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[1] PU: Public, CO: Confidential, only for members of the consortium (including the Commission Services)
[2] RE: Report, OT: Other; ORDP: Open Research Data Pilot

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Abbreviations and acronyms

TERMS, ABBREVIATIONS AND ACRONYMS	
AAS	Asset Administration Shell
CC	Competence Center
CF2	Connected Factories II/2
DEI	Digitizing European Industry
DIH	Digital Innovation Hub
EC	European Commission
IdF	Industrie du Futur
IDS(A)	International Data Space (Association)
LNI	Labs Network Industrie
LEP	Local Enterpise Partnership
RAMI 4.0	Reference Architecture Model Industrie 4.0
RIS	Regional Innovation Scheme
SCI	Standardization Council Industrie
SME	Small Medium Enterprise

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Executive Summary

One of the key objectives of the Connected Factories 2 (CF2) project is to identify pathways to the industrial take-up of digital technologies and digital platforms by taking into account industrial requirements and challenges from a variety of manufacturing initiatives and companies in Europe. In order to achieve this objective CF2 engages with the research and industrial actors in both European, national and regional ecosystems, bringing together manufacturing companies, technology, component suppliers and more, and herewith make sure that requirements and boundary conditions are reflected in the pathways to digitalisation of manufacturing. Moreover, CF2 aims at generating a broad awareness about the pathways as it is for example inspiring cases that include SMEs.

In accordance with the strategic objectives of CF2, the objective of this document is to provide input from the national/regional/European initiatives.

In the preceding ConnectedFactories CSA (CF1) and in the ConnectedFactories 2 CSA (CF2) the following pathways have been developed or are under development : Autonomous Smart Factories, Hyperconnected Factories, Collaborative Product-Service Factories, Dataspaces Pathway, Circular Economy Pathway and Cybersecurity Pathway.

Chapters 2 and 3 provide insights into national and EU level initiatives related to Digitizing European Industry with a focus on manufacturing industry. A list of national initiatives is presented in chapter 2 and a list of the innovation pillar of EIT Manufacturing is presented in chapter 3. The initiatives have been chosen as they represent significant efforts to increase the take-up of digital technologies and circularity in manufacturing. However, the examples do not cover all European or national initiatives active in this area. In each case, overall information is provided for the national activities while in some cases a projection to CF2 pathways is presented.

The feedback collected and its analysis in national level depict that the ConnectedFactories pathways definition is pertinent and reflects activities/initiatives in national and EU level.

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1 Introduction

One of the key objectives of the Connected Factories 2 (CF2) project is to identify pathways to the industrial take-up of digital technologies and digital platforms by taking into account legacy systems, industrial requirements and challenges. In order to achieve this objective CF2 engages with the research and industrial actors in both European, National and regional ecosystems, bringing together manufacturing companies, technology, component suppliers and more, and herewith make sure that requirements and boundary conditions are reflected in the pathways to digitalisation of manufacturing. Moreover, CF2 aims at generating a broad awareness about the pathways, as it is for example inspiring cases that include SMEs.

In accordance with the strategic objectives of CF2 the objective of this document is to provide input from the national/regional/European

The structure of the document is as follows:

1. Chapter 2 provides input from different initiatives in EU countries.
2. Chapter 3 provides input from in EU level via the activities in EIT Manufacturing.
3. Chapter 4 provides some conclusions and discusses on the next steps in the context of this activity.

2 National Initiatives and regional Initiatives

2.1 Overview

This chapter provides an overview of the initiatives regarding digital transformation of manufacturing companies in Europe. The objective is to gather information from the different initiatives that will contribute to the alignment of the CF1 and CF2 pathways with relevant work done within these initiatives and the second is to identify the possible ways to validate the CF1 and CF2 pathways from organizations and stakeholders behind the initiatives.

2.2 Austria: Industrie 4.0 Oesterreich

2.2.1 Autonomous Smart Factories

There was public funding for setting up Pilot Factories by the Federal Ministry for Climate. The first one was established in Vienna – Aspern by the University of Technology Vienna as a pilot project in 2015. A call for further pilot factories was issued in 2016 which led to the establishment of two further pilot factories, one is the Smart Factory @ TU Graz, the other one the Linz Institute of Technology Factory (LIT Factory).

Further pilot factories were built at various Applied Universities. Among these are the Smart Production Lab at the Applied University Joanneum in Kapfenberg, the Center for Smart Manufacturing at the University of Applied Science Upper Austria in Wels, the Robotics Lab at the FH Technikum Wien, the Digital Factory Vorarlberg in Dornbirn, the Learning Factory at the University of Applied Sciences Kufstein, and others.

Furthermore there was infrastructure established in Vienna, Graz and Kapfenberg that focuses on security (see Figure 1).

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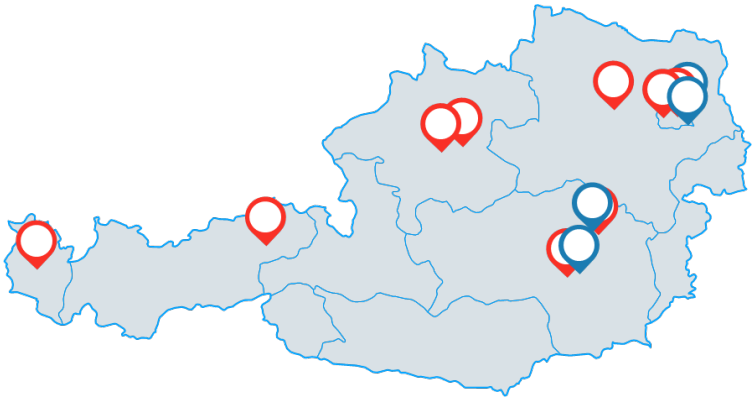


Figure 1 Overview of pilot factories for Smart Production (in red) and for Security (in blue)

In a recent initiative, the 42. Call for Proposal within the framework of the funding scheme "Production of the Future" the interconnection of pilot factories and testbeds was addressed. In detail, the following issues should be covered:

- Goal 1: Efficient use of resources and raw materials and efficient production technologies
- Goal 2: Flexible production
- Goal 3: Production of high-quality products

As of 13th of Sept. 2022 the evaluation of the proposals took place, a consortium was selected, and contract negotiations are underway.

2.2.2 Hyperconnected Factories

There is no programme or initiative in Austria that specifically addresses hyperconnected factories.

2.2.3 Collaborative Product-Service Factories

In line with the strategy of the European Commission on European Digital Innovation Hubs, several initiatives were started in Austria.

A first step was the selection of national Digital Innovation Hubs, three were selected in 2019 and further three in 2021.

Moreover, a call for proposal for European Digital Innovation Hubs was launched in 2021 and 4 projects selected in 2022 (InnovATE, Applied CPS, AI5production[3] and Crowd in Motion) that foster the digital transformation among SMEs and Mid-Caps. At the core of the projects are collaborative product-service factories where companies can test solutions before any investment decision.

The official press release (in German) gives some details. All four projects are currently in a negotiation phase.

[3] The Platform Industry 4.0 Austria is involved in this consortium.

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2.2.4 Data Spaces

In Austria, businesses, academic institutions as well as governmental stakeholders recognize the increasing opportunities and potential of using and sharing data. However, the situation can be compared to Germany where 63% of enterprises do not share data with other enterprises yet (Bitkom, 2022)[4].

It can be assumed that the enterprises already engaging in data sharing do so on a highly individual basis. This means that businesses cooperate with customers/suppliers via individual and customized APIs. While this leads to benefits for both parties, it can most often be considered quite inefficient and not scalable, especially when a whole network of companies or suppliers should be added to the existing systems.

Therefore, international standards increasingly gain importance throughout Austria. While a lot of industry standards are proprietary, open approaches and initiatives have emerged over the last couple of years which can be considered of high relevance for the specialized Austrian manufacturing sector. Among others, those initiatives include Gaia-X[5], IDSA[6], BDVA[7] or FIWARE[8]. Austrian companies observe and cautiously but increasingly engage in those organizations to follow the development regarding data sharing and the establishment of data spaces.

Austrian manufacturing companies are often highly specialized on specific niche products they supply for the European market. For instance, there are many companies focusing on supplying parts for the (German) automotive sector. Therefore, data space initiative like Catena-X[9] and the standards arising from it are considered highly relevant. Also, initiatives like Manufacturing-X[10] (non-automotive manufacturing) or Omega-X[11] (energy) are interesting for the Austrian economy.

As of now, there is a small number of early adopters already engaged in the data spaces mentioned. However, this number is bound to increase as more and more awareness for data spaces is created throughout Austria. For instance, in Q2 2022 the official Austrian Gaia-X Hub[12] was established in order to help companies understand the concept behind the European project Gaia-X and to get them engaged in the project.

For motivating companies to join data spaces, incentives play a major role as well. The Austrian Ministry of Climate Action and Energy has already funded some flagship projects that encourage Austrian businesses to develop use cases for data sharing. For instance, one project that has been funded through the Austrian state is called EuProGigant[13] through which use cases of data sharing in manufacturing will be developed until 2025. Projects like this provide inspiration to further companies for engaging with the topic.

While there has been positive development in the last couple of years, there are still many steps to be taken regarding data spaces in Austria. Currently, there is a need for translation of political and macro-economic goals (e.g., “data sovereignty”) into language and terms businesses understand. Projects like Gaia-X need to be connected to the actual shopfloor so that Austrian factories are able to grasp its potential and actual

[4] https://www.bitkom.org/EN/List-and-detailpages/Publications/Data-Spaces-Ecosystems-First-Explainer-Current-Status
[5] https://gaia-x.eu/
[6] https://internationaldataspaces.org/
[7] https://www.bdva.eu/
[8] https://www.fiware.org/
[9] https://catena-x.net/de/
[10] https://www.handelsblatt.com/technik/it-internet/manufacturing-x-sap-und-maschinenbauer-bauen-cloud-plattform-fuer-die-industrie/28617112.html
[11] https://internationaldataspaces.org/omega-x-an-energy-data-space-to-boost-the-european-data-economy/
[12] https://www.gaia-x.at/
[13] https://euprogigant.com/

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impact for them. Therefore, closing the gap between high level goals and the current state of technology in Austrian factories will be a major goal for the Austrian Platform Industry 4.0 in Q4 2022 as well as Q1-Q2 2023.

2.2.5 Circular Economy

For a long time, circular economy has been a theoretical concept for most Austrian businesses. While striving towards a more green and sustainable way of doing business has been the focus of a small community in the past, the concepts have gained a lot of traction in the last couple of years. For instance, the R.U.S.Z. has focused on repairing and recycling electronics since 1998 – in Q2 2022 the Austrian Ministry of Climate Action and Energy has introduced a "Reparaturbonus"[14], which covers 50% of the costs of repairing electronics.

In manufacturing itself, measures towards a more circular economy are also receiving increased attention. In different sectors, more and more organizations take on the topic and discuss successful approaches. For instance, the Austrian Automotive Transformation Platform (AATP)[15] was established in Q4 2021 in order to support the Austrian automotive suppliers in becoming greener and more circular. Also, the Platform Industry 4.0 has taken up the topic, e.g. as a focus area of the Summit Industry 4.0 2022 by collaborating with the Circular Economy Forum Austria.[16]

Many major Austrian subsidy programs are increasingly generating incentives for the Austrian industry to become more circular. For instance, "Produktion der Zukunft"[17], a major subsidy scheme for Austrian manufacturing companies, has increasingly focused on resource and energy preservation. Also, new programs like "AI for Green"[18] have been established recently to push the development of Artificial Intelligence (AI) for a more sustainable economy.

Digital tools will play a major role in the future for establishing a truly circular economy. Austrian businesses are therefore highly interested in concepts like the Digital Product Passport (DPP)[19] or digital twins. In order to help those ideas become a reality on Austrian shopfloors, many actions are still needed. Standards like the Asset Administration Shell (AAS)[20] can play a major role in getting businesses attention and in supporting them, especially SMEs. In Q4 2022 and 2023, informing the Austrian industry about those concepts and delivering up to date information will be a focus for the Austrian Platform Industry 4.0.

2.2.6 Cyber Security

current status regarding digital transformation initiatives

For the successful implementation of Industry 4.0 and the comprehensive networking of value chains, a reliable, highly available and permanently secure use of globally networked machines and systems as well as innovative, data-driven technologies is indispensable. Companies in Austria are confronted with an ever-increasing rate of cyber-attacks; we can observe a raising awareness to set appropriate security measures. Increasingly companies of various sectors see security as an integral part of their business model and provide security solutions to their products.

[14] https://www.reparaturbonus.at/
[15] https://aatp.at/
[16] https://plattformindustrie40.at/blog/2022/06/02/and-the-winner-is-das-war-der-6-summit-industrie-4-0/
[17] https://produktionderzukunft.at/de/mission/
[18] https://www.ffg.at/ai
[19] https://ec.europa.eu/commission/presscorner/detail/en/IP_22_2013
[20] https://www.plattform-i40.de/IP/Redaktion/DE/Downloads/Publikation/Details_of_the_Asset_Administration_Shell_Part1_V3.html

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At the political level, the NIS-2 Directive (Directive on measures for a high common level of cybersecurity across the Union) exists and is a new regulation of cyber security in the EU. It is expected that the implementation into national law will take place by autumn 2024.

The Austrian Security Research Programme KIRAS is a national programme to promote (civil) security research in Austria. KIRAS supports national research projects with the aim of increasing the security of Austria and its population. The programme was already established in 2005, over time one could observe a shift to topics around security and resilience.

The Austrian Institute of Technology (AIT) built up a Cyber-Range for training purposes and is involved in Austrian and European light-tower projects (e.g. CyberSec4EU, IoT4CPS – which was finalised end of 2020) and SBA Research (involved in CONCORDIA – Cyber Security Competence for Research and Innovation). Moreover, in some of the pilot factories in Austria, security is one of the focus points, e.g. FH Joanneum.

With the expert group "Security and Safety", Platform Industry 4.0 Austria raises awareness on the importance and significance of security for Industry 4.0, connects relevant actors in Austria and contributes to establishing security and safety as an Austrian competitive advantage.

Joint activities include the creation of an Austrian cyber-security ecosystem of science, research and business as well as a cyber-security guide for manufacturing companies with the aim of sensitising SMEs in particular to the topic, highlighting critical points in the area of security and safety in corporate decisions and offering initial assistance. The appendix to the cyber security guide is intended to present all members of the Platform Industry 4.0 who offer IT-security services.

The cyber-security guide in German is available under the following link.

The Platform Industry 4.0 has created a cyber-security ecosystem that is divided into five sectors: technology provider, capacity building & practice training, qualification & skills, critical infrastructure & authorities, and community building. This gives a structured overview of major actors in the Austrian security landscape.

2.3 Germany: Industrie 4.0

2.3.1 Key initiatives

The recent years have been very productive for Industrie 4.0 initiatives in Germany in terms of making, testing and experimenting the boosting digital solution. In particular, several respective activities are worth to be presented in context of the ConnectdFactories2 as depicted in this subchapter.

The German Plattform Industrie 4.0 is one of the central nodes that successfully promotes the digital transformation of manufacturing in Germany. Under its umbrella, several experts from business, science, associations and the trade unions develop operational solutions together with representatives from various federal ministries in thematic working groups. In particular, the Plattform Industrie 4.0 has the goal to develop pre-competitive concepts and solutions and put these into practices; to support companies with recommendations for action, information and use cases; and to feed the results into the international Industrie 4.0 discourse, especially bringing these into the national and international standardization processes. The key work is being done by six working groups, which address topics from the fields of

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standardisation, technology and application scenarios, integrated systems security, legal frameworks, work, continuing vocational education and training, and digital business models.

The Standardization Council Industrie 4.0 (SCI 4.0) is an important strategic organization that establishes recommendations for action for Industrie 4.0 and coordinates their implementation in standards and specifications. Therefore, the SCI 4.0 thus mediates between the Platform Industrie 4.0 and the various standards organizations and bundles the stakeholders in Germany in cooperation with the Platform Industrie 4.0.

The Labs Network Industrie 4.0 (LNI 4.0) enables small and medium-sized enterprises to implement the strategic recommendations for action (defined by SCI 4.0 and other core initiatives) and further test new technologies and use cases in pilot projects approving the technical feasibility of the underlying concepts.

The Industrial Digital Twin Association (IDTA) is a brand new initiative that has been founded on 23 September 2020, by VDMA, ZVEI and 20 additional well-known German industrial companies to drive forward the broad use and application of the Asset Administration Shell and digital twin concepts.

The project Gaia-X aims to create a federated data infrastructure to strengthen the European ecosystem: a secure, federated system that meets the highest standards of digital sovereignty while promoting innovation.

The International Data Spaces Association (IDSA) has the mission to create the future of the global, digital economy with International Data Spaces (IDS), a secure, sovereign system of data exchange in which all participants can realize the full value of their data.

The use of innovative technologies in companies requires different competencies and qualifications and can therefore change the professions themselves. In October 2018, the Federal Ministry of Labor and Social Affairs created a new, interdisciplinary and agile organizational unit, the Policy Lab Digital, Work & Society. This combines in an interdisciplinary way the functions and working methods of a classic policy with those of a modern future lab. The aim of the initiative is to identify new fields of action arising from digitization and other trends at an early stage, to view the labor market more strongly in a societal context and to develop new solutions for the labor market of the future. The project assumes a central support function for science, practical players and the social partners.

The Digital Hub Initiative (also known as *de:hub*) is a national initiative that promotes collaborations and partnerships in particular. The initiative comprises twelve Digital Hubs throughout Germany and provides a stable network that enables the exchange of technological and business knowledge, programs and ideas. In each Digital Hub, startups, companies and research institutions come together to jointly develop solutions to the challenges and prospects of digitization.

The Mittelstand-Digital is one of the best-known and most popular initiatives in Germany, focusing in particular on small business and their digitization efforts. For example, it offers small and medium-sized enterprises and the skilled trades guidance on digital transformation, provides information on the opportunities and challenges of digitization, and provides financial support for digitization projects. The Federal Ministry for Economic Affairs and Climate Action makes it possible for all these services to be provided free of charge.

The Ministry of Economic Affairs, Labour and Tourism offers funding for research and innovation projects as part of the Invest BW program to support companies in their plans. Funding is available for individual

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companies based in Baden-Württemberg as well as for cooperations between companies and research institutions or universities.

Catena-X is the alliance for building an open, scalable network for cross-company and secure information and data exchange in the automotive industry.

PAiCE is a technology program of the German Federal Ministry for Economic Affairs and Climate Action (BMWK), for which 16 consortia from science and industry have qualified for around 50 Mio. Euro funding during 2016-2021. The aim of this program is to strengthen Germany's leading position as a high-quality production location and as a provider of cutting-edge production technologies.

CF2 partners are deeply involved and monitor the activities of the above-described initiatives and organisations at several working group levels (e.g. directly through membership and active contributions or indirectly through dedicated expert discussions) establishing an important link to the transfer of ConnectedFactories2 results.

2.3.2 Integrated results and activities in focus

Several important activities and achievements of the platform could be summarized across the initiatives and highlighted in the next abstracts under the reference to ConnectedFactory 2 objectives.

Related to Pathways

At the German Federal Government's Digital Summit 2020, the platform presented practice examples and three pathways towards resource efficiency, transparency, and networking to an ecologically sustainable Industrie 4.0. According to it, sustainability is one of the fundamental cornerstones of societal values that becomes increasingly the focus of public debate. Therefore, the platform has compiled an analysis of more than 60 examples of sustainable, digital manufacturing from companies and research showing that Industrie 4.0 is already enabling more resource-efficient and climate-friendly manufacturing today.

There is increasing evidence of coordination bodies and working groups in various committees and initiatives presenting their deliverables in the form of roadmaps. Thus, there has been a lot of work in this direction in national standardization recently, with many roadmaps emerging in the fields of Industry 4.0, artificial intelligence, human and their work in such innovative environments. From a practical point of view, such roadmaps are a very good basis for creating pathways and providing necessary support during pathways' development.

For instance, one of the key outputs of the SCI 4.0 with focus on Industry 4.0 is the German Standardization Roadmap Industrie 4.0. This work document not only pursues the goal of initiating digital production standards in Germany but also defines the focus actors and needs for new projects and organizes their international implementation. The fourth edition of the German Standardization Roadmap Industry 4.0 as well as the newly published Progress Report summarize the previous standardization gaps and highlight useful standards for Industrie 4.0. The topics are covering such important technological requirements as e.g. systems and their properties, industrial security, interoperability and semantics, integration and communication protocols, terms and definitions, semantics and onthologies, human and work, and others. The document not only identifies the standards landscape, but also provides a basic theoretical foundation for the key requirements and needs expected by industry and stakeholders. The results of the roadmap have been successfully presented to a broader set of projects in several CF2 events and, where possible, translated into the Pathways.

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Related to Aspects of Human at Work, Skills and Knowledge Transfer

Further work of the Plattform Industrie 4.0 includes the development of a "Charter for Learning and Working in Industrie 4.0", which is intended to help companies and employees collectively shape the transformation of Industrie 4.0 along the three dimensions 'people', 'technology' and 'organisation'.

The world of work is in a constant state of change. This is because the way work will look in the future is influenced by various factors such as technological progress or political decisions as well as social changes (e.g. a pandemic, such as the current coronavirus (Covid-19)). Thus, the Roadmap Innovative Work Environment (published 2021 by DIN e.V.) describes the complexity of modern working environments and presents the current research results in a structured way. It considers i.e. various aspects of the digital transformation, the topics of knowledge, competence and learning in the innovative worlds of Industry 4.0, as these inevitably promote new opportunities for knowledge management, competence building, the implementation of new forms of learning and a work organization conducive to learning. To describe the practical relevance for CF2, the roadmap provides useful use cases from the areas of production and services and describes the fundamental transformation concepts in relation to the work of the future.

An intensive exchange of ideas and information is just as important for the development of realistic future scenarios and knowledge transfer. Supportive programs that help industry and other stakeholders to reflect the diverse range of existing knowledge, interests and experience as e.g. provided by the Policy Lab in form of various small discussion sessions, workshops and co-creation processes through to multi-day design thinking labs has a large impact and help to develop new ideas and digital business models.

Related to Aspects of Interoperability, Data Infrastructure and Standardization

In terms of interoperability, the Platform Industrie 4.0 have formulated a holistic approach to the design of digital ecosystems with the core idea based on three strategic fields of action in Industrie 4.0: Autonomy, Interoperability and Sustainability. The core principles are described in the 2030 Vision for Industrie 4.0: Shaping Digital Ecosystems Globally where it designs the mission statement 2030 and concentrates on the design of digital ecosystems. The statement clearly points out the main necessary activities to overcome in the next period. This work has been deeply analysed in the project's crosscutting task "Interoperability".

In 2022, the Plattform Industrie 4.0 successfully continued its work with a series of many publications and position papers that were developed in various working groups. Other important results such as strategy papers of the German government, studies of partners as well as photos, videos, infographics and much more were made available to stakeholders from the industry. Since years, the platform enjoys great popularity and is an important medium and communication channel between science, politics and industry. Thus, the current focus areas (as observed by CF2 through recent events and publications) are triggering scientific discussions in the following areas, such as (1) ecosystems and multilateral data exchange in Industrie 4.0; (2) interoperability and solutions for digital twins (with theoretical and practical support); (3) Industrie 4.0 and data spaces for resilience, competitiveness and sustainability; (4) secure communication for Industrie 4. 0 as well as industrial security and the development of AI applications in the edge domain; (5) learning and working in Industrie 4.0; (6) the value chains of the future - Industrie 4.0 data space; (7) sustainable digital production and circular economy and perspectives from research as well as the smart way to carbon footprint in the factory, among others.

The further important work of the platform in terms of interoperability relates to the development of the Reference Architecture Modell Industrie 4.0 (RAMI 4.0) and Asset Administration Shell (AAS). RAMI 4.0 been

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so far accepted by international bodies as an international standard. The current work of the Plattform Industrie 4.0 together with national bodies is now focusing on internationalization of AAS concepts in IEC TC 65 Working Group 24 Asset Administration Shell for Industrial Applications. Very good results have been achieved in discussion regarding the AAS structure, properties and services. The Plattform Industrie 4.0 working group on standards invites everybody to join in and can create experimentally their own Asset Administration Shell in practical web seminars. The following work has been included in the analysis of the project's task "Standardization" and have been since the beginning the driving force in the discussion within the ConnectedFactories2 Digital Manufacturing Platform (DMP) Cluster.

The Plattform Industrie 4.0 co-initiated the foundation of the Industrial Digital Twin Association (IDTA). The association develops the industrial digital twin as an open source solution and brings it to the market. In close collaboration with IDTA, the InterOpera project is developing methodological approaches and supports the development of sub-models of the Asset Administration Shell, which stand in the focus of IDTA. Both works have been closely monitored in the relation to the CF2 digitalization pathways e.g. "Data space pathway". In addition, CF2 has provided a link between InterOpera and CF2 supervised projects regarding the development/implementation of new sub-models for the Asset Administration Shell.

Standards and technical specifications play an important role in the field of artificial intelligence (AI) as well. In this context, the standardization activities of the "German Standardization Roadmap for Artificial Intelligence" are worthy of particular mention. The roadmap is being developed by DIN and DKE as well as around 300 experts from the related national committees and groups. The roadmap implements the German government's AI strategy in the field of standardization. Following the publication of the first edition in 2020, the second edition is planned for the end of 2022.

However, to strengthen collaboration and interoperable solutions, much more effort and support is needed from the government. Hubs offer very good mechanisms so far, if the organization will have simple participation rules, which do not hinder its collaboration policies.

A good example of such lightweight initiatives is the de:hub. In special innovation programs (incubators and accelerators) and using uncomplicated framework conditions, the hub develops new solutions for industry-relevant areas ranging from artificial intelligence to mobility and smart infrastructure.

At Invest BW program in particular, the current funding focus is on technological research and developments aimed at new products, new services, new business models and processes, and databased services (smart services) and service platforms across all industries. In 2022, funding will be provided in particular for innovative projects on the topic of digitization and artificial intelligence.

The Mittelstand-Digital initiative enjoys great popularity between German industry and research. Through its three interdisciplinary areas, the initiative leverages its success:

1. the Mittelstand-Digital Innovation Hubs as part of the nationwide Mittelstand-Digital network, offering various demonstration centres, networking and information events, expert knowledge, workshops, training courses, support with practical examples on the topics of digitalization;
2. the "Digital Now" investment grant program with financial support for investments in digital technologies and digital skills of employees (the funding rate is scaled according to company size); and
3. the Cybersecurity for SMEs initiative that offers tailored services to help small and medium-sized enterprises improve their IT security.

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Related to Cases and Ecosystems

In Germany, Industrie 4.0 is not only within reach of large companies, but is also being successively prepared for small and medium-sized enterprises in close cooperation. Thus, LNI 4.0 is committed to and cooperates with numerous stakeholders in this area. In particular, it offers companies and research institutions suitable access to competence centres and test infrastructures in close physical proximity. At the test centre, the LNI 4.0 members can test their ideas for technological feasibility and market readiness in practice with suitable partners without risk. In addition, LNI 4.0 offers access to ongoing test projects and experts to enable a topic-specific exchange of experience. A profound list of use cases summarizes the work and gives an overview of the achieved work. Among other objectives, important Industry 4.0 topics such as in the area of interoperability, security, artificial intelligence, 5G developments are addressed in LNI 4.0 applications.

Security and cybersecurity topics gain a very special focus throughput the practically all German initiatives, industrial associations, and organisations addressing Industrie 4.0 concepts and developing solutions. For instance, the work of the IDSA should not be missing in this context. It brings together more than 120 member organizations, i.e. companies, scientists, lawmakers and relevant stakeholders, to cooperate in an open, not-for-profit coalition creating the technical standard with a new vision for a global, digital future in Europe and worldwide. This vision includes a special framework that has been developed according to the International Data Spaces Reference Architecture Model (IDS-RAM) and that is integral to the overall EU data strategy.

The IDS standard is a central element of the GAIA-X architecture, which, in its term, also addresses data related topics. Thus, the ability to both access and share data securely and confidently is becoming more and more important in the vision of Industrie 4.0 and GAIA-X community. In this context, more than 300 companies are already contributing to the development of the federated data infrastructure, i.e. the GAIA-X ecosystem that connects centralised and decentralised infrastructures in order to turn them into a homogeneous, user-friendly system. One of the crossing points with the work of ConnectedFactories2 is the standardization aspect that belongs to one of the GAYA-X key objectives.

The research on open, cross-company solutions is still ongoing. Catena-X is definitely one of the best practice examples of how to build such ecosystems concentration on a specific application area. It establishes a global network for the automotive industry based on European values. One of the main claims in the project is data sovereignty. According to its vision, whoever makes data available should retain control and decide individually who is involved in the data exchange, how, when, and where. On this premise, the initiative develops and implements use cases for digital, end-to-end supply chains with secure, sovereign, and standardized data exchange.

2.4 Spain: Industria Conectada 4.0 and Basque Industry 4.0

2.4.1 INDUSTRIA CONECTADA 4.0

Industria Conectada 4.0 - Página Principal (industriaconectada40.gob.es)

The Industria Conectada 4.0 strategy responds to a triple objective:
1. Increase industrial added value and qualified employment in the industrial sector.
2. Favour the future industrial model for Spanish industry, to strengthen the future industrial sectors of the Spanish economy and increase its growth potential, while developing the local offer of digital solutions.
3. Develop differential competitive levers to favour Spanish industry and boost its exports.

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Based on these main objectives, a plan is developed with four lines of action and 8 strategic areas, with their corresponding actions.

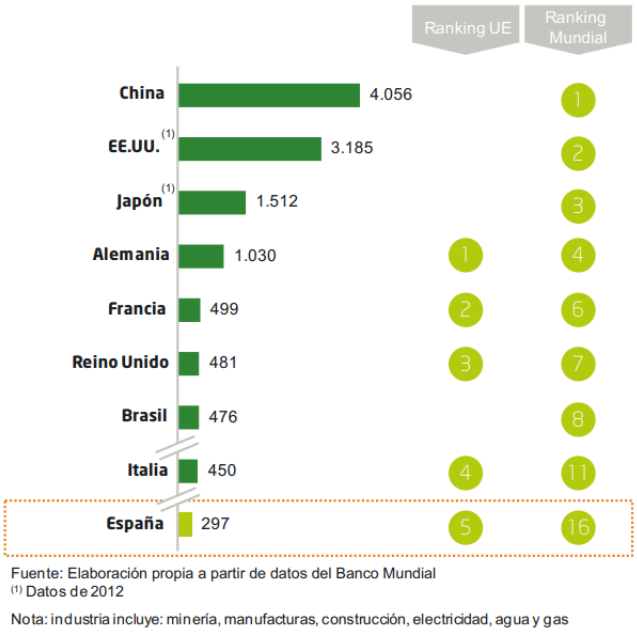


Figure 2: Comparison of Industrial Added Value

From the point of view of its role in the Spanish economy, the services sector is the most relevant, having gained weight over the years, to the detriment of construction and industry, both in generating wealth in the country and in employment. Spanish industry represents 13% of the added value of the country 5 despite having recently lost weight. Within the framework of European industrial policy, in 2012 the European Commission formulated the objective of increasing the weight of industry to represent 20% of European GDP, since having a relevant industry allows better resistance to recessions and offers a more stable and qualified offer. job. In addition, industry is the main contributor to the positive trade balance, with an average annual growth in exports of 4.8% since 2000. On the other hand, it employs 11% of the 6% of the Spanish employed population and the trend in industrial job creation is positive: it created 42% of new jobs in Spain in 2015. Thus, the discussions and developments around digital transformation of manufacturing industry is more than pertinent and so are the definitions of the CF 2 pathways.

Objectives of Connected Industry 4.0

• Increase industrial added value and qualified employment in the industrial sector

• Favour the industrial model of the future for Spanish industry, in order to strengthen the industrial sectors of the economy's future and increase its growth potential, while developing the local offer of digital solutions

• Develop differential competitive levers to favour Spanish industry and boost its exports.

Action plan

• Guarantee knowledge of the Industry 4.0 concept and its associated technologies, as well as the development of Industry 4.0 skills in Spain.

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• Promote collaboration between companies from various industrial sectors, technology companies, research centers and other entities to promote the development of 4.0 solutions adapted to the needs of the industry.

• Promote the development of a Spanish offer of digital enablers.

• Promote the appropriate actions for the implementation of Industry 4.0 in industry

Industria Connectada 4.0 makes a thorough analysis of the Spanish industry and its size. As a result, it fits in the CF2 Autonomous smart factories pathway.

After Industria Connectada 4.0, which is a 6-year-old initiative from the previous government, the existing Spanish government has created a Ministry secretary on "digitalization and AI" which is is addressing CF2 Artificial Intelligence pathway.

2.4.2 BASQUE INDUSTRY 4.0

Basque Industry 4.0 is the commitment of the Basque Country to incorporate the processes and technologies of the fourth industrial revolution into companies. Or what is the same, a public-private collaboration program to incorporate digital intelligence, new technologies, advanced materials, new processes, efficiency and sustainability to Basque industrial companies that want to integrate high value-added services.

In recent years, the Basque Country has been consolidating itself as a world reference region in new technologies for industry, being the epicenter of action for some of the main protagonists of the new industrial revolution. And these are some of the initiatives that, added to the industrial tradition, the productive fabric and the commitment to innovation; they have made it possible.

Basque Industry 4.0 is based on three pillars:

- Bind 4.0
- Basque Digital Innovation Hubs (BDIH)
- Basque Funding program

At the same time, the Basque Government has published an Agenda 2030 which is a document addressing circularity in the Basque country. It fits, along with Basque Industry 4.0, in the CF2 Circular Economy pathway.

2.4.2.1 Bind 4.0

The Bind 4.0 business acceleration program seeks companies and startups that have developed a product or launched a solution based on 4.0 technologies to accompany them in the next step. To do this, those selected have the possibility of signing contracts of up to €150,000 with leading multinationals, mentoring, training, access to grants, networking, participation in events, technological support, and workspace.

Since the first edition, 38 companies have been part of the program, developing products and solutions in the Internet of Things, big data, cybersecurity, artificial vision, additive manufacturing, virtual or augmented reality, robotics and artificial intelligence.

In this year edition focused on attracting talent, products and services in areas such as advanced manufacturing, smart energy, and health technology, it has partners such as Aernnova, Orona, Danobat,

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Biele, Maier, Fagor Ederlan, Batz, Euskaltel , Cikautxo Faes Farma, Mercedes Benz, Arcelor Mittal, ABB, Iberdrola, Siemens, Gestamp, Michelin, Cie Automotive, Repsol, Tubacex, CAF, Quirón, Sener, ITP, Sidenor or Ulma.

2.4.2.2 Basque Digital Innovation Hub

The BDIH is a network of connected advanced manufacturing assets and services that allows industrial SMEs to have the necessary technologies to face the challenges posed by industry 4.0. This collaboration network includes universities, technology centers, R&D centers and international agents from the public and private sectors that can help industries to carry out higher value manufacturing activities.

Thanks to BDIH, all Basque industrial companies (especially SMEs) have infrastructures, laboratories, equipment, software and science to embrace advanced manufacturing through training, research, testing and validation of their proposals. As the industrial companies attending have various needs in the digital transformation, the Basque Digital Innovation hub can take advantage of the CF 2 pathways in diverse ways. In particular, the BDIH nodes for data driven solutions, cybersecurity and connected machines addres the respective CF 2 pathways very well.

2.4.2.3 Programa de ayudas a la industria 4.0

The SPRI Group also offers the possibility of requesting aid for the start-up of processes related to advanced manufacturing. Specifically, its Basque Industry 4.0 program offers subsidies of up to 25% for industrial manufacturing companies to support industrial research and experimental development.

The fields addressed by this aid program are cyber-physical systems applied to advanced manufacturing (communication, cybersecurity, big data, analytics, business intelligence, etc.) which are all relevant for the CF 2 pathways.

2.5 France: Alliance pour l'Industrie du Futur

As introduced in D2.3, **The Alliance Industry of the Future** (**AIF** - http://www.industrie-dufutur.org) is an association created in 2015 and regrouping 33 active members, bringing together the actors of its four Colleges: professional, technological, academic and funding organizations. Its role is to support French companies, in particular SMEs, in the modernization of their industrial tools and transformation of their economic models with new technologies, in particular digital. Beyond innovation, the AIF considers the integration of people with their know-how, skills, and interpersonal skills as a major element in the success of the modernization and transformation of SMEs.

As introduced in D2.3, the **"Vitrine Industrie du Futur" label** (https://vitrinesindustriedufutur.org) distinguishes emblematic French industrial achievements for showcases. Since December 2020, when D2.3 was written, 16 new companies have been showcased in France, with a total of 108 showcased companies in August 2022. Among these recently showcased companies, we can find illustrations of Connected Factories 2 pathways, such as:

- Autonomous Smart Factories:
  - Lisi aerospace is the world specialist in fasteners and structural components for the aeronautics market. Lisi deployed new simulation tools and methods allowing to considerably reduce the time and cost of product development as well as to drastically

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optimize the associated manufacturing operations. http://www.industrie-dufutur.org/actualit%C3%A9s/laif-labellise-6-nouvelles-vitrines-industrie-futur/

- Soitec is a Grenoble ISE, world leader in innovative materials for the semiconductor industry. They have implemented innovative means of data processing and storage, statistical analysis, servo loop, control and management devices that have enabled the industrialization of the production of this complex product.
- Viwamétal provides its industrial customers with its know-how and its means of production in fine sheet metal work. In less than five years, Viwamétal created ex nihilo a whole digital suite completing an old but insufficient ERP structuring, in order to respond to growing complexity and guarantee its responsiveness. The results are there: reduction of the mental load, the production staff is the driving force behind beta testing; Customer emergencies immediately transmitted: deadlines can be communicated in real time; Reversibility of all command parameters instantly; Ability to offer IT consulting in addition to sheet metal work; Automation of controls, eradication of input errors, quality rate close to 99%; Reduction of input times by three and methods by 30%; Instant access to costing reports. http://www.industrie-dufutur.org/Vitrines/viwametal-vitrine-industrie-futur/

- Collaborative Product-Service Factories
  - Someflu is an industrial SME specializing in the design and manufacture of centrifugal pumps of standard catalog construction or made to measure. economy of use, by aiming for an optimized total cost of ownership of the machine over time. This ambition requires a profound transformation of digital tools, and purchasing practices governed by human beings, still at the center of the industry of tomorrow. http://www.industrie-dufutur.org/Actualit%C3%A9s/laif-labellise-6-nouvelles-vitrines-industrie-futur-2/
- Dataspaces
  - Siemens Haguenau has a factory which today produces pressure transmitters, flow meters and gas analyzers. This requires a coherent implementation of several "Industry 4.0" technologies, and in particular the use of data, through the Siemens IoT platform to carry out predictive maintenance, improve product quality, or even reduce energy consumption. This digital strategy has a strong participatory dimension, and is based on the involvement of employees. https://vitrinesindustriedufutur.org/vitrine/siemens/
- Circular Economy:
  - Recytech specializes in the treatment and recovery of industrial residues containing zinc. The circular economy has become its priority and multiple strategic projects have thus been initiated and implemented thanks to digital transformation, the development of industrial partnerships and R&D programs around co-products, material flows, metallurgy or even energy. http://www.industrie-dufutur.org/actualit%C3%A9s/labellisation-de-4-nouvelles-vitrines-industrie-futur/
  - The L'Oréal plant located in Vichy initiated the "ARIA" approach 2 years ago: Agile, Responsible, Irreproachable, “Accueillant” (Welcoming). Its vision: to place the environment and people at the heart of their projects. L'Oréal has thus forged partnerships with start-ups and large groups to deploy, with technological innovations, their environmental and societal responsibility. A focus is given on water (100% of the washing water comes from the recycling of their effluents), the control of electricity consumption thanks in particular to the installation of solar panels, the use of rapeseed fuel produced in France, and the ergonomic dimension of the investments, with the establishment of training in virtual reality. http://www.industrie-dufutur.org/Vitrines/loreal-site-de-vichy-03-allier-labellise-vitrine-industrie-futur/

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In April 2021, in a process of structuring the sector, the "**Solutions for the Industry of the Future**" (**SIF**) sector was set up within the framework of the National Council for Industry, to promote the French offer of machines and production connected solutions and encourage industrial companies to make use of it. The Industry of the Future Alliance (AIF), which brings together the ecosystem of manufacturers making up the new sector, has become its supporting association.

The SIF sector thus gives visibility to the providers of solutions at the service of other sectors, by setting up an open community, in particular thanks to the sector's digital platform - www.solutionsindustriedufutur.org - which facilitates connections and exchanges between demand and supply of Industry of the Future Solutions.

32,000 companies are part of this new Industry of the Future Solutions Sector, which holds the 3rd place in terms of industrial GDP (€36 billion in added value), and has 500,000 employees who work together to enhance the French Industry of the Future offer (hardware and software). This necessary inter-sector collaboration brings together the appropriate ecosystems in order to wisely integrate the technological revolution driven by French companies: 5G, system interoperability, digital continuity, AI, collaborative and mobile robotics, additive manufacturing, 3D design, simulation / digital test / validation…

In addition, a new Industry of the Future Solutions Accelerator aims to help high-potential companies structure their development in order to maximize their growth. This system adapts to the specificities of companies in the new Industry of the Future Solutions sector by providing them with responses adapted to their situation in order to increase their commercial performance, adapt their offers to new market needs and structure a network of powerful and competitive solution providers (hardware and software).

In this context, twenty-one French SMEs are preparing to follow an 18-month support program, financed by the Future Investments Program (PIA), combining personalized advice, training, days dedicated to the sector and networking, in order to offer managers all the tools they need to reach their full growth potential.

2.6 Hungary: IPAR4.0 National Technology Initiative

2.6.1 Industrial Policy and Economic overview

The Hungarian Government intends to facilitate the digitisation of industry and In order to achieve this goal, traditional industries and existing business models need to be transformed since innovation is the key to value creation. Hungary needs to move forward from mass production to a country that offers quality, added value, and knowledge in conformance with its role in the global value chain – and the application of Industry 4.0, i.e. Connected Factories achievements are undoubtedly the decisive elements of success.

In order to meet the challenges of Industry 4.0 and taking into account local specificities, Hungary has developed its reindustrialization strategy and its complex set of tools, which is identified as the Strategic Program for Innovative Industrial Development, named after János Irinyi. In line with the European Union reindustrialization strategy, the focus of the Iriny Plan is on machinery and vehicle manufacturing, the health and green economy, the food industry, the defence industry, and the ICT sector.

Regarding digital policies, the National Digitalisation Strategy provides the strategic policy framework for 2021-2030. It is an umbrella strategy which groups, clarifies and, in some cases, complements the measures contained in various other strategic documents. The strategy is structured around the four main pillars; digital

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infrastructure, digital skills, digital economy and digital state. Hungary has the very ambitious and challenging aim of exceeding the EU average in digital development by the middle of the decade and of being among the 10 leading EU economies in terms of digitalisation by 2030.

The significant proportion of enterprises registered in Hungary are SMEs (99,1 %), that is much higher than the EU average, so their development is highly important, thus the development strategy has targeted interventions at all stages of the business life cycle (startup, growing, mature, renewable, declining) and the associated financial resources. SMEs require a special policy focus, as only 34% of them have at least basic level of digital intensity (EU average: 55%), as opposed to the Digital Decade target of at least 90%.

The Hungarian industrial community reacts flexible on the challenges and their effects (like COVID pandemics, Russian–Ukrainian war) and traces the new technology trends and directions of applications (emphasized focus on AI technologies). E.g. as a consequence of Russia- Ukraine conflict, the overall threat level in cyberspace has increased. The National Cybersecurity Centre (NCSC) is, therefore, monitoring the Hungarian cyberspace in an increased preparedness mode on a 24/7 basis and has also informed government agencies and critical infrastructure operators of the increased risk-level

The key issue of the Industry 4.0 paradigm is the existence and competitiveness of smart factories, which is why the pathways identified within the connected factory are so important. In addition to Irinyi Plan a lot of initiatives have been taken in several areas. The following are the most related to this project:

2.6.2 Digital Success Programme 2.0

The Digital Success Programme intends to contribute to Hungary's preparation for the digital transformation in new areas. In addition to making the Internet accessible and affordable for everyone, and besides infrastructure development the digitalisation of education, and other ongoing programmes are in the field of activity. The Hungarian Government decided to extend the Digital Success Programme and to accept Digital Success Programme 2.0., which is a strategy for gaining digital advantage, as its digitalisation-supporting programmes cover almost every field of the digital development of the Hungarian economy, the operation of the state, and the Hungarian society. Digitalisation is the largest economic development program of the coming decade and one of the most important means to achieve success and growth. DJP2.0 sets out 89 actions in 26 thematic areas along five pillars.

2.6.3 DJP2030 - Digital Government

One of the main tasks of DJP2030 is to propose new solutions and institutions that can effectively interpret and address the global challenges and opportunities created by digitalisation in international cooperation. The starting point of DJP is that the state is also responsible for the digital well-being of its citizens, therefore the central theme of the DJP2030 is digital state governance. The DJP2030 defines its strategic goals and areas of intervention in a triple division, in relation to the human-machine system. In 2020, several key strategic documents prepared within the framework of the DJP2030 will be submitted to the Government, such as the Artificial Intelligence and Sport Strategy of Hungary and the Action Plan of the Digital Agricultural Strategy.

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2.6.4 Public Benefit Nonprofit Ltd. - IFKA

The activities of IFKA can be divided into three categories: management, key- and support processes. Management processes include e.g. strategic and business planning, business development; key processes include e.g. economic development, employment expansion, logistics, research and development, green economy; while supporting processes are e.g. procurement, asset management, finance, IT, HR, communication and legal affairs.

IFKA is the operator of the Modern Model Factory Program I. (previously: Industry 4.0 Model Factories), a flagship project aimed at bringing the opportunities offered by industry 4.0 to SMEs in the convergence region, leading them onto a development path. From 2020, the program aims to promote and support the organizational renewal and technology change of micro, small and medium-sized businesses, thus improving competitiveness, developing an entrepreneurial environment and culture. In addition to its knowledge-based, development services, as part of the approach to raise awareness, it organizes the Modern Factories' Night each year for the general public, which has become a priority government program with a special focus on SMEs, industrial workers and young people about to make a career choice.

2.6.5 The Industry 4.0 National Technology Platform Association (I4.0 NTP)

The Industry 4.0 National Technology Platform **Association** - was established in May 2016 under the leadership of the Institute for Computer Science and Control (SZTAKI), Hungarian Academy of Sciences, with the participation of research institutions, companies, universities and professional organizations having premises in Hungary, and with the full support and commitment of the Government of Hungary**.**

The main goals of the Platform are:

- to assist the actors in recognizing the paramount importance of the I4.0 paradigm, especially SMEs constitute the target group since they, as being in the supply chain of market leader international manufacturing companies, play a fundamental role in strengthening the competitiveness of the country,
- to propagate the new digitisation technologies,
- to facilitate the development of the digital competencies.

The Platform should be regarded as the catalyser of performing high added value research and development work in Hungary and an essential tool for preparing the industrial sector for adapting to the requirements of innovation and to contribute to the overall success of the national Industry 4.0 program.

The NTP reacts flexible to the new challenges as well and develops strategic studies for the economical, industrial leaders e.g. in case of COVID pandemics.

- The direct and long term effects of the COVID-19 pandemics on the machine industry and the connected logistics, Industry 4.0 National Technology Platform, 2021. (in Hungarian).
- National I 4.0 strategy for the competitive and sustainable economy, Industrial development strategy focusing on robotics and automation aspects, for the Ministry of Innovation and Technology, (2021). Industry 4.0 National Technology Platform, (in Hungarian).

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2.6.6 5GK - Hungarian 5G Coalition

The 5G Coalition in Hungary was formed on 19 June 2017 with the participation of forty-six governmental and market participants, professional and advocacy organizations, universities, and scientific organisations.

The goal of the Hungarian 5G Coalition (5GC) is to become one of the European centres of 5G developments and to play a leading regional role in the development and testing of 5G-based applications. The 5G mobile is able to provide wide bandwidth in all fields of life, creating the infrastructural background for high-data developments

The latest generation of mobile networking technology, 5G, opens up completely new dimensions in mobile data transmission. Hungary has the world's leading 4G and 4G + mobile networks, so Hungary in a good position to gain a competitive advantage by taking the lead in 5G mobile developments in the next phase of the digital transformation. As an example, the Zalaegerszeg automotive test track, which is also unique in Europe and suitable for testing self-driving vehicles, has been completed in Hungary. This environment is suitable for testing 5G grid-connected vehicles in the field of intelligent transport and modeling traffic situations in a live environment.

2.6.7 Artificial Intelligence Coalition

The Hungarian Artificial Intelligence (AI) Coalition was founded upon the initiative of the Ministry of Innovation and Technology under the Digital Success Program as an expert and consultation forum of the local AI ecosystem.

AI coalition platform connects stakeholders in business, research, academia and government in the field of artificial intelligence to prepare the Hungarian economy and society for the AI revolution. The AI Coalition released an Action Plan in October 2019, and then in 2020 it drew up Hungary's AI Strategy for the Hungarian Government.

The mission of the AI Coalition is to

- propel Hungary to the European forefront in the area of AI developments;
- strengthen the competitiveness of domestic enterprises through extensive dissemination and utilization AI-based use-cases;
- facilitate the participation of Hungarian start-ups and SMEs in AI development activities in partnerships with large enterprises, universities or international partners;
- make sure that the government, as a user of AI-powered solutions, should be actively engaged in developing the local AI ecosystem by systematically utilizing the national data asset pool.

AI coalition is continuously expanding. Among members are from the top of the local business and research communities as well as academia and government; altogether 385 member organizations, 900+ experts and 6 working groups.

2.6.8 Autonomous Systems National Laboratory

The Autonomous Systems National Laboratory aims to provide effective and innovative solutions for research tasks, relying on the available expertise, technical equipment and relevant research results in an integrated way with a focus on-road vehicles, aircraft and mobile robots. The generated research results and know-how not only help to increase the added value of the domestic automotive industry but, through the

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communication of the results and the promotion of closer collaboration between industry and academia, it will also raise public confidence in autonomous vehicles.

Research and development in cyber-physical production systems made up of autonomous elements focus on the following research activities:

- autonomous robotics, including in particular human-machine interaction and collaboration;
- internal logistic system comprising autonomous vehicles;
- digital twin models and integration of the above systems;
- industrial data analysis;
- reliability identification and control of autonomous systems using the stochastic methods of machine learning;
- setting up a production and logistic lab organised from autonomous elements.

In the above fields, research is motivated by practical industrial needs, so the Laboratory intends to develop evidence-based solutions to complex problems such as the people-centred automation of production systems, human-robot collaboration, autonomous internal logistics, supported by digital twin modeling, and continuous adaptation through industrial data analysis.

2.6.9 Artificial Intelligence National Laboratory (MILAB)

The Artificial Intelligence National Laboratory (MILAB) aims to strengthen Hungary's position in AI. The international and domestic environment of AI is characterized by competition for professionals, opportunities for disruption, and quick product launch time. The European Union is making serious efforts to catch up with US and Chinese development capabilities and MILAB joins to this line.

MILAB is founded in 2020 as the coordinated national artificial intelligence umbrella for the collaboration of all major research centers, universities and large-scale national programs. MILAB adds business needs and international research relations by leveraging on the existing relationship of its partner institutions and strengthens social innovation to embrace technological innovation.

Research in MILAB is initiated by integrating flagship projects in medical image processing, transportation, manufacturing, privacy/security, logistics, and by relying on internationally renowned Hungarian mathematicians and physicists among others in the areas of graph theory and network science.

Objectives and Tasks of MILAB:

- Funding for flagship basic and applied research projects (publications, patents, emerging industrial relations, technology transfer).
- Networking, strengthening synergies between actors, representing competencies in industry and international projects.
- International relations, interconnected research ecosystem.
- Source multiplication, funding for risky or high societal utility research
- Coordination with market and application needs, organization of demos and conferences.

The MILAB research plan follows the Hungarian National Artificial Intelligence Strategy (2020-2030) and implements its research components. Stakeholder needs and requirements from industry, society and government are considered in the cooperation of the MILAB Project Office and the Hungarian Artificial Intelligence Coalition Program Office.

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2.6.10 Industry 4.0 Technology Center (ITC) at the Budapest University of Technology and Economics

The goal of the ITC is to show different I 4.0 solutions for as many visitors as possible creating with this activity a live „Industry 4.0 marketplace" where new projects can be organized supporting the development of Hungarian SMEs, the Hungarian industry.

The technologies demonstrated and applied in the projects organized by the ITC are; IoT (Internet of Things), Big Data, Digital Twins, 3D printing, Automated Guided Vehicle (AGV), RFID (Radio Frequency IDentification) and artificial intelligence based applications.

2.6.11 Eötvös Loránd University (ELTE) Department of Artificial Intelligence

The department focuses on human-centered Artificial Intelligence (AI), on a trustworthy, ethical technology that enhances human capabilities. The mission is to empower citizens and society to benefit from the AI revolution and to avoid the challenges of our age.

The activities are going on with a diverse set of technologies, like Deep Learning, Evolutionary Technologies, Embodied and Societal Intelligence.

The cooperation between ELTE and Bosch is a new structure in AI field. It is believed that industry-academy collaboration is the most fruitful driver of research and technology education that combines scientific rigour with practical relevance. This creates synergies that result in excellence not only in research and education, but in innovation as well.

2.6.12 Connection to the Pathways

The following table present the relevance between each initiative and the predefined pathways.

Initiative	Autonomous Smart Factories	Hyperconnected factories	Collaborative Product-service	Dataspaces	Circular economy	Cyber security
Digital Success Programme 2.0	X		X	X	X	
DJP2030 - Digital Government	X		X	X	X	
Public Benefit Nonprofit Ltd. - IFKA	**X**		**X**	**X**	**X**	
Industry 4.0 National Technology Platform Association	X	X	X		X	
Hungarian 5G Coalition	X	X		X		X
Artificial Intelligence Coalition	X	X		X		X
Autonomous Systems National Laboratory	X	X	X	X		X
Artificial Intelligence National Laboratory	X	X		X		X
Industry 4.0 Technology Center	X	X	X		X	
(ELTE) Department of Artificial Intelligence	**X**	**X**		**X**		**X**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

2.7 Italy: Industria 4.0

In previous deliverable D2.3, the "Piano Industria 4.0" has been described as well as its network of Competence Centres and Digital Innovation Hubs.

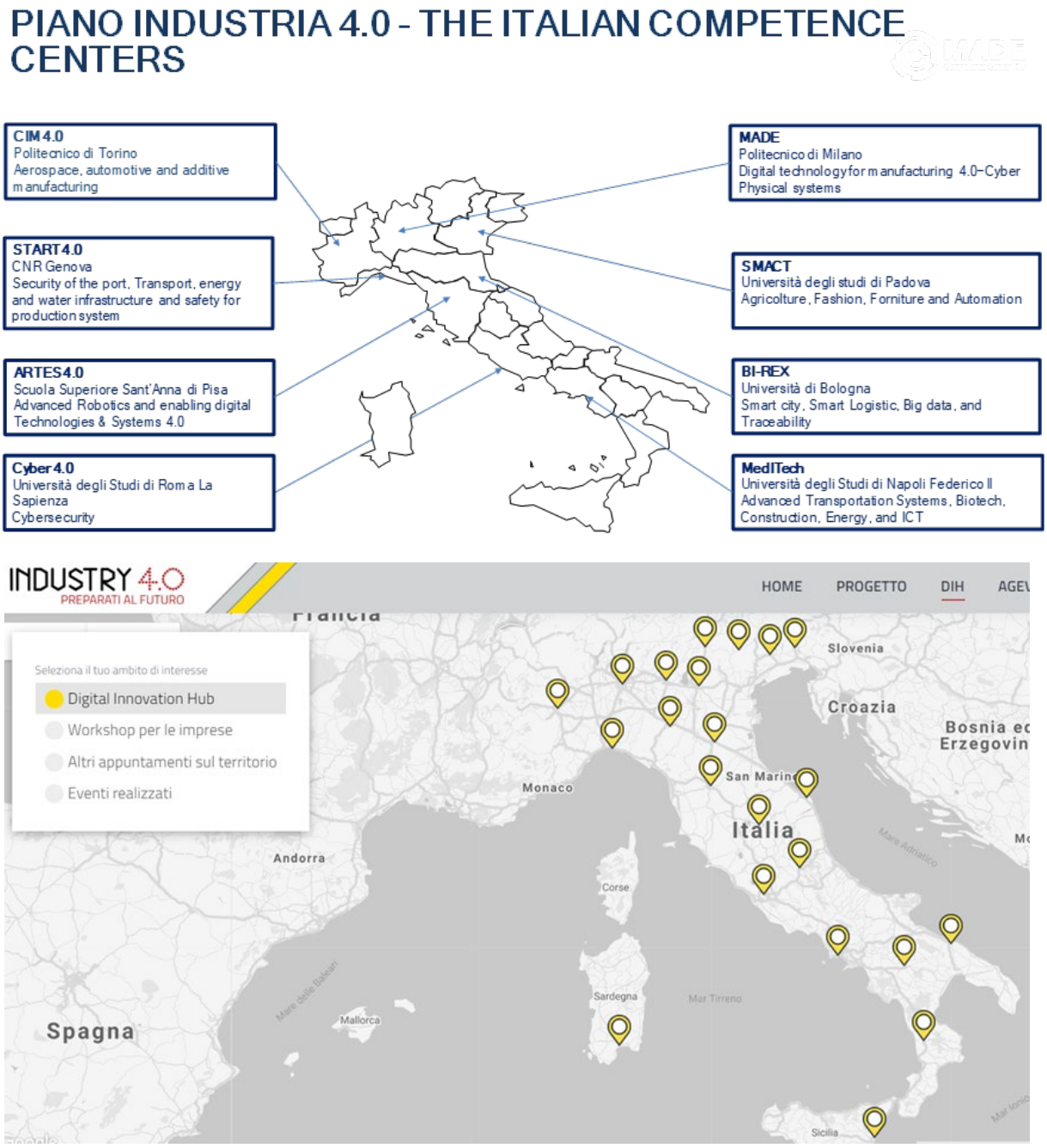


Figure 3: Competence Centres and Digital Innovation Hubs in the Italian Industry 4.0 Plan

In particular, among the 9 Competence Centres and the 22 regional Digital Innovation hubs, In D2.3 we proceeded with a more detailed description of **MADE competence centre** in Milano (Digital Manufacturing and Cyber-Physical Production Systems for I4.0) and the **DIH Lombardy** (territorial Confindustria association).

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MADE six physical **Technological Islands** (Virtual Design, Smart Logistics, Energy Monitoring, Zero Defect and Additive Manufacturing, Collaborative Robotics and Cyber Secure Data Management) are providing **TEF** (Testing and Experimentation Facilities) services – orientation, training, consultancy, business strategy, proof of concept, test before invest – to manufacturing companies, in particular to SMEs.

DIH Lombardy is instead focussing on creating awareness and increasing adoption of Digital Technologies in Lombardy manufacturing industry, especially SMEs, by means of assessing the enterprise digital maturity ("Testindustria 4.0") and of tailoring and supporting the implementation of a transformation roadmap, in order to provide them with a picture of their current position in the I4.0 scenario.

In the last period since D2.3, both MADE and DIH Lombardy have been deeply involved in the preparation of the **Digital Europe Programme** calls about **European Digital Innovation Hubs** (the EDIH Lombardy proposal) and **AI TEF for Manufacturing** (the AI MATTERS proposal), where the **CF2 pathways of Data Spaces and AI for Manufacturing** have been extensively exploited in order to identify, design and develop the ecosystem of digital services for manufacturing SMEs. This is reported in the following §2.8.1 and §2.8.2.

Regarding the **CF2 Circular Economy pathway**, Lombardy Region elaborated recently its **Research and Innovation Roadmap for Circular Manufacturing** where the assessment of readiness levels, the identification of circularity gaps and the development of improvement plans and measures is identified as a necessary precondition for a sound and safe implementation of sustainable, resilient and circular manufacturing value chains. This will be reported in §2.8.3.

2.7.1 Regione Lombardia project for the EU Digital Innovation Hubs call and CF2 DS Pathway

The **CF2 Data Spaces** pathway has a twofold perspective in this initiative: on the one side it is able to understand for each of the MADE Technological Islands involved in the experiments the current (as-is) and required (to-be) level of Maturity in terms of **Data FAIRness** (Findable Accessible Interoperable Reusable), **Industrial Data Platforms openness** and **inter-company data sharing policies and agreements**. On the other side, the same exercise can be replicated for the SMEs accessing the DIH Lombardy digital maturity assessment methods and tools (Test Industria 4.0). In synthesis, the CF2 DS Pathway represents a valid instrument to position the target manufacturing SMEs in a perspective of "Data Economy and Data as a Product" business model.

EDIH Lombardia (EDIH L) is one of the Italian European Digital Innovation Hubs awarded Seal of Excellence by European Commission

The mission of EDIH Lombardia (EDIH L) is to lead and implement digital-sustainable twin transition of Lombardy manufacturing industry.

EDIH Lombardia objectives are:
OB1.Increase digital technologies adoption, supporting the understanding of digital transformation paradigm and technologies and the implementation of project solutions for manufacturing industry and PA;
OB2. Support digital skills development, as a consequence of the need for specialized operators, technicians and managers responding effectively to global changes, requiring new professional figures;
OB3. Foster innovative business model adoption, allowing the implementation of digital transformation projects and transfer to market of the results;
OB4. Integrate digital European value chain, with complementary sectoral and technology expertise, to integrating supply chain for distributed and collaborative manufacturing;

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EDIH Lombardia is composed a **consortium of 15 partners**: 1 Competence Center, 1 Digital Innovation Hub, both acknowledged as DIH in JRC catalogue, 5 Regional Technology clusters, 4 Business Association, 2 Financial Institutes and 2 European Institute of Technology nodes (Figure 5 EDIH Lombardia consortium).



Figure 4 EDIH Lombardia consortium

EDIH L will spread and make use of the **capacities of Digital Europe Programme**[21] (Figure 6) by:

- *Know, implement, transfer* to market deploying the EDIH services portfolio through Test Before Invest, Skills and Training, Access to finance and Innovation ecosystem and network services.
- *Multiply* such capacities in Lombardy territory cooperating with Lombardy digital innovation ecosystem, including regional technology clusters. EDIH L will utilize DTA "Train the trainer" programme, networking tools, sharing approaches with other EDIHs, make use of existing methodologies developed by relevant EU projects (e.g. AI4EU, AI Regio) to diffuse, accelerate the best use of digital capacities.
- *Connect* to DIGITAL Cybersecurity and HPC competence centres to raise SME awareness on those technologies and access tech expertise in case EDIH lacks it. It will enhance EDIH L service portfolio (e.g., access to HPC infrastructure for calculation power, engage in large scale R&I projects; request for trainer on vertical CS topic), avoiding overlap with existing activities.
- *Engage* Lombardy SME with the necessary digital maturity, gained with EDIH L support, in DIGITAL initiatives aiming at implementing Digital Europe Capacities such as testing the future AI Testing and Experimentation Facilities, and the training of the Advanced digital skills project.

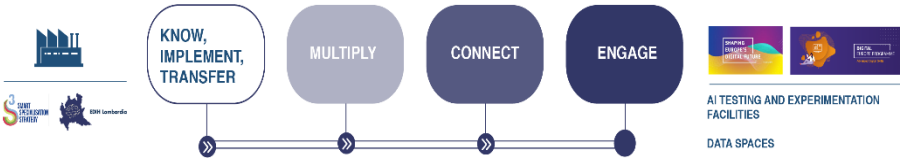


Figure 5: Shaping Lombardy's digital future: EDIH L methodology to spread DIGITAL capacities

In addition, EDIH L actively contributes to policy objectives at European, national and regional level including **European Data Strategy**, fostering the industrial and commercial use of data and creation of an EU single market for data experimenting the potential of data spaces within cross regional manufacturing value chain;

[21] SO1-HPC, SO2–Cybersecurity and trust, SO3-Artificial Intelligence, SO4–Advanced Digital Skills, SO5–Best use of digital capacities

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To accomplish this, the complementary expertise of the EDIH L consortium allowed to define a **service portfolio** (Table 1) to be customized in coherence with the needs and digital maturity readiness of the customers, in particular manufacturing SMEs. EDIH L services and activities relies on technology use cases, available at MADE Competence Center (see Sect 2.8). EDIH Lombardia will deliver service through a tailor-made *customer journey* defining the most effective service pipeline for end user and technology providers leveraging existing methodologies (e.g. AI Regio project).

Table 1: EDIH Lombardia service portfolio

Activity	Services
TEST BEFORE INVEST	1.Proof of concept
	2.Industrial Pilot
	3.Technology Verification
SKILLS AND TRAINING	4.Skills Assessment
	5.Learning experience
	6.Train the trainer
	7.Teaching Factory
ACCESS TO FUNDS	8. R&I Funds screening
	9. Project implementation
	10.Go to market
INNOVATION ECOSYSTEM AND NETWORK	11.Digital Strategy Roadmap
	12.Tech scouting, trend watching
	13.Value chain digitization

Specifically to support the adoption, validation and market scale up of digital technologies of both end users and technology adopters, EDIH L **Test Before Invest** set of services ensures *Access to EDIH L testing facilities* providing technological and methodological environments and tools to practically test the concept (e.g., renting equipment, lab facilities, support to low-rate production). EDIH L test before invest services includes:

1.1 Proof of concept, to understand the conceptual and technical feasibility of adopting a new digital technology in an existing process, such as manufacturing data spaces. It includes *design of experiment concept development and validation*, *development of minimum viable products* to be demonstrated with real customers.
1.2 Industrial pilot to optimize and scale up digital technologies already implemented at industry premises. EDIH L support the *codesign and optimization of requirements*, *demonstration*, *demo-cases* to demonstrate in front of customers and prototyping (if appropriate). *Industrial validation* at customer pilot line and *industrial consulting* aims at supporting industrial uptake.
1.3 Technology verification to verify the correct execution of the digital solution provided by technology developer (e.g. system integrator). It encompasses solution *qualification.* and *demonstration* and demo-cases to demonstrate the product to customers.

Such services will eventually be implemented with SME and evaluated to assess the short term and long-term impact.

2.7.2 AI MATTERS Italian Node for the AI TEF for Manufacturing call and CF2 AI4Man Pathway

The **CF2 AI for Manufacturing** pathway envisages different increasing levels of autonomous behavior in the **Human-AI**, **Human-Machine** and **Human-Robot** interaction. The most relevant level in the AI MATTERS (the Italian node proposal in AI TEF for Manufacturing) perspective is **MAL4** (Manufacturing Autonomous Level 4) where the interaction between humans and intelligent systems can be modelled and simulated as a real Collaborative Intelligence or Mixed Team in the decisional processes. Moreover, level 4 can also generate interesting considerations about ethical and regulatory issues concerned with Wellbeing, Inclusiveness, Safety and Ergonomics (WISE) of the workers.

The overarching objective of the AI-MATTERS proposal is to implement concrete steps towards strengthening of Europe's positioning and leadership in the uptake of human-centric Artificial Intelligence systems that can enable robotics and other advanced technologies to create leap transformations of the EU manufacturing system. More specifically, **AI-MATTERS project sets out**: i) to create a world-class cluster of large-scale reference sites for testing and experimentation of AI-powered solutions; ii) to enable pathways to impact for

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the deployment of trustworthy, transferable and scalable Industrial AI in Europe; iii) to help accelerating the transition towards a more AI-driven manufacturing industry that can improve the quality and sustainability of production; iv) to advance technologies and capabilities in and across the main themes identified as the scope of this sectorial TEF programme: factory-level optimization; collaborative robotics; circular economy; any other impactful topics helping adoption of AI-enabled technologies in manufacturing; v) to establish/enrich collaborative links/synergies with other EC-funded networks and programmes. Once operational, AI-MATTERS network will have seven "nodes" offering both physical and digital services across the Czech Republic, Denmark, France, Germany, Italy, Spain and the Netherlands with several node-members connected to the main nodes.

The **Italian node** is composed by MADE Competence Center; ENG Engineering Ingegneria Informatica; Fondazione Bruno Kessler contributing to the three AI domains indicated in TEF. The main activity areas are:

- factory level optimisation
- collaborative robotics
- circular economy



2.7.3 Regione Lombardia Circular Economy R&I Roadmap and CF2 Circular pathway

The **Lombardy Roadmap for Research and Innovation on Circular Economy** intends to provide a framework for the development of a sustainable, low carbon, resource efficient and competitive strategy for the transition to a more circular economy in the Lombardy Region, under a smart specialization perspective. It represents a versatile cultural and technical reference that can stimulate the cooperation between public and private stakeholders with the aim to build strategic initiatives on circular economy.

Based on the priorities of the roadmap, which are widely shared among regional stakeholders, private and public investors can cooperate to support emerging initiatives with financing instruments which include public administration incentives and innovative additional financing tools.

The elaboration of this roadmap started in 2019, seeking the challenge of the Lombardy's Smart Specialization Strategy (in brief S3) to give answers and, where possible, anticipate market changes, to address new social and cultural needs. In particular, after the third update of Lombardy S3, formalized in DGR X/7450/2017, **Circular Economy** has been introduced as one of the main drivers to foster the development of mature into emerging industry in the Region.

Accordingly, the Roadmap has been recognized as an opportunity to define a structured strategy to boost circular economy in the region starting from the needs and the priorities collaboratively pointed out by diverse regional stakeholders.The roadmap describes in detail the methodology implemented for the definition of regional R&I priorities related to circular economy.

As reported in the figure below, it consisted in a mixed top-down/bottom-up approach which was adapted from the already tested and consolidated approach developed by the Italian National Technology Cluster on

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Intelligent Factory, in cooperation with AFIL - Lombardy Intelligent Factory Association, and applied for the definition of the national Roadmap on Intelligent Manufacturing. Research and innovation priorities were described with reference to the Circular Economy Value Chain Model entailing all lifecycle phases, from production to recycling.

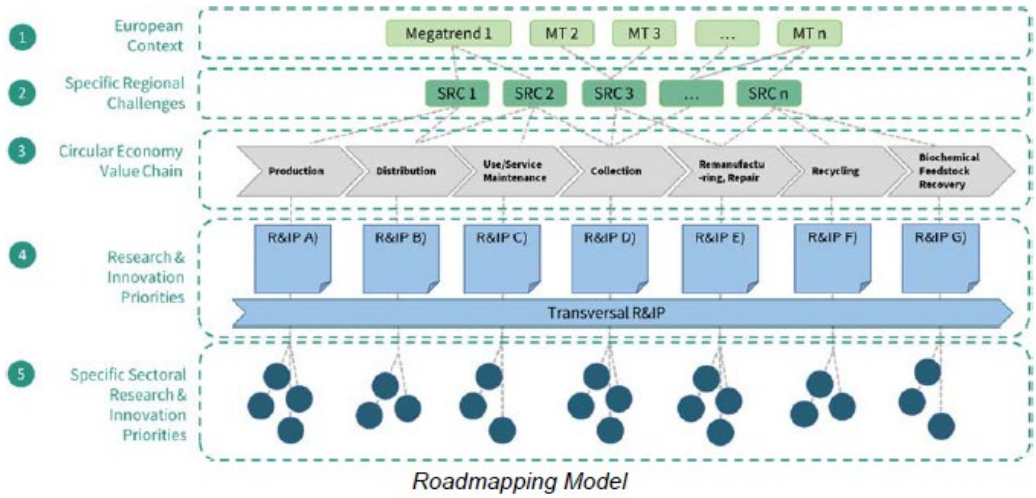


Figure 6: Roadmapping Model

According to this methodology, the R&I priorities were identified combining specific sectorial economy challenges deriving from the regional smart specialization (bottom-up approach) with the broad international and European megatrends and research directions (top down approach). The Roadmap considers the 7 Specialization Areas of Lombardy's S3 (Aerospace, Agro-food, Eco-industry, Creative and cultural industries, Advanced manufacturing and Smart Mobility), highlighting the cross-sectoral potential of Circular Economy topic.

The resulting set of Research and Innovation priorities is summarized in the following table and are described in detail in the roadmap explaining motivations and technical challenges.

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A. Production	B. Distribution
• Design for Circular Economy • Circular Production Processes • Enabling traceability in product and processes • New Cross-Sectorial Business Models for Circular Economy • Support to CE Oriented Production	• Establishment of Synergies Among Forward and Reverse Logistics • Development of Market/Pricing Strategies to Increase the Willingness to Buy of Sustainable Products • Exploitation of Local Production-Distribution-Consumption Networks • Circular Economy Driven Public/Private Procurement
C. Use and Service	**D. Collection**
• Product Life-Cycle Extension • Product-Service System	• Reverse Logistics • Citizens engagement and incentives
E. Remanufacturing / Repair	**F. Recycling**
• Innovative Remanufacturing Technologies • Distributed and Flexible Remanufacturing Networks	• Innovative technologies for sorting and recycling
G. Biochemical Feedstock Recovery	
• Development of New Biotechnologies • Valorise bio-waste to support the transition from fossil-based to bio-based processes	

In addition to value-chain based priorities, the Roadmap highlights the need of focusing on a set of **non-technical priorities** to favour the transition to Circular Economy enabling the adoption of systemic approach rather than the implementation of incremental improvements to the existing linear model. Those priorities, summarised as *Legislation and Regulation, Piloting and demonstration infrastructures, Education and skills, Awareness and culture* and *Ecosystem building* have been detailed in terms of recommendations and strategic actions to be implemented by several stakeholders (from policy makers to industrial associations, from universities and research bodies to companies). Therefore, this Roadmap will serve as guideline for Lombardy Region to further strengthen its Smart Specialisation Strategies and update its policies with regional innovation ecosystem needs. To this end, updates will be constantly delivered in alignment with new programming periods and in coordination with Smart Specialisation and Sustainable Development Strategies. Furthermore, the document will be also exploited to identify synergies and complementarities with other regions in terms of R&I priorities, thus establishing strategic collaborations in specific domains based on S3 strategies.

The **CF2 Circular Economy pathway** represents a valuable complementary tool to a CE Roadmapping exercise, as it enables to assess the current maturity of a manufacturing company in applying CE strategies. More in detail, the maturity scale that has been developed within the CF2 project is based on the 5 levels of maturity which are evaluated along the value chain as reported in the table below:

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Table 2: 5 levels of CE maturity evaluated along the value chain

Linear value chain	Linearity	Industrial CE piloting	Systemic material management	CE thinking	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. **refuse**? 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. **PRethink?**	Environmental impact assessment is a driving force of product development (eco design). Products are designed to avoid loss and premature end-of-life. The disassembly is considered in the product design. **PRethink?**	Products are fully circular by design, enhancing purpose-based durability during the life-cycle and enabling multiple **reuse, repair, remanufacturing, refurbish** and **recycling** at end-of-life.
Sourcing	No actions to **reduce** the consumption of energy and/or materials are being implemented. Materials are sourced based on performance and price.	Company seeks to minimise inputs of energy and materials. **Reduce**. Material sourcing is being shifted from unsustainable to sustainable raw materials.	Sourcing is based on code of conduct guidelines for circularity and the sustainability of materials. The amount of waste is minimised and side streams are utilised. **Reduce, reuse, recover**	Raw materials are sourced mainly from known and monitored secondary markets and through **reverse** logistics. Social impacts are considered in the sourcing process. **PREthink, recover, refuse and reuse**?	Full circularity is enabled by sustainable materials that have less environmental impact (on biodiversity, climate change, acidification, etc.) than traditional counterparts. **Recycle, reduce, recover**
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. **reduce**	Production-on-demand allows the company to limit inputs and to reduce outputs, avoiding unnecessary use of raw materials, water and energy. **Reduce** Zero defect goal	Circular production is reconfigurable, i.e. responsive for variations of orders, materials, products, market changes, systemic shocks etc. **remanufacturing,**	Production is environmentally sound, which is enabled by close monitoring of the environmental impacts of production processes. **Reduce, reuse, recycle…**
Logistics and delivery channels	Company has no goal to optimise logistics.	Logistics optimisation pilots are taking place. **reduce**	In addition to deliveries, logistics covers raw materials, waste and used products. **Reduce, reuse**	Linear and **reverse** logistics are considered with partners. Traceability of products is implemented. **Reduce, reuse**	Value chains are localised, and closed loops are implemented. Transparency of products, production and logistics is enabled. **Reduce, reuse, recycle** Product-as-a-service and X-as-a-service approaches are implemented.
Marketing and sales **Customers -> Stakeholders communication**	Company has not included CE sustainability viewpoints in their marketing activities.	Communication of CE piloting activities is planned as part of strengthening the company's image. Preliminary footprint calculations exploited.	Materials origins, work force and locations are communicated transparently. The reception of used products is organized.	Proactive demonstrations of sustainability activities on the environmental, social and economic levels are capitalised. Transparent LCA or footprint calculations.	Proactive handprint is transparent and describes the expected positive environmental impacts.

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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. **Remanufacture, refurbish, repurpose**	Multisource product usage data is systematically gathered. The reception of used and faulty products is organised? **Repair, reuse, remanufacture, repurpose**, **refurbish**	Prolonged life-cycle, upgrades and repairs to products are enabled. **Repair, reuse, refurbish, remanufacture**	Sharing economy business models provide novel alternatives for product usage maximisation. At end–of-life the **reuse, repair, remanufacturing, refurbish** or **recycling** is enabled.
End-of-life	At end-of-life, the product is treated as waste.	Pilots are undertaken that upgrade materials or products for **reuse**. **Remanufacture, refurbish, repurpose**	**Reuse** of products, side flows and waste is implemented. **Remanufacture, refurbish, repurpose**	Environmental, social and economic impacts of end-of-life products are known. Zero defect goal?	The next life-cycle of a product is known, with its environmental, social and economic impacts. Emphasising the zero defect goal and positive environmental impacts?

Considering the value chain perspective that must be employed by manufacturing companies to embrace CE, and the value chain orientation of **both the roadmapping tool and the maturity scale**, these two tools are complementary in supporting manufacturing companies towards the undertaking of the proper path embracing circularity. Indeed, the maturity scale could be considered the starting point to enable manufacturing companies in assessing their current state while the roadmapping tool can be used to suggest the required approach to be undertaken by manufacturing companies, according to their current maturity level assessed, with the final aim to improve their current CE maturity. Therefore, on one side, The CF2 pathway is aimed at mapping a manufacturing company along the value chain across the 5 levels of maturity giving an overall picture of the current state. On the other hand, the roadmapping tool suggests approaches to be employed by manufacturing companies in embracing CE, which can be better tailored to companies' current needs if the company maturity level has been previously assessed.

2.8 Netherlands: Smart Industry

2.8.1 Smart Industry in the Netherlands

This section gives a description of the current status and activities regarding the digital transformation initiatives of the manufacturing industry in the Netherlands (called Smart Industry) related to the CFI and CF2 pathways/topics, namely:

1. Autonomous Smart Factories,
2. Hyperconnected Factories,
3. Collaborative Product Service Factories,
4. Dataspaces,
5. Circular Economy, and
6. Cybersecurity.

We will illustrate the status in the Netherlands by providing examples per pathway.

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2.8.2 Autonomous Smart Factories

The first pathway concerns the autonomous smart factories, which focuses on intra factory manufacturing automation and optimisation, including advanced human in the loop workspaces. Various manufacturing firms (including SMEs) in the Netherlands are active on this topic for instance via public private partnerships such as field labs. *"Field labs are practical environments in which companies and knowledge institutions develop, test and implement Smart Industry solutions"*[22]

There are 50 field labs founded in the Netherlands.[23] 38 of them are active, 12 of them are alumni.
Examples of field labs that work on elements relevant to come to an autonomous factory are for instance:

- **Field lab Robotics**[24]**:** In this field lab, the partners allow robots, AGVs, self-driving machines and intelligent software to cooperate. They show that more is possible than often believed.
- **RoboHouse**[25]**:** Is a field lab where manufacturing companies and innovative organisations can discover the possibilities cognitive robotics offer, develop their own applications and test them in an industrial setting. A few organisations already make use of advanced robots, that apply artificial intelligence, are self-learning and can work autonomously.
- **Field lab Industrial Robotics**[26]**:** Industrial robotics is developing education and certification for the latest technological and market developments for robotics.
- **Smart welding factory**[27]**:** The mission of Smart Welding Factory and the involved partners is to enable flexible and fully automated production using welding robots, with no programming time, "First Time Right" and "Consumer specific".
- **Flexible manufacturing**[28]**:** Firms and knowledge institutes collaborate in the development and demonstration of flexible production automation, assembly, robotics and digitalization solutions for flexible and high-quality small series production for the price of mass production.

Another good example is the cooperation between 5 practise labs in the Netherlands and Belgium that enable firms in cooperation with knowledge institutes to develop, test and implement the following technologies[29]:

- Flexible operator support in the workplace: collaborative robots and augmented reality support in high mix low volume production environments.
- Connected workplaces and machines: smart integration and connection of machines in the workplace in the context of complex high-quality components.

Companies can use the knowledge and infrastructure of the 5 practise labs to develop, test and implement applications together with the knowledge partners on these 2 themes as a step towards the factory of the future.

[22] Smart Industry Action agenda 2015.
[23] Schaalsprong agenda 2022-2026: https://open.overheid.nl/repository/ronl-b01093f75135ad2ed28456366e6acf6972051aa3/1/pdf/22221006bijlage-1-schaalsprong-agenda-2022.pdf
[24] https://www.fieldlabrobotics.com/
[25] https://www.tudelft.nl/innovatie-impact/home-of-innovation/special/robohouse
[26] https://www.fieldlabir.nl/
[27] Monitoring fieldlabs 2018
[28] Monitoring Field labs 2018
[29] https://www.tno.nl/nl/aandachtsgebieden/industrie/roadmaps/smart-industry/projecten/naar-een-slimme-fabriek-van-de-toekomst/

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2.8.3 Hyperconnected Factories

The second pathway is called the hyperconnected factories, which focuses on networked enterprises in complex, dynamic supply chains and value networks. A good example is the Dutch Smart Connected Supplier Network[30,31]: Smart Connected Supplier Network is an initiative of manufacturing companies and their IT-suppliers in the manufacturing supply chain that developed a standard for information sharing. The SCSN standard builds on the International Data Spaces (IDS) standard. This is a European standard for data sharing that enables data sovereignty developed by the partners of the International Data Spaces Association. SCSN and IDS bring a "connect-once -reach the entire supply chain scenario" to manufacturing firms. The aim is to facilitate cross-factory communication and thus ensuring supply chain transparency and interoperability, to increase the productivity and reduce the costs. This is realized by reducing the administrative burden and facilitating collaboration between supply chain partners. Unlike traditional centralized platform initiatives, SCSN is based on the principles of both digital and data sovereignty. There is no central entity that controls the data. A non-profit foundation chairs the data sharing agreements, but the implementation is done by the involved IT-suppliers. Unlike existing EDI-initiatives, these agreements not only address the semantics, but also the technical and legal aspects among partners in the ecosystem. Many firms are already connected via SCSN, for more details on the connected parties see the website: https://smart-connected.nl/en.

2.8.4 Collaborative Product Service Factories

The third pathway is based on the collaborative product service factories, which focuses on data driven product service engineering in knowledge intensive factories. This is in the Netherlands called servitization: for which firms no longer sell their hardware, but a service while the hardware remains the property of the manufacturer.[32] Such a service-based revenue model is not necessarily new. Just think about the coffee machine in the office. The offices in the Netherlands can use these machines for a fixed amount of money per month or year, while the manufacturer takes care of maintenance, repairs and coffee beans. Thanks to digitalization the possibilities to develop a servitization based approach increased and made manufacturing firms more interested to apply it. It offers for instance the opportunity to make a firm business model circular. For more details on circularity see pathway 5.

Océ (leasing of copiers), ThermoFisher (electron microscopes) and machine manufacturer Boessenkool are examples of firms that are strongly committed to servitization. [33] Servitization is increasing in the Netherlands and various initiatives are established. Such as the School of Rotterdam which is working on a servitization community for manufacturing firms that want to know more about the steps towards a service-based revenue model.[34] There are also field labs that work on servititization. Examples are Campione[35], Camino[36], Techport[37] focussing especially on condition based maintenance.

[30] https://euhubs4data.eu/members/smart-connected-supplier-network/
[31] https://repository.tudelft.nl/islandora/object/uuid%3A36745cb0-3d5f-4f79-9034-93e02e80529c
[32] https://www.ptindustrieelmanagement.nl/manufacturing/artikel/2019/02/servitization-door-smart-industry-ontstaan-nieuwe-businessmodellen-1012092
[33] https://www.ptindustrieelmanagement.nl/manufacturing/artikel/2019/02/servitization-door-smart-industry-ontstaan-nieuwe-businessmodellen-1012092
[34] https://blog.smartindustry.nl/servitization-betekenis-toepassing
[35] Fieldlab CAMPIONE - World Class Maintenance
[36] Fieldlab CAMINO - World Class Maintenance
[37] Fieldlab Techport Smart Maintenance - World Class Maintenance

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2.8.5 Dataspaces

The fourth pathway focus on the dataspaces. "The term 'data space' refers to a type of data relationship between trusted partners who adhere to the same high level standards and guidelines in relation to data storage and sharing within one or many Vertical Ecosystems."[38] A data space is the sum of all its participants, which may be data users, providers, and intermediaries.[39] Data spaces can be nested and overlapping.[40] For instance, a data provider can participate in several data spaces at once.[41] The idea is that these data spaces will offer a secure and trusted environment for firms to share their data based upon voluntary agreements.[42] Dataspaces are actually an enabler for the aforementioned Hyperconnected factories since they enable the digital connection of partners in dynamic supply chains and value networks. The European data strategy of February 2020 announced the creation of data spaces in 10 strategic fields, of which manufacturing is one of them.[43] The ultimate goal is that the data spaces will form a single European data space: a genuine single market for data.[44]

An example of a manufacturing data space in the Netherlands is the aforementioned Smart Connected Supplier Network, which provides a data space for supply chain partners that want to share information (e.g. about orders and invoice, products etc.).[45] It is remarkable to see that other various manufacturing initiatives currently do not apply the data space approach based on a decentralized architecture. They often apply a centralized cloud approach. Manufacturing-as-a-Service platforms, which connect supply and demand for instance for CNC machining or 3D printing (e.g. Batchforce[46], 3DHubs[47]) are an example of a manufacturing initiatives that often apply a central cloud approach.[48] A potential explanation could be that since data spaces are a more recent development it is not largely adopted in the Netherlands yet.

2.8.6 Circular economy

The fifth pathway concerns circular economy. The Dutch RTO TNO published a paper on this topic called "Digitisation is crucial for circular industry – Looking back from 2050".[49] This paper looks back on our era from the vantage point of 2050 and indicates how to use digitalization to achieve a sustainable society and circular economy. This document describes the goals, resources and a roadmap required to achieve this for the Dutch manufacturing industry.

The core of circular economy is based on the high quality and long term and intensive use of as few materials, components and goods as possible in order to reduce the environmental footprint.[50] This development is stimulated by the scarcity of materials and the inevitable climate change meaning that action needs to be taken. That means that is important to focus on maximum reuse of materials, complete reduction of waste, CO2-neutral production and sustainable generation of energy.[51] Therefore a lot of Dutch Smart Industry firms

[38] https://gaia-x.eu/what-is-gaia-x/core-elements/data-spaces/
[39] Ibid
[40] Ibid
[41] Ibid
[42] Ibid
[43] https://digital-strategy.ec.europa.eu/en/library/staff-working-document-data-spaces
[44] Ibid
[45] https://smart-connected.nl/nl/nieuws/data-uitwisseling-in-de-maakindustrie-op-grote-schaal-mogelijk-door-scsn-tno-en-kpn
[46] Direct CNC Productie Inkopen | Batchforce™ Supply Chain

[48] Industrial B2B platforms: The race Europe cannot afford to lose: https://repository.tno.nl/islandora/object/uuid%3A425cb6d9-57d3-4c81-8b3e-461d190f15b0
[49] Digitisation is crucial for circular industry https://publications.tno.nl/publication/34638598/A0DJfm/TNO-2021-digitisation.pdf
[50] https://www.duurzaam-ondernemen.nl/wordpress/wp-content/uploads/2018/07/Rapport-Smart-Industry-naar-een-CE.pdf
[51] Digitisation is crucial for circular industry https://publications.tno.nl/publication/34638598/A0DJfm/TNO-2021-digitisation.pdf

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already work circular, in some cases without having circularity as their main driver [52], or without realizing they are circular.[53] The Dutch manufacturing industry works a lot with capital intensive assets, whereby intensive use, high uptime and a long lifespan directly contribute to the operational performance of the firms and their customers.[54] That explains why circularity is almost automatically incorporated in their approach. This approach often builds on maintenance strategies that are part of their service package, often with the help of recent technological developments.[55]

Other firms indicate that they are consciously engaged in sustainable innovations in a broad sense including innovations that fall under the circular action perspectives, such as refurbishment, predictive maintenance and various other forms of servitization. [56] The use of high-quality sensors is crucial in almost all cases in achieving the required results, meaning that "smartness" provides a significant contribution to more efficient use of materials.[57]

The Netherlands also has a circularity field lab, called “field lab Circular Innovations in the Manufacturing industry”.[58] Firms that want to become more circular often have a good idea of what they want, but do not always have the knowledge and experience in implementing their circular idea. Therefore, the field lab provides advice about the best practices and business models to stimulate the implementation.

2.8.7 Cybersecurity

The sixth pathway, cybersecurity, concerns the protection of internet connected systems such as hardware, software and data from cyberthreats. Globally, the cyber threat continues to evolve at a rapid pace, making the protection of manufacturing systems against hackers more and more important.

In the Netherlands are various initiatives dedicated to cybersecurity for manufacturing firms such as the Cyber Security Scan available on the website of the Program Bureau Smart Industry (the scan can be found via this link: https://smartindustry.nl/diensten/assessments/cyber-security-scan). With this scan, SMEs in the manufacturing industry gain insight into the cyber security of their organization and receive advice and tips to protect themselves against cyber threats. The scan provides targeted advice on three important topics that can help to increase the digital resilience of the organization, namely:

1. Organization and management,
2. Interaction with systems and
3. Technology.

Another initiative is the Industrial Platform Cyber Security of the Dutch standardization organization NEN.[59] The platform pays attention to the cybersecurity risks in the industry with the aim of mitigating and limiting

[52] Ibid
[53] https://circulairemaakindustrie.nl/app/uploads/2020/10/TNO-2019-R11623-CESI-Brabant-eindrapport-3.pdf
[54] https://www.duurzaam-ondernemen.nl/wordpress/wp-content/uploads/2018/07/Rapport-Smart-Industry-naar-een-CE.pdf
[55] Ibid
[56] https://circulairemaakindustrie.nl/app/uploads/2020/10/TNO-2019-R11623-CESI-Brabant-eindrapport-3.pdf
[57] Ibid
[58] https://boostsmartindustry.nl/samenwerkingen/fieldlab-circulaire-innovaties-de-maakindustrie-cim
[59] https://www.nen.nl/en/elektrotechniek/industriele-cyber-security/industrieel-platform-cyber-security

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them. By bringing different disciplines together via the platform, Dutch manufacturing firms and their partners can be informed and can exchange knowledge on the relevant cyber security standards. [60]

Besides that, a group of Dutch partners established the Cybersecurity Centre for the Manufacturing Industry, also called the "Digital Trust Centre".[61] The aim of the centre is to make the manufacturing industry digitally resilient.[62] The centre provides a couple of services[63] such as a cybersecurity scan for firms of about 250 Euro, they provide practical tips and extensive advice from a cybersecurity expert. There are also various R&D projects running about cyber security for Smart Industry which indicate that steps are taken towards a better and more mature cyber security in smart industry.[64]

2.8.8 Concluding remark

Based on the analysis of the aforementioned six CF pathways we see that Dutch manufacturing firms are active on each pathway. However, these firms (especially small SMEs) often have some challenges in making the whole transformation by themselves. Therefore, field labs and or other public private partnerships and the exchange of best practises are important enablers for them.

2.9 Portugal: Indústria 4.0

The Portuguese Recovery and Resilience Plan (https://recuperarportugal.gov.pt/?lang=en) is a nationally applicable programme lasting until 2026. The plan will implement a set of reforms and investments aimed at restoring sustained economic growth, supporting the goal of convergence with Europe over the next decade. Its dimensions are:

1. Resilience
2. Climate Change
3. Digital Transition

The most relevant areas to the Connected Factories pathways are presented next under the corresponding dimension:

1. Resilience

(https://recuperarportugal.gov.pt/resilience/?lang=en)

Resilience is associated with an increase in the capacity to react to crises and overcome their associated current and future challenges. It promotes a transformative, lasting, fair, sustainable and inclusive recovery, and is understood in the RRP context in all its aspects: social resilience, economic and manufacturing resilience, and territorial resilience.

Resilience considers nine components to strengthen Portugal's social, economic and territorial resilience. These include a robust set of interventions in strategic areas, namely in health, housing, social responses,

[60] Ibid
[61] https://www.digitaltrustcenter.nl/cybersecurity-initiatieven/cybersecurity-centrum-maakindustrie
[62] Ibid
[63] https://novelt.com/nl/cybersecurity/
[64] https://www.ictinpractice.nl/previous-editions/ict-in-practice-2020/talks/casper-schellekens-cyber-security-in-smart-industry/

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culture, innovative business investment, qualifications and skills, infrastructure, forestry and water management.

Relevant to CF2 are:

Capitalisation and Business Innovation

(https://recuperarportugal.gov.pt/capitalisation-and-business-innovation-c5/?lang=en)

Goal: Increasing the competitiveness and resilience of the economy based on R&D, innovation, diversification and productive structure specialisation. Providing capital to enterprises that were economically viable prior to the economic recession caused by the pandemic, and encouraging productive investment in areas of strategic national and European interest.

Business Innovation mobilisation Agendas/Alliances

The Mobilising Agendas/Alliances for business innovation, with emphasis on reindustrialisation, aim to accelerate the structural transformation of the Portuguese economy, improving its specialisation profile through the formation of solid and structured consortia that guarantee the development, diversification and specialisation of national value chains, pursuing objective goals in terms of exports, qualified employment and investment in R&D.

The initiative will be highly focused and directed at a narrow set of strategic development areas with strong growth potential - a rationale inspired by the "innovation partnerships" of Horizon 2020.

The eight thematic areas to be supported are aligned with the smart strategic priorities defined in the National Research and Innovation Strategy for Smart Specialisation (ENEI) and include manufacturing industries and technologies.

Qualifications and Skills

(https://recuperarportugal.gov.pt/qualifications-and-skills-c6/?lang=en)

Goal: Increase the responsiveness of the education and training system in combating social and gender inequalities and increase the resilience of employment (in situations of economic crisis such as the one caused by the pandemic), especially for young people and adults with few qualifications, as well as ensuring the balanced participation of women and men in the job market.

Modernisation of vocational education and training establishments and their courses

To achieve the strategic objectives of this PRR funding for qualifications, it is essential to invest in the reform of vocational education and training:

1. To re-equip and strengthen the technological infrastructure of educational establishments offering professional education through the acquisition of equipment, enabling the modernisation and/or creation of 365 Specialised Technological Centres;

2. To provide workshops at schools and vocational training centres in the IEFP network

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3. To adjust and refurbish the physical spaces of schools and vocational training centres in the IEFP network to meet the demands of the different courses;

4. To create, install and upgrade centres and hubs in the IEFP sectoral training network in strategic and emerging sectors and to enhance coverage and reduce imbalances and territorial gaps.

Adult Incentives

As part of this programme, three complementary instruments will be introduced within the scope of promoting lifelong learning: two as part of the Qualifica Programme, the National Plan for Adult Literacyand the Qualifica Accelerator, and a third, the Adult Impulse, within higher education and aimed at higher education institutes, including universities and polytechnics in coordination with public and private employers.

2. Climate Transition

(https://recuperarportugal.gov.pt/climate-transition/?lang=en)

The Climate Transition is a result of Portugal's commitment and contribution to the climate targets that will enable it to reach carbon neutrality by 2050. The decarbonisation of the economy and society offers important opportunities and prepares the country for the realities that will shape competitiveness factors in the near future. Six Climate Transition components were considered such as the sea, sustainable mobility, decarbonisation of industry, bio-economy, energy efficiency in buildings and renewable energies.

Relevant to CF2 are:

Decarbonisation of Industry

(https://recuperarportugal.gov.pt/decarbonisation-of-industry-c11/?lang=en)

This component aims to decarbonise the industrial and business sector and promote a paradigm shift in the use of resources, implementing measures in the National Energy and Climate Plan 2030 (PNEC), and constitutes a central strategic RRP objective given that it contributes towards accelerating the transition to a carbon-neutral economy and, at the same time, promotes the competitiveness of industry and enterprises through decarbonisation, reduced energy consumption and promotion of endogenous energy sources.

Decarbonisation of Industry

This investment, led by IAPMEI, IP, is intended to promote and support financially the national industry initiative for multi-dimensional action at the environmental level, and is structured for the development of projects in four areas:

1. Low-carbon processes and technologies in industry, through the introduction of new product processes and business models and the modification of processes to lead to their decarbonisation, including new low-carbon technologies; the incorporation of new raw materials, fuels derived from waste and biomass; the use of industrial symbioses and circular economy measures, incorporating innovation; and the replacement and/or adaptation of equipment and processes for new sustainable technologies and renewable energy sources. Also of note are measures to adopt fluorinated gases with low global warming potential. It is also important to increase the electrification of final energy consumption, particularly in

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industry, and to increase access to it as well as the quality of service, especially in industrial areas;

2. Adoption of energy efficiency measures in industry, allowing for the simultaneous reduction of energy consumption and greenhouse gas emissions, in parallel with the adoption of consumption monitoring and management systems that allow for the management and optimisation of energy consumption, taking advantage of the potential of digitalisation and automation;

3. Incorporation of energy from renewable sources and energy storage. It is also important to promote the incorporation of hydrogen and renewable gases in industry, particularly where the technological options for decarbonisation through electrification are more limited;

4. Supporting capacity building for enterprises and the development of information and support tools, such as sectoral roadmaps for carbon neutrality in industry, to identify effective, domestic industry-specific and cost-effective technological solutions that incorporate greater innovation and for promoting their dissemination and support for the measures listed.

3. Digital Transition

(https://recuperarportugal.gov.pt/digital-transition/?lang=en)

In the Digital Transition dimension, significant reforms and investments are planned in the areas of digitalisation of companies, in the state and providing digital skills in education, health, culture, and forest management.

To ensure that Portugal accelerates the transition to a more digital society, the national options in the RRP are based on 5 components in the following areas: empowerment and digital inclusion of people through education, training in digital skills and promotion of digital literacy, digital transformation of the business sector and digitalisation of the State.

Relevant to CF2 are:

Enterprises 4.0

(https://recuperarportugal.gov.pt/enterprises-4-0-c16/?lang=en)

Enhancing the digitalisation of enterprises and catching up with the digital transition process

This component, with the specific goal of enhancing the digitalisation of enterprises, aims at catching up with the digital transition process, allowing access to knowledge and digital technological means that promote modernisation of work and production processes, elimination of workflows, mitigation of skills deficits in the use of digital technologies, balanced inclusion of women and men, incorporation of remote working tools and methodologies, creation of new digital channels for marketing and selling products and services, adoption of a culture of experimentation and innovation, strengthening of the national entrepreneurial ecosystem, and incorporation of disruptive technologies in enterprises' value propositions.

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Digital Empowerment of Enterprises

This investment, led and coordinated by IAPMEI, I.P. in association with the public entities responsible for employment, vocational training and qualifications, foresees the creation of two interconnected training programmes, using innovative approaches that aim to fill gaps in the digital skills of workers (employees and entrepreneurs) and enterprises:

Portugal Digital Academy– platform and large-scale digital skills development programme that should allow workers in the business sector to: i) produce a self-assessment of their current digital skills level, taking into account the Portuguese Digital Skills Framework (PCDF) based on DigComp; ii) receive a personalised digital skills training plan with concrete goals, considering individual levels in each domain, personal goals and specific demands of the labour market (current and future) that may be linked to meeting skills needs in a more comprehensive way, to promote qualification completion paths; iii) access online training resources that allow the acquisition of new skills and attainment of the goals mentioned above; and iv) develop a personal passport that itemises, centralises and certifies information on the worker's digital skills (whenever justified, in association with other existing systems, particularly the Qualifica passport);

Digital Jobs 2025– program for digital technologies skills building that aims to respond to the challenges and opportunities in a number of business sectors that are strongly impacted by digital transformation processes and the COVID-19 pandemic. It is aimed at company workers regardless of their digital skills level. Similar to the Employment + Digital programme launched in 2020, this initiative will be developed in close coordination with business confederations and associations.

Digital Transition of Enterprises

This investment, which is being coordinated by IAPMEI, I.P. in close collaboration with various public bodies and associations, will contribute to the transformation of Portuguese SME business models and their digitalisation, with the goal of achieving greater competitiveness and resilience. It incorporates the promotion of business digitalisation through the acceleration and automation of decision-making and execution based on artificial intelligence, the redesign of value and supply chains, optimising speed and resilience and the use of cross-sectoral data spaces, supported by European cloud and edge computing infrastructures that are innovative, secure and energy efficient, providing enterprises with a way to reposition their businesses in a digitally advanced ecosystem. It encompasses the National Test Beds Network, Digital Commerce (Coaching 4.0) and Entrepreneurship programmes.

The four programmes converging towards this objective by addressing the various aspects of the digital transition are:

1. National Test Beds Network
2. Support for Digital Transition Business Models (Coaching);
3. Entrepreneurship – Investments that result in enhancing the strategic focus on the development of the entrepreneurial ecosystem

Catalysing the Digital Transition of Enterprises

This investment, to be coordinated by IAPMEI, I.P. in collaboration with other entities, is made via public technological catalysation projects that seek to reduce the use of paper through the dematerialisation of invoicing, creating a more secure and reliable digital business environment through a set of certifications,

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and generally reducing context costs. It will also encourage the development of knowledge transfer structures, where the intention is to stimulate the development of more technological products and services as well as support skills development.

The investment is structured through the following three programmes:

1. Digital Innovation Hubs (DIHs) seek to centralise a set of support services for the digital transition of enterprises under more accessible conditions, focusing this process on three disruptive technologies: AI, HPC and Cybersecurity. This programme aims to extend and develop a national DIH network, enhancing the investment forecast by complementing the network that is already under development within the framework of the Digital Europe Programme (DEP) to reach a total of 126 additional hubs.

2. Dematerialisation of Invoicing– an initiative that aims to automate the process of affixing a qualified electronic signature for issuing invoices through AMA's Electronic Invoice Signature Service (SAFE) and to increase the use of digital invoicing in B2B and B2C transactions by providing a solution that uses the Unique Digital Address, enabling invoices to be sent to the customer (citizen or company) by email;

3. Certification Seals for Cybersecurity, Privacy, Usability and Sustainability– investment in four new certification platforms involving cybersecurity, privacy, usability and sustainability, as well as a promotion campaign and training of conformity assessment bodies and technical assessment laboratories, and the award of seals.

Finally, the **"Indústria 4.0" Programme** continues as described in Deliverable 2.3 - Pathways alignment with National / Regional Initiatives - First Iteration.

2.10 Finland

In line with the national development initiatives reported in D2.3, the transition to circular and data-based business in manufacturing continues in different Finnish networks and communities summarized above. This is well aligned with several Connected Factories pathways, in particular with the development of the novel pathways related to Circular Economy, Data Spaces and Artificial Intelligence.

The national Sustainable Manufacturing Finland[65] program continues to promote digital and green transitions in manufacturing. The program has been launched by Business Finland and it aims to renew business models and increase productivity, while actively seeking solutions to the challenges of climate change. The program supports new sustainable solutions with significant export prospects. Furthermore, the Sustainable Manufacturing Finland program encourages companies to utilize European cooperation networks and EU funding instruments. In addition to the Sustainable Manufacturing Finland program, Business Finland provide remarkable funding to the research agendas of the so-called lead companies and their ecosystems[66]. There several manufacturing companies are funded and sustainability as well as digitalisation are highly emphasized with these agendas.

[65] https://www.businessfinland.fi/en/for-finnish-customers/services/programs/sustainable-manufacturing-finland

[66] https://www.businessfinland.fi/en/for-finnish-customers/services/funding/funding-for-leading-companies-and-ecosystems

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Business Finland, VTT and lead companies collaborate closely also in supporting manufacturing industry in the participation in European collaboration and in agenda setting. The Open Smart Manufacturing Ecosystem (OSME) is one example of such collaboration led by a globally operating OEM company[67]. The Connected Factories pathways are important tools to engage companies actively in the program to formulate digital and circular transition steps. For instance, the circular economy (CE) pathway has been validated with the OSME companies during the spring 2022. The results of CE pathway validation proved that each company has started their journey towards sustainable manufacturing as there were no hits to the lowest maturity level, linearity. Neither did any manufacturing company reach the highest level, ideal circularity. Typically, companies struggle with their products and customer interface as MNEs are split to departments having internal customers and many SMEs do not have own products but deliver subcomponents to the OEM. As such, the findings of this validation round are in line with the previous discussions at the national workshop[68], where Sustainable Manufacturing Finland program and associated companies gave valuable feedback on several pathways.

In addition, the national initiative Sustainable Industry X (SIX)[69] offers services that help the manufacturing companies to realise transition to digital and circular business. 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 (such as SIX Smart Manufacturing and SIX Mobile Machines) that promote innovation and competence development around different topics. The Connected Factories pathways have already been used in the development of the SIX services and have helped identify future development needs of manufacturing industry SMEs.

Finland has several national activities for boosting utilisation of data. For instance, newly started activities at SITRA will speed up the data driven economy in Finland[70]. VTT is participating in the development of the data program and its road map and can thus bring insights from the Connected Factories projects to the road map. Business Finland will soon launch a new program on data with a planned focus on industry and health sectors. This will offer tools and funding to put plans in to practise and test and cultivate the pathways (in particular, the data pathway) in the future. VTT and SITRA have worked closely together in the data related research and development. The Finnish hub of The International Data Spaces Association (IDSA Hub Finland), launched by VTT, has a mission to create the future of the global, digital economy with International Data Spaces (IDS)[71]. There, a secure, sovereign system of data sharing in which all participants can realize the full value of their data. VTT also has implemented an IDS testbed and made it available for use cases as an experimentation platform. Here, the first pilots with the manufacturing industry companies have already implemented at the, the Industrial Data Excellence (InDEx) program [72] and at the above mentioned OSME-ecosystem. In line with this agenda, at the autumn 2022, SITRA will open a Gaia-X Finland funding call to boost the maturity of business-driven data sharing use cases and potential data space initiatives.[73]

[67] https://www.sustainabletechnologyhub.com/new-open-smart-manufacturing-ecosystem-aims-at-transforming-manufacturing-collaboration/

[68] see details CF National Workshop report - Circular economy and digital manufacturing – Building Sustainability and Circularity for Manufacturing Industry

[69] https://www.six.fi/

[70] https://www.sitra.fi/en/themes/fair-data-economy/#latest

[71] https://www.idsa-finland.fi/

[72] https://www.dimecc.com/dimecc-services/index/

[73] https://www.sitra.fi/en/news/funding-to-boost-maturity-of-finnish-data-space-initiatives/

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Furthermore, the new national strategic agenda called Artificial Intelligence 4.0 (AI4.0)74 has collected the key Finnish stakeholders together to accelerate twin transition towards green and digital industry. The program is a continuation of the earlier national artificial intelligence program75 but focused on industry, and on the manufacturing sector. With the Artificial Intelligence 4.0 programme, Finland aims to strengthen green transition, digitalisation and economic growth. Encouraging cooperation between different sectors, increasing investments in digitalisation and, in particular, improving digital skills in SMEs are the key objectives of the programme. The program also supports setting up of Finland's European Digital Innovation Hubs, which is an opportunity to direct resources to twin transition in manufacturing industries. VTT is in the core of the execution of the AI4.0 program and has thus ensured, that the findings of the program have been taken into account in the development of the Connected Factories pathways. At the same time, the program exploits the results of the Connected Factories project, including the pathways. For example, the Circular Economy pathway has given insight to the programs working group Green transition and the other pathways have been valuable for the working group dedicated to manufacturing SMEs. Finally, the Finnish AI4.0 program contributes strongly on the Finnish Digital Compass. Most actions in the Finnish digital compass that concern industry and SMEs are based on the priorities of the AI4.0 the program. One can say that Connected Factories results have partly helped to define these targets as well, as VTT has had the opportunity to support the definition of compass's targets.

Within these above presented national agendas, Finland has an ambition to grow exports in these expanding markets related to sustainability, circularity and carbon neutrality with the help of digitalisation. The Connected Factories pathways, in particular the pathway for circular economy, has a close link to these national agendas and activities.

2.11 UK

Within the UK, the largest and most famous Industry 4.0 initiative remains **Made Smarter**[76]. Note that the term Industry 4.0 is less common in the UK – Made Smarter uses the term "Industrial Digital Technologies" (IDTs). Originating as an industry-led report into the challenges and opportunities of applying IDTs[77], Made Smarter is now a broad "movement" funded by the UK government with two programmes - to promote IDT *adoption*, and to fund *innovation* programmes, as well as a use-case collection initiative

Made Smarter also provides general purpose advice about the benefits of digital technology adoption[78], and guiding principles for how to manage digitalisation adoption[79].

2.11.1 Made Smarter: Adoption

Within the Adoption programme of Made Smarter, support is split into four threads and has been allocated £8 million of funding to help 1,000 SMEs:

74 https://tem.fi/en/artificial-intelligence-4.0-programme https://tem.fi/-/tekoaly-4.0-ohjelma-vauhdittaa-liiketoiminnan-digitalisaatiota?languageId=en_US
75 https://www.tekoalyaika.fi/en/
76 https://www.madesmarter.uk/
77 https://www.gov.uk/government/publications/made-smarter-review
78 https://www.madesmarter.uk/adoption/benefits-of-digital-technology/
79 https://www.madesmarter.uk/about/guiding-principles-for-digitalisation/

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- *Advice*[80]: Made Smarter will pair manufacturers with impartial digital technology advisors to guide companies in their digitalisation journey and identify areas where value could be added with IDTs.
- *Transformation*[81]: Made Smarter will run digital transformation workshops with companies to help elicit practical steps that can be taken to digitalise a business, and what funding and support options are available.
- *Leadership*[82]: Made Smarter will help manufacturers identify technical skills gaps and sources of training. It will also help manufacturers develop the leadership skills required to pursue a digitalisation initiative within an organisation.
- *Funding*[83]: Made Smarter can help manufacturers identify potential sources of funding to help offset the costs of IDT adoption.

Presently, this support is limited to the following regions of the UK, identified as areas lacking in IDT adoption and for which the investment will make the maximum impact. These regions are:

- North West England, administered by **The Growth Company**[84].
- North East, administered by the **North East Local Enterprise Partnership**[85] and the **Tees Valley Combined Authority**[86].
- Coventry and Warwickshire (often referred to as the West Midlands), administered by the **Coventry and Warwickshire Growth Hub**[87].
- Yorkshire and The Humber, administered by the **South Yorkshire Combined Authority**[88].

[80] https://www.madesmarter.uk/adoption/support-assistance-from-made-smarter/
[81] https://www.madesmarter.uk/adoption/plan-for-your-digital-transformation/
[82] https://www.madesmarter.uk/adoption/develop-your-digital-leadership/
[83] https://www.madesmarter.uk/adoption/investing-in-the-digital-tools/
[84] https://www.growthco.uk/
[85] https://www.northeastlep.co.uk/
[86] https://www.teesvalleybusiness.com/
[87] https://www.cwgrowthhub.co.uk/
[88] https://southyorkshire-ca.gov.uk/

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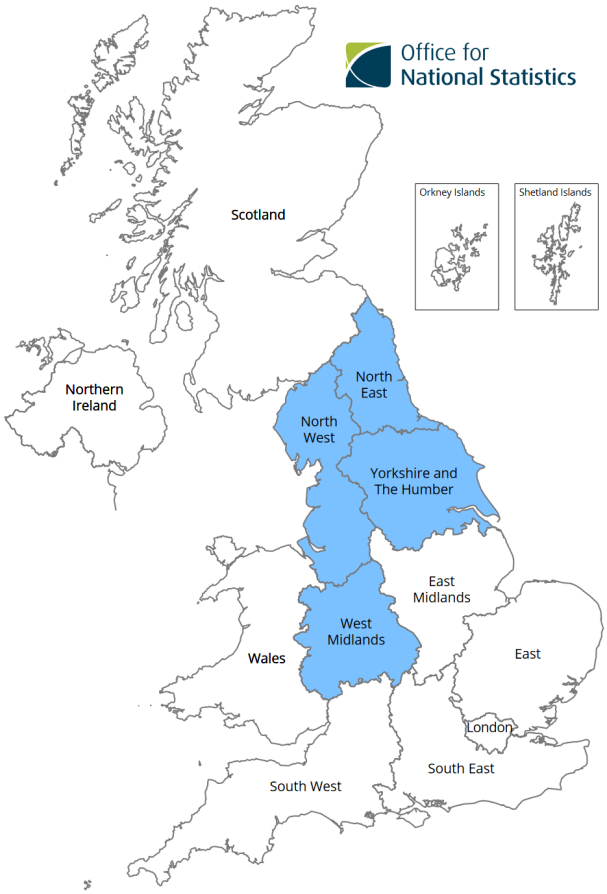


Figure 7: Regions of the UK currently receiving direct Made Smarter support (in blue). Source: Office for National Statistics licensed under the Open Government Licence v.3.0. Contains OS data © Crown copyright and database right 2018.

The Pathways developed in the Connected Factories project could be beneficial to the Adoption programme of Made Smarter, and the focus on IDTs has relevance to the pathways. The critical IDTs identified in the Made Smarter Report and their relation to pathways are detailed in *D2.3 Pathways alignment with National / Regional Initiatives - First Iteration.* Since D2.3, the Made Smarter movement's adoption programme has moved from IDT identification to a focus on the promotion of these technologies.

2.11.2 Made Smarter: Innovation

The second programme of the Made Smarter movement is the funding of innovation in the areas of IDTs and their application to manufacturing processes. **The Made Smarter Innovation programme** has been allocated £147m from the UK government via the **Industrial Strategy Challenge Fund**[89] which is discussed in section 2.11.5, matched by a minimum of £147 from industry. Unlike the Adoption programme, these funding methods are not region-specific.

They key areas the innovation programme is focusing on (and their relevance to the Connected Factories pathways are:

[89] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/

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	Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
Artificial Intelligence, Machine Learning and Data Analytics	■			■		■
Additive Manufacturing						
Robotics and Automation						
Virtual Reality and Augmented Reality						
Industrial Internet of Things and Connectivity	■	■				■
Sensors	■		■	■	■	■
Blockchain		■	■	■	■	■

Innovation funding is being allocated via six methods, described in the following sections.

2.11.2.1 The Made Smarter Technology Accelerator

The **Made Smarter Technology Accelerator** (MSTA)[90] is a programme delivered by the UK Digital Catapult[91]. The MSTA focuses on defining critical manufacturing challenges from UK manufacturing enterprises, and matching those with start-up and scale-ups to deliver prototypes (with £20,000 of funding) and minimum viable product development (with £100,000 of funding).

The MSTA focuses on five themes, with the following relationship to the pathways:

	Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
Intelligent factory/site management and control	■					■
Intelligent product verification and validation	■			■	■	■
Transparent and data-driven procurement	■	■	■	■		■
Digitally enabled factory/site workforce	■	■				■
Resource measurement and analytics	■					■

[90] https://accelerator.madesmarter.uk/

[91] https://www.digicatapult.org.uk/ Note: Connected Factories 2 member the Manufacturing Technology Centre is a part of the Catapult network, but as part of the High Value Manufacturing Catapult.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

The MSTA has fourteen current challenges defined within the five themes. There are seven current industrial partners, each with two challenges. These are:

Partner Company	Babcock International Group					
Company Sector	Defence (Marine, Land, Aviation, Nuclear)					
Challenge 1 Name	**Warrior Base Overhaul**					
Description	Development of digital twins for Warrior armoured vehicle overhaul program for NDT measurement of vehicle hulls. Visualisation and traceability.					
	Autonomous Smart Factories	**Hyperconnected Factories**	**Collaborative Product-Service Factories**	**Dataspaces**	**Circular Economy**	**Cybersecurity**
Pathways Relevance						
Challenge 2 Name	**Digital Shipbuilding**					
Description	3D CAD design data for ships to flow down supply chain and ensure data is presented where it is needed, with access controls.					
	Autonomous Smart Factories	**Hyperconnected Factories**	**Collaborative Product-Service Factories**	**Dataspaces**	**Circular Economy**	**Cybersecurity**
Pathways Relevance						

Partner Company	BAE Systems					
Company Sector	Defence, Aerospace, Cybersecurity					
Challenge 1 Name	**Scalable artificial intelligence for visual inspection systems**					
Description	AI-enhanced visual inspection system for low-volume complex products, which is easy to deploy with minimal training datasets.					
	Autonomous Smart Factories	**Hyperconnected Factories**	**Collaborative Product-Service Factories**	**Dataspaces**	**Circular Economy**	**Cybersecurity**
Pathways Relevance						
Challenge 2 Name	**Dynamic Workflow Management**					

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Description	Scheduling and workflow management that is responsive to disruptions and changes, including in the supply chain.					
	Autonomous Smart Factories	**Hyperconnected Factories**	**Collaborative Product-Service Factories**	**Dataspaces**	**Circular Economy**	**Cybersecurity**
Pathways Relevance						

Partner Company	GAF					
Company Sector	Building Materials Manufacturing (Roofing and Waterproofing)					
Challenge 1 Name	**Asphalt material characterisation**					
Description	Automatic identification of 'critical to quality' results to inform downstream processes, particularly with regards to varying ingredient supply quality.					
	Autonomous Smart Factories	**Hyperconnected Factories**	**Collaborative Product-Service Factories**	**Dataspaces**	**Circular Economy**	**Cybersecurity**
Pathways Relevance						
Challenge 2 Name	**Machine vision system – supporting product conformance**					
Description	Use of machine vision and sensing technologies to characterise roofing shingle quality, to identify deviations and process conditions which contribute to these.					
	Autonomous Smart Factories	**Hyperconnected Factories**	**Collaborative Product-Service Factories**	**Dataspaces**	**Circular Economy**	**Cybersecurity**
Pathways Relevance						

Partner Company	Northumbrian Water
Company Sector	Water Supply and Sewerage Services
Challenge 1 Name	**Sewer blockages smart Porcupine**
Description	Creation of smart porcupines (blockage avoidance devices in sewers) capable of identifying and reacting to issues before blockages or flooding.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

	Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
Pathways Relevance						
Challenge 2 Name	**Water network monitoring and real time analysis**					
Description	Development of a sensing solution for monitoring water quality as it is delivered, as a replacement for current manual sampling.					
	Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
Pathways Relevance						

Partner Company	O'Neills Irish International Sports Company Limited					
Company Sector	Sportswear Manufacturer					
Challenge 1 Name	**Product customisation – intelligent verification**					
Description	Use of machine visions and other IDTs to verify product correctness for individually customised garments.					
	Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
Pathways Relevance						
Challenge 2 Name	**Automation of production – in the sewing environment**					
Description	AI-guided robotics for 'seambots' - raw material feeds into sewing equipment, as a means to address a skills shortage.					
	Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
Pathways Relevance						

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Partner Company	Safran Landing Systems					
Company Sector	Aerospace – landing and braking systems					
Challenge 1 Name	**Adaptive scheduling and performance monitoring**					
Description	Rule-based dynamic scheduling for reacting to changing customer demand, assisting the workforce with the complexity around the impact and consequences of decisions.					
	Autonomous Smart Factories	**Hyperconnected Factories**	**Collaborative Product-Service Factories**	**Dataspaces**	**Circular Economy**	**Cybersecurity**
Pathways Relevance						
Challenge 2 Name	**Implementation of statistical process control on all test rigs in the Assembly shop**					
Description	Solutions that give operators better visibility of the parameters that effect test rig performance and integrating those to improve first-time pass rates.					
	Autonomous Smart Factories	**Hyperconnected Factories**	**Collaborative Product-Service Factories**	**Dataspaces**	**Circular Economy**	**Cybersecurity**
Pathways Relevance						

Partner Company	Sainsbury's					
Company Sector	Supermarket					
Challenge 1 Name	**Microbial control in ready to eat foods**					
Description	Development of tools to identify bacteria strains in food products, specifically embedding in the supply chain to identify issues before products are delivered to Sainsburys.					
	Autonomous Smart Factories	**Hyperconnected Factories**	**Collaborative Product-Service Factories**	**Dataspaces**	**Circular Economy**	**Cybersecurity**
Pathways Relevance						
Challenge 2 Name	**Increasing shelf life and sell through of products while reducing waste.**					

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Description	Data-based automatic feedback and control loops for optimisation of time, temperature, and other hygiene controls that will enable maximisation of product shelf life.					
	Autonomous Smart Factories	**Hyperconnected Factories**	**Collaborative Product-Service Factories**	**Dataspaces**	**Circular Economy**	**Cybersecurity**
Pathways Relevance						

2.11.2.2 Made Smarter Innovation Hubs

The **Made Smarter Innovation Hubs**[92] are fully-funded development programmes in specific digital areas. £33 million has been allocated to these hubs, split into a Smart Factory Innovation Hub (£20m), Digital Supply Chain Innovation Hub (£10m), and three Fast Start Test Hubs: a smart factory testbed, a digital supply chain marketplace, and a digital validation and verification hub[93].

Currently, information is only available for the **Digital Supply Chain Innovation Hub**, which will be managed by the Digital Catapult[94] in association with the High Value Manufacturing Catapult[95], National Physical Laboratory[96], and The Welding Institute[97]. This hub focuses on five main projects:

- *Last Mile Living Lab*: Development of delivery resource management infrastructure for last mile delivery. Lead: Digital Catapult.
- *Digital Enabled Manufacturing Sourcing*: Connection of manufacturing capacity with needs to increase capacity utilisation and production flexibility. Lead: TWI.
- *Differentiator Hub*: Development of supply-chain models for clinical trials. Lead: AMRC[98]
- *Connected Tempest Hub*: acceleration of digital skills development and connectivity of supply chains to enable the Tempest programme[99]. Leads: NCC[100] and AMRC.
- *Supply-Chain Lab*: Helping SMEs identify challenges in their supply chains, and develop 120-day roadmaps to solution implementation. Lead: Deloitte[101].

[92] https://www.madesmarter.uk/made-smarter-innovation/hubs/
[93] https://www.ukri.org/news/ukri-invests-33m-in-made-smarter-innovation-hubs/
[94] https://www.digicatapult.org.uk/
[95] https://hvm.catapult.org.uk/
[96] https://www.npl.co.uk/
[97] https://www.twi-global.com
[98] https://www.amrc.co.uk/
[99] https://www.raf.mod.uk/what-we-do/team-tempest/
[100] https://www.nccuk.com/
[101] https://www2.deloitte.com/uk/en/explore/home.html

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

	Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
Last Mile Living Lab		■				
Digital-Enabled Manufacturing Sourcing		■		■		
Differentiator Hub				■		
Connected Tempest Hub		■		■		■
Supply-Chain Lab						

2.11.2.3 Made Smarter Innovation Network

The **Made Smarter Innovation Network**[102] is a programme for enabling manufacturers, technology providers, government entities, and innovation funders to connect and foster cross-sector collaboration. Managed by the Knowledge Transfer Network (KTN)[103], this network builds on KTN's existing networks in additive manufacturing[104]; artificial intelligence, machine learning, and data analytics[105]; robotics and automation[106]; augmented reality and virtual reality[107]; and industrial internet of things and connectivity[108].

Key activities in the network are primarily around enabling companies to access appropriate funding sources, dissemination of developments and news on the network topics, and also organising and sharing webinars on a relevant topics. For Made Smarter, webinars were run on the following topics and recordings are available[109]:

- New Product Development
- Predictive Maintenance
- Factory Floor and Production Systems
- Industrial Energy Efficiency
- Web-Based Customer Order Tracking
- Continuous Improvement
- Quality Management
- Mass Customisation
- Circular Economy
- Design for Manufacture
- Flexible Manufacturing

[102] https://www.madesmarter.uk/made-smarter-innovation/network/
[103] https://ktn-uk.org/
[104] https://ktn-uk.org/manufacturing/additive-manufacturing/
[105] https://ktn-uk.org/robotics-ai/ai/
[106] https://ktn-uk.org/robotics-ai/
[107] https://www.immerseuk.org/
[108] https://ktn-uk.org/digital/internet-of-things/
[109] https://ktn-uk.org/news/making-manufacturing-smarter/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

2.11.2.4 Made Smarter Innovation Standards

The **Made Smarter Innovation Standards initiative**[110] is a collection of relevant international standards to enable digital solution providers and manufacturers to better understand how to implement IDTs. It also seeks to identify gaps in current standards and methods to close these.

There is currently no other information available on this initiative, it is likely in the early stages of initiation.

2.11.2.5 Made Smarter Innovation Research Centres

Made Smarter is investing £25 million in **Made Smarter Research Centres**[111] to focus on the commercialisation of emerging technologies. These centres are industry-sponsored collaborations between several research institutions to ensure the developments are industrially relevant.

These research centres are:

- *InterAct:* Increasing the cooperation of social science research in the innovation and diffusion of digital technologies in the UK manufacturing sector[112]. Institutions: Universities of Loughborough, Sheffield, Strathclyde.
- *Smart, Collaborative Industrial Robots*: Creating a network of research and industry to increase the adoption of automation in the UK, with a focus on collaboration, autonomy, simplicity, and acceptance[113]. Institutions: Universities of Loughborough, Cranfield, Strathclyde, Dundee, Warwick and Bristol.
- *People-Led Digitalization*: Increasing the uptake of digital technologies by increasing the knowledge and awareness of what's available in manufacturers[114]. Institutions: Universities of Bath, Nottingham and Loughborough**.**
- *Connected Factories*: Creation of concepts for connected and morphing factories able to more rapidly respond to changing demands and disruptions[115]. Institutions: Universities of Nottingham, Cambridge and Sheffield.
- *Digital Medicines Manufacturing*: Creation of digital supply chains for on-demand medicines manufacturing and flexible clinical trials[116]. Institutions: Universities of Strathclyde, Cambridge and Loughborough.
- *Materials Made Smarter*: Digitalisation of the materials supply processes to bring the UK's advanced materials sector into the digital era, enabling the verification and validation of materials procurement[117]. Institutions: A collaboration between the Manufacturing Using Advanced Powder

[110] https://www.madesmarter.uk/made-smarter-innovation/standards/
[111] https://www.madesmarter.uk/made-smarter-innovation/research-centres/
[112] https://interact-hub.org/
[113] https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=EP/V062158/1
[114] https://www.bath.ac.uk/projects/made-smarter-innovation-centre-for-people-led-digitalisation/
[115] https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=EP/V062123/1
[116] https://www.madesmarter.uk/made-smarter-innovation/research-centres/digital-medicines-manufacturing-dm2-research-centre/
[117] https://www.madesmarter.uk/made-smarter-innovation/research-centres/materials-made-smarter-research-centre/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Processes Hub[118], Liquid Metal Engineering Hub[119], SUSTAIN Future Steel Manufacturing Research Hub[120], Future Composites Manufacturing Research Hub[121], and the Institute of Work Psychology[122].

	Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
InterAct						
Smart, Collaborative Industrial Robots	■					
People-Led Digitalisation						
Connected Factories	■	■		■		
Digital Medicines Manufacturing	■			■		
Materials Made Smarter				■	■	

2.11.2.6 Made Smarter Collaborative R&D Funding

The Made Smarter programme also funds **collaborative research and development (R&D) projects** that either take technology solutions in the research phase and refine them in manufacturing pilots, or that develop solutions which are immediately appropriate for industrial deployment. This allows technology developers in the IDT areas to be matched with companies to test their developments over two years.

These projects have to be tied to a specific call. There are, however, no currently live calls for funding. The most recent was the Sustainable Smart Factory call, which closed in January 2022[123].

Made Smarter provides a summary of current and previous collaborative research and development projects, with a description of the aims and a video of the project[124].

2.11.3 Made Smarter: Cases

In addition to adoption and innovation, Made Smarter also has a library of case studies to help inspire manufacturers to adopt IDTs[125]. There are 81 case studies (at time of writing), with each explaining their case in one of two standard formats:

- Challenge / Solution / Benefits / Future

[118] https://mapp.ac.uk/
[119] https://www.lime.ac.uk/
[120] https://www.sustainsteel.ac.uk/
[121] https://cimcomp.ac.uk/
[122] https://www.sheffield.ac.uk/iwp
[123] https://ktn-uk.org/opportunities/made-smarter-innovation-sustainable-smart-factory/
[124] https://www.madesmarter.uk/made-smarter-innovation/collaborative-r-d/
[125] https://www.madesmarter.uk/resources/?page=1&category=1914

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

- Inspiration / Innovation / Impact

Each case summarises the developments into a two-page PDF, quickly and easily summarising the approach to and benefits of digitalisation. A few examples include:

- A manufacturer of drinks dispensers developing an augmented reality solution to enhance its sales process[126].
- A software provider developing a mass-customisation workflow for build-to-order orthotics[127].
- A partnership between a parts refurbishment specialist and an additive manufacturing solution provider to enable remanufacturing of more components as part of the circular economy[128].



Figure 8: An example of a Made Smarter Case Study two-pager.

[126] https://www.madesmarter.uk/resources/case-study-generationjuice-1/

[127] https://www.madesmarter.uk/resources/case-study-cae-tech-helps-usa-company-take-giant-step-towards-mass-customised-manufacturing/

[128] https://www.madesmarter.uk/resources/case-study-angus-3d-solutions/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

2.11.4 Connected Everything

As reported in the previous deliverable D2.3, the United Kingdom Research and Innovation's[129] Engineering and Physical Sciences Research Council[130] funds the **Connected Everything**[131] network, a research network for the digital manufacturing community in the UK.

Since the last deliverable, the network has developed the Digital World 2050 report[132], which aims to identify the key cross-cutting themes for investigation by network members in the next 30 years. The four cross cutting themes identified by the report are:

1. *Industrial Digital Technologies in 2050*: Emerging industrial digital technologies identified by the Made Smarter report are having far-reaching implications for how the UK manufactures things, exchange information and interact across supply chains.
2. *Digitisation and The Manufacturing Workforce of the Future*: The impact of digitalisation on the manufacturing workforce is uncertain. How can technology providers design technology and systems which will enable the future workplace to operate in safe, effective and productive workplaces?
3. *Digital Support for Achieving Net Zero Manufacturing by 2050*: The manufacturing and construction sector is the third largest sector in terms of carbon emissions in the UK. Digital technologies are becoming a key contributor to understanding how manufacturers can achieve net zero by 2050.
4. *Digitally Enabled Manufacturing Resilience*: Manufacturers face unprecedented disruption with the combination of the UK leaving the European Union, the global pandemic and the humanitarian disaster in Ukraine, combined with soaring transport, energy and raw material costs.

The report identifies five key objectives which are common across the four themes. They are:

- Connect digital technology developers to manufacturers.
- Reduce digital manufacturing knowledge barriers.
- Consolidate digital manufacturing guidance.
- Support employee wellbeing during transition.
- Transparency of value chain data.

[129] https://www.ukri.org/
[130] https://www.ukri.org/councils/epsrc/
[131] https://connectedeverything.ac.uk
[132] Public release is due in the near future.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

The relevance of these themes and objectives to the pathways are as follows.

	Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
Industrial Digital Technologies in 2050	■	■				■
Digitisation and The Manufacturing Workforce of the Future	■					
Digital Support for Achieving Net Zero Manufacturing by 2050		■		■	■	
Digitally Enabled Manufacturing Resilience	■	■		■	■	■
Connect digital technology developers to manufacturers						
Reduce digital manufacturing knowledge barriers	■	■	■	■	■	■
Consolidate digital manufacturing guidance	■	■	■	■	■	■
Support employee wellbeing during transition						
Transparency of value chain data		■		■		

2.11.5 Industrial Strategy Challenge Fund

The UK's **Industrial Strategy Challenge Fund (ISCF)**[133] is a funding programme to tackle big societal challenges faced by UK businesses. The focus of the fund is not on the manufacturing sector, but the manufacturing sector can benefit from a number of the funding challenges. The ISCF has access to £2.6 billion of government funding, with £3 billion of matched private funding.

ISCF funding is split into 23 challenges across four themes:

- Clean Growth
- Ageing Society
- Future of Mobility
- Artificial Intelligence and the Data Economy

Each challenge has a defined scope, a list of existing activities and case studies, and in some cases consolidated innovation and research activities. Where relevant, a matrix of relationships to pathways is included.

2.11.5.1 Industrial Decarbonisation

The industrial decarbonisation challenge[134] focuses on the creation of new low-carbon technologies and infrastructure, and their deployment into industry, with a particular focus on energy intensive industries such

[133] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/
[134] https://www.ukri.org/what-we-offer/browse-our-areas-of-investment-and-support/industrial-decarbonisation/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

as iron, steel, cement, refining, and chemical manufacturing. The The UK Industrial Decarbonisation Research and Innovation Centre brings together research in this area[135].

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
				■	

2.11.5.2 Low-Cost Nuclear

The low-cost nuclear challenge[136] looks to create new technologies for future low-carbon base power through the creation of standardised, compact nuclear power station modules which are mass manufactured. £210m has been awarded to Rolls-Royce to develop these products[137].

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
■					■

2.11.5.3 Made Smarter Innovation Challenge

The entirety of the Made Smarter Innovation programme discussed in section 2.11.2 is funded as a challenge within the ISCF[138].

[135] https://idric.org/

[136] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/clean-growth/low-cost-nuclear-challenge/

[137] https://www.ukri.org/publications/low-cost-nuclear-phase-two-grant-award-to-rolls-royce-smr-ltd/low-cost-nuclear-phase-two-grant-award-to-rolls-royce-smr-ltd-information/

[138] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/clean-growth/made-smarter-innovation-challenge/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity

2.11.5.4 Prospering from the Energy Revolution Challenge

This challenge seeks to invest more than £200m in smart local energy systems which integrate heat, power, and transportation. Much of the research in this area is concentrated in the EnergyREV consortium[139].

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity

2.11.5.5 Smart Sustainable Plastic Packaging Challenge

This challenge invests £60m in plastic packaging fit for the needs of a sustainable future, including the development of new sustainable plastic materials and designs, integrated circular manufacturing value chains, and knowledge dissemination of best practises and developments.

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity

[139] https://www.energyrev.org.uk/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

2.11.5.6 Transforming Construction Challenge

This challenge invests £170m with £250m of matched funding to transform the manufacturing sector from bespoke on-site work to a digitally-enabled manufacturing process with a value outcome approach that takes lessons and developments from other manufacturing sectors. Three key research investments have been made for this challenge:

- The Construction Innovation Hub[140] hosted by the Manufacturing Technology Centre, Building Research Establishment, and Centre for Digital Built Britain.
- The Transforming Construction Network Plus[141].
- The Active Building Centre[142].

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
■	■		■	■	

2.11.5.7 Transforming Food Production Challenge

This challenge[143] aims to reduce emissions and pollution in food production, while simultaneously meeting the needs of a growing global population. A key aspect of this is the investment of £16 in future food production systems, including the use of soldier flies to convert food waste into animal feed[144], data-enabled productivity maximisation of vertical farming[145], and point-of-consumption autonomous growing of high-value produce[146].

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
■	■		■	■	

[140] https://constructioninnovationhub.org.uk/
[141] https://www.ucl.ac.uk/bartlett/construction/about-us/transforming-construction-network-plus
[142] https://www.activebuildingcentre.com/
[143] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/clean-growth/transforming-food-production-challenge/
[144] https://www.ukri.org/news/using-insects-to-convert-food-waste-into-sustainable-animal-feed/
[145] https://gtr.ukri.org/projects?ref=49078
[146] https://www.evogro.com/#

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

2.11.5.8 Transforming Foundation Industries Challenge

Covering cement, metals, glass, paper, ceramic, and chemical manufacturing sectors, this challenge seeks to transform these sectors for the 21st century, making them internationally competitive and growing the sector in a sustainable manner[147].

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
■	■		■	■	

2.11.5.9 Ageing Population Theme

The ageing population theme includes four challenges[148]:

- Accelerating detection of disease
- Healthy ageing
- From data to early diagnosis and precision medicine
- Leading-edge healthcare

Though manufacturing and digitalisation may play a part in these challenges, the theme is of tangential relevance to the pathways.

2.11.5.10 Driving the Electric Revolution Challenge

This challenge focuses on the development of power electronics, electric machines, and drives (PEMD) to support a push towards a net-zero carbon economy[149]. Though much of the research in this challenge is on the fundamental technologies enabling electrification, much is also in the manufacturing and scale-up of producing these technologies[150], as well as enabling the supply chains[151].

[147] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/clean-growth/transforming-foundation-industries-challenge/
[148] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/ageing-society/
[149] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/future-of-mobility/driving-the-electric-revolution-challenge/
[150] https://www.der-ic.org.uk/
[151] https://www.ukri.org/news/driving-the-uks-electric-revolution/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
■			■	■	

2.11.5.11 Future Flight Challenge

The future flight challenge funds research and innovation in the creation of electric and hydrogen powered aircraft, as well as autonomous air vehicles. As with the previous challenge, much of the funding is devoted to the fundamental technology development, but funding is also available for developments in secure, connected digital systems to manage autonomous vehicles as part of supply networks[152]. It is however in general of limited applicability to the pathways.

2.11.5.12 Faraday battery challenge

This challenge is devoted to promoting the growth of battery manufacturing in the UK[153]. Some of the work is on the underlying electrochemical energy storage research, but most is concerned with the manufacturing and whole-life strategies for battery recycling and reuse. As part of this, the Faraday Institution has been created t bring together scientists and industry partners[154], and the UK Battery Industrialisation Centre has been created to enable the scale-up and skills training for battery-sector companies[155].

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
■			■	■	

[152] https://www.altitudeangel.com/news/uk-government-gives-the-green-light-for-worlds-longest-drone-superhighway

[153] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/future-of-mobility/faraday-battery-challenge/

[154] https://www.faraday.ac.uk/

[155] https://www.ukbic.co.uk/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

2.11.5.13 National Satellite Test Facility

The National Satellite Test Facility will be a £105m investment in a comprehensive set of satellite testing facilities, allowing the manufacture of larger, more complex satellites in the UK[156]. The nature of satellite manufacturing means the pathways of Connected Factories are of limited applicability.

2.11.5.14 Robots for a Safer World

The robots for a safer world challenge awarded £112m to 200 organisations to increase the development and uptake of advanced robotics and autonomous systems[157]. A key focus was on applications for offshore, nuclear, space, and drilling applications, but a number of resilience and cross-cutting projects also explored robotics for manufacturing applications. This theme invested in four research hubs:

- The Future AI and Robotics for Space Hub[158]
- The National Centre for Nuclear Robotics[159]
- The Offshore Robotics for the Certification of Assets Hub[160]
- The Robotics and Artificial Intelligence for Nuclear Hub[161]

This theme has concluded. A list of projects investigated can be found here[162].

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
■				■	

2.11.5.15 Self-Driving Vehicles

The ISCF is investing £28m in artificial intelligence and control systems for driverless cars, focusing on three projects; deployment of driverless cars for journeys between cities, development of driverless electric delivery vans, and development of safety validation, insurance, and service models for driverless cars.

[156] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/future-of-mobility/national-satellite-test-facility/
[157] https://www.ukri.org/what-we-offer/browse-our-areas-of-investment-and-support/robots-for-a-safer-world/
[158] https://www.fairspacehub.org/
[159] https://www.ncnr.org.uk/
[160] https://orcahub.org/about-us/vision
[161] https://rainhub.org.uk/
[162] https://www.ukri.org/wp-content/uploads/2022/03/UKRI-090622-RoboticsSaferWorld-RoboticsArtificialIntelligenceExtremeEnvironmentsProjectDirectory.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
		■	■		■

2.11.5.16 Audience of the Future

This challenge seeks to invest £39m in new immersive technologies for application in the fields of art, culture, heritage and entertainment[163]. Although the development of VR/AR technologies may be applicable to manufacturing contexts, this challenge is not relevant to the pathways.

2.11.5.17 Commercialising Quantum Technologies

This challenge looks at establishing the UK as a global leader in quantum technologies by awarding £153m of government funding and £205 of industrial funding[164]. This funding focuses on:

- Quantum product and service innovations, including secure encryption and data security.
- Industry-led development projects addressing the underlying technical challenges.
- Establishment of the supply chain necessary for quantum products.
- Investment in early stage, start-ups, and scale-ups in quantum areas.

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
		■			■

2.11.5.18 The Creative Industries Clusters

This challenge invested in nine clusters of creative research and development, including the fashion, film, television, informatics, design, computer gaming, performance, and immersive technologies areas[165]. This challenge is of limited applicability to the pathways.

[163] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/artificial-intelligence-and-data-economy/audience-of-the-future-challenge/

[164] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/artificial-intelligence-and-data-economy/commercialising-quantum-technologies-challenge/

[165] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/artificial-intelligence-and-data-economy/creative-industries-clusters/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

2.11.5.19 Digital Security by Design

This challenge helps the UK develop secure computing infrastructure[166]. As a major global challenge, cybersecurity is a key consideration for all UK businesses, and the manufacturing sector is no different. Projects funded by this challenge include:

- *Arm Morello*: The development of a new processor infrastructure that is secure and resistant to key security breaches[167]. This is an example of capability hardware, hardware with additional security features such as memory safety and compartmentalisation.
- *Discribe*: Research in increasing the adoption of secure technologies, improving readiness of UK businesses, development of regulation and policy, and doing all these, while being aware of varying contexts and cultures which influence approaches to cybersecurity[168].
- *Secure Code for Capability Hardware*: Formal analysis tools for detecting security issues in capability hardware i.e. Morello[169].
- *Holistic Design of Secure Systems on Capability Hardware*: Establishing and verifying application-level security requirements with capability hardware features[170].
- *Capability Architectures in Trusted Execution*: Development of architectures and trusted execution environments for safety critical systems [171]

Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories		Dataspaces	Circular Economy	Cybersecurity

2.11.5.20 Next-Generation Services

This challenge allocated £20m to 40 projects in the development of AI-enhanced services in the accountancy, insurance, and legal services sectors, which account for 80% of the UK economy[172]. A summary of the projects funded can be found here[173]. Though accountancy, insurance, and legal services are important to manufacturing, they are not represented by the pathways.

[166] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/artificial-intelligence-and-data-economy/digital-security-by-design-challenge/
[167] https://www.arm.com/architecture/cpu/morello
[168] https://www.discribehub.org/
[169] https://scorch-project.github.io/about/
[170] https://hd-sec.github.io/
[171] https://research.birmingham.ac.uk/en/projects/cap-tee-capability-architectures-in-trusted-execution
[172] https://www.ukri.org/what-we-offer/browse-our-areas-of-investment-and-support/next-generation-services/
[173] https://www.ukri.org/wp-content/uploads/2022/03/5980-Next-generation-brochure-CS-v2-1.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

2.12 Greece

2.12.1 Greece 2.0 initiative

"Greece 2.0" aspires to lead the country - economy, society and institutions - into a new era, to trigger a fundamental change in the economic paradigm towards a more extroverted, competitive and green production model, with a more efficient and digitized state, less bureaucratic, with a drastically reduced shadow economy, with a tax system friendly to development and with a quality and efficient social protection network, accessible to all. The National Recovery and Resilience Plan Greece 2.0 was approved on 13 July 2021 by the Economic and Fiscal Affairs Council of the European Union (Ecofin). "Greece 2.0" includes 106 investments and 68 reforms, divided into 4 pillars and collects 31.16 billion euros, of which 30.5 billion euros are European funds (18.43 billion euros aid and 12.73 billion euros loans) to mobilize €60 billion of total investment in the country over the next five years.

The four pillars of Greece 2.0 are:

1. Green transition,
2. Digital transformation,
3. Employment, skills and social cohesion (health, education, social protection),
4. Private investment and economic and institutional transformation.

The goal of Axis 4.5 of "Greece 2.0" is to increase public and private investment in research and development (R&D), strengthen links between science and business, and develop world-class pioneering R&D infrastructure. This will be achieved through a series of projects, as well as through reforms to encourage innovative companies to invest in R&D. This Axis will contribute to strengthening the links between academia and the productive sector by increasing the competitiveness of Greek industry, will increase the exploitation of intellectual property rights, reverse the "brain drain", strengthen the Greek start-up innovation ecosystem and mobilize the R&D spending by businesses.

2.12.2 EIT Manufacturing CLC South-East (Athens)

The European innovation network EIT Manufacturing created a new innovation hub, the Co-Location Center South-East, CLC SE for short in Athens-Greece. EIT Manufacturing is the manufacturing-focused Knowledge and Innovation Community within the European Institute of Innovation and Technology (EIT), a body of the European Union. The setup of the CLC SE legal entity has been concluded as of the 27th of April 2022.

CLC SE is the sixth EIT Manufacturing hub and will serve eight countries in South-East Europe: Albania, Bulgaria, Cyprus, Greece, Moldova, North Macedonia, Romania and Turkey. These countries are of key strategic focus for EIT Manufacturing and hold great potential for developing and strengthening the European manufacturing industry. The role of CLC SE is to

- stimulate the local manufacturing eco-system in South East Europe,
- accelerate the cross-national synergies across the different players: Industry (Large industry, SMEs, start ups), Universities, Research Institutes,
- collaborate and establish synergies with regional/national authorities,
- attract stakeholders from the local CLC ecosystem and help them to participate in EIT Manufacturing activities and
- promote the Knowledge Triangle Integration; Bring together Education and Training, Innovation and Research and Business Creation.

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2.12.3 Competence Center for Manufacturing

With the support of the General Secretariat for Research and Innovation in Greece the Teaching Factory Competence Center (http://teachingfactory-cc.eu/) has been setup in Patras, Greece under the coordination of LMS. The Teaching Factory Competence Center (TF-CC) is oriented on providing education, innovation, and entrepreneurial services to the manufacturing industry. It focuses on enabling the knowledge exchange between the academia and industry and on creating added value for the services and products of manufacturing companies by promoting innovative technology and research activities. TF CC is strongly connected with EIT Manufacturing group by offering interconnection services with it through EIT Manufacturing RIS Hub and CLC SE operating in Greece. Its Technological Areas have emerged from the needs and challenges of the national manufacturing industry, combined with a set of solutions based on the technologies of the 4th Industrial Revolution.

The services offered by Teaching Factory Competence Center focus on the following thematic areas:

- *Digital Manufacturing*: Aims at flexible production systems through the adoption and development of Artificial Intelligence (AI) solutions.
- *Advanced Manufacturing*: Creating smart solutions, upgrading, and modernizing processing / production devices to increase competitiveness are based on the discussed tools. More specifically, the modelling and simulation of complex production processes to optimize them, using advanced methods of analysis (e.g., Neural Networks, Artificial Intelligence systems, molecular dynamics, hybrid methods, finite elements, etc.) are key tool for improving productivity and product quality of manufacturing industries.
- *Mixed Reality and Sensing*: Mixed Reality technologies are a combination of augmented reality (AR) and virtual reality (VR). These technologies have a dual purpose: 1) to monitor, supervise and control production remotely or in a mixed way, contributing to physical safety and ergonomics, 2) to contribute on training by offering various realistic handling scenarios (both literally and figuratively) using Mixed Reality technology.
- *Communications and 5G*: 5G infrastructure will promote rapid technological changes that will enable the full development of the digital industry, the intelligent systems industry, the Internet of Things, as well as the advanced production systems.

In the table below the links between the thematic areas and the CF2 pathways is provided.

	Autonomous Smart Factories	Hyperconnected Factories	Collaborative Product-Service Factories	Dataspaces	Circular Economy	Cybersecurity
Digital Manufacturing	■	■		■		■
Advanced Manufacturing			■		■	
Mixed Reality and Sensing	■		■			
Communications and 5G		■				■

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3 European Initiatives

3.1 EIT Manufacturing

EIT Manufacturing aims at putting Europe at the centre of a global revolution and boost manufacturing innovation in Europe by connecting people with skills, technologies with markets, and innovators with investors. . In 2022, EIT Manufacturing has launched a Call for Proposals (for Activities to be executed starting in 2023) always keeping in mind and building upon the experiences and lessons learnt from previous years. All activities of EIT Manufacturing serve the purpose of targeting four focus areas – its Flagships which are the following:

- *Flexible Production Systems for Competitive Manufacturing*. Emerging technologies enable almost limitless flexibility in product design and production, allowing full customisation.
- *Low Environmental Footprint Systems & Circular Economy for Green Manufacturing*. Using new technology to minimise use of resources, energy, and material in production systems enables new circular business models.
- *Digital & Collaborative Solutions for Innovative Manufacturing Ecosystems*. Collaboration and business on digital platforms and value networks enables companies to create new and highly efficient value chains.
- *Human-machine co-working for socially sustainable manufacturing*. Smart use of automation and robots enables great workplaces, flexible production, and sustainable human work.

The following table presents the relevance between each activity in the innovation pillar of EIT Manufacturing and the predefined pathways.

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EIT Innovation Activity	Focus Area	Autonomous Smart Factories	Hyperconnected factories	Collaborative Product-service	Dataspaces	Circular economy	Cyber security
Redamp: REal time monitoring of DED Additive Manufacturing Process for Zero Defect Manufacturing	Flexible Production Systems for Competitive Manufacturing	X				X	
Connected Assets iNteroperability framework Via AAS (CanvAAS)	Flexible Production Systems for Competitive Manufacturing	X			X		X
Additive Manufacturing and Artificial Intelligence (AMAI)	Flexible Production Systems for Competitive Manufacturing	X				X	
Software tools for hybrid robot based additive manufacturing for industrial applications (SoftDREAM)	Flexible Production Systems for Competitive Manufacturing			X			
Next Generation Fresh Fish Picking System and Spectral Quality Control (PICK-A-FUTURE)	Human-machine Co-working for Socially Sustainable Manufacturing	X					

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EIT Innovation Activity	Focus Area	Autonomous Smart Factories	Hyperconnected factories	Collaborative Product-service	Dataspaces	Circular economy	Cyber security
Sustainable human-robot co-production for cargo bicycles (Robofiets)	Human-machine Co-working for Socially Sustainable Manufacturing			X			
Displacing intensive manual labour towards human focused collaborative robots	Human-machine Co-working for Socially Sustainable Manufacturing	X		X			
Leverage Abrasive Blasting by Robotic Intelligent Devices (LABROID)	Human-machine Co-working for Socially Sustainable Manufacturing			X			
Mobile Autonomous Robot for Safe sorting (dual-safety mode: safe mode in a human environment / full speed in a non-human environment) (MARS)	Human-machine Co-working for Socially Sustainable Manufacturing	X		X			
Smart and Flexible Clamping Solutions for Sealing (Sofocles)	Human-machine Co-working for Socially Sustainable Manufacturing	X		X			
AI-based Toolkit for enhancing Human-Robot Interaction in Industry 4.0 (WORKSUIT4.0)	Human-machine Co-working for Socially Sustainable Manufacturing	X		X			
enaBling techn0logies fOr data Sovereignty in	Digital & Collaborative Solutions for Innovative				X		X

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EIT Innovation Activity	Focus Area	Autonomous Smart Factories	Hyperconnected factories	Collaborative Product-service	Dataspaces	Circular economy	Cyber security
manufacTuring sERvices (Booster)	Manufacturing Ecosystems						
AI Sovereignty	Digital & Collaborative Solutions for Innovative Manufacturing Ecosystems	X			X		X
Collaborative processes for industry and logistics interaction (COL4INDLOG)	Digital & Collaborative Solutions for Innovative Manufacturing Ecosystems		X		X		
Manufacturing Data Spaces (ManuDataSpa)	Digital & Collaborative Solutions for Innovative Manufacturing Ecosystems				X		
Sensor integrated high speed machining for Zero-Defects 'Mach 4 Zero Defect' (MACH4)	Low Environmental Footprint Systems & Circular Economy for Green Manufacturing	X		X			
Smart Measurement Assisted Assembly Lines for large-scale structures (SMAAL)	Low Environmental Footprint Systems & Circular Economy for Green Manufacturing	X		X			
Transitioning to a waste-free production – international cryogenic+MQL machining activity (CRYO-MQL)	Low Environmental Footprint Systems & Circular Economy for Green Manufacturing					X	

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EIT Innovation Activity	Focus Area	Autonomous Smart Factories	Hyperconnected factories	Collaborative Product-service	Dataspaces	Circular economy	Cyber security
Edge intelligence for condition monitoring and status visibility of assets in harsh industrial environments (AssetYp4.0)	Low Environmental Footprint Systems & Circular Economy for Green Manufacturing	X		X			
Prescriptive Production Assistant (IVE)	Low Environmental Footprint Systems & Circular Economy for Green Manufacturing	X		X			
air Purification Unit for manufactuRing Environment (PURE)	Low Environmental Footprint Systems & Circular Economy for Green Manufacturing	X					
Automation of Visual Inspection and Finishing Processes for Aero-engines (AVISPA2)	Low Environmental Footprint Systems & Circular Economy for Green Manufacturing	X					
modular dECisiOn Support SYSTEM for a waste-free Manufacturing through digital support and artificial intelligence (ECOSYSTEM)	Low Environmental Footprint Systems & Circular Economy for Green Manufacturing	X				X	
Zero-defect wELDing for e-mobility (ZELD-e)	Low Environmental Footprint Systems & Circular Economy for Green Manufacturing	X		X			

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3.2 Other European initiatives

On top to the EIT Manufacturing there are other important actions in Europe that can benefit of ConnectedFacotries 2 pathways and of other results of the DT-ICT-07 project cluster:

- Made In Europe PPP: As the CF2 project belongs to the Factories of the Future PPP, it is natural that the current manufacturing partnership Made In Europe PPP exploits the pathways when renewing the strategic research agenda and defining the future calls. All pathways are highly relevant in the scoping of Made in Europe.
- The more digitally oriented European partnerships, such as Artificial Intelligence, Data and Robotics, High performance Computing and Key Digital Technologies (or Chips Act) have many activities addressing digitalisation of industry. Exploitation AI, Data and Cybersecurity pathways through these partnerships is a possibility.
- The Process4Planet partnership has a strong focus on circularity. CF2 Circular Economy pathway is highly relevant for P4Planet PPP.
- The Eureka SMART program focuses on manufacturing and has potential to benefit of all the CF2 pathways.
- Digital Europe Program: The Digital Europe Program has major activities in the deployment of digital technologies in companies, in particular in SMEs. Indeed, European Digital Innovations hubs (EDIH) supported by the program have been mentioned as important instruments in many of the national initiatives. The network of EDIHs active in manufacturing are very important for the future dissemination of the CF2 pathways. In addition, the Artificial Intelligence TEFs could benefit of the results generated by CF2 and the project cluster. The most CF2 pathways for the Digital Europe program but in particular the AI, Data and Cybersecurity pathways.

4 Conclusions and next steps

In accordance with the strategic objectives of ConnectedFacotries 2, this document has contributed to the collection of preliminary input from the national/regional/European initiatives. National (Chapter 2) and EU level (Chapter 3) initiatives related to Digitizing European Industry with a focus on manufacturing industry are discussed. In each case, overall information is provided for the national activities while in some cases a projection to ConnectedFactories pathways is presented. The feedback and analysis on the national level depicts verify the results of previous deliverable CF2 D2.3 that the ConnectedFactories pathways definition are pertinent and reflect activities/initiatives in national and EU level.

The analysis has shown the relevance of the pathways' approach and topics to the different initiatives. However, it has also indicated that more needs to be done for the step-wise transformation model proposed by the ConnectedFactories pathways to be integrated in the initiatives. The pathways should be an integral part of the digital transformation services offered by several Industry 4.0 service providers and end-users around Europe. In the future, more dissemination, awareness creation and industrial case demonstration efforts should take place to support the adoption of the pathway models within the different initiatives.

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