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 - Final version
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Summary:

The purpose of this document is to summarize activities on the dissemination and exploitation of the SERENA project obtained in the final one and a half year of its lifetime. Additionally, it includes information about the project's as well as individual partners' strategies for dissemination, exploitation and communication. Furthermore, activities related to standardization and open data are included.

Contents

List of Abbreviations

CA	Consortium Agreement
DoA	Description of Action
GA	Grant Agreement
PdM	Predictive Maintenance
ROI	Return On Interest
S&T	Scientific and Technical
SME	Small and Medium Sized Enterprise
SWOT	Strengths Weaknesses Opportunities and

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Executive Summary

The 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 30/09/2019 to 31/03/2021:

- T7.2: Academic and industrial dissemination
- T7.3: Exploitation activities: Roadmap, implementation and IPR management
- T7.4: Standardization – proposals, roadmap and activities

The main results are the following:

- Update on the dissemination activities undertaken since D7.3
- SERENA audiences' statistics through the project social accounts and portal
- News on the SERENA participation in ForeSee cluster of projects about predictive maintenance
- Updated Assets for the project including the IPR situation
- Assets maintenance and accessibility
- Updated Market analysis
- Evaluation towards commercial exploitation
- Update of Competition Analysis
- Updated SWOT analysis
- Updated SERENA partners Individual Exploitation Plans
- Standardization activities in SERENA
- Update regarding open access datasets

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 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 D7.3 as it regards the **joint and individual** partners' exploitation strategy.

In **Section 4**, activities related to **Standardization** are reported and followed by a brief update about the SERENA **open-access** datasets in **Section 5**.

Annex I presents the final ***IPR and Ownership Identification Agreement*** agreed by the end of the project by all SERENA partners which detail ownership of all SERENA Exploitable Assets, licenses and how co-ownerships are managed.

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, as well as material corresponding to the progress of the project. Access to the public and private web portal is provided by the following link:

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

The SERENA public portal has been updated, in the period from M28, with a new slider on the front page, to make the portal more attractive to the visitor, providing, at the same time, some of the results and necessary information regarding the concept of the project (Figure 1).

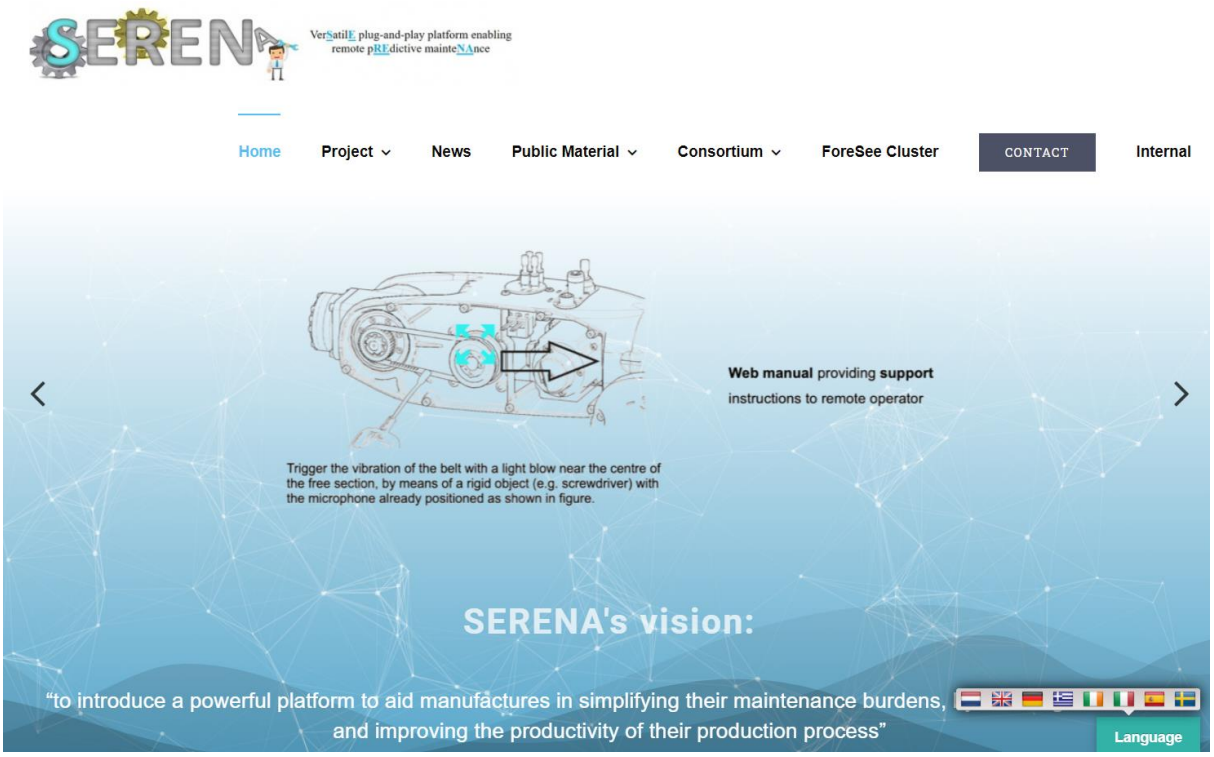


Figure 1: New slider in the front page of the SERENA public portal

SERENA portal activity (01/10/2019 – 31/03/2021)

Google Analytics has been used to monitor the activity in SERENA public portal[1]. Using Google Analytics, the following numbers (Table 1) have been recorded (Figure 2):

Performance measure	Value	Difference from D7.3
Sessions	4.441	+2,149
Users	3.304	+1,696
Pageviews	7.389	+3,146
Avg. Session Duration	1 min.16sec	-5sec
Bounce Rate	74.53	+4.11%
New visitors	3.288	+1,692

No	*Country*	*Users*	
-	United States	1.330	40.06%
-	Italy	210	6.33%
-	Greece	206	6.20%
-	China	178	5.36%
-	Germany	143	4.31%
-	Spain	99	2.98%
-	Finland	95	2.86%
-	France	95	2.86%
-	India	87	2.62%
-	United Kingdom	66	1.99%

Table 1: SERENA public portal analytics

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

2.2 Web 2.0 – Social media

SERENA holds a presence in social media and more specifically in Facebook and Twitter (Figure 3, Figure 4). These media are mainly used to promote SERENA activities, as well as to create awareness of the SERENA project through the publication of relevant news and activities from all around the world. In the following table (Table 2), the updated activity in the SERENA social media accounts is presented along with the difference from the period covered in D7.3.

[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.

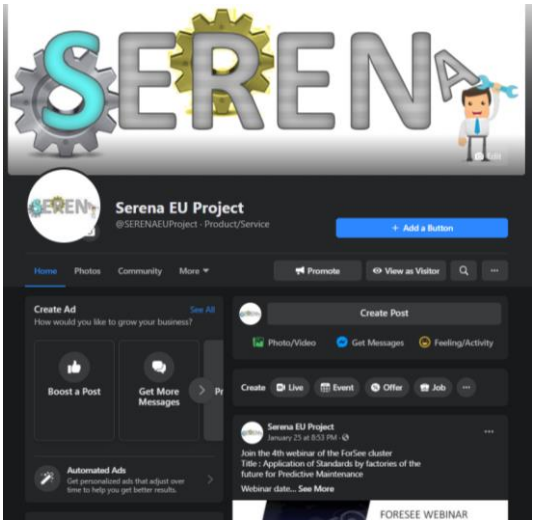


Figure 3: SERENA on Facebook

Figure 4: SERENA on Twitter

SERENA social media activity (01/10/2019 – 31/03/2021)

Performance measure		Value	Difference from D7.3
Facebook	Total Followers	64	+7
	Total Likes	59	+6
Twitter	Tweets	24	+9
	Following	29	+2
	Followers	142	+43

Table 2: SERENA social media statistics

Furthermore, the average number of people who reached each post of SERENA is presented in the below image (Figure 5). The average number has been calculated for the posts that include image or link. The calculation refers to the period from 2017 to 2021.

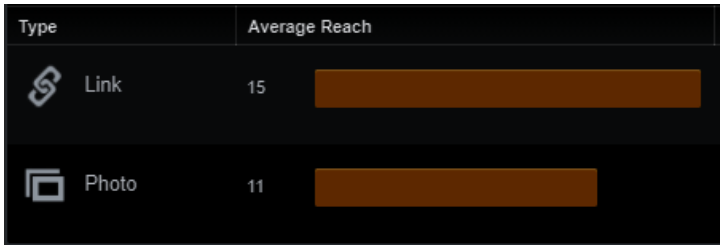


Figure 5: Average reach per post

2.3 Communication Material

The SERENA project newsletters are yearly released, providing its readers with updates on the SERENA project including recent activities, events, results 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. The latest edition of the SERENA newsletter is presented in Figure 6.

Figure 6: SERENA Newsletter – Issue No.3

The 3rd issue of the SERENA newsletter is intended to conclude the newsletter series and cover the concluding activities of the SERENA project with a clear focus on the validation activities and their achieved impact. Moreover, the newsletter aims to bridge the gap between the project closure and the steps to reach the consortium members either for information related to the project or for potential future exploitation of its results. As such, the aforementioned newsletter will be released right after the official closure of the project on March 30th, 2021.

2.4 List of dissemination and communication activities between 30/10/2019 to 31/03/2021

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.	Journal paper	A cloud-to-edge approach to support predictive analytics in robotics industry	January 2020	MDPI Electronics	COMAU, POLITO	Published	https://doi.org/10.3390/electronics9030492	Yes
2.	Conference paper	Scheduling predictive maintenance with production tasks: A steel industry case study	February 2020	I-ESA2020	LMS	Accepted		
3.	Conference paper	A microservice architecture for predictive analytics in manufacturing	February 2020	FAIM2020	LMS, ENG, COMAU, POLITO, SYNAREA	Published	https://doi.org/10.1016/j.promfg.2020.10.153	Yes
4.	Conference paper	Enabling predictive analytics for smart manufacturing through an IoT platform	February 2020	IFAC AMEST 2020	POLITO, LMS, ENG	Published	https://doi.org/10.1016/j.ifacol.2020.11.029	Yes
5.	Conference paper	Low Cost Solutions for Maintenance with a Raspberry Pi	June 2020	ESREL 2020, Venice, Italy	VTT	Published	t.ly/qRBc	Yes
6.	Journal paper	Energy-Based Prognosis of the Remaining Useful Life of the	June 2020	MDPI Applied Sciences	LMS	Published	https://doi.org/10.3390/app10196827	Yes

[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.

No	*Activity type*	Title	Date	Place	Author	Status of submission, publication	Permanent identifiers[2] (if available)	Is open access provided to this publication[3]
		Coating Segments in Hot Rolling Mill						
7.	Journal paper	MIMOSA for Condition-based Maintenance	July 2020	International Journal of Condition Monitoring and Diagnostic Engineering Management	VTT	Submitted		
8.	Conference paper	A machine learning approach for improved shop-floor operator support using a two-level collaborative filtering and gamification features	July 2020	53rd CIRP Conference on Manufacturing Systems 2020	LMS	Published	https://doi.org/10.1016/j.procir.2020.05.160	Yes
9.	Journal paper	A Deep Learning Model for Predictive Maintenance in Cyber-Physical Production Systems Using LSTM Autoencoders	February 2021	MDPI Sensors	LMS	Published	https://doi.org/10.3390/s21030972	Yes
10.	Book	Predictive Maintenance in Smart Factories - Architectures, Methodologies, and Use-cases	March 2021	Springer	SERENA Consortium	To be submitted		

2.4.2 Dissemination and communication activities

No	Activity type	Title	Date	Place	Beneficiary	Size of audience
1.	MIMOSA group meeting	SERENA concept presentation	2-5/12/2019	Houston, Texas, US	LMS, DELL, VTT	Small
2.	World Manufacturing Forum 2019	Serena Concepts and project presentation	25-27/12/2019	Cernobbio, Italy	TRIMEK	Large
3.	A&T 2020 Trade Fair	SERENA project presentation to visitors	12-14/02/2020	Turin, Italy	SynArea	Large
4.	Metromeet	Serena Concepts and project presentation	1-5/03/2020	Bilbao, Spain	TRIMEK	Large
5.	Innovalia Week	Serena Concepts and project presentation	13-17/07/2020	Bilbao, Spain (Online)	TRIMEK	Small
6.	Prima@Home	Serena Concepts and project presentation	8/9/2020	Web event	Finn-Power oy	Large

2.4.3 PhD, Master and bachelor thesis

No	*Activity type*	Title	Date	Place	Beneficiary
1	Master Thesis	Development of a Concept for the Integration and Evaluation of Workflow Systems for Digital Worker Assistance in Manufacturing Companies	2020-2021	Germany	OCULAVIS

2.4.4 Videos and newsletters

No	*Activity type*	Title	Date	Place	Beneficiary	Size of audience
1	Newsletter	SERENA final Newsletter	March 2021	Internet		

2.4.5 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 7: ForeSee cluster logo

The ForeSee cluster includes the following projects:

SERENA	SERENA project will build upon these needs for saving time and money, minimizing the costly production downtimes.
UPTIME UNIFIED PREDICTIVE MAINTENANCE	UPTIME aims to design a unified predictive maintenance framework and an associated unified information system to enable the predictive maintenance strategy implementation in manufacturing industries.
ZBRE4K	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 the operating life of production systems.
PROGRAMS	The proposers' approach can improve overall business effectiveness concerning 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.
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 remaining life, reduce the probability of false alarms and ultimately increase in-service efficiency of machines.

PROPHESY	The technical solutions provided by the project will be the pillar to establish an ecosystem of PdM services. The purpose is to lower the deployment time and cost associated with the operation of PdM solutions, providing, at the same time, a host of business opportunities for all stakeholders.

In the context of the ForeSee cluster, regular telcos have been set up and a roadmap regarding predictive maintenance technologies for production systems has been compiled out of the practices and experiences of all cluster projects. The roadmap at the point of compiling this report is at a full draft state (Figure 8).

Figure 8: ForeSee cluster roadmap

Additionally, a web site has been set up, informing the wider audience about the ForeSee cluster, providing an update on its recent events and activities. The portal is available through the following link:

http://foresee-cluster.eu/

2.4.6 Joint events with other projects

No	*Activity type*	Title	Date	Place	Beneficiary	Size of audience
1	Cluster participation	IFAC AMEST 2020	February 2020	Online	POLITO, LMS, ENG	Medium
2	Cluster participation	ForeSee Cluster webinar series	September 2020	Online	LMS	Medium
3	Cluster participation	IESA2020	November 2020	Online	LMS	Large
4	Cluster participation	ForeSee Cluster webinar series	January 2021	Online	LMS	Medium

Recently, the focus has been placed upon the standardization activities across the ForeSee cluster and a series of webinars has been conducted. The videos of the ForeSee cluster webinar series are available through the cluster's YouTube channel, accessible via the following URL:

https://www.youtube.com/channel/UCTV44zbYW7JaAmtbXeUdeSw

2.4.7 Overall dissemination progress

The purpose of this section is to highlight the overall progress of the dissemination activities of the SERENA project. Moreover, statistics are introduced in the following images (Figure 10 to Figure 11).

Activity \ Period		from 1/1/2018 to 30/10/2019	from 30/10/2019 to 31/03/2021	Total
Publications	Conference	9	5	14
	Books & Chapters	1 Chapter	1 Book	2
	Journal	0	4	4
Dissemination Events		27	6	33
Lectures		3	0	3
PhD, Master and bachelor thesis		3	1	4
Videos and newsletters		2	1	3
Joint events with other projects		4	2	6
Standardisation activities		2	3	5

Figure 9: SERENA overall dissemination activities

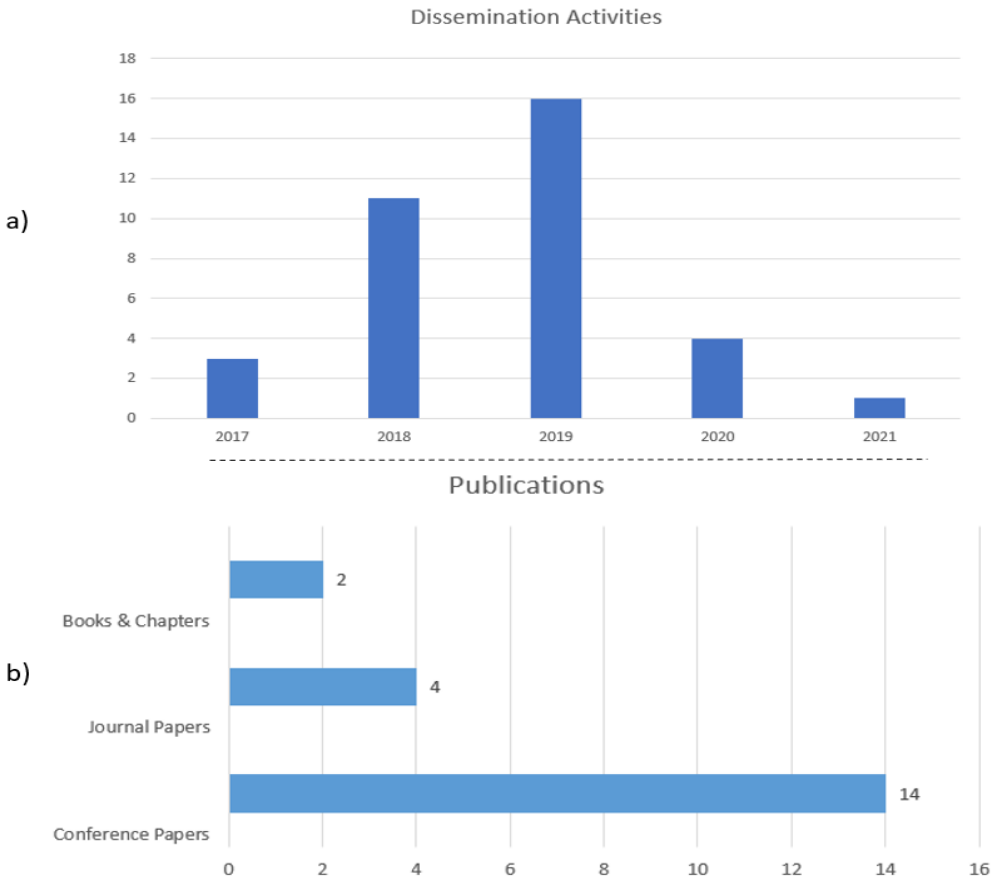


Figure 10: a) The dissemination activities of the project. b) All the publications of the SERENA project

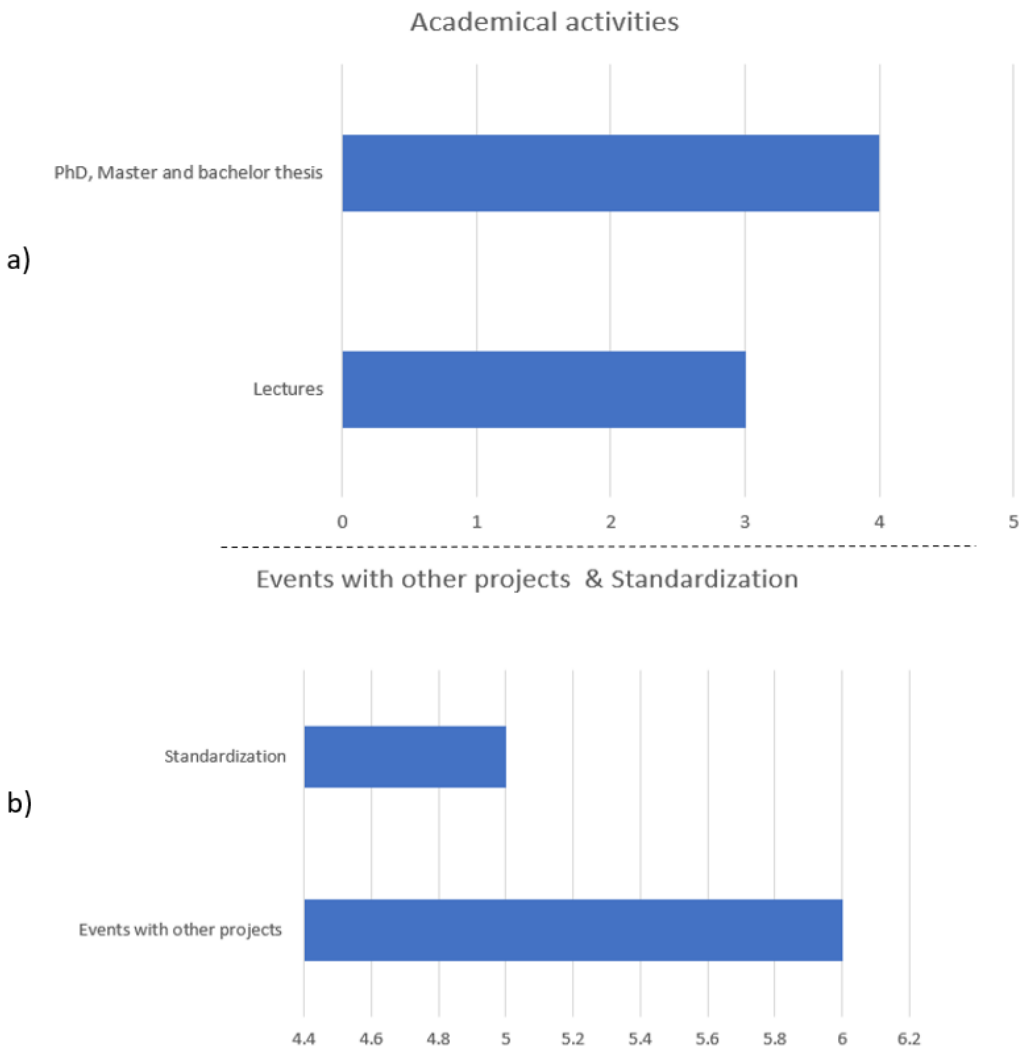


Figure 11: a) The academic activities of the project. b) Events with other projects & Standardization

It should be noted that the dissemination activities and especially the participation in events were affected by the COVID19 outbreak.

3 Updated exploitation plan and activities

In this section, we present relevant updates to the SERENA exploitation plan, according to the strategy presented in D7.3 and highlighting the main updates and deviations (i.e. to minimise repetition as much as possible). The Assets were all updated by partners and, as a core element of the exploitation, are reported in particular adding the License type and agreed co-owners in the consortium.

3.1 Updated Assets, Ownership and IPR (M42 update)

In the following, we summarize the exploitable assets, updated at M42, and including a summary of the ownership and IPR. In Annex I we present the detailed IPR and Ownership Agreement among partners. For more details, we refer to D7.3.

	Asset	License Type	IPR Owners
1	Cloud-based platform for versatile remote diagnostics	Mixed	ENG, DELL, SYNAREA, LMS, IPT, POLITO, OCULAVIS, VTT
2	SERENA Repository API (SRA), Sensor Data and Metadata Cloud Storage (SCS)	Proprietary	DELL
3	Pilot on versatile maintenance for tool providers	NA	COMAU
4	Remote factory condition monitoring and control - Databox Hardware	Proprietary	IPT
5	Remote factory condition monitoring and control - universal data collection (including pre-processing and forwarding)	Proprietary	IPT, DELL
6	Edge Analytics	Proprietary	POLITO, DELL
7	Pilot cell for versatile maintenance in Elevators production industry	Proprietary	KONE
8	AR-based technologies for remote assistance and human operator support	Proprietary	OCULAVIS
9	Pilot cell for versatile maintenance in Metrological engineering industry	Proprietary	TRIMEK
10	Versatile maintenance in Steel parts production and link to other industries	NA	VDLWEW
11	AI condition-based maintenance and planning systems	Proprietary	VTT
12	State Detection	Proprietary	VTT
13	Health Assessment	Proprietary	VTT
14	Prognostic Assessment	Proprietary	VTT
15	Advisory Generation	Proprietary	VTT
16	Pilot cell for versatile maintenance in White goods industry	NA	WHEMEA
17	3D Interactive technologies for Operator Maintenance Support	Proprietary	SynArea
18	Maintenance planning and scheduling tool	Proprietary	LMS
19	Data-driven predictive maintenance pipeline	Proprietary	POLITO
20	SERENA Wiki	Copyleft	ALL
21	Prima Power "Customer Web"	Proprietary	Prima Power
22	Pilot on versatile maintenance for tool providers	NA	COMAU

23	SERENA Repository API (SRA), Sensor Data and Metadata Cloud Storage (SCS)	Proprietary	DELL
24	Remote factory condition monitoring and control - universal data collection (including pre-processing and forwarding)	Proprietary	IPT, DELL
25	Edge Analytics	Proprietary	POLITO, DELL
26	Pilot cell for versatile maintenance in Elevators production industry	Proprietary	KONE
27	AR-based technologies for remote assistance and human operator support	Proprietary	OCULAVIS
28	Versatile maintenance in Steel parts production and link to other industries	NA	VDLWEW
29	AI condition-based maintenance and planning systems	Proprietary	VTT
30	State Detection	Proprietary	VTT

3.2 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 (concerning the analysis carried out in D7.2 and D7.3).

3.2.1 Manufacturing and Digital Manufacturing Trends, Challenge and Needs

Update related to COVID-19 pandemic

A recent survey by PwC, showed that 80% of manufacturers expect the pandemic to have a financial impact on their business (source: National Association of Manufacturers) Cross-industry companies expecting the same was 48%, showing that manufacturing is expecting one of the hardest impacts due to COVID-19. A recent study also forecast 2020 compared to 2019 quarter 4 data with a -2.8% drop value (source: Baker McKenzie and Oxford Economics). However, there is a projected recovery in 2021 with a 6% value add globally compared to 2019 (ibid.).

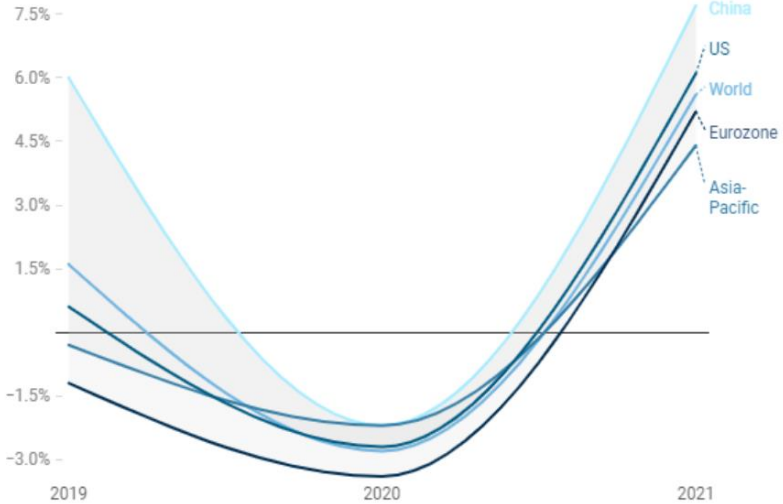


Figure 12: Forecast of global manufacturing value-added output for 2021. Source: Baler McKenzie & Oxford Economics.

A critical topic in manufacturing potentially impacted by the pandemic is supply chain management. Various analysts (e.g. Industry Week), highlight how the 'global' supply chain model, strongly relying on China and Asia, is now under scrutiny with of COVID-related disruptions, indicating that domestic or local supply chains could re-emerge as a paradigm, and even hinting that companies (in both EU and US) might start reshoring.

Analysis by Deloitte on the evolution of manufacturing at mid-2020[4] also highlights the role of digitization, where manufacturers seek to improve efficiency in both production and supply chain management (and also in light of the pandemic), through IT services, simulation, and production. This is a very relevant trend for SERENA.

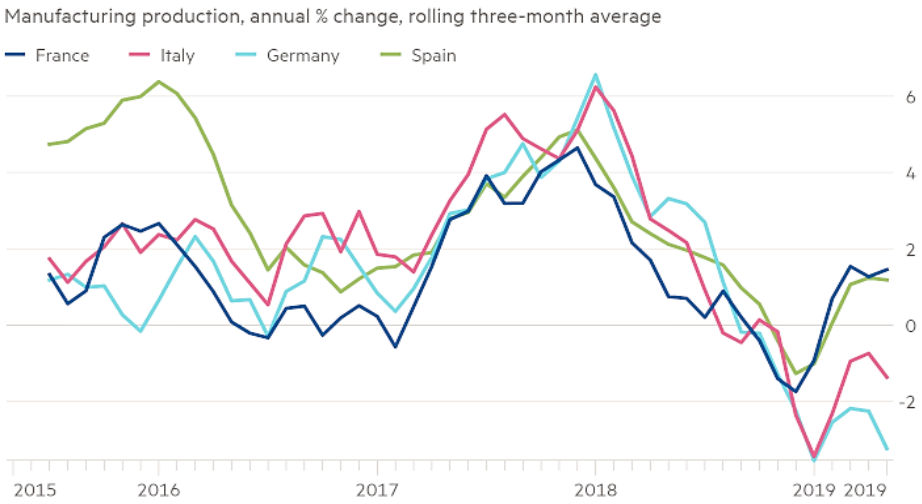


Figure 13: Manufacturing production % change, 3-month average – source: © Refinery

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 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. Manufacturing 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

- As of the beginning of 2021, Manufacturing companies are recovering from the 'emergency' mode for the **COVID-19 pandemic** and the **middle-market** are exploring how best to remain flexible and profitable in the long term. A key element within this effort is the digitization of industrial processes including maintenance and supply chain management. In the near future, a shift from traditional, linear supply chains toward more network-driven systems is forecast (source: RSM LLP).
- **Predictive Maintenance can keep production under control and competitive.** A survey among manufacturing companies showed that 98% of 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 by 20% and outages by 50%. This trend is 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%) of 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

[4] https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/manufacturing-industry-outlook.html

implemented or in place to apply IoT technologies to their processes (34%) or to embed IoT technologies into products (32%).

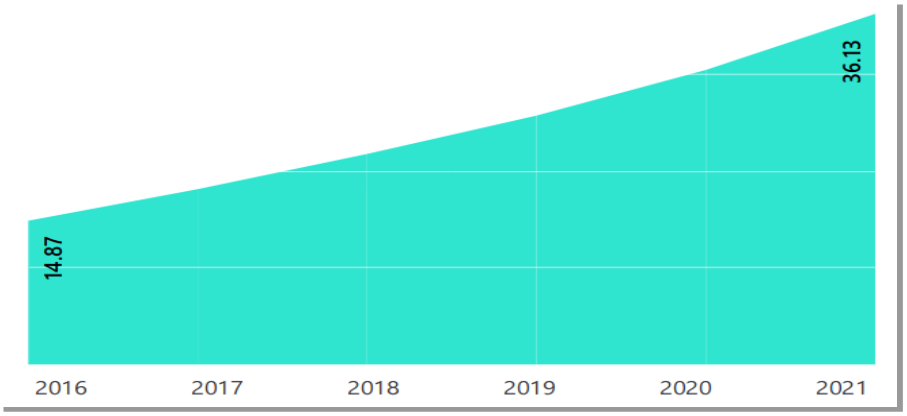


Figure 14: Number of IoT connections worldwide (forecast in billions) – Source: © Microsoft

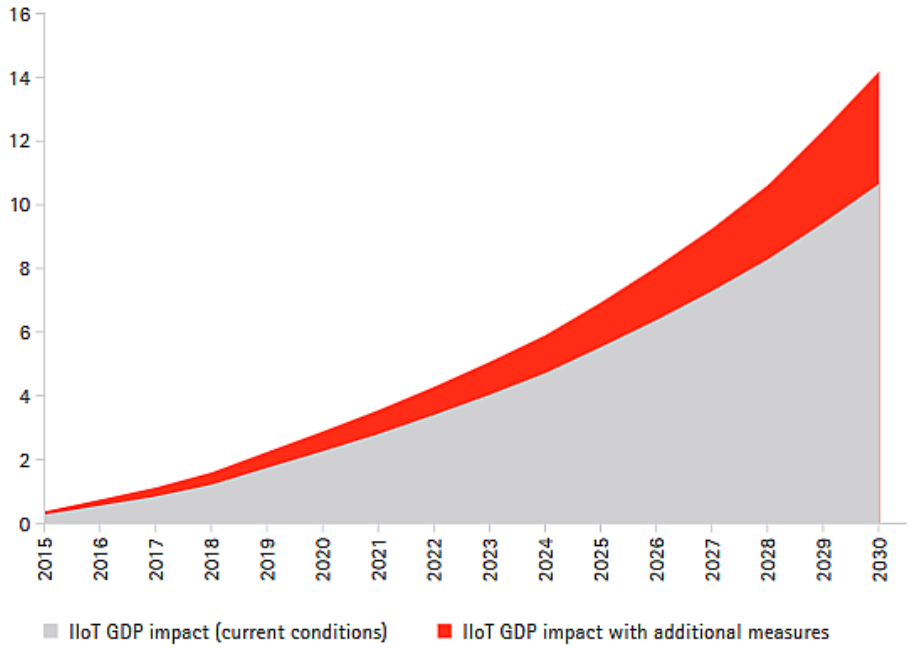


Figure 15: Cumulative GDP impact of IoT (US$ trillion) – Source: © Accenture and Frontier Economics

- ***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% per cent 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 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 used.

- ***The potential impact of GDPR.*** As manufacturers increasingly adopt Big Data, GDPR poses data management challenges. The company have employees, suppliers and customers and must therefore comply with the regulation. Additionally, companies that 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 the 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% per cent 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 per cent of all global machinery production revenue in 2019.

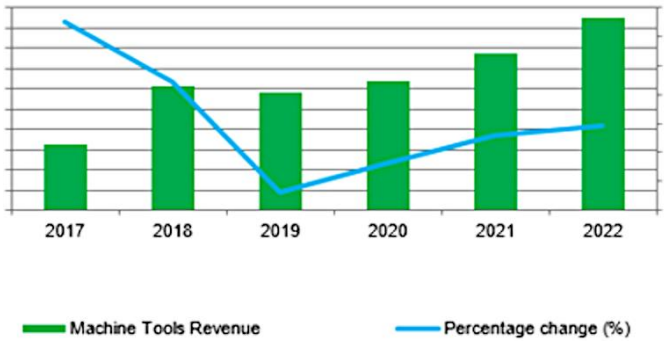


Figure 16: Total machine tools production revenues and growth rates 2017-2022 – Source: © IHS Markit

The largest downstream industries in the machine tool sector remain automotive, with 25 per cent of revenues, and consumer electronics, with 16 per cent.

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 Industry 4.0: 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. The 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).

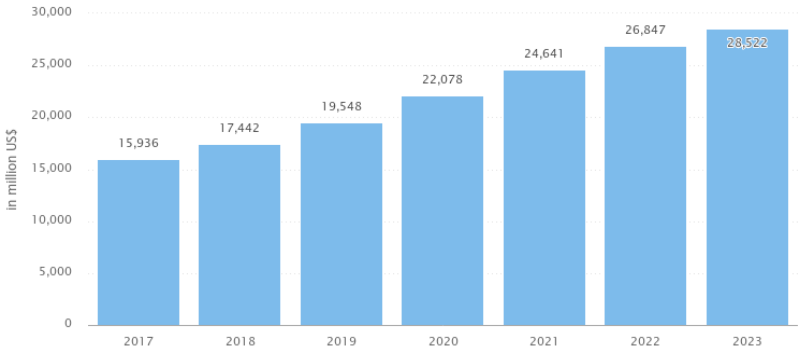


Figure 17: Household market revenue 2017-2023 – source: © Statista

The 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.

With regards to the COVID-19 pandemic, while sales were mainly impacted by lock-downs, on the other hand, demand has been rising especially in the consumer market due to 'stay at home needs. To this end summer, 2021 and end of 2021 should see increased demand and production.

> Predictive Maintenance

Recent market analyses confirm the strong growth trend for predictive maintenance outlined previously. According to a 2019 market report by ReportBuyer, the 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 a 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 projects are still in the 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.
- **The 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, a result of a globalized, digitalized and connected society. Platforms we use daily such as Social Networks (Facebook, Twitter, LinkedIn, etc.),

[5] See https://iot-analytics.com/numbers-of-predictive-maintenance-vendors-surges/

international organizations and non-governmental organizations, research centres, public and private databases, open data-sets, 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 of $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 the 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 the "Worldwide Semiannual 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 by 9.2% by 2020.[7]
Geographically, the Global Big Data Market[8] (Figure 18) 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 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, the 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.
Emerging countries of the 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.

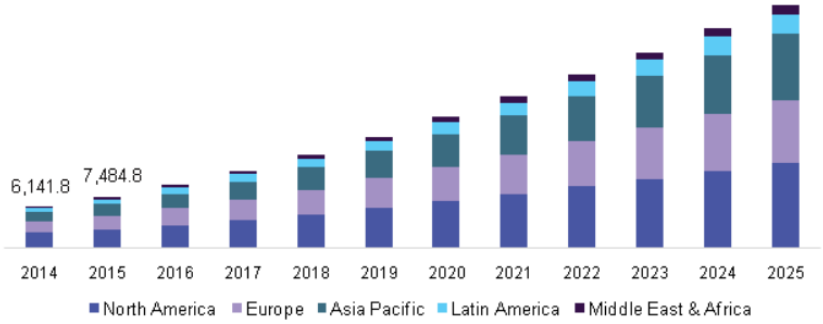


Figure 18: The Global Big Data Market, 2014 – 2025 (USD Million)

> Big Data in Manufacturing controls ca. 18% market share in terms of revenue in Global Big Data market. It is expected to become the sixth-largest industry in terms of its market share position in 2020. The goal of Big Data in the Global Manufacturing Market is to allow operations managers to use advanced analytics 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 analyzing them to reveal important insights. The global **Big Data analytics in the manufacturing** industry market is expected to register a CAGR of 38.62 %, from 2018 to 2023. As shown in Figure 18, in the next years manufacturing industry will be one of the most dynamic sectors in Big Data investments considering information ownership an essential element of competitive differentiation.

[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

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:

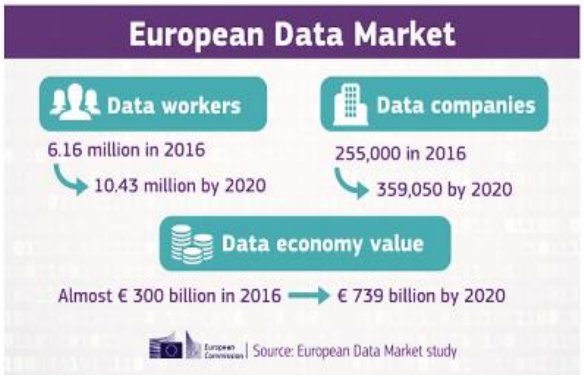


Figure 19 – European Data Market study – Source: European Commission

The study confirms the leading position of the 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/.

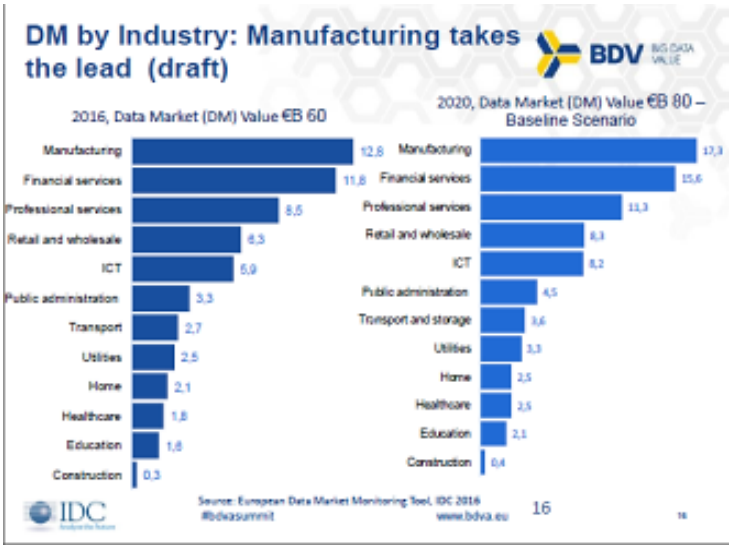


Figure 20 – Data Market by industry - Source: IDC / BDVA

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 acquired smoothly, 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** are to applying 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 grasp the actual business benefits of 'Digital Manufacturing'**. A recent study about the 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 rolled out company-wide solutions showing that real-world implementation is still challenging.

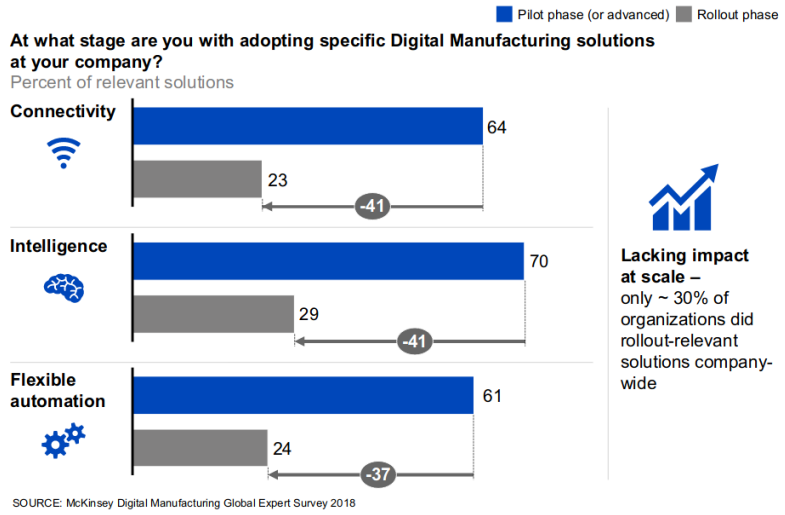


Figure 21 – Only 30% of manufacturing companies surveyed rolled out Digital Manufacturing (Source: McKinsey)

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 enabling 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.

3.2.2 Metrological industry market segment and SERENA relevance

To help establish advanced process chains for the **manufacturing industry**, manufacturers require the integration of new solutions based on Information and Communication Technologies (ICTs) that provide new systems for monitoring, verification and quality control of production processes, so that they are

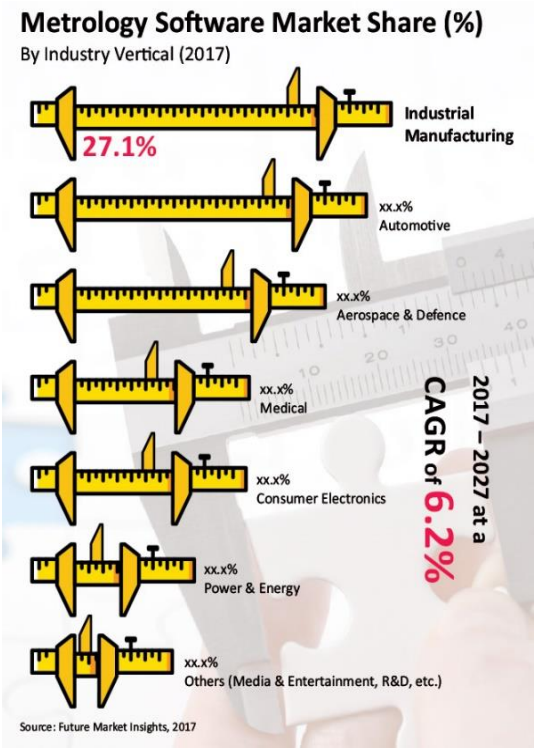
[9] A. Behrendt et. al. *Digital manufacturing—escaping pilot purgatory*, McKinsey, July 2018, https://www.mckinsey.com/~/media/mckinsey/business%20functions/operations/our%20insights/how%20digital%20manufacturing%20can%20escape%20pilot%20purgatory/digital-manufacturing-escaping-pilot-purgatory.ashx

more flexible, fast and precise, and that is adapted to the needs of each case. Besides, they help reduce production breakdowns and increase machine productivity.
Currently, the manufacturing industry is constantly seeking to **automate processes**, to achieve the goal of zero-defect manufacturing. For this, new technologies and methodologies are being developed in the field of industrial dimensional metrology. The strong **time requirements**, the information acquired and the integration in the production line, together with the **need to inspect 100%** of the parts, makes it necessary to resort to optical (non-contact) dimensional transducers.

Non-contact 3D inspection is one of the technologies that offer greater capabilities and functionalities to ensure product quality throughout the value chain, since it allows generating large amounts of information on all the operations carried out in manufacturing processes, by generating point clouds for the digital representation of mechanical components, significantly reducing inspection times and providing valuable information for subsequent operations of the process. This working environment is encouraging companies to start integrating dimensional quality controls in their processes, thus, increasing the number of mechanical components inspected.
In this way, companies will be able to efficiently migrate to these new technologies and maintain more automated control over the metrological information they manage, using it for the benefit of their production process and the entire life cycle of their product.

Growth in the **global market for metrological software solutions** is expected in the period 2017-2027 from $ 814 M to $ 1,450 M, with an estimate of the compound annual growth rate of profit obtained of 6.2% during this period. Likewise, by segmenting the said market by industrial sector, it is expected that the mechanical manufacturing area will maintain its current dominance in terms of profit throughout the period analysed; As guideline, the aforementioned industrial segment had a value of € 210.9 million in 2016.

The dimensional metrology market is undergoing **multiple changes** concerning technological innovations. The increasing need for hardware and software solutions that meet the demands of end-users is becoming a key factor in its growth. Investments in dimensional metrology solutions in industrialized countries are estimated to represent an expenditure equivalent to 1% of Gross Domestic Product (GDP), leading to a rate of return of around 2-7% of GDP.



Currently, in the mechanical manufacturing industry, the costs derived from inspection and quality control constitutes between 10 and 15% of the total production costs. This, together with the fact that almost 100% dimensional control of the delivered mechanical components is being demanded, makes it impossible to use traditional methodologies for dimensional quality control, imposing the integration of measurement equipment.

On the other hand, as part of the fourth industrial revolution (Industry 4.0), the Essential Facilitating Technologies or KETs support the digitization of products, services and production processes. The application of said technologies allows improving the control of the productive processes, as well as the precision of the information collected in them. Its increasing degree of sophistication is aimed at achieving the goal of zero defects in manufacturing processes.

In this context, expertise exists within **SERENA** to address this market and related needs, in particular, **TRIMEK** can assist customers in the maintenance activities associated with these machines. In this sense, TRIMEK company has identified the opportunity to offer to the market a more powerful and advanced metrological solution, by providing the ability to automate control and monitoring processes of its machines to establish a maintenance system that helps to reduce production downtimes and increases productivity of coordinate measuring machines. This system also includes a series of guided processes accessible by maintenance technicians to streamline CMM maintenance processes and schedule their visits. TRIMEK has extensive experience in the dimensional control and metrological software sector and intends to direct and market the results of the **SERENA** project in the general mechanical manufacturing industry sector. It should be noted that this very generic and broad sector is technologically leading, so that it will allow TRIMEK to position itself at the forefront of technology, providing not only product sales but also collaborations in R&D projects that continue to improve the quality of its services and products.

3.2.3 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.

3.2.3.1 GE Predix

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

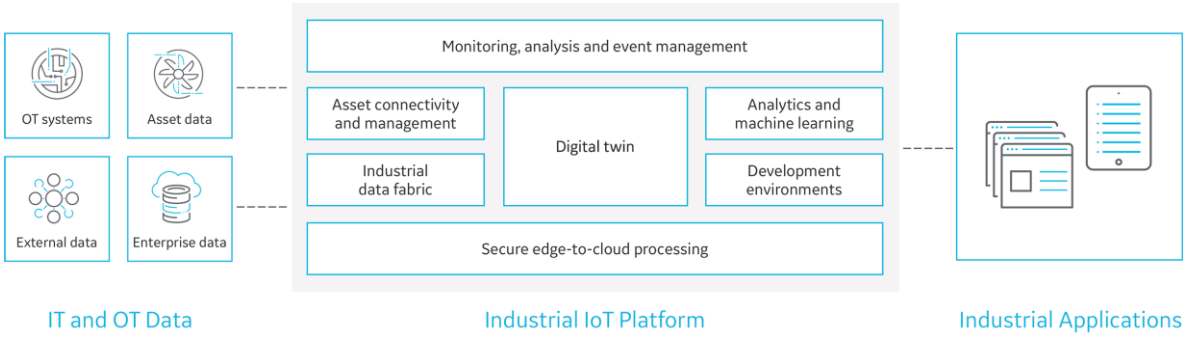


Figure 22 – Predix Platform (Source: General Electric)

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 the Cloud Foundry open-source platform (www.cloudfoundry.org) using the concept of microservices and Apps.
In **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

3.2.3.1.1 Main services and offering

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

3.2.3.1.2 Value Proposition

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

3.2.3.1.3 Partners

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

3.2.3.2 MachineSense

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

Figure 23 – MachineSense (Source: MachineSense)

MachineSense specialises in sensors and related technology which monitors the condition and leverages 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 unmatched 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."

3.2.3.2.1 Main products and services and offers

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

3.2.3.2.2 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

3.2.3.2.3 Partners
Siemens, Microsoft and other technology providers.

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

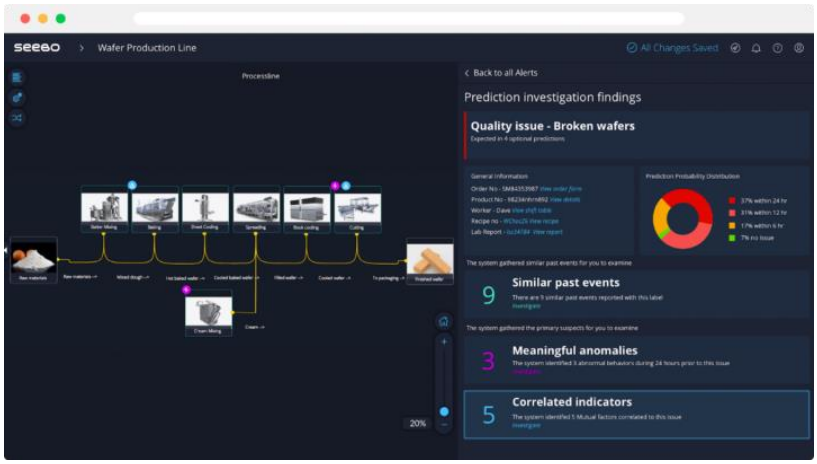


Figure 24 – Seebo Predictive Maintenance solution (MachineSense (Source: Seebo)

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.

3.2.3.3.1 Main products and services and offers
- Seebo Predictive Maintenance platform
- IoT Modeling
- Simulation
- Predictive Analytics
- Digital Twin Prototype
- Predictive Maintenance Dashboards
- Data Acquisition

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

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

3.3 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 (Industry 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 an 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 the integration of components • Hard to address larger enterprises • Unfamiliar to potential 'customers' (reputation as a business) • Leadership and management of SERENA assets

O - Opportunities	T – Threats
• New potential products/markets emerging through COVID-19 situation • Support and push the European manufacturing sector towards digitization • Allow the development and the increase of Industry4.0 • Innovate current industrial 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	• COVID-19 pandemic impacting the manufacturing sector and therefore related solutions like SERENA for instance with reduced investment possibilities • 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. SERENA has is researching the services, methodologies and tools related to innovative predictive maintenance applications and paradigms in this sector: a set of activities that most companies don't perform in such an extensive manner.

Most partners are 'champions' in their sector and are involved in important initiatives (not only at a technical level but also in policy-making) and also have access to important stakeholders who could become customers of products and services related to SERENA. The inclusion in the partnership of industry leaders at a global scale and the creation of internal value chains already within the project is a demonstration of the 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 can 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', to attract interested actors and so that it can be used for demos and promotion purposes. Indeed, this weakness can 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 collection of 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 allows it 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 an 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 in 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.

It is clear that at the time of writing the main threat, for the manufacturing industry as a whole – not just for SERENA – is the economic crisis being generated by the COVID-19 pandemic. As of now, the actual impact is not easy to forecast, with some projections indicating a recovery starting in 2022. At the same time industry is also reacting to the crisis and, for instance, repurposing towards products that are still relevant, or even in greater need (e.g. medical equipment or parts) to face and overcome the pandemic. To this end, SERENA as marketplace offering services for the manufacturing industry can easily adapt to these changes and evolutions, regardless of the main products/services produced. This is shown already by the variety of the business cases domains presented in the next section.

3.4 Evaluation of SERENA technical feasibility towards commercial upscaling and financial projections

While a set of technical and user evaluation activities have been carried by the SERENA partners in different Work Packages (namely WP1, WP2 and WP3), in the context of exploitation we aim to evaluate what kinds of operations/interventions are needed to bring SERENA at a commercial level.

Therefore we do not carry out here a 'technical' evaluation, but an evaluation (with projections) of the involved activities and related effort, mapped as an ROI (Return On Investment) analysis considering the overall costs. At the same time, we will also provide a forecast of potential incomes from selling SERENA-related services to provide a full picture of how those costs can be sustained by revenue.

It should be noted that while in a usual business plan, for instance when a start-up is created or a completely new product launched, ROI and other financial projections aim mostly to attract investors and secure funds – essentially reassuring such potential investors of the financial viability of the new endeavour – in the case of SERENA, a research project, the projections are aimed at providing a 'management roadmap' to be used as periodic assessment tools of the financial performance. To this end, our analysis considers a *baseline* scenario and two additional *worst-case* and *optimal case* scenarios. The former forecasts a business scenario where SERENA does not achieve baseline nor optimal goals, but at least covers the costs/investments; the latter foresees an optimal business performance (above baseline). The baseline objective is to provide a set of financial indicators which, even in the *worst case*, ensure the minimisation of financial loss (i.e. break even without additional incomes).

Year	1	2	3
	2021	2022	2023

Year	*1*	*2*	*3*
Yearly Running Costs (€)	**2021**	**2022**	**2023**
Further Engineering costs	€ 420,000.0	€ 210,000.0	€ 126,000.0
Administrative costs	€ 50,000.0	€ 50,000.0	€ 80,000.0
Internal and client training	€ 50,000.0	€ 50,000.0	€ 50,000.0
Platform updates	€ 100,000.0	€ 75,000.0	€ 50,000.0
Marketing and sales	€ 200,000.0	€ 200,000.0	€ 200,000.0
Overheads (10%)	€ 82,000.0	€ 58,500.0	€ 50,600.0
Totals	**€ 902,000.0**	**€ 643,500.0**	**€ 556,600.0**

Yearly Revenue (€)	**2021**	**2022**	**2023**
Platform Deployment	€400,000.0	€480,000.0	€640,000.0
Yearly Subscription	€100,000.0	€120,000.0	€160,000.0
IT consultancy	€240,000.0	€480,000.0	€720,000.0
External funding (e.g. grants)	€50,000.0	€50,000.0	€100,000.0
Totals	**€ 790,000.0**	**€ 1,130,000.0**	**€ 1,620,000.0**

Net Yearly Revenue	**-€112,000.0**	**€486,500.0**	**€1,063,400.0**
Cashflow	**-€112,000.0**	**€374,500.0**	**€1,437,900.0**

Total Net Revenue:	**€1,437,900**
ROI:	**68.4%** *
IRR:	**494.2%**

** (Net income method)*

Figure 25: SERENA ROI – Baseline scenario

Year	1	2	3
Yearly Running Costs (€)	**2021**	**2022**	**2023**
Further Engineering costs	€ 420,000.0	€ 210,000.0	€ 100,000.0
Administrative costs	€ 50,000.0	€ 30,000.0	€ 15,000.0
Internal and client training	€ 50,000.0	€ 30,000.0	€ 0.0
Platform updates	€ 100,000.0	€ 70,000.0	€ 30,000.0
Marketing and sales	€ 200,000.0	€ 200,000.0	€ 150,000.0
Overheads (10%)	€ 82,000.0	€ 54,000.0	€ 29,500.0
Totals	**€ 902,000.0**	**€ 594,000.0**	**€ 324,500.0**

Yearly Revenue (€)	**2021**	**2022**	**2023**
Platform Deployment	€80,000.0	€80,000.0	€160,000.0
Yearly Subscription	€20,000.0	€20,000.0	€40,000.0
IT consultancy	€240,000.0	€480,000.0	€720,000.0
External funding (e.g. grants)			
Totals	**€ 340,000.0**	**€ 580,000.0**	**€ 920,000.0**

Net Yearly Revenue	**-€562,000.0**	**-€14,000.0**	**€595,500.0**
Cashflow	**-€562,000.0**	**-€576,000.0**	**€19,500.0**

Total Net Revenue:	**€19,500**
ROI:	**1.1%** *
IRR:	**1.7%**

** (Net income method)*

Figure 20: SERENA ROI – Worst case scenario

Year	1	2	3
Yearly Running Costs (€)	**2021**	**2022**	**2023**
Further Engineering costs	€ 420,000.0	€ 250,000.0	€ 126,000.0
Administrative costs	€ 50,000.0	€ 90,000.0	€ 90,000.0
Internal and client training	€ 50,000.0	€ 70,000.0	€ 70,000.0
Platform updates	€ 100,000.0	€ 75,000.0	€ 50,000.0
Marketing and sales	€ 200,000.0	€ 250,000.0	€ 250,000.0
Overheads (10%)	€ 82,000.0	€ 73,500.0	€ 58,600.0
Totals	**€ 902,000.0**	**€ 808,500.0**	**€ 644,600.0**

Yearly Revenue (€)	**2021**	**2022**	**2023**
Platform Deployment	€400,000.0	€560,000.0	€960,000.0
Yearly Subscription	€100,000.0	€140,000.0	€240,000.0
IT consultancy	€240,000.0	€480,000.0	€960,000.0
External funding (e.g. grants)	€50,000.0	€150,000.0	€400,000.0
Totals	**€ 790,000.0**	**€ 1,330,000.0**	**€ 2,560,000.0**

Net Yearly Revenue	**-€112,000.0**	**€521,500.0**	**€1,915,400.0**
Cashflow	**-€112,000.0**	**€409,500.0**	**€2,324,900.0**

Total Net Revenue:	**€2,324,900**
ROI:	**98.7%** *
IRR:	**607.4%**

** (Net income method)*

Figure 20: SERENA ROI – Best case scenario

In the following table, we report the **average** yearly foreseen unit costs/unit income for the different types of offer (i.e. Platform Deployment, Yearly Subscription and IT consultancy) in which we have included external funding (e.g. research and innovation grants) as if they were a sales item. As already mentioned it should be kept the ROI analysis is intended in this case as a '***business* guidance***'* to drive the endeavour and provide periodic cross-checks in terms of financial results.

Platform Deployment	€ 80,000
Yearly Subscription	€ 20,000
IT consultancy	€ 30,000
External funding (e.g. grants)	€ 50,000

Figure 26: Average yearly unit/income for ROI estimation

Sales Quantity Forecast (Units)	1	2	3
Platform Deployment	5	6	8
Yearly Subscription	5	6	8
IT cosultancy	8	16	24
External funding (e.g. grants)	1	1	1
Totals	**19**	**29**	**41**

Sales Quantity Forecast (Units)	1	2	3
Platform Deployment	1	1	2
Yearly Subscription	1	1	2
IT cosultancy	8	16	24
External funding (e.g. grants)	0	0	0
Totals	**10**	**18**	**28**

Sales Quantity Forecast (Units)	1	2	3
Platform Deployment	5	7	12
Yearly Subscription	5	7	12
IT cosultancy	8	16	32
External funding (e.g. grants)	1	3	4
Totals	**19**	**33**	**60**

Figure 20: Comparison of yearly sales: from top to bottom, baseline, worst and best case scenario

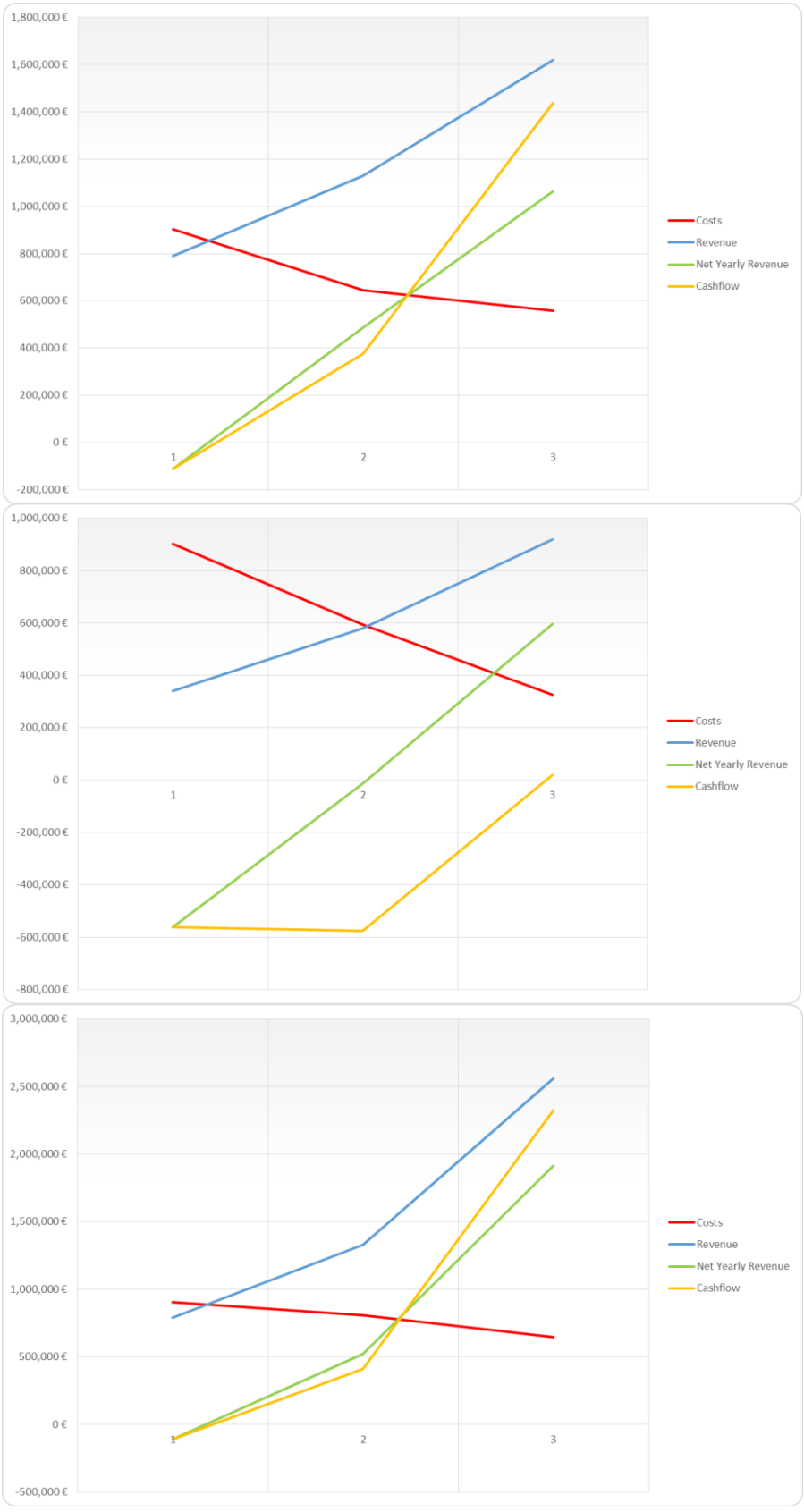


Figure 20: Comparison of yearly financials: Costs (red), Revenue (blue), Net Revenue (green), Cash flow (yellow). From left to right: baseline, worst and best-case scenarios.

3.5 Joint Exploitation Strategy

In this section, we outline a strategy for joint exploitation of SERENA Joint exploitation strategy, in line with the above analyses and also based on partners' individual exploitation plans (see next section). The exploitation strategy builds on the project's key assets in terms of the platform and the generation of value-added services (e.g. IT consultancy), based on the various other assets. In the final phase of the project, the IPR for each asset (as well as its ownership) has been clarified (see also Annex I). Key features of the exploitation are, therefore:

- **Joint exploitation of the project results in the scope of the SERENA ecosystem:**

The SERENA partners will engage in joint exploitation activities within the project's (business) ecosystem. To this end, partners will engage inflexible 'supply-chain' like agreements allowing for the provision of platform deployments as well as technical support services, training and other consulting services to enterprises (manufacturing companies, IT providers, maintenance companies, etc.) making use of the project platform and tools.

- **Exploitation of the SERENA Pilot assets:**

The various pilot assets 4 main Demonstrators will act as important 'business funnels' to exploit SERENA, as they constitute real-world proof of the added value SERENA can provide.

- **Partners' exploitation plans:**

As explained in detail in Section 3.6, each partner has elaborated an individual exploitation plan and are also involved in business and/or research activities in smart manufacturing, manufacturing, IT and other fields relevant to SERENA. SERENA will enable them to strengthen and expand these activities, enhancing their existing products and service portfolios as well as enabling them to acquire greater market shares.

Business relationships among partners in terms of the participation and contribution(s) to the SERENA ecosystem will start from the IPR agreement which constitutes a blueprint for more operational and commercial agreements which will be negotiated involving the relevant management teams and/or business units within the partner organizations.

All SERENA partners are interested in actively participating in this kind of activity, each with its specifics. In this view, the main potential actors involved in the SERENA project, together with potential exploitation objectives of each stakeholder are the following:

1. **Manufacturing sector**: this segment brings in the main potential users/clients of SERENA. For them, SERENA is primarily developing its services and technologies. Regarding maintenance-related service providers, they are will also be interested to enlarge their business offerings (and therefore market position) thanks to the added values and value propositions offered directly or indirectly by SERENA.
2. **IT Industry**: for the IT Companies participating in SERENA and interested in exploiting project results by providing their clients with IT services related to their business. IT consultancy services (integration in legacy systems, the addition of SERENA data services, set-up of new environments, etc.) plus the possibility to launch Open Source projects (to be developed also after the end of SERENA) are the main exploitation possibilities. Some partners are also particularly interested in expanding their business portfolio within the manufacturing domain with new offerings and strengthened business liaisons with other partners.
3. **Universities**: they benefit from SERENA by increasing their knowledge and expertise, and potentially launching spin-offs in a vision of Open Innovation, aiming to obtain external innovation opportunities by exploiting capabilities and resources built by the SERENA project. Further research and funding opportunities will also arise thanks to participation in relevant H2020 and Horizon Europe projects.

4. **Citizens**: in the SERENA vision they are especially final consumers (e.g. of white goods), who will benefit from the added-value services SERENA will be able to provide, receiving higher quality products at competitive prices.

3.6 Future availability strategy and partner roles

From a more business-strategic point of view, there is a consensus t**o maintain certain SERENA assets 'live'** (e.g. the WHR platform instantiation), as-is online for a certain number of years (at least 2) after the project end, as an end-user/partner sandbox. Partners will be facilitated in accessing these environments, in particular through the active collaboration of IT and pilot partners (e.g. ENG + WHR). Access will also be **facilitated to users who request access**: typically this will happen via SERENA current partners' introduction/endorsement, also in line with their exploitation plans, and therefore individual **exploitation channels**. This will serve on the one hand to make easier the internal exploitation; on the other hand, joint exploitation (towards external actors) will leverage the existing platform instantiations as a showcase.

To this end, it was agreed by partners that **ENG**, based on its typical business experience and as leading some of the technical activities in the project, will be the main '**commercial facing**' partner in tight collaboration with **COMAU** who, as coordinator and industrial partner, will be the main actor in then managing possible contracts/agreements. IPR management will be based on the agreed Ownership Agreement (see Annex). The typical workflow will therefore foresee that once received an external request, COMAU (as project coordinator) will contact the asset owner(s) as specified in the IPR agreement. Commercial exploitation will be mainly focused on offering **value-added services**, or what could be (very broadly) defined as **deployment and consultancy services**, as well as training around the SERENA platform and assets leveraging the stakeholders brought in by partners through these joint exploitation initiatives.

External companies/organizations will be able to reach- and learn about SERENA via the current **dissemination and communication** channels (e.g. public portal, participation in public events, social media, etc.). To this end, LMS, COMAU, ENG (with support from all partners via their communication channels, for which also see Section 3.6), will support the **maintenance of dissemination channels** in liaison with current initiatives. For instance, ENG is involved in other Smart Manufacturing related initiatives and projects where it has already started disseminating some of the SERENA solutions and results.

3.7 Updates of individual partner's strategy for exploitation

3.7.1 COMAU S.p.A. (COMAU)

COMAU has already started implementing the entire SERENA system on its premises to evaluate each service and system capabilities. Our exploitation strategy is to gradually test the 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".

3.7.2 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.

3.7.3 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 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 are 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 a 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.

3.7.4 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 to 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 to have a meaningful dataset for our processes, one-year data is mandatory: this requires anticipating FMECA and sensor and data design.

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

1. Partnership with the Equipment Supplier (Cannon-Afros) to install a prototype sensorized injection head: this will generate a complete new dataflow regarding mechanical data of the cleaning piston.
2. 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.

3.7.5 Kone Industrial Ltd (KONE)

KONE confirms to continue with the same exploitation plan mentioned in D7.2. KONE has a high interest in developing its predictive maintenance methods and applications for critical machinery producing the elevator parts. SERENA project, its results until now and further potential has been internally shared to different global supply units using similar machines that were used in the project.

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

In the final part of the project, 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. were to further disseminate and promote SERENA.

Additionally, ENG will continue to push, in a more focused manner, its offering innovative solutions to its clients through SERENA, especially in the manufacturing domain. SERENA results are now more mature and after the completion of the SERENA project 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 be analysed.

ENG will also evaluate the possibility of new H2020 or Horizon Europe projects where SERENA results could be used, as well as emerging initiative (e.g. IDSA) where it is also active since the start of the project.

3.7.7 OCULAVIS GmbH (OCULAVIS)

Oculavis has decided to start the development of a commercial step-by-step AR guidance solution after the Serena project has been completed. The decision was based, in part, on the results of the Serena research project. Preliminary tests and demonstrations were conducted with the use case partners in the Serena project. But Oculavis has also discussed the potential benefits of such a system with other potential customers, which are not related to the Serena project. For example, Oculavis has presented the results from the project in large industrial fairs like the EMO Hannover 2019. In 2020, due to the Covid situation, Oculavis has increasingly offered webinars to pitch the results from the project to interested customers. Oculavis has also presented the module at the internal AllAboutRemote Conferences 2019 and 2020.

The feedback obtained during those presentations has been very positive. The general scope and approach taken during the research project were confirmed to be valid (e.g. the solution has to be easy to use, the creation of new content has to very simple and should not require expert knowledge). The feedback has shown that the solution may be applicable for many use cases, such as training, self-help guides or as a documentation tool. Lastly, the feedback from the partners has shown that a higher technology readiness level and greater feature scope are required for the solution to be commercially exploited. Therefore, Oculavis will continue to work on the technology readiness level and feature scope after the SERENA project has been completed. Oculavis will also create marketing material and other documents to prepare the commercial exploitation of the module.

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

SynArea also 2019 has attended as an 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 has been exploited.
The COMAU RobotBox test-bed used in the project was installed in our stand, showing all the system with the real-time position, sensor data and predictive analysis 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 smartglasses.
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).

3.7.9 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 many 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 are still in their 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 internal deployment, and Dell has been assisting them in this work, with both technical knowledge and equipment, such as commercially available IoT gateways.

3.7.10 Laboratory for Manufacturing Systems & Automation (LMS)

LMS is responsible for 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 may be adopted on a case-by-case basis, and there is no specific restriction on any exploitation strategy. However, as a university, LMS targets primarily 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 the potential future launch of R&D projects in collaboration with existing and/or similar organisations.

3.7.11 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.

3.7.12 VTT Technical Research Centre of Finland Ltd (VTT)

Involvement and return expected
The VTT project goal is to produce new services for the 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. Also, results will be published in conferences and scientific articles, including dissemination through the web for increasing impact and credibility. We also expect to learn more about what kind of tracking solutions or AR applications are needed by the industry. We expect to reach a 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 industrial environments can change quite much each day even during normal use. It might be the case that the areas where AR could be useful, might also be the areas that 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 research 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 the 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. Also, 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.

3.7.13 TRIMEK S.A. (TRIMEK)

TRIMEK, as the metrology use case, has contributed to the SERENA project by demonstrating the benefits of the SERENA solution in the metrological area. TRIMEK provides its expertise in metrology and quality control processes. TRIMEK is focused on developing the necessary services and applications that support the correct operation of the coordinate measuring machines (CMMs) in the metrology laboratories. The analysis of the data coming from the CMM and the sensors to monitor some parameters allow to predict malfunctions and reduce reaction and intervention times.

Involvement and return expected

TRIMEK aims at exploiting the SERENA solution as a remote predictive maintenance service for its clients. SERENA solution will allow TRIMEK to provide its clients support on maintenance, for better management of maintenance resources (from both sides, TRIMEK and clients) to get announcements from the machines when parameters are close to the limits (e.g. air consumption decreasing and close to the lower threshold) and to have access to verification results to evaluate the tendency weekly or monthly to warn the client about potential problems (error out of the threshold).

These new features and services benefit both TRIMEK and its clients since clients will not need to be responsible for the maintenance works and will have more durable and reliable systems. Moreover, TRIMEK will be able to plan maintenance activities, in a cost-effective and efficient approach. The expected impacts when exploiting SERENA solution are:

- Reduction of maintenance costs in terms of repairing or replacement of pieces
- Reduction of costs related to unexpected maintenance works
- Reduction of hardware problems
- Reduction of costs in shutdowns since calibrations will be scheduled and planned
- Increase in customers' satisfaction from the measuring equipment and the provided services
- Expansion of TRIMEK's services including predictive maintenance. This will make stronger its market position and increase its competitiveness.

Potential risks identified

The developed algorithms for the predictive activities are not good enough and the results are not totally reliable.

Mitigation action: to acquire as much data as possible with and without failures to enable machine learning and an accurate prediction of potential malfunctions (if conditions allow it to)

Strategic future commitment

TRIMEK intends to provide more complete and advanced services thanks to SERENA; the idea is to include this solution within its services/products portfolio. In this sense, TRIMEK expects to continue the collaboration with SERENA partners to refine and improve the solution to achieve a competitive solution in the market.

Business plan

Following the plan drawn above, the TRIMEK business model has been divided into four main areas:

1. Product and services: Product and services provided by TRIMEK. Added value proposed by the business as well as a technological leap in the state of the art;
2. Market analysis: Examination of competitors and potential clients. Also, an environmental (external and internal) analysis will be elaborated to adequate TRIMEK most suitable strategies to the current situation;
3. Strategy and Implementation: Exploration of the resources and framework to implement and the strategy to perform in the long and short term;
4. Financial plan: Expenses and revenues from the business. Forecasting financial issues.

The Business Plan definition begins with a definition of the product & services that the SERENA solution will offer to their potential clients, thanks to the improvements acquired in the CMM operation and monitoring during the development of the project. Then, the deepest examination of TRIMEK's target market and competitors is settled to determine the following strategies to reach the established goals. To define a full market analysis, several investigations are developed. Not only direct factors may affect CMM implementation, thus, every single aspect concerning the business, both internal and external factors, are explored. Needs of the market's knowledge provide TRIMEK key and the essential information to develop the product and set a marketing plan. In this light, a strong competitors' current situation analysis has been done.

There are currently three large multinationals that take up most of the metrological market share: Zeiss, Hexagon and Mitutoyo. Other companies in the sector with relevance in the market are Nikon metrology, Metrologic, and Renishaw. Carrying out a comparative study between them is difficult because not all of them offer the same tools. What can be said is that Europe is currently at the head of the world market in terms of technological development in metrology.

The new generated product will be included in the TRIMEK product catalogues, following cooperation with INNOVALIA METROLOGY members in the marketing and distribution of the final solution. Manufacturers of equipment and components, and large companies (automotive, aerospace, energy, naval, construction ...) need a solution that allows them to fully exploit the investment they have been making to automate their industrial processes. This group of companies is made up of the manufacturers like SEAT, VOLKSWAGEN, AIRBUS, BOEING and GAMESA, among others, as well as all its component suppliers, such as reinforcements for structures, doors, blades of wind turbines, in short; the list is very extensive. Software development companies, including competitors in the market, need to improve the capabilities and functionalities of their products to be more attractive to companies.

The product distribution strategy will be based on the distribution channels of the companies of the INNOVALIA METROLOGY strategic alliance, which are companies in the dimensional metrology and quality control sector, specifically producers of tools and controls, with an internationally consolidated market. They are supporting TRIMEK in the establishment of commercial networks of interest for the distribution of their products. Currently, there are possibilities to easily reach Latin American markets such as Argentina and Mexico, and Europeans, such as Portugal, France and Germany, this being the main market. Studies are being carried out to enter in greater depth in the Asian market (China, India etc.).

TRIMEK expects to increase revenues (an increase of turnover of 5-10%) since new and innovative services can be provided and a greater acceptance of these quality control equipment is presumed due to its higher quality and performance. Thanks to these solutions TRIMEK's clients will save in costs since unforeseen shut-downs or stoppages caused by the metrological equipment will decrease.

Improvement in services and products directly impacts warranty cost, estimating a reduction of the cost in 20-30%.

3.7.14 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

1. tightly coupled with SERENA industrial requirements and use cases,
2. based on state-of-the-art Big Data technological solutions, and
3. 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 are currently driving the **impact of 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:

1. 4 papers published in peer-reviewed international conferences
2. 2 joint papers (with some SERENE partners) published in peer-reviewed international workshops
3. 1 best paper award
4. 1 book chapter in the volume “La Fabbrica del Futuro”
5. 1 talk to ASP (Alta Scuola Politenica), a top-level multi-university graduate curriculum
6. 1 seminar to small and medium-sized enterprises
7. 1 seminar in undergraduate courses
8. 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 mitigating 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 envisions a future rich in post-project initiatives including jointly applied research contracts with both current partners and new stakeholders. Research contracts with industries are foreseen thanks to the newly acquired know-how. The current evidence of great interest in predictive maintenance for all industries at large also motivates to set the basis for the founding of new spin-offs and start-up companies in the field, besides possible patent registrations.

4 Standardization Activities

4.1 Methodology

SERENA worked in tandem with the ForeSee cluster as well as on its own in the context of the standardization activities. Within the ForeSee cluster, its members worked together to assess standardisation opportunities and sharing knowledge and best practices. In this context, standardisation elements evaluated included:

- interfaces
- communication protocols,
- quality inspection,
- management systems,
- performance monitoring,
- key risk indicators for manufacturing and
- others,

towards, supporting new regulations and standards to accelerate the adoption of the new manufacturing systems and easier acceptance of the individual projects' solutions.

The consideration of standards in SERENA, as part of the cluster, included the below 4 steps:

1. Identification of needs from the projects' use cases and market assessment (2018).
2. Analysis and evaluation of standards followed by classification (2019).
3. Evaluation of the application of standards in the projects' use cases and knowledge exchange (2020).
4. Identify and adopt best practices towards a common approach on predictive maintenance standardisation (2021).

As a result, a radar chart was suggested and adopted by the cluster members to visualise the adoption of standards as well as their consideration within the cluster individual projects (Figure 27).

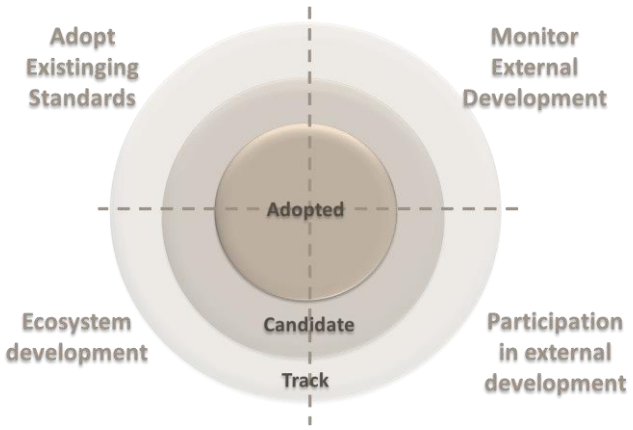


Figure 27: ForeSee cluster radar chart for standards

Besides the cluster initiatives, the SERENA partners approached the MIMOSA core group for support, concerning the use of the MIMOSA standard in the context of the SERENA platform. The focus was to check on the combination of the known at the moment MIMOSA XML schema to a JSON, one more suitable for web applications.

4.2 Relevant standards for SERENA

4.2.1 Data related standards

Type	Name	Standard
Technological	NGSI	Manages the Context Information about Context Entities
	HTTP	Hypertext Transfer Protocol
	MQTT	ISO/IEC 20922:2016 - Message Queuing Telemetry Transport protocol
	XML	Extensible Markup Language
	JSON	JavaScript Object Notation
	JSON-LD	JavaScript Object Notation for Linked Data
	RDF	Resource Description Framework
	OWL	Web Ontology Language
	PMML 4.3	Predictive Model Markup Language
	CoAP	Constrained Application Protocol
	MODBUS	Communication protocol to information over serial lines between electronic devices
	OPC-UA	OPC Unified Architecture
	OPC-UA Vision	OPC-UA for image processing and industrial automation
Transverse	Systems and Software Engineering	ISO 29148:2018
	System Engineering Management	IEEE 26702:2017
	Risk Management	ISO 31000:2018
	RAMI 4.0 (AAS)	Reference Architectural Model Industry 4.0
	IIC RA	Industrial Internet Consortium – Reference Architecture

4.2.2 Maintenance-related standards

Type	Name	Standard
Technical	AMQP	ISO/IEC 19464:2014 - Advanced Message Queuing Protocol
	Machine tool spindles	ISO/TR 17243-1:2014
	ECMA 404	JavaScript Object Notation
	Mechanical Vibration	ISO 10816-3:2009 & ISO/TR 17243-3:2020
	Condition monitoring and diagnostics – data process	ISO 13374-4:2015
	Maintenance Terminology	EN 13306:2017
	MIMOSA	OSA-CBM - Operations and Maintenance Association
	FMEA & FMECA	IEC 60812:2018
	Safety of machinery	ISO12100:2010
Domain	Maintenance KPIs	EN 15341:2019
	Root Cause Analysis	IEC 62740:2015
	Life Management Cycle (Industry)	ISO 13372:2012
	Asset Management	ISO 55000:2014
	Condition Monitoring and Diagnostics – vocabulary	ISO 13372:2012
	Dependability Management	IEC 60300:2017
	Maintenance Indicators (selection and formation)	VDI 2893:2019

Type	Name	Standard
	Condition monitoring and diagnostics - Diagnostics	ISO 13379-2:2015
	Condition monitoring and diagnostics - Prognostics	ISO 13381:2015
	Risk-Based Inspection and Maintenance	EN 16991:2018

4.3 Consideration of Standards in SERENA

SERENA considered an existing data model suitable for condition monitoring and predictive maintenance, namely the MIMOSA OSA-EAI specification, providing a schema for data modelling and connection. Thus, SERENA sores its metadata in MIMOSA CRIS Version 3-2-3, defining the main segment asset hierarchy and associated type tables (Figure 28).

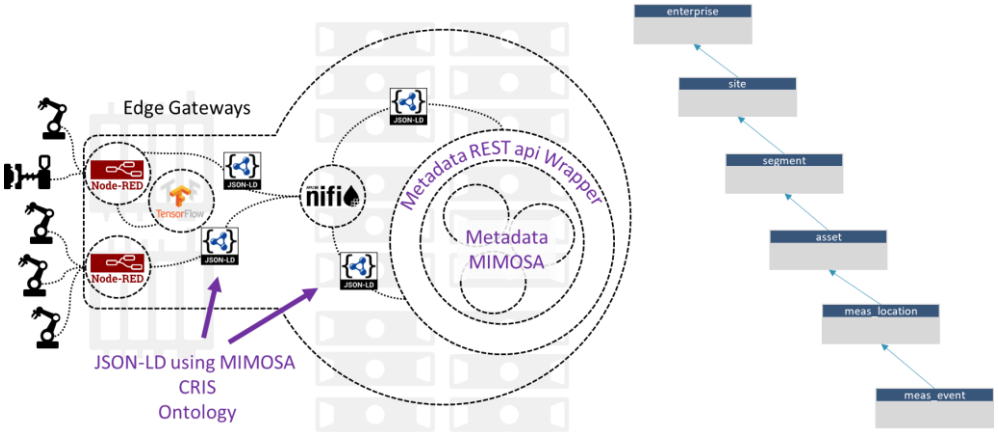


Figure 28: MIMOSA and JSON-LD in SERENA

The data transfer and communication across the SERENA system modules are based upon a JSON-LD message format, which uses the MIMOSA CRIS ontology. Moreover, SERENA IDs come from the MIMOSA database. Finally, another RDF ontology is used in the maintenance scheduling tool that defines a hierarchical structure for manufacturing entities.

Hence, the standards that are considered in the context of the SERENA project are presented using the ForeSee cluster radar chart in the following figure (Figure 29).

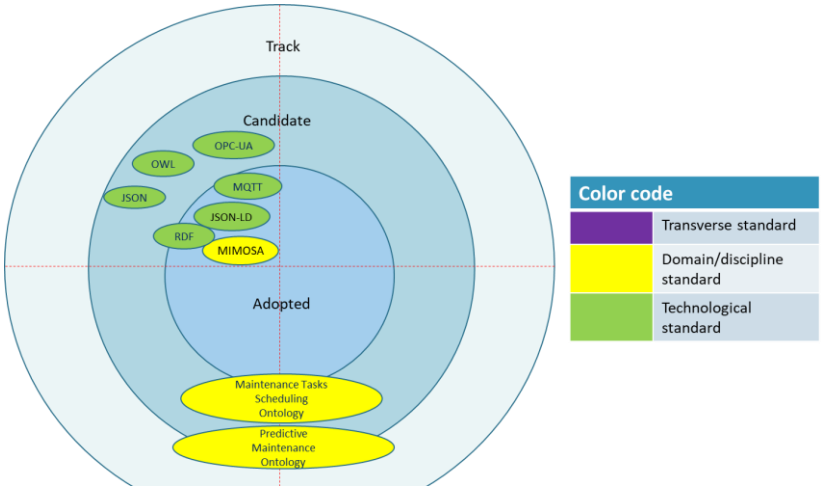


Figure 29: Standards considered in SERENA.

4.4 Contribution of SERENA to standardization and participation in standardization activities

Regarding the contribution to standards, SERENA worked in combining the MIMOSA CRIS (XML) schema with a JSON-LD message format making it more suitable for web applications. The main motivation was that it was not known from the MIMOSA site and public material that this was either under investigation or pending by the MIMOSA group.

However, during the MIMOSA group meeting in Houston, it became clear that the MIMOSA people were working on a JSON schema that was not revealed in their public portal but was announced shortly after the meeting. Thus, much of the work that was performed by the SERENA partners in the context of MIMOSA and connecting it with a JSON schema was done in parallel to the MIMOSA technical groups.

Moreover, SERENA has actively participated in and arranged several activities as part of the ForeSee cluster. In particular, the ForeSee cluster arranged a sequence of webinars and workshops meetings so physical as online during the last years to contribute their results into the standardization. Moreover, the consortium participated in the MIMOSA meeting which took place in the United States. Extensive information regarding the standardization activities is introduced below (Table 3).

Table 3: Standardization events

No	*Activity type*	Title	Date	Place	Beneficiary	Size of audience
1	Cluster participation	IFAC AMEST 2020	February 2020	Online	POLITO, LMS, ENG	Medium
2	Cluster participation	ForeSee Cluster webinar series	September 2020	Online	LMS	Medium
3	Cluster participation	IESA2020	November 2020	Online	LMS	Large
4	Cluster participation	ForeSee Cluster webinar series	January 2021	Online	LMS	Medium

5 Open-access datasets

During the SERENA project, several types and high amounts of raw data are generated through the five pilot cases. The ZENODO platform has been selected for the data decided by the members of the consortium to become publicly available, as detailed in D7.5. The space or community for the SERENA project, "named Serena-data" is accessible via the following link:

https://zenodo.org/search?page=1&size=20&q=serena-data

At the time of compiling this document, 7 datasets coming from the SERENA end-users have been made publicly available in the ZENODO space (Figure 30) and linked to the SERENA public portal, (Figure 31), and H2020 grant management system (Figure 32).

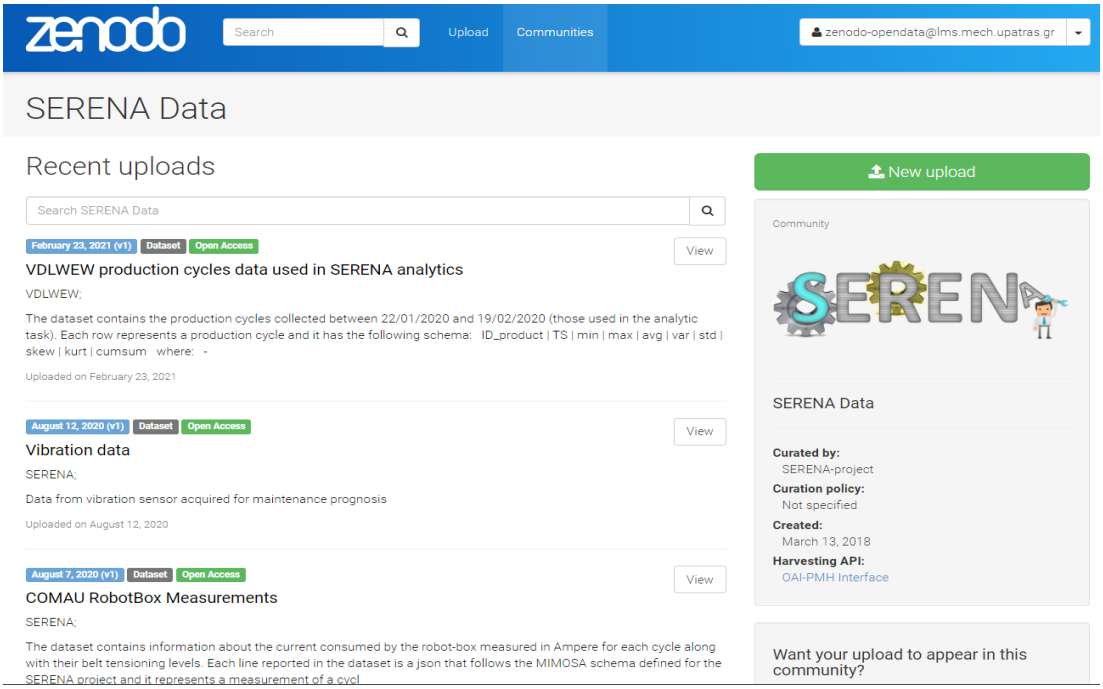


Figure 30: SERENA community in the ZENODO platform

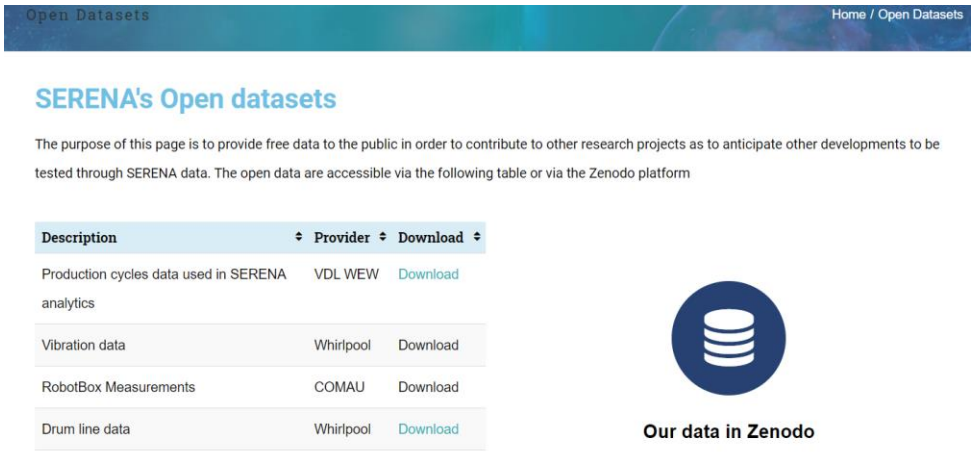
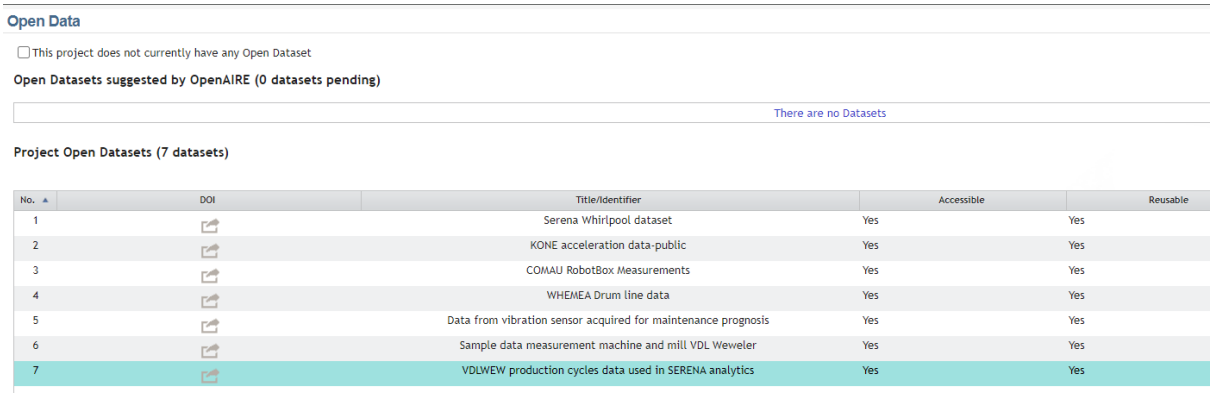


Figure 31: SERENA public portal open datasets tab



Open Data

This project does not currently have any Open Dataset

Open Datasets suggested by OpenAIRE (0 datasets pending)

There are no Datasets

Project Open Datasets (7 datasets)

No.	DOI	Title/Identifier	Accessible	Reusable
1		Serena Whirlpool dataset	Yes	Yes
2		KONE acceleration data-public	Yes	Yes
3		COMAU RobotBox Measurements	Yes	Yes
4		WHEMEA Drum line data	Yes	Yes
5		Data from vibration sensor acquired for maintenance prognosis	Yes	Yes
6		Sample data measurement machine and mill VDL Weweler	Yes	Yes
7		VDLWEW production cycles data used in SERENA analytics	Yes	Yes

Figure 32: Data upload in the System for Grant Management

6 Conclusions

In this deliverable D7.4, we have presented the updates on dissemination, exploitation and standardization activities.

Since the last plan, a series of **dissemination actions** have been carried out including continuous update of the project website, social media (Twitter and Facebook), which saw increases in the last period compared to D7.3. Upcoming newsletter (planned after March 2021, i.e. official project end), and a set of papers submitted at conferences and journals have been presented. Most papers are available via Open Access. A series of events were attended presenting SERENA and a Master Thesis was based on SERENA results. SERENA is also part of the ForeSee cluster, encompassing projects from the FoF-09-2017 call.

Regarding **exploitation,** an updated market and competition analysis were presented. Inevitably the analysis takes into account the ongoing and yet uncertain COVID-19 crisis. The market for SERENA still looks promising and analyses show that a recovery of the overall manufacturing and productive sector should take place around the end of 2021 – beginning of 2022. In particular digital services and digitization (such as the solutions offered by SERENA), will be required to boost the recovery. As highlighted by the updated SWOT analysis, COVID-19 could encourage the need for new solutions in particular regarding remote access and monitoring, given the higher remote work rates experienced during the pandemic. SERENA exploitation is based on complementary and converging joint and individual exploitation plans and strategies which leverage the SERENA Assets. The assets, continuously updated throughout the project, have been finalized and presented in the report. At the same time, the consortium has also finalized an agreement about ownership (and in particular co-ownership) of the assets and their IP, which will be the baseline for future use of these results. Feasibility and maintainability of the assets have also been presented by developing some Return Over Interest financial projections and a strategy for future availability.

SERENA has carried out a series of activities related to **standardization**, in particular in liaison with the ForeSee cluster, and has identified a series of standards relevant for the project which have been reported in this deliverable. SERENA has also made data available as **Open Data** through the ZENODO platform.

Annex I - IPR and Ownership Identification Agreement

Contents

List of Abbreviations

CEN	European Committee for Standardization
CC	Creative Commons
CWA	CEN Workshop Agreement
GPL	GNU Public License
ICT	Information and Communications Technology
IPR	Intellectual Property Rights

The following parties

1. COMAU SPA, established in VIA RIVALTA 30, 10095, GRUGLIASCO ITALY, represented by MASSIMO IPPOLITO or his authorized representative(s) ("the Coordinator", "COMAU")

2. Finn-Power OY, established in PL 38, 62201, KAUHAVA FINLAND, represented by PAOLO CALEFATI, or his authorized representative(s) ("Finn-Power").

3. VDL Weweler BV, established in ECOFACTERIJ 10, APELDOORN, 7325WC, NETHERLANDS, represented by MICHIEL PIETERS, or his representative(s) ("VDLWEW").

4. WHIRLPOOL EMEA SpA, established in VIA CARLO PISACANE 1, 20016, PERO ITALY, represented by PAOLA BASTA, or his authorized representative(s) ("WHEMEA").

5. Kone Industrial Ltd, established in KUUMOLANKATU 1 PL 670, 05801, HELSINKI-UUSIMAA HYVINKAA FINLAND, represented by VILLE RYYNANEN, or his representative(s) ("KONE").

6. Engineering Ingegneria Informatica S.p.A., established in PIAZZALE DELL'AGRICOLTURA 24, 00144, ROMA ITALY, represented by MICHELE CINAGLIA, or his representative(s) ("ENG").

7. OCULAVIS GmbH, established in STEINBACHSTRAßE 17 52074, AACHEN GERMANY, represented by MARTIN PLUTZ, or his representative(s) ("OCULAVIS").

8. SynArea Consultants S.r.l., established in CORSO TORTONA 17 10153, TORINO ITALY, represented by GUIDO COPPO and DANILO SOPRANI, or his representative(s) ("SynArea").

9. EMC INFORMATION SYSTEMS INTERNATIONAL, established in IDA INDUSTRIAL ESTATE, OVENS, CO. CORK, IRELAND represented by GER HALLISSEY, or his representative(s) ("EMC").

10. LABORATORY FOR MANUFACTURING SYSTEMS AND AUTOMATION – UNIVERSITY OF PATRAS, established in UNIVERSITY CAMPUS RIO PATRAS, RIO PATRAS, 26504, Greece, represented by GEORGE CHRYSSOLOURIS, or his authorized representative(s) ("LMS").

11. Fraunhofer Gesellschaft zur Förderung der angewandten Forschung, established in Hansastraße 27c, 80686 Munich, Germany, represented by Kathrin Werner and Valentina Kojic, or its representative(s), acting as legal entity for and on behalf of its Fraunhofer Institute IPT ("IPT").

12. VTT Technical Research Centre of Finland Ltd, established in VUORIMIEHENTIE 3 02150, ESPOO FINLAND, represented by SIMO-PEKKA LEINOor his representative(s) ("VTT").

13. TRIMEK S.A., established in CAMINO DE LA YESERA 2 01139, ZUYA ALAVA Spain, represented by SILVIA DE LA MAZA or his representative(s) ("TRIMEK").

14. Politecnico Di Torino, established in CORSO DUCA DEGLI ABRUZZI 24 10129, TORINO ITALY, represented by MARCO GILLI and/or CLAUDIO GIOVANNI DEMARTINI ("POLITO").

1 Object of the Agreement and General approach

The approach followed for the definition of an Ownership and Intellectual Property Rights (IPR) management framework follows the principles already defined and agreed by partners in the already signed SERENA **Consortium Agreement (in the following also referred as "CA")**. All Parties signed a Consortium Agreement dated 15th October 2018 and based on "REGULATION (EU) No 1290/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 laying down the rules for the participation and dissemination in "Horizon 2020 – the Framework Programme for Research and Innovation (2014-2020)" (hereinafter referred to as "Rules for Participation"), and the European Commission Multi-beneficiary General Model Grant Agreement and its Annexes".
The principles agreed in the above Consortium Agreement shall lay down the intentions by the Consortium Parties in respect of the exploitation results including their Foreground and therefore resulting from the activities carried out in SERENA.
All provisions agreed in the Consortium Agreement that are targeted or have an effect on a term after the Project´s expiry shall remain in full force.

The following were agreed in the already signed CA (Section 8):

- Joint ownership of results (foreground)
- Transfer of Foreground
- Dissemination, including publications, publications of another Party's Foreground or Background, cooperation obligations, use of names, logos and trademarks
- Access rights to Background and Foreground general principles.

The present agreement specifies the Foreground of the PROJECT and in particular identifies:

- Parties owning Foreground
- Licenses for the Exploitable Assets (EA)
- Conditions of use for SERENA partners

This agreement shall not limit a Party´s rights to its Results or Background. The definition of "Exploitable Results" shall only allow the partners to define the Results and identify the rights´ owners.

2 Ownerships and Licensing of results

The following table reports the list of the potentially Foreground generated within the **SERENA** by Parties, the related ownerships and Licenses.

Table 4: Ownership and License of SERENA Foreground Results ("Assets")

Asset code	Asset	License	License Type	IPR Owners
S_PLAT	Cloud-based platform for versatile remote diagnostics	Mixed	Mixed	ENG, DELL, SYNAREA, LMS, IPT, POLITO, OCULAVIS, VTT
S_REP	SERENA Repository API (SRA), Sensor Data and Metadata Cloud Storage (SCS)	Proprietary	Proprietary	DELL

Asset code	Asset	License	License Type	IPR Owners
PVM	Pilot on versatile maintenance for tool providers	NA	NA	COMAU
RFCM	Remote factory condition monitoring and control - Databox Hardware	Proprietary	Proprietary	IPT
RFCMC	Remote factory condition monitoring and control - universal data collection (including pre-processing and forwarding)	Proprietary	Proprietary	IPT, DELL
EA	Edge Analytics	Proprietary	Proprietary	POLITO, DELL
PC_ELEV	Pilot cell for versatile maintenance in Elevators production industry	Proprietary	Proprietary	KONE
AR	AR-based technologies for remote assistance and human operator support	Proprietary	Proprietary	OCULAVIS
PC_MET	Pilot cell for versatile maintenance in Metrological engineering industry	Proprietary	Proprietary	TRIMEK
VM_STEEL	Versatile maintenance in Steel parts production and link to other industries	NA	NA	VDLWEW
AI_CON	AI condition-based maintenance and planning systems	Proprietary	Proprietary	VTT
SD	State Detection	Proprietary	Proprietary	VTT
HA	Health Assessment	Proprietary	Proprietary	VTT
PA	Prognostic Assessment	Proprietary	Proprietary	VTT
AG	Advisory Generation	Proprietary	Proprietary	VTT
PC_WHG	Pilot cell for versatile maintenance in White goods industry	NA	NA	WHEMEA
3D_OMS	3D Interactive technologies for Operator Maintenance Support	Proprietary	Proprietary	SynArea
MPST	Maintenance planning and scheduling tool	Proprietary	Proprietary	LMS
DDPMP	Data-driven predictive maintenance pipeline	Proprietary	Proprietary	POLITO
S_WIKI	SERENA Wiki	Creative Commons Attribution Share Alike	Copyleft	ALL
PP_CW	Prima Power "Customer Web"	Proprietary	Proprietary	Prima Power
PVM	Pilot on versatile maintenance for tool providers	NA	NA	COMAU
S_REP	SERENA Repository API (SRA), Sensor Data and Metadata Cloud Storage (SCS)	Proprietary	Proprietary	DELL
RFCMC	Remote factory condition monitoring and control - universal data collection (including pre-processing and	Proprietary	Proprietary	IPT, DELL

Asset code	Asset	License	License Type	IPR Owners
	forwarding)			
EA	Edge Analytics	Proprietary	Proprietary	POLITO, DELL
PC_ELEV	Pilot cell for versatile maintenance in Elevators production industry	Proprietary	Proprietary	KONE
AR	AR-based technologies for remote assistance and human operator support	Proprietary	Proprietary	OCULAVIS
VM_STEEL	Versatile maintenance in Steel parts production and link to other industries	NA	NA	VDLWEW
AI_CON	AI condition-based maintenance and planning systems	Proprietary	Proprietary	VTT
SD	State Detection	Proprietary	Proprietary	VTT

2.1 Ownership

It is agreed that the owners of the Foreground Results indicated in the above **Table 1 (**Table 4 in the deliverable**).** own or co-own the assets. For the co-owned assets ownership percentage is agreed as follows in **Table 2 (**Table 5 in the deliverable**)**:

Table 5: Agreed co-ownership in % of co-owned assets

Asset code	Asset	Owners (percentage)
S_PLAT	Cloud-based platform for versatile remote diagnostics	ENG: 25% DELL: 17% SYNAREA: 12% IPT: 10% LMS: 10% POLITO: 9% COMAU: 8% OCULAVIS: 5% VTT: 4%
RFCMC	Remote factory condition monitoring and control - universal data collection (including pre-processing and forwarding)	IPT: 50%, DELL: 50%
EA	Edge Analytics	POLITO: 50% DELL: 50%
S_WIKI	SERENA Wiki	n.a.

2.2 Licensing

Licenses indicated as “Open Source” or “Copyleft” imply that the asset source code is freely available on the terms of the specified license. Open Source licenses are the following and partners agree that source code of the assets under these licenses will be made freely available to the public on conditions set forth by the respective Controlled Licence and therefore to other partners: "Creative Commons",

"Apache xml-rpc ", "Eclipse Public License (EPL, V2.0)", "Eclipse public licence", "Apache 2.0", "Apache License 2.1", "AGPL 3.1", "GNU LGPL v3.1", "Affero GPL", "Apache 2.1", "Eclipse Public License 1.1".
The asset "SERENA Wiki" is made of contributions by all partners who also agree to release it with a Creative Commons Attribution Share Alike License therefore for free (gratis) subordinate to the license conditions (see: https://creativecommons.org/licenses/by-sa/4.0/).

All Assets with "Proprietary" licenses will abide to specific terms defined by the Asset Owners and 3. Conditions of use for co-owners and 4. Conditions of use for other SERENA partners.

Assets in Table 1 with a licence type 'None' are these were no IPR is involved on the asset (e.g. a demo which has been carried out).

3 Conditions of use for co-owners

Condition of use for co-owners as indicated in Section 2.1 above follows principles established in the already signed Consortium Agreement.

3.1 Transfer of rights

Each Party may transfer ownership of its own Results following the procedures of the Grant Agreement Article 30 and under the conditions specified in the CA, articles 8.3.

4 Conditions of dissemination by other SERENA partners

Following on the principles expressed in the already signed Consortium Agreement, Parties agreed to allow the use of the Foreground to other partners of SERENA not owning the specific Foreground under the following conditions:
4.1 For dissemination activities during the SERENA project duration and for a period of 36 months after the end of the Project, under the following conditions: shall be governed by the procedure of Article 29.1 of the Grant Agreement subject to the following provisions. Prior notice of any planned publication shall be given to the other Parties at least 45 calendar days before the publication. Any objection to the planned publication shall be made in accordance with the regulations of the Grant Agreement in writing to the SERENA Project Coordinator (COMAU) and to the Party or Parties proposing the dissemination within 30 calendar days after receipt of the notice. If no objection is made within the time limit stated above, the publication is permitted. Other partners may not disseminate other Parties Foreground without receiving a prior written consent of the owner(s) with the exception of assets licensed under an Open Source license as specified in 2.2 above.

5 Signatures

Date and Place:

Party:

Signature(s):

Name(s):

Title(s):