanding, deep learning and meaningfulness of data, supporting forecasting, prediction, prescription and autonomy
- **Data Visualisation and User Interaction**: Advanced visualisation approaches for improved user experience
- **Data Sharing** along Value Ecosystems and Innovation Support: Data platforms for data sharing include, in particular, Industrial and Personal Data Platforms, but also other data sharing platforms like Research Data Platforms (RDPs) and Urban/City Data Platforms (UDPs).

These six dimensions have been chosen for the analysis of "Data Space" maturity of a Manufacturing company (SME), along five levels of maturity defined as:

1. **No Data Control**. This is a level where companies do not have CONTROL of DATA along their lifecycle. DATA are of course generated but no models, no processes, no awareness is in place. Smart Machines, Smart Products and Smart Value Chains do produce data but they are dispersed in several areas and the company does not have any control on them.

2. **Data Silos**. This is a level where the company understands the relevance of Data lifecycle management as for feeding Enterprise applications such as PLM ERP SCM CRM MES. Data are captured, protected, processed, analysed, visualized in the context of their Enterprise application, so some data is NOT managed, some data is duplicated, but in any case DATA is SILOED.
3. **Data Bridges**. This is a level where for feeding some advanced applications in the domain of planning, optimisation, prediction, the company needs to integrate data from different sources (e.g. ERP-CRM; ERP-MES, PLM-MES). Ad-hoc integration bridges are developed but without an holistic and comprehensive strategy for data management and governance.
4. **Data Interoperability**. This is a level where enterprises define a strategy and a set of processes for managing and governing the Data generated inside and acquired from outside along their complete lifecycle. Data Spaces are generated where common standard data models, ontologies, industrial data platforms are set up inside the company and along the product lifecycle and the value chain. Any new application can be easily plugged & played in this data space just by configuration, so that scalability is assured.

Data Valorisation. This level is when the enterprise fully understands how data can be profitably exploited inside and outside of the value chain. Data Marketplaces and/or Trusted Data Networks are setup and managed in agreement with Data Protection (personal data) and Data Sovereignty (non-personal data) principles. This does not necessarily imply a monetisation and revenue stream, but the full exploitation of the intrinsic value of data-information-knowledge

QU4LITY Contribution to CF2 Data Spaces Pathway

To deepen into the Data Space pathway, on 3rd December, 2020, ConnectedFactories 2 organised a DMP Plenary Cluster Web Meeting inviting all members of the DMP cluster, to discuss about the Data Space Pathway.

Provided that the Data Space Pathway was already validated, the objective of the meeting was not to go into details of rows and levels, but to make participants reflect about following topics, related to Data Spaces:

- **Obstacles and challenges**: Which are the barriers that keep manufacturing enterprises stuck to the lowest levels? Or more in general, which obstacles do enterprises face when they want to improve their "data maturity"?
- **Industrial cases**: According to personal experience, which projects/activities (and in which way) have supported and stimulated the implementation of Data Space in Manufacturing?
- **Future Opportunities**: Which are the most relevant opportunities in manufacturing industry derived from Data Economy?

The goal was to collect comments, ideas and personal opinions in order to:

- create a shared awareness and a profitable starting point about the main issues that are currently affecting the manufacturing domain,
- depict the current state of the art of Data Space in manufacturing in projects and research,

- identify the advantages of adopting Data Economy as an incentive to be shown to enterprises to drive them in the transformation.

Figure 25 Online Board of the DMP Plenary Cluster Web Meeting (3rd Dec '20)

5 Community Building results: the OPEN DEI cross-sector CSA(Action5)

ACTION5. QU4LITY needs to contribute to **OPEN DEI Task Forces** in order to open-up new opportunities for dissemination and exploitation of its assets to other domains, e.g. **Agrifood** (tractors and other machineries for agriculture, regarding production, supply chain and product lifecycle), **Healthcare** (clinical and diagnostic equipment for health & care, regarding production, supply chain and product lifecycle), **Energy** (renewable energy systems value chain and smart home equipment manufacturing and lifecycle management). In particular, two Task Forces will be operational in 2020: TF1 addressing the challenge of common EU Data Spaces building blocks and design principles, TF3 addressing the challenge of common Reference Architectures and Open Source Reference Implementations.

The OPEN DEI cross-sector CSAs

The Innovations Actions are aimed to address four different activities which are below briefly described:

- In platform building according to which proposals need to develop digital platforms which are an innovative improvement based on the state of the art and the integration of the already available technologies (e.g., AI and Robotics). The idea is to have these platforms interoperable and open to avoid problems of lock-in but based on standards and regulations.
- In large-scale piloting according to which once the platforms have been developed, applied and validated they need to be used by Pilots in real-world environment by adapting according to their context the platforms with the final aim to foster take up and large scale deployment.
- In ecosystem building according to which is expected to foster the expansion the ecosystem of players extending it to small and innovative players.
- In standardisation according to which it is expected to create a usable as standard or as a pre-normative activity.

Two CSAs were founded to support the Innovations Actions. These two CSAs are digiPLACE, focused on the construction industry, and OPEN DEI addressing Manufacturing, Energy, Agrifood and Health&Care. More specifically, 27 Innovation Actions from OPEN DEI covering these four domains are reported in Figure 26.

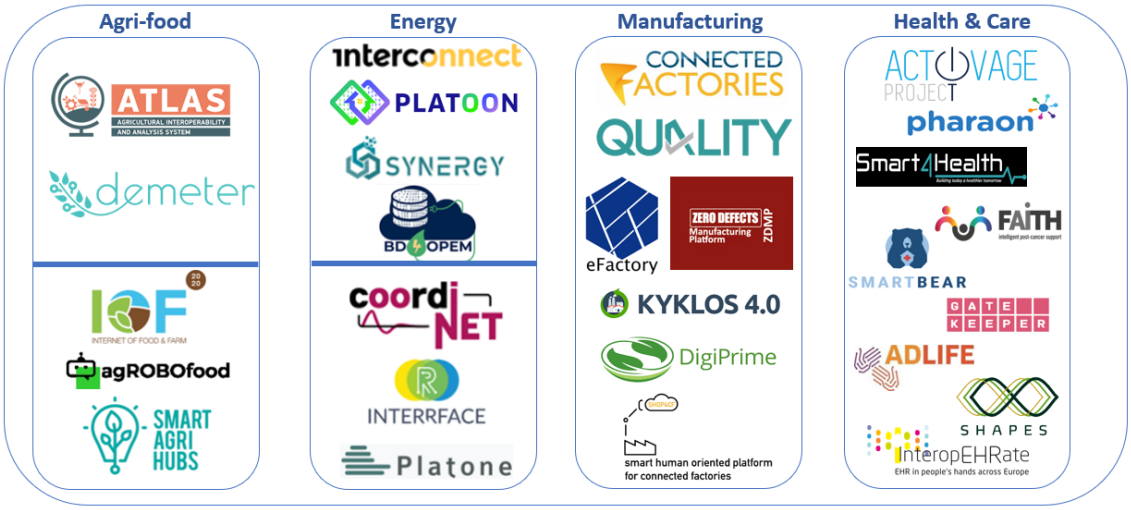


Figure 26 – OPEN DEI portfolio of Innovation Actions

OPEN DEI is aimed at facilitating collaboration and joint dissemination among the projects and in doing it, OPEN DEI has organised some Task Force (TF) to make experts from the projects be concentrated on common challenges among the four domains of manufacturing, energy, health&care an agrifood. In particular, TF1 "Data Sharing Spaces", focused on the implementation of data spaces in the four domains intended also to clarify the design principles of data spaces, and TF3 "Reference Architectures and Open Source implementations", focused on the definition of a cross-domain reference architecture framework around three levels of Data Space, and open source implementations, were activated in Fall 2020. They both require the active contribution from all the projects among which QU4LITY. For instance, regarding TF1, QU4LITY has to contribute in identifying the shared cross-domain challenges with the aim to establish a bi-directional exchange of knowledge and assets within the four application domains of Digital Platforms.

QU4LITY and the TF3 "Reference Architecture and Interoperability and Standards"

The OPEN DEI TF3

One of the main objectives of OPEN DEI is to understand and support the process of Digital Transformation in different industries. Accelerating the digital transformation requires taking advantage of synergies between sectors. There are technical elements that are cross-sectorial though specific requirements and context conditions apply at sectorial level. For the common parts industries can learn from what has been done in other vertical sectors, but furthermore there is an opportunity for reusability of architectures/technologies and cooperation. It is not just about reusing a building block from one sector to another, but also about ensuring that communication can happen in between platforms developed in different sectorial projects.

Following that context, the Task Force 3 will address major technical elements for Digital Transformation with a cross-domain perspective, including Reference Architectures, solutions that could be used for implementing such architectures with a focus on Open Source and standards, as a vehicle to promote interoperability.

The Task Force 3 intends to:

- Create awareness and learn from previous works on Reference Architectures and understand how different approaches can be integrated or combined looking at scenarios of Digital Transformation.
- Review the current landscape of standards, identify which areas require further work in terms of promotion of new standards (or extension of current ones) and help in their adoption by providing practical guidance to organizations.
- Help in the journey from specifications and conceptual work represented by architectures to the implementation of real solutions through an overview of open source reusable components that could ease and accelerate developments.
- Help in the evaluation of the Digital Transformation Pathways and Achievements to support projects in enhancement of their impacts for digital transformation and identify best practices that can be reused or considered by other projects, leading to a cross-sector learning experience.

The Task Force 3 provides a collaborative environment to achieve a common and harmonised approach across the OPEN DEI projects' ecosystem. The final aim is to cooperatively develop a collaboration framework for cross-sector ICT standardization activities to support OPEN DEI projects in the implementation of next generation European digital platforms in the four basic industrial domains: Manufacturing, Agriculture, Energy, and Health&Care. Task Force 3 constitutes a comprehensive forum where a common framework to assess the approach adopted by piloting activities and projects can be shared, discussed, reviewed, approved and, eventually, adopted. In this role, this Task Force 3 will regularly interact with relevant stakeholders in each project of the OPEN DEI inner and outer ecosystem and organize the work between OPEN DEI representatives and project stakeholders.

The Task Force's ultimate goal is to offer solid guidance to the OPEN DEI ecosystem projects to accompany and inform the design and implementation of their respective platforms.

The Task Force 3 aims at generating new technical knowledge from participative and collaborative activities among experts, partly provided by the projects, partly provided by the OPEN DEI Consortium, and partly provided by external independent domain experts. The Task Force 3 is based on collaborative innovation, think tank open living labs principles, leveraging on the heterogeneity of roles, skills, experience, background brought to discussion by the Task Force 3 coordinators and the domains' experts. The outcome of the Task Force 3 enriches the common knowledge base of the OPEN DEI ecosystem and unleashes the potential of new

innovation opportunities (e.g., knowledge transfer, cross-fertilisation) for the projects' ecosystem and their domain-specific Working Groups.

The main objective of the Task Force 3 is to produce knowledge and tools to foster effective sharing and assessment of experiences and lessons learned on how systems supporting Digital Transformation can be architected, crossing the boundaries of specific applicative sectors.

Task Force 3 will support the OPEN DEI ecosystem projects' in developing their Digital Platforms along two different iterations each subdivided in one or more phases. The first iteration aims at providing a cross-domain and multi-domain overview of reverent state-of-the-art looking at architectural patterns, building blocks, reference implementations and specific functionalities and value enabled by those choices. Moreover, major architectural elements and interoperability mechanisms used in the four sectors are considered. In the second iteration, based on the inputs provided by the first iteration, a framework for cross-sector Digital Assessment will be developed to support projects in enhancement of their impacts for digital transformation.

The main objectives are to develop, build and operate a Task Force about Digital Platforms, Pilots and Standards through the definition of reference architectures, interoperability mechanisms and standards to be used by the projects (iteration 1) an analysis of use cases from piloting activities to identify and assess their impact of a Digital Transformation (iteration 2), and the setting up of a collaboration framework for standardization activities

QU4LITY Contribution to OPEN DEI TF3

The operational phase of the Task Force 3 started from January 2022 by setting up the task force member engaging relevant internal stakeholders from each domain as well as external stakeholders from relevant EU initiatives and projects.

So far, the TF3 has **43 members**, and there is the possibility to have future members in case the raised open points and actions by the TF would be relevant and interesting for other stakeholders, both internal and external. Table 4 provides a summary of experts who are a part of the Task Force 3 from QU4LITY and Manufacturing domain.

Table 4 experts who are a part of the Task Force 3 from QU4LITY and Manufacturing domain

Name Surname	Organization	Role
Gabriella Monteleone	POLIMI	TF3 Coordinator
Sergio Gusmeroli	POLIMI	TF3 Supervisor
Angelo Marguglio	ENG	WP8 Technical Coordinator
Riccardo Zanetti	ENG	WP8 Task Coordinator
Silvia Castellvi	IDSA	TF1 Manager
Carmen Polcaro	INNOVALIA	Manufacturing Ambassador
Ane Zuluaga	INNOVALIA	TF2 Coordinator
Oscar Lazaro	INNOVALIA	TF2 Supervisor

Luis Usatorre	TECNALIA	Manufacturing
Ingo Martens	HANSE AEROSPACE	Manufacturing
Olga Meyer	Fraunhofer IPA	Manufacturing
Usman Wajid	Information Catalyst	Manufacturing
João Sarraipa	UNINOVA	Manufacturing
Artem Nazarenko	UNINOVA	Manufacturing

The kick-off meeting of TF3 was organised on the 15th of February 2022. The KoM was merged with the first interactive workshop of the TF3 in order to accelerate the activities of the Task Force. The KoM was designed with a first part providing an overview of the OPEN DEI project, the aims and objectives of the Task Force, the technical objectives of the White Paper as well as an overview of relevant state-of-the-art on architectural elements and interoperability mechanisms. A second part providing an interactive session with MURAL exercises has been organized to stimulate the team to collaborate visually and brainstorm solutions to the technical challenges.

The workshops provided a concrete analysis related to the digital platforms in general and for the four main domains of Manufacturing, Energy, Agrifood and Health&Care from a technical perspective. As result, the outline of the paper has been established as a starting point for the second workshop of "White Paper co-design" where it 'has been refined.

The First section of the White Paper will provide a framework for alignment of common digital platforms considering:

- Reference architecture
- Interoperability
- Topics of interest for federated platforms
    - Digital twin integration
    - Semiotic approach
    - Trustworthiness
    - Resource management (Identity management and distributed agreement
    - Interoperability approaches (Ontology – Smart data models)

Further sections will provide insight on how to align domain platforms (energy, health and care, agrifood and manufacturing).

The structure and guidelines for the section related to Manufacturing domain are presented in Figure 27.

5 REFERENCE ARCHITECTURES AND INTEROPERABILITY FOR DIGITAL MANUFACTURING PLATFORMS

5.1 Context for Manufacturing

- *List important concepts*
- *List important architecture references*
- *List important applications and reference business cases*
- *List important standards (e.g., ISO 23247-1 Automation systems and integration - Digital twin framework for manufacturing)*
- *List important communities/initiatives*
- *List important documents/papers*

5.2 Reference Architectures for Manufacturing

- *Provide specific architecture artefacts*
  - *Entity of interests, stakeholders, concerns, viewpoints, views, model kinds, legends*
  - *Specific functional views*
- *List specific ecosystem views*
  - *Specific cross-cutting view (safety, security, resilience, reliability, …*
- *Mention*
  - *harmonisation of reference architecture models addressed by JWG 21_and IEC TR 63319 ED1: A meta-modelling analysis approach to smart manufacturing reference models (SMRM)*
  - *IDS RAM alignment with RAM 4.0I*
- *List existing work on digital twins (TC 184)*

5.3 Interoperability Frameworks for Manufacturing

- *List important communities/initiatives*
- *List important ontologies, data models, …*
- *Take into account*
  - *Interoperability pillar in Plattform Industrie 4.0 "Vision 2030" https://www.plattform-i40.de/IP/Navigation/EN/Industrie40/Vision/vision.html*
  - *Analyse interoperability from a RAMI perspective*

5.4 Aligning the Manufacturing domain for DEI

- *Take into account*
  - *IIC reference architecture*
  - *Work addressed by DMP Cluster on standards mapping, incl. also interoperability standards (https://www.efpf.org/event/DMP-Cluster-Meeting)*
  - *Zero-defects related aspects, including application of AI/ML in quality control*
  - *RA Manufacturing Process Industry (SPIRE) (6) projects: COGNITWIN, CAPRI, FACTLOG, COGNIPLANT, HYPERCOG, INEVITABLE (paper) (Arne J. Berre)*
  - *https://www.researchgate.net/publication/275211047_Digital_Twin_Manufacturing_Excellence_through_Virtual_Factory_Replicatio*
  - *https://storage-iecetech-prd-iec-ch.s3.eu-west-1.amazonaws.com/2020-05/etech_2019-06.pdf*
  - *https://www.researchgate.net/publication/331233156_Digital_twin_based_synchronised_control_and_simulation_of_the_industrial_robotic_cell_using_virtual_reality*

Figure 27 Reference architecture and interoperability for digital manufacturing platforms

The white paper is expected to be finalised by the end of April of 2022. The first version of the White Paper will be disseminated among the OPEN DEI projects and communities to collect feedbacks and practical experiences and we will consolidate the contents in a final version by the end of September

6 Community Building results: the Manufacturing and Digital Associations (Action6 and Action7)

This chapter elucidates the updates regarding the Digital Factory Alliance with respect to the D9.7

ACTION6. QU4LITY needs to contribute to **Manufacturing PPPs and Associations** in order to meet the needs of European manufacturing industry and to bridge H2020 towards Made in Europe Partnership. In the EFFRA working group, QU4LITY home is obviously the **4ZDM cluster**. Particular attention will be given to cluster with DT-FOF-11 new projects which address quite similar challenges but from the DG RTD perspective and in the view of the Made in Europe partnership. **EIT Manufacturing** is the ideal vehicle to bring to the market QU4LITY AQ solutions by EIT M Innovation Activities and to materialise intensive Capacity Building programs by EIT M Education Activities. The six Innovation Actions in the **SPIRE-06** call open up new dissemination and exploitation opportunities for QU4LITY towards the process industry, where AQ topics and cognitive solutions to achieve that goal are of paramount importance, due to the huge investments and continuous production cycles of SPIRE. Finally, embedded and smart systems for Autonomous Quality are also essential for **ECSEL JU** initiative, the Industry4.E CSA and the Productive4.0 lighthouse project.

ACTION7. QU4LITY needs to contribute to several initiatives in the domain of **Digital Technologies** in order to be able to adopt and uptake in manufacturing pilots (champions) the latest and most innovative Digital Technologies. **EIT DIGITAL** initiative and in particular its "Digital Industry" focus area has allowed QU4LITY innovations to meet investors and to consider the incubation and acceleration of innovative start-ups. Industrial IoT technologies are at the basis of many machine-oriented AQ applications and their evolution in **AIOTI** working groups needs to be carefully monitored. Big Data Technologies are at the basis of several AQ applications and need to be constantly updated (especially towards AI and cognitive capabilities) thanks to intense relations with **BDVA** and its working groups. Data Economy and Data Sharing Spaces are also fundamental enablers for Autonomous Quality, especially along the lifecycle of a product and along its full value chain. **IDSA** and Data Sovereignty are important reference concepts and architectures in order to build a Data Sharing Space for Autonomous Quality.

QU4LITY and the Digital Factory Alliance DFA

The Digital Factory Alliance

The Digital Factory Alliance (DFA) initiative was born under the EC QU4LITY project and enriched by the results of other relevant European projects. The aim is to modernize and digitalize the assets of the factories of the future (FoF), with the strong conviction that these actions will have a critical influence in the way these factories will be operated and managed in the years to come, by promoting the use of Artificial Intelligence Technologies and Data Intelligence to strive for Zero-X Manufacturing Environments. This initiative allows its members to get access to the most updated knowledge, trends and "ready-to-implement" products in the field and, at the same time, gain exposure to a growing Zero-X Manufacturing marketplace, with the added brand recognition and access to new business opportunities.

Founding members

The goal is to deliver a fast and intelligent response to manufacturing issues by using data-driven intelligence and digital systems integration, thus supporting the improvement of three key manufacturing capabilities: resilience, sustainability and efficiency.

The DFA will facilitate the creation and access to new market opportunities in Zero-X Manufacturing by integrating and exploiting results coming from solutions generated in related initiatives. In this scenario, the DFA is positioned to complement the efforts done in other initiatives such as:

- Public and Private Partnerships like BDVA (Big Data Value Association) and EFFRA (European Factories of the Future Research Association), whose role plays an important impact in the definition of needs and challenges from the digital and manufacturing points of view.
- A conglomerate of interconnected projects such as IDSA (International Data Space Association), FIWARE Foundation and GAIA-X, playing an important role in defining standards, interoperability, developing of open source-based solutions and providing operated and managed services.

The DFA will build upon these efforts, leveraging these results and adding value through a Zero-X Marketplace of validated digital-based and ready to implement solutions for manufacturing companies, in a user-friendly "search and implement" environment.

The DFA is grounded on four main pillars that encompass the whole spectrum of activities to be carried out in the initiative and the services to be offered (Figure 28).

Figure 28. DFA pillars

i. **Body Of Knowledge:** Search for knowledge. Expertise available in the community on topics of interest in digital manufacturing to support stakeholder activities and participation in the DFA network.
ii. **Innovation Campus:** Be part of a community. Get to know the open community of stakeholders involved in the field of Digital Manufacturing Innovation, build connections and partner with the DFA.
iii. **Flagship Initiatives:** Search for solutions. To find the products within the Zero-X Manufacturing environment that will improve the levels of Zero-X Autonomy in factories.
iv. **Business Network:** Search for business. To create new business opportunities within the Zero-X Manufacturing environment.

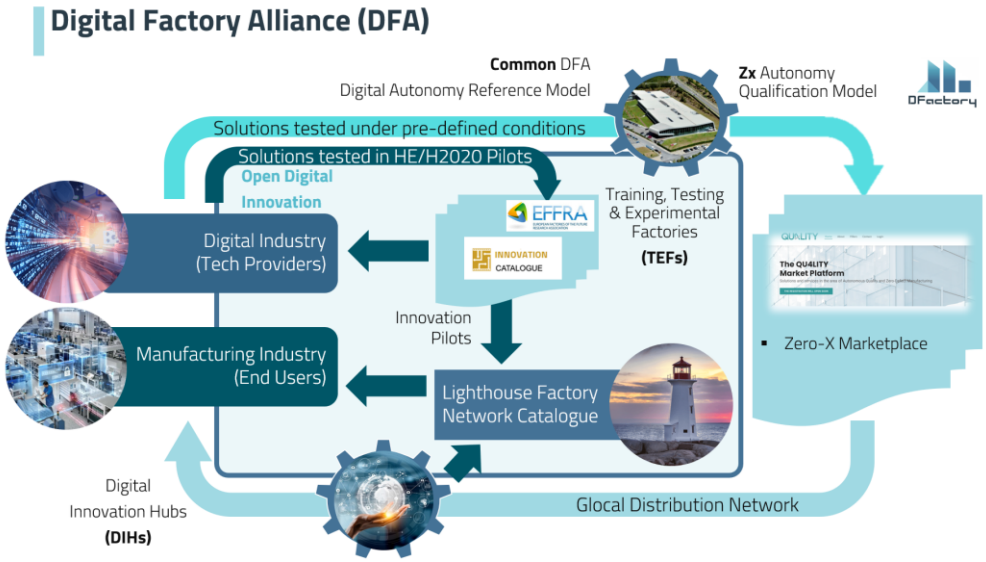


Figure 29. Main operating cycles within the DFA

Figure 29 shows the main operating cycles within the DFA. As it can be seen, there are two main loops of operation for achieving a Rapid Innovation Cycle for Zero X Manufacturing: Open Digital Innovation (internal loop – blue colour) and Market

Driven Innovation (external loop – green colour). In those loops, 4 key stakeholders can be tracked and identified: Technology Providers, End Users, Training, testing and Experimental Factories (TEF) and Digital Innovation Hubs (DIH).

QU4LITY Contribution to the Digital Factory Alliance

As mentioned before, the Digital Factory Alliance (DFA)[24] is a result from QU4LITY project. It is a trusted international community that aims to lead a digital transformation through the integration of AI digital technologies and Data driven Intelligence of Zero-X Manufacturing and it will base its success on the knowledge sharing and industrial collaboration.

QU4LITY have made available the Lighthouse Factory Network Catalogue[25] (see Figure 30), where the results from the pilots from the different projects are published in an easily understandable format so the manufacturing industry end users can have access to this information and understand if they can apply these solutions to their manufacturing equipment or processes.

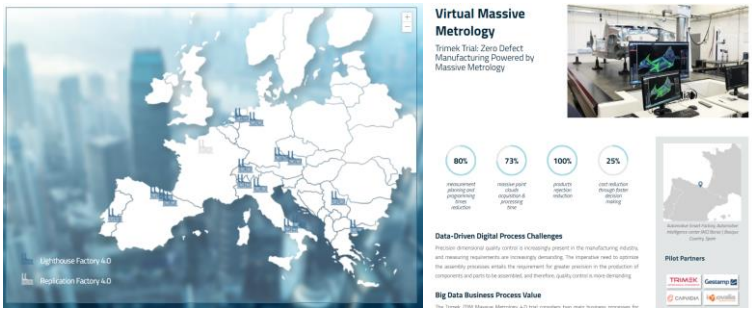


Figure 30. Lighthouse Factory Network Catalogue

The solutions developed in this framework, could become in standardised products after being certified by the DFA Training and experimental facilities, and afterwards included in the Zero - X Marketplace (see Figure 31). This is a set of certified and standardised digital solutions for a certain Autonomy level that can be easily deployed in the final manufacturing users via the digital innovation hubs that participate in the DFA.

[24] https://digitalfactoryalliance.eu/

[25] https://digitalfactoryalliance.eu/lighthouse-digital-factory-network/

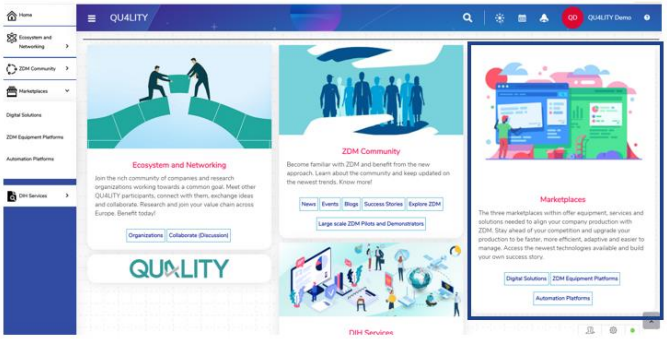


Figure 31. Zero X-Marketplace

7 Community Building results: National and Regional Initiatives (Action8)

QU4LITY is also quite well linked to Regional and National initiatives in the domain of ZDM and Industry 4.0 more in general"

This chapter elucidates the new contributions, with respect to the D9.7, regarding the different regional and national initiatives.

ACTION8 QU4LITY needs to contribute to **National and Regional** initiatives in the domain of Industry 4.0. In particular, a bi-directional win-win liaison between QU4LITY and I4.0 local initiatives needs to be established and nurtured. As a pre-condition, QU4LITY should become the lighthouse action of ZDM and AQ initiatives in Europe thanks to its relations explained in the rest of this D9.7 document. Afterwards, through QU4LITY and its Marketplace, EU-level assets and solutions could find a local National / Regional dissemination and exploitation channel in this ACTION8, dramatically improving the potential impact of EU-level ZDM solutions. On the other side, very innovative companies developing and providing advanced ZDM solutions and at the moment stuck at their local territorial level, could achieve a pan-EU stage and marketplace through QU4LITY and ACTION8. Finally, in all the Countries mentioned in section 5, QU4LITY beneficiaries will organise joint events with National / Regional initiatives and contribute to the QU4LITY impact creation.0.

ITALY

POLIMI presented QU4LITY project to MADE Competence Center, which is one of the 8 Italian Competence Centers acknowledged by Italian Plan 4.0. Competence Center are public-private partnerships whose task is to foster digital and green transformation of Italian industry and support in the implementation of innovation with industrial R&D projects following Test Before Invest principle. It aims at the realization, by companies and in particular SMEs, new products, processes or services (or their improvement) through advanced technologies in the Industry 4.0 field.

MADE is also officially acknowledged as Digital Innovation Hub by European Union (JRC catalogue) and it is leading European Digital Innovation Hub Lombardia (EDIH Lombardia) consortium. European Digital Innovation Hubs (EDIHs), as indicated in Digital Europe programme, will serve as access points for the latest digital capacities, including AI acting as single-entry points in accessing tested and validated technologies, providing support in the area of advanced digital skills thus helping companies improve business/production processes, products, or services using digital technologies. The network of European Digital Innovation Hubs should ensure broad geographical coverage across Europe, for this purpose EDIH Lombardia is leading EDIH Manufacturing Network (EDIH4Manu), a network of 25 EDIHs coming from the most competitive European Regions sharing manufacturing smart specialization strategy.

QU4LITY involved MADE in Open dialogue 6 (The role of DIHs in the Digital Migration of Manufacturing SMEs), to explain the role of EDIH and DIH to support digital transition of European SMEs. In particular, thanks to the intervention of DIGIHALL (Ile de France) and DIH Basque (Basque Region), the information day illustrated the opportunities of EDIH cross regional cooperation.

GERMANY

Fraunhofer IAO presented QU4LITY and its intended results to the Allianz Industrie 4.0, a public alliance initiative in the state of Baden-Wuerttemberg, which is lead by the Mechanical Engineering Industry Association (VDMA) of Baden-Wuerttemberg. The discussion with the members was very fruitful, as they could be made aware of QU4LITY and the related zero-defect manufacturing (ZDM) issues and solutions – and even more could give input to advance the work and results of QU4LITY, at least what concerns Fraunhofer IAO. Furthermore, Fraunhofer IAO introduced QU4LITY and ZDM to the partners of its Future Engineering Network, where companies jointly research the product creation of the future, based on digitalization and directed towards sustainability. Also this link was very fruitful, as valuable information flew in both directions, resulting in mutual benefit. Furthermore, in talks at events on a regional and world-wide level, QU4LITY was introduced and feedback gathered, e.g. in the resource-efficiency congress of the state of Baden-Wurttemberg in front of around 60 live participants, and transmitted online, as well as at the Tencent Intelligent Manufacturing and Industrial Internet series of talks, for thousands of remote participants.

SPAIN

QU4LITY contributed to the regional initiative "Basque Digital Innovation Hub[26]" (see Figure 32) that aims to be part of the European Digital Innovation Hubs (first call opened on November 2021). This network is connected to actives and services from advance manufacturing, offering to the Basque Manufacturing Companies a strong infrastructure for the investigation, testing and validation of their processes and equipment.

Some of the partners from QU4LITY take part in this initiative. For example, AIC as an experimental facility, will be supporting the node coordinators in the execution of technical advisory board.

[26] https://basqueindustry.spri.eus/es/basque-digital-innovation-hub/

Figure 32.Basque Digital Innovation Hub (EDIH)

In addition, several equipment developed inside the QU4LITY project have been selected to be part of this initiative, such as the measurement machine with the M3 software from Innovalia Association inside the nodes of additive manufacturing and collaborative manufacturing (see Figure 33).

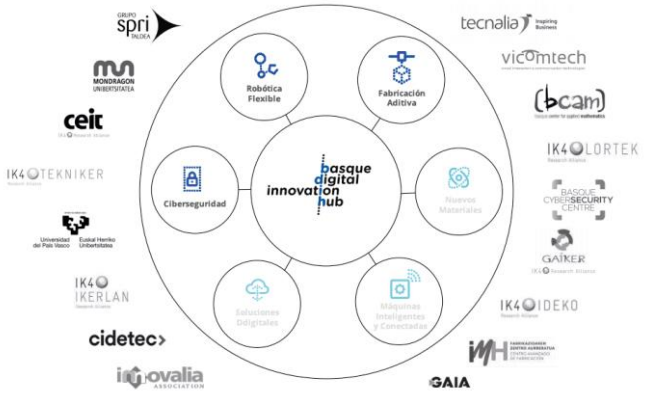


Figure 33. Basque Digital Innovation Hub (nodes)

FINLAND

VTT is an actor in **Sustainable Industry X (SIX)** initiative and Academy of Finland funded project **Sustainable Industry Ecosystem (SIE)**. Both have common aims to international networking, collaboration and could act as dissemination channels to various actors and stakeholders.

In Sustainable Industry X -SIX (https://www.six.fi/). The aim is to form a unifying renewal vision & agenda in Finland together with the industry, research, and public sector. As one implementing element, SIX helps actors to form industry-driven clusters that promote innovation and competence development around different topics. One of the clusters is ***SIX Smart Manufacturing***. Finnish manufacturing industry's strengths are discrete manufacturing and highly specialized one-off and small series production. The metal and machinery industry is strong and combined with digitalization in product development, leads the way in e.g. intelligent machine

building. Six Smart Manufacturing enables wider industry-based cooperation between different actors in the development of innovation and know-how.

SIX Manufacturing EDIH (EDIH national candidate). Sustainable Industry X (SIX) Manufacturing EDIH ensures the future competitiveness of manufacturing companies and maximum benefit of local, national, and European tools and know-how. As a service centre, SIX Manufacturing EDIH unifies development capabilities, infrastructures and services leading manufacturing SMEs forward on a digitalization path in an industry-driven way. Building on Sustainable Industry X (SIX) initiative, the EDIH has close collaboration links to different networks and ecosystems as well as agendas, projects and investment plans. The SIX Manufacturing EDIH network consists of Finland's most advanced manufacturing and digitization expertise, infrastructures, & ecosystems. SIX Manufacturing EDIH is an open platform, welcoming new collaborators, to make sustainable manufacturing the cornerstone of our wellbeing.

SIE - Sustainable Industry Ecosystem, 2021-2022, project funded by Academy of Finland (https://sites.tuni.fi/sie-en/). The main objectives of the SIE are to establish an open, self-organizing, online community to promote the national and regional scientific development for digitalization of Finnish industry. The SIE project also builds the SIX initiative. Following topics are identified as macroregional 'strongholds' of Finland: Robotics and Autonomy of systems, Green energy and Circular economy, Industry 4.0, IoT and AI development, Pilot lines and Future Research and education networks.

The SIE project explores new ways of utilizing research-based knowledge to support the macroregional collaboration by addressing specific challenges related to the SME based industry and promoting the benefits of the advanced ICT infrastructure, digitalisation, robotics and green design. The project will generate and strengthen smart cross-sectoral, and cross-regional partnerships involving universities, SMEs and a wide range of other stakeholders. The SIE project builds a community trust to overcome the gaps between companies regarding digital maturity. The SIE project targets also those entities such as regional stakeholders and ministries who consider the traditional project based partnerships challenging.

NORWAY

Activities in the ZDM Sub-group in Manufuture

SINTEF is leading the Sub-group in Manufuture together with the 4ZDM Group, which consist of partners from POLIMI, IDEKO and SINTEF. The group have been drivers for several webinars together with earlier and new ZDM Project. At the moment the activity is concentrated around building up a new webpage https://zdmanufuture.org/ for the ZDM Sub-group in Manufuture which will provide different common activities for the ongoing project from FOF-11-calls in Horizont 2020. Together with QU4LITY and ZDMP the Platform projects, the ZDM Projects OPTIMAI, I4Q, PENELOPE, DAT4ZERO and InterQ are making dissemination activities

together and exploiting this through the ZDM Sub-Group like webinars and activities together with EFFRA's CSA Connected Factories, IDSA on Dataspaces and DIN for Standardization.

Testing and Experimental Facilities in AI for

In a national program administered by The Industrial Development Corporation of Norway (SIVA) on behalf of the Norwegian Ministry of Trade, and in partnership with Innovation Norway and The Research Council of Norway. SINTEF is shareholder in a Catapult Center which assists companies in developing prototypes, offers expertise and equipment for testing, visualization and simulation to turn innovative ideas into new products and services in an effective manner at a lower risk. The Manufacturing Technology Catapult (MNTC) provide expertise, contacts and facilities in various technological areas, and can assist companies to access new markets and captivate interest from other potential business partners. The IP is always owned by the partner/customer without exception, but the knowledge the catapult centre gain will be used to further develop the services provided for present and future clients. MTNC has a range of industrial test equipment available and new investment projects are in pipe. One of the aims for SINTEF this year is to build a Digital Manufacturing Hub for testing AI in Manufacturing by use of cases from our ongoing Projects in SINTEF.

SLOVENIA

JSI coordinates Strategic Research and Innovation Partnership Factories of the Future (SRIP FoF), which gathers and connects Slovenian research and innovation knowledge and experience from the industrial and academic spheres in the field of key technologies relevant for the Factories of the Future. SRIP FoF creates and supports business and research synergies in the field of Factories of the Future for new products, services and technologies and helps companies enter the global market by focusing on niche areas where Slovenian companies can become an important European provider of such solutions. This is based on the synergy of outstanding academic knowledge in Slovenia and industry-led research.

SRIP FoF encourages continuous innovation and development in companies that achieve significant shares in the global market with their products. It supports the automation of production processes and the introduction of other key technologies established within the SRIP FoF, in order to enable fast and most efficient transition to Industry 4.0 in Slovenian manufacturing companies. The innovative use of key FoF technologies gives companies an additional competitive advantage. A special challenge and opportunity lies also in the development of demonstration capacities and pilot tests of new business models in the connection between public, state administration and industry (Slovenia as a reference country).

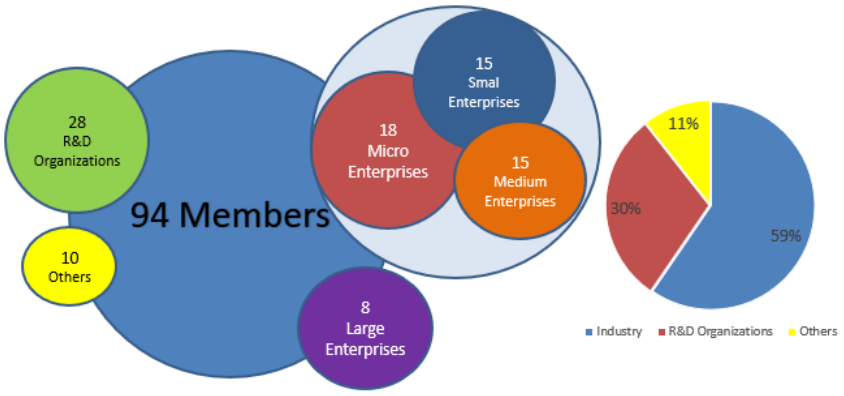


Figure 34 Membership of Slovene SRIP FoF

The following key value chains are supported by SRIP FoF: robotic systems and components, intelligent control systems for future factories, smart mechatronic tools, intelligent laser systems for factories and clinics of the future, smart plasma systems, advanced sensors, new materials and smart factories and six (6) horizontal networks (key enabling technologies): robotics, control technologies, nanotechnologies, photonics, plasma technologies, modern production technologies for materials.

SRIP FoF currently has 94 members, of which 56 are companies, 28 are representatives of research organizations and 10 other members. Approximately 74% of members are based in the western Slovenian region, and 26% in the eastern Slovenian region. Research organizations cover 80% of all Slovenian research capacities for key SRIP FoF technologies. 1,087 researchers are contributed by SRIP FoF development teams / departments.

A supportive environment of shared services with professional entities for members, coming from industry and research organizations has been established. These will meet future staffing challenges at both the entrepreneurial and academic levels and will ensure the rapid transfer of knowledge to industry and the introduction of new content into education systems. The supportive environment provides appropriate services to companies that are embarking on the path of transformation into the factories of the future, considering their level of development and the desired dynamics. This empowers companies to produce efficiently at home by introducing production processes that are capable of automatically changing, adapting and learning to achieve the required quality at an affordable price for competitive performance in the global economy.

The internationalization efforts of SRIP FoF include active involvement in the Vanguard initiative in the field of digitalization, smart factories and 3D printing. Within the S3 platform in the field of industrial modernization, we are assigned as a leading partner in the AI & HMI initiative and as a leading partner in SMEs' integration to Industry 4.0. We have established active membership in the focus groups EFFRA, SPIRE and WMF, where we actively represent the interests of Slovenian industry.

8 Community Building results: the first call of HEP Cluster 4 Destination I Twin Transition (Action9)

ACTION9. QU4LITY needs to contribute to the elaboration and planning of the 2021-2027 **Multiannual Financial Framework** of the European Commission in the domain of Industry 4.0. The **Made in Europe** Partnership includes several technical challenges which QU4LITY already addressed (see §6.1), in particular Zero-defect and zero-downtime high-precision manufacturing, Artificial intelligence for productive, excellent, robust and agile manufacturing chains, Zero-defect and zero-downtime high-precision manufacturing. The **AI, Data, Robotics Partnership** represents the ICT side of the AQ coin with its technical enablers to be deployed embedded, at the edge and in the cloud of Autonomous Quality systems.

QU4LITY and the Circular TwAIn project (TW TR 01 02)

The TW TR 2021 01 02 Topic "Zero-defect manufacturing towards zero-waste"

In the last decade the sensitivity of individuals, companies and Public Administrations on environment and climate change increased rapidly, leading investors and researchers to fund and develop solutions for Industries to reduce the waste of products, and mostly to revise the supply chain under a "green" feeling.

This echo translated into technological solutions mainly based on AI to assist manufacturers in routinary activities such as predictive maintenance, quality and waste management and generative product design. The limit of currently available solutions is their extent, aimed to solve specific issues are not considering a holistic approach. A fully digitalized chain, feeding a single data base would be eligible to support multiple use cases while guaranteeing the full knowledge of the history of each part, product and process. In other words, what is lacking now is an integrated solution that implements circular manufacturing process chains and end-to-end waste optimization strategies at plant and value chain levels.

Circular TwAIn is aimed to support, within a unique AI platform, manufacturing and process industry towards sustainable, eco-friendly and circular production. The key factor is a full integration among systems, reached through the usage of AI digital twins for each level (product/process/value chain) leading to the 'Circularity by-design'.

The two major outcomes of Circular TwAIn will be:

- Seamless data sharing Apps: data spaces with not only product-specific information, but also sustainability and waste data, will be fed in order to get accurate models and improve the overall product and production (life)cycle. Direct benefits will be a better orchestration of the supply chain, de-manufacturing and re-manufacturing optimization.

- Collaborative AI will be exploited by operators in daily activities: supervised algorithms will help humans in: (i) product/part recognition through machine vision; (ii) disassembly, given the knowledge provided by digital twins and models built within the data space; and (iii) production and shopfloor process optimization thanks to a continuous monitoring of operators (including machines and robot) and products/parts. Being the interaction between the operators and AI tools fundamental for the success of the project, keen on UI/UX will be crucial.

Project's demonstrators are spanning on different sectors (i.e. e-mobility, WEEE and petrol-chemical) linked, from a socio-economical perspective, by a strong interest in increasing the production sustainability, and, from a manufacturing viewpoint by an extreme accuracy needed to be successful and competitive in the market.

Demonstrators will showcase how digital twins and AI algorithms help in the optimization of sustainability aspects for their products, production lines and production processes, maximizing the performance across the circular value chain i.e. taking advantage of circular activities like remanufacturing, de-manufacturing and waste recycling, leading to a reduction of production waste. Along with highly specialized demonstrators, the Consortium is made by strong technological partners that will contribute with their expertise on AI industrial applications, enhancing and customising pre-existent assets under a holistic, interoperable approach, and with well-established relationship with international communities.

QU4LITY Contribution to the Digital TwAIn project

QU4LITY has specified and implemented a novel approach to quality management and Zero Defects Manufacturing (ZDM), namely an intelligent and Autonomous Quality (AQ) paradigm. The realization of this paradigm relies on the combination of a variety of predictive, preventive, and reactive control strategies, which are implemented at both the product and the process levels. The implementation of these strategies is based on cutting edge digital technologies such as cloud computing, Big Data, Industrial Internet of Things and Artificial Intelligence. QU4LITY introduces a novel approach to the implementation of quality management solutions based on the above-listed digital technologies. Specifically, it leverages a set of reusable digital components as building blocks of integrated solutions, which adhere to the structuring principles of the QU4LITY reference architecture. In the context of the QU4LITY project, the building blocks are conveniently called digital enablers. QU4LITY digital enablers span various technologies, including Big Data and Artificial Intelligence (AI) technologies. The latter are integral elements of most quality management and ZDM solutions, while the former are data intensive.

The above listed categories of digital enablers are combined and integrated in the scope of the QU4LITY pilots. Specifically, the IIoT platforms are used to facilitate on-line data collection and Big Data management in the pilots, while enabling the execution of ML enablers on top of them. The integration of the project's IIoT

platforms with the ML enablers in various pilots leads to a multiplicative benefit. Nevertheless, each of the listed enablers is also individually exploitable e.g., the presented ML enablers do not rely on a specific IIoT platform for their operation, but rather are usable over any infrastructures that can provide them proper industrial data for the training and the operation of ML algorithms.

The digital enablers developed and tested in QU4LITY will be further exploited in Circular TwAIn thanks to the presence of several partners in both the actions.

QU4LITY and the self s-X-AI4PI project (TW TR 01 07)

The TW TR 2021 01 07 Topic "Artificial Intelligence for sustainable, agile manufacturing"

The s-X-AIPI Project objective is to develop and experiment an innovative toolset of custom trustworthy self-X AI technologies, so autonomous AI that minimizes human involvement in the loop and exhibits self-improving capabilities. AI applications aim to help workers to deal with external and internal influences while enabling agile and resilient reaction for European process industry processes and products' lifecycle for a proficient integration into the circular manufacturing economy ecosystem.

The objective is to provide existing process industries and workers with the agility of operation, improvement of performance across different indicators, leveraging state of the art AI-based sustainability tools for the design, development, engineering, operation and monitoring of their plants, products and value chains. Particular care will be put for simplifying interfacing, without requiring highly skilled workforce, showing longer useful life and requiring less specialized maintenance, such as data labelling, training, validation.

For this process industry is even more challenging, given the complexity, instability and unpredictability of their processes and impact on their value chain. These solutions are usually running in harsh conditions, with dynamic changes in the values of process parameters, missing a consistent or at all monitoring/measurement of some parameters important for analysing process behaviour and difficult to measure in real time. For AI-based solutions, these can be more critical constraints, since AI requires a considerable amount of high-quality data to ensure the performance of the learning process in terms of precision and efficiency. Moreover, obtaining high quality data usually requires huge involvement of human experts in curating the data in a time-consuming process. And a supervised learning process requires labelling/classifying training samples by domain experts, which makes an AI solution not cost-effective. Thus, the Autonomic approach and self-X AI concept minimizes human involvement in the AI loop, generating relevant changes in the organization of the AI process/lifecycle.

The deployment and demonstration in the chosen industrial use cases (asphalt, steel, aluminium and pharmaceutics) will create a showcase portfolio of trustworthy AI technologies (data sets, AI model and applications), integrated into an innovative

open source toolset available for industry and research as an example of self-X AI technologies integrated in actual process industries' value chains.

s-X-AIPI toolset of AI technologies will include an innovative AI data pipeline with autonomic computing capabilities (self-X AI and autonomic manager), architecture, realistic datasets together with their respective algorithms derived from the demonstration in four realistic use cases of process industry.

s-X-AIPI technologies will consider workers' heterogeneous skill levels and self-adaptation capabilities to the actual profile of the worker respecting their human-in-the-loop role.

The Consortium has interdisciplinary abilities, spanning from AI integration and Big Data analytics, to use case process understanding, modelling and digital platforms, covering research, industry, SMEs, to address all communication, exploitation, standardisation, as well as all ground-breaking innovations.

QU4LITY Contribution to the self s-X-AIPI for PI project

For companies involved in discrete manufacturing processes or even in process industries it is still a challenge to enter the world of Industry 4.0, and more in the case of technologies such as Industrial IoT, Edge Computing, Big Data Analytics, Artificial Intelligence & Machine Learning, and Digital Twin. All of them provide infinite possibilities to improve factory processes thanks to an increase gained in the fields of either Intelligent Automation or Artificial Intelligence, or both of them:

- **Intelligent Automation**. This is an indicator of the ability by a machine or system to automatically perform a series of operations.
- **Artificial Intelligence**. This is an indicator of the consciousness that machines and systems have in their environment and the ability to improve the knowledge about the processes and products.

Currently there is a wide range of Industry 4.0 solutions companies may apply to boost the digitisation and servitisation. QU4LITY will serve as a starting point for s-X-AIPI implementations, relying on a wide set of digital solutions providing a comprehensive and holistic picture of how the vertical integration of the information across a manufacturing company would look like, and also provides an insight on how the digital thread would be like.

In this respect, QU4LITY enables traceable and interoperable Zero-Defect Manufacturing via the provision of Digital Services or Big Data-driven Manufacturing, and the Manufacturing Autonomy Level categorization for Autonomous Quality, which are, respectively, the two pillars of the QU4LITY Project. As part of digital transformation and the rise of technologies such as Big Data, Data Spaces and the Digital Twin, and tools such as the Digital Thread, which helps us keeping track of data all along the Product Value Chain, x-s-AIPI will explore and satisfy the need to find a way to provide a standardized and comprehensible representation not only of the information flow (from the Field to the common Data Lake or Data Space, then to the technical stakeholder who may provide some Data Analytics, for instance), but considering as well the integration of information vertically across the company

providing autonomic capabilities and self-healing characteristics based on the results already achieved in QU4LITY.

9 Conclusions and Future Outlook

This Deliverable D9.8 is the final edition of the QU4LITY Community Building Report, following the initial edition D9.7. In both deliverables, we have analysed different communities which are related to the scientific, technical and experimental impact of QU4LITY. A series of actions have been identified, highlighted in grey and have driven our community building activities throughout the whole duration of the project. The present D9.8 describes the concrete activities undertaken by the QU4LITY consortium to materialise the actions reported here below.

Contribution to Digital Transformation

ACTION1. **QU4LITY** needs to start effective collaborations with the "**Support to Hub**" Community on DT-ICT workprogramme. Three main axes have been considered and have brought significant SMEs audience to QU4LITY dissemination and communication campaign

1-i. The EDIH call in Digital Europe Program DEP has seen the participation of many QU4LITY beneficiaries transferring to their respective regional service portfolios methods, tools and platforms developed and experimented in QU4LITY. QU4LITY WP6 has been inspiring many consortia in the structuring of their service portfolio as our VDIH community.

1-ii. The DIH4Industry portal, under the supervision of the AI REGIO project (coordinated by POLIMI and with the active participation of other QU4LITY beneficiaries such as CEA, ENG, IMECH) is growing and growing, collecting D BEST services to support the Digital Transformation of SMEs. Behind such services, especially the Data, Skills and Technology ones, QU4LITY assets and Autonomous Quality resources are playing an important role.

1-iii. The AI REGIO Didactic Factories initiative has seen its KOM in September 2021 with the active participation of several QU4LITY VDIH presenting their facilities and their DR BEST services. In the Remotisation class, QU4LITY activities in Asset Administration Shell Data Models and in Digital Twins have been presented. The network is constantly growing and providing cross-DF collaboration opportunities.

1-iv. The AI TEF for Manufacturing call in Digital Europe Program is approaching with its structure in Nodes and Satellites. Many QU4LITY partners are currently engaged in the AI MATTERS proposal which have been presented in the infoday held on February 28th 2022.

ACTION2. **QU4LITY** needs to intensify its collaboration with the "**DMP Cluster**" Community in DT-ICT-07. Very strong relationship is already in place with **ZDMP** which has been funded under the same sub-topic. In particular, in the course of WG1 Standardisation, several actions are in place, like for instance the joint development of three CWAs (Terminology in Zero Defect Manufacturing, DMP Manufacturing

Marketplace Requirements and DMP Data Exchange), the joint participation to Plattform I4.0 Standardisation Council SCI4.0[27] meetings and to CEN/CENELEC/ETSI Smart Manufacturing Coordination Group SMaCG. With the other projects (especially **SHOP4CF**, **digiPRIME** and **KYKLOS4.0**), common activities have been implemented for WG7 WG2 and WG3 regarding Reference Architectures, as well as common Research and Dissemination activities. In particular, the Autonomous Quality concept has been discussed with digiPRIME (coordinated by POLIMI) and KYKLOS 4.0 from a Circular Economy perspective.

ACTION3. **QU4LITY** needs to contribute to the **ConnectedFactories Pathways** by bringing its experience in terms of autonomous quality solutions and pilot cases in the three scenarios of Smart Factory (Autonomous Factory pathway), Smart Value Chain (Hyper-connected Factory pathway) and Smart Product lifecycle (Collaborative Product-Service pathway). CF1 was born to support ICT-11 RIA projects but now need to evolve towards DT-ICT-07 and their new contributions. Specific AQ views to the three pathways (**zero defect manufacturing and autonomous quality** in our case) have been developed and relevant assets and cases inserted in the EFFRA Innovation Portal. What does it mean ZDM and AQ in the Factory, in the Value Chain and in the Product lifecycle management (including end-of-life)? The presence and impact of QU4LITY in CF pathways evolution and validation have been therefore materialised in the Portal, now that QU4LITY AQ solutions and industrial pilots are available and mature.

ACTION4. **QU4LITY** needs to contribute to the new pathways proposed by **ConnectedFactories2** CSA: Circular Economy and Data Spaces. VTT and POLIMI (QU4LITY beneficiaries) are leading the two pathways, so substantial contributions from QU4LITY have been provided not just in the validation (identifying industrial and technological cases to be mapped in the 2D space) but also in the development phase. Interviews to QU4LITY industrial stakeholders (from the demand and the supply side have been conducted and in particular a 1:1 meeting held on February 3rd 2022.

ACTION5. **QU4LITY** needs to contribute to **OPEN DEI Task Forces** in order to open-up new opportunities for dissemination and exploitation of its assets to other domains, e.g. **Agrifood** (tractors and other machineries for agriculture, regarding production, supply chain and product lifecycle), **Healthcare** (clinical and diagnostic equipment for health & care, regarding production, supply chain and product lifecycle), **Energy** (renewable energy systems value chain and smart home equipment manufacturing and lifecycle management). QU4LITY experts contributed

[27] https://www.sci40.de/english/

to the Manufacturing section of OPEN DEI white paper about "Design Principles for Data Spaces" in TF1, while TF3 (Reference Architectures Interoperability and Standards) just started and during the KOM (February 15th 2022) Olga Meyer from FhG and QU4LITY proposed a cross-domain collaboration originated by DMP Cluster WG1 about Standardisation

Contribution to Associations / PPPs

ACTION6. **QU4LITY** needs to contribute to **Manufacturing PPPs and Associations** in order to meet the needs of European manufacturing industry and to bridge H2020 towards Made in Europe Partnership. In the EFFRA working group, QU4LITY home has been obviously the **4ZDM cluster**. Particular attention has been given to cluster with DT-FOF-11 new projects which address quite similar challenges but from the DG RTD perspective and in the view of the Made in Europe partnership. **EIT Manufacturing** is the ideal vehicle to bring to the market QU4LITY AQ solutions by EIT M Innovation Activities and to materialise intensive Capacity Building programs by EIT M Education Activities like in the AI.SOV EITM KAVA21 Innovation Activity, where AQ" solutions have been couples with Data Spaces. The six Innovation Actions in the **SPIRE-06** call open up new dissemination and exploitation opportunities for QU4LITY towards the process industry, where AQ topics and cognitive solutions to achieve that goal are of paramount importance, due to the huge investments and continuous production cycles of SPIRE. The SPIRE-06 is organising periodical meetings where Discrete Manufacturing projects are also invited. In particular, the presence of POLIMI and ENG in the CAPRI project facilitated the dissemination of AQ concepts to Process Industry. Moreover, embedded and smart systems for Autonomous Quality are also essential for **ECSEL JU** initiative, the Industry4.E CSA and the Productive4.0 lighthouse project. Finally, QU4LITY will exploit the **DFA**, an international initiative which bases its success on the knowledge sharing and industrial collaboration, to boost the integration of AI digital technologies and Data driven Intelligence of Zero-X Manufacturing.

ACTION7. **QU4LITY** needs to contribute to several initiatives in the domain of **Digital Technologies** in order to be able to adopt and uptake in manufacturing pilots (champions) the latest and most innovative Digital Technologies. **EIT DIGITAL** initiative and in particular its "Digital Industry" focus area has allowed QU4LITY innovations to meet investors and to consider the incubation and acceleration of innovative start-ups. Industrial IoT technologies are at the basis of many machine-oriented AQ applications and their evolution in **AIOTI** working groups has been carefully monitored such as the joint event on February 8th. In the coming IOT WEEK in Dublin, the Manufacturing day on June 22nd will see

the active participation of several QU4LITY beneficiaries and cases. Big Data Technologies are at the basis of several AQ applications and need to be constantly updated (especially towards AI and cognitive capabilities) thanks to intense relations with **BDVA** and its working groups. The coming Data Week at the end of May 2022 will be a good opportunity to disseminate QU4LITY outcomes to the data / AI communities. Data Economy and Data Sharing Spaces are also fundamental enablers for Autonomous Quality, especially along the lifecycle of a product and along its full value chain. **IDSA** and Data Sovereignty are important reference concepts and architectures in order to build a Data Sharing Space for Autonomous Quality. The scenario Number 1 of the DS for Manufacturing call in DEP is fully compliant with the AQ concept of QU4LITY. Furthermore, as mentioned in ACTION6, QU4LITY will rely on the **DFA**, initiative born under the EC QU4LITY project and enriched by the results of other relevant European projects. In particular, QU4LITY have made available the Lighthouse Factory Network Catalogue reporting the results from different projects pilots.

Contribution to Local I4.0 initiatives

ACTION8. **QU4LITY** needs to contribute to **National and Regional** initiatives in the domain of Industry 4.0. In particular, a bi-directional win-win liaison between QU4LITY and I4.0 local initiatives has been established and nurtured. QU4LITY and its Marketplace, EU-level assets and solutions have found a local National / Regional dissemination and exploitation channel in this ACTION8, dramatically improving the potential impact of EU-level ZDM solutions. On the other side, very innovative companies developing and providing advanced ZDM solutions and at the moment stuck at their local territorial level, could achieve a pan-EU stage and marketplace through QU4LITY and ACTION8. Finally, in all the Countries mentioned in section 7, QU4LITY beneficiaries have organised joint events with National / Regional initiatives and contributed to the QU4LITY impact creation.

Contribution to EC 2021-2027 MFF

ACTION9. **QU4LITY** needs to contribute to the elaboration and planning of the 2021-2027 **Multiannual Financial Framework** of the European Commission in the domain of Industry 4.0. The **Made in Europe** Partnership includes several technical challenges which QU4LITY already addressed, in particular Zero-defect and zero-downtime high-precision manufacturing, Artificial intelligence for productive, excellent, robust and agile manufacturing chains, Zero-defect and zero-downtime high-precision manufacturing. Two examples of HEP MiE projects funded recently and inspired by QU4LITY have been presented. The **AI, Data, Robotics Partnership** represents the ICT side of the AQ coin with its

technical enablers to be deployed embedded, at the edge and in the cloud of Autonomous Quality systems. Joint collaborations with technology driven project have been developed and brought to the recent selection of ADRA projects with a consistent participation of QU4LITY assets and solutions.

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AI - Artificial Intelligence
AQ – Autonomous Quality
AR – Augmented Reality
BDVA - Big Data Value Association
CAGR - Compound Annual Growth Rate
CAP - Cognitive Automation Platform
CC - Competence Center
CEN - Comité européen de normalisation
CF - Connected Factory
CM - Circular Manufacturing
CPPS - Cyber Physical Production Systems
CPS – Cyber Physical System
CRM - Customer Relationship Managment
CSA - Coordination and Support Action
DG RTD European Commission Directorate-General for Research and Innovation
DIH – Digital Innovation Hub
DMP - Digital Manufacturing Platform
DSM - Digital Single Market
DT - Digital Transformation
EC – European Commission
EFFRA - European factories of the Future Research Association
EIT - European Institute of Innovation & Technology
EITM - Environmental Information Technology Management
EQ – Emotional Quotient
ERP - Enterprise Resource Planning
ESM - Efficient and Sustainable Manufacturing
GDPR - General Data Protection Regulation
IA - Innovation Action
ICPS – Industrial Cyber Physical System
ICT – Information and Communication Technologies
IDC - International Data Corporation
IDSA - International Data Space Association
IEC – International Electrotechnical Commission
IIoT - Industrial Internet of Things
IoT - Internet of Things
IPCEI - Important Projects of Common European Interest
IPR – Intellectual Property Rights
KIC - Knowledge and Innovation Community
KOM - Kick Off Meeting
MES - Manufacturing Execution System
MFF - Multiannual Financial Framework
MIDIH - Manufacturing Industry Digital Innovation Hubs
MOM - Manufacturing Operations Management
MOOCs - Massive open online courses
MSM – Multi-sided Marketplace
MSME – Micro, Small or Medium Enterprise

OC - Open Call
PLC – Programmable Logic Controller
PLM - Product Lifecycle System
PPP - Public Private Partnership
PQP - Product Quality Prediction
RA – Reference Architecture
RAF - Reference Architecture Framework
RFID - Radio-frequency identification
RIA - Research Innovation Action
RIS - Regional Innovation Scheme
SAE – Smart Anything Everywhere
SIG - Special Interest Groups
SMACC - Smart Machines and Manufacturing Competence Centre
SME – Small or Medium Enterprise
SMI - Smart Manufacturing Industry
SRIDA - Strategic Reasearch, Innovation and Deployment Agenda
SSO - Single Sign-On
TT – Technology Transfer
VR – Virtual Reality
WG - Working Group
ZDM – Zero Defect Manufacturing

Partners:


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Atos
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