VerSatilE plug-and-play platform enabling remote pREdictive mainteNANce

Grant Agreement No	:	767561
Project Acronym	:	SERENA
Project Start Date	:	1st October 2017
Consortium	:	COMAU S.p.A. Finn-Power Oyj VDL Weweler BV WHIRLPOOL EMEA SpA Kone Industrial Ltd Engineering Ingegneria Informatica S.p.A. OCULAVIS GmbH SynArea Consultants S.r.l. DELL EMC Laboratory for Manufacturing Systems & Automation Fraunhofer Gesellschaft zur Förderung der angewandten Forschung VTT Technical Research Centre of Finland Ltd TRIMEK S.A. Politecnico Di Torino

Title	:	Dissemination and exploitation activities- Intermediate version
Reference	:	D7.3
Dissemination Level	:	PU (Public)
Date	:	2019-09-30
Author/s	:	LMS/ENG/SERENA Consortium
Circulation	:	EU/Consortium

Summary:

Purpose of this document is to summarize activities on the dissemination and exploitation of the SERENA project obtained in the second year of its lifetime. Additionally, it includes information about the project's as well as individual partners' strategies for dissemination exploitation and communication.

Contents

List of Abbreviations

SME	Small and Medium Sized Enterprise
PdM	Predictive Maintenance
S&T	Scientific and Technical
DoA	Description of Action
CA	Consortium Agreement
GA	Grant Agreement

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Executive Summary

Purpose of this deliverable is to present the detailed plan of dissemination activities, as well as the intermediate version of the project exploitation plan to be followed by the consortium.

The content of this document is the outcome of the following SERENA tasks and during the period from 1/10/2018 to 30/09/2019:

- T7.2: Academic and industrial dissemination
- T7.3: Exploitation activities: Roadmap, implementation and IPR management

The main results are the following:

- ✓ Dissemination activities undertaken during the second year of the project, following the dissemination plan described in D7.2.
- ✓ Migration to a new SERENA public portal theme
- ✓ News on the SERENA participation in ForeSee cluster of projects about predictive maintenance
- ✓ Updated Assets for the project including IPR situation
- ✓ Updated Market analysis
- ✓ Initial Competition Analysis
- ✓ Updated SWOT analysis
- ✓ Updated SERENA partners Individual Exploitation Plans

1 Introduction

1.1 Scope and objectives of this deliverable

This deliverable aims to report the outcomes of the dissemination and exploitation activities undertaken during the second year of the SERENA project lifetime and as outlined by the WP7 individual tasks, namely:

- Task 7.1 – SERENA Web Portal
- Task 7.2 – Academic and industrial dissemination
- Task 7.3 - Exploitation activities: Roadmap, implementation and IPR management
- Task 7.4 - Standardization – proposals, roadmap, and activities [*To begin in October 2019*]

1.2 Structure of the document

The updates related to the dissemination of the project results including the updates to the project public portal and its social media management is included in Section 2. Additionally, within the same section are reported updates on SERENA publications either published or pending for publication.

Next and in section 3, an update of the exploitation activities is presented along with the current list of exploitation assets, updated market and competition analysis and SWOT and potential changes and deviations from the exploitation plan as reported in D7.2 as it regards the individual partners exploitation strategy.

2 Update on dissemination activities

2.1 Project website

The SERENA project public portal has been accessible since M01 providing public information about the SERENA project. Access to the public and private web portal is provided by the link:

http://www.serena-project.eu/

The SERENA public portal and in the period from M13 to M24 has been updated with a new theme, aiming to make the portal more attractive to a visitor, facilitating the dissemination of the project results to wider audiences, while supporting the language of every consortium member.

Figure 1: New front page of the SERENA public portal

SERENA portal activity (01/10/2018 – 23/9/2019)

Google Analytics has been used to monitor the activity in SERENA public portal[1]. Using Google Analytics, the following numbers have been recorded:

Performance measure	Value	Difference from D7.2
Sessions	2,292	+ 157
Users	1,608	+ 416
Pageviews	4,243	+ 1573
Avg. Session Duration	1min 21sec	- 1 min
Bounce Rate	70.42%	+ 11.06%
New visitors	1,596	-

No	Country	Users	
1.	United States	403	24.80%
2.	Greece	172	10.58%
3.	Italy	157	9.66%
4.	Germany	96	5.91%
5.	Spain	76	4.68%
6.	Canada	70	4.31%
7.	India	61	3.75%
8.	France	42	2.58%
9.	United Kingdom	39	2.40%

Table 1: SERENA public portal analytics

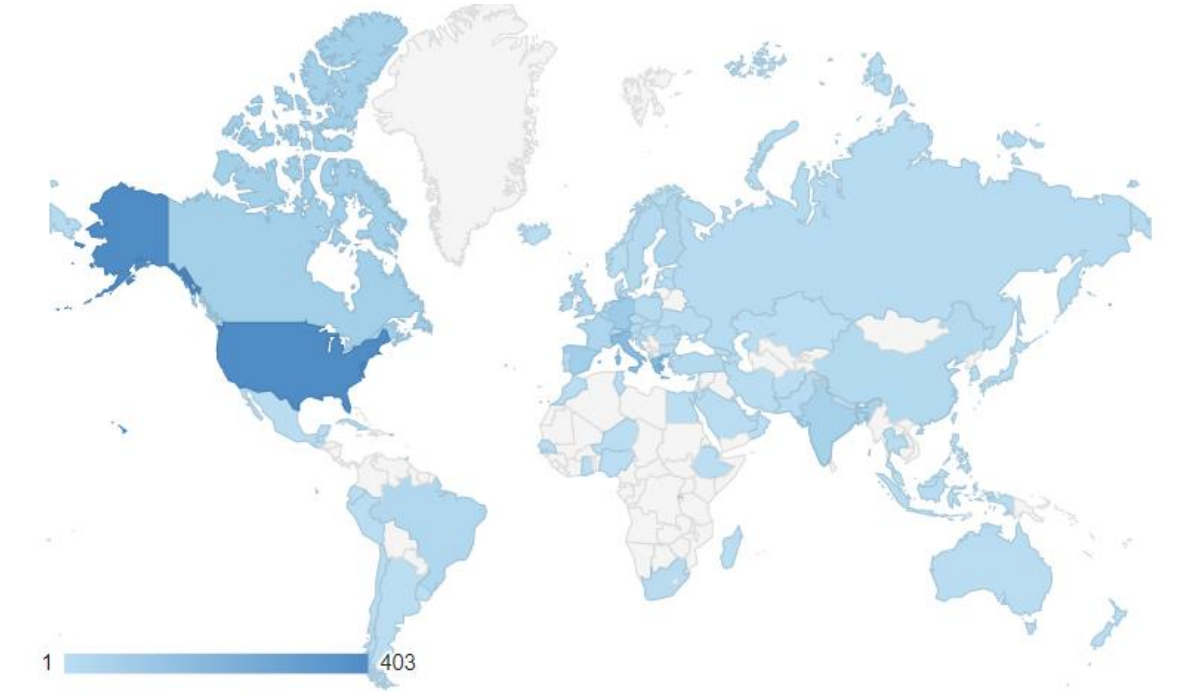

Figure 2: Map of countries (in blue) that have visited SERENA portal

[1] The activity reported involves only the SERENA public portal however it does not exclude the activity of SERENA partners when visiting the public portal.

2.2 Web 2.0 – Social media

SERENA holds presence in social media and more specifically in Facebook and Twitter. These media are mainly used to promote SERENA activities as well as to create awareness to the SERENA project through the publication of relevant news and activities from all around the world. In the following table the updated activity in the SERENA social media accounts is presented along with the difference from the previous period covered by D7.2.

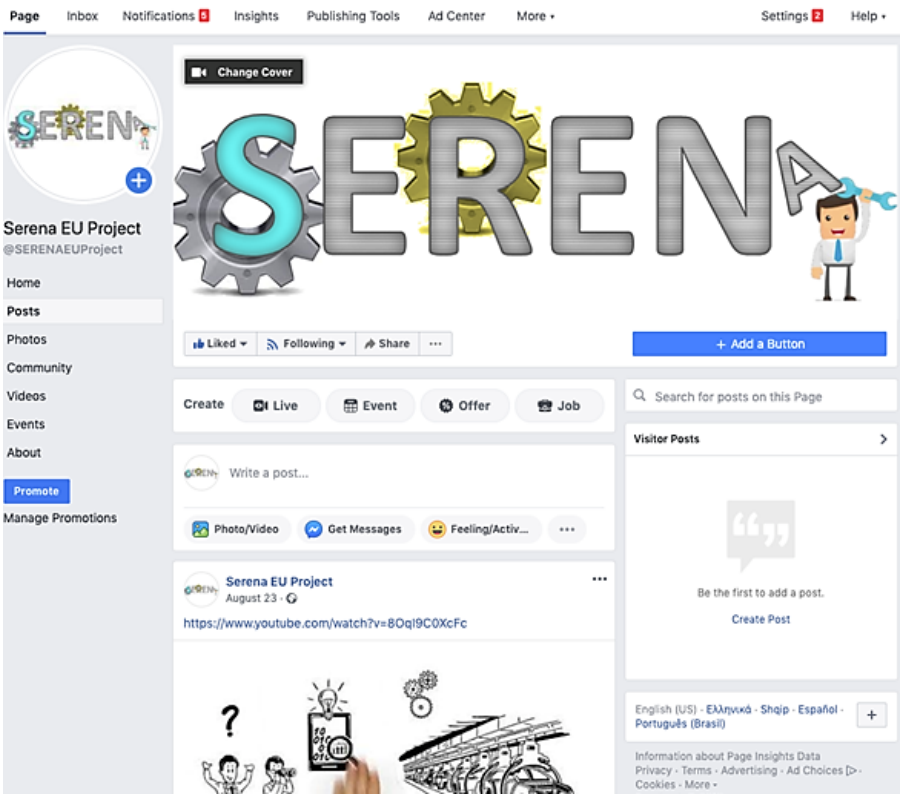

Figure 3: SERENA on Facebook

Figure 4: SERENA on Twitter

SERENA social media activity (01/10/2018 – 20/9/2019)

Performance measure		Value	Difference from D7.2
Facebook	Total Followers	57	+11
	Total Likes	53	+11
Twitter	Tweets	15	-3
	Following	27	+7
	Followers	99	+49

Table 2: SERENA social media statistics

2.3 Communication Material

The SERENA project newsletters are yearly released providing its readers with updates on the SERENA project including recent activities, events, developments as well as information on the SERENA participation in the ForeSee cluster. The SERENA newsletters are available through the public portal under the *"News > Press Material"* tab.

Figure 5: SERENA 2nd newsletter

2.4 List of dissemination and communication activities between 1/10/2018 (M13) to 30/09/2019 (M24)

2.4.1 Scientific publications

No	*Activity type*	Title	Date	Place	Author	Status of submission, publication	Permanent identifiers[2] (if available)	Is open access provided to this publication[3]
1.	Conference paper	On an evolutionary information system for providing personalized support to plant operators	June 2019	CIRP CMS 2019	LMS	published	https://doi.org/10.1016/j.procir.2019.03.153	yes
2.	Conference paper	A cloud-to-edge architecture for predictive analytics	26 March 2019	EDBT/ICDT 2018 Workshops	DELL, ENG, COMAU, LMS, SynArea, POLITO, IPT	published	http://ceur-ws.org/Vol-2322/DARLIAP_1.pdf	yes
3.	Conference paper	A fog computing approach for predictive maintenance	April 2019	31st International Conference on Advanced Information Systems Engineering	LMS	published	https://doi.org/10.1007/978-3-030-20948-3_13	
4.	Conference paper	Mimosa Strong Medicine for Maintenance	September 2019	Huddersfield, Britain	VTT	accepted		

[2] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository)

[3] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

5.	Conference paper	iSTEP, an Integrated Self-Tuning Engine for Predictive Maintenance in Industry 4.0	December 2018	In IEEE International Conference on Parallel & Distributed Processing with Applications, Ubiquitous Computing & Communications, Big Data & Cloud Computing, Social Computing & Networking, Sustainable Computing & Communications, ISPA/IUCC/BD Cloud/SocialCom/SustainCom 2018, Melbourne, Australia, December 11-13, 2018. IEEE 2018. ISBN 978-1-7281-1141-4	POLITO	published	https://ieeexplore.ieee.org/document/8672266	gold
6.	Conference paper	PREMISES, a Scalable Data-Driven Service to Predict Alarms in Slowly-Degrading Multi-Cycle Industrial	July 2019	2019 IEEE International Congress on Big Data, BigData Congress 2019,	POLITO	published	https://ieeexplore.ieee.org/document/8818217	gold

		Processes		Milan, Italy, July 8-13, 2019. IEEE 2019, ISBN 978-1-7281-2772-9				
7.	Conference paper	A New Unsupervised Predictive-Model Self-Assessment Approach That SCALEs.	July 2019	2019 IEEE International Congress on Big Data, BigData Congress 2019, Milan, Italy, July 8-13, 2019. IEEE 2019, ISBN 978-1-7281-2772-9	POLITO	published	https://ieeexplore.ieee.org/document/8818187	gold
8.	Book chapter	Elaborare i dati raccolti negli ambienti di produzione, creare valore e strutturare conoscenza: metodi, sfide e opportunità.	March 2019	Il futuro della fabbrica. La via italiana per il rinascimento della manifattura. Editor: ESTE ISBN: 978-88-98053-32-2	POLITO		https://www.este.it/editoria/libri/view/81:il-futuro-della-fabbrica.html	

2.4.2 Dissemination and communication activities

No	*Activity type*	Title	Date	Place	Beneficiary	Size of audience
1.	A&T 2019 Trade Fair	SERENA project presentation to visitors	13-15 February 2019	Turin, Italy	SynArea	Large
2.	Euroblech 2018 Hannofer	AR Concept presentation to Visitors	23-25.10.2018	Hannover, Germany	Finn-Power oy	Large
3.	International Sales meeting Prima Power	Serena concepts	20.12.2019	Seinäjoki, Finalnd	Finn-Power oy	Large

4.	Seminar presentation AI case exaples in Finnish industry	Serena Predictive maintenance concepts	25.3.2109	Seinäjoki, Finalnd	Finn-Power oy	
5.	Seamk Innnovation week use cases	Serena Concepts	10.3.2019	Seinäjoki, Finalnd	Finn-Power oy	
6.	VAMK Innovation course use Cases	Serena Concepts	25.10.2018	Vaasa,Finland	Finn-Power oy	
7.	FIWARE Summit	Serena Concepts and project brochures	21-22.5.2019	Milan, Italy	ENG	Large
8.	IEEE World Congress On Services 2019	Serena Concepts	11.7.2019	Milan, Italy	ENG	Large
9.	EMO Hannover 2019	Serena Concepts and project presentation	15.09-20.09.2019	Hannover, Germany	OCULAVIS	Large
10.	Hannover Messe 2019	Serena Concepts and project presentation	01.04-05.04.19	Hannover, Germany	OCULAVIS	Large
11.	LIGNA 2019	Serena Concepts and project presentation	27.05-30.05.19	Hannover, Germany	OCULAVIS	Large
12.	Forum Deutscher Mittelstand	Serena Concepts and project presentation	11.09-12.09.19	Stuttgart, Germany	OCULAVIS	Medium
13.	ITMA 2019	Serena Concepts and project presentation	20.06-22.06.19	Barcelona, Spain	OCULAVIS	Large
14.	FoF community day	SERENA project presentation to visitors	27 June 2018	BluePoint Centre, Brussels	TRIMEK	small
15.	EMO Hannover 2019	Serena Concepts and project presentation	15.09-20.09.2019	Hannover, Germany	TRIMEK	Large
16.	Metromeet	Serena Concepts booth exhibition	10-12.04.2019	Bilbao, Spain	TRIMEK	
17.	Industrial Internet Consortium	SERENA Architecture Presentation	21 May 2019	Cork, Ireland	Dell	Large

2.4.3 Lectures

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2.4.4 PhD, Master, and bachelor thesis

No	*Activity type*	Title	Date	Place	Beneficiary
1	Bachelor thesis	Buss system reliability	2018-2019	Finland	Finn-Power oy
2	Part of PhD	Data Business models	2018-2020	Finland	Finn-Power oy
3	Bachelor thesis	OEE in Sheet metal machines	2018-2019	Finland	Finn-Power oy

2.4.5 Videos and newsletters

No	*Activity type*	Title	Date	Place	Beneficiary	Size of audience
1	Newsletter	SERENA newsletter v2	9/2019	SERENA portal	LMS	web

2.4.6 Liaison with other projects

The SERENA project participates in the FoF-09-2017 cluster named ForeSee. The logo of the cluster is presented below:

Figure 6: ForeSee cluster logo

The ForeSee cluster includes the following projects:

	SERENA project will build upon these needs for saving time and money, minimizing the costly production downtimes. The proposed solutions are covering the requirements for versatility, transferability, remote monitoring and control by a) a plug-and-play cloud based communication platform for managing the data and data processing remotely, b) advanced IoT system and smart devices for data collection and monitoring of machinery conditions, c) artificial intelligence methods for predictive maintenance and planning of maintenance and production activities, d) AR based technologies for supporting the human operator for maintenance activities and monitoring of the production machinery status.
	UPTIME aims to design a unified predictive maintenance framework and an associated unified information system in order to enable the predictive maintenance strategy implementation in manufacturing industries. The UPTIME predictive maintenance system will extend and unify the new digital, e-maintenance services and tools and will incorporate information from heterogeneous data sources to more accurately estimate the process performances.
	The main scope of the project is the development of Strategies and Predictive Maintenance models wrapped around physical production systems for minimizing unexpected breakdowns and maximizing operating life of production systems.

PROGRAMS	The main objectives of this project are to develop a model-based prognostics method integrating the FMECA and PRM approaches for the smart prediction of equipment condition, a novel MDSS tool for smart industries maintenance strategy determination and resource management integrating ERP support, and the introduction of an MSP tool to share information between involved personnel. The proposers' approach is able to improve overall business effectiveness with respect to the following perspectives: increasing Availability and Overall Equipment Effectiveness, continuously monitoring the criticality of system components, building physical-based models of the components, determining an optimal strategy for the maintenance activities, providing in a machine condition monitoring system, developing an Intra Factory Information Service. The production and maintenance schedule of complete production lines and entire plants will run with real-time flexibility to perform at the required level of efficiency, optimize resources and plan repair interventions.
PRECOM Predictive Cognitive Maintenance Decision Support System	The project will deploy and test a predictive cognitive maintenance decision-support system able to identify and localize damage, assess damage severity, predict damage evolution, assess remaining asset life, reduce the probability of false alarms, provide more accurate failure detection, issue notices to conduct preventive maintenance actions and ultimately increase in-service efficiency of machines by at least 10%.
PROPHESY	The technical solutions provided by the project will be the pillar to establish an ecosystem of PdM services to enable all the stakeholders to engage the development and deployment of innovative PdM services. This ecosystem will focus on the development, deployment, and operationalization of dynamic, self-adaptive and cost-effective (turn-key) PdM solutions. The purpose is to lower the deployment time and cost associated with the operation of PdM solutions, while at the same time providing a host of business opportunities for all stakeholders.

In the context of the ForeSee cluster, there have been identified the following activity areas which are under the leadership of each project. In particular:

- AA1: Analysis of technology in the market and in the pipeline (*Lead:* ***PROPHECY***)
- AA2: ForeSee predictive maintenance concept for the Factory of the Future (*Lead:* ***PROGRAMS***)

- AA3: Trend-Setting for the future factory (*Lead: **Z-BREA4K***)
- AA4: New model for sustainable factories through efficient predictive maintenance (*Lead: **PRECOM***)
- AA5: Skills building paradigm for predictive maintenance (*Lead: **SERENA***)
- AA6: Community building and dissemination (*Lead: **UPTIME***)

Recently the focus has been placed upon the standardization activities across the ForeSee cluster and is an ongoing work topic. Additionally, a web site has been setup informing the wider audiences about the ForeSee cluster and providing an update on its recent events and activities. The portal is available through the following link:

http://foresee-cluster.eu/

2.4.7 Joint events with other projects

No	*Activity type*	Title	Date	Place	Beneficiary	Size of audience
1.	Cluster joint event	SERENA project presentation	January 2019	Cluster workshop, Drachten, Netherlands	LMS	Medium
2.	Cluster participation	SERENA project presentation	May 2019	FoF community day, Brussels, Belgium	LMS	Large
3.	Cluster participation	SERENA joint paper presentation	June 2019	KET4DF workshop, Rome, Italy	LMS	Medium

3 Updated exploitation plan and activities

In this section we present relevant updates to the SERENA exploitation plan, according to the strategy presented in D7.2 and highlighting the main updates and deviations (i.e. in order to minimise repetition as much as possible). The Assets where al updated by partners and, as a core element of the exploitation, are reported again in order to provide a comprehensive overview.

3.1 Identified Exploitation Assets (M24 update)

In order to ensure consistency and a unified approach, the definition of Assets was carried out as a collaborative and distributed process with all partners, through the creation of a live 'Assets Database' and using a shared template. The template is presented (along with descriptions) in Table 3-1 below.

Asset title	'Business' name for the asset
Description	A description of the asset: Focus on main value proposition(s), selling points
Lead partner(s) (point of reference)	Lead (point of reference) partner for the asset
SERENA results and components involved	Example one or more of the other Assets if relevant
License	The target license(s) for the Asset
Type(s) of asset	Examples (multiple possible): Product, Service, Demonstrator,
Relevant stakeholders	Stakeholders involved in the use of the asset. This should include parties already contacted / involved in SERENA and exploitation already put forward, for example by direct contact, presentation, take-up of the component. Example: direct customers, direct suppliers, suppliers of complementary products
Exploitation channel(s)	The main exploitation channels for the asset, e.g. Support, Training, Consulting, Extension/Customization. More than one channel is possible for an asset also depending on the partners involved
Possible competitors	Possible competitors in the market offering similar/competing value propositions
Replicability in other domains and ecosystems	Replication capabilities in different domains. They should be as much as possible concrete and based on the bottom-up capability of the partners.
Action plan / status	Concrete action (plans) for pushing the asset to the market: i.e. so that it is concrete and not just theory.

Table 3-1: SERENA Exploitation Assets definition template

3.1.1 Remote factory condition monitoring and control

Asset title	Remote factory condition monitoring and control
Description	Core development of WP2 will be the versatile data acquisition platform, referred to as DataBox. To allow an easy adaption of the solution to various use cases, the platform needs to be highly modular and flexible in terms of hard and software.
Lead partner(s) (point of reference)	IPT
SERENA results and components involved	Databox Hardware Prototype for TRIMEK use case,

License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	management
Exploitation channel(s)	publications, trade fairs, existing customer relations
Possible competitors	other automation suppliers/vendors, other research consortiums
Replicability in other domains and ecosystems	large variety of machinery in production and research.
Action plan / status	not yet scheduled, exploitation on customer request

3.1.2 AI condition-based maintenance and planning systems

Asset title	AI condition-based maintenance and planning systems
Description	Purpose of WP3 is to improve existing solutions for predictive maintenance as well as planning of maintenance solutions regarding data analytics algorithms and predicting potential failures on the equipment. Hybrid approaches including both data driven, and physics-based models of the machine/ equipment will be implemented in the cases if higher prediction accuracy is needed.
Lead partner(s) (point of reference)	VTT
SERENA results and components involved	State detection, Health Assessment, Prognostics Assessment and Advisory Generation blocks, Maintenance aware scheduling
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	Industrial companies both process and mobile machinery manufacturers
Exploitation channel(s)	publications, trade fairs, existing customer relations
Possible competitors	Other research organizations
Replicability in other domains and ecosystems	large variety of machinery in production and research.
Action plan / status	internal exploitation, utilization in commercial and jointly funded projects

3.1.3 AR-based technologies for remote assistance and human operator support

Asset title	AR-based technologies for remote assistance and human operator support
Description	Core development of work package 4 will be an augmented reality-based step-by-step worker guidance system that can run on mobile devices like smart glasses and tablets. A web-based modelling environment serves maintenance managers as authoring tool.
Lead partner(s) (point of reference)	OCULAVIS
SERENA results and components involved	Manual Editor, Manual Viewer Application, Notification System, Scheduling System, other visualization results
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	SERENA partners, direct customers, existing leads
Exploitation channel(s)	Trade Fairs, Consulting, Customization, Joint collaborations within SERENA partners
Possible competitors	Other software companies in the field of augmented reality
Replicability in other	system can easily be adopted to different domains

domains and ecosystems	
Action plan / status	internal exploitation, utilization in commercial projects

3.1.4 Cloud-based platform for versatile remote diagnostics

Asset title	Cloud-based platform for versatile remote diagnostics
Description	This is the SERENA Cloud Platform, mainly the outcome of WP5, which is able to provide networking infrastructure, cloud computing, data processing, and the shared situation awareness components. The platform is able to provide data processing and related capabilities. First selling point will be the incorporation of the innovative SERENA paradigms. A selling point will be the possibility to integrate the Platform with existing equipment actually 'augmenting' it and transforming legacy equipment into smart equipment. The Platform will offer innovative analytics and data processing features, for example reasoning and complex event processing, allowing to detect and faulty or non-optimal components but also assess the overall process efficiency. The Platform includes security and confidentiality 'by design' at all layers ensuring full security of clients as well as compliance with standards regarding personal data.
Lead partner(s) (point of reference)	ENG
SERENA results and components involved	All components involved in the Platform
License	Mixed
Type(s) of asset	Platform Demonstrator
Relevant stakeholders	Serena partners, manufacturing clients, data providers, machinery providers
Exploitation channel(s)	Joint collaborations within SERENA exploitation strategy, client relations, dissemination and communication events, further research, and innovation
Possible competitors	Suppliers of predictive maintenance and diagnostics applications
Replicability in other domains and ecosystems	Construction, Healthcare, Agriculture, IoT-based industries
Action plan / status	- In the next period piggy-back on SERENA external communication and dissemination activities - Internal presentations and 'pitching' by relevant partners - Early demos

3.1.5 Pilot cell for versatile maintenance in White goods industry

Asset title	Pilot cell for versatile maintenance in White goods industry
Description	The pilot cell is based on a Foaming Machine equipped with sensors to monitor process parameters. The main asset to exploit is mostly intangible and it is constituted by the transferability of the architecture to other machines.
Lead partner(s) (point of reference)	WHEMEA
SERENA results and components involved	-
License	NA
Type(s) of asset	Demonstrator

Relevant stakeholders	WHR Factory managers; External suppliers of similar machines;
Exploitation channel(s)	Extension to other Foaming Equipment in WHR production sites.
Possible competitors	Suppliers of equipment could offer integrated Predictive Maintenance functionalities or services embedded in the system
Replicability in other domains and ecosystems	Foaming Equipment in all Refrigeration WHR factories
Action plan / status	Internal exploitation only.

3.1.6 Pilot cell for versatile maintenance in Elevators production industry

Asset title	Pilot cell for versatile maintenance in Elevators production industry
Description	Elevator industry pilot is based on monitoring automated thin metal sheet manufacturing equipment. The main asset is to forward potential failure data from various sources to provide analyses for predictive maintenance actions.
Lead partner(s) (point of reference)	KONE
SERENA results and components involved	Vibration data collection to Serena platform. HW: Vibration sensors.
License	Proprietary
Type(s) of asset	Demonstrator
Relevant stakeholders	KONE personnel and equipment manufacturer
Exploitation channel(s)	Exploited within KONE Supply Units
Possible competitors	Predictive maintenance services
Replicability in other domains and ecosystems	Other KONE Supply Unit with similar machinery.
Action plan / status	Internal exploitation only. Not yet scheduled.

3.1.7 Pilot cell for versatile maintenance in Metrological engineering industry

Asset title	Pilot cell for versatile maintenance in Metrological engineering industry
Description	Metrology demonstrator is focused on monitoring the performance of the coordinate measuring machine at the metrology laboratory in order to predict potential failures. TRIMEK will offer a remote predictive maintenance service based on the access to data from different sources in order to detect potential failures and synchronise scheduled for maintenance activities with production and logistics activities.
Lead partner(s) (point of reference)	TRIMEK
SERENA results and components involved	Upgraded predictive maintenance service for calibration and repairing. Upgraded HW package: sensors, software module...
License	Proprietary
Type(s) of asset	Demonstrator
Relevant stakeholders	TRIMEK maintenance personnel and R&D managers.
Exploitation channel(s)	Customer relations, trade fairs
Possible competitors	Suppliers of CMMs with predictive maintenance services
Replicability in other domains and ecosystems	CMMs and other quality control systems in different manufacturing plants

Action plan / status	not yet scheduled

3.1.8 Versatile maintenance in Steel parts production and link to other industries

Asset title	Versatile maintenance in Steel parts production and link to other industries
Description	Steel parts demonstrator is based on monitoring the production (hot rolling) of a steel part. The main asset is prediction of the potential failure of the rolling segments.
Lead partner(s) (point of reference)	VDLWEW
SERENA results and components involved	By M24: - gateway - serena cloud platform - operator support (pending)
License	NA
Type(s) of asset	Demonstrator
Relevant stakeholders	VDL Weweler personnel
Exploitation channel(s)	Exploited within VDL Weweler
Possible competitors	-
Replicability in other domains and ecosystems	Other forming machines within VDL Weweler
Action plan / status	not yet scheduled

3.1.9 Pilot on versatile maintenance for tool providers

Asset title	Pilot on versatile maintenance for tool providers
Description	The demonstrator ("Robot Box") consists of a real robot motor and an accelerometer sensor, it is designed in order to provide a test bench to get data and extract features. The main asset consists in easily manipulate the robot box to extract fault data, useful for the analytics study.
Lead partner(s) (point of reference)	COMAU
SERENA results and components involved	
License	NA
Type(s) of asset	Demonstrator
Relevant stakeholders	Innovation and robotics R&D managers and mechanical designers. Serena partners, data analysts.
Exploitation channel(s)	Personnel working in customer care directly involved in plant operation.
Possible competitors	Other automation suppliers/vendors who offer integrated predictive maintenance functionalities.
Replicability in other domains and ecosystems	Other studies regarding motor performance degradation.
Action plan / status	Other Business Units and R&D industry partners.

3.1.10 Databox HW

Asset title	Databox HW
Description	The hardware of the databox will consist of a central processing device, such as an industrial field pc. To achieve the modularity needed, WAGO interface modules will be used. These can be extended by many available in- and output modules that are available from WAGO.
Lead partner(s) (point of reference)	IPT
SERENA results and components involved	Databox Hardware Prototype for TRIMEK use case
License	Proprietary
Type(s) of asset	Demonstrator
Relevant stakeholders	Equipment suppliers, Automation providers
Exploitation channel(s)	publications, trade fairs, existing customer relations
Possible competitors	other automation suppliers/vendors, other research consortiums
Replicability in other domains and ecosystems	large variety of machinery in production and research.
Action plan / status	not yet scheduled, exploitation on customer request

3.1.11 Universal data collection

Asset title	Universal data collection
Description	This task will be realised by designing the software in a modular way, allowing easy exchange of input/output and data algorithm modules. For this, the software will be divided and packaged into docker containers, which are organised and distributed by the central cloud system.
Lead partner(s) (point of reference)	IPT
SERENA results and components involved	Swarm architecture with a modular and easy to configure setup of the acquisition flows/processing
License	Proprietary
Type(s) of asset	Demonstrator
Relevant stakeholders	production management
Exploitation channel(s)	publications, trade fairs, existing customer relations
Possible competitors	other automation suppliers/vendors, other research consortiums
Replicability in other domains and ecosystems	large variety of machinery in production and research.
Action plan / status	not yet scheduled, exploitation on customer request

3.1.12 Data pre-processing and forwarding

Asset title	Data pre-processing and forwarding
Description	Data pre-processing is realised by adding smart data algorithms to the functionality containers. These algorithms can range from simple value extractions to advanced waveform analytics.
Lead partner(s) (point of reference)	IPT
SERENA results and components involved	Containerization of pre-processing algorithms in DOCKER services
License	Proprietary

Type(s) of asset	Demonstrator
Relevant stakeholders	Equipment suppliers, Automation providers
Exploitation channel(s)	publications, trade fairs, existing customer relations
Possible competitors	other automation suppliers/vendors, other research consortiums
Replicability in other domains and ecosystems	large variety of machinery in production and research.
Action plan / status	not yet scheduled, exploitation on customer request

3.1.13 Edge Analytics

Asset title	Edge Analytics
Description	Edge Analytics can be included if needed. This might require more powerful edge devices and an additional software component for managing the load distribution to all participants. For the first version of Serena it is intended to keep the processing load of the Edge devices low by only using standard pre-processing algorithms.
Lead partner(s) (point of reference)	IPT
SERENA results and components involved	
License	Proprietary
Type(s) of asset	-
Relevant stakeholders	Equipment suppliers, Automation providers
Exploitation channel(s)	publications, trade fairs, existing customer relations
Possible competitors	other automation suppliers/vendors, other research consortiums
Replicability in other domains and ecosystems	large variety of machinery in production and research.
Action plan / status	not yet scheduled, exploitation on customer request

3.1.14 State Detection

Asset title	State Detection
Description	State Detection (SD block): facilitates the creation and maintenance of normal baseline “profiles”, searches for abnormalities whenever new data are acquired, and determines in which abnormality zone, if any, the data belong (e.g. “alert” or “alarm”).
Lead partner(s) (point of reference)	VTT
SERENA results and components involved	Included in 2. AICM - AI condition-based maintenance and planning system
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	Industrial companies both process and mobile machinery manufacturers
Exploitation channel(s)	publications, trade fairs, existing customer relations
Possible competitors	Other research organizations
Replicability in other domains and ecosystems	large variety of machinery in production and research.
Action plan / status	internal exploitation, utilization in commercial and jointly funded projects

3.1.15 Health Assessment

Asset title	Health Assessment
Description	Health Assessment (HA) block diagnoses any faults and rates the current health of the equipment or process, considering all state information.
Lead partner(s) (point of reference)	VTT
SERENA results and components involved	Included in 2. AICM - AI condition-based maintenance and planning system
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	Industrial companies both process and mobile machinery manufacturers
Exploitation channel(s)	publications, trade fairs, existing customer relations
Possible competitors	Other research organizations
Replicability in other domains and ecosystems	large variety of machinery in production and research.
Action plan / status	internal exploitation, utilization in commercial and jointly funded projects

3.1.16 Prognostic Assessment

Asset title	Prognostic Assessment
Description	Prognostic Assessment (PA) block determines future health states and failure modes based on the current health assessment and projected usage loads on the equipment and/or process, as well as remaining useful life predictions.
Lead partner(s) (point of reference)	VTT
SERENA results and components involved	Included in 2. AICM - AI condition-based maintenance and planning system
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	Industrial companies both process and mobile machinery manufacturers
Exploitation channel(s)	publications, trade fairs, existing customer relations
Possible competitors	Other research organizations
Replicability in other domains and ecosystems	large variety of machinery in production and research.
Action plan / status	internal exploitation, utilization in commercial and jointly funded projects

3.1.17 Advisory Generation

Asset title	Advisory Generation
Description	Advisory Generation (AG) block provides actionable information regarding maintenance or operational changes required to optimize the life of the process and/or equipment.
Lead partner(s) (point of reference)	VTT
SERENA results and components involved	Included in 2. AICM - AI condition-based maintenance and planning system

License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	Industrial companies both process and mobile machinery manufacturers
Exploitation channel(s)	publications, trade fairs, existing customer relations
Possible competitors	Other research organizations
Replicability in other domains and ecosystems	large variety of machinery in production and research.
Action plan / status	internal exploitation, utilization in commercial and jointly funded projects

3.1.18 SERENA Repository API (SRA), Sensor Data and Metadata Cloud Storage (SCS)

Asset title	SERENA Repository API (SRA), Sensor Data and Metadata Cloud Storage (SCS)
Description	The SERENA storage driver is a key asset that separates the SERENA subsystem component from the underlying storage implementation. SERENA uses container technology to encapsulate discrete parts of its functionality, such as databases and analytics engines. This makes the SERENA system highly dynamic, scalable, and resilient, as each subsystem can be implemented as a cluster of stateless clones. The state of the cluster is externalized from the cluster containers by means of the SERENA storage driver, which maps the container's storage state to virtual volumes, where individual data assets are represented as storage objects. The storage driver, and the underlying storage virtualization infrastructure, synchronise access to the storage objects. When the individual containers in the subsystem cluster change location of new containers are instantiated, the virtual volumes are made available to the containers at their new location.
Lead partner(s) (point of reference)	DELL
SERENA results and components involved	None at this time
License	Proprietary
Type(s) of asset	Demonstrator, Product
Relevant stakeholders	None at this time
Exploitation channel(s)	Through Dell's existing customer and partner channels
Possible competitors	Certain CSP vendors provide proprietary interfaces to their storage solutions, and this storage driver is intended to be a more accessible solution.
Replicability in other domains and ecosystems	The storage driver is intended to be a generic solution, rather than being tied to any one industry vertical.
Action plan / status	Not yet defined

3.1.19 3D Interactive technologies for Operator Maintenance Support

Asset title	3D Interactive technologies for Operator Maintenance Support
Description	Interactive 3D step by step maintenance procedures and visualization services to show information coming from the SERENA system as sensor data, metadata, results of analytic algorithms and predictive analysis. Available on Desktop, Mobile and Smart Glasses

Lead partner(s) (point of reference)	SynArea
SERENA results and components involved	3D models of machinery from partners, sensor data and analytics coming from SERENA platform.
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	Serena partners, manufacturing clients, machinery manufacturers
Exploitation channel(s)	Trade fairs, dissemination and communication events, existing customer relations, consulting.
Possible competitors	Other software companies in the field of VR/AR technologies.
Replicability in other domains and ecosystems	The technologies and methodologies adopted can be applied to a large variety of machinery, manufacturing systems and research.
Action plan / status	Dissemination, utilization in commercial and jointly funded projects, exploitation on customer request

3.2 Exploitable assets IPR

Asset title	Type(s) of asset	License
Remote factory condition monitoring and control	Service, Demonstrator	Proprietary
AI condition-based maintenance and planning systems	Service, Demonstrator	Proprietary
AR-based technologies for remote assistance and human operator support	Service, Demonstrator	Proprietary
Cloud-based platform for versatile remote diagnostics	Platform Demonstrator	Mixed
Pilot cell for versatile maintenance in White goods industry	Demonstrator	NA
Pilot cell for versatile maintenance in Elevators production industry	Demonstrator	Proprietary
Pilot cell for versatile maintenance in Metrological engineering industry	Demonstrator	Proprietary
Versatile maintenance in Steel parts production and link to other industries	Demonstrator	NA
Pilot on versatile maintenance for tool providers	Demonstrator	NA
Databox HW	Demonstrator	Proprietary
Universal data collection	Demonstrator	Proprietary
Data pre-processing and forwarding	Demonstrator	Proprietary
Edge Analytics	-	Proprietary
State Detection	Service, Demonstrator	Proprietary
Health Assessment	Service, Demonstrator	Proprietary
Prognostic Assessment	Service, Demonstrator	Proprietary
Advisory Generation	Service, Demonstrator	Proprietary
SERENA Repository API (SRA), Sensor Data and Metadata Cloud Storage (SCS)	Demonstrator, Product	Proprietary
3D Interactive technologies for Operator Maintenance Support	Service, Demonstrator	Proprietary

Table 3-2 The SERENA Exploitable Assets at Month 24

3.3 Market update and Competition Analysis

In this section we provide an update to the market, trends and needs analysis relevant for the SERENA Exploitation, focusing (with respect to the analysis carried out in D7.2) on segments and trends which will be useful to develop the final SERENA business plan to be presented at M36.

3.3.1 Manufacturing and Digital Manufacturing Trends, Challenge and Needs

Latest analyses have shown a slowdown between 2018 and 2019 in Europe, mostly due to the slow-down of leading national economies such as Germany, Italy, and France. Indeed, the European Commission's May 2019 '*European Economic Forecast. Spring 2019'*[4] highlights a weakness in European manufacturing which has slowed down in 2018 largely due to an overall slowdown at global levels. The automotive sector is clearly one of the strongest indicators of the slowdown. It is interesting to note, that on the other hand the so-called 'service economy' has suffered less from the slowdown.

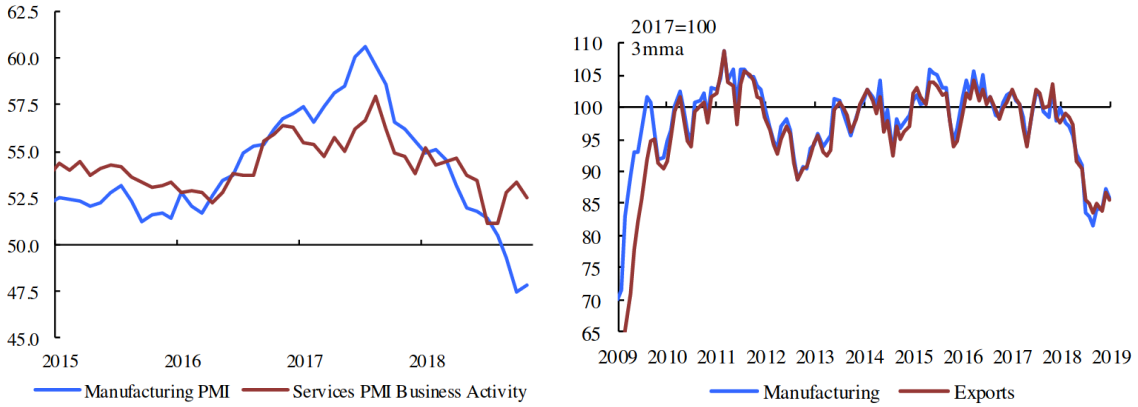

Figure 7: PMI of manufacturing vs. services (left) - Germany: volume of manufacturing and e exports of passenger cars (right) – source: European Commission

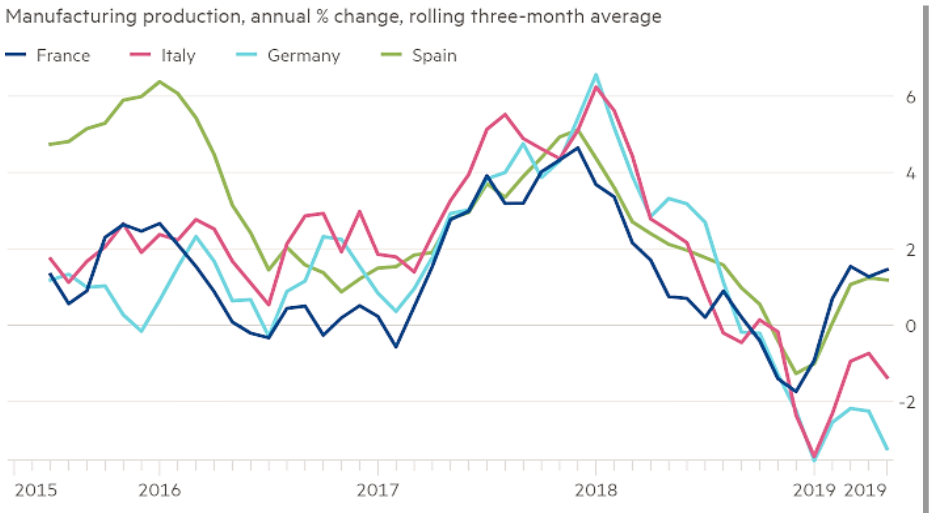

Figure 8: Manufacturing production % change, 3-month average – source: © Refinery

This means that there is an even stronger push for competitiveness and innovation for manufacturing companies to maintain a position in the market or, in certain cases, even to 'survive'. At the same

[4] https://ec.europa.eu/info/sites/info/files/economy-finance/ip102_en.pdf

times it shows that services can be more resilient. While at the moment of writing it is hard to understand what the trends in manufacturing will be in the mid-short term, there are a set of trends and take-aways which are relevant for SERENA. Definitely, manufacturing still remains one of the economic backbones of Europe, and the capability to innovate and provide new services is key for both manufacturing enterprises *and* related stakeholders (such as supply chain and technology services).

Key trends in European and Global Manufacturing

- **Predictive Maintenance can keep production under control and competitive.** A survey among manufacturing companies showed that 98% organisations believe that 1-hour downtime can cost up to $ 100,000. McKinsey & Co. believe that on the other hand predictive maintenance could reduce costs of 20% and outages of 50%. This trend is clearly very relevant for SERENA (see also specific focus below).
- **Ever increasing relevance of IoT and smart connected devices**. 63% of manufacturers believe that IoT can increase profitability. Investments in IoT are forecast to reach $267 billion by 2020. Currently about one third (31%) production processes and equipment and non-production processes and equipment (30%) already incorporate some kind of smart device/embedded intelligence (source: MPI Group). Similar percentages of manufacturers have a company strategy implemented or in place to apply IoT technologies to their processes (34%) or to embed IoT technologies into products (32%).

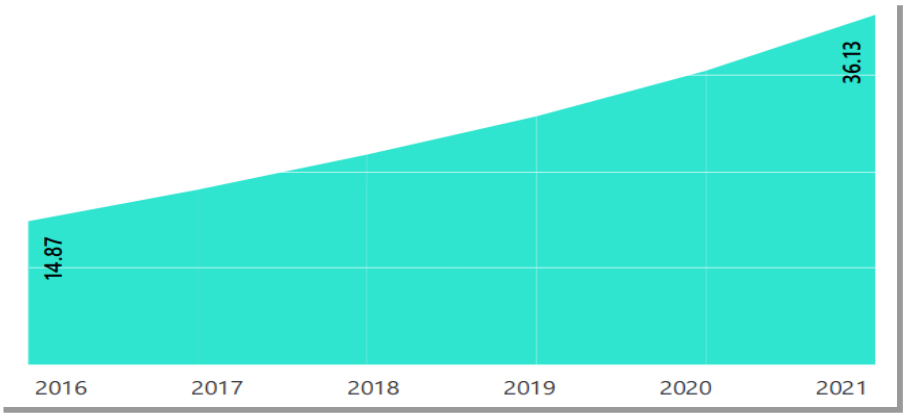

Figure 9: Number of IoT connections worldwide (forecast in billions) – source: © Microsoft

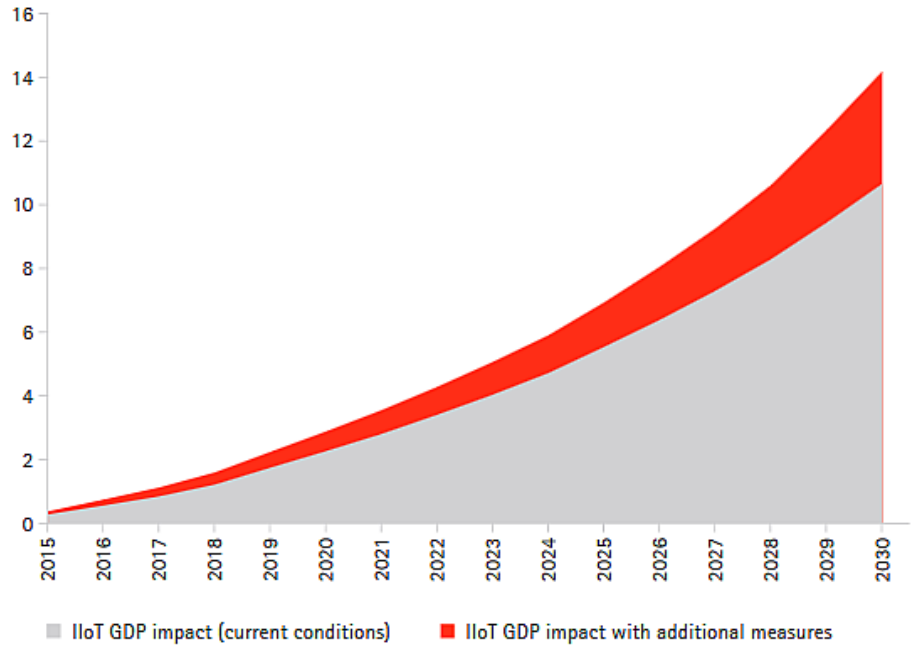

Figure 10: Cumulative GDP impact of IoT (US$ trillion) – Source: © Accenture and Frontier Economics

- ***Industrial production up in Europe.*** In 2017 EU28 industrial production was up by 3.3% and **manufacturing expanded by 3.6%**. Top three manufacturing performers in 2017 were Romania (+10.0%), Slovenia (+8.7%), and Latvia (8.2%) (source: EEF)
- ***Digital Transformation still a challenge for the manufacturing sector.*** According to PwC analysts in 2018 just 10% percent of global manufacturing companies are 'Digital Champions', while almost two-thirds have barely or not yet initiated a digital transformation process. While automotive and electronics industries lead the digitization process, industrial manufacturing is still lagging. From a geographic perspective, Asia is leading the transformation.
- ***Data-driven intelligence.*** Analysts foresee a growth and consolidation of predictive analytics in manufacturing, which in recent years has still seen mixed results due to the challenges posed by increasing volumes, velocity and variety of product, operational and customer data. But as manufacturing (and industry in general) is digitised, algorithms can provide efficiency, for example by improving accuracy, time, and materials use.
- ***Potential impact of GDPR.*** As manufacturers increasingly adopt Big Data, GDPR poses data management challenges. Company have employees, suppliers and customers and must therefore comply with the regulation. Additionally, companies which ship or sell directly to customers or use personalized and targeted marketing also have to comply. The first challenge is to assess what data they have and to move quickly to be compliant and factor in related costs.

> Focus: The Machinery and Equipment Manufacturing segment

The global industrial machinery manufacturing market was valued at around $115 billion in 2017. North America was the largest region in the industrial machinery manufacturing market in 2017, accounting for under 33% market share (source: Business research company). Indeed 2017 was the first positive year in this segment since 2011. Returned business confidence in Europe showed two-year highs similarly to as does US industrial production. Global trade growth of +6.8% and USD weakness is forecast to will support activity because 50% of machinery exports happen in USD (source: Euler Hermes).

The general industrial slowdown of 2019 has mitigated growth expectations we had presented in the previous D7.2. Indeed 2019 has been a tough year for machine manufacturers: overall global machine production revenue is growing at a CAGR of 2.1% percent from 2017, reaching $1.6 trillion in 2022.

While year-over-year Euro-zone machine production revenues are expected to contract slightly by 0.4% in 2019 the Asia-Pacific region will grow slowly (especially due to growth slow-down in China). The machine tools category comprises 5.7 percent of all global machinery production revenue in 2019.

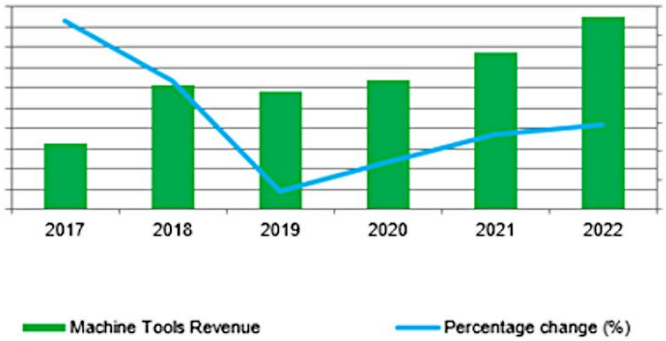

Figure 11: Total machine tools production revenues and growth rates 2017-2022 – Source: © IHS Markit

The largest downstream industries in the machine tool sector remain automotive, with 25 percent of revenues, and consumer electronics, with 16 percent.
Geographically, while the Asia Pacific area produces alone nearly 50% of the production (2016 data, source: HIS Market), Europe follows with 29.3%. In Europe the strongest country is Germany which also accounts as the second exporter and third importer. European countries such as Germany and Italy are also considered to be (together with China and Japan) top competitors for the US market (source: SelectUSA).

This segment is one of the possibly most impacted by Industrie 4.0: in fact, A BCG study predicted a productivity increase of 13-16 B€ within 10 years just for Germany, if the full potential of connected industry "Industry 4.0" is implemented throughout the sector value chain.

> Focus: White Goods segment

Revenue in the Household Appliances segment will hit $19,5 billion in 2019 and expected to show an annual growth rate (CAGR 2019-2023) of 9.9%, resulting in a market volume of US$28,5 Billion by 2023 (source Statista). User penetration of these products is forecast at 20.0% in 2018 and expected to hit 24.1% by 2022. Average revenue per user (ARPU) currently amounts to €130.97. From a geographical perspective highest revenue is being generated in China (€23,8 billion in 2018).

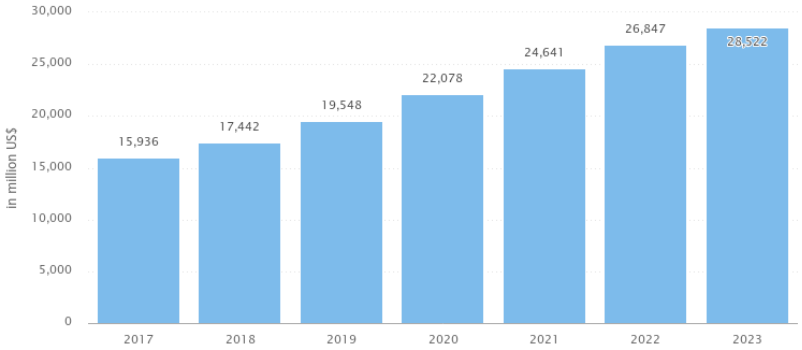

Figure 12: Household market revenue 2017-2023 – source: © Statista

Global consumption value of household appliances from 2013 to 2020 will grow from $428.17 billion in 21013 to $588.83 billion in 2020. A growing trend within this market is the within the home

appliance industry is the 'smart appliance' market. Washing machines, refrigerators and air-conditioners are projected as the main appliance categories within the smart appliances market worldwide.

> Predictive Maintenance

Recent market analyses confirm the strong growing trend for predictive maintenance outlined previously. According to a 2019 market report by ReportBuyer, global Predictive Maintenance Market size is expected to reach $12.7 billion by 2025, rising at a market growth of 28.4% CAGR during the forecast period. Some of the current trends within the market (as reported by IoT Analytics)[5] are:

- **Cost avoidance**. Predictive Maintenance initiatives can provide 10-50% reduction in maintenance costs. An estimated $17B were saved by organizations worldwide in 2018 alone, thanks to new, sophisticated Predictive Maintenance programs.
- The **number of Predictive Maintenance vendors** has doubled in 2 years
- **Maturing market**. While most project are still in pilot and research stage, many projects are starting to scale – some companies are now performing Predictive Maintenance on 100k+ assets. This trend in particular seems very relevant for SERENA given its project timing and potential to push forward within a market which is maturing but still open.
- **Increasing role of analytics**. Sophisticated analytics (paired with advances in AI) are becoming more and more important and make up a larger share of the overall predictive maintenance market segment.
- **More focus on people**. As the market and solutions are getting more mature implementation challenges have shifted from being data model-related to data quality and people-related. For instance, how can workers adapt to- and optimize their flows to predictive maintenance.

> Big Data and Data Analytics market

Big Data represents an endless flow of information, result of a globalized, digitalized, and connected society. Platforms we use daily such as Social Networks (Facebook, Twitter, LinkedIn, etc.), international organizations and non-governmental organizations, research centres, public and private databases, open datasets, and many other actors feed a huge daily data stream.

Various market studies set the Big Data global market value forecast for 2025 in the range $150 to $200 Billion. More specifically Visual analytics market alone is expected to grow $5.7 Billion by 2025 (from $ 2.2 Billion in 2017 – source: BusinessWire). This growth is driven by increasing penetration of Big Data in analytics services and the availability of affordable Big Data solution and services to end users.

An IDC study about "Worldwide Semi-annual Big Data and Analytics Spending Guide"[6] directed in 53 Countries out of 19 sectors, shows that organizations confirm that the data collections and analysis play an important role within the digital transformation strategies of European companies, especially those in Western Europe. Public and private investment in Big Data and Business Analytics reached $34.1 billion in 2017 and the annual growth rate is expected to increase of 9.2% by 2020.[7]

Geographically, the Global Big Data Market[8] (**Figure 13**) has been split among North America, Latin America, Asia Pacific, Middle East & Africa, and Europe. The growing number of Internet users in North America and in Europe and the unstoppable Internet penetration has been driving the Big Data market across the region. Several end users, such as financial institutions, the retail market, healthcare sector, the media industry, and the governments, are turning their attention towards big data to understand the vast amount of data generated by Internet users in a meaningful manner.

[5] See https://iot-analytics.com/numbers-of-predictive-maintenance-vendors-surges/
[6] See e.g. http://www.idc.com/getdoc.jsp?containerId=IDC_P33195
[7] See e.g. http://www.ictbusiness.it/cont/news/banche-manifattura-e-servizi-spingono-il-treno-dei-big-data/39101/1.html#.WOeaBoVOJu0
[8] See e.g. http://www.grandviewresearch.com/industry-analysis/big-data-industry

Emerging countries of Asia Pacific such as Japan, China, and India are projected to offer remarkable opportunities in the market. The thriving businesses in these countries will encourage the constructive usage of Big Data in the coming years. Instead, The Middle East & Africa seem to stay behind the rest of the world without increasing the item of expenditure on enabling internet technologies both now and in the next years.

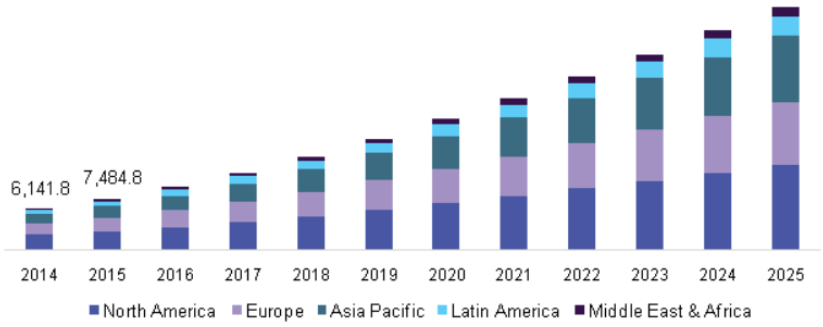

Figure 13: The Global Big Data Market, 2014 – 2025 (USD Million)

> Big Data in Manufacturing controls ca. 18% market share in terms of revenue in Global Big Data market. It is expected to become sixth largest industry in terms of its market share position in 2020. The goal of Big Data in Global Manufacturing Market is to allow operations managers to use advanced analytics in order to look into historical process data, identify patterns and relationships among process steps and inputs, and then optimize the factors that prove to have the greatest effect on yield. Many global manufacturers in a range of industries and geographies now have an abundance of real-time shop-floor data and the capability to conduct such sophisticated statistical assessments. They are taking previously isolated data sets, aggregating them, and analysing them to reveal important insights. The global Big Data analytics in manufacturing industry market is expected to register a CAGR of 38.62 %, from 2018 to 2023. As shown in Figure 13, in the next years manufacturing industry will be one of the most dynamic sectors in Big Data investments considering the information ownership an essential element of competitive differentiation.

Addressing the European Digital Market

The European Data Market study (elaborated by IDC under an EC contract), elaborated three main growth scenarios for the Data Economy in 2020:

- *A Baseline scenario was developed first, with the main assumptions based on the continuation of current growth trends and evolution of current framework conditions;*
- *A High Growth Scenario, where the data market enters a faster growth trajectory, thanks to more favourable framework conditions;*
- *A Challenge Scenario, where the data market grows more slowly than in the Baseline scenario, because of less favourable framework conditions and a less positive macroeconomic context.*

The Baseline scenario shows a considerable growth of the market in all its aspects:

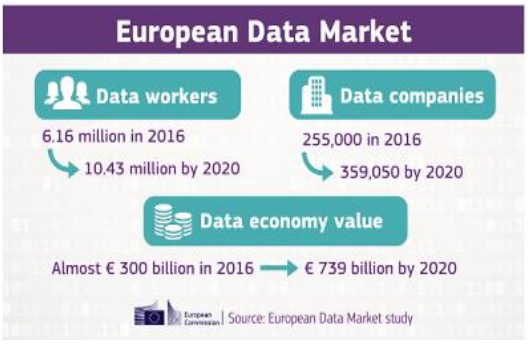

Figure 14 – European Data Market study – Source: European Commission

The study confirms the leading position of Manufacturing sector among the possible areas of development of the Data Economy. More details are available in the whole report, available at http://datalandscape.eu/ .

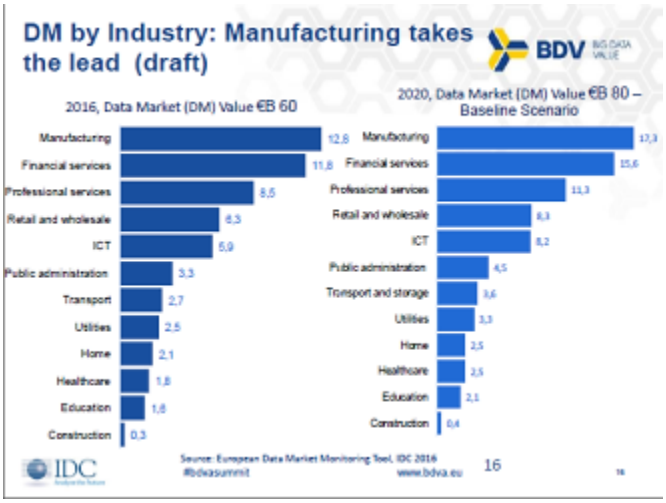

Figure 15 – Data Market by industry - Source: IDC / BDVA

Challenges in Digital Transformation within the Manufacturing sector

Today **manufacturers** virtually have huge amounts of data at their disposal, however making sense of such data and using it to improve processes, business is the real challenge. On the one hand there are a series of **technological and technical problems** ranging from mere data volumes, infrastructure update, data standards and formats, which manufacturers need to address; on the other hand, even once the data is actually acquired in a smooth manner, useful insights, trends, and monitoring events need to be **extracted** from the high volumes of data flowing into systems. Therefore, the key **business *and* technical need** is to apply the right (algorithmic) processes to derive insights along the whole 'data chain', from the shop floor to the (not necessarily technical) user's device.

In particular, the current scenario is that **companies still need to clearly grasp the actual business benefits of 'Digital Manufacturing'**. A recent study about implementation of Digital Manufacturing conducted by McKinsey[9] reported that while most manufacturers consider Digital Manufacturing a top priority at the same time only 30% of organisations actually rolled out company-wide solutions showing that real-world implementation is still challenging.

[9] A. Behrendt et. al. *Digital manufacturing—escaping pilot purgatory*, McKinsey, July 2018, https://www.mckinsey.com/~/media/mckinsey/business%20functions/operations/our%20insights/how%20digital%20manufacturing%20can%20escape%20pilot%20purgatory/digital-manufacturing-escaping-pilot-purgatory.ashx

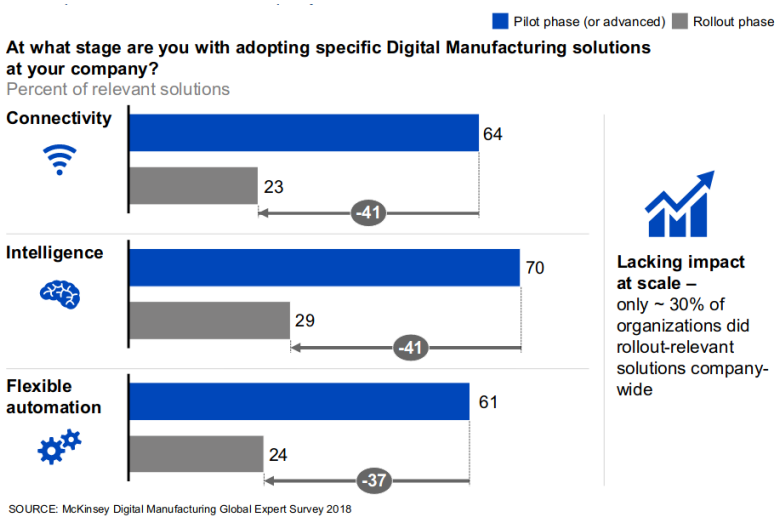

Figure 16 – Only 30% of manufacturing companies surveyed actually rolled out Digital Manufacturing (Source: McKinsey)

The **blockers towards actual adoption** and push are various but mainly boil down to technical/infrastructural, organisational/competence and vision/management. From our **business design perspective** while the latter is out of scope, a solution such as the SERENA can respond to the former two. From a **technical** point of view SERENA aims at 10% increased in-service efficiency through reduced failures rates, downtime due to repair, unplanned plant/production system outages and extension of component life. From the organisational and competence points of view SERENA will allow to enable easy-to-use interfaces for managing data and providing human operator support for machines status and maintenance guidance using AR devices, essentially shifting the perception of 'digital manufacturing' in both industry and workers.

3.3.2 Initial Competition Analysis: Predictive Maintenance solutions

In this section we analyse three leading market players in the Predictive Maintenance landscape, as this is the reference segment for SERENA. In the final version of the SERENA exploitation we will add a competition matrix within the outline of a more articulate business plan blueprint.

3.3.2.1 GE Predix

Company: General Electric
Website: https://www.ge.com/digital/iiot-platform

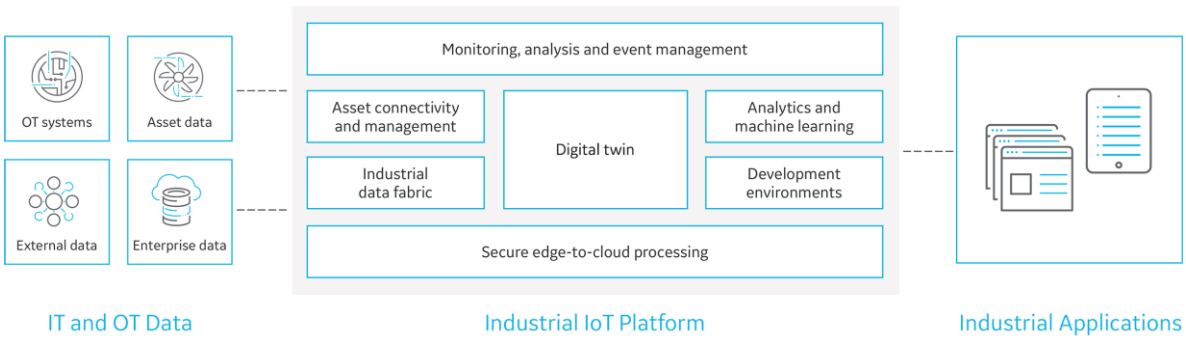

Figure 17 – Predix Platform (Source: General Electric)

Predix is also a broader data collection and analysis cloud platform aimed at different industries with a strong focus on IoT. Predix is built on top of Cloud Foundry open source platform (www.cloudfoundry.org) using the concept of microservices and Apps.

In the **predictive maintenance** and towards manufacturing in particular Predix offers to provide an 'asset-centric' platform for all types of data management. It can supply analytics for anomaly detection, predictive maintenance, prescriptive controls, and others. It also aims to provide a rich analytics library and framework to create or import machine learning analytics being aimed at a developer ecosystem. Its focus on security and industrial applications

3.3.2.1.1 Main services and offering

- asset connectivity
- edge technologies
- analytics and machine learning
- big data processing
- and asset-centric digital twins

3.3.2.1.2 Value Proposition

- Enable digital transformation
- Managing high volumes of different data
- Improve Performance (OTP)
- Protect revenue and reduce disruption impact of outages
- Data Security

3.3.2.1.3 Partners

GE offers a GE Digital Alliance Program for companies interested in using Predix.

3.3.2.2 MachineSense

Company: MachineSense
Website: https://machinesense.com/

Figure 18 – MachineSense (Source: MachineSense)

MachineSense specialises in sensors and related technology which monitors condition and leverages on cloud-based software. It uses Siemens MindSphere (https://new.siemens.com/it/it/prodotti/software/mindsphere.html). "MachineSense is a disruptive technology company with strong roots in the machinery and manufacturing sector. Our affordable technology features our patent pending SignaGuardTM vibration and power signature monitoring and analytics to help with predictive maintenance for industrial machinery, components, and systems. MachineSense uses flexible models, proven diagnostic instruments, sophisticated software and unmatchted analytic expertise to deliver sustainable, scalable and cost-effective based maintenance

and monitoring programs that ensure industrial asset availability, helping to maximize runtime productivity and reduce total maintenance expense."

3.3.2.2.1 Main products and services and offering

- Vibration Signature Technology
- Electrical Signature Technology
- Wearable Sensors
- Customized Firmware
- WiFi and Ethernet enabled Datahubs
- Data Analytics (cloud, desktop, and mobile apps)

3.3.2.2.2 Value Proposition

- Manufacturing and machinery expertise
- Offer sensor hardware and data at economical price points previously unavailable in the industrial sector
- 24/7 online monitoring
- Data analytics

3.3.2.2.3 Partners

Siemens, Microsoft, and other technology providers.

3.3.2.3 Seebo

Company: Seebo
Website: https://www.seebo.com

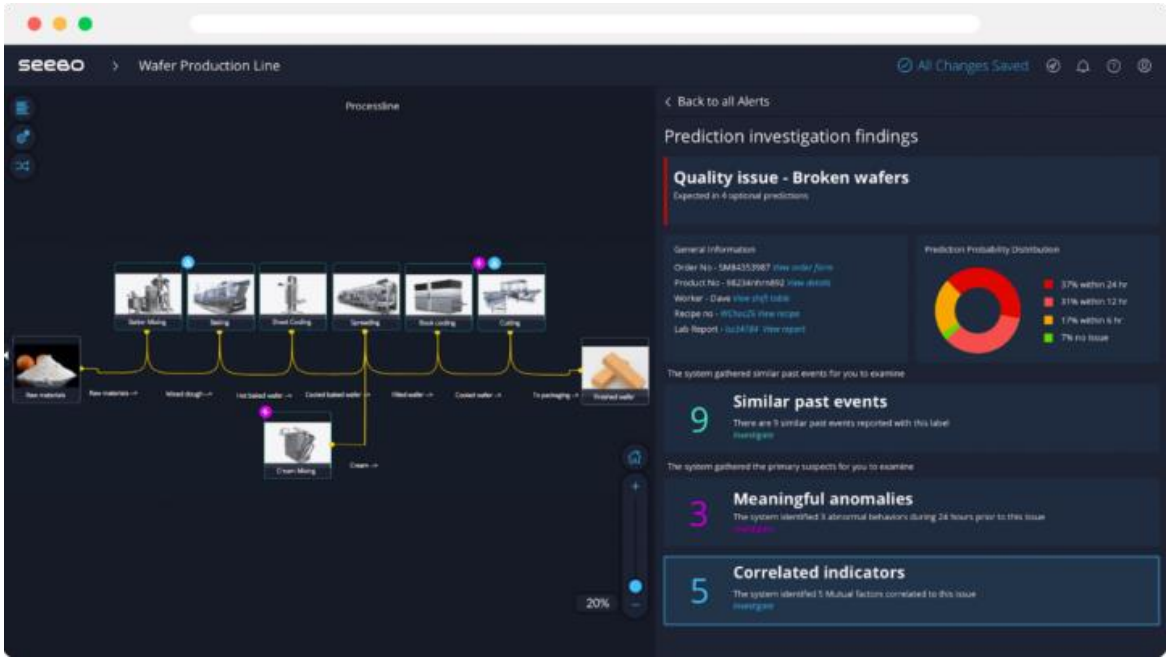

Figure 19 – Seebo Predictive Maintenance solution (MachineSense (Source: Seebo)

Seebo specialises in "Process-Based Industrial Artificial Intelligence" and includes a Predictive maintenance solution within its offer, powered by its own IoT solution. It addresses both OEMs and factories and promises fast delivery and implementation.

3.3.2.3.1 Main products and services and offering

- Seebo Predictive Maintenance platform
- IoT Modelling
- Simulation
- Predictive Analytics
- Digital Twin Prototype
- Predictive Maintenance Dashboards
- Data Acquisition

3.3.2.3.2 Value Proposition

- Reduce unplanned downtime
- Boost Overall Equipment Effectiveness
- Maximize throughput
- Reduce defects
- Reduce time-to-repair and cost-to-repair
- Data Security

3.3.2.3.3 Partners

Microsoft, Autodesk, SAP, Dassault Systems, and other technology providers

3.4 Update of SERENA SWOT Analysis

S - Strengths	W - Weaknesses
• SERENA results piloted validated by important industrial players in the market • Addressing a key sector in Europe and key challenges, i.e. maintenance and services • Enable to reduce downtime and save maintenance costs • Ability to mobilize important communities (Industrie 4.0, EFFRA, AIOTI, etc.) • Strong alignment to EU strategies, policies, and challenges • Great expertise in the consortium in the domain of innovation and manufacturing with some partners leaders in their sector • Top rank Business and Research partners covering various European countries • Great transversal networking potential (partners, EU, other projects etc.) • Modular approach • Innovation philosophy and innovation-driven platform • Cooperation as evolution of competition • Strong Open Source mind-set	• Need to achieve convergence for several commercial technologies and strategies to avoid problems and complexity of integration • Lack of use cases that allow validation tests and that have additive manufacturing technologies • Potential immaturity of some components of the system • Partners may have different ambitions • Unclear positioning of the SERENA 'brand' • Difficulties in integration of components • Hard to address larger enterprises • Unfamiliar to potential 'customers' (reputation as business) • Leadership and management of SERENA assets
O - Opportunities	**T – Threats**
• Support and push the European manufacturing sector towards digitization • Allow the development and the increase of Industry4.0 • Innovate current industrial of standards for (predictive) maintenance • Support EU reshoring • Creation of a rich Business Ecosystem around SERENA • Consulting around SERENA expertise and services • Further Research and education • Address new domains for innovation • Assets exploitable as ‘stand-alone’ • Promote recommendations and best practices	• Emergence of competing solutions and/or ecosystems, especially in emerging markets like Asia • Manufacturers' hesitation to adopt ‘outsourced’ technologies • Lack of employee's skills and low adoption of standards • Lack of SERENA ecosystem to become sustainable during the project development • Reluctance to pay for innovative services • Possible competition in some of the technologies e.g. semantic web technologies • Retreat or loss of interest from partner(s) after the project period • IPR management • Similar projects/initiatives perceived as equivalent • Potential 'clients' not willing to accept certain paradigms such as predictive maintenance

SWOT Discussion

SERENA shows a clear plus by drawing together top rank partners from all over Europe and from both Industrial, Research and Business environments. In fact, SERENA has is carrying out research on

the services, methodologies and tools related to innovative predictive maintenance applications and paradigms in this sector: a set of activities which most companies do not perform in such an extensive manner.

Most partners are 'champions' in their sector and are involved in important initiatives (not only at technical level but also in policy making) and also have access to important stakeholders which could become customers of products and services related to SERENA. The inclusion in the partnership of industrial leaders at a global scale and the creation of internal value chains already within the project is a demonstration of this strength SERENA has and enabled by the international nature of the project.

True, even though all SERENA partners have very good reputations as individuals and are very active, SERENA is still unknown and will be a newcomer to the market. Nonetheless during the project, a set of important dissemination activities have started (see sections 2-4 above), and will be put forward, involving important organisations and companies outside the consortium. Additionally, as a counterbalancing strength the aims of SERENA and the tools it is developing are strongly in line with the policies and challenges identified by the EU and the strategies indicated to tackle such challenges in the manufacturing domain in Europe: indeed, SERENA has the capability to present itself to potential customers with a very strong 'European Seal'. As was discussed above, the manufacturing sector is still one of the economic 'backbones' of Europe, a fertile terrain for improvement and application innovation processes, activating collaboration and boosting successful product developments.

A possible weakness of SERENA (as for any research project) is that not all components may have the same maturity level by end of the project: indeed, this weakness could lead to SERENA being superseded by possible existing solutions which constitute a rather well established marked. To this end we consider maintaining the platform up and running as a free 'sandbox', so as to attract interested actors and so that it can be used to for demos and promotion purposes. Indeed, this weakness can actually be turned into an opportunity where, once the value proposition behind SERENA has been marketed to a potential client, partners will be able to offer value-added services in terms of further engineering, customisation etc. With SERENA assets being released as open source this will also enable to collect technical feedback and testing from a wide expert community contributing to the enhancement of the software.

Additionally, SERENA follows a modular and Service Oriented Architecture approach which gives it the opportunity to offer single assets (and related support services) and push different solutions towards different customers segments, keeping in mind the great networking potential the consortium has, from both a geographical and diversification point of view, opening up the opportunity to create various business and innovation/business ecosystems. Such approach is also well in line with the cloud and big data market trends we described above.

The strong innovation philosophy which partners in SERENA naturally have, provides many diversified consulting opportunities and the possibility to carry on further research. Of course there is a risk of partners losing interest for the project, or simply pursuing different paths once the project is over: this risk is mitigated by the aforementioned modularity of SERENA and the fact that the platform will be maintained alive, but also by certain strategies implemented, such as the release of certain components as Open Source, thus ensuring that even if a party leaves, its work can be taken up by another one and possibly be further developed, improved, customized.

3.5 Updates of individual partner's strategy for exploitation

3.5.1 COMAU S.p.A. (COMAU)

COMAU has already started implementing the entire SERENA system on its premises in order to evaluate each service and system capabilities. Our exploitation strategy is to gradually test SERENA system and integrate it more and more in COMAU processes with the purpose to merge some SERENA services with our company IIoT solution "In.Grid".

3.5.2 Finn-Power Oyj (Finn-Power)

Within the project exploitation strategy, Finn-Power presented SERENA results to international customers during the EuroBlech exhibition in Germany in October 2018. Additionally, SERENA project results have been demonstrated to both international and Finnish customers during the 2019 global sales meeting in Finland. Finally, SERENA results were utilized during the university-company collaboration at the Innovation Week 2019 organized by the Seinäjoki University of Applied Sciences in Finland. Finn-Power will continue the exploitation activities of project results as planned.

3.5.3 VDL Weweler BV (VDLWEW)

VDL Weweler is expecting to use the knowledge acquired through the SERENA project in its production process, including in particular the gateway and operator support aspects. The steel production process is a quite complex one with numerous parameters that can be potentially monitored and influence the product. Hence, the identification and isolation of the appropriate set of parameters is challenging. However, the SERENA system has been partially deployed in an existing production line capturing sensor data and the same approach has been already transferred to newly introduced equipment with new dataset already being acquired. In this context, the exploitation strategy needs to be discussed and defined with all involved partners and is expected to take place during the last year of the project and after the delivery of the project's full prototypes.

3.5.4 WHIRLPOOL EMEA SpA (WHEMEA)

WHR is confirming the Exploitation strategy as presented in D7.2. In particular, the first and most important result, despite intangible one, is being transferred to the company: the need of deploy sensors in the machine well in advance in respect of the need. In fact, in many factories the organization is not yet mature to implement predictive maintenance. This is also a prescription of WCM who is recommending the step of Proactive maintenance only when a solid organization, skillset and basic condition are established. But one of the main results of SERENA is related to the fact that in order to have a meaningful dataset for our processes, one-year data is mandatory: this require to anticipate FMECA and sensor and data design.

In addition, Whirlpool has started some collaboration with additional partners to extend knowledge and improve impact of predictive maintenance:

18. Partnership with the Equipment Supplier (Cannon-Afros) to install a prototype sensorized injection-head: this will generate a completely new dataflow regarding mechanical data of the cleaning piston.
19. Partnership with a Public Consortium: the 2-year long dataset generated by the Foaming Machine has been made available to some universities and ICT companies to test innovative algorithm and data visualization techniques on real production data.

3.5.5 Kone Industrial Ltd (KONE)

No relevant update. Please refer to D7.2.

3.5.6 Engineering Ingegneria Informatica S.p.A. (ENG)

In the last months ENG has been involved in pushing forward various technical aspects in SERENA as well as connecting to various communities (e.g. FIWARE) where SERENA was also presented. ENG still aims to operate within these strategic networks and initiatives, comprising leading industries, Future Internet initiatives, etc. where to further disseminate and promote SERENA. Additionally, ENG will continue to push, in a more focused manner, its offering in innovative solutions to its clients through SERENA, especially in the manufacturing domain. SERENA results are now more mature and in the next period ENG aims at assessing potential re-use and adaptation of the technologies developed in SERENA (e.g. Cloud-based platform for versatile remote diagnostics), internal pitching towards relevant business units and within the different research labs. Replicability in other domains (relevant to ENG business units) will also by analysed.

3.5.7 OCULAVIS GmbH (OCULAVIS)

No relevant update. Please refer to D7.2.

3.5.8 SynArea Consultants S.r.l. (SynArea)

SynArea also in 2019 has attended as exhibitor at the A&T trade fair in Turin, dedicated to innovation, technologies, and Industry 4.0. In particular, in collaboration with COMAU and PrimaPower companies, SERENA project partners, the intermediate results of the SERENA project have been exploited.
The COMAU RobotBox testbed used in the project was installed in our stand, showing all the system with the real-time position, sensor data and predictive analisys visualisation services applied to the 3D model.
Moreover, the first VR/AR interactive procedure of the PrimaPower laser cutting head was presented, both in Windows, Android and on the Microsoft Hololens smartglass.
SynArea also disseminated the SERENA's results both to its customers and during the trade fair.
At last but not least, SynArea has contributed to the realization of some papers presented at international conferences and workshops (DARLI-AP 2019, KET4DF 2019, Springer Computing).

3.5.9 DELL EMC (DELL EMC)

Dell has been hosting the SERENA use cases on its infinite IIoT testbed for several quarters and has gained significant inside into how to build and operate a fully containerised machine learning platform for the manufacturing industry. Whilst Dell has a great deal of analytic platforms, the industrial use cases for Factory of the Future provide new challenges. The main exploitation focus has been around the externalization of Docker storage, to provide a resilient and scalable solution, based on Dell products, which are currently under development. The development and exploitation of the Docker storage solution is still in its early stages, and this whole area is currently very fluid, but we hope to see progress in the coming months. As mentioned in COMAU's exploitation strategy, they are in the process of building their own internal deployment, and Dell has been assisting them in this work, with both technical knowledge and equipment, such as commercially available IoT gateways.

3.5.10 Laboratory for Manufacturing Systems & Automation (LMS)

LMS is responsible of the development of the scheduling component within its activities in WP3 as well as its integration with the required SERENA systems to support the implemented workflow in the

context of the developments as well as the final demonstrators. As such, the scheduling tool includes both background and foreground knowledge.
Different strategies maybe adopted on a case-by-case basis, and there is no specific restriction on any exploitation strategy. However, as a university, LMS targets primarily on knowledge acquisition that will be incorporated in educational courses, undergraduate and postgraduate.
Furthermore, the experience from the SERENA developments is expected to enrich the R&D consultation capabilities of LMS, to several national and European industrial partners. The output of the project will serve as the basis of future research and development activities as well as potential future launch of R&D projects in collaboration with existing and/or similar organisations.

3.5.11 Fraunhofer Gesellschaft zur Förderung der angewandten Forschung (IPT)

The exploitation activities of the SERENA results at IPT are mainly focused on our project partners from other research projects and industrial projects. As SERENA fits into IPTs overall activities of industrial production process digitalization, its results can be reused in this context. Especially components like the Databox have already been used in the research field of in-process data acquisition. Also, the software containerization mechanism using the Docker environment has been used in a project for the automatization of laboratory equipment.

3.5.12 VTT Technical Research Centre of Finland Ltd (VTT)

***Contribution* to the project**

• In WP1, VTT will define requirements identifications for remote factory condition monitoring and control and AI condition-based maintenance.
• In WP2, VTT will participate for design of versatile framework for factory condition monitoring, multi-level sensing and machine data matching and monitoring and control framework implementation.
• In WP3, VTT will improve existing solutions for predictive maintenance regarding data analytics algorithms.
• In WP4, related to task 4.2 “Applications development enabling augmented reality tracking and recognition”, we will provide ALVAR tracking library to be used in the pilot cases, where needed. The ALVAR provides visual tracking using either point clouds or marker setups. It can be used in Unity applications using our ALVAR for Unity library.
• In WP6, VTT will participate for demonstrators’ realization
• In WP7, VTT will influence impact creation together with other participants

***Involvement* and return expected**

The VTT project goal is to produce new services for European market for improving product(s) lifetime and optimize the lifecycle, by developing and taking advantage of the predictive maintenance strategy. Product maintenance related innovations expand companies’ business opportunities by gaining considerable cost savings in maintenance due to the reliability, availability, and safety of products. The gained benefits include operational optimization in terms of process/operation efficiency and waste reduction and increased Overall Equipment Effectiveness. Predictive maintenance knowledge, domain understanding, and data-analytics will be transferred to the products through knowledge and technology transfer. The actual technology e.g. sensor investment costs are reasonable compared to the gained business profit by companies. VTT will help companies to exploit new services by arranging public workshops, seminars within the value chain actors. In addition, results will be published in conferences and scientific articles, including dissemination through web for increasing impact and credibility. We also expect to learn more what kind of tracking solutions or AR applications are needed by the industry. We expect to reach deeper understanding what are the practical limitations of said technologies in real environments. We hope to recognize the areas where visual AR tracking technologies could be used in practice and where they could give the end users

some added value. If some good focus application areas are recognized, we hope to see some future commercial projects where those ideas could be put to practice. If all goes well there is also a possibility for license revenue.

***Potential* risks identified**

The most important risks are related to the following:

• Data-analytics solutions are case-specific and require customization in every use case, which means that resource adequacy, is one of the biggest challenges

• The quality of the data in terms of its sufficiency, reliability, and comprehensiveness

• Prognostic predictability regarding the RUL

• All visual AR tracking solutions are vulnerable to changing environments and typical industry environments can change quite much each day even during a normal use. It might be the case that the areas where AR could be useful, might also be the areas which are too difficult to handle using visual tracking solutions. Tracking robustness can be increased using visual markers in the environment, but in some situations this approach might be too cumbersome and there might be some practical limitations for their use.

***Strategic* future commitment**

VTT Technical Research Centre of Finland Ltd is one of the leading researches and technology organizations in Europe. Our research and innovation services give our partners, both private and public, all over the world a competitive edge. We pave the way for the future by developing new smart technologies, profitable solutions, and innovation services. We have an excellent combination of the understanding of the selected applications through lifecycle from system level to phenomena (e.g. wear and fatigue) in the field of predictive maintenance and data-driven data analysis.

All key European and Finnish research communities are strongly connected to the international research community with the previous European ITEA, Artemis and ECSEL projects which have succeeded in making use of internationally recognized results to apply for information and communication technology research in production environments. Those involved in the project industrial partners come from different industries from SMEs to large companies. In addition, most industries and SME partners operate globally on comparable products and services in international markets. VTT has networked ITEA, Artemis, ECSEL, EFNMS, ESReDA, GOST, SPIRE and H2020 in communities, knowledge has been developed and will be developed, among others Arrowhead http://www.arrowhead.eu, Mantis http://www.mantis-project.eu/, Productive4.0 https://productive40.eu/ and MORSE https://www.spire2030.eu/morse projects.

3.5.13 TRIMEK S.A. (TRIMEK)

No major update. Please refer to D7.2.

3.5.14 Politecnico Di Torino (POLITO)

Contribution to the project

Polito contributes to the SERENA project by providing the design, development, and experimental evaluation of a data-analysis pipeline constituting a scalable, versatile, and effective predictive platform.

The proposed approach represents a key asset of the project outcomes by being

9. tightly coupled with SERENA industrial requirements and use cases,
10. based on state-of-the-art Big Data technological solutions, and
11. able to address the needs of modern smart-manufacturing industries.

Involvement and return expected

Polito, as a research university with deep and long-standing relationships with the industrial ecosystem, is already exploiting SERENA outcomes to further enhance its impact on society, both in quality and in quantity.

The additional know-how acquired during the execution of cutting-edge research activities in predictive maintenance within the SERENA project is leading to an increase in **impact quality**: the acquired know-how has strengthened collaborations with industries and generated impact in real-world challenges, which indirectly benefit the society at large by providing lower maintenance costs, better products and services, reduced wasting and polluting emissions.

New contacts and interest in opening collaborations with diverse industrial and academic partners is currently driving the **impact quantity** improvement. Widening our network of scientific and business relationships is indeed a cornerstone of our technology-transfer mission.

Furthermore, Polito is exploiting SERENA outcomes to (i) reach premier venues of scientific publications, both international conferences and peer-reviewed journals, and (ii) introduce updated content in under-graduate and post-graduate university courses, hence leading to better prepared engineers and post-doc researchers for the society. Specifically, the following activities have been performed in the last year:

4. 4 papers published in peer-reviewed international conferences
5. 2 joint papers (with some SERENE partners) published in peer-reviewed international workshops
6. 1 best paper award
7. 1 book chapter in the volume “La Fabbrica del Futuro”
8. 1 talk to ASP (Alta Scuola Politenica), a top-level multi-university graduate curriculum
9. 1 seminar to small and medium-sized enterprises
10. 1 seminar in undergraduate courses
11. 1 seminar in Phd courses

Potential risks identified

Polito mainly identifies a class of risks stemming from the different mindsets between academia and industry. Such difference might lead to high-quality theoretical solutions that do not fit the real-world industrial use cases, not only in terms of explicit performance (i.e., performance KPI of the predictive maintenance, such as failure recall), but also in terms of implicit requirements, such as flexibility, availability, and scalability of the SERENA solutions with legacy systems.

Polito is committed to mitigate such risks by leveraging its strong expertise in industrial collaborations, by iteratively sharing its intermediate results with industrial partners within the SERENA project in an agile fashion, and by being actively involved in the development of demonstrators within the proposed use cases. Such tight collaboration with industrial partners is crucial to reach high-impact solutions, fitting real-world problems and able to generate the most widespread benefits for society.

Strategic future commitment

Polito envision a future rich of post-project initiatives including joint applied research contracts with both current partners and new stakeholders. Research contracts with industries are foreseen thanks to the newly acquired knowledge. The current evidence of great interest in predictive maintenance for all industries at large also provides motivation to set the basis for the founding of new spin-offs and start-up companies in the field, besides possible patent registrations.

4 Conclusion

Purpose of this document is to provide an update on the dissemination, communication and exploitation activities undertaken during the second year of the SERENA project lifetime and on the basis of the dissemination and exploitation plans presented in the previous deliverable D7.2.

Moving to the final year of the project, the developments are expected to be finalised and gradually be deployed and tested at the premises of the SERENA end-users. Hence, the focus during the final year will be the exploitation activities, the identification of technical gaps in the SERENA system and the IPR management within the SERENA consortium.

The final version of the dissemination and exploitation activities including efforts towards standardization will be included in the final deliverable D7.4 to be compiled by the end of the project.