Ecosystem for COllaborative Manufacturing PrOceSses – Intra- and Interfactory Integration and AutomaTION
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# D9.8 Market Segmentation and Potential of COMPOSITION in European Industry

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# Index:

# 1 Executive Summary

This deliverable describes the segments of the primary markets for the COMPOSITION exploitable assets and their exploitation potential, providing an overview of the different market segments that COMPOSITION can address, thus allowing partners to make an informed decision on how to define their own individual exploitation plans.

The market description and analysis focuses on two primary markets 1) the market for the COMPOSITION solution as a whole based on user applications explored in the project pilots and 2) the market for software development tools for those that develop, deploy, and maintain IIoT (industrial Internet of Things) applications for industrial customers.

At this point in the project, the understanding of the final industrial applications for the Smart Manufacturing industry is still limited. Several use cases have been defined which will eventually be developed and evaluated by the end users in the pilots. Therefore, mainly the market for development tools has been addressed.

By building on well-known paradigms, such as marketplace emulation, the intention is that COMPOSITION will extend manufacturing execution systems to provide a holistic and collaborative integrated information management system (IIMS). The aim is that the IIMS will incorporate the entire *Supply* and *Value Chain,* providing the necessary tools to compare production indicators within and between manufacturing facilities.

The development work in COMPOSITION has two main goals:

The first goal is to integrate data along the value chain inside a factory into one integrated information management system, combining physical world, simulation, planning and forecasting data to enhance re-configurability, scalability and optimisation of resources and processes inside the factory.

The second goal is to create a (semi-)automatic ecosystem, which extends the local IIMS concept to a collaborative system incorporating and interlinking both the supply and value chains.

At this point in the COMPOSITION project, eight exploitable assets have been identified:

1. Asset and Component Tracker Components
2. Blockchain Components
3. Security Enhancing Components
4. Decision Support System for Optimising Manufacturing Processes
5. Digital Platform for Smart Environments for Factories
6. Digital Factory Modelling Components
7. Deep Learning Toolkit
8. The Virtual Agent-based Marketplace

Looking at the exploitable assets for COMPOSITION it is clear that not only is the research and development in COMPOSITION part of the fourth industrial revolution, also the potential for the COMPOSITION market place is both present and growing.

Based on the market information obtained, two broad market segments have been identified, with substantially different market actors and interactions, buying motives and market price mechanisms, distribution channels and clusters etc.:

1. Smart Factory Software Components and Subsystems for suppliers of complete software solutions to industry actors in both the intra- and Inter-Factory ecosystems. Technology segments include:
    - Integrated information management system for manufacturing
    - Collaborative ecosystem frameworks
    - Intra-Factory automation solutions
    - Lifecycle management.

2. Stand-alone Smart Factory solutions for industry based on the COMPOSITION user applications deployed at the pilot sites. Technology segments include:
    - Specific Intra-Factory automation solutions, e.g. using deep learning methods
    - Waste management solutions using IIoT integration
    - Open market place for Inter-Factory integration.

In the present deliverable, a full market analysis for the first segment: ‘Smart Factory Software Components and Subsystems and subsystems’ is presented- The understanding of the industrial applications for the manufacturing industry is still limited at this point in the project. Once the pilot applications have been deployed and evaluated the market for Stand-alone Smart Factory solutions will be revisited and reported in D9.10 Exploitation Planning Framework and First Draft of Exploitation Plans (February 2018).

A full market analysis for the segment Smart Factory Software Components and Subsystems has been undertaken, including market description, market size, Unique Selling Points and SWOT analysis. Three main market drivers (Expanded internet connectivity, high mobile adoption & change from IoT sensors and solutions) and three barriers have been identified (Security concerns, technological fragmentation & implementation).

The COMPOSITION IIMS will be used to optimise the manufacturing processes by exploiting existing data, knowledge, and tools to increase productivity and dynamically adapt to changing market requirements with the following Unique Selling Points (USP) and features:

- Real-time information about actual performance and historical data of past performance is captured at machine level using state-of-the-art IIoT components
- Machine-learning-based prediction of machine or part failure and replacement eliminates unnecessary costs of production process interruption
- Improved material management by keeping track of various aspects of the material flow through the factory, analysing the flow and presenting the results for operators on dashboards in real time and in the form of periodic or on-demand reports
- A Batch Tracking System where operators can tag each tray or reel with products in progress when they are manually transferred from one Production Unit to another. The data can be shown to users on a Material Management Dashboard
- A Material Management Dashboard is the key interface between operators and the IIMS, providing information details as necessary for decision support..

The COMPOSITION component specific strengths, weaknesses, opportunities, and threats have been analysed and the results presented in the SWOT matrix shown below.

Such analysis requires substantial more clarity as to the products that will be exploited and on which markets. Hence, it will be postponed until the future deliverables *D9.10 Exploitation Planning Framework and First Draft of Exploitation Plans* and *D9.11 Final Exploitation Strategy and Business Plans.* Meanwhile, we will provide an initial market positioning strategy based on the general knowledge of the market needs and the USP elaborated above.

Based on the market information, segmentation, competition, USP, and SWOT analysis. the final step is to position the components on the market in relation to both market needs and their competitive strengths. The products are analysed relative to their position in each market segments and conclusions are arrived with respect to the exploitation potential and associated strategy as presented in Figure 10.

The COMPOSITION products that have initially been grouped into the identified market segments are:

- Components and Tools for the Integrated Information Management Systems for Manufacturing
- Components and Tools for Collaborative Ecosystem Framework
- Components and Tools for Intra-Factory Automation

In conclusion, the prioritisation of the COMPOSITION solutions is assessed as follows:

The most attractive market segment is the Intra-Factory Automation. This segment has a high demand and established suppliers. The market is best serviced with strong partnerships with an established knowledge base of issues and solutions in factory automation.

Another attractive market is the Collaborative Ecosystem Framework. The market growth is high for solutions for supply chain and product lifecycle management, partly driven by technology push and regulatory and business pulls. The market is not fully developed yet, which leaves good openings for newcomers with novel solutions, A partnership with a renowned actor in the field will be instrumental for the trust that buyers will place in the COMPOSITION solution.

Finally, the market for Integrated Information Management Systems for Manufacturing may turn out to be slightly less attractive with the present status of the project. This market is by far the largest in terms of volume and actors. However, to be a credible player, it is not enough to deliver integration tools – a solid command and experience in the applications and services that are to be integrated is also required. The only conceivable way at this point is to team up with an existing system integrator or solution provider in the market, and deliver total solutions in partnerships.

## 2 Abbreviations and Acronyms

| Abbreviation | Meaning |
|---|---|
| API | Application Programming Interface |
| B2B | Business to Business |
| BMS | Building Management System |
| CAGR | Compound Annual Growth Rate |
| CPS | Cyber-Physical System |
| DSS | Decision Support System |
| EPC(IS) | Electronic Product Code (Information Service) |
| ERP | Enterprise Resource Planning |
| FoF | Factories of the Future |
| GDPR | General Data Protection Regulation |
| HVAC | Heating, Ventilation, Air Conditioning |
| IaaS | Infrastructure as a Service |
| IIMS | Integrated Information Management System |
| IIoT | Industrial Internet of Things |
| IoT | Internet of Things |
| IP(R) | Intellectual Property (Rights) |
| M2M | Machine to Machine |
| MES | Manufacturing Execution System |
| MQTT | Message Queue Telemetry Transport |
| OPC | Open Platform Communication |
| PaaS | Platform as a Service |
| PLC | Programmable Logic Controller |
| PLM | Product Lifecycle Management |
| PPP | Private Public Partnership |
| RFID | Radio Frequency Identification |
| RoI | Return on Investment |
| RTLS | Real-Time Location Systems |
| SaaS | Software as a Service |
| SCADA | Supervisory Control and Data Acquisition |
| SCM(S) | Supply Chain Management (Software) |
| SME | Small and Medium Enterprise |
| SWOT | Strengths, Weaknesses, Opportunities, Threats |
| USP | Unique Selling Point |

# 3 Introduction

The COMPOSITION project has two main goals: To create value by integrating data along the value chain inside a factory into one integrated information management system (IIMS) and to create a (semi-)automatic ecosystem which extends the local IIMS concept to a holistic and collaborative system, incorporating and inter-linking both the *Supply* and the *Value Chains*.

Thus, the final users of the COMPOSITION outcomes come from two business ecosystems: One comprises an INTRA-factory ecosystem, encompassing the Value Chain within one factory. The other is an INTER-factory ecosystem, involving the B2B interactions between actors of a Supply Chain.

To position COMPOSITION on the market for intra- and inter-factory solutions and to establish its potential, the project has identified initial exploitable assets, analysed the Smart Factory market and identified the most relevant market segments that COMPOSITION will address. The market analysis presented in this document forms the foundation for assessing the priority of the market segments in terms of attractiveness and market access and is thus a fundamental background for the partners' exploitation plans.

## 3.1 Purpose, Context and Scope of this Deliverable

The purpose of this deliverable is to describe the segments of the primary markets for the COMPOSITION exploitable assets and their exploitation potential, providing an overview of the situation in the different market segments that COMPOSITION can address, thus allowing partners to make an informed decision on how to define their own individual exploitation plans.

The deliverable is part of Task 9.3 Business Models for Ecosystem and Applications and Subtask 9.3.1 Market Description and Analysis with the aim to analyse the market and position COMPOSITION accordingly. As such, the market analysis and segmentation is an important first step in the preparation of exploitation plans and development of business models in COMPOSITION which has commenced.

The market description and analysis in COMPOSITION focuses on two primary markets 1) the market for the COMPOSITION solution as a whole, based on user applications explored in the project pilots and 2) the market for software development tools for those that develop, deploy, and maintain IIoT applications for industrial customers.

The first target group is the manufacturing industry interested in the various commercial implementations of the developed industrial applications that are being demonstrated and validated through the COMPOSITION use cases. The second target group consists of software companies delivering Smart Factory software solutions to actors in the Inter-Factory and Intra-Factory ecosystems.

At this point in the project, the understanding of the final industrial applications for the Smart Manufacturing industry is still rudimentary. Several use cases have been defined (see Appendix A) which will eventually be developed and evaluated by the end users in the pilots. The scope of this deliverable is thus mainly limited to the market for development tools.

Once the pilot applications have been deployed and evaluated by end users, the knowledge will be augmented with business models and cases in *D9.9 Sustainable Business Models for IIMS in Manufacturing Industries*, due at the end of August 2018. The market for industrial applications will be revisited in *D9.10 Exploitation Planning Framework and First Draft of Exploitation Plans* (February 2018), and the combined knowledge will form the basis for the final exploitation plans in *D9.11 Final Exploitation Strategy and Business Plans*, due at the end of the project.

## 3.2 Structure

This deliverable is structured as follows:

Chapter 4 provides an overview of COMPOSITION and the proposed architecture. Chapter 5 outlines how exploitable assets are assessed and briefly describes the exploitable products. Chapter 6 gives an overall description of the European industrial market. Chapter 7 defines the market and market segmentation for Smart Factory software components and subsystems, while Chapter 8 provides the corresponding market analysis. Conclusions and recommendations can be found in Chapter 9.

Appendix A provides a prioritised list of COMPOSITION scenarios and use cases, and Appendix B lists competitive vendors for different aspects of COMPOSITION.

# 4 Overview of COMPOSITION

By building on well-known paradigms, such as marketplace emulation, the intention is that COMPOSITION will extend manufacturing execution systems to provide a holistic and collaborative integrated information management system. The aim is that the IIMS will incorporate the entire *Supply* and *Value Chain,* providing the necessary tools to compare production indicators within and between manufacturing facilities.

Sharing products and production data with other actors in the supply chain (sub-manufacturers, suppliers) seldom occurs, and when this happens, it is generally on an ad-hoc basis. Where specific systems have been developed in actual factories, they are often bespoke, non-transparent, inflexible, and provide little if any client-side feedback. Tracking information along the supply chain is getting increasingly important, because nowadays products are not necessarily produced in a single manufacturing plant. Instead, they may be sent from one factory to another and possibly back again, according to the production process needs and phases.

A major problem in the manufacturing domain is to connect supply chain data and services between enterprises and to connect value chain data within a factory, so that it can meaningfully support decision making. On this background, COMPOSITION will create a digital automation framework – the COMPOSITION Integrated Information Management System (IIMS) – that optimises the manufacturing processes by exploiting existing data, knowledge, and tools to increase productivity and dynamically adapt to changing market requirements. COMPOSITION will implement, demonstrate, and validate a series of prioritised Use Cases as shown in Appendix A. Intra-Factory pilots target the Value Chain within a factory, focusing on the integrated information management system in a multi-sided manufacturing process. Inter-Factory pilots focus on the Supply Chain interaction between different companies, using the COMPOSITION ecosystem with an agent-based marketplace for collaboration.

## 4.1 COMPOSITION Architecture Overview

The development work in COMPOSITION has two main goals:

The first goal is to integrate data along the value chain inside a factory into one integrated information management system (IIMS), combining physical world, simulation, planning and forecasting data to enhance re-configurability, scalability and optimisation of resources and processes inside the factory, thus optimising manufacturing and logistics processes.

The second goal is to create a (semi-)automatic ecosystem, which extends the local IIMS concept to a holistic and collaborative system incorporating and interlinking both the supply and value chains. This should be able to dynamically adapt to changing market requirements.

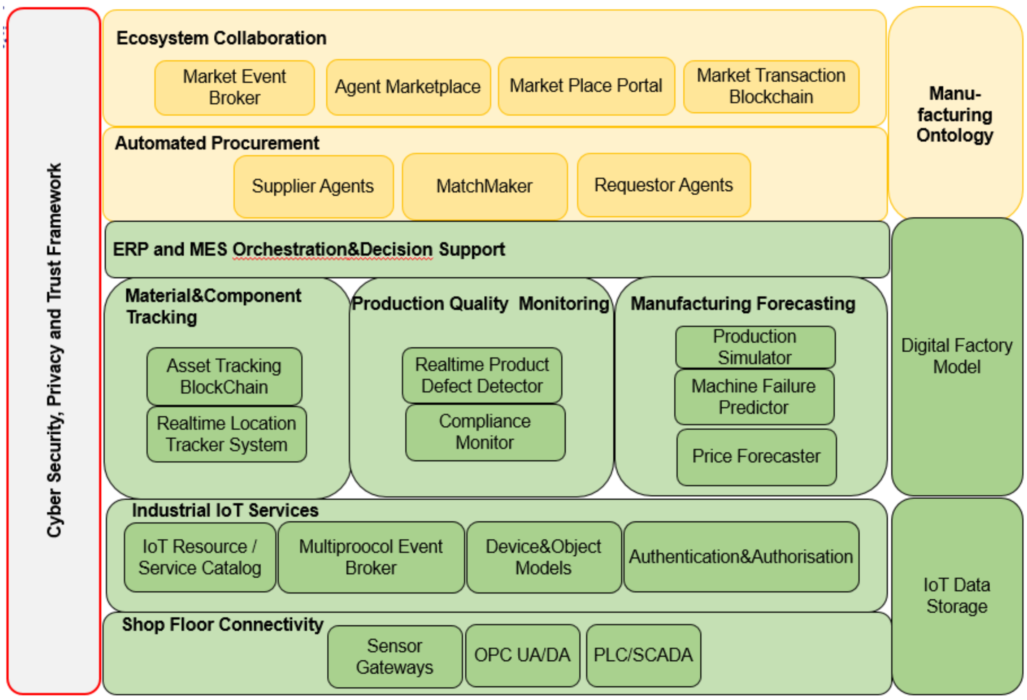


**Figure 1: COMPOSITION conceptual architecture**

Figure 1 above shows the conceptual architecture of COMPOSITON, as detailed in Deliverable *D2.3 The COMPOSITION architecture specification I*. The digital automation framework combines the data sources in the factory value chain, data from the production lines, ERP systems, forecasting, simulation and analytics data to form an integrated information management system (the COMPOSITION IIMS).

**Shop Floor Connectivity**

At the lowest level, the *Shop Floor Connectivity* provides access to devices, machines, equipment and sensors installed in the factory.

**Industrial IoT Services**

The *Industrial IoT Services* layer creates an Internet of Things environment and enables standardised communication, discovery, data exchange and service innovation mechanisms.

This layer feeds a number of business services with collected IoT and other production data:

**Material & Component Tracking**

A *Real-time Location Tracker System* keeps track of where products and other valuable components are on the shop floor whilst an *Asset Tracking Blockchain* is used to log transfer and movements of components in the manufacturing chain.

**Product Quality Monitoring**

The *Compliance Monitor* is responsible for checking that a product is manufactured and handled according to relevant regulations. The *Real-time Product Defect Detector* uses advanced data fusion and big data analytics to detect any deficiencies in a product.

**Manufacturing Forecasting**

The *Machine Failure Predicto*r uses deep learning and advanced big data analytics to predict failures of machines and needs of maintenance. The *Price Forecaster* uses trained artificial neural networks to forecast the price of products and components. A Production Simulation and Forecasting Engine allows shop managers to simulate effects of re-configuration of processes inside the factory to optimise manufacturing and logistics processes.

**ERP and MES Orchestration & Decision Support**

This layer provides integration with the Enterprise Resource Planning systems and the Manufacturing Execution Systems in the factory. This will incorporate? APIs for exporting and importing of data from existing systems.

**Automated Procurement**

One of the main innovations of COMPOSITION is the use of agent technologies to automate the procurement and negotiation process. Autonomous *Supplier* or *Requestor Agents* negotiate and reach agreements with other stakeholders. A *Matchmaker* helps in finding and matching best available offers with request.

**Ecosystem Collaboration Framework**

A virtual marketplace is envisioned where each party is represented by one or more semi-autonomous agents. To enable the COMPOSITION ecosystem, an infrastructure for an *Agent Marketplace* is developed to support dynamic and automated connections between stakeholders in the supply chain, making manufacturers, suppliers and logistics interoperable and optimisable. The *Market Event Broker* propagates messages between different actors in the marketplace. Trust is achieved by the use of an *Audit Log Blockchain* to maintain an immutable ledger of agreements and transactions.

**Meta Data and Storage**

Finally, *IoT Storage* allows for logging and storing of historical data from the shop floor. The *Digital Factory Mode*l is a high-level representation of the shop floor, stations, cells, productions lines and all the IoT sensors. The *Manufacturing Ontology* contains semantics about the market place.

**Cyber Security, Privacy and Trust Framework**

The Security Framework managing Cyber Security, Privacy and Trust, is a cross-cutting concern spanning the entire platform, providing end-to-end security by means of standard and widely used protocols for identification and distributed trust (e.g. OpenID and the Bitcoin blockchain protocol).

# 5 Exploitable Assets

Before performing a market analysis, it is necessary to define the products that are expected to be marketed: In other words: What is the value proposition offered by the outcome(s) of the COMPOSITION project.

## 5.1 Method for Assessing Exploitable Assets

An initial set of exploitable assets for COMPOSITION has been identified by technology partners, end users and research partners. They have been defined from a Smart Factory point of view with focus on:

- Interoperability – machines, devices, sensors and people that connect and communicate with one another
- Information transparency – the systems create a virtual copy of the physical world through sensor data in order to contextualise information
- Technical assistance – the ability of the systems to support humans in making decisions and solving problems and the ability to assist humans with tasks that are too difficult or unsafe for humans
- Decision making – the ability of cyber-physical systems to make simple decisions on their own and become as autonomous as possible.

For example, blockchain technology is expected to help support and enable transactions and traceability within a network-of-factories model. The network model will be characterised by open hardware designs: secure, cooperative supply chains and a royalty model for shared designs. The future state envisioned by digital manufacturing, with micro-factories producing customised products, holds the potential to have a significant positive impact on the industry as it continues to globalise and strives to meet customer requirements. A successful transition to the future state paradigm will also produce potentially significant financial benefits to companies that implement and use digitisation well.

To assess the exploitable assets, a first step will be to compare their Unique Selling Points (USP) to user needs and the competitive position in a SWOT analysis. The markets will be segmented in order to arrive at the most realistic target markets and the market potential will be discussed.

The work on identification of Intellectual Property (IP) is just starting for each exploitable outcome identified so far. The partners will agree on the IP ownership of each component.

Secondly, initial business models for use in industrial settings are being developed to support the exploitation planning for the partners who have IP rights or need user rights for the different assets. The business models will be described in *D9.9 Sustainable Business Models for IIMS in Manufacturing Industries*.

The full process will be revisited and updated in the deliverable *D9.10 Exploitation Planning Framework and First Draft of Exploitation Plans*, where IPR results will also be resolved. All the information will form the basis for each partner’s exploitation plans, to be fully documented in *D9.11 Final Exploitation Strategy and Business Plans*.

## 5.2 Preliminarily Identified Exploitable Assets

At this point in the COMPOSITION project, eight exploitable assets (products, components, applications) have been identified:

1. Asset and Component Tracker Components
2. Blockchain Components
3. Security Enhancing Components
4. Decision Support System for Optimising Manufacturing Processes
5. Digital Platform for Smart Environments for Factories
6. Digital Factory Modelling Components
7. Deep Learning Toolkit.
8. The Virtual Agent-based Marketplace

### 5.2.1 Asset and Component Tracker Components

Of specific interest in this suite of components is the *Real-time Event Broker* and the *PLC Shop Floor Connector* combined with *Machine Failure Predictor*, and *Big Data Storage*. This software suite will help customers track and understand how their products are manufactured, but also their actual usage when installed at end-user sites. Asset and Component Tracker inside the factory together with Real-time Location Positioning are also exploitable components.

### 5.2.2 Blockchain Components

*Compliance Blockchain* is a highly exploitable result, since it is necessary to track and validate the internal production of components, to verify that the components have been manufactured according to existing rules and regulations. This will be achieved through the immutable ledger and the trusted sensor technologies being developed as part the *Compliance Blockchain*. The *Ecosystem Blockchain* is a secondary exploitation option for blockchain components, which will be used to track transactions and information exchanges between different stakeholders in the existing ecosystem of collaborative manufacturing industry. A further exploitation strategy for blockchain technology is for offerings towards IoT application developers.

### 5.2.3 Security Enhancing Components

COMPOSITION provides several solutions that will follow different exploitation paths. As these solutions are domain-agnostic, they can be applied to different verticals in addition to the manufacturing sector. For example, the *Multi-Stakeholder Attribute Based Access Control and Authorization Engine* based on the XACML standards has been developed by Atos in other R&D related projects (TREDISEC, RERUM) and released as open source with Apache 2.0 licence. In COMPOSITION, this engine will be enhanced with stronger authentication provided by the integration with KeyCloak, an open source identity and access management solution, licensed as Apache Licence 2.0. This will also be applied to secure messaging for IoT devices and services by means of RabbitMQ (Licence Mozilla v1.1, Apache compatible).

### 5.2.4 Decision Support System for Optimising Manufacturing Processes

The *COMPOSITION Decision Support System (DSS)* allows for optimal solutions to be proposed after a short period of implementation at each manufacturing site and/or enterprise, independent of size and complexity. Taking input from machine learning and big data, it produces actions and knowledge. Using machine learning algorithms, it dynamically assesses all available data and suggests alternative scenarios, so that all involved parties can reach quickly a decision based on their business priorities and plans. It enables decentralised decision making and contributes to the improvement of the overall system efficiency. It contains business rules and logic for simulation and forecast. It is easy to use and is built upon a micro-service model which allows for fast scalability.

### 5.2.5 Digital Platform for Smart Environments for Factories

Leveraging on a cloud-based and highly distributed system (i.e., reference design and use case implementations), ATL's residential smart environment system is enhanced through deep analysis of the existing supply, production and delivery chain, and of ERP software systems currently in use by COMPOSITION end users. The interoperability with IIMS software components will be guaranteed by implementing communication layers and adapters, allowing the information to flow from the BMS to the modules responsible for the data analysis. Participation in the COMPOSITION project will increase experience with Smart Factories, allowing ATL to offer consultancy and training services on advanced ICT subjects for the industry sector and to consolidate NXW's Symphony BMS roadmap for Smart Factories in order to establish new business relationships.

### 5.2.6 Digital Factory Modelling Components

The Digital Factory modelling, simulation and forecasting and syntactic and semantic matchmaking engine provide a high level of simplicity, extensibility, interoperability and openness and can be used as input for simulation and forecasting tools as well as DSSs. Also, the *Broker* and its core *Matchmaking Engine* are strong assets. The *Matchmaking Engine* can infer new knowledge by applying semantic rules in the knowledge stored into the Collaborative Manufacturing Services Ontology and Language developed by CERTH.

### 5.2.7 Deep Learning Toolkit

The Deep Learning Toolkit provides predictions leveraging on continuous learning algorithms, either as part of the decision-making process at the shop floor level or to the Agent-based Marketplace, providing a novel intelligence layer to the agent for trading in the most suitable conditions.

### 5.2.8 The Virtual Agent-based Marketplace

One of the biggest assets of a virtual marketplace is the same as an old-fashioned marketplace: that small or big vendors sell different things, but together they attract a lot of customers, or in a digital world, a lot of traffic. Through an agent-based marketplace, the ecosystem of stakeholders is connected in a virtual market. This is made possible through the use of agents, whereby each party is represented by one or more agents, endowed with sufficient autonomy to set up exchanges and to enable new economic collaboration models. The goal is to improve the ability of the supply chains to dynamically change product lines. The virtual marketplace also helps keep track of the entire process from orders and payments to deliveries.

# 6 Industrial Landscape and Trends

## 6.1 The European Manufacturing Industry

Manufacturing represents a major social and economic force in Europe, see for example (EFF, 2013), which reports that EU exports consist mainly of manufactured products: their share has annually been more than 80% of total EU exports. European strengths include high levels of automation for mass production, a strong machine building industry (in parts of EU), and general strong knowledge base in manufacturing.

### 6.1.1 Strengths and Weaknesses

Manufacturing outsourcing has mainly concerned low-cost products, and even in the case where high-cost products are manufactured outside Europe, manufacturing reference plants are still maintained close to product development within Europe. Other strengths of Europe are the Joint Technology Initiatives and Private Public Partnerships in areas such as the Factories of the Future (FoF) and Embedded systems/Electronics/Cyber-Physical Systems (CPS) that provide means for collaborative research. Finally, European strengths in general include a high-quality infrastructure (communication, energy and transportation).

Among the weaknesses, there is a lack of a full integration between the lifecycle stages along the manufacturing stages (from development over production and logistics, to aftermarket including service), which is also the situation outside Europe. In Europe, this is due on the one hand to business, capital and innovation, referring to a culture relatively reluctant to risk taking, tax policies not promoting investments, insufficient venture capital, costly labour, and relatively low turnout from research investments. Other weaknesses have to do with some of the skills required for full CPS exploitation. Europe has a shortage of market leading internet companies and software platforms. European manufacturing is dominated by SMEs, among which there is limited knowledge of the potential of CPS, especially solutions based on software and internet.

Deficiencies in the educational system represent a further weakness. Education has not generally been prioritised at the political level; the status of, and high-level support for, teaching is generally low. International evaluations (e.g., the PISA reports[1]) show deteriorating results over the years. Finally, Europe represents a multilingual, multicultural, multi-policy environment, representing collaboration challenges.

### 6.1.2 Opportunities and Threats

The strong potential for growth in relation to CPS is clearly indicated by research and innovation roadmaps such as the Factory of the Future roadmap and the McKinsey study on disruptive technologies (EFF, 2013), (Manyika et al, 2013). Manufacturing provides an indispensable element of the innovation chain where CPS technology provides more and more opportunities for innovations, involving goods, services and lifecycle approaches that promise to resolve some of the societal challenges.

Opportunities are provided on the one hand by new technologies and by combinations of new and existing technologies, such as 3D scanners, 3D printers, business, enterprise and engineering integrated information systems, new materials, new manufacturing processes, and smart components and manufacturing machines integrated into smart factories.

Opportunities are also emerging from the use of new, and internet-related business models, involving crowd-sourcing and new technologies paving the way for flexible and customisable distributed manufacturing schemes. The adoption of business models, new in the area of manufacturing, has already been reported in CyPhERS deliverable D4.2 – CPS Technologies.

Another example is that of using open competitions through web-based technologies, for example as applied by GE in developing new jet engines[2]. These advancements lower the barriers for making business in manufacturing, thus providing opportunities for start-ups and SMEs. They also notably provide opportunities towards establishing a truly circular economy (EMA, 2012).

Synergies in human and robot collaboration schemes further promise to enhance manufacturing flexibility and performance. Using CPS technology to make automation more flexible and provide cost-efficient and adaptive manufacturing brings opportunities for increasing the level of manufacturing in Europe. Together with innovation in products and services, opportunities lie in grasping new and emerging markets. Access to global talent is beneficial in terms of innovation. The development of international standards could also bring

[1] http://www.oecd.org/pisa/
[2] http://www.ge.com/about-us/openinnovation

opportunities for Europe to establish technologies in a global marketplace. Finally, there are opportunities to exploit manufacturing competence and solutions in other domains. Representing a domain with early adoption of CPS technology, manufacturing technologies are being transferred to other domains. A prime example is that of robotics. The US robotics roadmap, for example, covers medical and service robotics, and the navigation and sensing technologies used in autonomous car prototypes originate from robotics, thus representing applications of robotics outside the traditional manufacturing domain.

As with all technology shifts, there are also multiple threats. There is a risk that other countries and regions may outpace Europe in innovation, including making use of the just mentioned opportunities. While Europe has a strong position in manufacturing, the US is making strong investments in manufacturing – e.g., through recent robotics and Industrial Internet initiatives – with the benefit of close involvement of leading ICT companies. In the US, an increasing use of robotics and higher levels of automation has enabled companies such as Apple, Lenovo and Tesla to invest in new US factories, and in-shoring is expected to continue (RTC, 2013).

Related threats include a tendency towards commoditisation of machines and manufacturing, due to the entry of low-price competitors, e.g., from China, and the risk that early adopters (EU) bear initialisation cost of new technology while fast adopters take the big market.

Global scale threats are that (economic, social and environmental) sustainability is not sufficiently taken into account, leading to a depletion of the earth's natural resources, while the remaining resources are largely controlled by other parts of the world. Manufacturing consumes material and energy and produces waste, and about 14% of the total of 2,652 million tons of waste generated in the EU-27 countries in 2008 was due to manufacturing, according to an estimate from Eurostat (Eur, 2011).

Future manufacturing will constitute increasingly complex systems in terms of heterogeneous interconnected CPS. The management of such systems, including dealing with security and safety risks and systems interoperability, posse barriers (threats) to their successful industrialisation. Lack of competence similarly poses threats that may prevent successful industrial evolution. Such threats include declining interest by students in the area, and conversely, large brain capital and stronger drivers for the young in developing countries and inadequate user and general involvement, leading to an increased digital divide and lack of adoption.

### 6.1.3 Trends and Key Strategy Recommendations

A number of strategies to grasp opportunities and deal with threats have been elaborated. Several of the identified strategies correlate well with the findings of Industry 4.0 (Kagermann, 2013), briefly summarised below. We also draw on the conclusions of the CyPhERS project and its identified complementary strategies, which will be used to single out the strategies that support the successful dissemination and exploitation of the COMPOSITION solutions.

The Industry 4.0 recommendations highlight the need for a dual strategy, involving (1) integration of information and communication IIMS technology into traditional manufacturing solutions and systems, and (2) creating and serving new leading markets for these technologies and products. The recommendation further highlights the following three features for Industry 4.0 implementation: a) Horizontal integration through value networks; b) End-to end digital integration of engineering across the entire value chain; and c) Vertical integration and networked manufacturing systems.

Many of these areas were also addressed in the CyPhERS SWOT analysis (CyPhERS, 2014]. We therefore focus now on specific aspects of the CyPhERS conclusions and Industry 4.0 recommendations which are relevant to COMPOSITION products, dissemination and exploitation.

<u>Multi-stakeholder learning networks:</u> Future manufacturing systems will require higher multidisciplinary and multi-stakeholder efforts. Promoting such "multi-x" efforts is facilitated by establishing networks of different forms, and are known to create synergies. While former Networks of Excellence have been relatively successful, more stakeholders need to be integrated into such efforts:

- Form network of excellence and learning networks across domains to expand knowledge, exchange best practices, build required skills, and promote cross-domain innovation. The networks should include industry and academia, and other relevant stakeholders
- Establish links between ARTEMIS-IA/ECSEL, FoF and ICT labs in order to cover advancement along multiple TRL levels.

<u>CPS design:</u> There is a large potential in improving CPS design, from optimal manufacturing machines to systems, which are more adaptive and easy to use, while still providing the desired performance and

availability levels. This is a multidisciplinary endeavour that spans human-machine interaction, machine design, manufacturing system design, control, systems engineering, etc. Theories, engineering methodology and toolboxes are required for these purposes. Current European projects often provide separated entries and calls, e.g., manufacturing, systems engineering, human-machine aspects. There is a need to develop mechanisms for cross-disciplinary collaboration in terms of projects which could be foundational and applied. Nevertheless, demonstrators will likely be very important for the purpose of integration. Robotics continues to be an important field, including manipulators and collaborative schemes (robots with robots and/or humans).

IIMS design: Interoperability, integration platforms and standardisation are key aspect of and encompass multiple dimensions in the Industry 4.0 recommendations. New integrations and services will require new software platforms such as the COMPOSTION IIMS. The opportunities lead to the following recommendations:

- Utilise European strengths to take the lead in interoperability efforts encompassing engineering tools and databases for manufacturing system optimisation and improved performance, as well as factory level platforms and interoperability approaches
- Promote integration platforms to accelerate rate of innovation, including promotion of open source EU software platform initiatives
- Investigate bottlenecks and key areas with potential for standardisation. Evaluate proposed and existing standards and propose improvements. Promote harmonisation or bridging among existing standards.

Sustainability: Investigate and develop incentives for Europe to drive sustainable solutions, including business aspects. Increase awareness. Fund research and innovation activities that address lifecycle gaps and use of new IIMS and CPS opportunities. There are already examples of companies that support a circular economy. Program-oriented aspects and funding (research, innovation and venture capital): With some relation to the previous bullets, we here further elaborate the funding aspects:

- Investigate and address gaps in the transition from research to industrialisation, and corresponding funding (including VC). Develop or target complementary funding measures accordingly
- Establish links between ARTEMIS-IA/ECSEL, FoF and ICT labs in order to cover advancement along multiple TRL levels
- Research and innovation: Focus on added value, high quality and disruptive technologies
- Support the development of regional clusters, "innovation eco-systems".

Innovation and risk taking: In order to stimulate and provide support measures to promote innovation and risk taking, the following recommendations are made:

- Establish close links between market needs and research activities and innovation. Research and innovation activities should include engineering, end-user and business stakeholders
- Support experiments and development proof of concepts with new manufacturing systems and services
- Promote risk taking by considering e.g. competitions, taxation and other incentive schemes including EU projects.
- Stimulate the development of and research into new business models, including those using social manufacturing and crowd-sourcing to engage a wider audience for innovation. Take measures to further raise awareness.

Education, training and brain capital: Although training and continued professional development was covered in (Schwab, 2016), we would like to emphasise the following aspects:

- There is a need to revise current FoF education programs to provide "T-shaped" engineers with lifecycle and sustainability "thinking"
- Strengthen links between secondary and primary education and university and industry, to stimulate interest. Initiate and promote open labs and maker spaces
- Establish exchange programmes with non-European countries and other incentives to attract talent. Facilitate immigration for highly qualified engineers, including accreditation/training programmes facilitating their integration
- Support machine building industry (including SMEs) in take-up of IIMS technologies.

## 6.2 Industrial Revolutions in Industrial Information Systems

In his book “The Fourth Industrial Revolution” Klaus Schwab (Schwab, 2016) writes: “We have yet to grasp fully the speed and breadth of this new revolution. Consider the unlimited possibilities of having billions of people connected by mobile devices, giving rise to unprecedented processing power, storage capabilities and knowledge access. Or think about the enormous? confluence of emerging technology breakthroughs, covering wide-ranging fields such as artificial intelligence (AI), robotics, the internet of things (IoT), autonomous vehicles, 3D printing, …….to name a few".

Looking at the exploitable assets for COMPOSITION it is clear that not only is the research and development in COMPOSITION part of the fourth industrial revolution, also the potential for the COMPOSITION market place is both present and growing. The illustration below gives a quick overview of the different industrial revolutions so far.

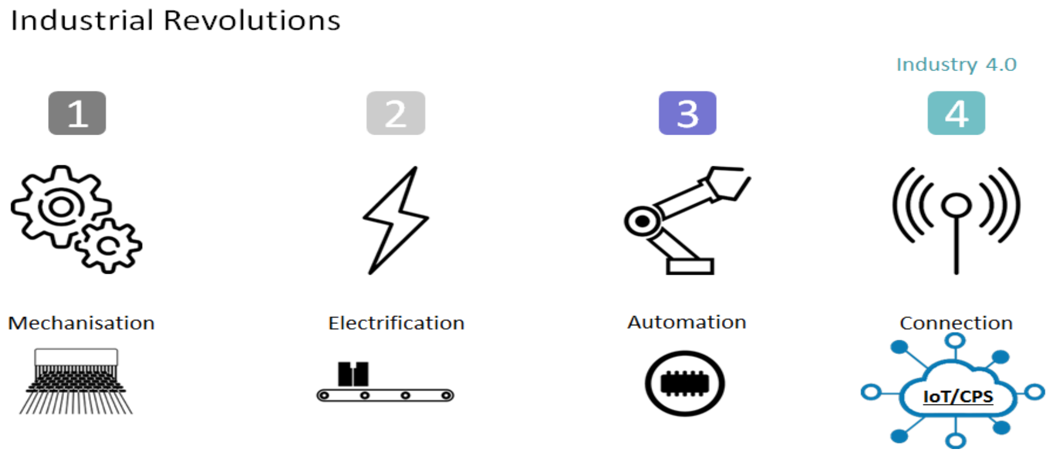


**Figure 2: Overview of industial revolutions**

Zooming in on The Internet of Things, it is predicted that in 2025 there will be 1 trillion sensors connected to the internet, and it is suggested that in the future it is possible for every physical product to be connected to a ubiquitous communication infrastructure. On a smaller scale, the illustrations below show what such a connectedness looks like in an Integrated Information Management system, both when it comes to the Intra-Factory and the Inter-Factory scenarios.

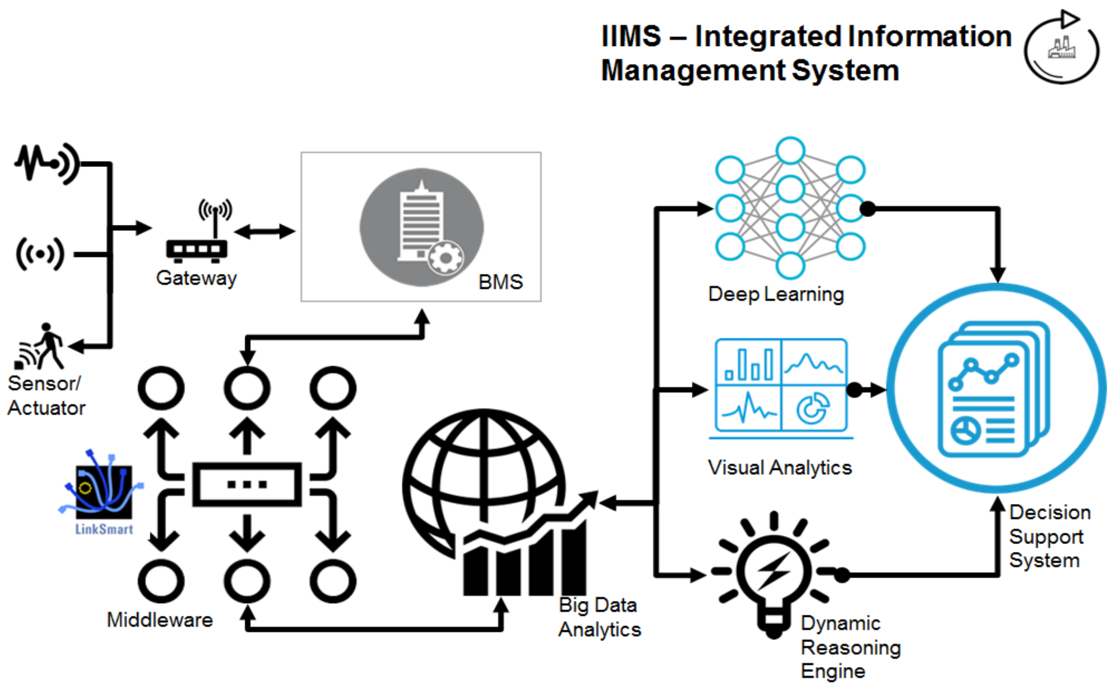


**Figure 3: IoT Integrated Information Management Systems – Intra-Factory**

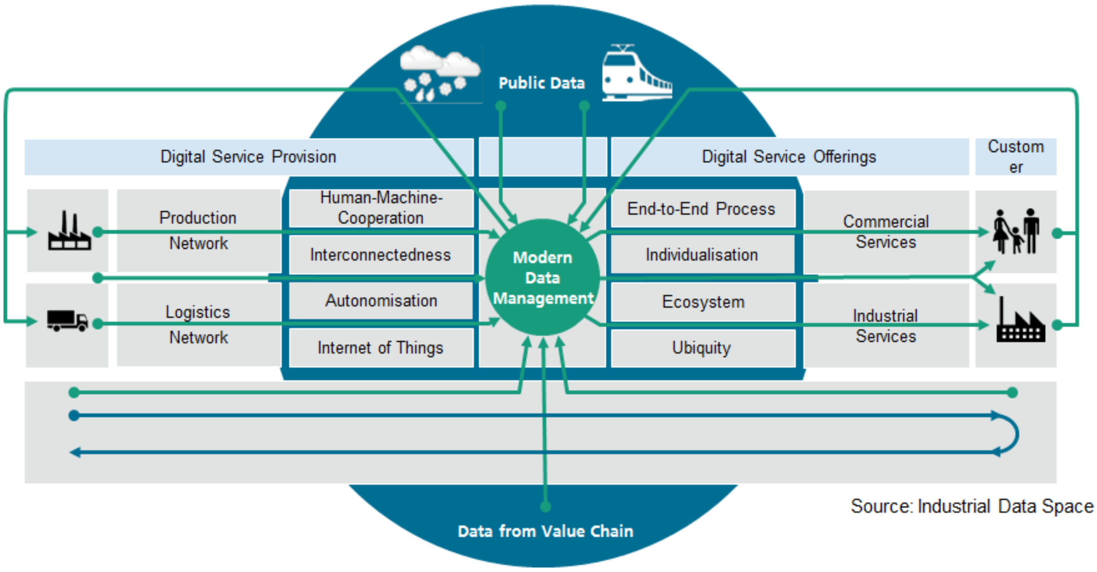


**Figure 4: IoT Integrated Information Management Systems – Inter-Factory (Otto et al, 2016)**

## 6.3 Estimated Market Size

The smart factory market was valued at USD 121,000 million in 2016 and is expected to grow at a Compound Annual Growth Rate (CAGR) of 9.3%, between 2017 and 2022. The factors driving the growth of the market include an increase in adoption of industrial robots, the evolution of Internet of Things (IoT), growth in demand for smart automation solutions, and increase in emphasis on regulatory compliance. There is a growing need to centralise the business data in enterprises and track multi-plant operations with the help of real-time data analysis. This demand is expected to grow, even among SMEs, due to the availability of cost-effective Manufacturing Execution System (MES) solutions for processes and industry verticals. The industrial robot technology is bringing a revolution in the manufacturing processes, improving productivity, reducing the risk of human error, and increasing the production volume. The North American region is a key market as it is home to some of the largest multinational corporations operating in this market, including a majority of the leading players. In addition to the rise in demand for advanced manufacturing solutions, the increased R&D in the field of IoT for new and improved technologies is expected to drive the growth of the smart factory market in North America. Nevertheless, the Asia-Pacific area is foreseen to become the largest market before long, owing to increase in investments in the development of manufacturing sectors and favourable government regulations (MandM, 2017).

A recent article from Boston Consulting Group (Küpper et al, 2016) reports on a global survey of more than 750 manufacturing companies in three industrial sectors: automotive, engineered products and process industries. They found that:

- 93% of global product leaders say that predictive maintenance combined with real-time equipment monitoring enabled by integration is a must-have for factory planning today
- 75% of global product leaders plan to implement factory of the future initiatives and programmes in the next five years or less, starting with Industry 4.0
- 67% of automotive executives expect that new technologies enabled by real-time integration will enable their teams to reach and exceed lean management and continuous improvement goals, starting in 2016 and accelerating through 2030.

Many manufacturers have started to implement elements of the Factory of the Future. The report analysed how conversion costs and manufacturing costs would be affected ten years after implementation. They found that total conversion costs will be reduced by up to 40%. Total manufacturing costs will be reduced by up to 20%, depending on the material costs. Manufacturers will also capture the benefits of enhanced flexibility, quality, speed, and safety. Over a ten-year period, a company’s cumulative investments to capture these benefits will amount to 13% to 19% of one year’s revenue.

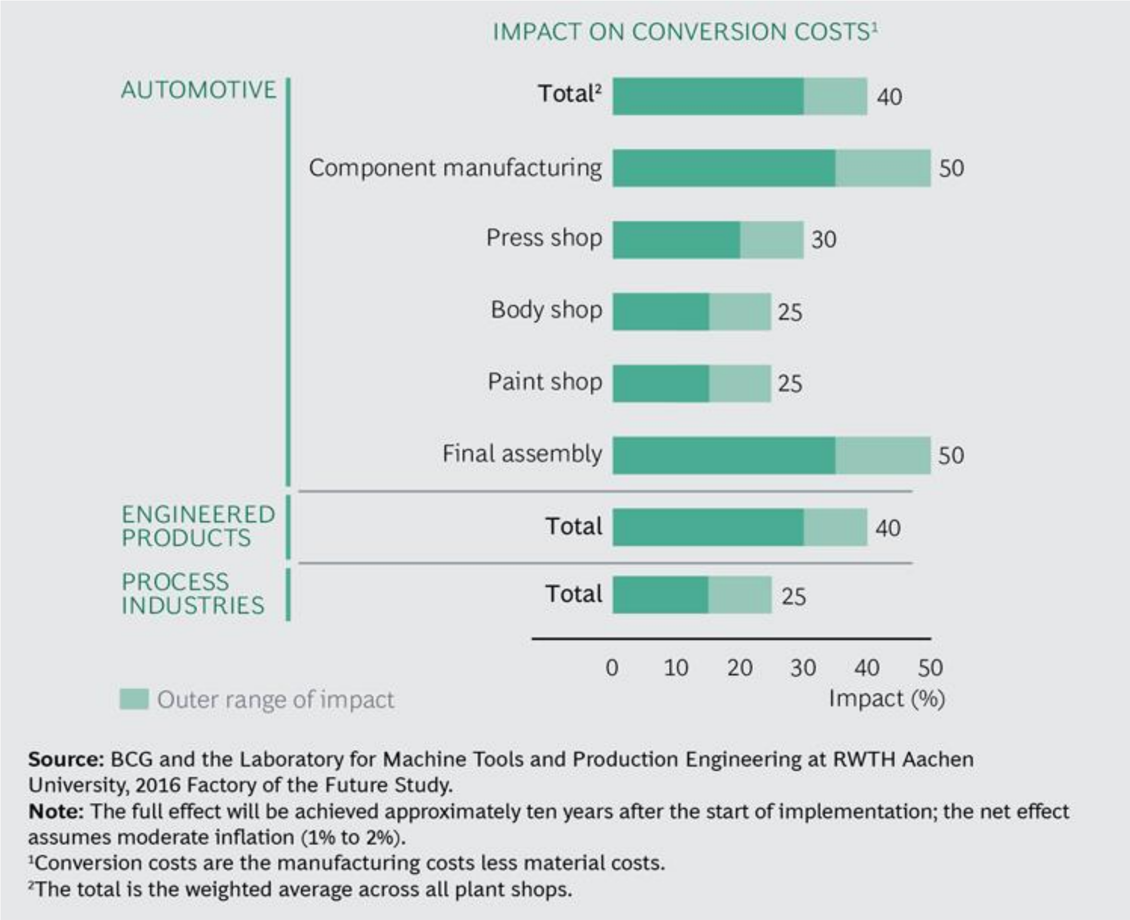


**Figure 5: The Factory of the Future Promotes Efficient Operations (BCG, 2016)**

In the factory of the future, the value chain (i.e., suppliers, component manufacturing, shop floors, final assembly, and the customer) will be fully integrated. Throughout the value chain, manufacturing will be facilitated by comprehensive integration of ICT systems and availability of all required production data.

Component manufacturing will benefit from greater flexibility and improved working conditions arising from communication between machines and products (e.g., 80% of automotive manufacturers cited the relevance of decentralised production steering and the automated adjustment of machine parameters as desired changes). Additionally, more than 70% of respondents noted that additive manufacturing (i.e., 3D printing) will be relevant to component manufacturing, not only for creating prototypes, but also for tools and spare parts. The shop floor will benefit from improved equipment effectiveness: 93% of automotive respondents have implemented, or plan to implement predictive maintenance within the next two years. For instance, Schuler has developed robots that, in addition to their normal activities, monitor the condition of components and signal to workers if a replacement is required. Smart robots and production simulations will allow to adjust actions in response to the information received, while simulations assist in the planning and configuration of the shop's layout. For the body shop that builds the Jeep Wrangler, Kuka and Microsoft have developed an intelligent system that not only connects all robots, but also monitors their wear and tear.

Increasingly, automotive companies will have to offer a wider variety of car models to meet higher customer expectations and government regulations; a multi-directional layout will enable producing a wider variety while maintaining high production output. With respect to plant processes, new technologies will enhance lean management and the continuous improvement of production processes. The use of production simulations, for example, will enable manufacturers to reduce waiting times and work in progress.

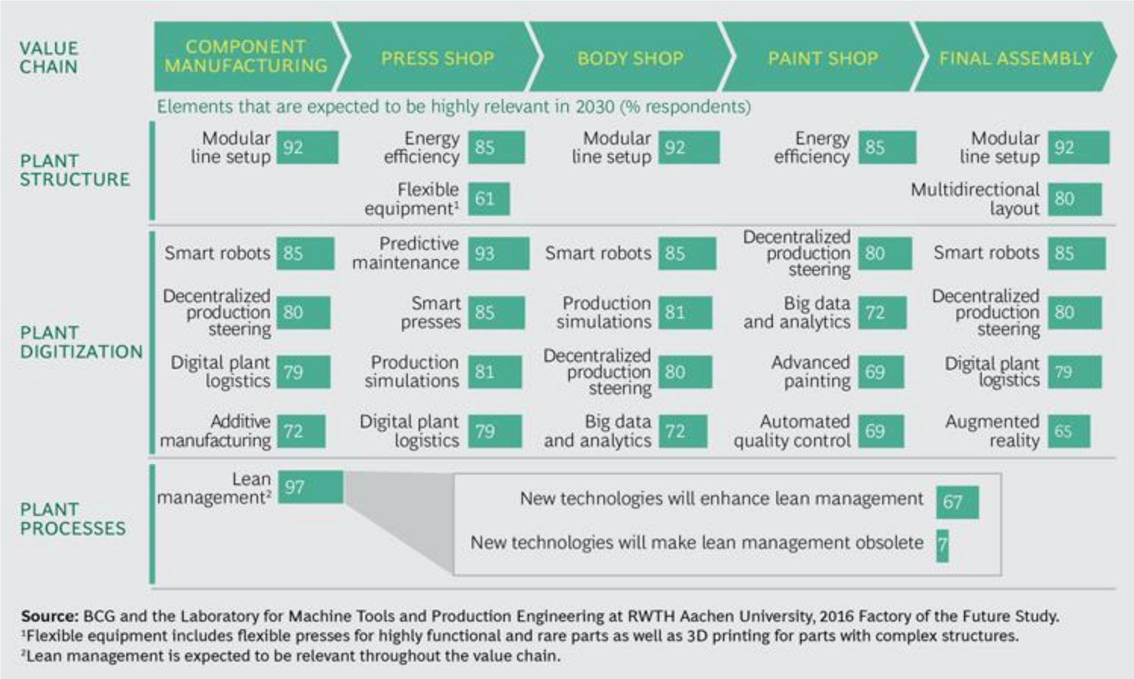


**Figure 6: Key Elements along the Automotive Value Chain in the Factory of the Future (BCG, 2016)**

## 6.4 Market Segmentation for European Smart Factory Solutions

In order to focus the ensuing analysis of market opportunities for COMPOSITION products, it is necessary to perform an initial segmentation of the huge market for Smart Factory Solutions. The segmentation further has the objective to give partners an overview of which different market segments that COMPOSITION can address and thus allow them to make informed decisions on how to define their individual exploitation plan.

The segmentation will be performed using the immediate end user (of the COMPOSITION solutions) as variable. This leaves us with two broad market segments with substantially different market actors and interactions, buying motives and market price mechanisms, distribution channels and clusters etc.

Using this segmentation, we conclude that COMPOSITION will be made to focus on two main markets

3. Smart Factory software components and subsystems for suppliers of complete software solutions to industry actors in both the intra- and Inter-Factory ecosystems. Technology segments include:
    - Integrated information management system for manufacturing
    - Collaborative ecosystem frameworks
    - Intra-Factory automation solutions
    - Lifecycle management.

4. Stand-alone Smart Factory solutions for the industry based on the COMPOSITION user applications deployed at the pilot sites. Technology segments include:
    - Specific Intra-Factory automation solutions, e.g. using deep learning methods
    - Waste management solution using IIoT integration
    - Open market place for Inter-Factory integration.

In the present deliverable, a full market analysis for the first segment: Smart Factory Software Components and subsystems is presented, including market description, market size, USP and SWOT analysis.

The understanding of the final industrial applications for the manufacturing industry is still limited at this point in the project. Several use cases have been defined (see Appendix A) which will eventually be developed and evaluated by the end users in the pilots. Once the pilot applications have been deployed and evaluated by end users, the market for Stand-alone Smart Factory solutions will be revisited and reported in *D9.10 Exploitation Planning Framework and First Draft of Exploitation Plans* (February 2018).

# 7 Market Description – Smart Factory Software Components and Subsystems

## 7.1 Overall Market Definition

Smart Factory systems for the Factories of the Future environment, leverage, among others, on the technical integration of Cyber-Physical Systems (CPS) in production and logistics as well as on the application of IoT and services in industrial processes. Part of the increased efficiency and flexibility can be realised by connecting and integrating these technologies in a smart and manageable manner and extracting actionable insights. IIoT technology, cloud solutions, big data analytics and cyber security components are key ingredients for this digitalisation. Internet connectivity expansion can play a key enabling role in integrating these ingredients and offering a ubiquitous platform to interconnect machines, robots, processes, workers, etc.

With a growing focus on manufacturing environments, data and services have become the key factor in integrated manufacturing processes. Some of the most imperative problems so far are to connect supply chain data and services between enterprises and then to connect it to the value chain data within a factory. And this is where the COMPOSITION marketplace comes in because solving these challenges would help support meaningful decision-making.

Overall, a typical characteristic of an IoT solution is the integration of, e.g., sensors, actuators or RFID tags. Communication technologies serve as the foundation of IoT and define how a variety of physical objects and devices around us can be associated to the Internet, allowing these objects and devices to cooperate and communicate with each other to reach common goals and support integrated and holistic processes within companies and within supply chains.

IIoT can be considered as a global industrial network infrastructure composed of numerous connected devices that rely on sensory, communication, networking, and information processing technologies for the provision of high-quality services to industrial enterprises and users. The success and wide uptake of IIoT depends on standardisation, which provides interoperability, compatibility, reliability and effective operations on a global scale. The technical standards need to be designed to define the specification for information exchange, processing, and communications between things.

The COMPOSITION components need to be based on an open market for reusable components. Some overall characteristics for such a market are, that it is supply driven and requires adaptive enterprises which again is based on ICT infrastructure that facilitates "reusability",”re-configurability”, "flexibility" and "replaceability".

## 7.2 Market Segmentation

Again, we perform a segmentation of the market for Smart Factory components and subsystems in order to create clarity of the relevant market opportunities. The segmentation is performed using the intended functionality and integrability as segmentation parameters. This transposes into three well-defined market segments with substantially different market actors and interactions, buying motives and market price mechanisms, distribution channels and clusters, etc.:

- Integrated Information Management Systems for Manufacturing
- Collaborative Ecosystem Framework
- Components for Intra-Factory Automation.

The different outcomes of the COMPOSITION project will be exploitable in varying degrees in these three market segments as defined by the exploitation partners.

### 7.2.1 Integrated Information Management Systems for Manufacturing

The market for an Integrated Information Management System (IIMS) is not static, currently there are rapid technological developments, suppliers are re-positioning themselves and new players are moving in to take market shares. On the other hand, the requirements and needs of the users and future users of IIMS will continue to change and need to be served.

The traditional view of a manufacturing system technologies is shown in Figure 7

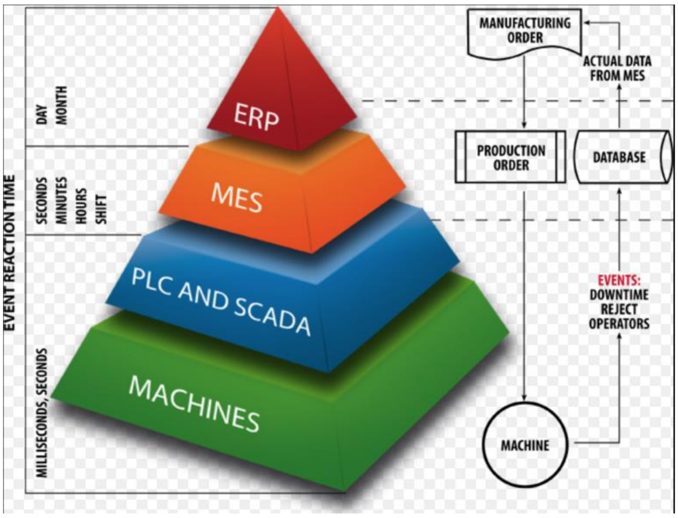


**Figure 7: Manufacturing system technologies**

Today, an established group of suppliers operates in each layer of the pyramid to fulfil the respective needs of the user groups in each layer. But with changing technological developments and competitive pressure, an integrated system and a supplier for such a system are needed.

Industrial IoT and cloud solutions introduce a new layer in this pyramid between the MES (Manufacturing Execution Systems) and PLC/SCADA (Programmable Logic Controller/Supervisory Control and Data Acquisition) layer.

Basically, there are presently four types of actors addressing this market:

- Suppliers at business system level – MES and ERP system suppliers
- Suppliers at manufacturing hardware level – PLC/SCADA providers
- Application specific solution providers – Asset Tracking, Forecasting Software, Predictive Analytics
- IoT and Cloud providers.

Manufacturing companies use Manufacturing Execution Systems (MES) to track and document the transformation of raw materials to finished goods. MES provides information that helps manufacturing decision makers understand how current conditions on the plant floor can be optimised to improve production output (McClelland, 1997). MES works in real time to enable the control of multiple elements of the production process (e.g., inputs, personnel, machines and support services). The MES architecture is typically relatively standard. It is an application that depends on a transactional database. The system always has a strong integration with both the field (receiving huge amounts of real-time atomic data) and with the enterprise resource planning (ERP) system (which provides aggregated information).

MES systems have previously been considered as the “legacy systems” by the IoT community, andPLC level devices seen as dumb components that should be connected to the cloud by IoT technologies. However, we are now seeing a rapid development where MES suppliers are expanding downwards, adding IoT connectivity and big data processing directly to their products.

There is also a big demand for connecting the PLC systems directly from the outside in order to perform remote management and maintenance of equipment. PLC/SCADA vendors are increasingly aiming at directly connecting their PLCs to the cloud using IIoT technologies.

These developments provide a number of challenges and possibilities for COMPOSITION. The open plug-and-play architecture of the COMPOSITION IIMS allows customers to establish interfaces and collaboration networks with different suppliers at different levels. It can also provide added value to MES suppliers who have not yet started the transformation to the IoT world. Other options are to liaise with suppliers of general IoT platforms to offer them a possibility to deliver packaged IIoT solutions.

### 7.2.2 Collaborative Ecosystem Framework

Collaborative Ecosystems enable participating actors in a manufacturing ecosystem to exchange data (e.g., requests/offers) deemed as relevant for identified production needs. Involved parties will have the ability to (semi-) automatically enter a virtual, agent-based, marketplace where needs, captured by the factory IIMS and expressed through a shared, high-level, and machine-understandable format will be matched with offers, described in the same language. By mimicking real market exchanges, suitable trade-offs between needs with their relative constraints and offers will be reached, exploiting automatic negotiation, auctions and controlled constraint relaxation/masking.

While being central to the marketplace, the Collaborative Ecosystem also allows supply chain formation and related activities (e.g. post-sale services). Active advertisement and support to service/stakeholder search is also a valuable asset, as witnessed by explicit requirements for added value services, e.g. consultancy, integration and customisation.

In the IIoT, decision-making relies on the company's intellectual property (IP) that captures data and encapsulates its collective knowledge into reusable, unique and optimised information assets. Embedding this IP in supply chain processes, the company can consistently solve large-scale, dynamic problems using its unique business logic, thereby creating competitive advantage. Platforms do not necessarily need to be deployed on-premises at the organisation. Companies can tap into emerging algorithmic marketplaces to sample and choose from a plethora of algorithms that solve a broad array of analytical and business problems. These marketplaces take advantage of the fact that many people are creating excellent algorithms and analytical capabilities but do not have the money or inclination to commercialise them.

Supply chain management software (SCMS) is the set of software tools or modules used in executing supply chain transactions, managing supplier relationships and controlling associated business processes. The most important trend at the moment is that this software segment is undergoing a change from premise-based installations to a cloud-based Software-as-a-Service model. This will also lower the barriers for COMPOSITION to enter as well as open possibilities for partnership.

The COMPOSITION Open Market Place will support a marketplace for connecting buyers and sellers of manufacturing services, raw materials and products toward integrating the global supply chains. The core component of this marketplace will be a novel, agent-based, brokering module that will apply both syntactic and semantic matching, box taxonomy based feature based on the participants manufacturing capabilities. The goal is to find the best possible supplier to fulfil a request for a service, raw material or products involved in the supply chain. Well established languages (MSDL, OWL-S, PSL, etc.) will be used for semantic description of manufacturing services. Also, different decision criteria for supplier selection according to several qualitative and quantitative factors will be considered (size of buyer’s organisation, cost, time, distance, due date, quality, price, technical capability, financial position, past performance, attitude, flexibility, etc.). Special focus will also be on dealing with the trade-off between performance and quality of matching, in order to provide responses in a reasonable time while at the same time minimising computational complexities.

The COMPOSITION Collaborative Ecosystem is a novel and innovative technology, and consequently there is no straightforward mapping to an existing market segment, but there are mainly two categories of vendors relevant for COMPOSITION. The first category is *supply chain management* software. Supply chain management (SCM), the management of the flow of goods and services, involves the movement and storage of raw materials, of work-in-progress inventory and of finished goods from point of origin to point of consumption. Interconnected or interlinked networks, channels and node businesses combine in the provision of products and services required by end customers in a supply chain.

### 7.2.3 Components for Intra-Factory Automation

Simulating continuous and discrete manufacturing processes, forecasting the behaviour of manufacturing systems and processes and designing products to an even larger extent through virtual mock-ups and optimisation methods integrated in the design and production chain are key enablers for Europe's future manufacturing sector. Today more and more machines and systems are connected to centralised, enterprise and public legacy data and information resources as well as to real-time data from Cyber-Physical Systems (CPS) monitoring the lifecycle processes and generating performance and usage data. This “Big Data” may contain stored supervisory and control data from the entire product lifecycle. Based on this feedback a seamless integration is achieved between products and end users, resulting in a complex design and operation process. Therefore the optimal management of that vast amount of information is of great importance that can bring a new paradigm shift how the system engineering is performed today for product development.

The applications of ICT tools to support sensor-based optimisation and monitoring are production efficiency, cost reduction, quality, fast disruption response and intervention and broader mass customisation flexibility. For this, various knowledge and information is fused along the entire Intra-Factory value chain through an interactive environment to be used for the analytics and decision support tools. The analytics tools include visualisations to look at the data from different perspectives aided by modelling and simulation approaches, to monitor various aspects of the process chain, to identify bottlenecks and to guide a quick response to disruptions of a process. Such information might include the factory/machine state before the disruption (data stored in a monitoring system), log data of the most recent operations on the machine, maintenance history, quality information about products that might be affected, or replacement parts. Optimisation tasks would further rely on energy costs, energy need statistics and workflow requirements of the various production processes.

COMPOSITION will create a digital automation framework (IIMS) that optimises the manufacturing processes by exploiting existing data, knowledge and tools to increase productivity and dynamically adapt to changing market requirements. This technology acts as the technical operating system for business connections between factories and their suppliers. Furthermore, it opens a new space for third party entities to actively interact in the value chain, e.g. by providing services to improve cycle time, cost, flexibility or resource usage. Data across the (multi sided) companies value chain is integrated by an IIMS with optimisation and modelling tools for resource management, including innovative, multi-level, real-time cross-domain analytics and a Decision Support System.

The COMPOSITION IIMS will further apply business intelligence to provide improved coordination mechanisms of collaborative manufacturing processes. It will be based on the continuous real-time monitoring and control of the underlying complex collaborative industrial and logistics processes.

### 7.3 Target Groups, Actors and Stakeholders

A general characterisation of the target groups, actors and stakeholders of Smart Factory Software Components and Subsystems is presented in this section. For each exploitable result and each segment, the target groups will be further defined and presented in *D9.10 Exploitation Planning Framework and First Draft of Exploitation Plans* when the technical development has progressed more. However, at this stage it is already possible to consider certain categories, such as: Manufacturing industry, Process industry, Subassembly suppliers, Raw material suppliers for enterprises, System integrators, Manufacturing Execution Systems developing companies.

Thus, three main target groups can be identified at this point:

1. Suppliers of commercial tools and solutions

   These are the direct customers for the COMPOSITION tools and solutions that is the outcome of the project. The market path for reaching out to them will depend on the exact solution in question, and it is tied to the market targeting approach of the relevant partner(s) of the consortium. This is the most straightforward target and the contact with them can start even before the development of the products, in order to engage them to become early adopters

2. Cooperation partners (integrators)

   This target group refers to integrators that can offer COMPOSITION products as part of their solution. They need to be targeted by the respective technology providing partners, in the sense that they are the most relevant to identify potential synergies and to tackle bridging and compatibility issues. The integrators are considered to have a direct interest in the exploitation of the COMPOSITION solutions, as they will be making them a part of their own suite of products

3. Resellers

   This is an alternative target solution for certain partners in terms of reaching out to the market if they desire to invest less effort in the actual sales promotion process. It is also a way to multiply the potential of the effect to the European market, especially if local representatives/resellers are to be used for designated European areas. The resellers are considered a target group that will be most probably reached out towards the end of the project, depending on the exploitation path of the partners. They have a secondary level of interest in the COMPOSITION outcomes, as they have a financial interest on the successful promotion of COMPOSITION products to the market.

As will be demonstrated in the pilot sites, the expected COMPOSITION stand-alone solutions offer the potential to directly address the end-users in the industrial market. The following actors and stakeholders have been identified and they are applicable for the defined target groups:

1. Process industries where unified process monitoring is critical and related to the quality of the end product
2. Discrete manufacturing industries with critical steps that are necessary to avoid bottlenecks
3. Manufacturing companies with high energy demands

4. Companies where the quality level of the finished product needs to be very high (biomedical, healthcare, energy providers, transports, etc.)
5. Manufacturing companies with expensive raw materials (biomedical, IoT devices, telecommunications, electronics, coatings, etc.)
6. Companies that carry sensitive data and are interested in the security and privacy aspects
7. Industries that have significant recycling activity, in the sense that large volume of recyclable material is gathered and handled.

In terms of these stakeholders, further analysis will take into consideration the effect they may have in the selection and adoption of the COMPOSITION solutions.

## 7.4 Estimation of Market Size

The growth in the area of IoT is highly visible. For example, Gartner, Inc. (Gartner, 2017) forecasts that 8.4 billion connected things will be in use worldwide in 2017, up 31 percent from 2016, and will reach 20,4 billion by 2020. Total spending on endpoints and services will reach almost USD 2 trillion in 2017. Regarding IIoT, especially applications tailored to specific industry verticals (including manufacturing field devices, process sensors for electrical generating plants and real-time location devices for healthcare) will drive the use of connected things among businesses through 2017, with 1.6 billion units deployed.

However, from 2018 onwards, cross-industry devices, such as those targeted at smart buildings (including LED lighting, HVAC and physical security systems) will take the lead, as connectivity is driven into higher-volume, lower cost devices. In 2020, cross-industry devices will reach 4,400 million units, while vertical-specific devices will amount to 3,200 million units. It can therefore be predicted that in digital manners, the IIoT has the largest market potential.

The largest IIoT market is manufacturing; i-scoop.eu (i-scoop, 2017) states that manufacturing is the largest industry from an IoT spending (software, hardware, connectivity and services) perspective. They predict that manufacturing, transportation and utilities will invest most in IoT in the period until 2020 – writing that "In 2016, manufacturing operations alone accounted for an IoT spend of USD 102,500 million on a total of USD 178,000 million, all IoT use cases in manufacturing combined. Thus, manufacturing overall is by far the largest industry in the Internet of Things AND of the Industrial IoT and the segment of manufacturing operations outweighs all other IoT use case investments across all industries, consumer included".

### 7.4.1 Integrated Information Management Systems for Manufacturing

Several state-of-the-art and comprehensive analyses of industry, trends, growth drivers, market share, size and demand on the global Product Lifecycle Management (PLM) have been published (GIAI, 2016). For example, it is expected that the automotive and transportation industry is the biggest contributor in terms of revenue contribution, while the growing markets of consumer goods and retail along with aerospace and defence, and Hi-Tech, Telecom and ICT are expected to experience increased market traction with high compound annual growth rate (CAGRs), during the upcoming period. According to Research Nester (ResearchNester, 2017)**,** the global Product Lifecycle Management (PLM) market is expected to strengthen a CAGR of 8.3% to reach at USD 76,000 million by 2022 worldwide**.** The PLM market is segmented by solutions, deployment types, organisation size, verticals and regions. Furthermore, user needs such as inventory control, material requirements planning (MRP) and job shop floor control/manufacturing execution are some of the demands taken care off by PLM. It is forecasted that the quality and lifecycle management software market is expected to grow from USD14,300 million in 2014 to USD 20,400 million in 2019, at a Compound Annual Growth Rate of 7.4% from 2014 to 2019 (MandM, 2014). The most attractive products are Bills of Material, change management, cost management, data management, compliance and governance management and new product introduction and development management are gaining popularity**,** acceptance and investment from various vendors.

SMEs have especially high potential regarding this new trend of IIoT. The annual report (TarE, 2016) on European SMEs (2015/2016) shows the power and influence of SMEs: "SMEs form the backbone of the EU28 economy. In 2015, just under 23 million SMEs generated €3,900,000,000,000 in value added and employed 90 million people. They accounted in 2015 for two thirds of EU28 employment and slightly less than three fifths of EU28 value added in the non-financial business sector. The vast majority of SMEs are micro enterprises with less than 10 employees – such very small firms account for almost 93% of all enterprises in the non–financial business sector. EU28 SMEs finally appear to have escaped from the fallout of the economic and financial crisis of late 2008 and 2009. Indeed, following a number of years of poor economic performance, EU28 SMEs experienced in 2015 good growth in value added for the second year in a row (3.8% in 2014 and 5.7% in 2015). For the first time since the recession, SME employment grew in 2014 (1.1%). In 2015, SME employment increased by 1.5%." If these two perspectives are combined it becomes clear that IIoT is one of the biggest potentials for SMEs in the following years.

The Manufacturing Execution System market is expected to reach USD 18,200 million by 2022, at a CAGR of 13.6% between 2016 and 2022. The growth of this market is propelled by low deployment cost, increasing use of industrial automation, adoption of MES owing to growing benefits and importance of regulatory compliance.

### 7.4.2 Collaborative Ecosystem Framework

Regarding the Collaborative Ecosystem market, there may be a relation to the annual revenue from SCMS (both premises-based and SaaS), which reached USD 10,000 million in 2014, a 12 percent increase over 2013. While premises-based software was still more widely used than SaaS solutions for SCMS in 2014, Gartner projects that about two-thirds of the growth in SCMS adoption between 2015 and 2018 will be based on the SaaS subscription model: driven by a growing realisation of the benefits of cloud-based services, the SaaS-based SCMS market grew by about 24 percent in 2014 and is projected to continue to grow at a 19 percent compound annual growth rate, reaching USD 4,400 million in annual sales by 2018.

### 7.4.3 Components for Intra-Factory Automation

The IoT platform market for Factory Automation is growing fast, and the coming years will see consolidations, because competition increases and because there is no single IoT platform that offers an all-round approach, making the big players look at others who have more specific solutions or capabilities in their solutions (i-scoop, 2016).

## 7.5 Market Drivers and Inhibitors

The market for Smart Factory and IoT solutions in general is driven by the possibilities brought about by technological changes, but more importantly by the bigger companies with appropriate resources to do their own R&D. Hence a market driver for COMPOSITION is also the accessibility of the advanced technologies for the large segment of SMEs (The Intra-Factory scenario). For the Inter-Factory scenarios, the main drivers are the introduction of new technologies, and the economic benefit that the COMPOSITION solution can offer in terms of costs savings and optimisations of the supply chain.

In the context of Smart Factory Software Components and Subsystems three main market drivers are found in studies:

- Expanded internet connectivity
- High mobile adoption
- Change from IoT sensors and solutions.

A main prerequisite of IIoT based IIMS services is the availability of a reliable digital infrastructure. Google and other major ICT market players are actively planning the deployment of global micro-satellite based digital communication infrastructures, which can be utilised by IIoT services in larger rural areas making the technology even more interesting.

Despite the great scope for growth, there are some factors restraining the market. These include different regulatory requirements. In April 2016, the EU approved the General Data Protection Regulation (GDPR)[3] concerning data privacy, which also includes regulation on eHealth applications, which will be relevant for companies like BSL. The regulation will enter in force from 25 May 2018. This will provide a regional level of harmonisation across all member states in the EU. How the GDPR will affect the market for IIoT remains to be seen, but security threats concerning data privacy, cultural issues in embracing technology and cases of sub-standard implementation due to inadequate data communication infrastructure and the use of immature technologies will all be market inhibitors.

Another driver is the speed of change in the global market in general and in the software business in particular. The exponential change of what is possible with the Industrial Internet of Things (IIoT) is a driver in itself.

In the context of Smart Factory Software Components and Subsystems three main market barriers are found in studies:

- Security concerns

[3] http://www.eugdpr.org/

- Technological fragmentation
- Implementation problems.

Cyber security is a growing area of concern in terms of IIoT services. The threats come in three aspects:

- Service continuity – Denial of service attacks that prevents the service from running
- Service authentication – Unlawful access to patient confidential data
- Service integrity – Illegal modification of specific data.

As stated in the report 'Internet of Things in Industries' (IEEE, 2014): "The solution to technology fragmentation in IIoT development environments is standardisation. Many countries and organisations are interested in the development of IoT standards because it can bring tremendous economic benefits in the future. Currently, numerous organisations such as International Telecommunication Union, International Electrotechnical Commission, International Organization for Standardization, IEEE, European Committee for Electrotechnical Standardization, China Electronics Standardization Institute, and American National Standards Institute are working on the development of various IoT standards. As so many organisations are involved in the development of IoT standards, a strong coordination between different standardisation organisations is necessary to coordinate and govern the relationships between international standards organisations and national/regional standards organisation. By establishing widely accepted standards, developers and users can implement IoT applications and services that would be deployed and used on a large scale, while saving the development and maintenance cost in the long run. The standardisation of the technologies in IoT will also accelerate the wide spread of IoT technology and innovations. So far, many countries have significantly invested on IoT initiatives. The U.K. government has launched a £5 million project to develop IoT. In the European Union, the IoT European Research Cluster (IERC) FP7 (http://www.rfid-in-action.eu/cerp/) has proposed a number of IoT projects and created an international IoT forum to develop a joint strategic and technical vision for the use of IoT in Europe. China aims to take a leading role in setting international standards for IoT technologies.

Inhibitors for an open market model may also be the shortage of ICT labour. Some large companies will pay exorbitant amounts for the right ICT skills and keep the developed software as a patented, licence-based system. Furthermore, security and liability issues of software components developed by someone else are inhibiting the growth. The reuse of components is also inhibited by the challenges that occur around updating software.

# 8 Market Analysis – Smart Factory Software Components and Subsystems

On basis of the market description, we will now analyse the market with respect to the specific COMPOSITION products for developers. The analysis comprises:

1. Competitor analysis
2. Unique Selling Points (USP)
3. SWOT analysis
4. Market prioritisation.

## 8.1 Competitor Analysis

The open plug-and-play architecture of the COMPOSITION platform allows us to establish interfaces and collaborations which different suppliers at different levels. It can also provide added value to MES suppliers who have not yet embarked on the transformational part into the IIoT world. Other possibilities open up in liaison with suppliers of General IoT Platforms to offer them a possibility to deliver packaged Industrial IoT solutions.

In this complex, multidimensional network of actors, it is clear that it is not a simple supplier-competitor relationship. The actors come together to interact in a process of co-producing value in value nets (Brandenburg 1996) where business actors are simultaneously both competition and cooperation. Whereas competitors divide markets, complementors help create or grow markets (in emerging markets most participants are complementors). With the emergence of IIoT and IIMS ecosystems, combined with the trend of the software market towards changing from premise-based installations to cloud-based Software-as-a-Service or Platform-as-a-Service models.

Hence, it is important that COMPOSITION exploitation takes full advantage of this dynamic, multidimensional marketplace by leveraging on continuously updated knowledge of market developments and competitors.

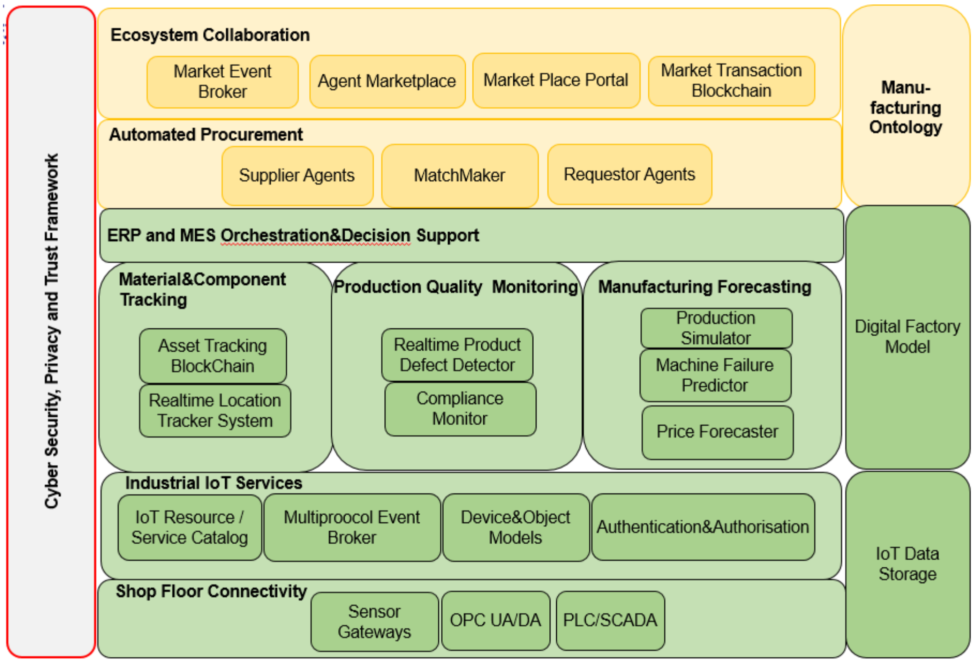


**Figure 8: COMPOSITION conceptual architecture**

The following section describes the competition landscape, based on the different layers in the COMPOSITION conceptual architecture, repeated in Figure 8 above for convenience. The IIMS is pictured as the green and the Collaborative Ecosystem as the yellow components.

### 8.1.1 COMPOSITION IIMS Integrated Information Management System

In general, suppliers of Industrial IoT Platforms like GE and ThingWorx are expanding upwards from pure connectivity solutions trying to add more analytics and decision support into their products not only data collection and storage mechanisms. Ignition IIoT product and Wonderware are some examples for competitors in the area of IoT connectivity and big data processing directly relevant for products and inductive automation.

**Shop Floor Connectivity**

There are a very large number of vendors offering OPC servers. Kepware, Codesys, Matrikon and Iconics are examples. OPC Foundation provides more information at https://opcfoundation.org.

The PLC provides a very low level and often a proprietary interface to its registers' data values. OPC (Open Platform Communications) has then been defined as the interoperability standard for the secure and reliable exchange of data in the industrial automation space and in other industries. It represents the PLC as a number of tags with data values. The old version OPC DA is based on a COM interface while OPC UA provides a more modern web service interface. The technology foundation in an OPC server is to provide drivers for many different PLCs, it can be seen as a middleware for PLC access.

SCADA is short for Supervisory Control and Data Access and is the third important product category in this layer. The SCADA system is responsible for connecting to and communicating with the PLCs in order to visualise the current status of the process being supervised. The SCADA system often runs on a PC in the factory's local network. The SCADA system normally uses OPC servers to get the data from the PLC. An important function is alarm handling to alert the operator if something in the process needs attention. All major PLC vendors also offer SCADA system for their PLCs but there are also a number of third-party products. SCADA systems have evolved from monolithic to networked (accessing several PLCs over a network) and now there are attempts to bring Internet of Things into to SCADA world.

In general, the *Shop Floor Connectivity* layer is a mature market and COMPOSITION relies on existing products in this layer but we shall need to understand how to interface and integrate with these products.

**Industrial IoT Services**

The *Industrial IoT Services* layer feeds a number of business services with collected IoT and other production data. This is the layer that "turns" the factory floor into an Internet of Things with functions for event generation, data storage and some form of device model representation. There are two types of potential competitors:

- General IoT Platforms
- Industrial IoT Platforms.

A huge number of software solutions are marketed as General IoT platform, LinkSmart, Bluemix, AllJoyn, IoTivity, MS Azure IoT, Carriots, and Kaa, to mention a few. These platforms typically offer device connectivity, device management, MQTT (Message Queue Telemetry Transport) messaging and cloud storage of collected data. Unlike the COMPOSITION IIMS, these platforms do not offer rich industrial features such as asset tracking, machine failure prediction, production simulation and digital factory models. However, many of the IoT platforms are marketed towards manufacturing and refer to Industrial IoT as an important use case for their platform. General IoT platforms can be used by developing consultants to create customer-specific solutions for factories, offering solutions for predictive maintenance and performance visualisation.

There are much fewer true Industrial IoT Platforms (IIoT). Three important platforms are GE Predix, ThingWorx and Siemens Mindsphere, which are specifically designed for industrial and manufacturing applications and in addition to the standard IoT features also offer digital twin representation, analytics and machine learning, security and compliance. ThingWorx is based on KepWare OPC connectivity and Siemens Mindsphere also natively supports OPC. Bosch and GE have signed an agreement to create an open-source industrial IoT platform based on GE Predix and Bosch IoT platform.

**Material and Component Tracking**

Manufacturing companies are looking to Real-Time Location Systems (RTLS) to improve their operational efficiency and lower operational costs by tracking equipment, goods, materials, work orders, safety, assembly lines, distribution and other growing applications. Some vendors supplying Real-Time Location Tracking Systems are Bluvision and Awarepoint. The entry of several leading companies – such as Bosch, Siemens, ABB, Emerson Electric and Honeywell International, Inc. – into the RTLS market for automation will raise the demand for these solutions.

The leading technologies used for asset tracking in manufacturing today – RFID (Radio Frequency Identification) and Barcoding – have several shortcomings. With Barcoding, an item (or box or pallet) fundamentally must be scanned into or out of a location, and even then, its true location is not necessarily known. Similarly, with RFID (both active and passive) the item must come into close proximity of a (typically expensive) RFID reader, usually at a choke point, for its location to be known.

The technologies in COMPOSITION overcome these shortcomings by using an indoor positioning system in combination with an Asset Tracking Blockchain that logs transfer and movements of components and material inside the factory. This innovative approach is unique on the market.

**Production Quality Monitoring**

There are a number of software tools available for Total Quality Management. There are a few that focus specifically on manufacturing and using the data from the shop floor to analyse defects and other quality problems. IQMS and Tableau are examples of tools that allow drill-down and analysing of performance trends. Flags are focusing on easy recording of inspections and detected faults.

COMPOSITION provides a unique solution in trying to detect product defects in real-time rather than using analysis of historical data.

**Manufacturing Forecasting**

Managers in a manufacturing environment must forecast the amount of inventory and supplies needed to meet demands. The forecasting methods often assume that past patterns and trends will continue with limited or predictable variance into the future. However, for forecasting to be effective, even seemingly random shifting trends must remain consistent over time. Many ERP-systems for manufacturing have support for forecasting, an example is IQMS Manufacturing ERP.

Forecasting of failure, Machine Failure Prediction, is one of the most requested forecasting tasks in manufacturing operations. Being able to predict machine failures in advance in order to avoid breakdowns and to better plan maintenance work saves costs. Companies like Bluvision and B&K Sound and Vibration offer solutions for this.

The competitive advantage of COMPOSITION is in integration of the latest deep learning technologies with trained neural networks. COMPOSITION also drives simulation of the production processes to better understand effects of different manufacturing decisions.

### 8.1.2 COMPOSITION Collaborative Ecosystem

The COMPOSITION Collaborative Ecosystem corresponds to the yellow parts in Figure 8.

**Automated Procurement**

*Procurement software* is business software that helps to automate the purchasing function of organisations. Activities including raising and approving purchase orders, selecting and ordering the product or service, receiving and matching the invoice and order, and electronic bill paying, enabling the procurement department to see everything that is ordered, ensure that nothing can be ordered without correct approvals, and extracts the best value by combining several orders for the same type of good or even getting suppliers to bid for the business. Examples of vendors are GateKeeper and Proposals Factory.

Current procurement systems automate much of the management of documents in the procurement process while COMPOSITION goes several steps further – COMPOSITION automates the finding of suitable vendors through an advanced matchmaking functionality. It also automates the actual negotiation of terms and prices using advanced agent technology.

**Ecosystem Collaboration**

There are mainly two categories relevant for COMPOSITION.

The first category is *supply chain management* software. Supply chain management software (SCMS) is the software tools or modules used in executing supply chain transactions, managing supplier relationships and controlling associated business processes. While functionality in such systems can often be broad – it commonly includes - Customer requirement processing, Purchase order processing, Sales and Distribution, Inventory management, Goods receipt and Warehouse management, Supplier Management/Sourcing. Many SCMS include forecasting. Such tools often attempt to balance the disparity between supply and demand by improving business processes and using algorithms and consumption analysis to better plan future needs.

The main vendors of SCM software are SAP, Oracle, JDA and Infor. COMPOSITION is contributing by adapting blockchain technology (Market Transaction Blockchain) to supply chain management. COMPOSITION also moves away from closed proprietary solutions for supply chain management to an open market place approach but still enforces trust and security by the use of Blockchain.

The second relevant technology is the *EPCglobal network*. The EPCglobal Network is a computer network used to share product data between trading partners. It was created by EPCglobal. The basis for the information flow in the network is the Electronic Product Code (EPC), which is a universally unique identifier for any physical object anywhere in the world, for all time. The EPC may be encoded in a Radio Frequency Identification (RFID) tag but is not designed exclusively for use with RFID data carriers. For example, EPCs can also be constructed based on the reading of optical data carriers, such as linear barcodes.

EPC Information Services (EPCIS) is an EPCglobal standard designed to enable EPC-related data sharing within and across enterprises. This data sharing is aimed at enabling participants in the EPCglobal Network to obtain a common view of the disposition of EPC-bearing objects within a business context. There are a number of EPCglobal certified software vendors. This includes RFID middleware providers, development tools providers and product traceability software. Examples are Frequentz and Axway. EPCglobal already has an ecosystem that is collaborating in the context of manufacturing and delivery of manufactured goods. This is a huge potential for COMPOSITION that could provide a layer on top of the EPCglobal network. First COMPOSITION offers an open market place and agent technologies which will make it easier and more attractive to join an EPCglobal network. COMPOSITION also adds a Market Event Broker and Market Transaction Blockchain to ensure trust and immutable ledger.

## 8.2 Unique Selling Points

The main selling point of the COMPOSITION IIMS platform lays in its ability to integrate data along the value chain inside a factory into one Integrated Information Management System (IIMS), thus providing unique features such as:

- Combining physical world, simulation, planning and forecasting data to enhance re-configurability, scalability and optimisation of resources and processes inside the factory
- Creating a (semi-)automatic ecosystem, which extends the local IIMS concept to a holistic and collaborative system incorporating and inter-linking both the Supply and the Value Chains
- Building on well-known paradigms, such as marketplace emulation, to extend factory IIMS into a holistic and collaborative IIMS incorporating the entire Supply and Value Chain, providing the necessary tools to compare production indicators within and between manufacturing facilities
- Sharing products and production data with other actors in the supply chain (subcontractors, suppliers).

Tracking information along the supply chain is getting increasingly important, because nowadays products are no longer produced in a single manufacturing plant. Instead, they are sent from one factory to another and possibly back again, according to the production process needs and phases. Additionally, there may be many ‘factories within factories’ with various manufacturing cells developing sub-assemblies or undertaking task such as preparation, coating, packaging, etc. Whilst tracking inside companies already occurs, crossing company borders is almost unknown.

The necessity of reacting to dynamically changing market demands is ever more important. A major problem in the manufacturing ecosystem is to connect supply chain data and services between enterprises and to connect value chain data within a factory, so that it can meaningfully support decision-making.

The COMPOSITION IIMS will be used to optimise the manufacturing processes by exploiting existing data, knowledge, and tools to increase productivity and dynamically adapt to changing market requirements with the following Unique Selling Points and features:

- Real-time information about actual performance and historical data of past performance is captured at machine level using state-of-the-art IIoT components
- Machine-learning-based prediction of machine or part failure and replacement eliminates unnecessary costs of production process interruption
- Improved material management by keeping track of various aspects of the material flow through the factory, analysing the flow and presenting the results for operators on dashboards in real time and in the form of periodic or on-demand reports
- A Batch Tracking System where operators can tag each tray or reel with products in progress when they are manually transferred from one Production Unit to another. The data can be shown to users on a Material Management Dashboard
- A Material Management Dashboard is the key interface between operators and the IIMS, providing information details as necessary for decision support. Reports with statistical information can be extracted on a regular basis or on demand and used to show systemic deviations from specific Production Units or from specific sub-suppliers.

The COMPOSITION research project also aims at bringing about a substantial advancement in comparison to the scientific State-of-the-Art. This advancement is a major prerequisite for the claimed Unique Selling Points

(UPS). Due to the advanced features, the primary driver in exploitation of the COMPOSITION components will be its leading technologies and functionalities. In the following table, a comparison between State-of-the-Art methods and approaches and COMPOSITION's Unique Selling Points are presented:

**Table 1: Uniqe Selling Points vs. SOTA**

| Aspect | SOTA | COMPOSITION USP |
|---|---|---|
| **Collaborative manufacturing ecosystem** | - Closed, often proprietary and predetermined supply chain management systems | - Open dynamic agent-based systems, still trustworthy through Block chain<br>- Interoperability between the different management systems |
| **Agent-based marketplace** | - Monolithic Agent platforms, agents must be developed within the same framework. Inter-framework operation hard if not impossible.<br>- Multi-agent systems adopted for automatic negotiation in stock market and in several small-scale applications | - Technology agnostic platform.<br>- Agents can be developed by using any programming language. Message-centric interaction, the only shared information is the language syntax.<br>- Application in fully decentralised real industrial environment. Design aimed at scaling at large deployments involving hundreds or thousands of agents. |
| **Blockchain** | - Application for creating trust and security in digital payment | - Application to collaborative manufacturing |
| **Multi-level big data analytics** | - Fixed learning systems | - Online re-configuration based on multi-level analysis |
| **Deep learning** | - Application-specific learning algorithms | - Profiling of opponent behaviour in an integrated ecosystem and open Agent-based Marketplace. Forecasting for supply-chain procurement/buffering policies |
| **Matchmaker** | - Classic information retrieval methods. Semantic matching using shared ontologies | - Exploit similarities in terms of manufacturing capabilities in a shared, agent-based marketplace.<br>- Multi-level matchmaking (both syntactic & semantic). Deal with trade-off between performance and quality of matchmaking |
| **Multi-level modelling and simulation** | - Manufacturing models model either tangible or intangible aspects<br>- Targeting mainly single-objective optimisation<br>- Domain-specific simulation models | - Multi-scaled digital factory models<br>- Multi-objective optimisation<br>- Explore novel algorithms (e.g. genetics) for optimisation in production & logistics.<br>- Early diagnosis of machinery faults/defects through advanced simulation/forecasting |

## 8.3 SWOT Analysis of the COMPOSITION Components

A detailed SWOT analysis is performed by analysing the Strengths and Weaknesses of the COMPOSITION Components against the Opportunities and Threats exposed by the market.

All identified Strengths are matched to the market Opportunities in order to create the foundation for a powerful sales and marketing strategy that fully exploits the superiority of the COMPOSITION Components. At the same token, the Weaknesses are matched to the market Threats in order to allow for relevant risk mitigation plans.

Since the COMPOSITION platform can be used for several market segments and in several business constellations the SWOT is made on a general level. Decisions which services and features to target will be developed further in deliverable *D9.11 Final Exploitation Strategy and Business Plans*.

**Strengths**

- Real-time information about actual performance and historical data of past performance is captured at machine level using state-of-the-art IIoT components
- Machine learning based predictions of machine parts failure and replacement eliminate unnecessary costs production process interruption
- Improved material management by keeping track of various aspects of the material flow through the factory, analysing the flow and presenting the results for operators on real-time dashboard and in the form of periodic or on-demand reports
- A Material Management Dashboard as the key interface between operators and the IIMS providing information details as necessary for decision support. Reports with statistical information can be extracted on a regular basis or on demand, which can be used to show systemic deviations from specific Production Units or from specific sub-suppliers
- Interoperability between different management systems using open dynamic agent-based systems, still trustworthy through Block chain
- Online re-configuration possibilities based on multi-level Big Data analysis
- Profiling of opponent behaviour in an integrated ecosystem and open Agent-based Marketplace. Forecasting for supply-chain procurement/buffering policies
- Multi-level matchmaking (both syntactic & semantic). Can deal with trade-off between performance and quality of matchmaking
- Multi-level modelling and simulation capabilities using multi-scaled digital factory models and novel multi-objective optimisation algorithms for early diagnosis of machinery faults/defects.

**Weaknesses**

- The COMPOSITION Components are research prototypes and considerable efforts are needed to transform them into a commercial product
- This weakness is enforced by an initial uncertainty towards what exactly should be marketed and which of the multidimensional market segments should be approached since COMPOSITION operates in a variety of different domains with several stakeholders
- The COMPOSITION platform is primarily an engine for innovative solutions; Commercial tools and services must be developed together with supporting tools, documentation, etc.

**Opportunities (for exploitation)**

- Technologies and tools are in demand that can add, implement and exploit the intelligence and interoperability embedded in individual devices, manufacturing environments and global supply chain networks
- There is an emerging need to enable new classes of applications combining virtual and physical world information from users, data repositories, devices and sensors into intelligent services based on an open architecture
- Manufacturers need to network their enterprise systems in order to provide higher value-added solutions for their customers with much more focus on intelligent solutions, where the complexity of the system is hidden behind user-friendly interfaces

- The exponential growth within the Industry IoT will continuously demand newer and better components
- Further, the open marketplace's ability to address customers that go "below the radar" of the major competitors is an opportunity for the COMPOSITION Components. The fact that a lot of the B2B will be between SMEs will be an opportunity both for the buyer and seller.

**Threats**

- Access to the Enterprises from the COMPOSITION platform through internet networks is highly critical from the security point of view. In this direction, specific measures must be adopted by the manufacturers ICT departments in order to avoid dangerous conditions and unauthorised access to a local network.

The analysis is summarised in the matrix shown in Table 2.

**Table 2: SWOT Analysis for COMPOSITION Components**

| **Strengths** | **Weaknesses** |
|---|---|
| • Real-time information captured at machine level using IIoT components<br>• Machine learning based predictions of machine parts failure<br>• Improved material management presented on real-time dashboards<br>• Interoperability using open dynamic agent-based systems, still trustworthy through Block chain<br>• Online re-configuration possibilities based on multi-level Big Data analysis<br>• Profiling of behaviour in an integrated ecosystem and open Agent-based Marketplace<br>• Multi-level matchmaking to deal with trade-off between performance and quality<br>• Multi-level modelling and simulation capabilities | • Considerable efforts are needed to transform components into a commercial product<br>• Uncertainty towards the variety of different domains with several stakeholders<br>• Commercial tools and services must be developed together with supporting tools, documentation, etc.<br>• No existing installed base or customer track record |
| **Opportunities** | **Threats** |
| • High growth market for IIoT manufacturing<br>• The consortiums standard knowledge and knowhow in IIoT<br>• Ongoing dialogues between internal partners but at the same time promoting the results of COMPOSTION through the dissemination<br>• Ability to address niche customers that go "below the radar" of the major competitors | • Large and powerful competitors in important segments<br>• Legal risks in case of breach on e.g. GDPR (General Data Protection Regulation)<br>• Security breaches of the COMPOSITION services |

The SWOT analysis requires substantial more clarity as to the products that will be exploited and on which markets. Hence, it will be postponed until the future deliverables *D9.10 Exploitation Planning Framework and First Draft of Exploitation Plans* and *D9.11 Final Exploitation Strategy and Business Plans.* Meanwhile, we will provide an initial market positioning strategy based on the general knowledge of the market needs and the USP elaborated above.

## 8.4 Initial Market Positioning

At this point, with the initial market segments having been identified and analysed and the COMPOSITION Components benchmarked against the competitive products and solutions, the next step is to position the components on the market in relation to both market needs and the strengths of the COMPOSITION Components.

### 8.4.1 Methodology

For the positioning analysis, the General Electric - McKinsey Market Attractiveness Matrix is often used in corporate strategic planning. It has been chosen as a *benchmarking methodology* to analyse the position of the COMPOSITION solutions vis-à-vis existing solutions on the one hand, and market needs and requirements on the other hand. Each exploitable asset is ranked according to its business strength and competitive situation. The ranking will determine the relative business strength on the horizontal scale in the Market Attractiveness matrix below.

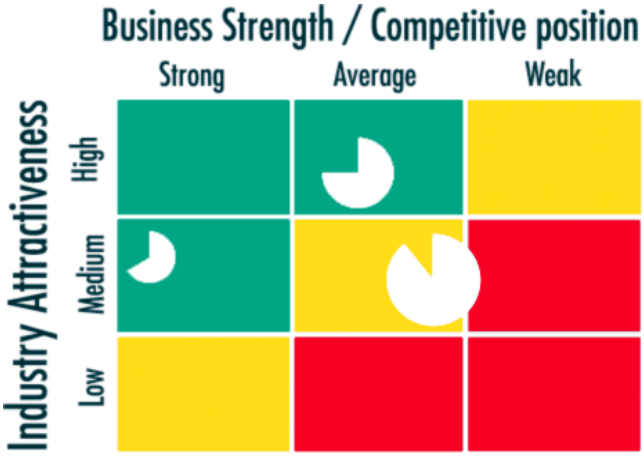


**Figure 9: A Generic Market Attractiveness matrix**

Each market segment is positioned for its attractiveness in terms of market access, purchasing power, number of customers, etc. The result of the analysis is a ranking corresponding to the vertical axis in the Market Attractiveness matrix.

Finally, each of the exploitable assets can be plotted according to these two coordinates and shown as the white figures in the matrix. Further information can be used to qualify the market attractiveness, if available. Often, the size of the figure indicates the potential size of the market for the particular exploitable assets, or the obtainable market share can be indicated by a pie form of the figure.

When completed, the Market Attractiveness provides a useful guideline as to which assets are directly exploitable. The assets in the green areas enjoy excellent positions with a combination of high business strength and attractive market conditions. These are the high priority assets that should be pursued immediately.

Any assets placed in the red areas should be avoided. They have low competitive strength and the market is unattractive or difficult. The assets need to be upgraded in terms of competitive position and repositioned for a different and more attractive market segment. Even if possible, this may require substantial investments and time. The assets in the yellow zone may be interesting, but need to be upgraded vis-à-vis the competition. If they move the left and become more attractive in the identified market segment, they may be exploitable.

### 8.4.2 COMPOSITION Market Attractiveness

This is an initial version on the market positioning, and more work has to be done as details of the project outcome emerge. Deliverable *D9.9 Sustainable Business Models for IIMS in Manufacturing Industries* will contain an updated version of the market attractiveness analysis based on the results of the technical development.

The COMPOSITION products have initially been grouped into the identified market segments as follows:

**COMPOSITION Components and Tools for the Integrated Information Management Systems for Manufacturing (and similar)**

Products involved:

1. Asset and Component Tracker Components
3. Security Enhancing Components
5. Digital Platform for Smart Environments for Factories
6. Digital Factory Modelling Components.

**COMPOSITION Components and Tools for Collaborative Ecosystem Framework**

Products involved:

2. Blockchain Components
3. Security Enhancing Components
5. Digital Platform for Smart Environments for Factories
6. Digital Factory Modelling Components.

**COMPOSITION Components and Tools for Intra-Factory Automation**

Products involved:

1. Asset and Component Tracker Components
4. Decision Support System for Optimising Manufacturing Processes
6. Digital Factory Modelling Components
7. Deep Learning Toolkit.
8. The Virtual Agent-based Marketplace

At this point, the resulting prioritisation of the COMPOSITION solutions is assessed as follows:

The most attractive market segment is the Intra-Factory Automation. This segment has a high demand and established suppliers. The needs for novel automation features, incorporation of IIoT tools, real-time processing, modelling and deep learning features are just emerging. The existing suppliers are regarded as being very open to incorporating new technologies in collaboration with technology developers, SMEs and academic institutions. The difficult part will be to meet the quality and security standards that are required when making software that is part of a closed-loop automation system. The market is thus best serviced with strong partnership with an established knowledge base of issues and solutions in factory automation.

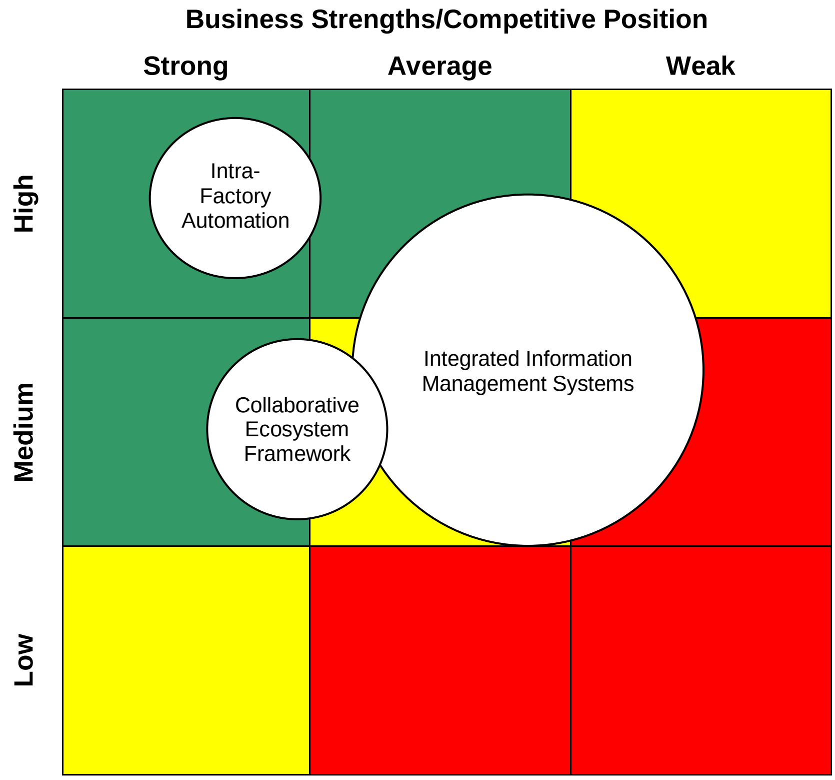


**Figure 10: COMPOSITION Market Attractiveness matrix**

Another attractive market is the Collaborative Ecosystem Framework. The market growth is enormous for solutions for supply chain and product lifecycle management, partly driven by technology push and regulatory and business pulls. The market is not fully developed yet, which leaves good openings for newcomers with novel solutions, However, the pitfall is that buyers, operators, integrators and the like, are not fully aware of what they need and thus cannot fully appreciate the solutions they may be buying in to. This can create massive disappointment and low threshold for frustration down the line. A partnership with a renowned actor in the field will be instrumental for the trust that buyers will place in the COMPOSITION solution.

Finally, the market for Integrated Information Management Systems for Manufacturing may turn out to be slightly less attractive with the present status of the project. This market is by far the largest in terms of volume and actors. However, to be a credible player, it is not enough to deliver integration tools – a solid command and experience in the applications and services that are to be integrated is also required. This may be the weakness of the exploiters of the COMPOSITION solutions, if the market was to be addressed with, e.g., stand-alone solutions or with upgrades of installed base solutions. The only conceivable way at this point is to team up with an existing system integrator or solution provider in the market, and deliver total solutions in partnerships.

# 9 Conclusions and Recommendations

## 9.1 The Methodology

The work undertaken focused on performing full market analysis and market segmentation given the relatively limited information available at this about the outcome of the project.

After first having identified eight exploitable assets (products, components, applications), a description of the most likely markets was performed including the following:

1. Market description and characteristics
2. Market segments
1. Target groups, actors and stakeholders,
2. Estimation of market size
3. Market drivers and Inhibitors

In the present deliverable, a full market analysis for the first segment: Smart Factory Software Components and subsystems is presented, including market description, market size, USP and SWOT analysis.

On basis of the market description, we further went on to analyse the market with respect to the specific COMPOSITION products for developers. The analysis comprised:

1. Competitor analysis
2. Unique Selling Points (USP)
3. SWOT analysis
4. Market prioritisation.

## 9.2 The Decisions Made

The market description and analysis in COMPOSITION focus on two primary markets 1) the market for the COMPOSITION solution as a whole, based on user applications explored in the project pilots and 2) the market for software development tools for those that develop, deploy, and maintain IIoT applications for industrial customers.

Using this segmentation, we decided first to focus on the market for software development tools:

Smart Factory software components and subsystems for suppliers of complete software solutions to industry actors in both the intra- and Inter-Factory ecosystems. Technology segments include:

- Integrated information management system for manufacturing
- Collaborative ecosystem frameworks
- Intra-Factory automation solutions
- Lifecycle management.

The understanding of the industrial applications for the manufacturing industry is still limited at this point in the project. Once the pilot applications have been deployed and evaluated the market for Stand-alone Smart Factory solutions will be revisited and reported in *D9.10 Exploitation Planning Framework and First Draft of Exploitation Plans (February 2018).*

Within the Smart Factory software market, three main target groups were identified:

1. Suppliers of commercial tools and solutions
2. Cooperation partners (integrators)
3. Resellers

The open plug-and-play architecture of the COMPOSITION platform allows us to establish interfaces and collaborations which different suppliers at different levels. It can also provide added value to MES suppliers who have not yet embarked on the transformational part into the IIoT world. Other possibilities open up in liaison with suppliers of General IoT Platforms to offer them a possibility to deliver packaged Industrial IoT solutions. Hence, we decided to focus on market entries based on partnerships with established software developers and suppliers. A detailed competitor analysis was made in this respect.

Since the COMPOSITION IIMS will be used to optimise the manufacturing processes by exploiting existing data, knowledge, and tools to increase productivity and dynamically adapt to changing market requirements, we decided on the following Unique Selling Points and features:

- Real-time information about actual performance and historical data of past performance is captured at machine level using state-of-the-art IIoT components
- Machine-learning-based prediction of machine or part failure and replacement eliminates unnecessary costs of production process interruption
- Improved material management by keeping track of various aspects of the material flow through the factory, analysing the flow and presenting the results for operators on dashboards in real time and in the form of periodic or on-demand reports
- A Batch Tracking System where operators can tag each tray or reel with products in progress when they are manually transferred from one Production Unit to another. The data can be shown to users on a Material Management Dashboard
- A Material Management Dashboard is the key interface between operators and the IIMS, providing information details as necessary for decision support. Reports with statistical information can be extracted on a regular basis or on demand and used to show systemic deviations from specific Production Units or from specific sub-suppliers.

Based on the market information, segmentation, competition, and USP, a traditional SWOT analysis was performed.

Finally, for the positioning analysis, the General Electric - McKinsey Market Attractiveness Matrix was used to to analyse the position of the COMPOSITION solutions vis-à-vis existing solutions on the one hand, and market needs and requirements on the other hand. Each exploitable asset is ranked according to its business strength and competitive situation. The ranking determines the relative business strength on the horizontal scale in the Market Attractiveness matrix and allows us to draw important conclusions regarding the most attractive markets for COMPOSITION exploitation.

### 9.3 The Conclusions Made

Based on the market analysis, we concluded on a number of strategies that could be effectively be deployed in order to successfully achieve market penetration.

The COMPOSITION products have initially been grouped into the identified market segments as follows:

- COMPOSITION Components and Tools for the Integrated Information Management Systems for Manufacturing (and similar)
- COMPOSITION Components and Tools for Collaborative Ecosystem Framework
- COMPOSITION Components and Tools for Intra-Factory Automation

The most attractive market segment is the Intra-Factory Automation. This segment has a high demand and established suppliers. The needs for novel automation features, incorporation of IIoT tools, real-time processing, modelling and deep learning features are just emerging. The market is best serviced with strong partnership with an established knowledge base of issues and solutions in factory automation.

Another attractive market is the Collaborative Ecosystem Framework. The market growth is enormous? for solutions for supply chain and product lifecycle management, partly driven by technology push and regulatory and business pulls. The market is not fully developed yet, which leaves good openings for newcomers with novel solutions, A partnership with a renowned actor in the field will be instrumental for the trust that buyers will place in the COMPOSITION solution.

Finally, the market for Integrated Information Management Systems for Manufacturing may turn out to be slightly less attractive with the present status of the project. This market is by far the largest in terms of volume and actors. However, to be a credible player, it is not enough to deliver integration tools – a solid command and experience in the applications and services that are to be integrated is also required. The only conceivable way at this point is to team up with an existing system integrator or solution provider in the market, and deliver total solutions in partnerships. However, when doing so, there is a huge potential for the successful exploitation of COMPOSITION Components and Subsystems.

### 9.4 Recommendations for Future Work

The understanding of the final industrial applications for the manufacturing industry is still limited at this point in the project. Several use cases have been defined (see Appendix A) which will eventually be developed and evaluated by the end users in the pilots. Once the pilot applications have been deployed and evaluated by end users, the market for Stand-alone Smart Factory solutions will be revisited and reported in *D9.10 Exploitation Planning Framework and First Draft of Exploitation Plans* (February 2018)

# 10 List of Figures and Tables

## 10.1 Figures



## 10.2 Tables

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# 12 Appendix A

The following table shows a prioritised list of industrial scenarios and use cases developed in the project and which form a guideline for the definition and help to explain the market focus of the developed products.

**Table 3: Use Case Priority List**

| Tier | Use Case | Scenario | End User Importance |
|---|---|---|---|
| | UC-BSL-2 Predictive Maintenance | | Very High (BSL) |
| | UC-KLE-1 Maintenance Decision Support | | Very High (KLE) |
| | UC-KLE-4 Scrap metal collection process | | Very High (KLE) |
| | UC-KLE-5 Scrap metal bidding process | | High (KLE, ELDIA) |
| | UC-KLE-6 Determining price for scrap metal with ELDIA acting as Logistician | | Medium (KLE, ELDIA) |
| | UC-BSL-5 Equipment Monitoring | INTRA-1 | High (BSL) |
| | UC-ELDIA-1 Fill-level Notification – Contractual solid recyclable waste management | | Very High (ELDIA) |
| | UC-ELDIA-2 Fill-level Notification – Contractual wood waste management | | High (ELDIA) |
| | UC-KLE-2 Delayed Process Step | | Very High (KLE) |
| | UC-BSL-3 Component Tracking | | High (BSL) |
| | UC-ATL-3 Searching for recommended solutions | INTER-4 | Very High (ATL) |
| | UC-BSL-1 NC Monitoring | INTRA-1 | Medium (BSL) |
| | UC-KLE-3 Scrap Metal and Recyclable Waste Transportation | INTRA-3 | High (KLE) |
| | UC-BSL-4 Automatic Solder Paste Touch Up | INTRA-4 | Medium (BSL) |
| | UC-KLE-7 Ordering raw materials | INTER-3 | High (KLE) |
| | UC-ATL-1 Selling software/consultancy | | High (ATL) |
| | UC-ATL-2 Searching for solutions | | High (ATL) |
| | UC-ATL/NXW-1 Integrate external product into own solution | | Medium (ATL, NXW) |
| | UC-NXW-1 Decision support over marketplace | | High (NXW) |

# Appendix B

This appendix provides a list of competitive suppliers for the different COMPOSITION layers.

**Shop Floor Connectivity Layer**

**KepWare**

https://www.kepware.com/en-us/

KEPServerEX® is a connectivity platform providing a single source of industrial automation data. Designed to streamline the deployment, management, and delivery of information, KEPServerEX is a smart manufacturing solution that connects the plant floor ecosystem with all aspects of the enterprise.

**Codesys**

https://www.codesys.com/products/codesys-runtime/opc-server.html

Main task of the CODESYS OPC Server is the exchange of data (read/write) with the controller for example for visualisations or for process data logging programs. The CODESYS OPC Server is an additional Windows program delivered along with the IEC 61131-3 Development System CODESYS.

**Matrikon**

http://www.matrikonopc.com/main/about.aspx

MatrikonOPC provides equipment data connectivity products based on the OPC standard. The MatrikonOPC promise is to empower customers with reliable data access to all major automation vendors' systems from native device connectivity to enterprise wide visibility, provide practical OPC training and deliver superior client care.

**Iconics**

http://www.iconics.com/Home/Products/OPC-Connectivity.aspx#.WaezA-QUm3A

ICONICS provides OPC-to-the-Core™ solutions ranging from a wide range of OPC servers and clients to a suite of toolkits for developing OPC toolkits.

**PLC Manufacturers**

https://en.wikipedia.org/wiki/List_of_PLC_manufacturers

**Industrial IoT Service Layer**

**ABB Group, Ability**

Recently announced partnership with Microsoft for services such as Azure IoT suite and Cortana Intelligence suite includes applications in fleet management, intelligent buildings, integrated mining, and sensing technology.

**Advantech, Wise-Pacs**

Advantech is partnering with Microsoft Azure as the IaaS and PaaS solution provider through the Microsoft Cloud Solution provider program to offer diverse functions for IoT applications. Also offers an IoT gateway starter kit.

**C3 IoT, C3 IoT Applications**

Cross-industry software solutions aggregate volumes of disparate data from enterprise systems and external sources and apply advanced machine-learning algorithms for predictive, continuous analyses that culminate in actionable insights.

**Cisco Systems, Industrial Network Director**

Purpose-built network devices; manage with real-time maps of automation device connectivity; network information delivered in the context of the automation process; existing assets integrated through APIs; common information framework shared by operators and IT to manage the industrial network.

**Dell, IoT Solutions**

Overlay intelligent gateways into existing legacy equipment, control systems, and assets. Deploy edge and core analytics. Deploy intelligent gateways across communications protocol networks and in the data centre and Cloud.

**Emerson Process Management, Plantweb Advisor Suite**

Suite applications include Health Advisor, Performance Advisor, and Energy Advisor. All leverage OSI Soft Pi System's scalable open-data infrastructure to capture and shape data generated by equipment. The information can be vital to improving a plant's profitability.

**GE Digital, Predix Industrial Cloud Platform**

https://www.ge.com/digital/predix

A Cloud-based platform for Industrial Internet applications based on a multi-tenant gated community model to reduce equipment costs, enhances effectiveness of machine operators. Start by installing a Predix-ready field agent into your infrastructure.

**Honeywell, Uniformance Suite**

Software solutions that turn data into actionable information-correlates historian information with KPIs and a database all in one tool. Visualise information in an asset-centric context.

**IBM BlueMix**

https://www.ibm.com

**IBM, Watson IoT Platform**

Easily and securely connect devices. Quickly build IoT applications that learn from the physical world. Analyse data from any source. Gain insight from huge volumes of IoT data to make better decisions and optimise operations.

**INTEL, Intel IoT Platform**

An end-to-end reference model and family of products that works with third-party solutions to connect devices, deliver data to the Cloud, and value through analytics. A broad spectrum of interoperable, cross eco-system IoT solutions can be bought and optimised.

**Meshify, Now**

Out of the box IoT solution minimises barriers to deploy data gathering, analysis, and visualisation. This product quickly connects a device to the Cloud to start analysing data in minutes. Bundle makes use of M1 dragonfly hardware.

**Microsoft, Azure IoT suite, Cortana Intelligence Suite**

Predictive-analytics and machine-learning applications include remote monitoring and predictive maintenance. Collect previously untapped data. Set up real-time analytics using SQL-based syntax. Integrate Azure IoT with CRM, ERP, and database applications.

**OSIsoft, PI System**

Discover trends and best practices in process industries using operation data in Big Data analytics; analyse and visualise data. An open infrastructure connects sensor-based data, operators, and people to enable real-time intelligence.

**PTC, ThingWorx IoT Platform**

Enterprise platform enables users to develop and deploy connected solutions. KEPServerEX provides a communications platform and single source of industrial automation data to multiple applications. ThingWorx agent in the IoT gateway moves industrial data from the edge into ThingWorx.

**Rockwell Automation, FactoryTalk Production Centre**

The connected enterprise leverages embedded intelligence and new sources of information. Partners with Cisco Systems to bring network connectivity and operations systems together holistically in a single unified network infrastructure.

**SAP, IoT Solutions**
https://www.sap.com/products/manufacturing-intelligence-integration.html

Become a highly adaptive manufacturer with SAP Manufacturing Integration and Intelligence (SAP MII). The software can help you leverage the Industrial Internet of Things (**IIoT**) by connecting your equipment, people, and operations to your extended supply chain. Get the manufacturing intelligence and visibility you need to run in real time. Data solutions apply machine learning and integrate with core business applications of SAP S/4HANA. A "jump start" package initiates operations/business connectivity to better monitor equipment and gain operational insights. An accelerator package adds **MES** and control environment.

**SAS, Analytics for IOT**

Whether your data is at the edge, in motion, or at rest, system supports good decision-making while reducing data transport and storage costs. Event stream processing engine handles huge volumes data at very high rates with extremely low latency.

**Schneider Electric Software, ExoStructure**

Architecture and platform delivers IoT-enabled solutions by leveraging connectivity and data to create controls and actionable business insights. With the combined power of analytics and closed-loop operators, enables a breadth of applications, analytics, and services on open IP protocols.

**Telit, deviceWISE for Factory**

Developed to operate within the four walls of the enterprise, the platform connects and integrates production machines and processes with ERP, MES, and SCADA. Decreases installation and maintenance costs by eliminating the use of intermediate PC technology, custom programming, and homegrown solutions.

**Business Services Layer**

**AspenTech**

http://home.aspentech.com

AspenTech customers use our solutions to improve their competitiveness and profitability by increasing throughput and productivity, reducing operating costs and unplanned downtime, enhancing capital efficiency, and decreasing working capital requirements. Maximise Uptime With Actionable Data. The APM suite supports your corporate reliability initiatives, taking an analytics-driven approach to asset availability. PM enables you to accurately predict and eliminate the root cause of all failures. With integrated aspenONE software, our customers can better design, operate and maintain their complex manufacturing environments.

**AwarePoint - Location as a Service**

http://www.awarepoint.com/industries/manufacturing

Awarepoint's next-generation real-time location system delivers contextual awareness and operational intelligence to the Internet of Things (IoT) to increase efficiency, improve quality management, and reduce cost. Awarepoint's RTLS infrastructure operates on proven industry-standard technologies, including Bluetooth® Low Energy (BLE) and Wi-Fi, to deliver high accuracy positioning but at a much lower cost than comparable solutions. Our approach leverages your existing Wi-Fi network, deploys rapidly, and provides the flexibility to monitor tags and mobile devices with greater than 99% accuracy and low latency (under two seconds).

**Bellhawk**

http://www.bellhawk.com

Real-Time Manufacturing Execution Systems (MES) and Manufacturing Operations Management (MOM)

**Bluvision**

http://bluvision.com/manufacturing/

Within manufacturing operations, there are several processes that are critical to the overall success of the organisation. Key amongst these are: Asset Tracking, Employee Optimisation, and Asset Condition Monitoring. Bluvision provides solutions for all three of these processes using the same infrastructure, thereby keeping costs low and optimising for the entire operation. Further, Bluvision provides distinct advantages for each of these processes.

**Cogiscan**

http://cogiscan.com/

Cogiscan is the leading track, trace and control (TTC) solutions provider for the electronics manufacturing industry. The Cogiscan platform integrates systems from all major equipment manufacturers and is highly configurable to address specific production needs of its customers.

**Critical Manufacturing**

http://www.criticalmanufacturing.com/

The architecture of Critical Manufacturing is already equipped for Smart Manufacturing based on connectivity to different protocols for equipment or devices, and supporting Internet-of-Things enabled products and production systems (CPS and CPPS). It is logically decentralised, vertically and horizontal integration ready and supports location sensing, mobile and advanced analytics.

**Flags**

http://www.flagssoftware.com

With FLAGS Software, everything about an inspection can be recorded electronically – in seconds: who performed it and where, and the exact location of any faults. With FLAGS Software, you can ensure that every required quality control step is completed, discover the root cause of any problems and add substantial security to gate release. Guarantee that no product is released before issues are rectified and that every product sold adheres to the standard you prescribe.

**Inductive Automation Partner**

https://inductiveautomation.com/solutions/iiot

Ignition is a powerful industrial software platform built for SCADA, MES & IIoT applications. Ignition IIoT by Inductive Automation is an end-to-end Industrial Internet of Things (IIoT) solution that combines the MQTT data-transfer protocol with the unlimited data acquisition and development power of the Ignition industrial application platform. With Ignition, you can easily connect to plant-floor and field devices at the edge of your network, and push data from thousands of devices across numerous sites through a central MQTT infrastructure to both industrial and business applications.

**IQMS**

https://www.iqms.com/manufacturing-software/process_monitoring.html

IQMS' RealTime™ Manufacturing Process Monitoring software gathers machine performance and process data at the PLC level in true real time. No batch interfaces. No SCADA or other batch software integration is needed. Data collected can be charted directly or can be viewed through the EnterpriseIQ SPC module to analyse trends in real time.

**Tableau**

http://www.tableau.com

Monitor production-defect data using a single dashboard. Analyse defects by type, time, and region. Then drill down to see which product family, category, and operator have produced the most defects.

**Vero**

http://vero.solutions/your-industry/manufacturing/

Vero offers a range of tracking solutions designed to help manufacturing businesses by improving their key processes from production to quality control through to distribution. Whether it's tracking production processes, managing your inventory or safeguarding your staff in your warehouse, our solutions are flexible and designed to accommodate your specific requirements.

**Wonderware, Industrial Information Management**

https://www.wonderware.com/industrial-information-management/

As a plethora of new connected devices becomes available and the cost of instrumenting remote equipment plummets, the need for unifying systems to provide context and organise data is essential. A managed historian unlocks information. Data analysis tools make sense of industrial Big Data.

**MES- Manufacturing Execution Systems**

https://en.wikipedia.org/wiki/Manufacturing_execution_system

**Automated Procurement**

**Gatekeeper**

http://www.gatekeeperhq.com/

Manage complex relationships simply and easily. Clarify ownership and centrally store all intelligence, messages, dates and key documentation - all in one place, always up to date, company-wide.

**Precoro**

http://precoro.com/

Precoro is an e-procurement software designed to streamline procurement process and increase Spend visibility. Reduce manual work for your employees, purchasing manager, procurement and financial department.

**Proposals Factory**

http://www.proposalsfactory.com

Create structured RFQs, RFPs and RFI in a shared repository with full audit trail for each requirement. eProcurement Software to invite vendors, compare bids, negotiate and award

**Ecosystem Collaboration**

**Supply Chain Management Software**

https://www.appsruntheworld.com/top-10-scm-software-vendors-and-market-forecast-2015-2020/

**EPCglobal Certified Software**

**Axway Amplify**

http://www.axway.com

Axway AMPLIFY™, customers can fuse data from anywhere to power a customer experience network that unites not only employees, but suppliers, partners and developers into an agile force for innovation that’s as fast and fluid as today’s digital consumer.

**Covectra**

http://www.covectra.com

Covectra provides packaging line serialisation, track & trace, and authentication technologies for brand protection, supply chain integrity, and other business benefits.

**Frequentz IRIS**

http://frequentz.com/

IRIS (Information Repository & Intelligence Server) software captures and shares critical product data and events with upstream and downstream trading partners. The platform seamlessly integrates into any businesses current operations, allowing for the biggest and smallest of companies to receive the benefits of traceability.

**EPCglobal Network**

https://www.gs1.org/epcglobal