AI Platform for Integrated Sustainable and Circular Manufacturing

Deliverable

D7.5 Innovation and Collaboration Marketplace - 1st version

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Definitions and acronyms

AI	*Artificial Intelligence*
AIM-NET	*Artificial Intelligence in Manufacturing Network*
AIoD	*Artificial Intelligence on Demand*
BDVA	*Big Data Value Association*
CMS	*Content Management System*
CSA	*Coordination and Support Action*
DFA	*Digital Factory Alliance*
DIH	*Digital Innovation Hub*
DoA	*Description of Action*
DPP	*Digital Product Passport*
DSBA	*Data Spaces Business Alliance*
DSSC	*Data Spaces Support Centre*
DT	*Digital Twins*
DYMER	*DYnamic information ModElling & Rendering*
EC	*European Commission*
EU	*European Union*
GA	*Grant Agreement*
ICT	*Information and Communication Technologies*
IDS	*International Data Space*
IDSA	*International Data Space Association*
IoT	*Internet of Things*
I4MS	*Innovation for Manufacturing SMEs*
P&R	*Plug and Respond*
RAM	*Reference Architecture Model*
R&D	*Research and Development*
SAE	*Smart and Embedded Systems*
SME	*Small and Medium Enterprise*
SPoK	*Single Point of Knowledge'*
TEFs	*Training, Testing and Experimental Factories*
ToC	*Table of Contents*
WEEE	*Waste Electrical and Electronic Equipment recycling*
WP	*Work Package*

Disclaimer

Executive Summary

To disseminate and exploit the Project and its results, and to create awareness on the newest technologies spreading over the usual "EU channels" and stakeholders, the Consortium is committed to create a marketplace to promote collaboration (among different stakeholders in circular value chains, and across different roles/expertise) and innovation (reporting on pioneering experiments and creating new opportunities for digital transformation).

Moreover, to reach a wider audience than the one strictly linked with Project Partners, Circular TwAIn coordination team and consortium decided to join an already established community, the Digital Factory Alliance (DFA) through a new initiative to be launched named as "*AI for Sustainable and Circular Manufacturing*", with the intention to extend Circular TwAIn innovation and collaboration ecosystem also to other projects addressing the common challenge of how AI technologies could support Manufacturing Industries in their twin transition towards circular value networks. The final aim of the new DFA initiative is twofold: on the one side to join forces on the technological side of AI, keeping solid links to the AI on Demand (AIoD) platform and the existing "AI for Manufacturing" cluster and AIM NET initiative, on the other side to collect a critical mass of experiments and industrial pilots in the circular manufacturing domain, so that to share lessons learned, identify criteria of success, stimulate innovation and collaboration initiatives among sectors and domains and derive recommendations for future initiatives.

The impact of the Circular TwAIn Marketplace is expected to be maximised leveraging an already established Community (the DFA), by introducing also other projects results in the concerning domain and providing to existent and new stakeholders a unique pool to gather news, reports and advices on the latest results in AI for Sustainable and Circular Manufacturing.

The main outcomes of the first period of task T7.6 Innovation and Collaboration Marketplace are:

- **Concept definition** - Through the partnership between Circular TwAIn and the DFA a Community of stakeholders will be created, to discuss on Project's relevant topics (AI, Data Spaces, Digital Twins, Digital Product Passport, Sustainability and Circularity). Project's results and success stories will be promoted by organizing events.
- **Positioning** – Among the Circular TwAIn technological topics, after analysing other projects and initiatives the selected subject for our new initiative is on "*AI for Sustainable and Circular Manufacturing*", exploiting a commonly recognized technology (AI) to investigate and improve sustainability and circularity in Manufacturing sector.
- **Action list** – A three years action plan has been defined: during the first year preparatory activities have been conducted (e.g., competitors analysis, strategy, concept and technical approach definition), during the second year the Marketplace will be launched as part of the Project website and the initiative will be kicked off. Other initiatives and projects of interest will be contacted to find synergies and explore possible joint activities.

- **Marketplace development and nurturing** – The strategy is to make accessible all relevant information on the "*AI for Sustainable and Circular Manufacturing" in a single access point* (Single Point of Knowledge - SPoK approach), by using the DFA website as reference and linking to it projects websites/marketplaces and other remarkable initiatives (e.g., IoT Catalogue or EFFRA Innovation Portal). The DYMER platform (provided by Engineering) will be employed as Content Management System (CMS) to orchestrate the contents on the DFA website.

1 Introduction

A *collaborative marketplace* in the digital manufacturing domain can be represented by an ecosystem platform (usually coming the form of an online portal) that brings technology providers, and end users (i.e., manufacturing companies, Digital Innovation Hubs - DIHs and Didactic Factories) together to discover, collaborate, purchase, create partnerships and doing business together more efficiently, combining different innovations to digital transform manufacturing businesses.

Online marketplaces combine the power of search and directories for discovery phases with tailored industry - or application-specific categories, unique tools for collaboration and messaging, repositories to share relevant documents and sections dedicated to open synergic discussion.

The strength of online digital manufacturing-focused marketplaces lays on the fact they naturally attract stakeholders from all over the world fostering the concept of collaboration and increasing the visibility of the solutions/services offered, paving the way to match supply and offer in a cooperating environment with stakeholders with different backgrounds. Thus, a collaborative platform is an opportunity for developing new business relationships.

1.1 Scope of the document

The document serves at reporting the activities of task *T7.6, Innovation and Collaboration Marketplace*. During the initial phase the focus has been on the understanding of the most proficient route towards the achievements of task's objectives. The scope of the Circular TwAIn Innovation and Collaboration Marketplace is to create awareness over Project's technical solutions and results, engage and support stakeholders beyond the Consortium, building a solid environment to "*rise to a new community and network aiming at defining, structuring, retaining and sharing knowledge and experiences around the two main dimensions of Circularity of Digital Twin and Sustainability"*[1].

The deliverable, from the Grant Agreement (GA), is of type OTHER, i.e., it is materialised by implementation results, nevertheless for this first iteration (the deliverable will have a follow up at M36 with its 2nd and final version) the activities were focused on the definition of the strategy to maximize Project's results and on the definition of a short- and long-term action plan.

1.2 Document Structure

Apart from the Introduction and the Conclusions and Future Outlook, the document is made by three main sections:

- Section 2 lists and describes some active marketplaces and initiatives considered relevant for the issues behind Circular TwAIn. Furthermore, it investigates around constraints and barriers for the success of a marketplace in the domains of interest for the Project. The outcomes of this analysis served as lesson learnt to establish the actual approach of "*AI for Sustainable and Circular Manufacturing*".

[1] *From task description on GA.*

- Section 3 describes the approach followed in the Project reporting on the activities (performed and planned for the next period) to design the Circular TwAIn Innovation and Collaboration Marketplace.
- Section 4 presents how the Circular TwAIn Innovation and Collaboration Marketplace will be implemented.

2 Build a collaborative marketplace, the challenges

The section presents some relevant initiatives at national and EU level that have been evaluated as competitors or that can be inspiring for the Circular TwAIn Marketplace (Section 2.1). Aligned with Project results, the segment of existing marketplaces/initiatives analysed covers the following topics, both technological and vertical:

- Artificial Intelligence
- Data Spaces
- Smart Manufacturing
- Circularity

Through such analysis, weaknesses, opportunities and major points of interest have been evidenced and summarized in Section 2.2.

2.1 Digital manufacturing marketplaces and relevant initiatives

Hereinafter the major marketplaces, projects and initiatives relevant for Circular TwAIn, i.e., involving the four topics identified (namely AI, Data Spaces, Smart Manufacturing and Circularity) are presented in order to build a common understanding about the current innovation scenario where Circular TwAIn is trying to contribute with the outcomes described in this report.

2.1.1 Initiatives on AI in Manufacturing

This first category groups the initiatives and marketplaces already established and with a solid base of stakeholders related to Artificial Intelligence applied to Smart Manufacturing. Probably this is the strongest community, but still lacking solid and common sustainability vehicle; this is among the first intended contribution Circular TwAIn will provide.

AIoD

AI on Demand, knowledge and services for AI community, is an open platform that fosters collaboration, reproducibility and experimentation, while maximising academic, social and industrial impact. The intended audience spans from technology providers and researchers to DIHs and SMEs. The offering of AIoD includes a platform for experiments (with predefined models and building blocks), an AI asset catalogue (that includes AI libraries, datasets, containers in use within the platform) and research bundles (to collect and publish projects results in a unique environment), while other services are on the roadmap (among the others particular relevance is on the *Matchmaking* service for connecting businesses, AI experts & hardware providers & exploring AI in different languages).

AI4manufacturing

It was created by the EU ICT-38 project cluster and it is open to all projects that want to participate. Among the participating projects, some have already been discussed in Circular TwAIn Consortium (and in some cases summarized in other deliverables) as projects of interest for the technical approach adopted, including XMANAI, KITT4SME, COALA, AUTO-

TWIN, STAR. AI4manufacturing is a community hub that promotes AI and manufacturing through the example of the participating projects, by publishing on the website news, articles and publications, and promoting events and webinars.

AIM-NET

Artificial Intelligence in Manufacturing NETwork is a collaborative network of industries, research centres and universities that aims to promote the adoption of AI in the Manufacturing sector: the most powerful of the network lays in the fact that AI end-users (i.e., industries) are well represented in the community and can provide their business vision and use cases to feed the discussion with real challenges and barriers. The initiative has already organized an event and a conference (that will take place in September) and has published a white paper[2] on the viewpoint of AIM-NET on the achievements and challenges of AI solutions with a target audience of policy makers, practitioners, and researchers.

AI Marketplace

German initiative to connect manufacturing companies and AI expert to work together on AI applications for product creation. The AI Marketplace provides a Data Space for development and test data to work collaboratively on the proposed business cases, and standardized AI building blocks to be easily adapted to the product needs. The initiative is supported by around 20 German technology providers, limiting the AI Marketplace (at least at the moment) to the German market, and lacking industry partners.

Bonseyes

It is an AI marketplace, an open platform for the development of systems of AI from cloud to edge devices, built as a result of the homonym H2020 EU-funded Project. The consortium is made up of academia, associations, industries and SMEs from all over Europe. The focus of the Project was on the design of an open architecture to enable an eco-system of companies to collaborate in building complex distributed AI powered systems, shifting from a cloud approach to an edge model. Supported by a marketplace and an open AI platform, even not expert technical users with the support of technology providers and academics can access AI as a service solution. After the end of Bonseyes (2020) the website has not been maintained anymore.

DIH4INDUSTRY

DIH4INDUSTRY is a portal built in close collaboration with the European Commission Digital Innovation Hubs tool, that aims at creating, nurturing and governing an Ecosystem of Digital Innovation Hubs with a regional Smart Specialisation in Manufacturing. DIH4INDUSTRY is a single access point for DIH practitioners and policy makers to identify which EC DIHs are active in the Manufacturing domain, where they are located, which experiments they are

[2] https://www.aim-net.eu/wp-content/uploads/2023/05/AIM-NET-Artificial-Intelligence-in-Manufacturing-white-paper.pdf

supporting and, last but not least, which services they are providing for the Digital Transformation of EU Manufacturing Industry. It offers services from 7 domains: Innovation for Manufacturing SMEs (I4MS), Smart and Embedded Systems (SAE), Robotics, Data, Industrial IoT, AI, Process Industry).

2.1.2 Initiatives on Data Spaces

Under this section, the initiatives born to promote the adoption of Data Spaces are described, while some of them are more focusing on the technical perspective (e.g., the Data Space Business Alliance - DSBA), some other seem to be more oriented towards the business models enabled by the adoption of a Data Space (e.g., Data Space 4.0 - DS4.0).

International Data Space Association (IDSA)

The International Data Space Association counts more than 140 member companies and through the organization of events, the publication of white papers[3], position papers[4] and mostly technical achievements like the IDS-RAM (Reference Architecture Model) aims at defining a global standard for International Data Spaces (IDS) and interfaces, as well as fostering the related technologies and business models that will drive the data economy of the future across industries.

Gaia-X

Gaia-X is an international association with the ambition to define the next generation of a data infrastructure for Europe and promote the digital sovereignty of European users of cloud services. It is based on the European values of transparency, openness, data protection and security. There are more than 1800 contributors and 350 (including around a 40% of SMEs) members in Gaia-X.

Data Spaces Business Alliance (DSBA)

The DSBA Initiative has been launched in September 2021, by the Big Data Value Association (BDVA), FIWARE, Gaia-X and IDSA with the objective to accelerate business transformation in the data economy. The three pillars of the DSBA are:

- One voice and a common framework based on existing architectures and models, leveraging each other's effort on infrastructure and implementations to make Data Spaces happen;
- Sharing the expertise, bringing together data providers, users and intermediaries, Data Spaces are key to driving businesses to competitively extract value out of data;
- Pooling the members, counting more than 1000 key industry players, research organizations, innovators and policy makers worldwide. The DSBA Hubs (at the time

[3] https://internationaldataspaces.org/publications/white-papers/
[4] https://internationaldataspaces.org/publications/position-papers/

this deliverable has been written) are more than 90 in over 34 countries, and represent the perfect environment to reach SMEs and diverse domains, to build on top of various use cases hence, to play with different requirements.

The DSBA has published two white papers (Technical convergence, v1 – September 2022 and v2 – April 2023) to portray the actual status of the discussion towards a common reference technology framework, to achieve interoperability and portability of solutions across Data Spaces, by harmonizing technology components and other elements.

Data Spaces Support Centre (DSSC)

The DSSC is a community funded by the European Commission as part of the Digital Europe Program to promote and support the adoption of a common Data Space. By exploring the needs of Data Space initiatives, DSSC aims at defining common requirements and establish best practices to accelerate the formation of a data sovereign, interoperable and trustworthy data sharing environment, to enable data reuse within and across sectors to boost digital transformation in all areas. Other sub-objectives of the DSSC include:

- Increase the general understanding of Data Spaces;
- Provide advice to stakeholders on how to set up a Data Space;
- Create a network of stakeholders (even known as Community of Practice) that comprehends both end-users and technological providers.

Data Space 4.0 (DS4.0)

Data Space 4.0 (DS4.0) is an Industry 4.0 community with the objective to create a unified voice and a shared pathway and governance model for scale-up of cross-sectorial Data Spaces for manufacturing. It is recently born, and its results will be boosted through a collaboration with the Digital Factory Alliance (DFA)[5]. The DS4.0 outcomes will be among the others, a Multi-stakeholder Governance Model for Data Spaces for Manufacturing, a Data Space 4.0 Canvas of design strategies and business modelling, a Directory of existing manufacturing DS assets, toolkits and blueprints, a set of Smart Data models and a roadmap towards the deployment of a pan-EU DS for manufacturing.

Manufacturing-X

Manufacturing-X is part of the German Industrie 4.0 initiative (promotion of the digitalization of the industries through the Plattform Industrie 4.0) and collects the Industrie 4.0 segment of stakeholders that in the landscape of digitalization in manufacturing are interested on the implementation of the Data Space Industrie 4.0. In a nutshell, Manufacturing-X supports the creation of trustworthy data ecosystems based on open standards also to align with the sustainability goals settled by the EC.

[5] http://www.digitalfactoryalliance.eu/

2.1.3 Initiatives in Circular Manufacturing

This section groups some projects notable for their positioning over Circular Economy strategies in Manufacturing. Each of them, through a set of innovative technologies deals with the ambition to improve (some of) the R-cycles (Reduce, Reuse, Remanufacture, Recycle and Recover). Given the short timing from the beginning of these projects to the time this deliverable is written for none of the following projects there are significant results in terms of demonstration.

CIRPASS

CIRPASS is a CSA funded by the European Commission started in October 2022 with the ambition to define a domain agnostic approach to the Digital Product Passport (DPP) and prove its value in a Circular Economy landscape. To enforce the concept of 'domain agnostic', within the Consortium there are no manufacturers, while the stakeholder community built in less than a year counts for hundreds of registered stakeholders (mostly in the textiles, electronics and battery sectors).

AIDEAS

AIDEAS is an EU Project that has been funded under the same topic of Circular TwAIn (i.e., focus on AI), it aims at developing AI technologies for supporting the entire life cycle of industrial equipment (design, manufacturing, use and repair/reuse/recycle) to improve sustainability, agility and resilience of the European machinery manufacturing companies (application to circular scenarios). Given the similarities among the two projects, a cooperation from a communication and dissemination perspective has already been established.

DaCapo

DaCapo is a Horizon Europe Project of the HORIZON-CL4-2022-TWIN-TRANSITION-01 call, started in January 2023. Da Capo aims at improving the adoption of Circular Economy strategies along both manufacturing value chains and products lifecycles (design and engineering, manufacturing, use phase and End of Life) through the application of AI-based systems and process and product Digital Twins. The backbone of the Project will be a new methodological approach supporting decision-making, considering business models, material flows and circular strategies along the manufacturing value chains.

AUTO-TWIN

It is a Horizon Europe Project kicked off in January 2023. Its focus is the creation of automated Digital Twins to enable decision making across different stakeholders in the circular value chain.

CIRC-UITS

Circ-uits started in January 2023, its scope is the development of digital solutions for the design, manufacture and management of electronic components and end-of-life products with the objective to improve sustainability through the application of circular models.

CircThread

CircThread is an H2020 Project with the objective to increase the awareness of products, components and materials along the manufacturing chain (Digital Product Passport), enabling the stakeholders to make decisions at all stages to shift to a circular economy. The main technical outcome will be an open-source software platform that allows data exchange across the extended product life cycle.

2.2 Challenges and opportunities identified

The focus of this section is to summarize the lesson learnt from the analysis of the initiatives, marketplaces and projects (that hereinafter will be named as *'initiatives'*) listed in 2.1.

The initiatives have been reported by topic since some common statements can be formulated by group (Table 1).

Table 1: Preliminary considerations from a 'by-topic' analysis of the relevant initiatives

	AI in Manufacturing	**Data Spaces**	**Circularity**
EC Objectives [1]	AI is a key topic of the Commission from more than a decade, nevertheless the interest is always increasing. A further proof of the concern is the AI Act [2], a pioneer regulatory framework proposed in April 2021 by the European Commission (EC).	The creation of a unique, cross-domain Data Space at European level is among the objectives of the EC for the next decade [3].	Circularity is the focus of the Circular Economy Action Plan 2020 [4] and constitutes one of the main building blocks of the European Green Deal [5].
Maturity Level of the initiatives	There are many initiatives on AI in Manufacturing, with well-established audience and action plans (see Section 2.1.1).	Data Spaces initiatives have recently started under a strong boost of the EC (see Section 2.1.2).	There are many projects with the focus on Circularity, but most of them are at their beginning (see Section 2.1.3). As well the enabling technologies (e.g., DPP) and regulations (e.g., the new regulation on batteries and waste batteries [6]) are evolving rapidly.

Stakeholders	The manufacturing sector is crucial for the European economy, as well the Artificial Intelligence usefulness is commonly recognized [7].	Theoretically all industries and their suppliers, but Data Space technology is not yet acknowledged from a wider audience [8].	Climate change is a topic that 'goes beyond the business', it is strongly pushed by the society. All industries have to align with the Green Objectives, achieving the progressive milestones of the Green Deal towards the carbon neutrality of 2050 [9].
Adherence with Circular TwAIn objectives	Circular TwAIn has been funded under an AI topic[6], and the development of collaborative AI is one of the expected results of the Project.	In Circular TwAIn the Data Space more than a result is an enabler for the circular scenarios execution.	Circular TwAIn aims at deliver AI-based solutions to support the circular actors towards a more efficient product/process management.

Overall, it seems that one of the most promising technologies to speed the Circular Economy is the Artificial Intelligence, the reason is twofold: on one side, at different levels all companies have already experienced it, building a strong trust on its benefits, on the other, even if rapidly evolving too, there are already plenty of efficient solutions ready to be adopted. Nevertheless, AI per se can be adopted for specific tasks with a limited landscape in manufacturing: to have a wider range to show all its breakthrough, it should be supported by other prominent technologies such as Digital Twins and DPP (to enable tracking and simulation) and Data Spaces (to feed the AI algorithms and the Digital Twins (DTs) with up to dated information, coming also from other stakeholders of the circular value chain).

The Circularity (in manufacturing) segment is still unexplored, no major initiatives have been found at European level, despite the strong push from the EC and the citizenship. Probably the reason is the difficulty to engage circular actors, and build new strong commercial relationships among cross-sectorial and cross-country stakeholders. This limitation must be overcome in the short term to meet the EU directives on Circular Economy, the EU Commission from its standpoint is driving the change through new regulation initiatives and by funding projects on the specific topic of circularity. The Circular Economy Action Plan, approved in 2020 and continuously updated, aims at defining the measures to be undertaken along the value chain, from the design to a responsible usage and dismantle. Key actions include [9]:

- improving product durability, reusability, upgradability and reparability;
- increasing recycled content in products;
- enabling remanufacturing and high-quality recycling;

[6] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl4-2021-twin-transition-01-07

- reducing carbon and environmental footprints;
- restricting single-use and countering premature obsolescence;
- introducing a ban on the destruction of unsold durable goods;
- incentivising product-as-a-service or other models where producers keep the ownership of the product or the responsibility for its performance throughout its lifecycle;
- mobilising the potential of digitalisation of product information, including solutions such as digital passports, tagging and watermarks;
- rewarding products based on their different sustainability performance, including by linking high performance levels to incentives.

On Data Spaces there are many initiatives that are trying to push their creation and adoption, but so far there is still reluctance from the end-users side in sharing their data, even in a trusted environment with precise data sovereignty and governance rules. Pivotal will be in the next few years the ability of the EC to increase the awareness on the potential business opened by the Data Spaces and to further protect/regulate their mechanisms to be more appealing to (industrial) stakeholders. Meanwhile, the effort of the scientific community is leading to a convergence on the technical side, making a step forward in the creation of standardized, scalable and interoperable infrastructures (building blocks) that can be easily tailored to meet the user requirements.

Finally, some of the initiatives above are mainly focused on the communication and dissemination of the projects (research oriented), while some others have been built on the expertise of technology providers and the needs of manufacturers (business oriented). The maintenance of the initiatives research-oriented is challenging: most of them, once the respective projects are over, lack of updates.

3 The Circular TwAIn Innovation Marketplace

The established approach for the definition and development of the Circular TwAIn Innovation and Collaboration Marketplace can be easily explained by assigning a specific meaning to each single words of "*Circular TwAIn Innovation and Collaboration Marketplace*":

Circular TwAIn – Project funded under the topic: HORIZON-CL4-2021-TWIN-TRANSITION-01-07 - Artificial Intelligence for sustainable, agile manufacturing. Its focus is on the application of AI services enabled through data sharing within a Data Space and product/process/human Digital Twins to Circular Scenarios.

Innovation – "innovation" for the Circular TwAIn Marketplace has a twofold meaning: on one side with respect to competitors the approach pursued is of coopetition (i.e., instead of competing, join the forces to gather higher benefits), on the other individual (business and technical) needs can be discussed within the community creating new synergies and partnerships.

Collaboration – the driver to succeed in the activity is a strong collaboration and coopetition among industrial and technical stakeholders, that should go beyond the Partners involved in the Project. The shift from an EGOsystem (Circular TwAIn stakeholders, needs, facilities, etc.) to an ECOsystem [10] (including DIHs and other similar projects with their respective stakeholders, cases, requirements and -similar - ambitions) increases the exchange of ideas, maximising the impact of the results and opening to new business and technical challenges.

Marketplace – the intended positioning of the Marketplace is the creation of an environment where established or potential stakeholders may find advice, inspiration and support to succeed in their business or technical challenges. The community participants will exploit the ecosystem to increase the business relationship leveraging the networking opportunities offered but also by contacting directly other entities that provide the suitable technological asset/the required know-how/the business challenge, constituting a match making opportunity.

The following sections will describe better the Circular TwAIn Innovation and Collaboration Marketplace positioning (Section 3.1), the strategy to get the predefined objectives for the Marketplace (Section 3.2) and its expected impact (Section 3.3).

3.1 Purpose and Positioning

The first and major decision to take while approaching the development of a marketplace are:

1. What is the offer?

   Circular TwAIn is dealing with AI applications applied to Manufacturing domain to boost the adoption of Circular Economy strategies. The offer can be reassumed as:

   Circular TwAIn offers AI based applications complemented by product, process and human Digital Twins, mainly through open source components running in a trusted ecosystem. Technical Project results will be made available (GitHub link), enriched with technical documentation and mostly with Circular TwAIn's pilots

demonstrations (e.g., demonstrative videos to highlight the improvements gained in the respective sector through quantitative KPIs).

2. Who are the stakeholders of such offer?

   The audience the Marketplace is targeted to follow a hybrid approach (considering the lesson learnt from Section 2.2).

   The Circular TwAIn Marketplace is targeting both other research and innovation projects (see Section 2.1.3), and players (e.g., international associations like IDSA or FIWARE) DIHs (starting from DIH4Industry)) and Didactic Factories, but aims to reach also industries and SMEs to provide support in the definition of digitalization strategies to boost Circularity and Sustainability, opening to new business models. The other projects that should be involved will bring their know-how to create a fervid discussion ecosystem and use cases/results to increase the proved domain application beyond the three sectors selected within Circular TwAIn (i.e., product industry – WEEE and BATTERY, process industry – PETRO-CHEMICAL).

3. How can these stakeholders be reached and engaged?

   The stakeholder engagement strategy follows different paths, considering the nature of the stakeholder (i.e., project of interest, scientific community, DIH and Didactic Factory, Industry or SME).

   The Circular TwAIn dissemination activities will be intensified from the second year of the Project, promoting the Project's early results through the Circular TwAIn website, Marketplace and Social Channels, but also attending at national and international events. Through the engagement of other projects (some joint activities – mainly for dissemination - have already started with the Circular TwAIn's sister project AIDEAS) the respective results will be published also in the Circular TwAIn Marketplace, increasing the available solutions for Circular Scenarios. The scientific community will be attracted mostly through the publication of white papers on the impact of AI and DT in the Manufacturing Sector, and on the new Business Models enabled. DIHs and Didactic Factories will be engaged through workshops and webinars (promoted by the Project and affiliated projects on social channels and websites). Finally, Industries and SMEs will be attracted during targeted joint events and exploiting the individual Partners stakeholder portfolio. The support towards digitalization service that will be available on the Marketplace is mainly targeted on them.

The Osterwalder Business Model Canvas has been used to depict the Circular TwAIn Marketplace value proposition and overall business perspective Figure 1.

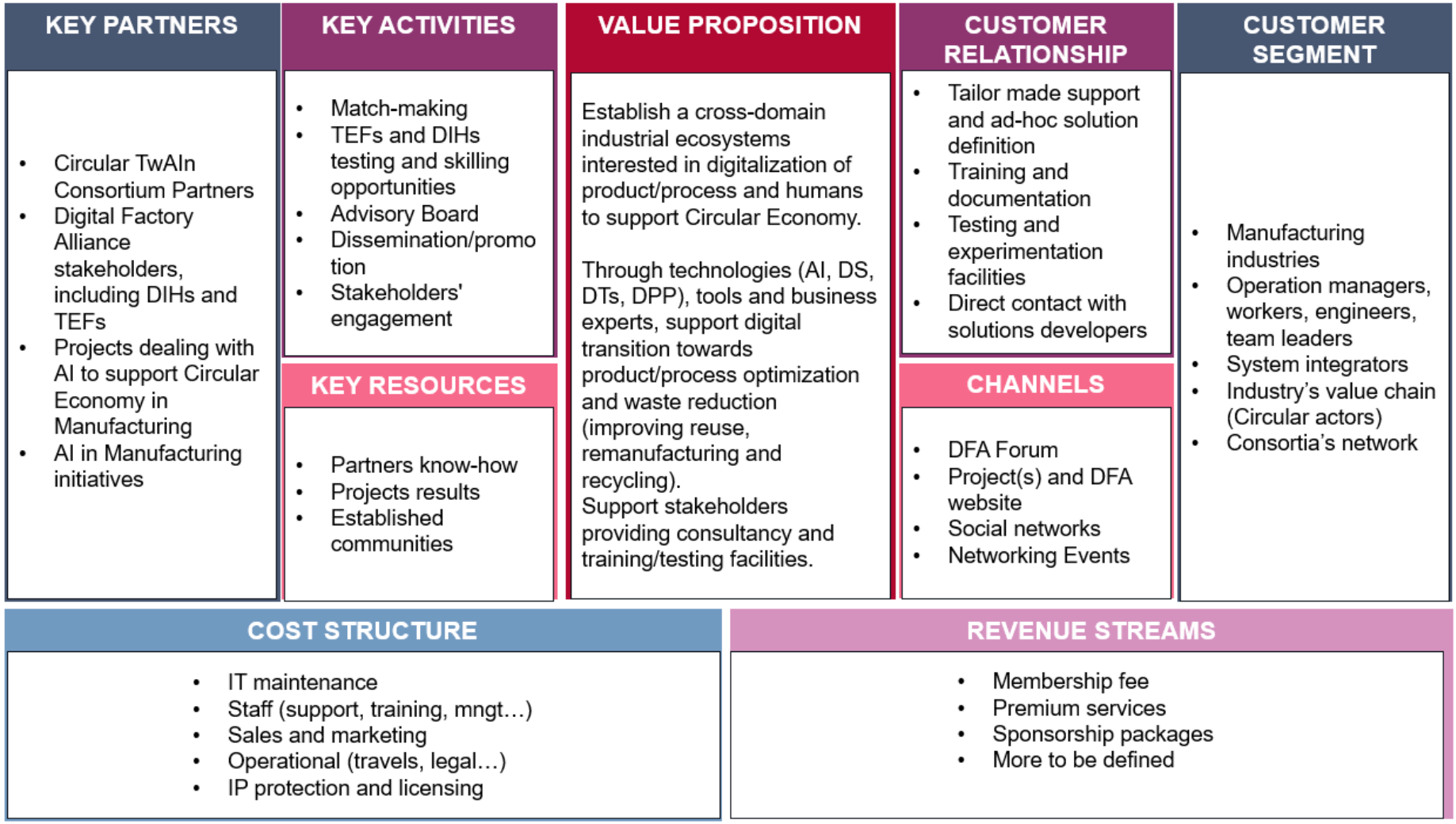

Figure 1: Circular TwAIn Marketplace - Business Model Canvas

3.2 The strategy

To speed up the activities for the Innovation and Collaboration Marketplace, under the collaboration spirit, it has been decided to exploit an already established community active in the data-driven manufacturing sector, mostly on the Zero Defect Manufacturing and Data Space topics: the **Digital Factory Alliance (DFA)**. The main rationale behind this decision is reported in the following sections.

3.2.1 Background: The Digital Factory Alliance

The Digital Factory Alliance is a community born to promote the digital transformation in the manufacturing sector by providing specialized services. The DFA stakeholders are tech providers, end users, DIHs and testing and experimental factories that can leverage the community to get access to the most updated knowledge, trends and products in the digital manufacturing field, to a marketplace, and to new business opportunities.

In fact, in line with the Innovation and Collaboration flavour of the Circular TwAIn Marketplace, the DFA is made up of 4 main pillars (Figure 2):

- Search for knowledge: Body of knowledge
- Be part of a community: Innovation campus
- Search for solution: Flagships Initiatives
- Search for business: Business network

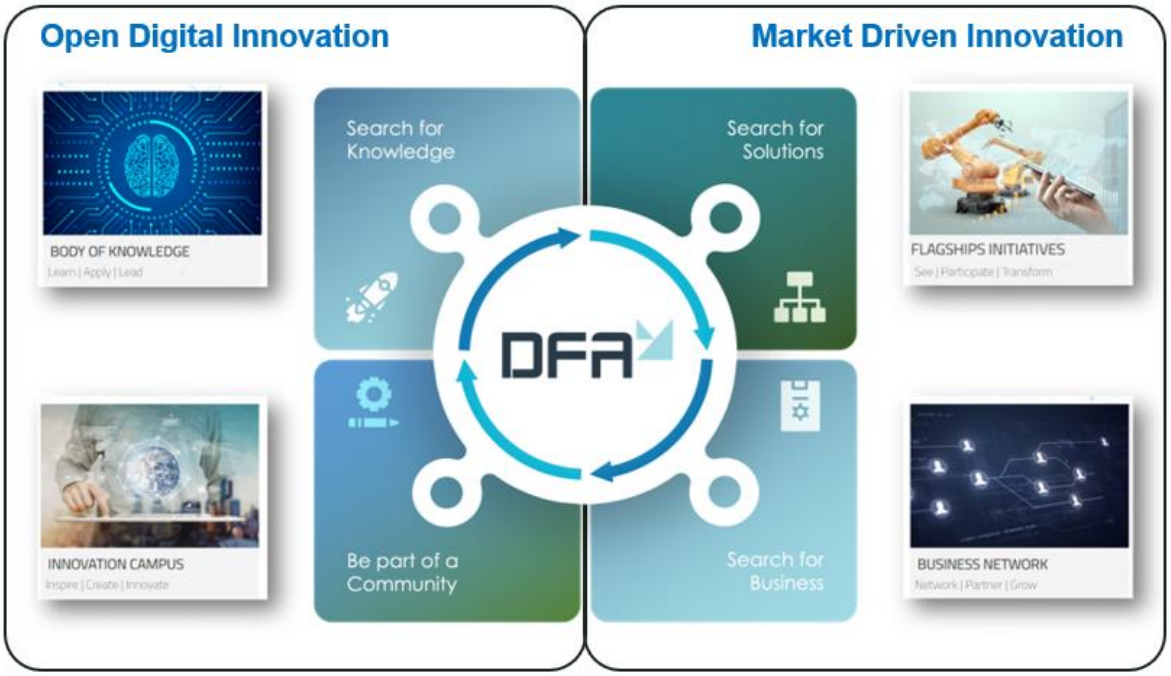

Figure 2: Digital Factory Alliance Framework

The 4 pillars of the Digital Factory Alliance Framework are grouped in two innovation loops Figure 3 the ‘Open Digital Innovation’ (that includes ‘Search for Knowledge’ and ‘Be part of a Community’) and the ‘Market Driven Innovation’ (that includes ‘Search for Solutions’ and ‘Search for Business’).

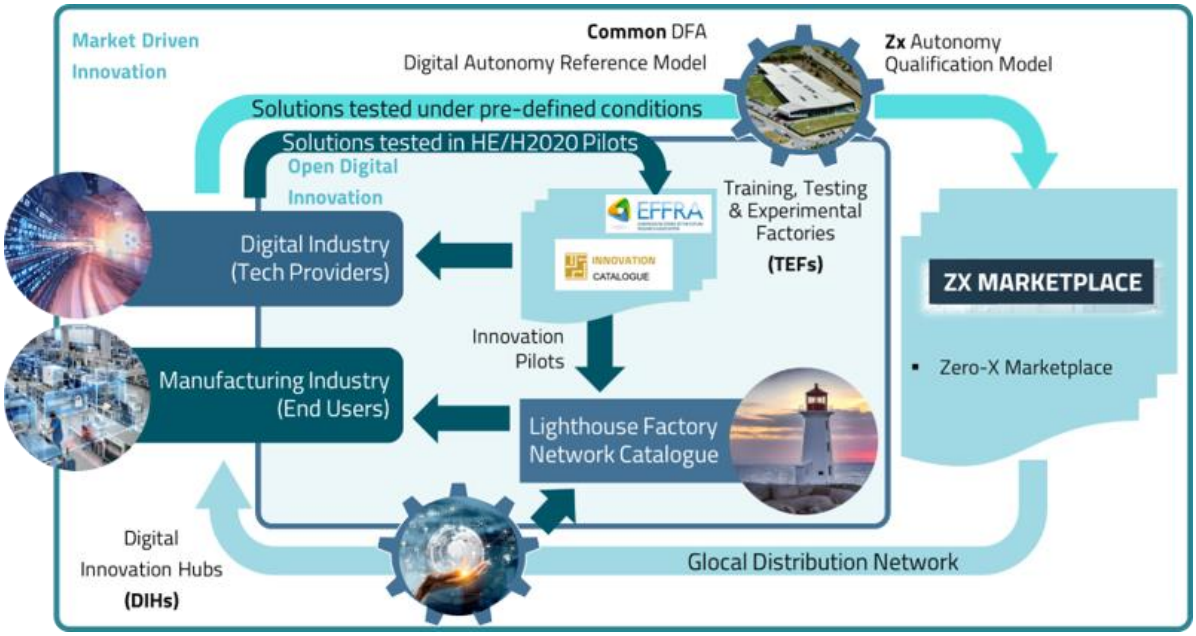

Figure 3: Digital Factory Alliance innovation loops

Under the 'Open Digital Innovation' there are open and freely accessible services that support the dissemination of R&D project results. Among the services there are the events 'DFA Auditorium' and 'Digital Corner' where stakeholders can deep dive into relevant topics for the digital manufacturing, engaging in dissemination activities focused on relevant sectorial topics, such as trends, technology demonstrations, use case descriptions. Furthermore, through the Innovation Campus it is possible to access to the Innovation Catalogue, linked with the EFFRA Catalogue, the DFA Innovation Catalogue and the Lighthouse Factory Network Catalogue. In these catalogues, any participant in the DFA community can showcase and browse innovation solutions and pilot cases developed in the Project. Practically, Circular TwAIn results can be described from a technical and business perspective, highlighting who was involved in their development and where they were applied (use cases description and demo video/images when available). Other DFA stakeholders may discover the solutions implemented and contact the owners to ask for more details and evaluate together the suitability of the solution to the specific business need. Thus, the DFA is becoming a market-maker of innovations, matching the supply and the demand side.

As bridge among the two loops, the Training, Testing and Experimental Factories (TEFs) may be leveraged to qualify the solutions and to measure them with a wider but still restricted environment, while the DIHs represent the so called "Glocal[7] Distribution Network", i.e., can support SMEs in the adoption of the new digital solutions by providing skilled personnel and a test before invest facility.

The 'Market Driven Innovation' loop instead is more business oriented and is only available for DFA members, with services grouped in Flagship Initiatives and Business Networks. Within the 'Flagship Initiatives', the ZX Marketplace constitutes a unique catalogue of products that have passed the DFA qualification process: once the maturity level of R&D

[7] *Glocal means referred to a particular area, but capable of exploiting the opportunities offered by the processes of globalization to spread worldwide.*

project's innovations reaches the capability to become a standardized solution (i.e., becoming a product).

3.2.2 Foreground: Identified synergies among Circular TwAIn and the DFA

Different positioning strategies have been evaluated to achieve the Circular TwAIn Marketplace objectives and align them with the general strategy of the DFA. The three major opportunities identified follow:

1. Data Space Initiative with specific focus on Circularity and Sustainability
2. Circular TwAIn as Flagship Project for a new Initiative on AI in Manufacturing
3. Circular TwAIn as Flagship Project for a new Initiative on Circular Manufacturing for Sustainability

Through the analysis reported in Section 2.2, and mostly on the comments summarized in Table 1, the most convenient route is a new initiative on 'AI for Sustainable and Circular Manufacturing': it is perfectly in line with Circular TwAIn focus (AI applied to Circular Scenarios), with the interest of the EC and stakeholders, there are many just started projects aligned with the topic and mostly there are no other initiatives targeted on the same issue. In fact, while for the first option it has been evaluated the Data Space technology not to be the main focus of Circular TwAIn, the second and the third had both a huge potential (in terms of stakeholders and possible applications), but for option 2 there are already many initiatives; whereas option 3 as described above is lacking of a concrete technology direction (that is actually the focus of Circular TwAIn). By merging option 2 and 3 the leading technical topic is clear (commonly recognized as powerful and the other considerations from Section 2.2 on AI in Manufacturing, as well as the application domain (gaining the comments from Section 2.2 on Circularity), differentiating the positioning from the existing initiatives.

The benefit from the '**AI for Sustainable and Circular Manufacturing**' initiative should be mutual among Circular TwAIn and the DFA:

1. On one side the, DFA provides its name and audience, a match making mindset and a collaborative approach among projects, communities and initiatives to businesses;
2. On the other side, Circular TwAIn offers the opportunity to explore the Circular Economy strategies, its results and its Consortium Partners. Moreover, through its website and social channels Circular TwAIn may increase the engagement over the DFA, bringing also new stakeholders starting from other EU projects leveraging the same technologies towards Sustainable and Circular Manufacturing.

The Digital Factory Alliance is the ideal community to exploit the Circular TwAIn potential, given its match making and its collaborative nature. Circular TwAIn will serve as guinea pig to explore a new ground, aligned with the overall DFA strategy. A new initiative on "**AI for Sustainable and Circular Manufacturing"** will be launched, gathering to the DFA new stakeholders interested on Circular Economy strategies, and promoting new results to the already established network.

3.3 Ways of working and impact

While a detailed technical plan for the development of the Circular TwAIn Innovation and Collaboration Marketplace is demanded to Section 4, the business challenges and the

engagement processes settled to gain impact from the “AI for Sustainable and Circular Manufacturing” are presented in Figure 4.

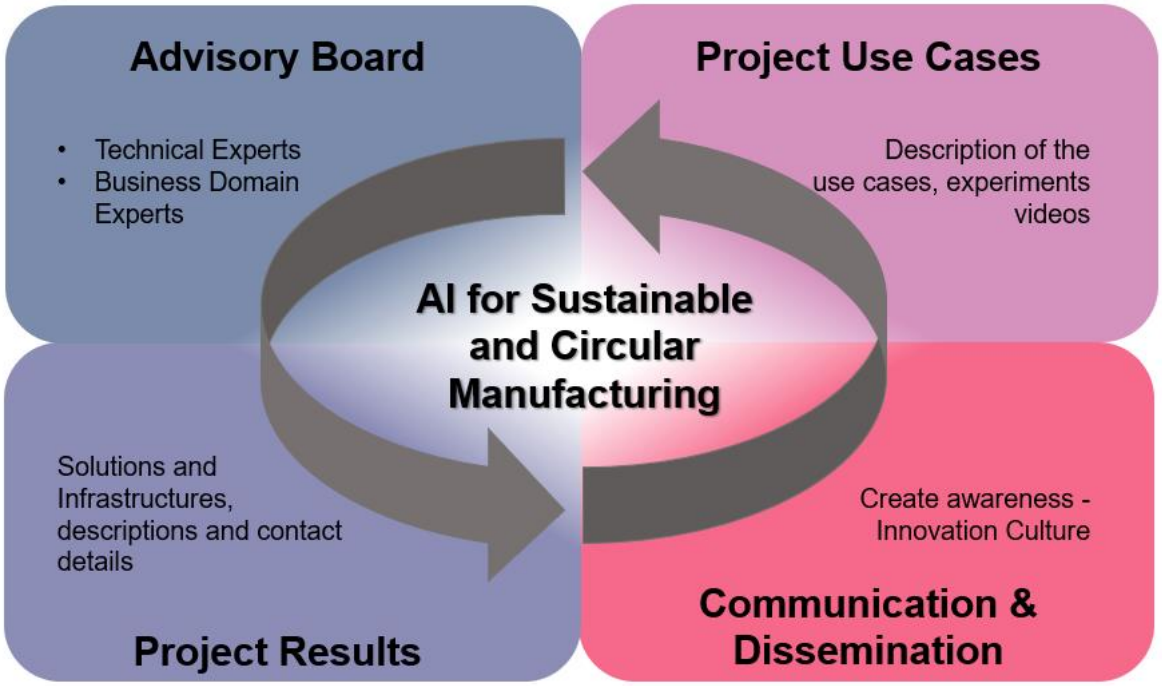

Figure 4: "AI for Sustainable and Circular Manufacturing" ways of working

What is often missing from potential industrial stakeholders are:

1. Lack of access to AI expertise,
2. Potential of AI is insufficiently known,
3. Lack of concrete examples of solutions (success stories),
4. Innovation culture.

The services that will be available through the “AI for Sustainable and Circular Manufacturing”, aimed to overcome the barriers listed above are summarized in Figure 4.

Advisory Board: technical experts and business domain experts will be available for advice, supporting circular actors finding the best route towards digitalization and Circular Economy.

Project Results: the technical achievements of the Project will be deeply described and when available related to publications. The contact details of the solution owner(s) will be available for interested users (matchmaking).

Project Use Cases: a set of use cases (success stories) will be described accompanied by explanatory videos of the experiments, highlighting through quantitative KPIs the benefit of the adoption of the technologies.

Communication and Dissemination: through the Marketplace, events and publication of interest will be promoted and advertised with the ambition to close the gap between the stakeholders and the experts.

To enrich the offer, relationship with other initiatives and projects will be established:

1. Initiatives: liaison with other initiatives of interest (a subset of those presented in Section 2.1.1 and 2.1.2) will be followed, assuring a good balance/representation of the prominent technologies (i.e., AI, Data Spaces, Digital Twins, Digital Product Passport), in agreement with the activities of T7.4, Didactic Factories Network and Training Action plan.
2. Projects: the projects already identified in Section 2.1.3 will be requested to cooperate with the new initiative (i.e., to publish their technical results and success stories) at the time they will have significant results, and joint communication and dissemination activities will be pursued. These projects will be included in different timing to progressively feed the "AI for Sustainable and Circular Manufacturing", providing new contents and keeping high the attention of the stakeholders.

3.3.1 Preliminary action list

For the services listed in previous section, a preliminary list of the actions to be taken to make them available has been drafted.

Advisory Board: among the Circular TwAIn's organizations on a voluntary basis at least three experts will be appointed, covering technical business and ethical aspects. In a second stage, when other projects will be on board, further experts will be engaged.

Project Results: Circular TwAIn's technical results will be published in the Marketplace, and continuously updated to reflect their status in the Project. Same will be applied to other projects achievements.

Project Use Cases: Circular TwAIn's use cases will be described in the Marketplace, and continuously updated to reflect their status in the Project. Same will be applied to other projects experimentations.

Communication and Dissemination: the kick-off of the new initiative will be an online event, Circular TwAIn's and DFA's social channels and websites will be leveraged to invite stakeholders as well as direct invitations to other projects consortia.

Further activities have to be considered for the development of the Marketplace:

- Technical standpoint: the development of the Marketplace will be the main part of the activities for the first period, considering also its integration with the DFA website and other external sources. A detailed plan is presented in Section 4.
- The Marketplace will have a section to:
    - Showcase the technical achievements with the contact details of the asset owner(s),
    - Showcase the trials with the contact details of the experiment owner(s),
    - Report on News (events, Project results, ongoing trials),
    - Highlight the publications and white papers,
    - Directly (cross)link to other platforms and portals.

The look and feel of the website, the user journeys (UX) will be aligned with the Circular TwAIn template and will be defined as part of the task T7.6.

The activities related to the Community building will include:

- Hackathons to be organized in/by universities among the Consortium – the definition of the business cases to be submitted should be agreed at Consortium level,
- Innovation workshops – to be organized on the topics where technology adoption is not mature enough,
- Expert board – already discussed at the beginning of the section.

3.3.2 High level action timeline

The high-level timeline for the next two years (i.e., along the Project lifetime) is reported in Figure 5. The final version of the deliverable (due at M36 – end of the Project) will also include a sustainability plan.

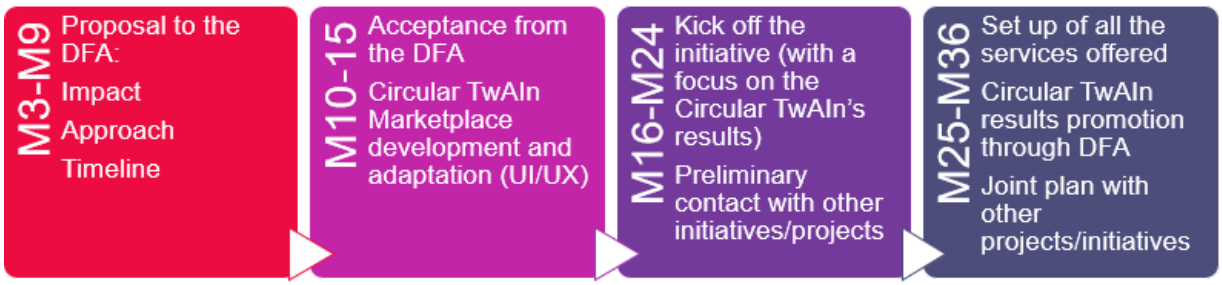

Figure 5: "AI for Sustainable and Circular Manufacturing" action plan

4 Towards the implementation

The main background platform to implement the Circular TwAIn Marketplace is based on an ENG asset, the **DIHIWARE**[8] Platform, a solution developed by ENG within the MIDIH H2020 EU project (http://midih.eu/) and currently in use in many innovation ecosystems in Europe.

The DIHIWARE is an integrated system leveraging on knowledge-driven services that fully integrate and explore a Catalogues Management System (CMS) provided by a sub-component named DYMER. This online environment is intended to be the place where providers and consumers of digital technologies related to AI, Digital Twin and Data Space development and adoption cannot just matching assets and needs, but they can collaborate to boost innovation. In a nutshell, it offers a complete collaboration environment, realizing a bridge among stakeholders with different experiences and backgrounds, pulling teams together and supplying a fertile ground for knowledge sharing. These knowledge-driven services are fully integrated with collaborative services in order to create a digital space where all the platform stakeholders can collaborate to boost innovation together.

Nevertheless, given the high ambition of the Circular TwAIn Marketplace as detailed in Section 3 to create synergies among already existing ecosystems and initiatives, the main developments will be focused on the DYMER itself, being at the core of our technical approach to relay on it as the core knowledge management and interoperability component for the extended innovation network we are targeting; the DYMER will be, in fact, the central component to realize the Circular TwAIn vision of a Content Management System as a Service (further described in the following), the cornerstone of the interoperability with the DFA tools, as well as with other external portals.

The technical approach that has been defined to build the “AI for Sustainable and Circular Manufacturing” initiative follows the “**Single Point of Knowledge**” (SPoK) principle. The stakeholders should be able to find all the information related with the initiative in a unique journey, leveraging through backend calls multiple sources. A high-level description of the interaction among the different components is shown in Figure 6.

[8] https://dih4industry.eu/

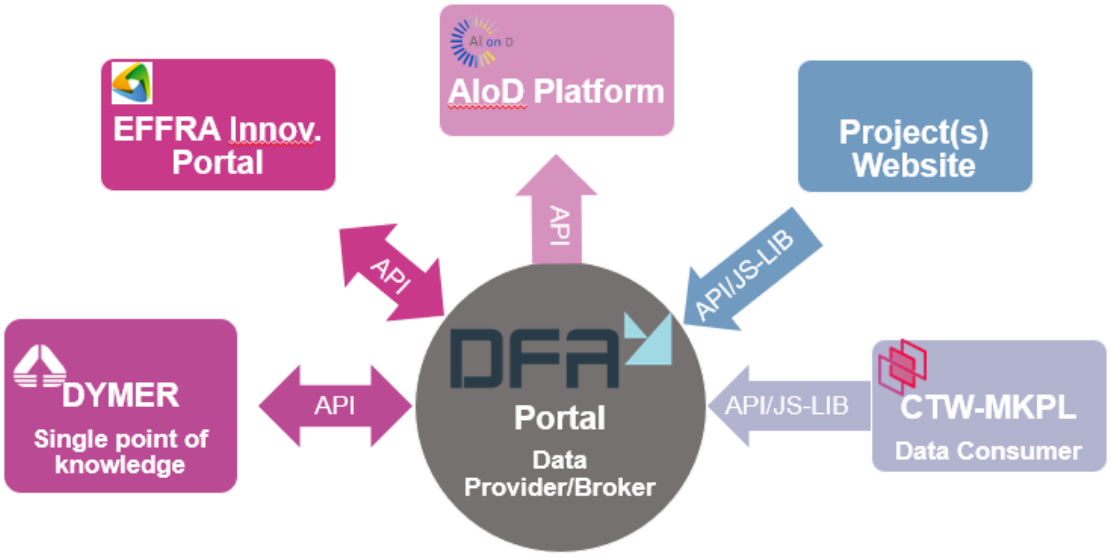

Figure 6: High level architecture of the Circular TwAIn Marketplace

The DFA is leveraged as a vehicle to empower the Circular TwAIn Marketplace and to ease the connection (as a broker) to other relevant portals/initiatives such as EFFRA, AIoD and others, but keeping the DFA as SPoK for the ecosystem managed. Thus, the DFA Portal will be the window to promote the relevant results/use cases/events available on the respective projects websites/marketplaces.

The need for a centralized approach to content management has become increasingly evident in today's data-driven world. An effective management of the information on use cases, projects results, publications and all relevant content for the new initiative is critical to attract, interest and keep the stakeholders on the DFA radar. The centralized approach on data/content management ensures that data is consistent, accurate, and up-to-date (single source of truth), allows the implementation of robust security measures (on a single environment), and overall is easily maintainable with respect to decentralized structures.

In this framework, the ENG asset named **DYMER** will play the role of orchestrator for the contents to be published in the DFA Portal, constituting a **Content Management System (CMS) as a Service**, i.e., the service provider manages the information (including images and videos) solely, towards an API-based approach. The DYMER is a suite for resource catalogue visualization and provides, on the one hand, advanced mapping capabilities between a data model in JSON format and its graphic template, on the other. In short, it provides a JavaScript framework for integrating the DYMER template into a web-based application.

The DYMER platform is flexible since it adopts open technologies and can be used in various environments without considerable requirements. By means of JavaScript language, and proper configurations, the DYMER is able to offer to the DFA Portal, besides data stored into its own database, several resources coming from external system which is based on API REST technology. These different external resources, along with the internal ones, can be then graphically rendered into the DFA Portal and the Circular TwAIn Marketplace (or others) in a totally transparent way to end users. In this way, a single access point for searches leveraging on a variety of information available from different organizations can be provided by creating a federation of catalogues for a scalable system (*data blending*).

The microservices architectural approach of the DYMER allows the development of applications as a suite of small services, each running in its own process and communicating with lightweight mechanisms using HTTP/REST protocols alongside JSON. These services are based on the core part (DYMER-core) of the DYMER system which offers also client-side component, the DYMER-viewer. The DYMER-viewer may be leveraged for the DFA Portal rendering of catalogues information. Figure 7 depicts the main blocks of this layer and its connections.

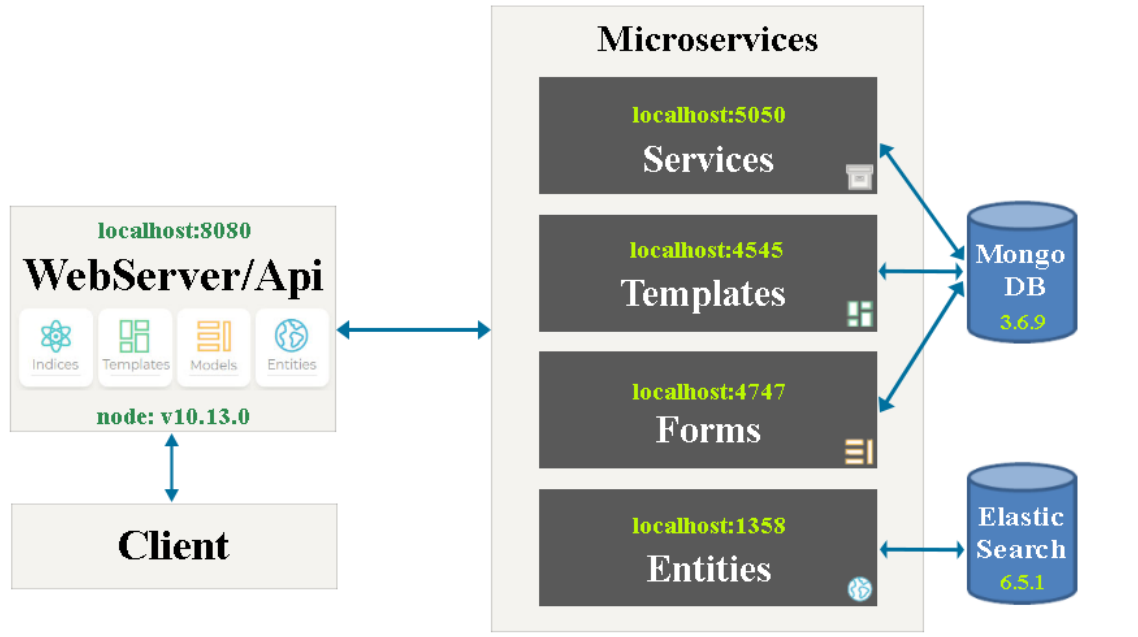

Figure 7: DYMER-based architecture of the Marketplace CMS

The interaction between the Marketplace and the catalogue information available in the system, is eased by the aforementioned DYMER-viewer which is a fast, small, and feature-rich JavaScript library run in the Client block. Thanks to it, it is possible to interact with the platform facilitating the user in the data retrieval operations by offering a single search point and displaying the results in special graphic templates.

The services deployed are configured through a docker-compose file, that is used to specify several details, first of each the docker image to be downloaded automatically at start-up for every container of every service defined in the file.

How to integrate the DFA Portal with the with the other environments (Figure 6) is still under discussion, in particular:

- EFFRA Innovation Portal and AIoD Platform: the idea is to cross-link relevant contents on/to the DFA Portal, but further investigation with the responsible of the two is required. (Same principle will be applied to other relevant external initiatives)

- (Other) projects websites/marketplaces: the projects that will be invited to join the initiative will have the opportunity to align with the SPoK approach by leveraging the DYMER too, otherwise a different integration strategy may be evaluated and applied.

- Circular TwAIn Marketplace: the ongoing discussion within the Consortium is on the convenience of creating a new website or leveraging the Project website. Both of the options present some pros and cons; by now the motivation to add a new section

"Marketplace" to the Project website seems the most suitable since the stakeholders will find all the information needed in the same place, making the user journey easier, and maintain one environment requires less effort, saving energy to be devoted to content management and community building.

5 Conclusions and Future Outlook

The deliverable serves as declaration of the approach intended for the development and exploitation of the Circular TwAIn Innovation and Collaboration Marketplace.

First of all, it is crucial to remark how Circular TwAIn intends an "Innovation and Collaboration Marketplace": the Marketplace will be a mean to discover the latest updates on "AI for Sustainable and Circular Manufacturing", end-users will be able to match making with technical providers and other actors of the target community. The innovativeness of the initiative is structured among a twofold pool of services, to increase the awareness on the topic and to ease access to market ready innovations. Lastly, the collaborative aspect of the initiative lays on the involvement of multiple portals, projects, communities and initiatives, on the opportunity to find relevant information in a unique orchestrated ecosystem.

The activities undertaken in the first year of the Project can be summarised as follows:

1. Overall idea for the Marketplace: a tool to increase the awareness on the technical and business challenges of Circular TwAIn, not limited to it, to spread the Collaboration and Innovation capabilities, other projects/communities should be leveraged to enable match making among different organizations and different portals.
2. The foundation of a new "AI for Sustainable and Circular Manufacturing" initiative within the Digital Factory Alliance, to empower the concepts of Collaboration and Innovation, taking advantage of an existing Community of technical and industrial stakeholders.
3. An initial plan of the activities to be carried out to launch and maintain the initiative for the Project lifetime, and in particular on how the services will be made available and other projects and initiatives will be involved.
4. The technical approach that will be pursued: the DFA website will constitute the Single Point of Knowledge, it will be fed with news, Project results, use cases and events leveraging the DYMER as Content Management System as a Service. Other portals and catalogues will be interoperated as well crosslinked to create a unique source of information for the "AI for Sustainable and Circular Manufacturing".

The next activities will be related to the actual development and population of the Marketplace, with dedicated user journeys and look and feel (aligned with the Circular TwAIn style), and to the integration of the various websites/portals within the DFA ecosystem.

In parallel, the relevant communities and projects identified in Section 2.1 will be contacted pursuing a collaborative relationship with Circular TwAIn.

Once the developments will be completed, the new initiative will be kicked off, and the plan for the next years is to organize at least every six months an event (online or in presence, leveraging also the other DFA events) to present the new achievements on the topic (both technical and success stories) and the projects that will join "AI for Sustainable and Circular Manufacturing".

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