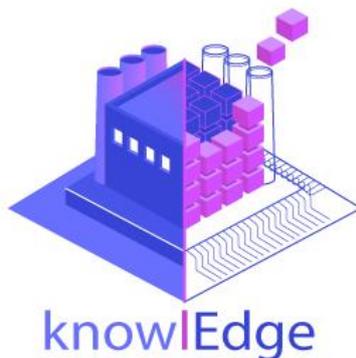


HORIZON 2020

Towards AI powered manufacturing services, processes, and products in an edge-to-cloud-knowlEdge continuum for humans [in-the-loop]



WP9: Dissemination and Exploitation

EU ID: D9.5 Exploitation Strategy v1.1

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Abstract

This deliverable describes the knowlEdge initial exploitation and IPR plans by all project partners as of Month 6 of the project. The plans detailed in this deliverable are based on the Value Roadmapping Method (VRM) to support technology and business investment decisions related to project outcomes.

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Status

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Further Information

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Project Partners:

For full details of partners go to www.knowlEdge-project.eu/partners



Executive Summary

This deliverable describes the work carried out in WP9 of the knowlEdge project, under the T9.3 Exploitation Strategy and IPR Management. As the deliverable is the first of the two deliverables, its main aim is to outline knowlEdge initial exploitation strategy which will be validated and refined as the project progresses. The second deliverable D9.11 will be submitted in M32, which will cover the final exploitation efforts and IPR Management.

It is proposed that the analysis of potential knowlEdge exploitation outcomes is carried out using the Value Roadmapping Method (VRM) [1]. to analyse current technological and market trends; value streams with potential sources of revenue; an analysis of enablers and barriers; research and technology development.

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0 Introduction

0.1 knowlEdge Project Overview

knowlEdge is a project funded by the H2020 Framework Program of the European Commission under Grant Agreement 957331 and conducted from January 2021 until December 2023. The knowlEdge consortium consists of 12 partners from 7 EU countries, and its solution will be tested and evaluated in 3 manufacturing sectors with a total budget of circa 6M€. Further information can be found at www.knowlEdge-project.eu

AI is one of the biggest mega-trends towards the 4th industrial revolution. While these technologies promise business sustainability and product/process quality, it seems that the ever-changing market demands and the lack of skilled humans, in combination with the complexity of technologies, raise an urgent need for new suggestions. Suggestions that will be agile, reusable, distributed, scalable, accountable, secure, standardized and collaborative.

To break the entry barriers for these technologies and unleash their potential, the knowlEdge project will develop a new generation of AI methods, systems and data management infrastructure. This framework will provide means for the secure management of distributed data and the computational infrastructure to execute the needed analytic algorithms and redistribute the knowledge towards a knowledge exchange society. To do so, knowlEdge proposes 6 major innovations in the areas of data management, data analytics and knowledge management: (i) A set of AI services that allow the usage of edge deployments as computational and live data infrastructure, an edge continuous learning execution pipeline; (ii) A digital twin of the shop-floor to test the AI models; (iii) A data management framework deployed from the edge to the cloud ensuring data quality, privacy and confidentiality, building a data safe fog continuum; (iv) Human-AI Collaboration and Domain Knowledge Fusion tools for domain experts to inject their experience into the system to trigger an automatic discovery of knowledge that allows the system to adapt automatically to system changes; (v) A set of standardization mechanisms for the exchange of trained AI-models from one context to another; (vi) A knowledge marketplace platform to distribute and interchange AI trained models.

0.2 Deliverable Purpose and Scope

The purpose of this document is to explore the overall context of exploitation strategy and activities that will be followed during the three years of the knowlEdge for the creation of project partners' exploitation plan. The core of the document provides description of knowlEdge Value Roadmapping Method and the exploration activities to help partners and the consortium to highlight the result of the project and to identify opportunities to utilise the project outcomes in an industrial or in a research context. Finally, the document presents the products and services that will be part of the knowledge value proposition which are the set of knowlEdge software components upon which use cases will be developed, deployed and executed.

0.3 Target Audience

This document is intended to address consortium partners in particular those individuals in strategic positions and those with decision-making roles related to transfer, IP exploitation and commercialisation.

0.4 Deliverable Context

This document is one of the cornerstones for achieving the project aims, particularly the successful exploitation of knowlEdge results. Its relationship to other documents is as follows:

- **Consortium Agreement (CA):** Deals with legal aspects between partners.
- **Description of Action (DOA):** Provides the foundation for the actual research and technological content of knowlEdge. Importantly, the Description of Action includes a description of the overall project work plan and the project vision.

However, it is subservient to those documents.

0.5 Document Dependencies

This document has no preceding documents and one more iteration is expected at month 32 of the project. If explicitly requested by reviewers, a definitive version can be made available at the end of the project.

0.6 Document Structure

This deliverable is broken down into the following sections:

- **Section 0: Introduction:** An introduction to this deliverable including a general overview of the project, and outline the purpose, scope, context, status, and target audience.
- **Section 1: knowlEdge Exploitation Strategy:** Summary of the exploitation strategy and outline of VRM method. Overview of the business model design.
- **Section 2: knowlEdge Market, Business Trends and Drivers:** Different external market trend drivers (social, economic, environmental, technological, political and market) that could influence the development of products and technology and the area of interest.
- **Section 3: knowlEdge Value Streams:** Sources of future revenue and savings: products, services, technology/IPR, cost/risk reduction, strategic position.
- **Section 4: knowlEdge Enablers and Barriers:** Technical and non-technical challenges and risks that directly affect the exploitability of technology's/capability's potential value.

- **Section 5: knowlEdge Research and Technology Development:** Current state of the art for the technology in development, future possibilities, competing and complementary technologies.
- **Section 6: Conclusions and Next Actions Planned**

0.7 Document Updates

None

1 knowlEdge Exploitation Strategy

This document presents the exploitation strategy approach taken by knowlEdge and as such it should be taken as a planning document with additional preliminary intentions of knowlEdge partners in terms of exploiting knowlEdge results. The knowlEdge WP9 Dissemination and Exploitation will evolve during the project execution and the main activity of T9.3 Exploitation Strategy and IPR Management is to validate and refresh the content throughout the duration of the project. The first iteration, which is what is being presented in this document summarises a number of areas that will be further validated throughout the project.

The knowlEdge exploitation strategy is composed of:

- review of the key exploitable results of the project (T9.2 and T9.3)
- utilise Value Roadmapping Method (VRM) to support technology evaluation and valuation (T9.3)
- revise, complement and clarify existing exploitation plans of project results (T9.3)
- utilise Business Model Canvas to identify all relevant stakeholders in the exploitation value chain (T9.2)
- support to perform a risk analysis related to the exploitation of results with SWOT (T9.3)

An exploitation strategy plan in the context of European projects is different in nature to those generated by companies, as the common product result of it is generated by the sum of efforts provided by different companies providing their core competences and previous software solutions. Due to this fact, the knowlEdge exploitation strategy covers the exploitation plans at two levels and both will be detailed extensively in the second deliverable D9.11 in M32.

- **General exploitation:** The project will look at potential commercialisation, converting pilot applications into commercial products with reasonable & competitive costs. Alternative exploitation scenarios will be assessed.
- **Specific exploitation plans:** Each partner in the project will develop individual exploitation plans which will be further elaborated during the project. The specific exploitable results of the project will be identified together with their analysis for the specific industrial sectors that are addressed through the use-cases as well as different industrial sectors.

Finally, the IPR analysis will take place to analyse the background/foreground and to manage the innovation and IP generated throughout the project.

1.1 knowlEdge and the Value Roadmapping Method

It is proposed that the project uses the Value Roadmapping Method (VRM), a qualitative systematic approach intended to help with identifying potential future value streams of technologies in their early stages of technology development project. The approach can be utilised to explore the value proposition and to improve the design of the technology development thus reducing the risk [1].

VRM brings together four different perspectives used when valuating and evaluating technology-oriented projects:

- **Market, business trends and drivers.** It collects different external market trend drivers that could influence the development of products and technology and the area of interest. Examples of such trend drivers are categorised in social, economic, environmental, technological, political and market.
- **Value streams.** It collects sources of potential revenue and savings. As can be anticipated, value streams are directly related with the generation of cash revenue. Examples of these sources are products, services, business/facilities, technology/IP, etc.
- **Enablers and barriers.** It collects technical and non-technical challenges and risks that directly affect the exploitability of technology's/capability's potential value.
- **Research and technology programmes.** It collects current state of the art for the technology), future possibilities, competing and complementary technologies.

knowlEdge VRM meets the Pathway to Impact criteria set by EC because it sets the logical steps towards the achievement of the expected impacts of the project over time, in particular beyond the duration of the project. The time horizon for knowlEdge VRM extends further into the future, providing a forward-looking radar [1].

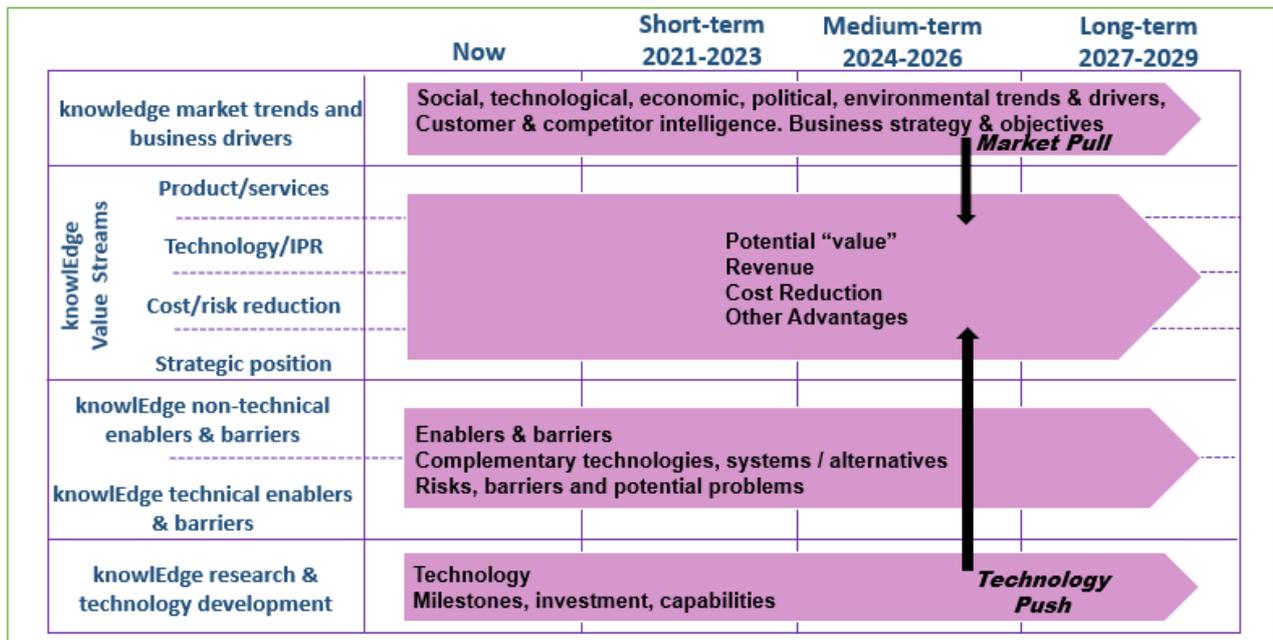


Figure 1. knowlEdge adaption of VRM

The initial knowlEdge VRM architecture is shown on Figure 1. The Sections 2, 3, 4, 5 of this document will discuss four different perspectives adopted for knowlEdge based on the DOA which will be further enriched by planned VRM process workshops. The aim of the workshops is to bring together the multifunctional four perspectives for knowlEdge and support the communication between partners. The workshop approach is chosen to stimulate an interdisciplinary debate and concerns the development of the roadmap in a collaborative session. As the roadmap content evolves and the technology matures and

exploitation routes will become clear. Engaging the right participants is a key success factor, including a good balance of technical and commercial functions leaders [1].

The planned workshop will take place at the beginning of 2022, however the date could change due to the COVID situation. The COVID contingency plan is (a) we delay the physical workshop or (b) make it virtual. Figure 2 shows the current schedule.

Exploitation Strategy Plan Schedule	Timeline
IPR survey for individual component	M9 (Sep 2021)
VRM introduction webinar	M13 (Jan 2022)
VRM 2 day physical workshop	M14 (Feb 2022)
Review of knowlEdge initial VRM	M16 (Apr 2022)
IPR workshop for joint exploitation	M17 (May 2022)
Component TRL update	M18 (Jun 2022)
Partners to provide their specific exploitation plan	M20 (Aug 2022)
Share knowlEdge final VRM with partners	M22 (Oct 2022)

Figure 2. Plan to support knowlEdge exploitation strategy

After the workshop we will conduct analysis and the final knowlEdge VRM will be shared with all partners and presented in the second deliverable of T9.3. To be effective, VRM must align with and support the knowlEdge Business Model Canvas (Section 1.2) and SWOT analysis (Section 4).

1.2 Business Model Canvas

Task 9.3 Exploitation Strategy and IPR Management and their deliverables D9.5 and D9.11 are related with T9.2 Business Model Development, and its associated deliverable D9.3 will cover with deeper detail the stakeholders involved in the exploitation of the knowlEdge platform.

This document presents a preliminary draft of main elements that are part of future business models to be explained on D9.3 Initial Business models & Requirements which will be completed in M16. There reason for adding this preliminary analysis here is to support the development of knowlEdge VRM as road mapping process works in tandem with other business processes. The important part of T9.3 is to validate and refresh the content throughout the duration of the project.

The construction of a clearly-defined, feasible and realistic business model with financial estimations will evolve during project implementation. At this stage the knowlEdge business model is from DOA shown in Figure 3 and it is expected that the design will include the following activities, goals and benefits which will be validated during the project. This preliminary canvas will be adopted to the technology development of knowlEdge and a comprehensive version will be included in the D9.3.

	Goals	Benefits	Key Resources	Key activities	Value Transactions
Owner: knowlEdge Joint Venture	-Increase AI usage in manufacturing -Prove the advantages &	-Introduce new market perspective	-Consumer client portfolio -Know-how	-After sale support -Design, Develop, Verify, Deploy	-Revenues -Customer engagement -Increased market share -Good reputation

	potential of spin-in concepts				
Partner: manufacturing and process industries	<ul style="list-style-type: none"> -Embrace AI powered solution for being competitive -Increase sales -Improve process planning -Increase quality of processes & products -Reduce wasted raw materials and downtimes 	<ul style="list-style-type: none"> -Expand knowlEdge & expertise on the application of their equipment on a break-through solution 	<ul style="list-style-type: none"> -AI models -Sensors 	<ul style="list-style-type: none"> -Tech support -Ability to adapt to the needs 	<ul style="list-style-type: none"> -Expansion of know-how -Valuable partnership -Reputation -Revenues
Partner: Technology Providers	<ul style="list-style-type: none"> -Expand their technologies to a wider range of applications 	<ul style="list-style-type: none"> -Increase market share -Maturation of their technologies 	<ul style="list-style-type: none"> -State-of-the-art expertise in AI and related technologies 	<ul style="list-style-type: none"> -Ability to adapt to the needs -Technical support 	<ul style="list-style-type: none"> -Wider range of applications -Expansion of market share -Valuable partnership
Customer: Machine Manufacturers & industries	<ul style="list-style-type: none"> -Optimised, more reliable, improved processes and products 	<ul style="list-style-type: none"> -Cost reductions -Increase market share 	<ul style="list-style-type: none"> -Contracts -Continuous updates 	<ul style="list-style-type: none"> -ITT -Word to mouth -Online PR Campaigns -Conferences, Workshops, Expert Summits 	<ul style="list-style-type: none"> -Overview of product development

Figure 3: knowlEdge business model design

1.3 IPR Strategy

The knowlEdge consortium will manage IPR in a way that will encourage openness among partners, securing access to their background, and maximising the potential for future exploitation of the project results. Each participant will own the foreground it generates. Background is identified within the consortium agreement (CA) and when applicable, granting of access rights will be clearly specified. When the foreground is generated jointly, participants will have to reach an agreement which defined in the CA. The IPR strategy of the project is an important part of the project exploitation plan, it is suggested that the internal results will be reviewed with the goal of identifying important ideas and defining an individual strategy for the positioning of these ideas in the standardisation and commercialisation processes.

A preliminary list of potential exploitable results/assets of knowlEdge has been formed (see Figure 4). The list will be reviewed and updated during the project implementation. There will be IPR workshop developed for each compound services/joint exploitation, e.g. Digital Twin Toolkit.

Exploitable Results	Type of Result	Owner(s)	IPR Strategy & Foreseen Exploitation
Industrial data collection and integration toolkit	Software	LINKS, NXW	Copyright; off-the-shelf product / paid support
Data quality and semantic enhancement for real-time solution	Software and knowledge	LINKS	Copyright, paid support or possible
Site-wide data storage and management suit	Software	FIT, LINKS	Copyright, open and free use, paid support
(Semi-)automatic knowledge discovery service	Software	FIT, WWU, BSC	Copyright; software-as-a-service / pay per use
Site-wide AI learning orchestration and monitoring service	Software	FIT, LINKS, BSC, UPC	Copyright; off-the-shelf product / paid support
Recommendations for Digital Twin for factories	Standard	VTT, CERTH, ICE	Open standard
knowlEdge Marketplace	Web application	CERTH	Copyright, open and free use by interested parties for selling and sharing the models and knowledge
Recommendations for knowledge / model exchange	Standard	WWU	Open standard
Secure provisioning and deployment and monitoring framework	Software	FIT, ICE, NXW	Copyright, open and free use, paid support
Digital Twin based simulation toolkit	Software	CERTH, VTT, ICE	Copyright, off-the-shelf product, paid support
DSF & Advanced visualization toolsets	Software	CERTH, FIT, VTT, UPC	Copyright, off-the-shelf product, paid support
Integrated knowlEdge solution	Software	All Partners	Copyright, paid service, paid support

Figure 4: knowlEdge initial exploitable result

The planned IPR workshop in M17 is to resolve any conflict or issues and establish each partner's IPR position and most importantly achieve IPR agreement between the partners planning to start joint exploitation. To do this we need identify IPR for each component for knowlEdge project. This will be done through survey conducted in M9. The clarity IPR associated with of individual component can support the effortless alignment with other components.

2 knowlEdge Market, Business Trends and Drivers

This VRM layer considers external market trends and drivers such as economic, social, environmental and normative trends that might influence the development and exploitation success of knowlEdge’s value opportunities.

This section relates to D2.3 Initial Market Radar and Technology Adaptations which completed in M6 and it offers a holistic vision of the presence of AI in the manufacturing sector, its current state, its potential and the trends with greater scope to make it more competitive. For this purpose, it will review the AI landscape in manufacturing and first-hand experiences in the implementation of this technology in the sector. The important part of T9.3 is to validate and refresh the content throughout the duration of the project.

The prime target markets of knowlEdge solution are the European Union’s manufacturing- and process-industries, their value chains, and EU AI-related companies. Of second priority are international markets such as Japan, USA (the largest globally), as well as China and Russia. Penetration to other wide markets, will also be examined as part of the post-project exploitation in the second deliverable of T9.3.

The latest report from World Manufacturing Foundation [2] highlights the impact of AI applications is significant across all levels of manufacturing activities and is expected to increase in the coming years. At the broadest Digital Supply Network level, AI has proved valuable in demand forecasts and the associated synchronized planning, automated warehouse management, automated design and development, and connected services. In the factory or shop floor level, AI applications are aimed at energy efficiency, product and process quality, scheduling optimisation, robotics, and enhancing the abilities of the human operator. At the most basic machine tool level where AI applications are most mature, automated quality inspection, monitoring, and control, data-driven tool wear models, and predictive maintenance stand to benefit from AI.

Figure 5 shows AI technologies have the impending to rise in production by 40% or more, boosting the economic growth on average 1.7% across 16 industries by 2035 [3]. According to Deloitte [4], the manufacturing sector will be one of the fastest-growing sectors in the

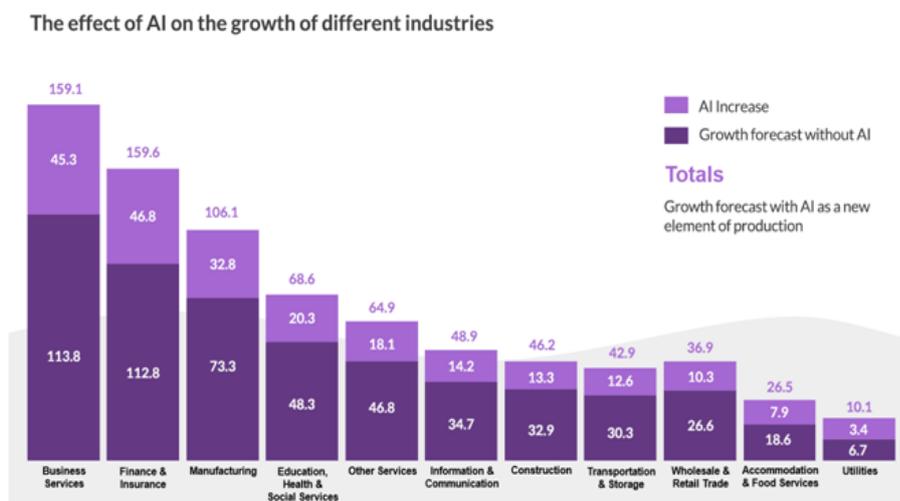


Figure 5. The growth forecast with AI as a new element of production

global AI market in the coming years.

The consortium of knowlEdge is committed to produce demand-driven AI solutions for manufacturing and process industries with view to being exploited shortly after the end-of-the-project. This AI solutions will be empowered by advanced analytic tools such as the Human-AI collaboration component, the 2-axis decision support system and the Digital Twin. This will permit for partners to capitalise on new market opportunities, generate considerable revenue and contribute to the creation of novel jobs in the European economy. knowlEdge partners are expected to exploit the project’s results in a rapidly growing market individually and also jointly under a common business/exploitation plan. All industrial partners are expected to extent their market growth after the completion of knowlEdge, during which they will have the opportunity to test and validate the created tools and AI features. Additionally, due to their AI-powered systems capable to learn, adapt and evolve over time, industries can significantly reduce time-to-market and cut costs in the process, as rapid prototyping and dynamic resource allocation are now a reality.

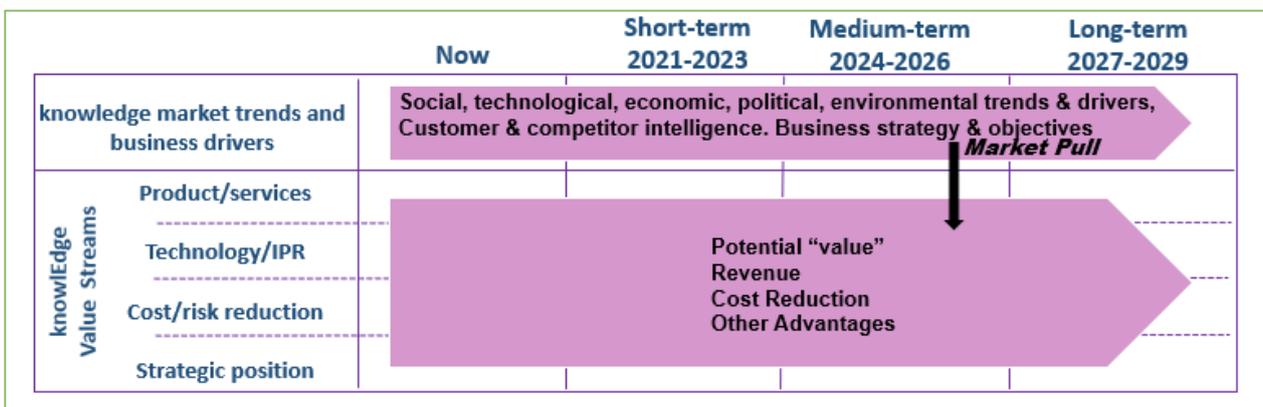


Figure 6. knowlEdge Market Pull

Different external market trend drivers (social, economic, environmental, technological, political and market) that could influence the planned development of knowlEdge products and technology and the area of interest which is shown in the Figure 6. This will be further analysed during the knowlEdge VRM workshop and result will be presented in the D9.11 in M32.

3 knowlEdge Value Streams

The knowlEdge platform will generate cost-efficient, highly resilient, collaborative, explainable and flexible AI powered systems able to improve process and product quality in industries in the cloud-fog-edge continuum. Exploitation opportunities will be identified within knowlEdge in order to promote market development of AI technologies for manufacturing and process industries, and enable novel service creation that will be used by operators (e.g. digital twin, decision support framework, etc.), by workers/service providers (knowledge injection), by value chain (process planning), etc.

knowlEdge DOA has been used as primary input in order to identify potential sources of revenue in the first instance. The revenues will be created from following 11 sources:

1. Industrial data collection and integration toolkit;
2. Site-wide data storage and management suit;
3. (Semi-) automatic knowledge discovery service;
4. Site-wide AI learning orchestration and monitoring service;
5. Recommendations for Digital Twin for factories;
6. knowlEdge Marketplace;
7. Recommendations for knowledge/model exchange;
8. Secure provisioning and deployment and monitoring framework;
9. Digital Twin based simulation toolkit;
10. DSF & Advanced visualisation toolsets, and
11. knowlEdge integrated solution.

The goal VRM to identify as many potential value-generating opportunities as possible. These are classified into 3 types:

- Product: new products or innovations of existing products
- Service: new services or innovations of existing services
- Knowledge: new knowledge with potential for dissemination to driving scientific communities.

knowlEdge value streams will be further analysed during the VRM workshop and result will be shared with the partners in M22 and presented in D9.11. Mapping of the value streams with stakeholders will be analysed in the T9.2 Business Model Development.

3.1 Technological and Industrial Exploitation

knowlEdge partners see a number of strategic motivations in the project. Particularly, a deep involvement in the collaborative AI community which will allow them to enhance and validate their current technologies. The validation of new AI features will enhance knowlEdge partners' ability to 'sell' latest and value-added solutions to clients, and thus reduce the time to market. To achieve the knowlEdge concept a number of technologies and tools have been developed which the project can validate, build upon and adapt to pilot partners' specific use

cases. The current Technology Readiness Level (TRL) and expected TRL at the project-end is shown in Figure 7.

knowlEdge Partner Technologies	Owner	TRL at the project start	TRL target at the project end	TRL achieved at the project end
knowlEdge Discovery Center: a service for a (semi)automatic extraction and exploitation of knowledge from time series	FIT	TRL3	TRL5	
AI Maturity Tool: a generic model, that includes Strategy and Management, Products and Services, Competence & Cooperation, Processes, Data & Technology	VTT	TRL5	TRL7	
Information Extraction Service: provides modern means and technologies for data-driven analysis of time series data	WWU	TRL4	TRL6	
Intelligent Knowledge Discovery Service: enables the transformation of data into knowledge	WWU	TRL4	TRL6	
Data Management Service: responsible for managing and querying data at scale	WWU	TRL4	TRL6	
Distributed Process Design, Execution and Monitoring: Visual tool to design, execute and monitor distributed processes/workflows	ICE	TRL5	TRL7	
ICE Data Platform: offered as PaaS with web-based interface.	ICE	TRL5	TRL7	
Framework for Analytic Dashboards: composed of open-source libraries and their extensions that allow the setup of analytic dashboard through a query-builder module	ICE	TRL6	TRL8	
IoT Toolkit for Condition Monitoring and Alerting: Installation and/or configuration of sensors in the shop-floors to extract relevant data that is analysed through a distributed micro-service based steam processing platform	ICE	TRL5	TRL7	
Digital Twin Toolkit: developing replications of performance and behavioural properties of machines and processes	ICE	TRL4	TRL6	
Data and Visual Analytic Services: Web-based visual analytics tool	CERTH	TRL4	TRL6	
Cognitive Analytics Models and Services: for predictive maintenance solutions for machines, especially for time series data	CERTH	TRL4	TRL5	
Decision Support System: enhance decision making by the end-users & provide solutions related to predictive maintenance actions such as the detection of anomalies etc.	CERTH	TRL4	TRL5	
Intelligent Decision Support Systems (IDSS) / Recommender Systems (RecSys): intelligent systems which provide valuable support to human end-users to make the final decisions on different domains, like in the manufacturing industry	UPC	TRL6	TRL7	
Symphony FE: automation system, featuring completely integrated services and high reliability	NXW	TRL6	TRL7	
Transfer Learning Library: reuse knowledge generated in order to solve a source task to solve another (related) target task	BSC	TRL6	TRL7	
Explainable Image Recognition: interpretability and explainability of CNN models performing image recognition tasks	BSC	TRL4	TRL7	

Graph Analytics: exploiting structural properties of high-dimensional, inter-connected datasets to learn from the relational patterns of its entities	BSC	TRL6	TRL7	
Massive Multi-agents Platform: analysing complex problems in cases where exact modeling is either impossible or very time-consuming	BSC	TRL6	TRL7	
Deep Learning Toolkit: leverages the Machine Learning and Deep Learning techniques for time series, for providing solution of predictive maintenance and/or anomaly detection in the Industry scenarios	LINKS	TRL5	TRL7	
Virtual Process Industries Resource: provides monitoring of the dataflow and enables the customization of the possible control on the data under several aspects	LINKS	TRL3	TRL6	

Figure 7: TRL in knowlEdge

It is important to establish the background technology and how it was enhanced during the project and establishing IPR agreements as many of the partners are planning to commercialise through licensing or joint venture model etc. The Figure 7 will be updated in M18 of the project to show if the partners achieved the target level. The updated TRL and licensing schema will be included the D9.11 which will be submitted in M32 and will also cover the final exploitation efforts and IPR management.

In addition to the previous components, WP8 is expected to do additional customisation to knowlEdge components, such as custom AI model as part of the industrial partners' pilots (K-T, PARM & BSK). The result of that effort will be offered (the terms and financial model to be clarified) in the marketplace to new industrial sectors, in a broader geographical area both directly and indirectly. SMEs partners (ICE, NXW) intent to use and integrate the project's major outcomes to their own solutions, validate them, and decrease time to market by using standardised solutions.

3.2 Scientific Exploitation

Research and technology organisations and academic partners (VTT, FIT, CERTH, UPC, BSC, WWU, LINKS) involved in the project aim to exploit the results and knowledge generated during the project in multiple ways. Their scientific exploitation goals will be achieved through:

- scientific publications of peer-reviewed articles at international conferences and in journal papers,
- increased number of R&D projects in the industry
- increased leadership in the respective areas of research on a European scale
- new marketing opportunities
- PhD thesis in the framework of the project

knowlEdge will produce valuable novel knowledge and empirical evidence within the multi-disciplinary research domain AI technologies, which in spite of its promising potential for businesses, still remain under-research with many concepts that have yet to be put to the test. knowlEdge will leverage new concepts to fully exploit the potential of AI, human and machine intelligence be tightly interwoven, and contribute to scientific and innovation potential of the agile manufacturing in the fields studied. Novel ideas such as generative AI

models, unsupervised data mining tools, secured and simplified schemes allowing operators independently provide their feedback, etc., and new business models will contribute not only to the integration, but also to the production of new knowledge.

4 knowlEdge Enablers and Barriers

Technical and non-technical challenges and risks that directly affect the exploitability of technology's/capability's potential value. This section identifies facilitators and barriers associated with knowlEdge technology exploitation. SWOT analysis from the DOA (see Figure 8 has been used to determine the impact on current time horizon for the knowlEdge project as a whole. The future time horizons will be further analysed during the VRM workshop for each partner's results which will be presented in the D9.11 in M32.

<p style="text-align: center;"><u>STRENGTHS</u></p> <ul style="list-style-type: none"> • Increase workplace & human productivity • Can be adopted in many industries and domains • Easy and effective to apply • Intelligent services to interconnected IIoT devices • Key players in cloud computing, AI technologies, manufacturing systems, digital manufacturing platforms, analytics and IIoT • Significant experience of partners in relative fields • Piloted with real life business cases • Ability to mobilize important communities (e.g. EFFRA, Industry 4.0, etc.) • knowlEdge partners have strong market presence • New generation of AI technologies 	<p style="text-align: center;"><u>WEAKNESSES</u></p> <ul style="list-style-type: none"> • Need a big dataset • Difficulty of integration regarding legacy systems • Sector-specific issues difficult to generalize • Data sets are local to the device (machine, quality inspection) and is difficult to extract to the organization • AI has slower adoption than desired in the manufacturing sector • Slow diffusion of knowlEdge among potential stakeholders due to functional disaggregation of the actors in the chain
<p style="text-align: center;"><u>OPPORTUNITIES</u></p> <ul style="list-style-type: none"> • Ability for combination of AI with newer forms of technologies • New products & services to cater a wide variety of applications • Create new business relationships and opportunities • Increasing interest in exploiting analytics and IIoT to quality enhancement, waste reduction and launching sustainable business models • Initial fund from EU to boost and pilot the concept at an international scene • Market growth 	<p style="text-align: center;"><u>THREATS</u></p> <ul style="list-style-type: none"> • People afraid to lose control or even jobs • General uncertainties (e.g. legal, security) • Data quality) • Unexpected requirements of the market • Constant change of the ICT and related technologies • Lack of supported standards • Underestimated time of development • Interoperability challenges • Stiff competition from domestic and international companies • Shortage of AI experts • Robust integration with legacy IT systems

Figure 8: knowlEdge SWOT analysis

5 knowlEdge Research and Technology Development

This VRM layer focuses on technical capabilities namely technologies, knowledge, and tools that will be achieved/developed throughout the project by partners. Figure 9 introduces the overall list of partners' IP, software or component being developed and finalised in the WP2.

knowlEdge Component Name	Task	Component Description
Data Integration & Interoperability	T3.1	This block will collect the data from the shopfloors of the different pilots and make them available for processing at the upper layers of the knowlEdge platform, using a uniform data model
Data Quality Assurance	T3.2	This block will perform data quality assessment providing structures, modules and algorithms dedicated to this
Historical Data Storage Service	T3.3	A scalable time series data storage service responsible for storing the IoT data across the Edge and the Cloud, orchestration and access control
Real-Time Brokering	T3.3	High performance message broker facilitating failure free data propagation across different services in edge and cloud
Knowledge Discovery Engine	T4.1	Information and feature store to be exploited by other components to give feedback based on interpretable information
AI Model Generation	T4.2	Automated continuous process of model training and testing based on synthetic datasets
Edge Embedded AI Kit	T4.2	Edge-ready lightweight module for execution of model inference and fine-tuning
HP AI Bootstrapping	T4.3	AI algorithms automated execution in HPC/Cloud with embedded trace-based performance analysis
Processing & Learning Orchestration	T4.4	Component in charge of fetching and orchestrating the AI models from T4.1 and T4.2
Overall Monitoring	T4.4	Main access point to all the services provided by the monitoring API, composed by several subcomponents at different levels
Fog Infrastructure Monitoring	T4.4	Sub-component of the monitoring API used to monitor the load (e.g. network usage) of the different deployed AI models on the various components of the fog infrastructure
Process Load Profiling & Monitoring	T4.4	Sub-component of the monitoring API used to monitor the machine resources (e.g. memory usage) used by the single instance of a model once deployed
Learning Performance Monitoring	T4.4	Sub-component of the monitoring API used to monitor the learning performances (e.g. accuracy) of the different API models
knowlEdge Management and Repository	T5.1 and T5.2	knowlEdge management infrastructure and repository will deal with the research and development of a distributed infrastructure and technical means in order to ensure efficient management and access of information and knowledge
knowlEdge Marketplace	T5.3	This component will provide an interface for the presentation of AI models' descriptions and metadata available from T5.1. Furthermore, the interface should provide further functionalities such as user profiles and their management, search capabilities, rating and feedback mechanisms etc.
Digital Twin	T6.2	Digital twin is a digital counterpart representation of a physical object, which accurately mirrors the current state of its corresponding physical twin. The digital twin will simulate the behaviour of the manufacturing processes based on simulators and AI algorithms and will provide results in 2D and 3D dashboards
Policy Manager	T6.3	To guarantee the availability of knowlEdge and the integrity and confidentiality of the information shared inside of knowlEdge a policy is need to be defined for each deployment.

		This policy needs to be enforced by all components, which means all components need to be supplied with the necessary information to make the correct decisions. The policy manager is the central source for policy information and the central sink for security relevant events.
Identity Provider	T6.3	This component provides a single sign on mechanism for the users who have to interact with the other component
Deployment Tool	T6.4	The server-side components of a configuration management system for edge applications. This component enables users to deploy software on remote edge devices, providing utilities to support bulk deployments, remote command execution, and deployment monitoring
Deployment Agent	T6.4	The client-side component of a configuration management system, deployed on every edge device. This component runs as a background service, connects to the server from behind firewalls and executes instructions on behalf of the user
Human-AI collaboration & Domain Knowledge Fusion	T7.1	This component will offer an interface for domain experts to interact with AI model, domain ontology and configuration. By doing so, it enables the domain experts (or machine operators) enter ground truth, configuration adaptation, model selection, and ontology enrichment
KPIs Extraction & Users' Rules Backend	T7.2	DSS backend with various reasoning mechanisms and KPIs extraction. It should be strongly connected with WP4 AI models. DSS ensuring desired process and product quality inspection and machine condition monitoring based on pilots' descriptions and needs
DSS	T7.3	Dynamic and interactive dashboard composed of several topics, such as machine use (highlight the key elements of its activity), alerts in order to identify areas where a fault or malfunction occurs and management info (maintenance time, operational costs, machine performance, etc.) as measured by key indicators The visualized KPIs will be created and calculated based on the need of each shop-floor and on multiple levels (product-level and process-level) to evaluate their success at reaching targets - should visualize T7.2 outcomes and live data from shop-floors (WP3)

Figure 9: knowlEdge components

The above table serves purpose of showing components as technical outcomes of knowlEdge. Most of the components work as standalone but it will be the main task of T9.3 to establish which components can work together to create additional value streams. knowlEdge work plan will help all partners to join forces to design and develop effective and efficient innovative technologies/ services tailored to the needs of all stakeholders involved in knowlEdge consortium. Current state of the art for the technology in development, future possibilities, competing and complementary technologies will be further analysed during the knowlEdge VRM workshop and result will be presented in the D9.11 in M32.

6 Exploitation Strategy Summary and Next Actions

Planned

This deliverable has defined the main exploitation activities of the knowlEdge to be performed until the end of the project. According to the VRM defined in Section 2, we will identify the project value streams; market drivers; enablers and barriers; and technology and research development for knowlEdge. The VRM workshops are planned from M13. The result of the main workshop will be analysed and presented in M16 and M22. The second deliverable D9.11 due in M32 will update this deliverable D9.5 by refining exploitation results from the workshops (VRM and IPR), but also adding individual exploitation plans by partners and any other joint exploitation plan and elaborating their business case based on the T9.2 Business Model Development and T2.3 Market Radar and Technology Adaptations.

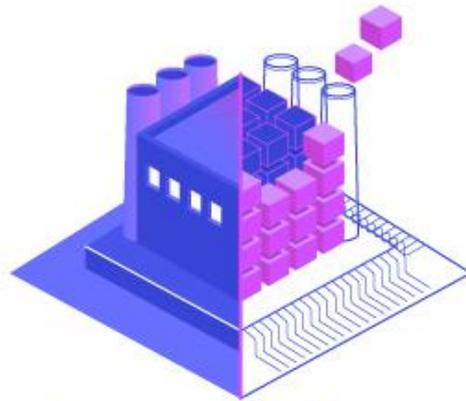
The document also has covered the current agreement in each section that is shared by partners, as for example, the agreed business model and the vision of the value that knowlEdge will provide them, an analysis of the market that knowlEdge will face and the initial list of software components with a potential to be exploited at the end of the project. All of these will be updated and enriched as the project progresses.

Annex A: History

Document History	
Versions	<p>V0.01:</p> <ul style="list-style-type: none">• Document set-up and draft table of contents by ICE <p>V0.02 – V0.9:</p> <ul style="list-style-type: none">• ICE reviews <p>V1.0:</p> <ul style="list-style-type: none">• First internal review by CERTH <p>V1.1:</p> <ul style="list-style-type: none">• Second internal review by VTT
Contributions	<ul style="list-style-type: none">• ICE, CERTH, VTT

Annex B: References

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