PID IN PRACTICE 1: POLICY IMPLEMENTATION RELEVANT TECH RADAR ON INTELLIGENT PRODUCTION SYSTEM

D.T2.3.2 – PID in practise 1 – Policy Implementation relevant Tech Radar Intelligent Production System	Version 3.00 04.2022

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Document Control

Document Summary	
Project Number	CE1662
Project Title	CEUP 2030
Work Package/Activity	A.T2.3 - Establish PID to Translate TINs Work into Future Robust Policy & Strategy Building
Deliverable	D.T2.3.2 - PID in practise 1 - Policy Implementation relevant Tech Radar on Intelligent Production System
Deliverable Responsible (if applicable)	PP10 / HAMAG
Deliverable Reviewer (If applicable)	All PPs, PP6/AFIL as WPT2 Leader
Deliverable Due Date	November 2020 (Delayed to November 2021)

Dissemination Level		
PU	Public	
PP	Restricted to other programme participants	
RE	Restricted to a group specified by the consortium	
CO	Confidential, only for members of the consortium	CO

Document History			
Date	Version	Issuer	Description of Changes
11.2021	1.00.00	PIA	Working draft, for review
11.2021	2.00.00	PIA	Working draft updated, for review
04.2022	3.00.00	PIA	Final document

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Executive Summary

Project Overview

CEUP 2030 aims to generate stable innovation networks which foster better understanding on Central Europe Advanced Manufacturing and Industry **4.0** (“**CAMI4.0**”) topics, to generate improved knowledge resource exchange on these technologies leading to an upgraded framework for policy-making and implementation.

Ultimately CEUP 2030 creates and tests a common method to promote improved knowledge dissemination to policy-making stakeholders using a collaborative exchange framework based in physical and digital-methods. These methods and the technology use-cases disseminated within the project, are harvested from existing, high-quality innovation know-how in the CE area.

The project focuses on:

- Identifying the highest-quality innovation know-how in the CE Area, on the CAMI4.0 Topics.
- Enhancing skills capabilities and knowledge of people in charge of local, regional, and (trans)national RTI Policies, associated to the CAMI4.0 Topics.
- Creating a sustainable structure for awareness-raising and shared, sustainable RTI knowledge resource use to enhance policy decision support.
- Anticipating and fast-tracking policy / strategy policy pilot actions to promote a joint RIS3 for CAMI4.0 Excellence in CE/EU.

Work Package and Activity Overview

The overall objective of WPT2 links to the project’s specific objective of ensuring awareness and shared sustainable responsibility on using research, technology and innovation knowledge resources in CE/EU for enhancing policy decision support.

The challenge manifests in two sub-objectives which are:

- To coordinate technology experts across the CE/EU regions for solution-oriented trend monitoring (the Trend and Innovation Networks)
- To streamline, process and manage the knowledge for improved policy decision making, in a practicable and sustainable manner (Policy Intelligence Dashboard).

The specific activity which is of relevance for this document is Activity A.T2.3, which is a common activity for all WPs and covers the development of the project’s Policy Intelligence Dashboard, which should translate the Trend & Innovation Network knowledge into future robust policy and strategy building. It is designed to establish strong partnerships around the 4 main CAMI4.0 topics in order to raise awareness and ensure a shared sustainable responsibility on using RTI knowledge resources in CE/EU for enhancing policy decision support. The Trend Innovation Networks (TIN) will be equipped with practicable, efficient policy tools, available on Policy Intelligence Dashboard (PID). Both those instruments will be exploited by the partners to select and channel appropriate decision-relevant information out of the daily big data cloud, assess it and provide understandable knowledge in a compact and high-quality format.

Specifically, the practical activities which are supported in this document are:

- Establishing links to key good – practice tools which can power the policy intelligence dashboard;
- Explain the process for the key requirements of the Policy Intelligence Dashboard;

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- Establish the working processes to develop these key requirements into a wireframe/base operating framework;
- Establish the working processes to develop the tech radar and risk heat maps on technology trends;
- Develop a link to the use-cases the Partners will develop on policy-instruments.

Project-Relevant Reference Material & Reading Prerequisites

(1) **CE1662 CEUP 2030 Application Form** (Version 1, 07/2019): The application form regarding CEUP 2030 for Interreg Central Europe

(2) **Guidance on Harvesting Agenda** (D.T2.1.1; Version final, 04/2020): A guidance document for A.T2.1 on harvested methodologies for the Trend & Innovation Networks and Policy Intelligence Dashboard.

(3) **Harvesting Agenda on CAMI 4.0 for Trend & Innovation Networks and Policy Intelligence Dashboard** (D.T2.1.2; version 2.0, 11/2020): A report and selection grid for best-in-class use of identified outputs and results in WPT2

(4) **Policy Intelligence Dashboard (PID) Design & Elaborate Technology Radar to improve CE/EU (DT.2.3.1.; version 3.0, 04/2022): A manual to establish the IT-based Policy Intelligence Dashboard, with CAMI4.0 Tech Radars and Industry Risk Heat Maps on Technology Trends**

All documents can be found on the project's central repository - Alfresco

Scope of Document & Deliverable Summary

Deliverable D.T2.3.2 is defined in the Application Form as a Trend Radar and Risk Heat Map on Intelligent Production System developed under joint Policy Intelligence Dashboard for the four 4 CAMI4.0 topics. The PID in Practise for IPS represents a Tech Radar (TR) including a Risk Heat Map where policy-relevant data sources (use cases, policy instruments, organisations and networks) are identified and classified with a goal to transfer and deliver relevant content for decision makers. The database of use cases collects 10 the most representative case studies collected within CEUP2030 project, as well as recommended and varied by PPs policy instruments dedicated to CAMI4.0 topics and descriptions of flagships originating from the project partnership. To deliver the tool that is functional and answers the expectations of the varied stakeholders groups a model of PID is to be tested with a balance group of stakeholders. DT2.3.2 presents the scope of the survey and delivers feedback received (test transfer to practice among target groups; feedback loops with regional/national stakeholders. The structure of Trend Radar and Risk Heat Map on IPS is in line with manual which provides the guidance required to establish an IT-based Policy Intelligence Dashboard which evidences CAMI4.0 Technology Radars and Risk Heat Maps on Technology Trends (DT.2.3.1)

This document contains the summary of PID in Practise demonstration testing and insights and conclusions collected valuable for further development of PID. It represents the "Policy Intelligence Dashboard in Practice", which highlight technology trends for IPS – one of the four CAMI4.0 topics. The Document provides background insight necessary to deliver the Dashboards along with implementation procedures and testing procedures. The purpose of

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the PID in practice 1: Policy implementation relevant Tech Radar on IPS (T2.3.2) is to provide the Partners the information which is required to create the Policy Intelligence Dashboard for Intelligent Production System technology which is a part of the key output of WPT2.

Output O.T2.2	CEUP 2030 Policy Intelligence Dashboard – Refocusing technology trend insights for policy makers	The Policy Intelligence Dashboard monitors, fine-tunes and streamlines policy relevant data on technology trends for a fast-track assessment based on a solid data gathering and evaluation (Tech Radars, A.T2.3). The PID will be tested in a common transnational manner, established and anchored in the activated stakeholder scheme (PLLs, TINs). The PID methodology sets the base for the joint policy exploitation with pilots as well as a future planning for 2021-2027 in T3 and beyond project´s end.	S.O.1.1 - Number of tools and services developed and/or implemented for strengthening linkages within the innovation systems	1,00	11.2021

Audience

This document is directed at all project partnership members, because all PPs are asked to participate in the development of the Policy Intelligence Dashboard and in testing its content.

Change Control Procedure & Structure

The Deliverable Responsible: HAMAG Croatia **(PP10)** created this document and it is hosted on the Project's common repository in the appropriately named deliverable folder. The document is under project deliverable change control protocols whereby Partners are requested to give feedback on the Draft Version within five working days. Feedback will be incorporated and Final Version will be issued by HAMAG. Thereafter the PPs have five additional working days for any final comments. At any time, partners believe a project methodology should change, the request should be brought to the Deliverable Responsible (HAMAG/PP10) and the Work Package Leader (AFIL/PP6) to consolidate feedback from other partners, and then further integrate and disseminate the final agreed changes. A new version of the document should be created, and recorded in the document's "Document History" table.

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Abbreviations

Abbreviation	Explanation
AF	Application Form
ASP	Associated Partner (i.e. Strategic Partner)
CAMI4.0	Central European Advance Manufacturing and Industry 4.0
PI	Policy Instrument
PIF	Policy Implementation Framework
PLL	Policy Learning Lab
PP	Project Partner
RIS3	Regional Innovation Strategy for Smart Specialisation
S3	Smart Specialisation Strategy
SBU	Strategy Boost & Upgrade
TGP	Technology Good Practice
TIN	Trend & Innovation Networks
TTTDM	TIN Transnational Technology Dialogue Meeting

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1. Key background information

1.1. AT2.3 activity within CEUP2030 project

Within WPT2 and between work packages, Activity T2.3 Establish PID to translate TINs work into future robust policy & strategy building is highly embedded within the other work of CEUP 2030. This is primarily because the PID is the partnership lasting model of how to deliver insight (beyond workshops) in an ongoing and sustainable way to key policy-making stakeholders (and also other stakeholders) who are interested in the four CAMI4.0 topics specifically or Industry 4.0 and Advanced Manufacturing in Central Europe, more generally.

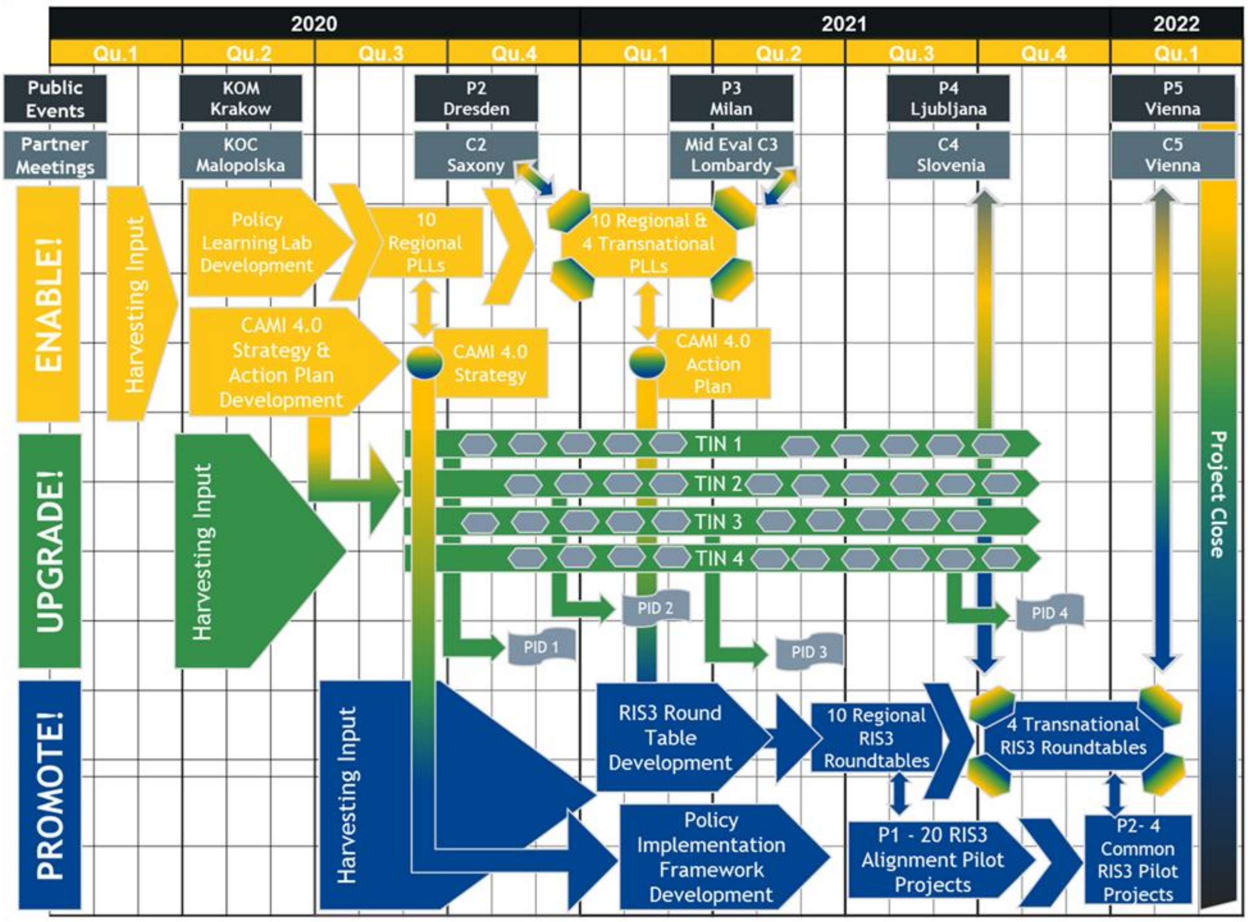

Figure 1 CEUP 2030 Plan on a Page (Source: Author Generated)

In particular, within AT2.3, four main activities have been performed:

- AT2.3.1 PID design & elaborate technology radars to improve CE/EU policy making (Responsible: PP1/KPT)
- **AT2.3.2 PID in practice 1: Policy implementation relevant Tech Radar on Intelligent Production System (Responsible:PP10/HAMAG)**
- AT2.3.3 PID in practice 2: Policy implementation relevant Tech Radar on Automation and Robotic (Responsible:PP3/PIA)

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- AT2.3.4 PID in practice 3: Policy implementation relevant Tech Radar on new materials (Responsible:PP8/PTP)

- AT2.3.5 PID in practice 4: Policy implementation relevant Tech Radar on Artificial Intelligence (Responsible:PP9/PBN)

1.2. AT2.2 - Connection to the Trend & Innovation Networks

The strongest connection exists between the PID and the Trend & Innovation Networks (TINs). This is because it is the insights, and input from the TIN Dialogue Sessions, which should be used to fill and validate the PID in Practice. The TINs are the “playground” where key foresight discussions should take place. These discussion points, technology foresight and development interpretations should be recorded within the PID in Practice. The TINs are directly connected to the Policy Learning Labs (AT1.2) and RIS3 Round Tables (AT3.2)

The PLLs and the RIS3 Roundtables (the consortia’s workshop series with policy-influencing stakeholders, and the lasting policy-making stakeholder engagement forum), are key areas where the Partnership should gain insight on the PID in Practice key Target Group. It is via exchange and presentation of concepts within these forums that the Policy Intelligence Dashboard will gain its purpose & its relevance.

The Policy Intelligence Dashboard is connected to the Policy Implementation Framework (PIF) and the Strategy Implementation Blueprint (WPT1). The Partners should be working to align the information provided in the PID, particularly success stories, to those recommendations which are provided in the use-cases delivered in the final phase of the project. The insights provided in the PID should lead stakeholders reviewing the document, to a logical understanding about what is presented in the Policy Implementation Framework. For instance, by trying to capitalise on a specific good practice or by trying to align for specific support for an emerging technology area.

This also means that Partners should be using all conversations associated to the development of the draft use-cases for the Strategy Implementation Blueprint, to be considering what would be effective use cases to present in the Policy Intelligence Dashboard.

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2. Description and goal of the Policy Intelligence Dashboard

Policy Intelligent Dashboard is the most complete one-stop-shop for policy makers and policy influencing stakeholders as research technology organizations and enterprises operating around intelligent production system area. PID gathers in one place practical and streamlined knowledge and insight on technology trends and potential industry impact for the entire innovation eco-system. Intelligent production system area represents a Tech Radar including a Risk Heat Map, where policy-relevant data sources as use cases, financial instruments, flagships and organizations are presented with a goal to support, transfer and enrich policy decision making processes in the area of this technologies. The Intelligent production System Trend & Innovation Network (TIN) established under CEUP2030 project played a big role in creating the PID. Community of stakeholders representing different target groups established around IPS discussed and shared trend and innovation foresights on the IPS topic. This community built on the stakeholders involved in PLL in WPT1 and were enriched with key experts identified by each partner. In order to foster the discussion on trend and innovation foresight on the IPS topics, 10 TTTDM - TIN Tech Trend Dialogue meetings were organised by CEUP2030 partners involving the regional stakeholders identified in the community. Besides their regional configuration, TINs also had an interregional dimension thanks to action of PPs that guaranteed connections among the different network exploiting the synergies that emerged during TINs development. In particular, PPs contributed and fostered the identification and development of use-cases in each network that can be concretely implemented in flagship projects involving partners from different regions, either PPs or their stakeholders. In summary, 333 stakeholders from 7 countries were involved in expert workshops on Intelligent Production Systems. The workshops were held exclusively online, and utilised plenary presentation, round-tables, and live-surveys to promote a co-creative atmosphere which allowed live discussion on the challenges and opportunities facing the central European manufacturing eco-system. The experts discussed issues on the future of IPS, from SME adoption of predictive maintenance technologies, to the utilisation of open-source resources to promote the functional use of big-data in industry. The TTTDM's validated that the sub-topics chosen by the partnership are relevant for the future of Intelligent Production Systems. In one area – sustainable production systems – there was less interest from the stakeholder community, however this could also be a great opportunity to foster it through further actions and may be through the definition of the Common Policy-Use Case. The IPS TTTDMs were also aimed at supporting the definition, development and submission of the A&R flagship projects, use cases and policy instruments. All these above mentioned feedback from stakeholders helped to create and developed the Policy Intelligence Dashboard. The PID is built around a core project principle, that policy-makers can directly benefit, and create onward benefits for the entire innovation eco-system, when they have practical and streamlined knowledge and insight on technology trends and potential industry impact.

The Partnership will, in total, create four "PID in Practice", one for each CAMI4.0. This document presents D.T2.3.2 PID in practice 1: Policy implementation relevant Tech Radar on Intelligent Production System /PP10/HAMAG, due in March 2022

PID Intelligent production system represents a Tech Radar (TR) including a Risk Heat Map (RHM), where policy-relevant data sources (use cases, organisations, actors, instruments)

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are identified and classified with a goal to transfer and interpret to policy-decisions. Key use cases should be presented in an easy- way enabling interactive enquire of knowledge and understanding of the key technologies and with contact details to hosting organisation.

3. Policy implementation relevant Tech Radar on Intelligent Production System

Policy implementation relevant Tech Radar on Intelligent Production System is located on the website http://ceup2030pid.eu/ and integrate knowledge and insight developed from dialogue occurring within the Partnership's workshop series includes the following elements for each CAMI4.0 topics :

- Introduction
- Analysis of theTech Radar
- Risk Heat Map
- Summary of the flagships
- Interesting use-cases
- Policy instruments
- Tools

This document D.T2.3.2 PID in practice 1: Policy implementation relevant Tech Radar on IPS includes all above mentioned elements.

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3.1. Introduction

The manufacturing industry has a strong influence on the national economies of European countries. The European Union is the largest exporter of high-quality products. In recent years, European countries have faced many challenges such as an aging population, and competition from China, the USA, and developing countries [1]. The countries of Central Europe are an important factor in keeping the EU as a global leader in the production of high-quality products. However, the manufacturing sector of many Central European countries is at risk due to possible relocations of manufacturing companies caused by the rising costs of production resources [2]. For the EU to maintain its status, innovations in manufacturing are necessary, which will result in increased efficiency of manufacturing processes and the supply chain.

To increase the efficiency of manufacturing processes, it is necessary to use the available resources optimally. Traditional manufacturing systems have difficulties coping with this challenge due to the limitations of the human operators in making decisions in conditions of high uncertainties and complexities of manufacturing processes [3].

Industry 4.0 is a business and manufacturing paradigm based on the integration of machines and people within complex manufacturing and logistics processes through the application of a cyber-physical system (CPS) [4]. The CPS is powered by a large amount of data collected through a network of sensors, which opens the possibility of creating intelligent production systems that can optimize manufacturing processes through data processing and analysis. Important features of an intelligent production system are sustainability, the use of big data, the use of additive manufacturing technologies, scalability, and flexibility.

Energy management and sustainability of manufacturing are some of the key topics when it comes to intelligent production systems. The application of Industry 4.0 technologies is expected to have a positive impact on waste reduction through increased productivity, flexibility, and resource efficiency [5,6]. Optimized processes will lead to products being made only to customer orders which will, in turn, result in reduced energy consumption. Critics of Industry 4.0 argue that an increase in energy consumption is also possible due to a large number of sensors and data centers for manufacturing operations [7].

The manufacturing sector generates and stores large amounts of data, and there is a need for solutions and algorithms that will allow the automated extraction of knowledge from this data [8]. Solutions based on machine learning have a high potential to help reduce production downtime, increase quality and productivity through the exploitation of collected data. Additive manufacturing technologies enable personalized production in small batches with lower development costs, shorter lead times, lower logistics and warehousing costs, and lower energy consumption [9]. Unlike technologies that remove material such as cutting and turning, technologies such as 3D printing generate significantly less waste [10]. The scalability and flexibility of manufacturing systems can be achieved through the use of additive technologies that increase the resistance of the supply chain to changes in demand. The flexibility of the manufacturing system can also be achieved through the application of smart scheduling systems that can adapt to dynamic and global market needs [11].

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3.2 Analysis of the Tech Radar

The Tech Radar and Risk Heat Map for Intelligent Production Systems under CEUP 2030 Policy Intelligent Dashboard offer open access to policy-relevant data sources as use cases, policy instruments, organisations and networks, technology trends in the most convenient, practicable and efficient way. They present impact of emerging technology and applications of Intelligent Production Systems with the most easy-to digest and streamlined knowledge and insight on technology trends and potential industry impact, as well as a socio-economic impact assessment of current and expected technologies use in field of Intelligent Production Systems.

It reflects also individual vision of Project Partners with some suggestions for how the negative impacts can be minimised, and the positive impacts maximised.

It is impossible to imagine modern industry without the intelligent networking of production and value chains with information and communications technology. The most important preconditions for flexible production systems are tracking and monitoring of all production processes as well as their transparency.

Within key factors of Intelligent Production Systems there should be listed:

1) Digital Twins

Digital twins provide a virtual counterpart to physical components used in industrial sectors. The arm of a robot used in automobile manufacturing, for example, can be monitored using a digital twin, which collects data about the arm's operation and provides information about components that need periodic maintenance or replacement. Digital twins make predictive maintenance easier, and they offer valuable visualization capabilities to improve efficiency. There are plenty of ways to harvest and manage IoT information, but digital twins deliver an intuitive and powerful approach.

2) Innovative Human-Machine Interfaces

Computer screens and more primitive displays still dominate in industrial areas, but this is changing. Augmented reality applications offer valuable feedback when looking at physical components, and providing employees with IoT-derived information about manufacturing equipment lets companies make better use of their investments. Virtual reality can also play a role, giving workers powerful visualization capabilities impossible with more traditional technologies. VR and AR are typically tailored to specific tasks, but the popularity and dropping prices of headsets and smart glasses are making these technologies more popular, particularly in industrial environments.

3) Better Predictive Maintenance

Predictive maintenance has been playing a larger role in industrial environments for years, but the continuing rise of IoT components is providing more information than even before. When combined with machine learning and other artificial intelligence tools, modern industrial software is better than even at determining when parts need to be replaced. Unlike other technologies, the benefits of predictive maintenance are easy to calculate,

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making it a technology that's sure to be at the top of C-level executives' priority lists going forward.

4) Increased Emphasis on Security

The early days of the IoT were somewhat haphazard in execution, and securing devices was not seen as a top priority for many companies. This is no longer the case, and companies looking to invest in the IoT are increasingly taking steps to ensure their new investments can be protected from cyberattacks. Part of this change is due to the increasingly lucrative nature of cyberattacks, and compromised industrial equipment can be especially tempting. One of the challenges companies will face going forward will be ensuring they're using the right security paradigms and ensuring compliance, as there's no one-step solution to keeping devices safe from attackers.

5) Greater Flexibility

Industrial organizations sometimes move slowly, as the high cost of downtime means it's often better to avoid hardware and software changes whenever possible. Increasing efficiency across the board, however, will compel companies to adopt a more nimble approach to operations. IoT analysis can lead to surprising results at times, as artificial intelligence is great at finding correlations that humans might never explore. A long-term shift for industrial entities will be finding ways to adjust to information more quickly, and this move will only continue to increase in the coming years.

6) Automation

Automation has always been a centerpiece in industry, and digital technology is extending this trend. Instead of investing in expensive heavy equipment, however, companies can now rely on low-cost devices that complement a broader range of manufacturing components. As automation systems continue to prove their worth, companies will invest more heavily and see significant efficiency gains and lower labor costs. However, hiring will still remain strong, as even the most heavily automated systems need people to monitor progress and look for ways to maximize efficiency.

7) Moving to the Edge

The sheer volume of data collected by IoT components can be staggering, and one of the bottlenecks in IIoT applications is making sure systems are capable of monitoring necessary information. A powerful components of IoT operations is relying on edge computing devices that collect, process, and even analyze data before it's sent to more centralized servers. Although investment in servers or off-site cloud solutions will continue to rise going forward, edge devices will see significant investment in the future and relieve some of the processing stress common to today's industrial environments.

IoT devices are a natural fit in industrial environment, as sensors have long been a core components of successful operations since well before the IoT concept arose. However, the benefits of general-purpose IoT devices are transforming industrial operations, and industry-specific IoT devices have become far more powerful over the years. Despite the conservative nature of industry, IoT adoption is rising at a rapid pace, and there's no doubt this trend will only continue to ramp up for the foreseeable future.

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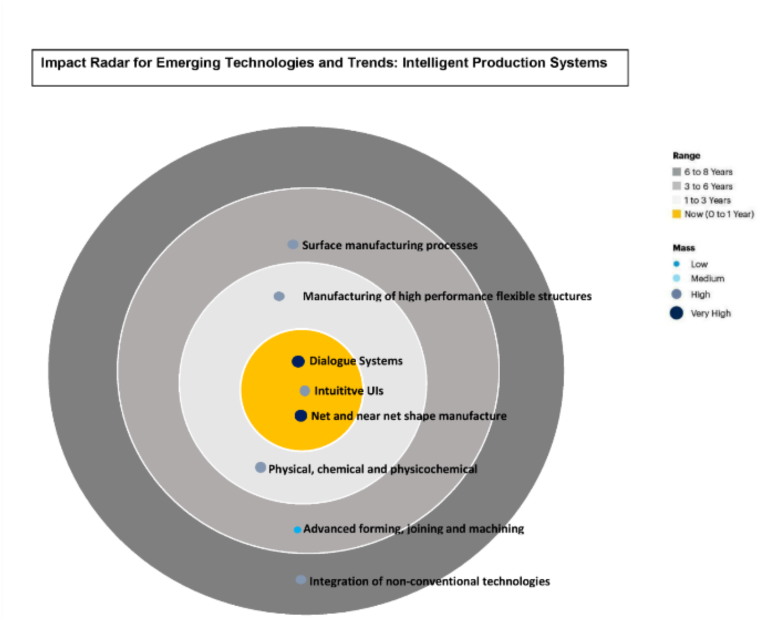

Gartner Top Strategic Technology Trends for 2022

3.3. Risk Heat Map

Within PLLs and TTTDM dedicated to CAMI4.0 Intelligent production system, the consortium Project Partners have identified several risks and challenges:

The highest risks in implementation of intelligent production systems are foreseen within:

1) Integration of systems

Machines are maintained and used for many years, often beyond a period whereby parts are easy to obtain. They remain part of the environment because replacing them would cost hundreds of thousands of dollars, an expense which smaller industrial companies find it very hard to justify when the existing machine works perfectly."

2) Connectivity

iWired connectivity is favoured in industrial, so with IoT pushing wireless connectivity this can represent a see change in the network infrastructure design. The use of wireless networking may lead to concerns over security."

3) Financing

Convincing management for funding based on theoretical benefits which are not yet demonstrable in the actual facility is challenging. Quantifying benefits must always show the correlation of operational improvements to the bottom line."

4) Skills and labour force

One of the most significant challenges in Industry 4.0 is the ability to have **trained people that can complete the automation project on time while retaining high-quality outcomes.**

The challenge is to whether the company has the skills in place to design, develop, implement, fine tune and maintain an IoT deployment. The range of skills required are

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considerable, from system architects with a detailed knowledge of manufacturing environments, systems integration specialists who can facilitate the implementation of the hardware into the manufacturing environment, to data analysts. **A shortage of trained resources will jeopardize project delivery and indirectly impair quality, lowering employee satisfaction.**

5) Fragmentation

The IoT industry as a whole must strive to deal with in an effort to simplify selection and planning, it affects also IPS. **The challenge in designing and developing IoT solutions for the industrial market is underlined by the varied list of partnerships being formed across hardware and software vendors, telecommunications firms, through to engineering and industrial companies.**

6) Security

If the network can be accessed, machines could potentially be hacked; the production process could be interfered with, and in the worst case scenario, halted. **Poorly handled security in an industrial IoT environment could result in a severe lack of trust between partners, upstream and downstream.**

3.4 Summary of the flagships

An integral part of the CEUP 2030 project is the development of so-called Flagships. Flagships are projects that the CEUP 2030 project partners have designed throughout the project. Ideally, the Flagships will soon be implemented – provided the necessary funding for most of the projects materializes.

On the topic of Intelligent Production System, 5 Flagships have been provided by the project partners.

In the following paragraphs the 6 Flagships are further described. The projects are highly diverse. However, all of them plan to use robots for solving societal challenges and for improving the project partner's regional economies within a bigger European ecosystem.

BIOSAM (Biologicalisation for Sustainable Advanced Manufacturing)

BIOSAM project proposed by Karlsruhe Institute of Technology aims to develop the biologicalisation in design for manufacturing. The research project will use bioinspired process and product design for manufacturing as a promising enabling strategy towards sustainable, value-added manufacturing that meet increasing consumer demands. Bio inspired solutions to manufacturing problems can give more capacity for manufacturing systems to handle problems in a greater systematic and automated manner. The implementation of the program is focussed on the demonstration of the complete

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approach through concrete use cases and applications developed within the project consortium. The focus is also on commercialisation of the applications and the holistic development of the ESRs involved within the project. This project will enrol 10 doctoral candidates (DCs), developing individual research projects within the doctoral network program. One of the many challenges being addressed by this project include the unavailability of trained R&D personnel in this field within Europe. By training DCs this project achieves this along with all the technological developments outlined. Target groups of the project are large enterprises, SMEs, and higher education and research organisations. The network of project partners is composed of 4 universities, 2 research and technology development organizations and 1 industrial partner from 4 different countries. The project will be funded by Horizon Europe MSCA DN funding program.

Smart Circuit

Smart Circuit project proposed by IWU: Fraunhofer tries to establish service corridors to promote sustainable transition in industrial production facilitated through digitally enabled technologies and to reduce implementation barriers and upgrade the production of sustainable products. The project consists of three key goals. First goal is improving capacities of and cooperation among innovation stakeholders by strengthening transnational innovation networks among digital innovation hubs. Second goal is exchanging good practice on digital circular economy in manufacturing and gaining insights from successes. Third and final goal is implementation of pilot actions to improve SMEs access to the research and technological innovation required to take up and support the roll out of innovative solutions to promote digitally enabled circularity. Target groups of this project are large enterprises, SMEs, higher education and research organisations, business support organisations, schools, and training institutes. The project will be implemented with the help of 7 business support organizations, 3 higher education and research organizations, 1 national public authority organization, other regional stakeholder ecosystem and associated partners. The financial resources required for the implementation of the project are provided from Interreg CE.

Purchase of autonomous production line (Teaching and Learning Factory)

Project proposed by Pannon Business Network Association called Purchase of autonomous production line (Teaching and Learning Factory) and smart material board and further developments aims to provide a holistic set of tools covering the entire production process, in addition to the former isolated digitalisation development solutions, suitable for both educational and demonstration purposes and for the implementation of specific R&D projects. Project goals are going to be met by development and procurement of a Teaching and Learning Factory which is a manufacturing unit with online, remote access to broaden cross-border services directly related to digitization competencies of the partners. The topics data science, autonomous robotics and 3D printing are integrated, enabling stakeholders to provide internationally competitive research and training infrastructure. With future actions, connectivity will be ensured, contributing to its sustainability for the 2021-2027 period. In parallel with the TLF procurement and development, PBN will also procured a smart material board, which can be considered as a complementary element of the TLF. Target groups of this project are large enterprises, SMEs, higher education and

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research organisations, business support organisations, schools, and training institutes. The implementation of the project is carried out with the help of 5 partners consisting of 3 business support organizations, 1 higher education and research organizations, and 1 large enterprise. The financial resources required for the implementation of the project are provided from Interreg V-A Austria-Hungary Cooperation Programme 2014-2020 and Interreg Central Europe Programme.

Testbed Exchange

Austrian Industry 4.0 Association (PIA) wants to create a solid framework that standardizes the view of Industry 4.0 and thus leads to a more concrete understanding of Industry 4.0 among the general public. For this purpose, they proposed a project called Testbed Exchange. The leading players in Industry 4.0 are currently in many cases universities and specialized departments of top companies. At academic institutions, so-called testbeds (in Austria called pilot factories) have emerged in recent years, which have both in-depth expertise and modern infrastructures. The aim of this project is to survey these testbeds and to create a sustainable network in which intensive communication, mutual learning and exchange of experience takes place. The project will be implemented by meeting two key goals. One goal is to create and implement a strategic plan to identify key areas of interest and plan concrete collaborations among the cooperating pilot factories. The second goal concerns the transfer and publication of expertise, which will be done through three seminars. These seminars are designed for cooperating testbeds, SMEs, students, and partner universities, as well as the general public, which are actually the target groups of the project. The project is implemented together with one higher education and research organization and is funded by INTERREG V-A Austria-Czech Republic funding program.

Human Centered AI Based Production Optimization (HAIPrO)

Human Centered AI Based Production Optimization (HAIPrO) is a project proposed by PROFACTOR GmbH. The project addresses the topic of vertical process optimization to increase productivity and sustainability, taking production data and human-centered assistance into account. The use of assistance systems is intended to make production more flexible (e.g. by supporting low volume, high mix production, greater transparency of both machine operation and process management). An inter-company quality data exchange or inter-company available evaluation and visualization services enable a cross-company increase in product quality (e.g. by integrating the Gaia-X platform). Tools are created to guarantee high interoperability of the quality data to be exchanged. Furthermore, the project aims to increase worker satisfaction, productivity, and the sustainability of human-centered manufacturing processes through an improvement in the safety and stability of manufacturing processes and through optimized, employee-centered production planning. This is made possible by processes such as transfer learning, data augmentation and data fabrication. This data is to be enriched by individual operating and handling data at operator and team level. An innovative platform for privacy-preserving-transform-learning and the integration of the open platform Gaia-X guarantee a high level of data security and data sovereignty even when using data sources with differing statistical characteristics. The target groups of the project are large enterprises, SMEs and higher education and research organisations and it is implemented with the help of 8 SMEs, 1 large enterprise and 1 higher education and research organization. This project is financed by Austrian Research

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Promotion Agency (FFG) and German Federal Ministry for Economic Affairs and Climate Action (BMWi/DLR-PT).

Rising competences in less developed regions focused on small scale food product & service

Rising competences in less developed regions focused on small scale food product & service providers through new transnational mentoring services is a project proposed by Pomurje Technology Park (PTP). The overall flagship objective is improving competences and skills in less developed rural regions which are characterized by lack of development capacities, high unemployment, brain drain and emigration. The Flagship is therefore focused on improving regional support ecosystems and their involvement into developed joint transnational mentoring services to transform small scale rural food and drink products and services into digital and circular attractive. Innovativeness is shown by developed transnational mentor services jointly offered to small scale food product & service providers, where regional support ecosystem and their mentors will have access to wide range of specialized digital & circular toolkits and access to pool of international experts to support digital & circular transition. Target groups of this project are large enterprises, SMEs, higher education and research organisations, business support organisations, schools, and training institutes. The implementation of the project is carried out with the help of 7 partners consisting of 5 business support organizations and 2 sectoral agencies. The financial resources required for the implementation of the project are going to be provided from Interreg Central Europe Programme.

3.5. Interesting use-cases

Fortunately, Central Europe is full of interesting companies and projects in the area of intelligent production system. The CEUP 2030 project partners have provided examples for use cases in order to showcase the diversity of solutions and activities in the field:

Learning Factory at Faculty of Mechanical Engineering and Naval Architecture

Learning factory was established at the beginning of 2022 at the Department of Industrial Engineering within the Faculty of Mechanical Engineering and Naval Architecture in Zagreb. By researching the existing solutions and needs of manufacturing companies, it was decided that the learning factory will simulate discrete manufacturing processes. The system consists of five workstations that accurately simulate real-world manufacturing processes. Workstations that simulate the change of properties (pressing), particle separation (drilling), storage and input/output of the production line are connected by a belt conveyor to achieve the possibility of a circular process. Manual workstation is separated from the others and a mobile robot was acquired to connect them (Figure 1). Each workstation can work on its own or be connected to other workstations, allowing system modularity and production flexibility. In addition to these modules, the learning factory also consists of smart maintenance and energy monitoring systems that greatly contribute to increasing the sustainability of the system and production. Each learning factory module is equipped with a large number of sensors connected to programmable logic controllers (PLCs) that enable system operation. All modules are connected using a manufacturing execution system (MES)

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that manages all processes by collecting and analyzing big data from sensors. The learning factory was established with the aim of facilitating the education of students and workers on discrete production systems within Industry 4.0. In the future, it is planned to expand the established learning factory with additional workstations and systems for machine learning and artificial intelligence.

Končar Power Transformers Ltd. Smart Digital Assistance

Končar Power Transformers Ltd. is a Croatian company engaged in the development, design, production, testing, sale, and servicing of power transformers. They specialize in the production of large power transformers of voltages up to 1000 kV, which are currently exported to 90 countries around the world. Transformers are designed to provide maximum grid availability through long lifecycle, maximum efficiency, connectivity, and optimized operation. Each transformer is adjusted to the customer's needs and on average two products are produced in series. Due to different customer needs, there are no standard parts. To increase sustainability and facilitate the flexibility of production, systems for smart digital assistance, tracking of metal parts and measurements in production have been implemented in production processes. Prior to the implementation of these systems, the necessary digitization and optimization of production processes and infrastructure was carried out. Smart Digital Assistance is a system consisting of a mobile stand and a large touch screen that allows employees easier access to the necessary documents and information in the workplace. The Smart Digital Assistance system currently provides digital information on work orders, technical documentation (drawings, BOMs) and work instructions. New parts of the system are being developed that will enable digital management of checklists, maintenance, and registration of working hours. The Metal Part Tracking system provides current information on the status of deliveries from the supplier and the location of the product in the warehouse. This information is very useful due to the large number of metal parts that make up each product. The system is based on RFID technology, and implemented using fixed antennas, forklifts with RFID and GPS antennas, mobile portals with antennas and handheld readers. Information on the status and location of the product obtained by reading RFID tags is stored directly in the ERP system. The Measurements in production system processes a large amount of data collected from various sensors and thus provides various information from the production process itself such as air quality inside the plant and the condition of machines. Additionally, it enables inspection of input material dimensions and product quality control. Control of dimensions of input materials and semi-finished products is performed by 3D scanning and automatic comparison with CAD models. Product quality control is performed during the production process using sensors that automatically measure the dimensions of product components. After checking each dimension, the system automatically enters its status within the checklist.

ISKRA d.o.o. eSTEP Solution

The eStep is digital interface that enables masters and workers paperless information exchange about work in progress or finished work. Master or lead worker can see most of the necessary information such as what should be producing, operations, planned workspace, planned start time, the state of stocks required for the operation. In addition to the list of tasks/operations, master will also have a list of employees, who are distribute to him. Then the master can simply assign the worker to a specific operation/job. When this is completed, supposedly before the start of the shift, the master has a plan in front of him, so that ‘his’ employees can work in this shift. This plan is also displayed on the monitors at the entrance to the production, so that every worker entering the production facilities can see what the master has assigned him for the current shift. The worker can therefore go to the job assigned to him and log in to the user interface with his username. Upon registration, he is immediately shown the tasks/operations assigned to him by master. The following information is available to the employee: work order/operation to be performed, total quantity ordered, information on the quantity already made, information on the quantity still to be produced, instructions for manufacture/operation, stock status required for the application. The start and end of the work are recorded within the ERP system.

Metal ADditivE for LOmbardy (MADE4LO)

Concerning Additive Manufacturing for metals, a “widespread” factory for the development of metal 3D printing technology was the objective of the project Metal ADditivE for LOmbardy (MADE4LO), with the involvement of two Universities (Politecnico di Milano and Università di Pavia), three Big Industries (Tenova, BLM, and GF Machining Solutions), and six SMEs (TTM Laser, 3D-NT, GFM, Fubri, Co. Stamp, and Officine Meccaniche G. Lafranconi). The project has addressed and proposed innovative solutions to the main technological challenges of additive manufacturing, such as: production of new metal powders, printing of complex materials, large and multi-material and the adoption of hybrid processes that include both additive and subtractive aspects. It also contributed to the creation of two regional and national competence centres dedicated to AM; GFM has founded, in collaboration with other industrial realities, the Additive Technology Centre – ATC, while GF Machining Solution has established a competence centre where additive printing is combined with traditional technologies. Several innovative applications such as:

- printing of pure copper components,
- difficult materials with high performance in terms of hardness,
- production of large, multi-material, geometrically complex components with a hybrid machining component,
- realization of a large and multi-material recuperator,
- creation of a mould with additive and subtractive hybrid process, realization of an Axial Vorticator for Gas Turbines

AGENT-3D: Additiv generative Fertigung

The AGENT-3D project aims to develop additive-generative manufacturing into the key technology of Industry 4.0 and enable its industrial breakthrough. The core of the work is the development of Additive Manufacturing technologies based on inks and pastes. The consortium considers the entire process chain starting from the preparation of raw materials, substrate pre-treatment, aerosol and dispenser printing, drying, curing, laser and plasma sintering and characterization of the final components. Materials include metals, polymers, ceramics, and composites. Important applications are flexible or conformal thermoelectric generators. Further technologies applied are for example powder bed processes, generative laser powder build-up welding, generative laser wire build-up welding

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and process monitoring. The second core field “materials” focuses on the development and characterization of innovative materials, material combinations and technologyspecific material adaptations primarily in metal as well as ceramics, polymers, composites, and nanomaterials. The aim is to secure desired product characteristics as well as the integration of additional functionalities into components. In parallel, the characteristics of already used materials can be improved, especially regarding the reproducibility of mechanical material characteristics, the aging process, electrical and other specific properties. Material production must reflect the increased usage of additive production processes and has to offer tailored material solutions.

For innovative, versatile production of the future

The Wertstromkinematik concept (WSK) is based on the vision of setting up a production completely with universally applicable robot kinematics of identical design, which can be placed on patterned shop floor to form specialized production cells. Their tasks not only include the handling tasks common in industrial robotics, but also manufacturing and assembly processes as well as quality assurance. The resulting elimination of expensive, less flexible special machines within a value stream greatly increases the flexibility of the production chain and makes it much easier for the user to switch to other end products. An essential research task for the implementation of Wertstromkinematik is to enable the kinematics to perform tasks with high accuracy or force requirements. Compared to expensive specialized machines (e.g., machining centers), classical industrial robots usually lack sufficient stiffness for this purpose. Wertstromkinematik solves this problem with an innovative coupling function. Several kinematics are mechanically connected with a coupling module to enable a joint production process with the aid of the associated increased overall rigidity. The vision of Wertstromkinematik also includes a digital process chain that guides engineers in planning future productions and monitoring current ones. With the digital platform, a significant part of the planning and commissioning can be carried out on a purely virtual basis and, in the future, also autonomously.

Autonomous and Intelligent Robotics Laboratory in Győr , West-Hungary

Students are introduced to a wide range of modern robotics at the Autonomous and Intelligent Robotics Laboratory (AIR-Lab). In addition to industrial robots, autonomous vehicles, service robots, and anthropomorphic systems are available in the lab. The main profile of the AIR laboratory, in addition to education, is research and development. The main research directions in the laboratory cover the topics of intelligent control of robots, human-machine cooperation tasks, sensor fusion and machine vision. The laboratory is well-equipped to carry out research and development tasks in both hardware and software, with modern instruments, tools and the basic elements and software required for robotics.

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Enabling the smart and sovereign use of data in manufacturing Hungary

The Austrian-German lighthouse project EuProGigant ("European Production Giganet for calamity avoiding self-orchestration of value chain and learning ecosystems") aims at building a multi-location, digitally networked production ecosystem with the goal of advancing a resilient, data-driven and sustainable industry in Europe. The project was started in 2021 and will continue until 2025. In alignment with the principles of Gaia-X, EuProGigant addresses three central research questions:

How can…
·…value chains be made resilient to market changes and capable of a large number of variants?
·…interdependencies between stages in the value creation process be recognised and used to increase economic efficiency?
·…we design platforms for production systems that are both responsive and universal?

The project wants to combine existing technologies and build a Gaia-X demonstrator in manufacturing with concrete use cases. For these use cases, the project will develop innovative, data-driven business models according to Gaia-X as a best practice example for Europe. The economic application of the business models will be pursued during the duration of the project. 16 Austrian and German project partners are involved with the execution, development, and implementation of the project. The leading project partners are the Technical University of Darmstadt in Germany and the Pilot Factory Industry 4.0 of the Technical University of Vienna in Austria.

3.6. Policy instruments (PIs) which might influence the development of the flagships

Policy instrument that will have the greatest impact on flagships is certainly national and / or regional financial assistance available from various funds and programs. In the Republic of Croatia, funding for research and development is currently planned through the National Recovery and Resilience Plan 2021-2026 and the National Development Strategy of the Republic of Croatia until 2030. The strategic plans of the Republic of Croatia are financed from the national budget and from European Union funds. Within both strategic plans are planned investments in research and development with the aim of strengthening science, research, and technology. In addition to Croatia, the partners involved in the project also come from Hungary, Slovenia, Germany, Italy, Austria, and Poland. When applying for projects, each of the partners proposed national and / or regional instruments to be used to finance the projects. The policy instruments for project financing identified by the project partners are shown in Table 1. Almost all partners list some of the regional funds and projects as financing instruments, and partners from Slovenia, Germany, Italy, and Poland also list some national instruments. Prominent national instruments for financing research and development are the National Funds for Learning Manufacturing Laboratories and SIO program (2020 - 2022) in Slovenia, Clusters4future-BMBF in Germany, Poland Prize in Poland and START4.0 in Italy. The regional funding instruments highlighted by the partners mainly

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relate to calls for funding from EU projects and funds, where the European Regional Development Fund (ERDF), Horizon Europe, Interreg Europe, Digital Europe and the Danube Transnational Program are the most represented.

Table 3.Policy instruments listed by the PPs

Partners	Country	National policy instruments	Regional policy instruments
PBN	Hungary		Horizon Europe Program Digital Europe Program Interreg Europe Program Interreg Central Europe Program Danube Transnational Program Cross-border cooperation opportunities EIT Manufacturing Interreg CE: SO 1.1 Interreg CE: SO 1.2
PTP	Slovenia	National funds LEARNING MANUFACTURING LABORATORIES (1,5 m€ from March 2021 on) SIO (2020-2022)	ERDF HORIZON-CL4-2021-TWIN-TRANSITION-01-07: Artificial Intelligence for sustainable, agile manufacturing (IA) HORIZON-CL4-2021-DATA-01-03: Technologies for data management (IA) HORIZON-CL4-2022-DATA-01-04: Technologies and solutions for data trading, monetizing, exchange and interoperability (IA)184 HORIZON-CL6- 2022- FARM2FORK-01 DIH2& cascade financed TTEs / EDIH calls yet to be published H2020 Interreg CE 21-27, SO 1.1 &SO 1.2 (skills) Interreg SI-AT Interreg SI-HU Interreg SI-HR EIT Food
IT	Germany	BMBF - BRIDGE2ERA	HORIZONCL4-2022-RESILIENCE-01-12 HORIZON-CL4-2022-DIGITALEMERGING-01-05 CE Interreg 21- 27, SO 1.1

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Partners	Country	National policy instruments	Regional policy instruments
IWU	Germany	Clusters4future-BMBF (German Federal Ministry of Education and Research)	
KPT	Poland	Poland Prize	European Development Fund
AFIL	Italy		EU project Private funding
SIIT	Italy	START4.0	
PRO	Austria	Not specified	HORIZON-CL4-2022-HUMAN-01-14 HORIZON-CL4-2022-DIGITAL-EMERGING-01-06 HORIZON-CL4-2022-TWIN-TRANSITION-01-04 HORIZON-CL4-2022-DIGITAL-EMERGING-01-05 HORIZON-CL4-2022-TWIN-TRANSITION-01-04 HORIZON-CL4-2022-DIGITAL-EMERGING-01-07 Interreg CE, ATHU, ATCZ, ATSK Bilateral AT DE Calls
PIA	Austria		Interreg V-A Slowakei – Österreich 2014-2020 Interreg CE 21-27, SO 1.1. Cloud Data and TEF (DIGITAL2021-CLOUDAI-01) Ministry of Agriculture and Rural Development of the Slovak Republic

KIT: Karlsruhe Institute of Technology (Germany)

Funding opportunities by the German Ministry of Education and Research (BMBF):

- Research program “From materials to innovations” offers several different national funding opportunities for collaborative projects for academic and industrial partners as well as specific programs for SMEs.
- National Strategy for Artificial Intelligence “AI made in Germany”
- Microelectronics Framework Programme Germany
- Federal Agency for Disruptive Innovation SPRIND is creating spaces for innovators, where they can take risks and think radically different.

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- Strategic international collaborations are fostered by specific bilateral calls (2+2 Projects), via dedicated ERA-Net programs (e.g. M.Era-Net)
- BRIDGE2ERA2021 program – for better integration of the regions of Central Eastern and South-eastern Europe

IWU: Fraunhofer (Germany)

To make it easier for companies to access new technologies, the Free State of Saxony has set up a range of support measures. Companies can take advantage of these support opportunities to introduce innovative products and processes and thus increase the competitiveness. The following funding measures are available:

- R&D project funding in the form of individual company projects or joint projects in cooperation between companies and/or companies and research institutions.
- Technology transfer funding (exclusively for SMEs) can be used to promote the acquisition of technical knowledge for the realization of new products or processes or those adapted to a new state of the art.
- The innovation award (exclusively for SMEs) supports the use of external R&D service providers for the development of new or improvement of existing products, processes, and services as well as technical support in the implementation phase.
- The KETs pilot line funding serves to implement research results in a pilot line.
- The InnoTeam program supports cooperation between small and medium-sized enterprises and universities or research institutions in the formation of competence teams.
- Funding for a transfer assistant supports the recruitment and employment of persons with relevant professional experience in science or business.

PBN: Pannon Business Network Association (Hungary)

The project defined by PBN in the Intelligent Production System topic is compatible with the local strategy, called SZOMBATHELY2030 since the vision of the strategy is to contribute to the improvement of the standard of living in Szombathely and its region by focusing on education and research and development by promoting industrial transformation and specializing on complex rehabilitation within the health industry.

PIA: Association Industry 4.0 Austria

"Production of the Future" is a national Austrian funding scheme that aims to promote cooperation between business and science, build up human resources and develop research infrastructure. There are two opportunities for receiving funding from "Production of the Future":

- National submission opportunities are regularly offered for funding regular R&D projects, lighthouse projects, and R&D services. Furthermore, endowed professorships and research infrastructure projects such as "Industry 4.0 pilot

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factories" were funded to make innovative production technology and ICT accessible to both scientists and companies.

- Transnational submission opportunities exist via the European Research Area Network M-ERA.NET "ERA-NET for research and innovation on materials and battery technologies, supporting the European Green deal". Bilateral submission opportunities have existed with China since 2014.

PRO: Profactor GmbH (Austria)

The Austrian partners of transnational and application-oriented research and development projects can apply for funding under one of the two FFG programs: Intelligent Production or Basic Program, as part of the European Research Area Network M-ERA.NET "From materials science and engineering to innovation for Europe."

PTP: Pomurje Technology Park (Slovenia)

Policy instruments which might influence the development of the flagships in Slovenia are:

- Public tender for the digital transformation of large companies – used to encourage raising and growing of productivity, optimization and reduction of production costs and costs of services and operations, and greater competitiveness and a more open market, as well as greater opportunities for the commercialization of innovative solutions.
- Public tender for the promotion of large investments for higher productivity and competitiveness in the Republic of Slovenia – used to encourage companies to sustainably invest by investing in more advanced technology and automation of business processes.

AFIL: Associazione Fabbrica Inelligente Lombardia (Italy)

Policy instruments which might influence the development of the flagships in Italy and Lombardy Region:

- Manifestazione di interesse Regione Lombardia e Uniocamere – regional initiative which can be used to support CEUP2030 CAMI4.0 projects in areas of sustainability and circularity, innovation and technology transfer, digitization, research and intellectual property and training.
- Piano Nazionale di Ripresa e Resilienza (PNRR) – Italian national COVID-19 recovery plan aligned with the European Next Generation EU (NGEU) program to facilitate Recovery and Resilience after pandemic.
- Smart Specialization Strategy (S3) – Lombardy Region strategy with objective to identify areas of competences and innovative potential priorities in terms of industrial transformation and resilience of the Lombardy economic and productive system, as well as emerging technological areas to focus regional investment.

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4. Conclusions & Next Steps

Deliverable D.T2.3.2 is defined in the AF as a Trend Radar and Risk Heat Map on Intelligent Production System developed under joint Policy Intelligence Dashboard for the four 4 CAMI4.0 topics.

The structure of Trend Radar and Risk Heat Map on Intelligent production system is in line with manual (DT.2.3.1) that provides the guidance required to establish an IT-based Policy Intelligence Dashboard to evidence CAMI4.0 Technology Radars and Risk Heat Maps on Technology Trends. To deliver the tool that is functional and answers the expectations of the varied stakeholders groups a model of PID was tested with a balance group of stakeholders. Testing as a critical part of the PID in Practice exercise covered 40 surveys cross the full partnership, with each Partner facilitating a minimum of 4 stakeholders to review the PID in Practices.

The tests were addressed to the community built within CEUP2030: those organisations who were attending the PLL and RIS3 Round Table and also new actors from business, RTO and RTD. The Project Partners gained insight from 4 stakeholders for each PID in Practice.

These experts provided feedback on the process of gathering content for input into the PID in Practice concerning on the functionality, usability and quality of content.

To ensure simplicity and effectiveness of the PID in Practise validation process, test survey will be organised using Microsoft Forms.

The summary of PID in Practise demonstration testing, insights and conclusions collected valuable for further development of PID will be attached as Annex to the deliverable D.T2.4.2- Interim Evaluation & Impact Assessment Report on TIN and PID in CE/EU policy context

5. Call to Action

The model, associated to each CAMI4.0 topic, which the PPs delivered for the PID have been tested with a balanced group of stakeholders and the recommendation and insights collected should be analysed, verified and implemented if relevant. The scope of modification of PID content will be agreed by relevant Deliverable Responsible Projects Partners and Lead Partner.

6. Next steps

KPT and PBN will integrate the recommended list of improvements on PID in brochure and PID website platform.

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