VerSatilE plug-and-play platform enabling remote pREdictive mainteNANce

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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

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Summary:

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

Contents

List of Abbreviations

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

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Executive Summary

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

The content of this document is the outcome of the following SERENA tasks and during the period from 1/10/2017 to 30/09/2018:

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

Primary conclusions / results include the following:

- ✓ A Dissemination Plan is essential to build awareness of a project results and maximize its commercial exploitation potential. The objective of the Dissemination Plan is to lay down the foundations for effective dissemination and communication of SERENA concept and potential benefits to the interested stakeholders at an international level.
- ✓ To align appropriately the interests of all parties within the consortium and the fact that the external communication strategy depends on well-organized internal coordination.
- ✓ For dissemination to be effective it must evolve in parallel to project development.
- ✓ SERENA results will be disseminated to a broad audience including private and public organisations, research community, industries, through activities such as workshops, conferences, journal publications and the internet.
- ✓ Identify initial exploitable results, in this context defined as 'Exploitable Assets'
- ✓ Define a common exploitation strategy in order to create a preliminary exploitation plan
- ✓ During the 1st year the main result is that the framework for disseminating project activities has been setup and preliminary exploitable results have been identified.
- ✓ In the following two years to come and as the project will be generating results that can be communicated to external audience and the exploitation potential will start becoming clearer, the project dissemination activities are expected to multiply. Additionally, the exploitation plan will gradually be refined and finalised towards the end of the project lifecycle.

1 Introduction

1.1 SERENA project in a nutshell

The European research project SERENA that started on October 1st with a term of three years, aims at developing solutions for truly connected production processes where all machinery data are accessible, allowing easier maintenance in case of unexpected events and minimization of costly production downtimes. As such, SERENA represents a powerful tool that will allow plug-and-play solutions for advanced predictive maintenance to aid manufacturers in simplifying their maintenance burdens, by reducing costs, time and improving the productivity of their production processes.

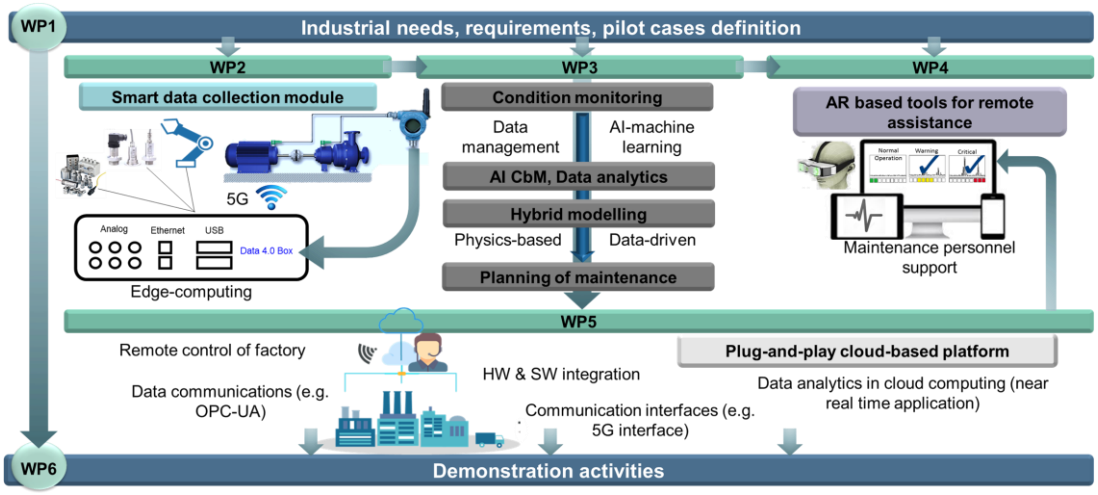


Figure 1: Overview of the SERENA approach

1.2 Scope and objectives of this deliverable

This document consists a report on the dissemination and exploitation activities undertaken during the first 12 months of the SERENA project, setting the communication, dissemination, and exploitation strategy, along with the means to promote the project findings and results.

1.3 Structure of the document

In Section 1 is provided a short introduction to the project high level activities and the objectives of this report. Section 2 continues with the target audience and means to achieve the objectives of the dissemination, communication, and exploitation activities in the SERENA project. The dissemination and communication strategies are presented in Sections 3 and 4 respectively. The initial exploitation plan for he envisaged SERENA solutions are presented in Section 5, while a list of the dissemination, exploitation and communication activities undertaken during the first year of the project is included in Section 6.

2 Objectives of communication, dissemination, and exploitation activities in SERENA

Purpose of the dissemination and communication activities is to endeavour to create awareness of the SERENA project, its vision, objectives as well as its scientific and technical activities throughout its lifecycle. Progressing to the final stage of the project, activities will be transforming into solid results which after being tested and validated in different industrial applications, may contribute to the European market by advancing existing solutions/technologies, where European partners may have a leading role.

2.1 Target audience

Type of Audience	Motivation
Academic and research community	This group targets all research communities interested in the SERENA project's developments, results, and innovation, which can be beneficiary for their own research activities. Scientific contributions of SERENA are particularly interesting for researchers working in the following fields: - Factory condition monitoring and control - Condition based predictive maintenance - Maintenance aware planning and scheduling - AR technologies for operator support - Cloud based platform for demote diagnostics and data security
Industrial sector, Professional Associations (wider audience)	A key objective of SERENA dissemination is to address and trigger the active involvement of industrial and user communities. SERENA is of utmost relevance for organizations in various industry verticals. SERENA has already attracted stakeholders from various industrial sectors (white goods industry, metrological engineering, steel parts production industry, robotics, elevators production industry) their potential for SERENA results exploitation will be analysed especially in the frame of elaboration of the exploitation plan. In the end of the project SERENA's dissemination impact analysis will be elaborated towards evaluating which industrial sectors would be addressed and to compare the response gained from the various companies, both internal and external. This will bring important information for further exploitation of SERENA project results by consortium partners after the end of this project, along with external ones.
Wider public	The wider public should be aware of SERENA scope and objectives, owing the innovative character as well as the potential impact of the developed technologies for companies worldwide.
EU or national, regional projects working on a similar domain	The participation of project partners in other relevant projects offers the opportunity for establishment of quick links among parties through common participants SERENA became member of the PdM (European cluster for sustainable predictive maintenance solutions in the factory of the future) cluster. Through the participation in this cluster SERENA will have the opportunity to: • Co-create the roadmap to promote future research in the domain based on experiences gained from the project implementation. • Promote the research results towards SMEs and web entrepreneurs. • Provide feature articles in the news alerts that will be circulated every month through the mailing list and posted online in the community portal and social media. • Publish position papers to the annual Enterprise Innovation Magazines. • Participate to jointly organized events and liaise with the other projects to exploit

	synergies through joint working groups. Moreover, SERENA plans to participate in events organized by European Factories of the Future Research Association (EFFRA) to communicate to a mainly industrial group the relevance and impact of its technologies to the industry as well as to wider public audiences.
Internal audience	Ensuring effective internal communication and dissemination among the Consortium partners represents an important key success element for the SERENA. Partners´ organizations are important for dissemination for two reasons. First they are potential users of SERENA project results themselves and at second they represent "influencers" because of their huge impact on the associated industrial sectors. Particularly SERENA consortium partners comprise important market players in various segments and this constitutes a natural channel for the dissemination of the project and its results to other potential customers. In this respect, the dissemination activities rely on the effort and the possibility of each partner in exploiting opportunities to present project and its result. Therefore, it is important to communicate information about SERENA project and its results to partners' management, consultants, and people responsible for their marketing and sales. The internal communication strategy also pursues the objective to maintain all partners fully informed about planning, work in progress and existing or potential problems.

Table 1: Target audience

2.2 Objectives

The main objective of the SERENA dissemination and exploitation plan are to specify the required steps and activities to achieve the following:

- Communicate the objectives and vision of the SERENA project;
- Build awareness around the project;
- Establish and reinforce a network of potential users/customers for the SERENA exploitable results;
- Analyse and maximise exploitation opportunities of the SERENA solutions throughout its lifecycle as well as beyond it.

2.3 Means to achieve objectives in relation to target audience

A suitable mean to reach the dissemination and exploitation objectives depends on the target audience. The following table lists the dissemination and exploitation goals and suggests some selected means to reach the objective for each target audience.

Audience	**Dissemination, Exploitation and Communication Goals**	**Dissemination Means**
Academic and Industrial Partners	Share knowledge, focus on research goals and exploitation potential	Distribution of documents via project collaboration tool; project meetings and internal presentations to other units and departments; research visits.
Research Community		Journal articles; presentations at conferences and workshops; papers; posters; research visits.
Industry		Standardisation activities; workshops; members of the user advisory board; conferences; exhibitions and trade fairs; newsletters; white papers; posters.
Students and Trainees	Attract students to share the existing knowledge (training/education) and generate new insights (foster research in PdM related problems), and to train employees	Attract students by lectures, summer schools, PhD/MSc/BSc-thesis topics that include solutions or problems related to PdM; research visits

Public	Inform public about the key ideas behind and the results of SERENA	Website; social networks; newsletters and public demonstrations; articles and videos for non-scientists.
Other Projects	Share knowledge, gain feedback, establish cooperation	Organize joint workshops or conferences; newsletters; research visits.
Consortium	Share knowledge, focus on S&T activities	Organize online and physical meetings; establish an internal we portal for knowledge exchange and communication;

Table 2: Dissemination, exploitation, communication goals and means per targeted audience

2.4 Roles

The dissemination, communication and exploitation activities in the SERENA project are mainly carried out by the following groups:

↗ Innovation Management

Innovation management inside SERENA stems from the orientation of the project towards creating a strategic advantage in the marketplace. As a result, the activity has been directly linked with the exploitation activities and the leading has been assigned to the same partner (ENG). The consortium will establish a task force to be led by ENG and involving COMAU, Finn-Power and LMS on innovation management with the duties below:

- Monitor and collect market needs and customer requirements on SERENA technologies.
- Observe additional added-value which may be created during the project implementation.
- Identify any mismatch between the project values and market/customer needs.
- Bring necessary attention to the GA for decisions, to respond to an external or internal opportunity.
- Implement the decisions into exploitation activities to seize the opportunity.

↗ Exploitation group

ENG is one of the primary partners interested in the execution of a proper exploitation of the whole set of results and demonstration that SERENA will produce. ENG and COMAU have already cooperation, globally to continue joint development and marketing of solutions for predictive maintenance based on modular hardware and software aimed at acquisition and analysis of field (Internet of Things data, Big data Analytics). Also, SynArea and DELL EMC will be involved in this phase, as a key player in the market of software solutions in different domains. As internationally software system developer in different areas, ENG, assisted by COMAU, DELL EMC and SynArea is the proper actor to handle the exploitation of SERENA results at all levels.

↗ End-users

This group consisting of the industrial partners of the SERENA consortium will contribute to the dissemination and exploitation of the SERENA solutions providing guiding and support based on their experience and background.

↗ Consortium

Finally, SERENA partners have individual plans (communication, dissemination, and exploitation), for national audiences as well as at an international level, according to their country of origin, purpose, expertise, and type of organization.

3 Dissemination plan

3.1 Dissemination Strategy

Objective of the dissemination activities inside the SERENA project is to provide the appropriate dissemination means and support for the effective communication of the results of the project. In order to ensure that the knowledge gained would be disseminated in the relevant audiences in the most efficient way, further objectives were set, i.e.:

- To achieve effective and sustainable dissemination of knowledge among and beyond the members of the consortium, during and beyond the life time of the project.
- To promote SERENA and European RTD efforts and to make research results available to a larger scientific community, providing visibility to the results and attracting interest.
- To coordinate knowledge management and other innovation-related activities.
- To engage policy makers, industrial stakeholders, SMEs, and other interested actors in a constant interaction and consultation mode with the project, as well as with their EU counterparts.

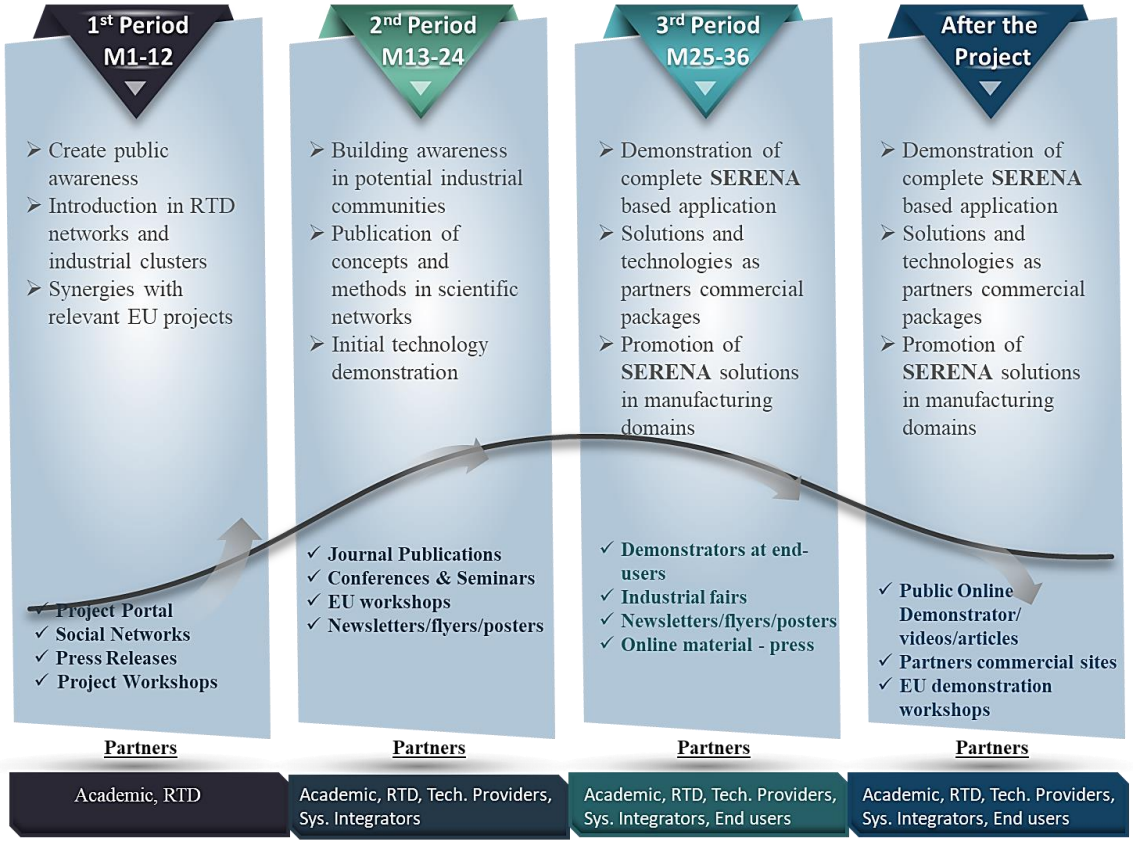


Figure 2: Plan for the use and dissemination of knowledge

Towards collecting and monitoring the performed and planned dissemination activities a google sheet for keeping log of the activities was created, including:
the current and foreseen scientific publications

- Dissemination and communication activities
- Lectures
- PhD, Master and bachelor thesis
- Videos and newsletters
- Information on the connection to other projects
- Joint events with other initiatives
- Standardization activities

Activity type (conference paper, journal, fair/exhibition, other, video)	Title/Reference	Date	Place
		Scientific Publicactions	
Conference paper	SERENA: Versatile plug-and-play platform enabling remote predictive maintenance	22-23 March 2018	Berlin, Germany
Conference paper	On a versatile scheduling concept of maintenance activities for increased availability of production resources		Internet
Conference paper	Remote factory condition monitoring and control framework architecture	June 2019	Ljubljana, Slovenia
		Dissemination and communication activities	
Deliverable upload	SERENA public portal	11/2017	Internet
SERENA twitter account	SERENA twitter	11/2017	Internet
SERENA facebook account	SERENA facebook	11/2017	Internet
Hanover Messe 2018	SERENA project presentation to visitors	23.-27. April 2018	Hanover, Germany
Patras IQ	SERENA project	27-29 April 2018	Patras, Greece
A&T Trade Fair	SERENA project presentation to visitors	18-20 April 2018	Turin, Italy
FoF community day	SERENA project presentation to visitors	27 June 2018	BluePoint Centre, Brussels
IEEE-IS2018	Artificial intelligence and Industry 4.0	25 Sep 2018	Madeira, Portugal

Figure 3: Dissemination, communication, and standardization activities log

3.2 Dissemination tools, and channels

SERENA focus will be to ensure the awareness across both scientific and industrial communities. Non-confidential results will be periodically diffused by means of traditional communication channels, to create a constant and continuous information flow towards the potential market. Furthermore, SERENA's project results have been and will be communicated through an appropriate set of channels that are summarised in the following table.

Dissemination tools and channels	*Digital*	*Physical*
Printed materials: newsletter, flyer, presentations, handbook	☑	☑
Target publications in scientific magazines	☑	☑
Project's events (not yet planned but suggested: one after 18 months and one at the end of the project	☐	☑
Other PdM, AI, data security, cloud related conferences and events	☐	☑
Business interest group (clustering)	☑	☑
Synergies with ongoing initiatives (clustering)	☑	☑
Seminars/Grants (education and training)	☐	☑
SERENA website	☑	☐
External websites (partner websites, etc.)	☑	☐

Table 3: Dissemination tools and channels

3.3 Journals and other scientific publications

The SERENA project consortium will target scientific journals and magazines to disseminate its research results and findings, including among others:

- Journal of Intelligent Manufacturing

- Journal of Advanced Computational Intelligence and Intelligent Informatics
- International Journal of Information Security (Springer)
- IEEE Transactions on Cloud Computing
- Computers and Security (Elsevier)
- IEEE Security and Privacy
- IEEE Transactions on Services Computing
- Journal of Services and Cloud Computing
- International Journal of Cloud Computing
- The international journal of production research
- Cognition, Technology & Work
- International Journal of Advanced Robotic Systems
- IEEE Transactions on Human-Machine Systems
- International Journal of Computer Integrated Manufacturing
- CIRP Annals - Manufacturing Technology
- CIRP Journal of Manufacturing Science and Technologies
- European Journal of Industrial Engineering
- International Journal of Industrial Engineering Computations
- International Journal of Industrial and Systems Engineering
- Advances in Manufacturing
- INFORMS Journal on Computing
- IEEE Internet of Things Journal
- IEEE Transactions on Industrial Informatics
- International Journal of Virtual Technology and Multimedia
- Journal of Modelling in Management

Publication procedure must follow the rules already defined in the Grant Agreement and the Consortium Agreement.

3.4 Conferences, EU events, trades, workshops

The objective of SERENA is to be present – through the submission of papers and posters – in the most relevant conferences. The project partners keep each other informed of upcoming dissemination opportunities to plan joint activities. The list of conferences and workshops relevant to the project is kept updated in the SERENA repository. Each partner detecting a new opportunity is expected to circulate the information to the consortium, update the list of Upcoming Events and if possible upload to the repository the relevant call-announcement.

A list of candidate outlets has been drawn up, many of which the project consortium already have previous experience of attending.

- ISOC Network and Distributed System Security Symposium
- The International Conference on Dependable Systems and Networks
- IEEE International Conference on Cloud Computing
- ACM Computer Human Interaction
- ACM International Conference on Multimodal Interfaces
- CIRP Conference on Manufacturing Systems
- CIRP Conference on Intelligent Computation in Manufacturing Engineering
- CIRP Global Web Conference
- CIRP General Assembly
- CIRP Sponsored conference on Life Cycle Engineering
- CIRP Sponsored conference on Changeable, Agile, Reconfigurable and Virtual Production
- CIRP Conference on Manufacturing Systems
- IEEE Conference on Emerging Technologies and Factory Automation

- IEEE Conference on Industrial Informatics
- IEEE Workshop on Factory Communication Systems
- The International Conference on Computer Modelling and Simulation
- IFAC Symposium on Information Control in Manufacturing

SERENA wants to make its results and objectives visible with a booth or at panel discussions, round tables or with presentations at important high level events, such as:

- EFFRA;
- EUROBOTICS;
- AIOTI;
- SPS Electric Automation – Systems and Components;
- Premiere Electronic Industry Conference and Exhibition; Metromeet (Bilbao)
- AMB Stuttgart,
- WMF and Manufuture, METAV, BIEMH, Control, Embedded World and CeBIT in Germany,
- DATE - Design Automation & Test, in France,
- Productronica in Munich, Germany;
- Robotica, Cleanzone;
- Hannover MESSE;
- Automatica Munich;
- IREX/Japan;
- IRVS/USA;
- BIMU and BIMEC/Italy;
- EMO.

3.5 Lectures, PhD/MSc/BSc – thesis, and other training

As an additional means to communicate the findings and results the SERENA project will be presented in several courses at different universities. The list of partners where lectures could be given includes, the academic institutions participating in the project. An additional goal is to attract students to contribute to SERENA, e.g. by choosing their PhD, Master's or Bachelor's thesis from the field of SERENA.

3.6 Technical reports

The public deliverables that will be produced as result of the project, will be also considered and used as scientific dissemination tools. They will be published by the respective academic partners on their websites and become available through the SERENA website, during the course of the project. This allows a fast and wide scientific distribution of the technical results.

3.7 Industrial workshop

In order to share the gained knowledge throughout the project and to receive the industrial feedback on the process of improving the project a series of workshops will be held. External experts and production/maintenance specialists will be engaged in these workshops.

4 Communication activities

Broad communication actions will be undertaken to promote the project's objectives, activities and findings in a clear and understandable manner for citizens and civil society at large. The SERENA communication strategy will pursue the following objectives:

- raise public awareness and ensure maximum visibility of the project key facts, objectives, activities, and findings among public at large;
- announce and promote SERENA events, contributing to upgrade its attendance and engagement potential;
- support the dissemination objectives.

Figure 4: Plan for communicating the SERENA knowledge and results

4.1 Graphic identity logo

A project logo is the first milestone related to the creation of all dissemination activities. The project logo has been in all materials and project related documents and used in all printed project related promotional materials throughout the project duration.

4.2 Project website

The SERENA public Web Portal has been primarily developed and is available online since project M01 for all people around the globe that are interested in the project and also to facilitate some of the project dissemination needs, for publishing news and information about that and communication between the project coordinator with everyone who is interested in the project. Access to the public and private web portal is provided by the link:

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

The public space of the portal is useful for dissemination of the knowledge of the project or publishing news and information about the project and the beneficiaries of it or communication between the coordinator with everyone who is interested in the project.

Figure 5: Front page of the SERENA portal

SERENA portal activity (01/10/2017 – 20/9/2018)

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

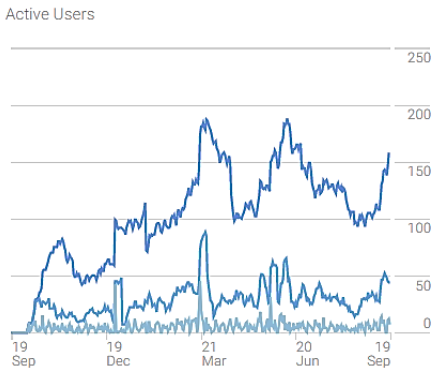
Performance measure	Value
Sessions	2135
Users	1192
Pageviews	2.67
Avg. Session Duration	2m 21s
Bounce Rate	59.36%
New visitors	-
Countries/Location 	*No* *Country* *Users* *1.* Greece 235 19.23% *2.* Italy 188 15.38% *3.* Germany 127 10.39% *4.* United States 117 9.57% *5.* Spain 59 4.83% *6.* Finland 44 3.60% *7.* Belgium 33 2.70% *8.* United Kingdom 29 2.37% *9.* Ireland 27 2.21%

Table 4: SERENA public portal analytics

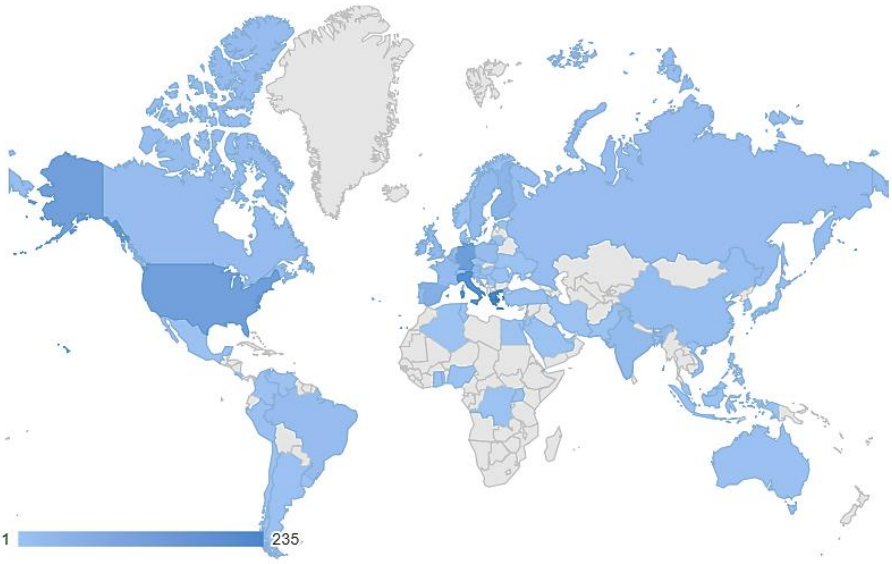


Figure 6: Map of countries (in blue) that have visited SERENA portal

4.3 Web 2.0 – Social media

SERENA has presence in social media and more specifically in Facebook and Twitter. These media will be used to promote SERENA activities to users of those media.

[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 7: SERENA on Facebook

Figure 8: SERENA on Twitter

SERENA social media activity (01/10/2017 – 20/9/2018)

Performance measure		Value
Facebook	Total Followers	46
	Total Likes	42
Twitter	Tweets	18
	Following	20
	Followers	50

Table 5: SERENA social media statistics

4.4 Communication Material

4.4.1 Project brochure

A project brochure has been prepared that communicates key-facts for the objective, structure etc. of the project. The brochure is publicly available on the portal and will be printed in high quality paper

in several copies to be provided to people interest in SERENA during events that SERENA participates.

Figure 9: SERENA brochure

4.4.2 Project poster

A poster of 60x90 cm size has been designed as a generic communication material and is available through the SERENA public portal. It presents the project's vision, objectives, use cases and expected impact, as well as the consortium members, and the contact details.

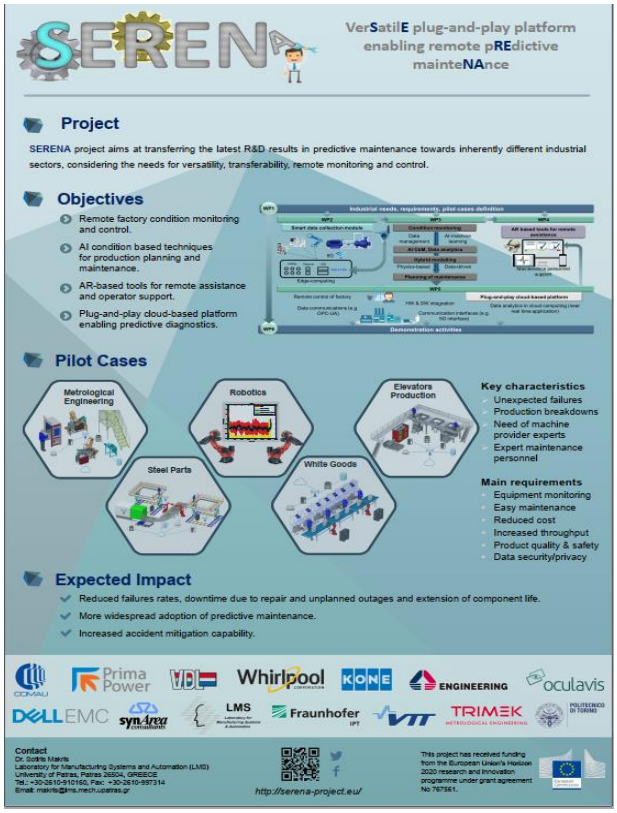


Figure 10: SERENA poster

4.4.3 Newsletter

Project newsletters, yearly released, will enable the consortium to update the project community with latest project activities and results. The first one will be published to the SERENA public portal by October 2018.

30 September 2018
Issue 1

Newsletter

Preface

Dear Reader,

We are glad to introduce you the first newsletter of the SERENA project.

Purpose of this newsletter is to provide an overview of the SERENA activities within its first year and a brief description of its industrial pilots. Finally, recent project activities and future events are presented.

SERENA is a European Union funded Research & Development Project under the Horizon 2020 Framework Program. The project has started on 1st October 2017 and will last until the 30th September 2020. The project engages 14 organizations from various EU countries and the consortium is coordinated by COMAU S.p.A, Italy.

SERENA will provide a bridge for transferring the latest R&D results in predictive maintenance by providing:

- advanced IoT systems and smart devices for collecting data from different resources and cloud-based remote management of these data
- platform for predictive maintenance activities & AR based operator local maintenance personnel support,
- advanced artificial intelligence methods for predictive maintenance,
- plug-and-play cloud-based communication framework.

SERENA represents a powerful platform to aid manufacturers in simplifying their maintenance burdens, by reducing costs, time and improving the productivity of their production processes.

Sincerely,

The SERENA project consortium

Predictive Maintenance

This project has received funding from the European Union's Horizon 2020 Framework Programme for research and innovation under grant agreement No 767561.

Inside this issue

Special points of interest

- Presentation of SERENA in IEEE-IS2018
- SERENA General Assembly meeting to take place in November in Bilbao
- Prototype demonstration for evaluating concept

Figure 11: SERENA 1st newsletter

5 Initial Exploitation Plan

5.1 Exploitation strategy

The **SERENA Exploitation** activities aim at transforming the project's outcomes into exploitable assets to answer the needs of target market segments, and to prepare market entry in the European manufacturing industry. The overall Exploitation strategy and objectives are summarised in the figure below and have been conceived in order to be aligned with the project Work Plan, phases and delivery of results.

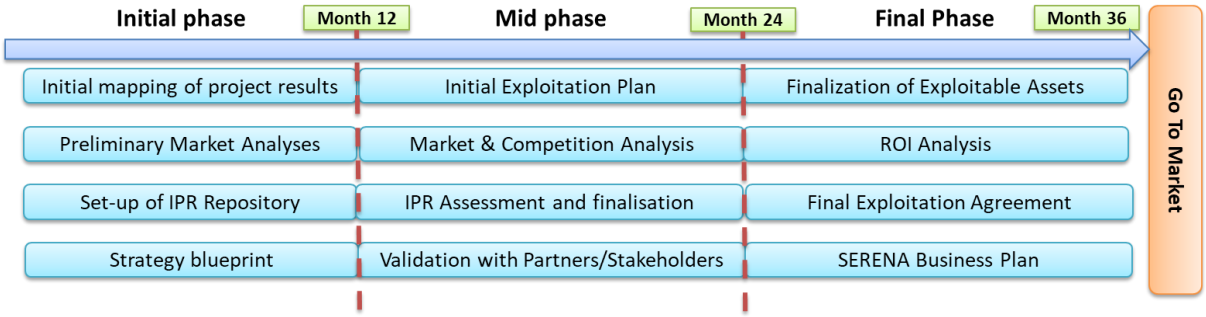


Figure 12: SERENA Overall Exploitation Strategy key phases

In the **Initial phase** (M1 to M12) and reported in this deliverable, we aim to have an initial results' definition for SERENA as well as preliminary Market and Needs analyses. In this phase, we also aim to set out each partner's Individual Exploitation commitments and intentions. Although the analysis in certain cases may appear as broad or theoretical, it was crucial to bring to all partners a shared understanding of the potential routes opened up with regard to the joint exploitation strategy and the SERENA governance. In order to have, already after the first year into the project, a clear view of the potential SERENA product(s) and in order to develop concrete Value Propositions and Business Models, we have already defined the key exploitable assets (described in detail in the next section) with a focus on their market value and business potential. To make sure the assets will always be up-to-date and in line both with the project evolution and the market and needs, SERENA partners have set-up an 'Assets Database' intended to be a live tool easy to update and monitor. The Assets database also serves as tool to define and monitor the IPR and its management, in the next Exploitation phases.

The **Mid exploitation phase** (running from M13 to M24, which will be reported in D7.3) will set-up a concrete Exploitation Plan and consolidate the Market Analysis, focusing on important segments and competition. The IPR Assessment will also be consolidated and finalised, and finally the plan validated with partners and possibly involving external stakeholders able to provide input and additional ideas.

In the **Final exploitation phase** (M25 to M36, to be reported in D7.4), a Business Plan for SERENA will be crafted. The Assets and their Value propositions will be updated both to follow the project results' evolution and to match the results of the demonstrators, in order to ensure the business mission and propositions are aligned to actual user needs. In this phase, the product positioning will be consolidated (including a ROI analysis) and an Agreement to be signed by all partners will be drafted.
A **post-project phase** is also foreseen and will start after the end of the project implementation, featuring the actual commercialization roadmap and activities for SERENA based on the Exploitation Plan defined in the previous phases.

5.1.1 Joint Exploitation Strategy Plan

First, in this section, we outline the **SERENA Joint exploitation strategy,** in line with the project evolution at month 12. This strategy, which is an initial one and will be updated as the project evolves, incorporates on the one hand a preliminary analysis on how to map the Market needs and Assets offered by SERENA to partners' characteristics and each asset's exploitation potentials, and on the other hand define a joint exploitation strategy which also incorporates elements of a future SERENA Business Plan that will be finalised by the end of the project.

The SERENA exploitation strategy will build on the project's key assets in terms of platform and the generation of maintenance and services for manufacturing value chain and matching business cases. These three main pillars of the project's exploitation strategy will be:

- **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. These activities will include the provision of technical support and services, business support, training, and other consulting services to enterprises (large manufacturing enterprises, machinery providers, ICT companies, etc.) making use of the project platform and tools.

- **Exploitation of the SERENA Demonstrators**:

The 4 main Demonstrators (carried out in WP6) will act as key 'business funnels' to exploit SERENA, as they will constitute real-wold proof of the added value SERENA can provide. To this end, a business plan for each Demonstrator, their expansion and the possibility for wider deployments in production environments will be devised.

- **Partners' individual exploitation plans**:

As explained in detail in Section 5.4, most partners are already involved in business and/or research activities in manufacturing, IoT, big data and Data Services and ICT. 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 be regulated in the scope of an exploitation agreement (EA) and a governance model to be selected and pursued. This exploitation agreement (to be defined by the last version of the Exploitation Plan in D7.4), will blueprint the operational and business roles of the partners in the scope of the ecosystem, while also regulating their future business relationships.

To have a shared vision and, consequently, a shared version of the exploitation agreement, initial feedback, and experiences from the actual results of exploitation activities put forward during the project period within the value chains will be taken into account, as well as partner visions and business objectives. To this end, a series of activities will be carried out to harmonise the various point of views and concentrate on a shared, common objective.

In this initial phase of the project, partners are positively evaluating the adoption of a ***Joint Exploitation model*** able to address, in particular, what is also defined as *external* exploitation, i.e. bringing the SERENA results to the outside world and generating business opportunities through these results. In its initial perspective, a SERENA Joint Exploitation is devised as a further step compared to individual exploitation, to develop a common and consistent vision by partners aimed at clarifying the following issues:

- Which **role** is played specifically by each profile involved in SERENA (Universities/Research Centres, ICT/tech industry, manufacturing companies, SMEs.
- What and **how** SERENA could be exploited by each stakeholder.
- How the joint exploitation strategy could be **introduced**.

All SERENA partners will actively participate in the establishment, operation, support and sustainability of the project ecosystem. Furthermore, they will contribute to the gradual and continuous expansion of the ecosystem based on additional stakeholders in both the manufacturing, maintenance and ICT/Data domains. 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***: these are the main potential users/clients of SERENA. For them, SERENA is primarily developing its services and technologies. Regarding maintenance providers, they are also 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, 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 other manufacturing and industrial domains (e.g. transport, construction, etc.) 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 to relevant H2020 calls (and potentially even *Horizon Europe*) and projects.
4. ***Research organizations***: similarly, to Universities and Industries, research partners will exploit the knowledge, expertise and results produced in SERENA in order to provide their clients with consulting research and business services and will, in turn, benefit from the research advances.
5. ***Citizens***: in the SERENA vision they are especially **final consumers**, who will benefit indirectly from SERENA which will enable manufacturers to provide better offers and better-quality products. In this view, citizens will ultimately become the final consumers of an innovative, more effective, and competitive manufacturing value chain, contributing to the overall positive growth of the European manufacturing market.

To make the SERENA strategy more concrete, a set of Assets (presented in detail in the next section) have been identified. These assets are the building blocks of SERENA while their exploitation potential has been recognized within them.

As part of the evolution of the **ecosystem**, additional services (e.g., innovation management services) could be provided. These services will need to fit in the partners' strategy for value generation, through offering some of these services at a fee, following an initial pilot phase of ecosystem expansion, where such services will be offered free of charge, also leveraging on the fact that several SERENA Assets will be Open Source.

From a more business-strategic point of view, there is a consensus in maintaining a 'live' version of the SERENA platform 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 able to access the **sandbox** and interested users will also be able to request access which will be provided for free, excluding possible transaction fees for the data. This will serve on the one hand to make easier the internal exploitation, in fact partners will be granted free access to the code; on the other hand, joint exploitation (towards external actors) will leverage the existing platform as a showcase. Commercial exploitation will be mainly focused on offering value added services, or what could be (very broadly) defined as integration and consultancy services, as well as training around the SERENA platform and assets leveraging the stakeholders brought in by partners through joint exploitation initiatives.

5.1.2 IPR Analysis and Management

As for all H2020 projects, SERENA is defining and agreeing upon an IPR management strategy to ensure exploitation objectives are met and ownership and intellectual property issues do not hinder after-project developments. It is important to underline, already in this first version of the SERENA Exploitation plan, that SERENA partners are strongly committed to releasing project results and assets as much as possible as Open Source (in the case of software) and with open/sharable licenses in the case of other types of IP.

Even with the clear 'Open Source objective' regarding IPR we have in SERENA, it is important here - in the context of our exploitation plan – to pinpoint some important concepts and baselines related to the topic, to seamlessly integrate a common IP management vision within our Exploitation.
The European Commission establishes basic common criteria for foreground generated in H2020 projects through the Annotated Grant Agreement with the Commission:

"Foreground shall be the property of the beneficiary carrying out the work generating that foreground".

In case of joint work, an agreement is foreseen between partners:

"Where several beneficiaries have jointly carried out work generating foreground and where their respective share of the work cannot be ascertained, they shall have joint ownership of such foreground. They shall establish an agreement regarding the allocation and terms of exercising that joint ownership"

Although apparently clear-cut, establishing IPR for foreground is not necessarily so, especially in the case of software, reason being that software is usually developed in an 'ecosystem' composed of previously developed software (e.g. libraries), platforms, and interactions with other platforms. Furthermore, IT research activities imply continuous updates and fine-tuning which is often impossible to plan ahead of time (e.g. use of certain libraries which prove to be technically non-satisfactory or use of platforms which do not handle formats required by the project). Therefore, it is important to establish a common understanding of the foreseen licenses for software and the (cross) implications such choices might generate, possibly taking into account barriers and issues while finding sensible and sustainable solutions.

As for ownership, especially related to software and platforms, there are various possible models for defining it. A 2012 White paper on IT software governance [2] published by the Commission already suggested six major models for determining ownership and agreements.

1. Lines of code produced

This method (also known as SLOC - Source lines of code) is straightforward as it defines a metric where lines of code produced are counted and ownership is assigned to the partner who produced those lines of code. This enables the use of a quantifiable measure of the effort involved in development which can easily be verified at a very detailed level. The main disadvantage of this method is that lines of code are not necessarily an accurate measurement of effort, favouring more terse developers and languages, resulting unfair to efficient coders, and possibly leading to artificial inflation.

2. Technical input provided

This approach attempts to quantify technical input, such as design ideas, requirements, testing, etc., that each party provided beyond the stark measuring of code lines, aiming at a more accurate and fair assessment of the effort and importance of the contributions. However, this approach suffers from difficulties related to the objective measurement of input. In fact, there are no established criteria to determine how certain activities contributed to the technical advancements of the project, and what their weight was. Practically, this means that each project should define its own agreed metrics and ensure accurate and fair measurement of such scores.

3. Agree on contributions

Because determining ownership based on lines of code or technical input can prove to be unfair or overly complex, the consortium can agree on defining metrics and proxies for technical input, such as financial effort (cost, funding, own input), manpower (hours, men months), responsibility (e.g. different weights for task leaders). Such a method still poses a certain risk of unfairness and subjectivity, depending on many factors such as seniority of employers working on the project, geographical differences, etc. However, it leaves a margin for negotiation and reasoning, and is thus foreseeable in consortiums where agreement between parties can easily be reached.

[2] Daniel Field (editor) - Ownership and governance models in collaborative IT projects – a whitepaper - http://ec.europa.eu/digital-agenda/events/cf/ios12/document.cfm?doc_id=23446

4. Musketeer model

This model [3] envisages all partners becoming joint owners ('one for all') of assets regardless of individual contributions. Essentially any partner is allowed to act as a single owner. The model requires signing a further agreement which establishes under what conditions results can be used. The main advantages of this model are flexibility and potential higher revenues for the single partners exploiting results. The musketeer model presents a risk of unfairness towards 'leading' partners as well as certain partners who have less capacity (due to the nature of their organisation) to exploit results, and thus needs a clear understanding of the expected results for each partner.

5. Mutual granting of access rights

This model foresees that partners grant each other access rights to the assets they produced and own while weaving rights to financial compensation deriving from those assets. Essentially in this model ownership is not transferred but use of results for commercial use is permitted. The scenario is somewhat like the one created in the musketeer approach, with less bureaucratic overheads, enabling easier and possibly more profitable exploitation of the results. In this model, there is a potential risk for unclear responsibility and commitment in the maintenance and further development of the software (e.g. the owner decides to cease development); additionally, non-owner partners may sometimes become dependent on the owning partner, e.g. concerning licensing, re-selling and rights granting.

6. Joint Ownership

This model is particularly adequate when one or both of the following conditions apply:

a) One partner has the main ownership/lead and maintains the package, with other partners only providing minor testing/integration contributions
b) One or more software packages are released with Open Source licenses

It is evident that when condition (a.) is true, it is easy to agree on- and assign ownership of the package to the single partner developing and maintaining it, thus the overall ownership of the platform is joint. The Open Source model foresees licensing of software with selected Open Source licenses, effectively allowing partners to use project results (or certain components) they do not directly own. Additionally, this potentially opens the possibility for external parties to access to the software given the rights established in the license. This model ensures easy access and use of assets to partners but also adds diffusion potential, community building and enlargement of the ecosystem. Depending on the selected licenses, ownership will carry different implications (weaker with permissive licenses, stronger with more restrictive ones), and a clear map shall have to be defined.

Table 5-1 below summarizes these models highlighting their pros and cons.

Model	Pros	Cons
Lines of code	- Objective measurement of effort - Easily quantifiable (also automatically) - Established in software cost assessment	- Can be unfair with respect to programming languages and coding styles - Can be artificially inflated - Only takes into account coding, not other contributions
Technical input	- More comprehensive quantification of technical inputs - Aims at more accurate and fair assessment	- Unclear metrics - Can be a lengthy process - Not always easy to agree on criteria

[3] Pioneered by the FP7 Aladin AAL project (http://www.aladdin-project.eu) and experimented by the Bonfire project http://www.bonfire-project.eu

Model	Pros	Cons
Contributions agreement	- Defines metrics tailored to the project - Can be perceived as fairer by parties	- Needs negotiations and agreement - Risk of 'bigger' partners having more weight - Certain metrics can still prove unfair (e.g. financial input vs. geography)
Musketeer model	- Flexibility - Potential for higher revenue generation	- Risk of favouring 'leading' parties - Requires further agreements - May result less beneficial for non-commercial partners -
Mutual granting of access rights	- Flexibility (similar to musketeer) - Less bureaucratic overheads	- Unclear responsibility with regards to maintaining the assets - Potential lack of commitment - Can generate dependency to owner partners from non-owners
Joint Ownership	- Easy to assign/agree ownership - Flexibility in offering services based on the assets - Best utilises the possibilities of Open Source - Compatible with having both open source and proprietary assets	- May be hard to implement if assets have been created by too many parties together - Needs further agreements on revenue distribution

Table 5-1: Summary of possible ownership models for IT projects

The SERENA consortium has analysed these models and currently the consensus among partners considers the Joint Ownership model as the most relevant for SERENA. In particular, we have outlined a "***Joint Ownership***".

Although, as stated above (and as demonstrated by the current version of our IPR repository), the current SERENA assets are intended to mostly Open Source, in a complex project, it is understandable that in the future not necessarily all assets might be Open Source (or with open licenses): even in this case joint ownership works well when there is a one-to-one relationship between owner partner and package (condition a. above), because Open Source packages will not effectively pose particular problems with regards to ownership, while proprietary packages will remain ownership of their own developers. Of course, for use of proprietary software, mutual access rights granting (e.g. in royalty free form) can still happen within the partnership: in this case, an adequate governance model has to be chosen. As outlined in section 3.4 there are essentially 4. Possible stages for revenue generation around open source: (1) making the software open source and available, (2) adding value-added services and support, (3) creating commercial/enterprise versions and (4) adding value to the core (e.g. through plug-ins and extensions). At this stage of the project all of these options are on the table and as the Assets (and business/exploitation actions evolve), will be refined and tailored to each asset, eventually flowing into the value propositions and business plan, also supported by economic analyses and forecasts.

5.1.2.1 Licences

In case of presence of software assets, the need of granting certain rights to third parties which will use them, while reserving other ones (effectively restricting certain uses) arises: [4] for example, a license

[4] European IPR Helpdesk, *Fact Sheet - IPR Management in Software Development* - https://www.iprhelpdesk.eu/sites/default/files/newsdocuments/Fact-Sheet-IPR-Management-in-Software-Development.pdf

may restrict usage (educational vs. commercial), the number of machines a software can be installed or run on (in case of physical installations) or number of user / API calls / usage volumes / instances allowed (in the case of the as a Service model). Broadly, the more the license is closed, the more rights are reserved and vice versa. In terms of licenses, two main categories of licenses exist: Open Source and proprietary licences. Open Source licenses restrict fewer rights (most notably unrestricted access to the source code of a program) compared to proprietary licenses. The term *proprietary* is sometimes confused with *commercial*: both Open Source and proprietary licenses can be commercial or not (an example of proprietary non-commercial licenses is freeware software).

5.1.2.2 Open Source

It is useful to observe that Open Source licenses often come in the form of *bare licenses* in that they do not imply a contract. Generally, a (bare) license, unlike a contract, does not imply two parties signing (and thus agreeing) to – and about – the terms: the licensee usually accepts and must comply with the terms of the license, or else an infringement occurs.

For a license to be a contract, there must be an *offer*, *acceptance*, and *consideration* [5] . These are legal terms with a precise meaning. An *offer* means "an expression of willingness to contract on certain terms, made with the intention that it shall become binding as soon as it is accepted by the person to whom it is addressed" [6] . In terms of Open Source software this usually means making the software source code available on a public repository with an indicated license. *Acceptance* means that the licensee accepts to create a contract, in turn accepting the license. In traditional contracts, a written agreement is usually signed. In the case of software, acceptance occurs when a user clicks on the "ACCEPT" button or simply unseals the box containing the software (so-called 'shrink-wrap'). In the case of online distribution, there should be an explicit acceptance of the license. *Consideration* is a rather complex aspect to define for Open Source software licenses, as it implies the exchange of value (usually, but not necessarily a payment) within a contract. In this view, one should argue that Open Source licenses, where software is offered for free - i.e. *gratis* – offer no *consideration*. Actually, some interpretations consider mere use of the software and acceptance of the license as substitutes for *consideration.*[5] Nevertheless where a licensor wants the license to also be a contract all three qualities (*promise, acceptance* and *consideration*) should be covered as best as possible.

Recent court decisions in both the United States[7] and Europe[8] have ruled the validity of Open Source licenses, although they explicitly comply with the characteristics of a contract as outlined above. Although debate is still currently underway, it is thus very sensible to consider bare open source licenses as valid.

While there are dozens of approved Open Source licenses, for the scope of this document we shall group them into three main categories: *Academic*, *Reciprocal* and *Context* licenses.[4]

- ***Academic* licenses** (so called because historically originated from Academic bodies, such as universities) are the most liberal type of license, essentially allowing licensees to use the code without any restriction whatsoever, apart from authorship recognition. Among these licenses, the Apache license (in particular the 2.0 version) is one of the most popular 'business-friendly' ones and will be considered for the Assets where possible. Other popular licenses with the same characteristics are the MIT, Eclipse and BSD licenses. The obvious advantage of using *Academic* style licenses in complex research projects such as SERENA is their openness, which enables wide dissemination of results without imposing restrictions or obligations on the licensee.

[5] Lawrence Rosen, Open Source Licensing - Software Freedom and Intellectual Property Law – Prentice Hall 2004 – Online edition http://www.rosenlaw.com/oslbook.htm

[6] *Offer and acceptance* - Wikipedia article - http://en.wikipedia.org/wiki/Offer_and_acceptance#Offer [last retrieved 19-06-2018]

[7] See for example Jacobsen v. Kamind associates, inc. – California, http://www.cafc.uscourts.gov/opinions/08-1001.pdf

[8] See for example Welte v. Fantec GmbH (Germany)

- ***Reciprocal* licenses,** as the name suggests, include licenses which allow free use, modification and distribution of derivate works as long as such works are themselves released with the same license. These licenses are also defined as *copyleft* in that they intentionally hinder exclusive rights restrictions based on copyright. This mechanism ensures that the initial developer of the code is guaranteed use of the same license in derivate works thus avoiding 'cannibalisation' of code. It is evident that reciprocal licenses impose very strong obligations on the licensee, and should be carefully pondered in multi-partner projects, especially where commercial entities are involved. Prominent examples of reciprocal licenses are the GPL v3 and the EUPL v1.1, a license created and recognised by the European Commission.[9]

- ***Context* licenses** stand in the middle of the former two. They are basically reciprocal licenses, but reciprocity can be waived under certain technical conditions. For example, if the code is used "as is" and not modified, context licenses allow for distribution in binary packages like in Academic licenses. However, if the code was modified, reciprocity rules apply, and the code must be distributed. The L-GPL is the most prominent example of a context license: it is a modified version of the GPL. While context licenses are often compatible with other licenses, they can create a very high risk of generating uncertainty and a 'grey area' for acceptable use: in fact, it is not always easy to technically determine if and how a work is allowed to include binaries or if it is required to comply with reciprocity obligations.

While considering open source licenses, it should be underlined that these explicitly foresee the software developer not to be held liable, in other words the software is distributed 'as is'. To this end SERENA partners shall not be considered liable for any use/misuse of the software it will distribute as open source as foreseen in the licenses. Indeed, the possibility to offer dual licenses for open source software, also stems from this consideration, because additional licenses or agreements can be offered to clients, for example SLA or liability licenses.

5.1.2.3 Proprietary licenses

As stated, we currently do not foresee the use of proprietary licenses, but we will briefly analyse some key aspects about them in case the need to apply them arises in the project.
As for other licenses, it is not easy to compile a taxonomy of licenses which are often included in commercial offerings and are hard to find in the public domain. Here, we shall provide an overview of certain widespread features of proprietary licenses as well as indications relevant to SERENA in the possible application and use of these licenses for SERENA components, should there be a need. As already explained, with proprietary licenses the licensor maintains certain exclusive rights and exercises those rights in the license with a series of provisions and limitations. Most widespread limitations used in proprietary licenses are:

- **Number of machines** a software can be installed on. Depending on the commercial agreements these can be fixed numbers or thresholds (e.g. up to 50 seats).
- **Technical restrictions on software capabilities**: this means the licensee implements a series of technical devices (e.g. license key, hardware lock, limited functionality) which regulate the functionalities of the software and may be subject to commercial agreements, pricing schemes etc., for example a 'personal' version of the software distributed for free with limitations on functionality, or a software which only works if a hardware key is attached to the machine.
- **Context of use**. This usually differentiates three main categories: personal/non-commercial, educational/academic, commercial. The former two categories are often offered more convenient economic conditions paired with specific versions of the software.
- **Availability of source code**. Proprietary licenses usually do not foresee distribution of the source code but may allow source code delivery when it is required to run the software (namely web applications) or for inspection by government agencies. Access by licensees to the source code is usually regulated by additional non-disclosure agreements.

[9] See https://joinup.ec.europa.eu/software/page/eupl

In the **as a Service (aaS)** model the above limitations are still relevant but are transposed to 'virtual' and online domains rather than physical. The **number of machines** becomes the number of instances and the 'seats' become the **number of users**. **Technical restrictions** (e.g. personal vs enterprise version), are embedded within the functionality of the provided aaS software (e.g. limited storage space, memory, compute time, data volumes for a personal accounts) and, similarly, **context of use** can determine the provided level of service and pricing strategy. In terms of **availability of the source code**, in the case of proprietary licenses in an aaS context, the situation is similar, with the only difference that for certain technologies (e.g. JavaScript which is run on users' clients), the exposure of part of the source code is unavoidable. However, the client code exposed is usually not the key technology/code for the software and therefore exposing it does not pose a threat to the core IP involved.

5.1.3 Governance Analysis

In order to carry out the SERENA Joint Exploitation Plan and reach its objectives, appropriate means for governance will have to be agreed upon. During the project period, the consortium is governed by the Consortium Agreement, but once SERENA enters its full exploitation phase, partners will have to agree on a shared governance model. Such model will essentially be the means to control the SERENA Exploitation in the post-project phase ensuring that objectives are pursued and met. The chosen governance model and methods are strongly interrelated to the business models described above. The following factors will have to be considered:

- **Objectives** clearly in line with the exploitation objectives and compatible with the ownership models and IPR strategies.
- **Model** chosen for the governing entity/initiative to pursue the above objectives
- **Roles** partners are willing to undertake. These roles shall be formalised through specific agreements for partners to sign, committing to the defined role(s).
- **Rules** for participation. In particular the consortium shall have to decide if it wants to pursue a model where only current project partners can join, or where external participation is foreseen.

Additionally, rules and schemes, including fees and revenue sharing, will be clearly set out.
In SERENA three main models are proposed and will be carefully considered, given the project nature and partners' characteristics, all of which have reportedly been successfully applied in other European IT research projects [10] .The three models are described hereafter, also highlighting the main pros and cons. Currently there is a preliminary consensus towards the last one, but a final decision will only be taken towards the end of the project and presented in the final version of the Exploitation Plan.

New legal entity

With this model, a new legal entity is created to manage the foreground generated and to pursue both commercial and non-commercial objectives of the SERENA exploitation. This model foresees a strong centralised management (company-like) and typical roles covered by partners who would usually provide staff and resources. The creation of a legal entity tends to face a certain degree of legal and 'bureaucratic' difficulties, thus certainly timing can be long. It enables a strong implementation of the exploitation strategies and, once set-up, would prove rather stable. Partners could join with different roles (as partners, stakeholders, etc.) and various levels of commitment. It should be mentioned that joining a profit-making entity might not always be a viable solution for some partners (e.g. non-for-profit and research organizations), however, various solutions exist for their involvement. There exists a risk that creating a new legal entity might result in a too convoluted and resource- and time-

[10] European IPR Helpdesk, *Fact Sheet The Plan for the Exploitation and Dissemination of Results in Horizon 2020* - https://www.iprhelpdesk.eu/sites/default/files/newsdocuments/FS-Plan-for-the-exploitation-and-dissemination-of-results_1.pdf

consuming activity. Additionally, the costs (i.e. overhead) for implementing and maintaining such a monolithic structure should be factored in and their long-term sustainability seriously taken into consideration.

PROS	CONS
- Central, efficient management - Stricter implementation of exploitation strategies - Stability	- Bureaucracy overhead - High monetary initial investment needed - Resource-consuming to run - Not very flexible - May not be viable for some partners

Joint venture

Through a joint venture new business opportunity could be pursued by SERENA partners who would also contribute with resources (financial, assets, skills, staff etc.) and share benefits and risks in the endeavour. In this case, a partnership would be created where shares could vary among partners. While a legal entity doesn't necessarily need to exist, a joint venture could use two partnership models:

a. A new organisation possibly managed by one of the partners. Participants could contribute with infrastructure, staff and resources and get a stake of the revenues.
b. No organisation would be created. This model would be like the current collaborative project model, where only staff efforts and resources are devoted to the endeavour. Very clear agreements on revenue sharing must be put forward in this case.

In both cases, a centralised joint venture agreement would be required to establish revenue, risks and liability sharing. This should make clear how decision making is carried out, setting up a board where the strategy and actions are decided. Venture partners should cover roles like those of a legal entity. The most complex part of setting up the joint venture is to agree for all partners on the costs and revenue sharing (who pays what and who cashes what). While more flexible than creating a legal entity, the SERENA partners expressed concern that this model also poses the risk of being too constrained. For some partners, it could still be hard to formally engage (and commit) to providing (even non-monetary) resources to the venture and sign such type of agreement. Although lower compared to a legal entity, the costs for management (e.g. board meetings etc.) should be factored into this model.

PROS	CONS
- Shared benefits and risks - Flexibility - Allows for both central and/or shared management - Allows to be widened to non-project entities	- Important changes need everyone's approval (slow) - May be harder to define profit sharing mechanisms - Lengthy process to set up the Venture and agree on revenue and cost models - Some partners (e.g. academia) may not be able to join due to legal constraints and bureaucracy

Multilateral collaboration agreements model

This model, which has already gained early consensus among SERENA partners, foresees flexible business agreements, with a series of partners collaborating in the delivery of products and services based on SERENA, without a central structure or entity. Therefore, a global agreement is not strictly necessary: in fact, each partner becomes a 'link' in a supply chain and essentially establishes agreements with the other interested partners: clearly agreements between the involved parties *are* required but offer a high degree of flexibility. Typically, this partners' chain will be covered by all or

most current SERENA partners, who will also be free to establish other business agreements with third parties. This type of governance will usually include at least the following actors/functions: sales, providers, and consultancies.

Adopting this flexible model will ensure that if certain roles cannot be covered by partners, third parties can be added. Partner responsibility will mostly be 'localised' in that partners will be responsible for delivery of their own product/service. Ownership and IPR are easily managed in this model, as each partner owns and manages its share and possible further agreements can be made on a case-by-case basis. Of course, this also considers an IPR strategy which will would foresee all partners to be able to access the current 'as is' SERENA assets as Open Source (see Section 4.). This model also fits well into the Big Data Value Chain cited above, where – depending on each partner's expertise – the various stages can be covered.

PROS	CONS
- Little bureaucracy - Relatively easy to set-up - Maintains partners' flexibility - All kinds of partners can participate - Fits well with the Virtual Enterprise model - Well suited to exploit modular assets in diverse environments	- Risk of individual objectives clashing - Week global objectives - Might favour some partner over others - Changes in links might disrupt the chain

From an organisational point of view, as already stated, there is a will to maintain the SERENA platform running for a period after the project end, and accessible by both SERENA partners and possibly interested third parties in the chain (be it clients or additional suppliers). This will provide a working sandbox of the system for all project partners, to be used as demo application and presentational tool. If this model is selected by partners, a main contact point for the project will be selected, easing communication within and outside the project consortium and facilitating the set-up of needed agreements.

5.2 Initial Exploitation Assets definition and mapping

In this section, an initial presentation of the exploitable assets planned to be delivered by SERENA, reflecting the early development stage of the project at month 12, is provided. Assets are defined as main project outcomes, elements of the SERENA Platform, or a combination of elements with a specific exploitation potential of different types, and include IT platforms and components, as well as frameworks, knowledge, and other results. It should be underlined that in the development of the presented assets, a series of other project results such as components, methodologies and paradigms will be delivered: here we focus on the main assets which we have also categorised (packaged) considering their exploitation (business) potential. Therefore, for each asset, an 'exploitation-oriented' description which underlines unique selling points and main features is provided together with the most relevant stakeholders and possible exploitation channels. For completeness purposes, interrelations and additional components involved are mentioned and possible competitors in the market are presented. Additionally, for each asset, replicability opportunities are also identified. The following table summarises all the current Assets.

Asset title	Target License
Remote factory condition monitoring and control	Proprietary
AI condition-based maintenance and planning systems	Proprietary
AR-based technologies for remote assistance and human operator support	Proprietary
Cloud-based platform for versatile remote diagnostics	Mixed
Pilot cell for versatile maintenance in White goods industry	n.a
Pilot cell for versatile maintenance in Elevators production industry	n.a
Pilot cell for versatile maintenance in Metrological engineering industry	Proprietary
Versatile maintenance in Steel parts production and link to other industries	t.b.d.
Pilot on versatile maintenance for tool providers	n.a.
Databox HW	Proprietary
Universal data collection	Proprietary
Data pre-processing and forwarding	Proprietary
Edge Analytics	Proprietary
State Detection	Proprietary
Health Assessment	Proprietary
Prognostic Assessment	Proprietary
Advisory Generation	Proprietary
SERENA Repository API (SRA), Sensor Data and Metadata Cloud Storage (SCS)	Proprietary

Table 5-2 The SERENA Exploitable Assets at Month 6

In order to ensure consistency and a unified approach, the definition of Assets was carried out as a collaborative and distributed process with all partners, through the creation of a live 'Assets Database' and using a shared template. The template is presented (along with descriptions) in Table 5-3 below.

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

Table 5-3: SERENA Exploitation Assets definition template

5.2.1 Remote factory condition monitoring and control

Asset title	Remote factory condition monitoring and control
Description	Core development of WP2 will be the versatile data acquisition platform, referred to as DataBox. To allow an easy adaption of the solution to various use cases, the platform needs to be highly modular and flexible in terms of hard and software.
Lead partner(s) (point of reference)	IPT
SERENA results and components involved	-
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	management
Exploitation channel(s)	publications, trade fairs, existing customer relations
Possible competitors	other automation suppliers/vendors, other research consortiums
Replicability in other domains and ecosystems	large variety of machinery in production and research.
Action plan / status	-

5.2.2 AI condition-based maintenance and planning systems

Asset title	AI condition-based maintenance and planning systems
Description	Purpose of WP3 is to improve existing solutions for predictive maintenance as well as planning of maintenance solutions regarding data analytics algorithms and predicting potential failures on the equipment. Hybrid approaches including both data driven and physics-based models of the machine/ equipment will be implemented in the cases if higher prediction accuracy is needed.
Lead partner(s) (point of reference)	VTT
SERENA results and components involved	State detection, Health Assessment, Prognostics Assessment and Advisory Generation blocks, Maintenance aware scheduling
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	All Serena partners and other customers of VTT
Exploitation channel(s)	Publications, trade fairs, existing customer relations
Possible competitors	Other R&D companies and universities
Replicability in other domains and ecosystems	System can easily be adopted to different domains.
Action plan / status	Not yet scheduled

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

Asset title	AR-based technologies for remote assistance and human operator support
Description	Core development of work package 4 will be an augmented reality-based step-by-step worker guidance system that can run on mobile devices like smart glasses and tablets. A web-based modelling environment serves maintenance managers as authoring tool.
Lead partner(s) (point of reference)	OCULAVIS
SERENA results and components involved	-
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	SERENA partners, direct customers, existing leads
Exploitation channel(s)	Consulting, Customization
Possible competitors	Other software companies in the field of augmented reality
Replicability in other domains and ecosystems	system can easily be adopted to different domains.
Action plan / status	not yet scheduled

5.2.4 Cloud-based platform for versatile remote diagnostics

Asset title	Cloud-based platform for versatile remote diagnostics
Description	This is the SERENA Cloud Platform, mainly the outcome of WP5, which is able to provide cloud computing and data processing capabilities to the overall SERENA solutions, in order to reinforce a shared situation awareness among all the connected components. First selling point will be the incorporation of the innovative SERENA paradigms, especially on communication and data sharing characteristics. A selling point will be the possibility to integrate the Platform with existing equipment actually 'augmenting' it and transforming legacy equipment in to smart equipment, thanks to the adoption of remove condition monitoring dedicated HW developed within WP2. The Platform will offer innovative analytics and data processing features based on a multi-container hybrid (edge and cloud) architecture, taking advantages of applying machine learning techniques, allowing to detect and faulty or non-optimal components but also assess the overall process efficiency. The Platform includes security and confidentiality 'by design' at all layers ensuring full security of clients as well as compliance with standards regarding personal data.
Lead partner(s) (point of reference)	ENG
SERENA results and components involved	All components involved in the Platform
License	Mixed
Type(s) of asset	Platform Demonstrator
Relevant	SERENA partners, manufacturing clients, data providers, machinery

stakeholders	providers
Exploitation channel(s)	Joint collaborations within SERENA exploitation strategy, client relations, dissemination and communication events, further research and innovation
Possible competitors	Suppliers of predictive maintenance and diagnostics applications
Replicability in other domains and ecosystems	Construction, Agriculture, IoT-based industries
Action plan / status	- In the next period piggy-back on SERENA external communication and dissemination activities - Internal presentations and 'pitching' by relevant partners - Early demos

5.2.5 Pilot cell for versatile maintenance in White goods industry

Asset title	Pilot cell for versatile maintenance in White goods industry
Description	The pilot cell is based on a Foaming Machine equipped with sensors to monitor process parameters. The main asset to exploit is mostly intangible and it's constituted by the transferability of the architecture to other machines.
Lead partner(s) (point of reference)	WHEMEA
SERENA results and components involved	-
License	-
Type(s) of asset	Demonstrator
Relevant stakeholders	WHR Factory managers; External suppliers of similar machines;
Exploitation channel(s)	Extension to other Foaming Equipment in WHR production sites.
Possible competitors	Suppliers of equipment could offer integrated Predictive Maintenance functionalities or services embedded in the system
Replicability in other domains and ecosystems	Foaming Equipment in all WHR factories
Action plan / status	Internal exploitation only.

5.2.6 Pilot cell for versatile maintenance in Elevators production industry

Asset title	Pilot cell for versatile maintenance in Elevators production industry
Description	Elevator industry pilot is based on monitoring automated thin metal sheet manufacturing equipment. The main asset is to forward potential failure data from various sources to provide analyses for predictive maintenance actions.
Lead partner(s) (point of reference)	KONE
SERENA results and components involved	-
License	-
Type(s) of asset	Demonstrator
Relevant stakeholders	KONE personnel and equipment manufacturer
Exploitation	Exploited within KONE Supply Units

channel(s)	
Possible competitors	-
Replicability in other domains and ecosystems	Other KONE Supply Unit with similar machinery.
Action plan / status	Internal exploitation only. Not yet scheduled.

5.2.7 Pilot cell for versatile maintenance in Metrological engineering industry

Asset title	Pilot cell for versatile maintenance in Metrological engineering industry
Description	Metrology demonstrator is focused on monitoring the performance of the coordinate measuring machine at the metrology laboratory in order to predict potential failures. TRIMEK will offer a remote predictive maintenance service which will enable the access to data from different sources in order to detect potential failures and synchronise maintenance activities with production and logistics activities.
Lead partner(s) (point of reference)	TRIMEK
SERENA results and components involved	-
License	Proprietary
Type(s) of asset	Demonstrator
Relevant stakeholders	TRIMEK maintenance personnel and R&D managers.
Exploitation channel(s)	Customer relations, trade fairs
Possible competitors	Suppliers of CMMs with predictive maintenance services
Replicability in other domains and ecosystems	CMMs and other quality control systems in different manufacturing plants
Action plan / status	not yet scheduled

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

Asset title	Versatile maintenance in Steel parts production and link to other industries
Description	VDL Weweler pilot case will be oriented on providing data for testing the **SERENA** platform and proposing maintenance/repairing activities within the monitored equipment. The focus within the **SERENA** Project will be twofold. The first aim will be given upon monitoring the working condition of the rolling machine itself through the use of external sensors as well as the data collected through the PLC. On the other hand, it is the product output of the trailing arm in terms of dimensions and straightness.
Lead partner(s) (point of reference)	VDL WEWELER
SERENA results and components involved	The **SERENA** platform is expected to predict the replacement of segments of the rolling mill machine. Through a collection of data from the sensors on the milling machine and the correlation of them with a digital twin model, the target is to accurately predict when the segments need to be replaced. Additionally, and as the quality of the product is strictly related to the working conditions of the milling machine, a measuring system is planned to be designed and developed. This measuring system will precise calculate

	the straightness of the formed trailing arms once the milling process will be completed. Based on the measured values and the correlation of them with the status of the milling machine, accurate maintenance predictions are foreseen. Moreover, the **SERENA** platform will schedule the maintenance activities aiming at reducing the production stoppage time and avoiding as much as possible any interruptions with the production plan. The maintenance operators will be equipped with AR technologies for guiding them through a correct task execution as well as for training reasons.
License	Proprietary
Type(s) of asset	Demonstrator
Relevant stakeholders	VDL VEWELER, VDL
Exploitation channel(s)	Exploited within VDL, VDLWEWELER production and supply Units
Possible competitors	-
Replicability in other domains and ecosystems	-
Action plan / status	Internal exploitation only. Not yet scheduled.

5.2.9 Pilot on versatile maintenance for tool providers

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

5.2.10 Databox HW

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

5.2.11 Universal data collection

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

5.2.12 Data pre-processing and forwarding

Asset title	Data pre-processing and forwarding
Description	Data pre-processing is realised by adding smart data algorithms to the functionality containers. These algorithms can range from simple value extractions to advanced waveform analytics.
Lead partner(s) (point of reference)	IPT
SERENA results and components involved	-
License	Proprietary
Type(s) of asset	Demonstrator
Relevant stakeholders	Equipment suppliers, Automation providers
Exploitation channel(s)	publications, trade fairs, existing customer relations
Possible competitors	other automation suppliers/vendors, other research consortiums
Replicability in other domains and ecosystems	large variety of machinery in production and research.
Action plan / status	not yet scheduled

5.2.13 Edge Analytics

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

5.2.14 State Detection

Asset title	State Detection
Description	State Detection (SD block): facilitates the creation and maintenance of normal baseline “profiles”, searches for abnormalities whenever new data are acquired, and determines in which abnormality zone, if any, the data

	belong (e.g. “alert” or “alarm”).
Lead partner(s) (point of reference)	VTT
SERENA results and components involved	Included in 2. AICM - AI condition-based maintenance and planning system
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	All Serena partners and other customers of VTT
Exploitation channel(s)	-
Possible competitors	Publications, trade fairs, existing customer relations
Replicability in other domains and ecosystems	-
Action plan / status	Other R&D companies and universities

5.2.15 Health Assessment

Asset title	Health Assessment
Description	Health Assessment (HA) block: diagnoses any faults and rates the current health of the equipment or process, considering all state information.
Lead partner(s) (point of reference)	VTT
SERENA results and components involved	Included in 2. AICM - AI condition-based maintenance and planning system
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	All Serena partners and other customers of VTT
Exploitation channel(s)	-
Possible competitors	Publications, trade fairs, existing customer relations
Replicability in other domains and ecosystems	-
Action plan / status	Other R&D companies and universities

5.2.16 Prognostic Assessment

Asset title	Prognostic Assessment
Description	Prognostic Assessment (PA) block: determines future health states and failure modes based on the current health assessment and projected usage loads on the equipment and/or process, as well as remaining useful life predictions.
Lead partner(s) (point of reference)	VTT
SERENA results and components involved	Included in 2. AICM - AI condition-based maintenance and planning system
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	All Serena partners and other customers of VTT

Exploitation channel(s)	-
Possible competitors	Publications, trade fairs, existing customer relations
Replicability in other domains and ecosystems	-
Action plan / status	Other R&D companies and universities

5.2.17 Advisory Generation

Asset title	Advisory Generation
Description	Advisory Generation (AG) block: provides actionable information regarding maintenance or operational changes required to optimize the life of the process and/or equipment.
Lead partner(s) (point of reference)	VTT
SERENA results and components involved	Included in 2. AICM - AI condition-based maintenance and planning system
License	Proprietary
Type(s) of asset	Service, Demonstrator
Relevant stakeholders	All Serena partners and other customers of VTT
Exploitation channel(s)	-
Possible competitors	Publications, trade fairs, existing customer relations
Replicability in other domains and ecosystems	-
Action plan / status	Other R&D companies and universities

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

Asset title	SERENA Repository API (SRA), Sensor Data and Metadata Cloud Storage (SCS)
Description	The SERENA storage driver is a key asset that separates the SERENA subsystem component from the underlying storage implementation. SERENA uses container technology to encapsulate discrete parts of its functionality, such as databases and analytics engines. This makes the SERENA system highly dynamic, scalable, and resilient, as each subsystem can be implemented as a cluster of stateless clones. The state of the cluster is externalized from the cluster containers by means of the SERENA storage driver, which maps the container's storage state to virtual volumes, where individual data assets are represented as storage objects. The storage driver, and the underlying storage virtualization infrastructure, synchronise access to the storage objects. When the individual containers in the subsystem cluster change location of new containers are instantiated, the virtual volumes are made available to the containers at their new location.
Lead partner(s) (point of reference)	DELL
SERENA results and components involved	None at this time

License	Proprietary
Type(s) of asset	Demonstrator, Product
Relevant stakeholders	None at this time
Exploitation channel(s)	Through Dell's existing customer and partner channels
Possible competitors	Certain CSP vendors provide proprietary interfaces to their storage solutions, and this storage driver is intended to be a more accessible solution.
Replicability in other domains and ecosystems	The storage driver is intended to be a generic solution, rather than being tied to any one industry vertical.
Action plan / status	Not yet defined

5.3 Preliminary market, trends and needs analysis

In this section we provide an initial market, trends and needs analysis relevant for the SERENA Exploitation. First, we overview current trends and figures for the manufacturing sector overall, with a strong focus on Europe. Then we focus on the segment of 'Industrial Maintenance and Services', considering trends and needs for predictive maintenance and similar/overlapping segments like 'Maintenance, Repair, & Overhaul'. We also overview the more general 'Data and Cloud' market which, although not directly related to the SERENA assets relates to these in terms of trends and needs of some of the underlying technologies and services. Finally, we provide a SWOT analysis for the current SERENA assets.

5.3.1 Manufacturing Trends, Challenge and Needs

An analysis by Eurostat about *Industrial production statistics* in Europe [11] shows that in 2016 the European Industrial had fully recovered from the devastating impact of the 2008 economic crisis. The positive trend was mainly due to production was mainly due to the manufacturing of motor vehicles, trailers & semi-trailers, and machinery & equipment.

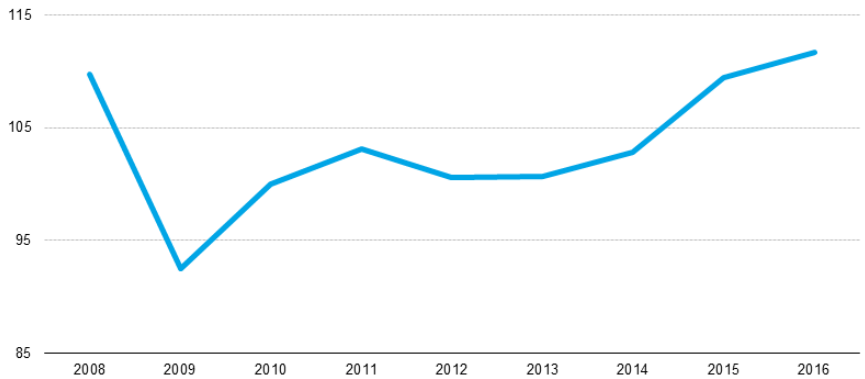


Figure 13: Value of sold industrial production, EU-28, 2008 - 2016 (2010=100) – source: Eurostat

[11] EUROSTAT, *Industrial production statistics* - https://ec.europa.eu/eurostat/statistics-explained/index.php/Industrial_production_statistics

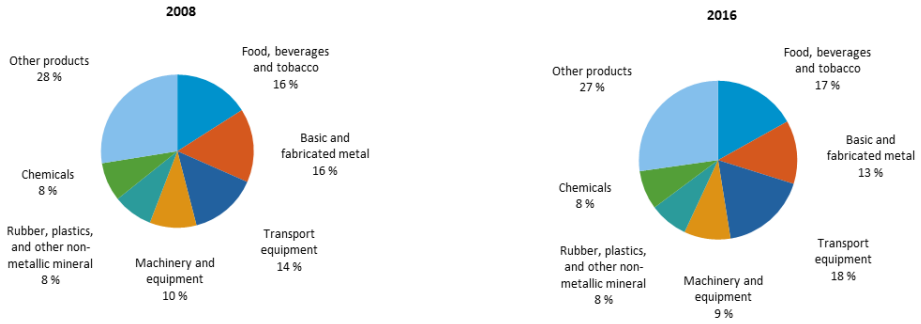


Figure 14: Value of sold production by manufacturing activity, EU-28, 2008 and 2016 (% of value of sold production) -- source: Eurostat

At the same time from a more macroscopic point of view it is well known that the Manufacturing Industry share in EU value added has been declining essentially since the 1970s [12]has been on a continuous decline for a number of years. In 2017 it represented 15% of total EU value added and 15% of total employment. It is also important to highlight, however, that manufacturing is also one of the highest contributors to R&D in Europe as well as trade (63% to 65% exports and imports) and competitiveness. So, while in terms of absolute numbers manufacturing has been declining, it is still one of the strongest contributors to overall EU growth, with a particular re-vitalization in the 'post-crisis' period.

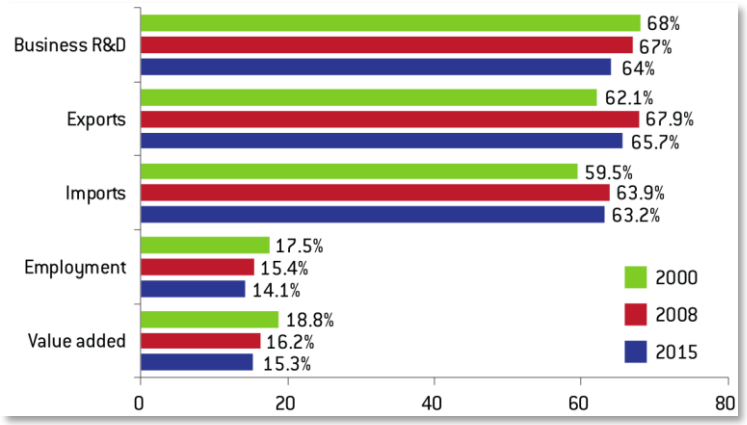


Figure 15: Manufacturing in the EU, key numbers as % of total economy – source: Bruegel based on Eurostat data

[12] Reinhilde Veugelers (editor), *Remaking Europe: the new manufacturing as an engine for growth*, Bruegel, 2017

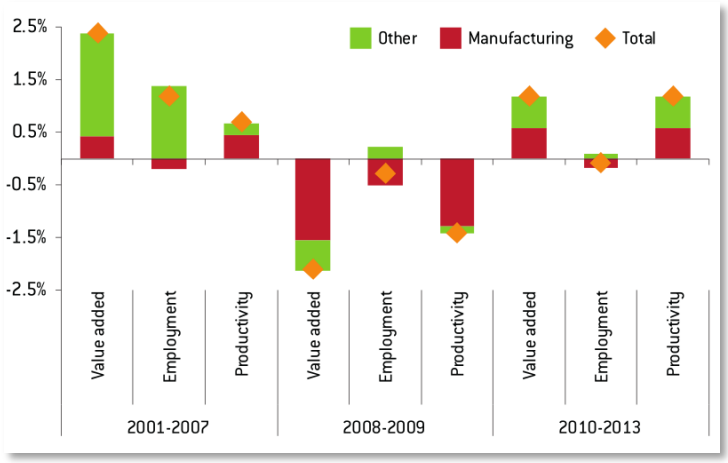


Figure 16: Contribution of manufacturing to total EU economic growth– source: Bruegel based on Eurostat data

In this current landscape two **important trends** emerge in European manufacturing: 1) as the service economy (which is today becoming mostly a digital services economy) rises steadily in Europe, **services** themselves become a driver for the growth and competitiveness of manufacturing both internally (i.e. with manufacturers offering services as well as products), and externally (i.e. providers offering services to manufacturers); 2) the key role of **IT adoption** and investments in manufacturing competitiveness: in fact analysts (e.g. see Brugel), found that greater growth in IT capital stock was associated with better productivity performance. SERENA is in line with both trends with a strong service-oriented approach and the development of innovative IT.

Key trends in European and Global Manufacturing

- The **global general manufacturing** market was valued at $628.5 billion in 2017 (source: PRNewswire)
- ***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)

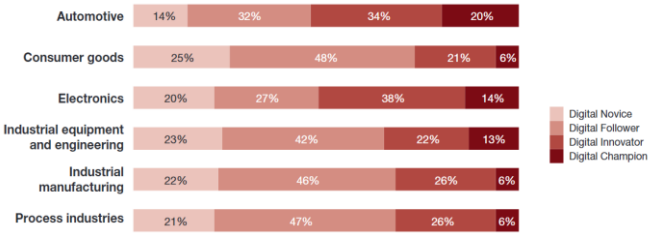


Figure 17: Levels of digital maturity by industry – source: PwC

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

> Focus: The Machinery and Equipment Manufacturing segment

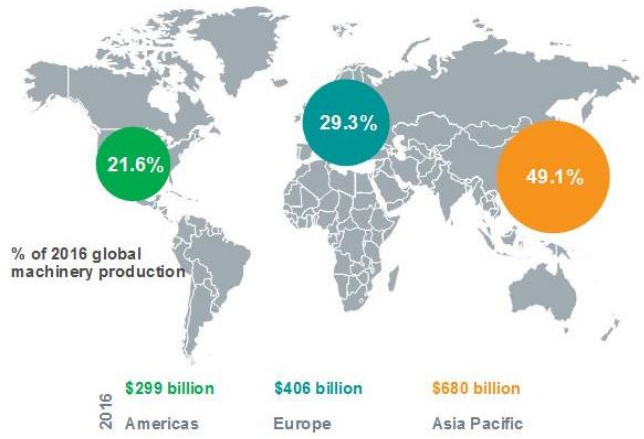


Figure 18 Percent of global machinery production -- source: HIS Market

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 major markets are all expected grow in the next period with construction equipment sales growth +3.4% in 2018, mining capex +7% in 2018, oil & gas capex +4% globally (source: Bloomberg consensus). New infrastructure investments US should drive orders of construction equipment; at the same time commodities and materials costs are rising and account for up to 75% of the total cost-base in certain sectors there potentially hindering profitability.

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.

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

> Focus: White Goods segment

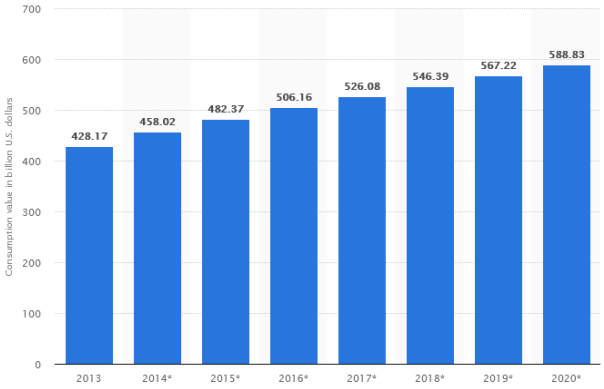


Figure 19 Global consumption value of household appliances from 2013 to 2020 (in billion U.S. dollars) – source: Statista

Revenue in the Household Appliances segment will amount to €17,6 billion in 2018and is expected to grow at an annual growth rate (CAGR 2018-2022) of 9.2%, resulting in a market volume of €25,2 billion by 2022 (source Statista). User penetration of these products is forecast at 20.0% in 2018 and expected to hit 24.1% by 2022. Average revenue per user (ARPU) currently amounts to €130.97. From a geographical perspective highest revenue is being generated in China (€23,8 billion in 2018).

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.

5.3.2 Industrial Maintenance and Services

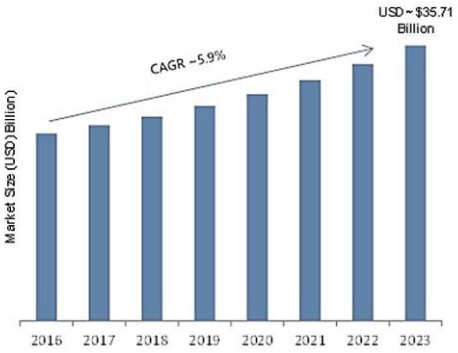


Figure 20: Industrial services market size 2016-2023 – source: Market Research Future

This sector within manufacture is very relevant to SERENA as it includes maintenance and predictive maintenance services. In this subsection we analyse the current market situation and key trends.

The industrial services market is anticipated to increase at a compound annual growth rate (CAGR) of 5.40 percent between 2017 and 2023 and would be worth ca. $35.4 billion by 2023 (source: Market Research Future). Key factors driving the increase of this market are the development service contracts and service agreements, product developments as well as alliances. An increased demand for operational excellence also drives the market, with the need for **lowest downtimes** (and related production halts) as possible. An importance trend is the growing demand for **maintenance as a service** due to increased equipment and production complexity as well as lack and cost of in-house skilled personnel. In fact, operational improvement and maintenance services projected to hold the most important share of the industrial services market (source: Market Research Future).

As with other sectors and segments we have analysed so far, also the industrial services market is expected to grow faster in Asia Pacific (APAC) between 2017 and 2023. In fact in this geographical segment there is also an increased trend of cloud connectivity and consequent adoption of IIoT (Industrial Internet of Things) and predictive maintenance services. Adoption.

In **Europe** the **Maintenance**, Repair, & Overhaul distribution market was valued at $89 billion in 2016 and is expected to reach $109 billion by 2025 (source Grand View Research). The **machinery and equipment** sector were the second largest end-use segment in 2016 for this market and is expected to grow at a CAGR of around 3% from 2017 to 2025.
Increasing manufacturing and industrialization are anticipated to further grow demand for maintenance repair & operations equipment and service providers. MRO distributors offer various **services**, such as the delivery of pure parts, service execution coordination, and comprehensive planning. Equipment used in the European manufacturing sector is becoming older, therefore manufacturers need to spend on equipment maintenance and repair services, with a predicted higher increase compared to other segments.

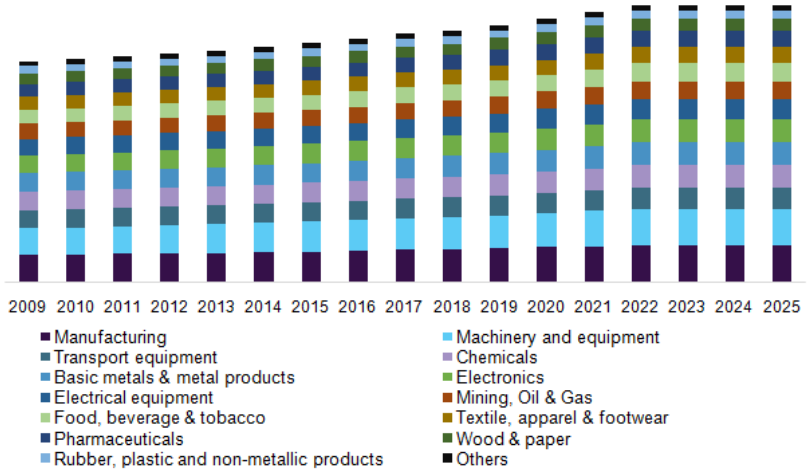


Figure 21 Europe MRO distribution market by end-use, 2009 - 2025 (USD Million) – source Grand View Research

The market shows a **strong outsourcing trend**, as many companies need to cut costs on inventory and specialized workforce. Such pressure to reduce costs while maintaining product quality has substantially increased the attractiveness of **specialised services**. Maintenance and repair operations are an integral part of daily operational activities in the manufacturing sector and most industries in Europe prefer to be associated with distributors rather than managing these activities in-house.

The **segment of preventive and scheduled maintenance is projected to be the dominant maintenance type** by 2025 (source Grand View Research). Breakdown and faults cause loss of time and money and in order to increase efficiency and profitability, while also focusing on improving Return on Investment, manufacturing companies cannot afford to face any breakdown circumstances. A strong regulatory framework for the industrial sector in Europe is an additional factor which contributes to the increase of market-share for this segment.

Figure 22 Global yearly forecast for predictive maintenance breakdown by sector – source TechSci Research

It is quite evident how the Machinery and Equipment segment is estimated to show above average growth rates in predictive maintenance, with growing by manufacturers about possible machine breakdown leading to high productivity losses. At a global level the predictive maintenance market is expected to grow from $1.4 billion in 2016 to $4,9 billion by 2021 with CAGR of 28.4% (source MarketsandMarkets).

5.3.3 Big Data Market and Trends

The Big Data market will be worth US$46.34 billion by end of 2018 (source: Analytics Insight). In fact Big Data is constantly growing its value and market share. IDC estimates that the global revenue from big data will reach US$203 billion by 2020. According to IDC, in 2016, the European data market was the second in value, following only the US but with a similar growth. In Europe, the Big Data Value Association (BDVA) points out that the European data market is a rapidly growing multi-billion Euro business, with a compound annual growth rate (CAGR) projected over the period 2016–2020 as high as 15.7% - a market value of ca. 107 billion Euro by 2020. In terms of data quantities, by 2020, there will be more than 16 zettabytes of useful data (16 trillion GB): growth of 236% per year from 2013 to 2020 (source BDVA).
At the same time, while basic ICT adoption has gained momentum in the EU, Eurostat reports that, in 2016, around three-quarters of businesses located in the European Union (EU), which employed at least 10 people, had a website, and almost half used social media. However, only 10% reported having analysed big data.

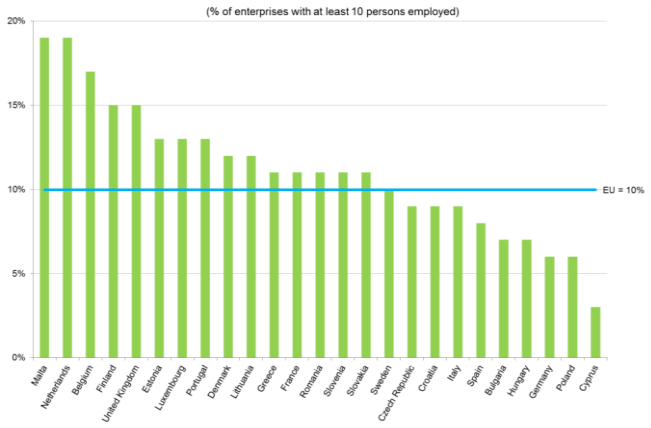


Figure 23: Businesses' use of Big Data analysis in EU Member States, 2016 (source: Eurostat)

The **current trends in big data** expected for the next period can be summarised as follows:[13]

- **Continuous, growing Move to The Cloud**. While this trend may seem obvious in 2018, it should be noted that for data-related applications, there have been in recent years concerns about the security of data and control. With the improved technical awareness and maturity of the market, the trend of low trust in cloud providers has reversed as it is now established that usually cloud services are more secure than on-site data hosting and management (as also demonstrated by recent security breaches with high media coverage). Remote jobs and smart working have also pushed the need for (secure) access to company data and cloud tools on the go. Cloud also offers (with a usually very good quality/price ratio), scalability, speed and convenience. To this end, Forrester predicts that 50% will embrace a cloud-first policy in 2018.
- **Real-Time Growing**. According to the *Streaming Analytics Market by Verticals - Worldwide Market Forecast & Analysis (2015 - 2020)* report, real-time analytics were predicted to see an average annual growth of 31.3% between 2015 and 2020. The concept of 'real-time' has now gained wider adoption and is now increasingly common amongst SMEs and Start-ups. More companies will be looking to in-memory and in-chip approaches (as they become more affordable), to capture and analyse data as quickly as possible. This move to real-time is also driven by the increasing necessity for companies of all sizes (not only the 'big players') to collect and analyse data to remain competitive in their markets.
- **Security and Breaches.** According to Innovation Enterprise, 8 of the top 10 hacks of all time have taken place in the last 3 years. While, on the one hand, data security is improving daily, on the other hand, hacking and breaching skills are improving in parallel. Additionally, the more data grows in quantity and complexity, the harder it is to monitor it and keep it safe, especially with traditional IT security tools and standards. According to a research from Symantec, in 2018 there was a 266% spike in the amount paid by companies to the hackers who infected them with ransomware compared to 2016. At the same time, with very few people being prosecuted for hacking there is a need to take cybersecurity very seriously and ensure systems are protected.
- **Relevance of Artificial Intelligence.** AI has already penetrated many sectors and is bound to increase its presence in data-driven applications. Companies are adopting AI for basic tasks, such as warehouse management and customer interaction (chat bots), but at the same time their adoption is expected to increase in more complex scenarios such as AI-powered booking engines [14] and tools [15] . AI is penetrating in consumer markets with products such as Google Home, Amazon Alexa, and Apple's HomePod. The mobile device producers are also pushing on AI with

[13] Source: Own analyses starting from Innovation Enterprise, Gartner, Forrester and Forbes.

[14] Avvio launches artificial intelligence-powered booking engine - https://www.hotelmanagement.net/tech/avvio-launches-ai-powered-booking-engine

[15] Artificial Intelligence Is Coming to Corporate Booking Tools - https://skift.com/2017/03/15/artificial-intelligence-is-coming-to-corporate-booking-tools/

AI chips enabling new services and better performance. The relevance of big data in the mobile domain makes AI even more relevant in this scenario. Analysts also believe that big data will drive AI and machine learning adoption, for example in data-driven market analysis and supply chain management. The capability of AI to predict patterns and, for instance, forecast sales or support marketing decisions is gaining more and more traction.

- **Mobile technologies.** The idea that big data is only relevant to super computers and data centres is evolving together with the broadening of the Big Data concept in itself. Today, the mobile industry is one of the key digital industries and widespread use of mobile devices goes beyond mere communication. In fact, big data is being used (and will increase its presence) in analytics, mobile analytics, media marketing, targeted advertising etc. Additionally, the big data generated by mobile applications and users will be more and more relevant as these platforms grow their market and usage presence.

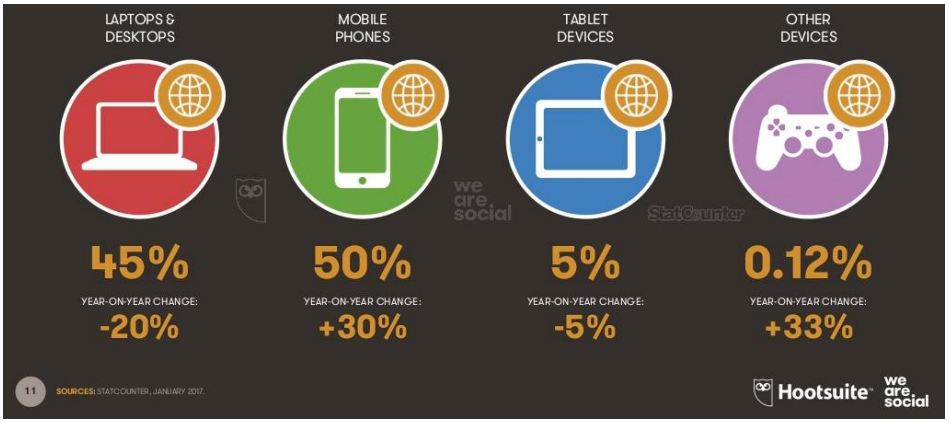


Figure 24: Share of web traffic by device, 2017 (source: © Hotsuite and Stacounter)

- **Blockchain technologies.** While blockchain are the central technology in cryptocurrencies, their impact and potential in the Big Data domain should not be underestimated in particular in terms of data decentralization, data integrity and security, secure transactions, not necessarily only monetary ones, but for example data exchanges. In fact blockchain opens the possibility for sharing principles involving "virtual currency" systems, where contribution and usage of data is valued accordingly, creating a fair balance between consumers and producers. From a data/business perspective (i.e. information- and digital data based business), blockchain has also the potential to reduce information frictions [16] by providing, for example, a shared ledger which logs a (data) asset's history along with its transactions, easier and automatic permission control, improved privacy and resilience to tampering. This allows to create trusted marketplaces for data and services supporting semi-automatic negotiations between data/service owners/providers and customers/users through the use (for example) of micro-contracts. Given the key role of block chain both in big data the potential of this technology will be further analysed in the upcoming releases of the Exploitation plan.
- **Privacy and Acceptance.** The presence of 'big data' in the media has increased exponentially in recent years. The hacks mentioned above and scandals such as Cambridge Analytica, have made people more aware of the presence of data , a data economy and the potential for misuse in our society. While (as reported above), big data holds huge value in terms of economy and job opportunities, media depiction in the mainstream landscape is often negative or critical. As a consequence, on the one hand big data (and related services) will be easier to explain and be understood by consumers, on the other hand business initiatives will have to be careful of potential negative media coverage and 'scaremongering'. Additionally, there is an impact on big data and

[16] Baley et at. *Information Globalization, Risk Sharing, and International Trade, 2014 Meeting Papers 1097*, Society for Economic Dynamics, 2014.

data handling related to the recent entering into force of the *EU General Data Protection Regulation* (GDPR), designed to 'harmonize data privacy laws across Europe, to protect and empower all EU citizens data privacy and to reshape the way organizations across the region approach data privacy' [17] . The main big data macro-area of impact from the GDPR is accountability, one of the key principles expressed by the regulation (in particular in Article 24): such accountability is both technical (data storage, security, integrity, etc.), and organisational (governance, compliancy, company culture, etc.).

5.3.3.1 Cloud Trends

Strong push of the Database Platform as a Service (dbPaaS)

Within the **Platform as a Service (PaaS)** domain, a fast-growing segment is **Database Platform as a Service (dbPaaS)**, expected to reach almost $10 billion by 2021. Hyperscale cloud providers are increasing the range of services they offer to include dbPaaS. A database platform as a service (dbPaaS) is any database management system or data store engineered as a scalable, elastic, multitenant subscription service with a degree of self-service. It is offered and supported by cloud service providers (CSP) or a third-party software vendor on a CSP infrastructure. Direct access to system services, such as the operating system and storage software, is not allowed. While, in the past, adoption of dbPaaS was slow, mostly due to security and data protection concerns ("why would I put private/confidential data in the cloud?"), today Gartner states that most cloud deployments are safer that on-premise ones. At the same time, hybrid solutions (on premise offered by cloud providers) are available. The key value proposition of dbPaaS is that it offers in a same "package" (combined in one solution) characteristics available in both cloud, hosting and IaaS set-ups (source Gartner):

- Fully managed service: zero or reduced maintenance; continuous patching and upgrading of DBMS software
- Cost-effectiveness and pricing flexibility
- Self-service options for management and monitoring
- Migration utilities
- Separation of compute and storage
- Hybrid capabilities
- Elastic scalability
- Shorter time to deploy solutions and to discontinue use as needed
- Best-fit for specific use cases
- Regional colocation of data
- Governance and security
- Improved developer productivity

Relevant **BI key trends** (source: Forbes):

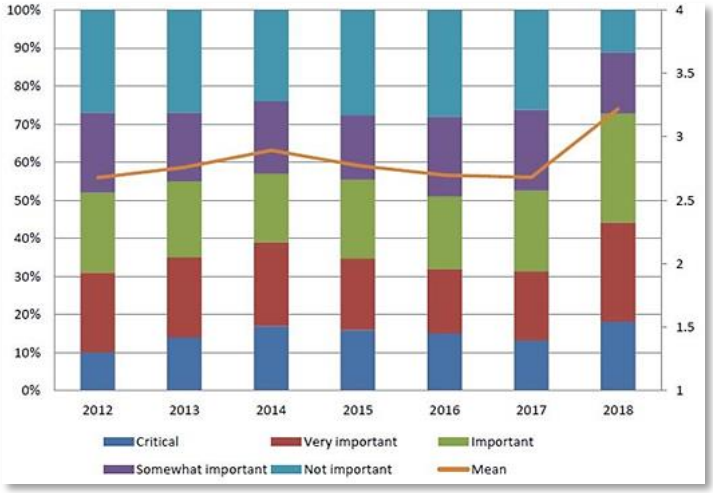


Figure 25 Cloud BI Importance 2012-2018 (source: © Dresner Advisory Services)

- Cloud BI adoption is soaring in 2018, nearly doubling 2016 adoption levels.
- Over 90% of Sales & Marketing teams say that Cloud BI is essential for getting their work done in 2018, leading all categories in the survey.
- 66% of organizations that consider themselves completely successful with Business Intelligence (BI) initiatives currently use the cloud.
- Financial Services (62%), Technology (54%), and Education (54%) have the highest Cloud BI adoption rates in 2018.

[17]The EU General Data Protection Regulation (GDPR) - https://www.eugdpr.org/

- 86% of Cloud BI adopters name Amazon AWS as their first choice, 82% name Microsoft Azure, 66% name Google Cloud, and 36% identify IBM Bluemix as their preferred provider of cloud BI services.

5.3.4 SERENA SWOT Analysis

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

SWOT Discussion

SERENA shows a clear plus by drawing together top rank partners from all over Europe and from both Industrial, Research and Business environments. In fact, SERENA has is carrying out research on the services, methodologies and tools related to innovative predictive maintenance applications and paradigms in this sector: a set of activities which most companies don't perform in such an extensive manner.

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

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

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

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

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

5.4 Updates/ Details of individual partner's strategy for exploitation

5.4.1 COMAU S.p.A. (COMAU)

Contribution to the project

COMAU contributes in Serena project in several ways:

- it offers the requirements and the use case;
- development of the Robot Box which allows to generate fault data (too expensive in real robots) and to do studies to highlight backlash effect with current and position;
- expertise on mechanical and robot domain, useful for predictive maintenance analyses;
- mechanical experience to define useful tampering on the reductor.

Involvement and return expected

COMAU develops a simple structure to extract belt tensioning data and backlash, useful for various analyses. In fact, these type of faults in real cases cause quality troubles. For this reason, the knowledge is important to prevent qualitative deviations or line stops.

Besides the predictive maintenance platform could be used in numerous plants to collect data and share information to improve the analytics algorithms. Virtual reality could show robot and plant status as well as some maintenance procedures.

Concerning economics, it is expected a reduction of the cost of maintenance activities, of robot's breakdowns, of the time needed for the maintenance activities by the operators and the optimization of the components' usage (reduce the unnecessary replacements).

Potential risks identified

A possible risk is that the collected data and their features could not be completely explanatory for the fault phenomena and maybe the inducted tampering could not well describe a large subset of real robot. Furthermore, the risk is that the algorithm does not works as expected and the cost of predictive maintenance could be too high.

Strategic future commitment

Because of the characteristics of the project, its versatility, we could install the platform in different plants to build a shared knowledge through the cloud platform to use our and our clients' data to improve our analytics solution. COMAU is also very interested in keeping collaboration with the Serena's partners to develop analytics solutions also in other aspects of our manufacturing plants.

5.4.2 Finn-Power Oyj (Finn-Power)

Contribution to the project

Finn-Power will work for customizing the SERENA solutions in the elevators production industry demonstrator as well as providing feedback on the project activities based on its experience.

Involvement and return expected

Finn-Power wants to expand its businesses, e.g., by participating the customer businesses in condition monitoring and maintenance. To be able to achieve this, real time data from production process must be measured extensively and the data must be analysed and processes on-line in order to know the machine performance capability in detail, in retrospect and to predict the production capabilities for the future, up to the next planned outage. These higher-level analytics services can either be offered remotely from the machine vendor via cloud or carried out on-site in the edge computer capable of connecting to the local machinery and of communicating to the remote applications in the cloud. Hence, the results of SERENA will allow Finn-Power to expand its portfolio of provided services to its customers and expands its business activities.

Potential risks identified
A possible risk is the lack of reliable data or collected data is excessively diverse and developed analytics do not reach level of confidence basically giving false predictions. FINN-POWER is heavily involved in the elevator use case.

Strategic future commitment
Under discussion. To be completed in the next version of the exploitation plan.

5.4.3 VDL Weweler BV (VDLWEW)

Contribution to the project
VDL Weweler pilot case will be oriented on providing data for testing the SERENA platform and proposing maintenance/repairing activities within the monitored equipment. Based on that approach, VDL Weweler will provide technical feedback for the validation of the project developments. Since VDL Weweler is a steel parts processing industry, focusing on automotive parts manufacturing, their involvement will be oriented on opening new links to other industrial sectors needing similar solutions for maintenance.

Involvement and return expected
In the context of the **SERENA** Project, the focus will be given on monitoring the forming/pressing process of the trailing arms. The expected results of the **SERENA** project are foreseen to be beneficial for the VDL Weweler production line. Through the **SERENA** developments, it is not only expected to increase the product quality by continuously monitoring the relevant equipment but additionally reduce the cycle time of the trailing arm productions. VDL Weweler will benefit from the adaption of the **SERENA** technologies in terms of providing to their customers their services in a lower price

Potential risks identified
The main foreseen challenges regarding the selected pilot case can be summarized as follows:
1. Reliable measurements with the implementation of sensors on the respective machine for monitoring its working condition and the development of a measuring system for monitoring the product quality.
2. Reliable aggregation of the collected data.
3. Development of an accurate digital model of the rolling machine and accurate modelling of the underlying process.
4. Accurate prediction of the equipment/part's condition, aiming at increasing their lifetime and minimizing the downtime costs.
5. Planning and scheduling of maintenance activities for the replacement/repair of the machine's parts.

Strategic future commitment
Under discussion. To be completed in the next version of the exploitation plan.

5.4.4 WHIRLPOOL EMEA SpA (WHEMEA)

Contribution to the project
WHR is going to contribute SERENA with an industrial use case based on a Foaming Machine operating at Whirlpool Refrigeration plant based in Cassinetta, Italy. The equipment is currently monitored through a set of sensors capturing some physical measures at every foam injection. All these data will be fed into SERENA architecture to develop a sounding predictive maintenance approach.

Involvement and return expected

WHR will exploit the results of SERENA in three ways:

1) Embedding Predictive maintenance best practices learnt in the project in its Whirlpool Production System, especially in Step 5 to Step 7 of Professional Maintenance pillar. In these way WHR ensure the best practices will become standard for all the factories in EMEA region
2) Direct exploitation: the full result (i.e. sensor model, data model, algorithms) of use case experimentation will be transferred to other Foaming Equipment present in Europe. This account for up to 40 machines spreads in Italy, Poland and Turkey.
3) Indirect Exploitation: partial results (i.e. approach, visualization, part of algorithms) will be studied to be applied to different equipment such as Injection Moulding Machines, Metal Stamping Presses and metal Sheet Bending machines.

The plan of implementation of Predictive Maintenance will follow individual plan of Professional Maintenance pillar evolution set for each single equipment and defined at factory level.

Potential risks identified

The first risk is related to the possibility that diagnostic algorithms under study are not providing any reliable result (e.g. non-alarm generated; too many alarms generated). The way to mitigate this is to allow the system to grow by feeding data and to let it learn within time and with expert feedback. This tune up is strongly depending on the physical process: if the process has very few negative events it will take months to make the system learn.

The second risk is related to the integration with legacy system: PM cannot be considered as a standalone system but must be integrated to existing application architectures and databases. The way to mitigate this is to ensure that a modular approach is strongly considered and implemented.

Strategic future commitment

WHR is strongly considering a future partnership with technology providers after the project with specific objectives of further develop the prototypes achieved during the project in order to

1) specialise them and refine the integration with legacy system
2) increase the TRL level of the solution to have a robust end-to-end commercial solution available on the market

WHR will also consider involving project partners and third parties in joint agreement in order to ensure competitive advantage versus direct competitors and to improve solution performances, usability and reliability.

5.4.5 Kone Industrial Ltd (KONE)

Contribution to the project

KONE Industrial as the elevator industry use case contributes demonstrator, use case related requirements and measurements of the monitored equipment from the area of thin metal sheet manufacturing. KONE provides its knowledge and data from actual production environment for the benefit of developed SERENA solutions. KONE is focused to support SERENA to develop its solutions and services for predictive maintenance.

Involvement and return expected

KONE will exploit SERENA solutions to improve equipment availability and production planning based on the analytics provided by the project. Solutions will be implemented to the daily operations, scheduling, and maintenance planning to reduce unplanned maintenance breaks. Thanks to SERENA KONE will be available to increase the level and quality of communication with the equipment provider FINN-POWER. SERENA provides an AR remote assistance and possibility to maintain spare part inventory more efficiently. KONE is also able to share best practices within its different supply units.

- Reduced maintenance costs
- Reduction of unplanned production stops
- Reduction of material defects and damages
- Improved capacity and predictive maintenance planning
- Shortened maintenance reaction time

Potential risks identified
A possible risk is the lack of reliable data or collected data is excessively diverse and developed analytics do not reach level of confidence basically giving false predictions. In elevator use case KONE can provide its expertise evaluating the given analyses.

Strategic future commitment
After the project KONE is interested in continuing developing analytic solutions created within SERENA and its partners.

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

Contribution to the project
Engineering (ENG) is Italy's largest systems integration company with strong expertise in IT, industry, and R&D: an expertise which ENG has brought to the SERENA consortium. ENG is a leader in the provision of complete IT services and consultancy. The R&D lab, founded in 1987, with 250 researchers has participated in more than 100 EU funded projects and gained international research awards. ENG has also a long-standing expertise in Industry and a strong focus on R&I projects, where it has shown the capacity of exploiting research results. In fact, ENG is also very active in many key international initiatives and activities including NESSI (Networked European Software and Service Initiative), founding partner of the Future Internet PPP initiative and FIWARE. ENG is corporate member of OW2 Consortium and Eclipse Foundation. It is also involved in other related projects where it can network and interact with major research and business players. ENG is leading activities related to the cloud-based platform enabling remote predictive maintenance (WP5 and also and are collaborating closely with other technical partners for introducing a cloud-based platform prototype.

Involvement and return expected
ENG expects to increase its capability of offering innovative solutions to its clients, especially in the manufacturing domain, by utilizing SERENA results and possibly expanding its current services portfolio. Additionally, ENG is interested in the potential re-use and adaptation of some innovative technologies being researched and developed in SERENA such as the Cloud-based platform for versatile remote diagnostics, not only in the SERENA use case domains but potentially within different markets where it already successfully operates such as Public Authorities and Utilities.

Potential risks identified
Possible risks for the exploitation of SERENA, as for other R&I projects, are mainly related to the maturity level of the platform and the capability of positioning a SERENA 'brand' in the market. ENG, as well as other partners, has a long experience in working in R&D and being able to advance results introducing them in real products. Indeed, as coordinator of the project ENG has created a project management and structure already conceived to avoid these risks and promote the exploitation of results.

Strategic future commitment
ENG is strongly interested in committing to joint initiatives with other project partners, to further exploit the SERENA results in the future. In fact, is evaluating the opportunity to maintain the SERENA platform's reference implementation available after the project period, for example as a

sandbox environment, and could act as leading entity to manage contacts and opportunities arising from the demonstration of the platform to potential interested parties. Furthermore, ENG has already specific business collaborations with some SERENA partners such as WHEMEA and COMAU. Collaboration and exploitation opportunities with these partners (and all others) will be further consolidated in line with the SERENA overall strategy, to continue joint development and marketing of solutions for predictive maintenance in relevant sectors including automotive, industrial manufacturing, food and beverage, pharma, white goods and according to the paradigm of Industry 4.0. ENG's commitment pertains to all Exploitation Packages and Assets, where it can provide its expertise - both internally and externally to the project - as well as utilizing its dual leader positioning: as a market leader and SERENA project partner.

Additionally, ENG operates within strong strategic networks and initiatives, comprising leading industries, Future Internet initiatives, etc. where it can further disseminate and promote SERENA.

5.4.7 OCULAVIS GmbH (OCULAVIS)

Contribution to the project

OCULAVIS develops augmented reality-based worker guidance system for displaying step-by-step instructions to maintenance staff. The system is supposed to be used both with innovative devices like different types of smart glasses as well as tablets and smartphones. The integration of this system into the overall SERENA platform enables this system to be one key human machine interface of SERENA. Therefore, the user interface design plays an important role in order to make information as comprehensible as possible to the worker. For a maximum exploitation of the results, the targeted software is designed to be modular so that it can be exploited commercially as a standalone module as well as an integration into other SERENA modules.

Involvement and return expected

OCULAVIS will offer a new augmented reality based step-by-step instruction module based on the research results of SERENA project. To sell this software based on a license model, the module will be marketed as a standalone solution with the option to integrate with other SERENA outcomes to keep integration complexity and sales efforts on a lower level. This step-by-step module is meant to work as a "door opener" to companies who want to use it for maintenance tasks. After successful deployment of the step-by-step module in such target companies, an upselling process of other SERENA modules can start (in cooperation with the SERENA partners overseeing these other modules). The integrations with the overall SERENA platform architecture open new use cases for OCULAVIS. Nowadays customer requests predominantly come from reactive maintenance scenarios where augmented reality, smart glasses etc. are intended to be used to fix problems instead of displaying predictive maintenance information. The know how that OCULAVIS gathers within SERENA project about such technologies enables OCULAVIS to enter predictive use cases in maintenance in a better way than nowadays.

Potential risks identified

The major risk is that the overall SERENA platform architecture does not fit individual customer requirements. To mitigate this risk, a modular software structure is our target to be able to address customers' needs as accurate as possible also with a standalone augmented reality-based worker guidance system.

Strategic future commitment

After SERENA project will be finished, OCULAVIS is interested in ongoing exploitation of the project's results. This will be achieved by ongoing marketing of the developed solutions on fairs or by offering the solutions to existing customers of OCULAVIS. A joint venture entity is not planned since the European partners can easily cooperate within other legal models like reseller contracts, sub-contracting etc.

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

Contribution to the project

VR/AR based training and maintenance applications and services usable on web browser, smart glasses, and mobile devices, providing information and operating procedures to the maintenance operator.

SynArea will focus on the development of VR/AR solutions which will be integrated with the SERENA cloud platform, increasing the impact and benefits of the predictive maintenance approaches with different kind of interaction: 3D visual and interactive procedures with multimedia and technical contents integration, audio/video remote connection, in mobility along the plant and in greater safe conditions.

The VR/AR application will be portable, simple, and particularly intuitive to explain complex operations sometimes difficult to understand with technical manuals, to provide an effective support to the maintenance activities and therefore to increase the efficiency and reduce the time and the cost of the service. Finally the same VR/AR applications can also be used for training activities, opportunely deployed into e-learning platforms as Moodle.

Involvement and return expected

SynArea main interests lie in the link between VR/AR product research and development and the continuous product/process/plant innovation in Industry 4.0.

From many years the Company has been dealing with VR/AR technologies and methodologies, it constantly follows the evolution of this market both for HW devices and for SW frameworks, and approximately invests about 10% of turnover in R&D activities. So, the SERENA project results will let us to exploit the knowledge gained on these technologies, applied to different operative factory context.

Having the opportunity to follow and apply these technologies that are constantly evolving within the Industry 4.0, SERENA will allow us to wider knowledge.

Furthermore, as we are a small enterprise, we would like to promote these technologies even more to SME, in order to find solutions that can give more growth opportunities in these markets too.

Potential risks identified

The SERENA consortium includes strong end-user involvement from different industrial sectors. Furthermore, there are technological partners in industrial and academic environments with significant specific and complementary skills. Therefore, SynArea believes that the project results will be fully exploited by all the partners with great collaboration, because all of them are strongly sensible to the evolution aspects of Industry 4.0.

Strategic future commitment

SynArea certainly aims to promote industrial and market exploitation of project results. It is interested to join an initiative or a collaboration with other partners in order to:

- demonstrate how VR/AR technologies can be effective, integrated into an efficient predictive maintenance system, based on artificial intelligence
- continue research and development on partner systems in order to optimize or develop new more effective solutions

Its focus will be mainly on the participation of SMEs, because these companies need to be more informed of the Industry 4.0 benefits.

5.4.9 DELL EMC (DELL EMC)

Contribution to the project

Dell EMC's main contribution to the SERENA project centres around the underlying cloud infrastructure to facilitate the implement of its predictive maintenance platform. Several years ago, Dell EMC Research Europe build one of the first six Industrial Internet Consortium testbeds, called Infinite. The Infinite testbed was specifically designed to host IoT solutions like SERENA, and Dell EMC is utilising the testbed to help implement the SERENA use cases. Additionally, Dell EMC is leveraging the experiences gain in building the testbed, to fulfil the technical requirements of SERENA, particularly in the areas of a) distributed container-based components and their management, b) platforms for machine learning; c) semantic technologies to support smart data; d) edge to cloud connectivity and security; and e) flexible hybrid storage implementations.

Involvement and return expected

Dell EMC is part of the Dell Technologies family of companies, which provide enterprise level computer hardware and innovative software products to the IO/OT market. Last year, Michael Dell announced Dell Technologies' IQT initiative [https://www.delltechnologies.com/en-ie/iqt-day/index.htm], to highlight is investment in the next stage of IoT, i.e. combining the smart collection of sensor data at the edge, with infrastructure to support analytics and machine learning in the cloud. Dell Technologies has made a considerable investment in new software packages and computer hardware equipment to support its customers as they take the next step in IoT. These technologies include the Dell family of IoT Edge Gateways and Industrial PCs, Dell EMC's High-Performance Compute and Big Data platforms, VMware's Pulse IoT management suite, and the new intelligent IoT intrusion detection system that is under development by RSA. Industry 4.0 is an important growing market for Dell, which is supported by its Irish based IoT labs and testbeds in Limerick and Cork. As part of its commitment to the SERENA project, Dell is providing its IoT Gateways to several other consortium partners, as well as the use of its Infinite IIoT testbed, developed and operated by Dell EMC Research Europe. Dell sees its alliances with international partners, such as Intel, and strategic customers, such as COMAU, as key to developing its market share in Industry 4.0 automation. For example, in partnership with Dell and Microsoft, ActionPoint, an SME based in Limerick, has built a rapid development kit for predictive maintenance of industrial equipment, called IoT-PREDICT [https://action-point.com/iot-predict/], which is based around a Dell's 3000 IoT Gateway. The SERENA project will allow Dell to demonstrate its IoT and machine learning infrastructure products in real world industrial scale predictive maintenance solutions, and the practical realization of its IQT initiative.

Potential risks identified

Creating a cohesive IIoT architecture, which spans both the cloud and the IoT edge devices on the factory floor, can be a challenge. There are numerous small implementation details that need to be worked out to build a working edge-to-cloud solution. As part of Dell building the Infinite testbed, we gained experience in resolving many of the small infrastructure challenges that will be faced when implementing the environment for the SERENA use cases. One example is the use of containers to isolate the SERENA system, thus making the implantation of the SERENA subsystem components more dynamic and flexible, as they are agnostic to the underlying hardware infrastructure.

In a classic system implementation, the data stores are tightly bound to the applications they serve. For example, the state of a database, its tables, records, etc. are typically held in data and log files, which are closely coupled to the database engine itself. If the database engine moves to a new physical or virtual server, the database files often need to move as well. SAN and NAS implementations can help to make the operation more transparent, by providing a common location to access the files, but this presumes that the new host servers have access to the remote storage. In a highly dynamic distributed environment, such as SERENA, a more proactive solution is required, such that the data follows the applications. SERENA can address this challenge by utilizing one of the essential features of

containers. Typically, containers are stateless, which allows them to by 'spun-down' and 'spun-up' at will. This makes the implementation of cluster services very dynamic and flexible, as each container is a stateless clone of its peers. The cluster of containers stores its collective state in a common external storage facility, which is logically decoupled from the containers themselves. Dell has many years of experience developing virtualised storage facilities and the storage drivers to access them, which will help SERENA to archive its 'plug-n-store' data storage objective.

Strategic future commitment

Dell sees SERENA as a reference architecture for how industrial scale predictive maintenance could be done in the future, and how such a system can be integrated with other emerging factory 4.0 solutions, such as Augmented Reality, to improve productivity in the workplace. By forming partnerships with other likeminded organisations, we hope to demonstrate the practical benefits and opportunities to our industrial customers, and the validation of Dell's products in real world factory settings. Dell is a participant in many industry collaborative and standards bodies, such as the Industrial Internet Consortium (IIC), and has its own vibrant IoT partnership programme [http://www.delliotpartners.com], which can exploit the SERENA deliverables.

5.4.10 Laboratory for Manufacturing Systems & Automation (LMS)

Contribution to the project

LMS will be supporting the project coordinator (COMAU) and will be mainly involved in the AI condition-based maintenance and planning techniques under WP3, leading the activities concerning the predictive maintenance aware planning and scheduling of maintenance operations, with respect to the equipment provider and user constraints, under T3.3 and T3.4. LMS will also lead the activities concerning the technologies to enable human operator to support for maintenance purposes under T4.3. LMS will provide the interface for authoring instructions as well as investigate the customization of the provided support information based on operator's feedback and evaluation. Additionally, LMS will support on the implementation of the SERENA versatile framework. Furthermore, LMS will develop the SERENA public web portal under T7.1 and will be the leader of T7.2 for the academic and industrial dissemination of the project results. Finally, LMS will support the participation for the SERENA project in the FoF-09 cluster activities.

Involvement and return expected

The experience and knowledge acquired by developing the INTERACT platform will be incorporated in educational courses, both at undergraduate and post-graduate levels, and will support two Ph.D. theses. It will also enhance the R&D consultation capabilities of LMS, to several national and European industrial partners. The output of the project will form the basis for further research and development actions. This will result in the future launch of R&D projects in collaboration with existing partners and/or similar organizations.

Potential risks identified

Failure to implement a physics-based model for hybrid predictive maintenance: LMS with POLITO and VTT will coordinate to integrate characteristics related to the physical deterioration of the equipment to the predictive maintenance algorithms. In case of foreseen high risk which will be evaluated by all partners, the effort will be put on providing a data driven predictive maintenance algorithm, potential integrating physical parameters with the weight put on the data analysis and not the physics-based modelling.

Strategic future commitment

LMS, as a non-profit partner, is mostly interested in research results and knowledge generation for extending its expertise in a national and international level. Hence, a future exploitation strategy could include mainly future project collaborations, with LMS participating as a scientific partner.

5.4.11 Fraunhofer Gesellschaft zur Förderung der angewandten Forschung (IPT)

Contribution to the project

IPT will contribute to the SERENA project in terms of hardware and software planning/development. This includes the composition of a universal data acquisition device ("DataBox") to gather production data from multiple different sources. In order to properly store, pre-process and forward the data to the cloud, a suitable software for this device will be created in cooperation with the partners. The Software is based on Node-red flows and Docker containers to make software modules easily exchangeable.

Involvement and return expected

Due to the many different fields of business that IPT participates in, the results of SERENA can be transferred to a wide variety of applications:

- Transfer to different machine tools at the IPT or customer shopfloor.
- Reuse of infrastructure for other projects that include measuring and evaluating of specific data.
- Adaption and reconfiguration of SERENAS hardware components or software algorithms
- Consulting for predictive maintenance projects

Potential risks identified

1. Creating a highly universal device and software to cover all potential applications of SERENA.
    a. Solution: Make Hard- and Software modular and easily adaptable, so functionalities can flexibly be added or removed to the system.

Strategic future commitment

IPT is looking forward to keeping the partnerships to the project consortium alive after the projects official end. These partnerships will be necessary to further development of the SERENA system into a market ready product. For the realisation of additional SERENA implementations in future use cases, the expertise of all partners, especially the use case partners will be needed. Therefore, IPT will aim for new cooperation's in research and industrial project work.

5.4.12 VTT Technical Research Centre of Finland Ltd (VTT)

Contribution to the project

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

Involvement and return expected

The VTT project goal is to produce new services for European market for improving product(s) life time 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 with in the value chain actors. In addition, results will be published in conferences and scientific articles, including dissemination through web for increasing impact and credibility. We also expect to learn more what kind of tracking solutions or AR applications are needed by the industry. We expect to reach deeper understanding what are the practical limitations of said technologies in real environments. We hope to recognize the areas where visual AR tracking technologies could be used in practice and where they could give the end users some added value. If some good focus application areas are recognized, we hope to see some future commercial projects where those ideas could be put to practice. If all goes well there is also a possibility for license revenue.

Potential risks identified

The most important risks are related to the following:

- Data-analytics solutions are case-specific and require customization in every use case, which means that resource adequacy, is one of the biggest challenges
- The quality of the data in terms of its sufficiency, reliability, and comprehensiveness
- Prognostic predictability regarding the RUL
- All visual AR tracking solutions are vulnerable to changing environments and typical industry environments can change quite much each day even during a normal use. It might be the case that the areas where AR could be useful, might also be the areas which are too difficult to handle using visual tracking solutions. Tracking robustness can be increased using visual markers in the environment, but in some situations this approach might be too cumbersome and there might be some practical limitations for their use.

Strategic future commitment

VTT Technical Research Centre of Finland Ltd is one of the leading 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 lifecycle from system level to phenomena (e.g. wear and fatigue) in the field of predictive maintenance and data-driven data analysis.

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

5.4.13 TRIMEK S.A. (TRIMEK)

Contribution to the project

TRIMEK, as the metrology use case, is going to contribute in SERENA project by demonstrating the benefits of SERENA solution in the metrological area. TRIMEK provides its expertise on metrology and quality control processes. TRIMEK is focused on developing the necessary services and

applications that will 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 will permit to predict malfunctions and reduce reaction and intervention time.

Involvement and return expected

TRIMEK aims at exploiting SERENA solution as a remote predictive maintenance service for its clients. SERENA solution will permit TRIMEK to provide TRIMEK's clients support on maintenance, to better management of maintenance resources (from both sides – TRIMEK-clients), to get announcements of 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 verifications results and evaluate the tendency weekly or monthly in order to warn the client about potential problems (error out of the threshold).

These new features and services will benefit both TRIMEK and clients since clients will not need to be responsible for the maintenance works and will have a more durable and reliable systems. Moreover, TRIMEK will be able to plan maintenance activities in advance, 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 and
- 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

Potential risks:

1. Failure in correlating the loss of accuracy with the parameters measured (air parameters). Mitigation risk is to install the most suitable sensors to monitor air parameters and to gather as much data as possible to be sure of the influence of the air in the measurements results. Moreover, TRIMEK's maintenance personnel confirms the connection between those variables based on their experience.
2. 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 in order to enable machine learning and an accurate prediction of potential malfunctions.

Strategic future commitment

TRIMEK intends to provide more complete and advanced services thanks to SERENA so the idea is to include this solution within its services/products portfolio in the future. 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.

5.4.14 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 aimed at scalable, versatile, and effective predictive performance. The proposed approach aims to become a key asset of the project outcomes by being (i) tightly coupled with SERENA industrial requirements and use cases, (ii) based on state-of-the-art Big Data technological solutions, and (iii) 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 committed to exploit SERENA outcomes to further enhance its impact on society, both in quality and in quantity. The increase in impact quality is driven by the additional know-how acquired thanks to the cutting-edge research activities in predictive maintenance within the SERENA project. Such know-how allows to strengthen collaborations with industries and generate 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. The improvement in impact quantity, instead, is provided by the contact and collaboration with many diverse industrial and academic partners in different European countries, thus widening our network of scientific and business relationships, a cornerstone of our technology-transfer mission.

Furthermore, Polito plans to exploit 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.

Potential risks identified

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

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

Strategic future commitment

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

6 List of dissemination, exploitation and communication activities between 1/10/2017 (M1) to 30/09/2018 (M12)

6.1 Scientific publications

No	*Activity type*	Title	Date	Place	Author	Status of submission, publication	Permanent identifiers[18] (if available)	Is open access provided to this publication[19]
1.	Conference paper	SERENA: Versatile plug-and-play platform enabling remote predictive maintenance	March 2018	IESA-2018, Berlin, Germany	COMAU, LMS	Completed, pending		
2.	Conference paper	On a versatile scheduling concept of maintenance activities for increased availability of production resources	June 2018	CIRPe, Internet	LMS	Completed, pending		
3.	Conference paper	Remote factory condition monitoring and control framework architecture	June 2019	52th CIRP CMS, Ljubljana, Slovenia	IPT, DELL	Pending		
4.	Conference paper	On an evolutionary information system for personalized support to plant operators	June 2019	52th CIRP CMS, Ljubljana, Slovenia	LMS	Pending		

6.2 Dissemination and communication activities

No	*Activity type*	Title	Date	Place	Beneficiary	Size of audience
1.	Public deliverable	SERENA public web portal	November 2017	SERENA portal	COMAU, LMS	Internet
2.	Social media	SERENA twitter account	November 2017	SERENA portal	LMS	Internet

[18] 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)

[19] 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.

3.	Social media	SERENA Facebook account	November 2017	SERENA portal	LMS	Internet
4.	Press material	Press release	November 2017	SERENA portal	LMS	Internet
5.	Press material	SERENA brochure	November 2017	SERENA portal	LMS	Internet
6.	Press material	SERENA Poster	March 2018	SERENA portal	LMS	Internet
7.	Public deliverable	Data Management Plan	March 2018	SERENA portal	LMS	Internet
8.	Project Dissemination	SERENA project presentation	April 2018	Hanover Messe 2018, Hanover, Germany	OCULAVIS	Large
9.	Project Dissemination	SERENA project presentation	April 2018	Patras IQ, Patras, Greece	LMS	Medium
10.	Project Dissemination	SERENA project presentation to visitors	April 2018	A&T Trade Fair, Turin, Italy	SynArea	Large
11.	Project Dissemination	SERENA project presentation to visitors	June 2018	FoF community day , BluePoint Centre, Brussels	LMS	Small
12.	Project Dissemination	Artificial intelligence and Industry 4.0	September 2018	IEEE-IS2018, Madeira, Portugal	LMS	Medium

6.3 Lectures

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6.4 PhD, Master and bachelor thesis

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6.5 Videos and newsletters

No	*Activity type*	Title	Date	Place	Beneficiary	Size of audience
1	Newsletter	1st SERENA Newsletter	September 2018	SERENA Portal	LMS	Internet

6.6 Liaison with other projects

The SERENA project participates in the FoF-09 cluster on predictive maintenance with the following projects:

	SERENA project will build upon these needs for saving time and money, minimizing the costly production downtimes. The proposed solutions are covering the requirements for versatility, transferability, remote monitoring and control by a) a plug-and-play cloud based communication platform for managing the data and data processing remotely, b) advanced IoT system and smart devices for data collection and monitoring of machinery conditions, c) artificial intelligence methods for predictive maintenance and planning of maintenance and production activities, d) AR based technologies for supporting the human operator for maintenance activities and monitoring of the production machinery status.

UPTIME UNIFIED PREDICTIVE MAINTENANCE	UPTIME aims to design a unified predictive maintenance framework and an associated unified information system in order to enable the predictive maintenance strategy implementation in manufacturing industries. The UPTIME predictive maintenance system will extend and unify the new digital, e-maintenance services and tools and will incorporate information from heterogeneous data sources to more accurately estimate the process performances.
BRE4K	The main scope of the project is the development of Strategies and Predictive Maintenance models wrapped around physical production systems for minimizing unexpected breakdowns and maximizing operating life of production systems.

PROGRAMS	The main objectives of this project are to develop a model-based prognostics method integrating the FMECA and PRM approaches for the smart prediction of equipment condition, a novel MDSS tool for smart industries maintenance strategy determination and resource management integrating ERP support, and the introduction of an MSP tool to share information between involved personnel. The proposers' approach is able to improve overall business effectiveness with respect to the following perspectives: increasing Availability and Overall Equipment Effectiveness, continuously monitoring the criticality of system components, building physical-based models of the components, determining an optimal strategy for the maintenance activities, providing in a machine condition monitoring system, developing an Intra Factory Information Service. The production and maintenance schedule of complete production lines and entire plants will run with real-time flexibility to perform at the required level of efficiency, optimize resources and plan repair interventions.
PRECOM Predictive Cognitive Maintenance Decision Support System	The project will deploy and test a predictive cognitive maintenance decision-support system able to identify and localize damage, assess damage severity, predict damage evolution, assess remaining asset life, reduce the probability of false alarms, provide more accurate failure detection, issue notices to conduct preventive maintenance actions and ultimately increase in-service efficiency of machines by at least 10%.

PROPHESY	The technical solutions provided by the project will be the pillar to establish an ecosystem of PdM services to enable all the stakeholders to engage the development and deployment of innovative PdM services. This ecosystem will focus on the development, deployment and operationalization of dynamic, self-adaptive and cost-effective (turn-key) PdM solutions. The purpose is to lower the deployment time and cost associated with the operation of PdM solutions, while at the same time providing a host of business opportunities for all stakeholders.

Table 4: Projects of the predictive maintenance cluster

6.7 Joint events with other projects

No	*Activity type*	Title	Date	Place	Beneficiary	Size of audience
1.	Cluster joint event	Participation in IESA 2018	March 2018	Berlin, Germany	LMS	Medium

7 Conclusion

This document constitutes the first step in the definition framework for the dissemination and communication of the SERENA knowledge leading to the upcoming exploitation of its main achievements and results.

The dissemination and communication of the project results and activities will be carried through the SERENA portal and other scientific, industrial, social media channels.

The SERENA consortium will continuously be working on building upon the identified exploitable results, which throughout the technical developments and their validation through the various test cases of the project, conclude to the final exploitable results of the project.

A revised version of this report will be presented in the next WP7 deliverables.