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D8.2 Pilot plans on the Shopfloors and preparation actions II

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1 Executive Summary

Deliverable *"D8.2 Pilot plans on the Shopfloor and preparation actions II",* presents the final version of preparation actions that have been performed until M30 of the COMPOSITION project. The developments of COMPOSITION are demonstrated and validated to four pilot partners. The first pilot, from the biomedical domain (Boston Scientific Ltd - BSL), focuses on the integrated information management system in a multisided manufacturing process (intra-factory). The second pilot from the lift manufacturing industry (KLEEMANN - KLE) concentrates on intra-factory procedures and on interaction between different companies using the COMPOSITION ecosystem with the agent-based marketplace for collaboration (inter-factory). The third pilot from the recycling industry (ELDIA) focuses on the reduction of the amount of waste that is disposed at the Sanitary Landfill (inter-factory). The fourth pilot from the industrial manufacturing software domain (ATLANTIS -ATL), focuses on the supply chain/Inter-factory cases and will deploy COMPOSITION for software upgrade and deployment.

This deliverable provides a methodology for planning and preparing the pilots' sites for the use case implementation. The methodology is comprised of four stages: 1. Factory Acceptance Testing, 2. Site Acceptance Testing, 3. Deployment and Commissioning and 4. Operation and Maintenance. COMPOSITION components, their usage and implementation per use case are described in detail. Preparation actions are categorised into value chain and supply chain use cases. After various partner meetings and workshops, some of the use cases were decided to be combined and some to be excluded. Finally, a concluding overall framework for pilot plans on the shopfloor and preparation actions is presented. This framework is common for all pilots and combines the developed components with each use case.

Deliverable *"D8.2Pilot plans on the Shopfloor and preparation actions II"* documents the actions that have been taken to prepare the shopfloor for the deployment of COMPOSITION tools. It is the second version of D8.1, which updates and documents the results of the preparation actions.

2 Abbreviations and Acronyms

Table 1: Abbreviations and acronyms used in the deliverable

Acronym	Definition
AMQP	Advanced Message Queuing Protocol
AMS	Agent Management Service
API	Application Programming Interface
BMS	Building Management Systems
CSO	Chief Sales Officer
DBSCAN	Density-Based Spatial Clustering and Correlation of Applications Noise
DFM	Digital Factor Model
DoA	Description of Action
DSS	Decision Support System
FAT	Factory Acceptance Testing
HMI	Human Machine Interfaces
HTTP	HyperText Transfer Protocol
IIMS	Integrated Information Management System
JWS	JSON Web Signature
KPIs	Key Performance Indicators
LA	Learning Agent
LOF	Local Outlier Factor
LS	Learning Service
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NFA	Nondeterministic Finite-state Automata
PCB	Printed Circuit Board
PCBAs	Printed Circuit Board Assemblies
REST	Representational State Transfer
RTLS	Real Time Location System
SAT	Site Acceptance Testing
SFT	Simulation and Forecasting Toolkit
SPD	Solder Paste Deposit
SPI	Solder Paste Inspection
STM	State Machines
UC(s)	Use Case(s)

3 Introduction

The present document is a deliverable of the COMPOSITION project, that is funded by the European Commission's Horizon 2020 Research and Innovation programme, reporting the results of the activities carried out by WP8. The aim of COMPOSITION is to create a digital automation framework (the COMPOSITION IIMS) that optimizes the manufacturing processes by exploiting existing data, knowledge and tools to increase productivity and dynamically adapt to changing market requirements. This is achieved through the connection of supply chain (inter-factory) data and services among enterprises and the connection of value chain (intra-factory) data within a factory, so that it can meaningfully support decision-making.

3.1 Purpose, context and scope of this deliverable

The purpose of this deliverable is to provide a systematic methodology for the planning and preparation actions that should be taken for the implementation of the use cases. This document focuses on the preparation of the COMPOSITION platform (components, tools, services, interfaces) and installation of infrastructures to the shopfloor. The document updates *"D8.1 Pilot plans on the Shopfloor and preparation actions I"*.

D8.2 describes the usage of COMPOSITION platform components that are necessary for the successful implementation of the use cases at the four pilot partners (Boston Scientific, KLEEMANN, ELDIA and ATLANTIS). The four pilots and their involvement in COMPOSITION are described in section 6.

3.2 Content and structure of this deliverable

The deliverable is structured as follows:

Section 4,includes details of the methodology regarding the planning of implementation on the shopfloors, the time scheduling and the evaluation of the pilots. In section 5, the architecture components and their usage and implementation are described. Section 6 includes details of the value chain (intra-factory) scenarios and supply chain (inter-factory) scenarios. Section 7 concludes the deliverable by presenting a framework of pilot plans on the shopfloor and preparation actions.

4 Methodology for Planning the Deployment on the Shopfloors

4.1 Shopfloor areas for the deployment of the use cases

Based on the use case prioritization, tier 1, tier 2 and tier 3 use cases are linked to specific shopfloor areas, according to specifications and user needs taking into account the on-going needs of the project. The end users provide figures that show the highlighted areas where the use cases are being implemented. Information about the industrial infrastructure for the deployment is also provided.

4.2 Planning of implementation

This section describes the planning methodology towards the deployment of the COMPOSITION system at the pilot sites, in order to better understand the scenarios and use cases that are being implemented based on the end-user's needs and requirements documented in "*D2.1 Industrial use cases for an Integrated Information Management System"* and "*D2.2. Initial requirements specification".* The main objective is to enhance and enrich the pilots' shopfloor environments by integrating the key enabling technologies and developed components.

4.2.1 Methodology

This section describes the processes that have been followed to bring the COMPOSITION tools and components into operation at the end users' shopfloors in the intended way. The key stages towards implementation are identified below.

- **Stage 1 Design of components – Preparatory actions (Factory Acceptance Testing, FAT)**

  Factory Acceptance Testing is used to make sure that the system performs as expected. It verifies the correct operation of the system and formally approves it. FAT makes sure that certain steps are met. It is a customized process for checking the system and its functions and includes 5 steps, i.e., Planning, Performing Test Activities, Gathering Test Results, Identifying and Correcting Issues (if necessary) and Sign-off (see Figure 1). The first step, planning, is related to the definition and the documentation of the tests that have to be performed: test criteria, protocols, tools needed along with specifications for variances and acceptability. Roles and responsibilities of the involved personnel should also be defined. In step 2, the involved stakeholders (end users' personnel and technical partners), collaborate in order to perform tests based on the planned requirements, specifications and agreements. Results and outcomes are gathered and measured to determine whether objectives and criteria of tests have been met (step 3). According to pre-determined criteria, step 4 identifies the faults, failures, errors and hazards that may occur. Any unresolved issue is addressed for acceptance. This process may require re-testing. Finally, the involved stakeholders sign-off on the acceptance of equipment/systems (step 5). Factory acceptance tests are performed by the end users along with the technical partners.

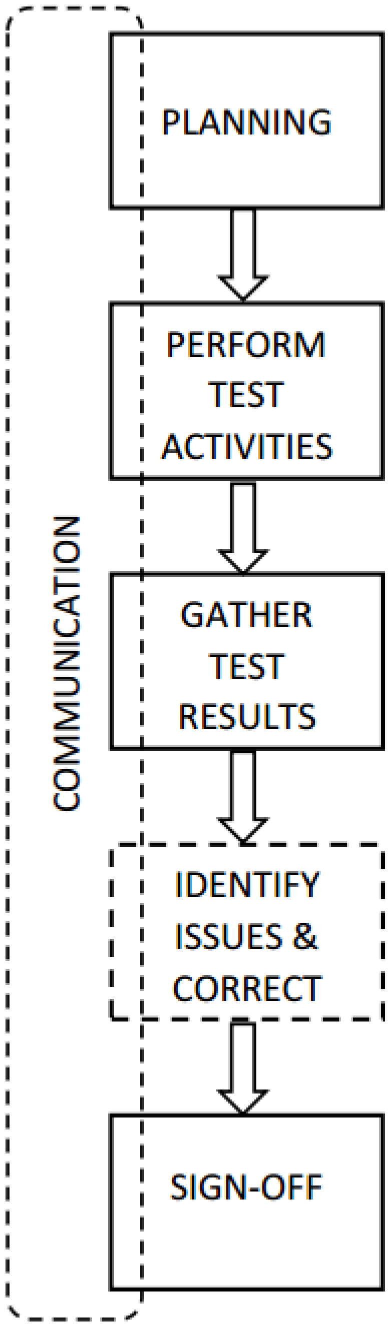

Figure 1: Factory Acceptance Testing

- **Stage 2 Set-up at the shopfloors (Site Acceptance Testing, SAT)**

  Site Acceptance Testing is used to show that the system is working as expected in its operational environment. More specifically, it makes sure that the COMPOSITION IIMS is adequately tested at the end user's facility and performs according to the end user's expectations and specifications. The tests also show whether the system interacts properly with all other systems at the site. The installation is performed by the technology providers in close collaboration with the end-user. The basic infrastructure and the equipment installation at the final position is done by end-user personnel according to health and safety regulations and in compliance with the regulation for commissioning equipment to shopfloor with specific industry pilot plants. The installation is performed by the technology providers either on site or remotely through the appropriate tools for accessing the infrastructures and the servers that will be used for COMPOSITION project. A two-part user preparation plan should also be designed. The first part, "user recruiting plan" describes the key messages that are delivered to the users and any incentives intended to promote participation in the pilot. The second part "user training plan" describes the training during the pilot covering topics such as the description of the UC, the expected results and a brief description of the COMPOSITION IIMS.

- **Stage 3 Deployment and Commissioning**

  In this stage, all required equipment (sensors, cables, gateways etc), software and connections, are installed. After the installation phase, the equipment is tested in a standalone environment including wireless and cabled connections. The developed software is deployed to the end users' facilities after successful testing. The end user performs the tests and any bugs found are reported to the technical partners.

- **Stage 4 Operation and Maintenance**

  Operation and maintenance include information related to the on-going operation and periodic maintenance required for each of the use case components and technologies.

The four stages of pilot planning on the shopfloor are presented below in Figure 2.To ensure successful pilot planning and testing, effective communication is important throughout the stages, setting clear expectations and clarifying roles and responsibilities before each stage is to be performed.

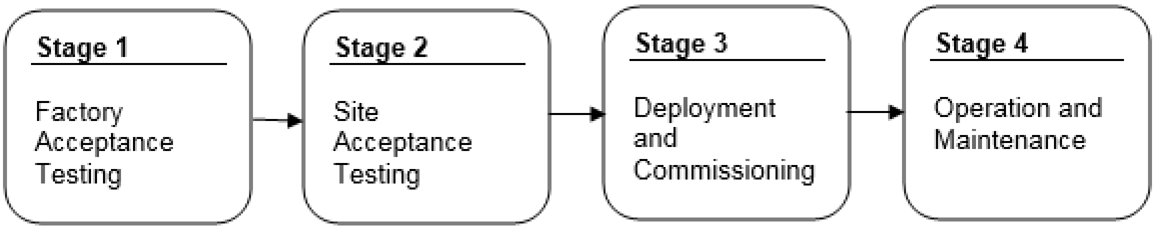

Figure 2: The four stages of pilot planning on the shopfloor

4.2.2 Implementation activities

In this section, the activities performed before and during the deployment and operation of the COMPOSITION platform will be described. The activities should be identified by the implementation team (pilot partners, technical partners, research partners) in every stage of the pilot planning and for every use case. Some examples are given in the table below.

Table 2: Activities and aspects description

No.	Activity/Aspect description	Input / Comments
1	Logical, sequential and efficient coordination of activities	
2	Develop clear deployment specifications	
3	Create an implementation report	
4	Other	

4.2.3 Time scheduling for each use case

A Gantt diagram of the implementation stages of the use cases should be provided in the beginning of each use case pilot. The Gantt diagram illustrates the project time schedule, the relationships between the use case stages and the current status. An example is given below.

Table 3: Gantt diagram UC scheduling

Use Case Stages	M18	M19	M20	M21	M22	M23	M..(n)	M36
UC- (Company) - (Number), e.g., UC-BSL-1								
Design-Preparation (FAT)								
Set up (SAT)								
Deployment - Commissioning								
Operation - Maintenance								

4.2.4 Evaluation of pilot results

In line with *"D8.7 Evaluation Framework"*, quantitative and qualitative data will be gathered through a combination of questionnaires, interviews, telco's and workshops. In addition to D8.7, the pilot results will be evaluated considering multiple criteria that will be defined during the implementation phase. Evaluation criteria will be classified into categories such as energy consumption, process viability, health and safety issues, cost efficiency etc. (see table below).

Table 4: Evaluation of pilot results

No.	Evaluation category	Input / Comments
1	Energy consumption	
2	Process viability	
3	Health and safety issues	
4	Cost efficiency	
5	Other	

5 Components and their Application in COMPOSITION Use Cases

5.1 User workshop and scenarios

Two user workshops were conducted at the BSL and KLEEMANN premises. These workshops included tours on the facilities, for the latter also a tour at ELDIA. The participants discussed relevant scenarios and developed value chain and supply chain use cases.

The workshops and developed use cases are described in detail in deliverable "*D2.1 Industrial Use Cases for an Integrated Information Management System"*.

5.2 COMPOSITION components

A brief summary of the COMPOSITION components is given below. Detailed descriptions are available in *"D2.4 The COMPOSITION architecture specification II"*. The diagram below shows the dependencies between COMPOSITION functional packages.

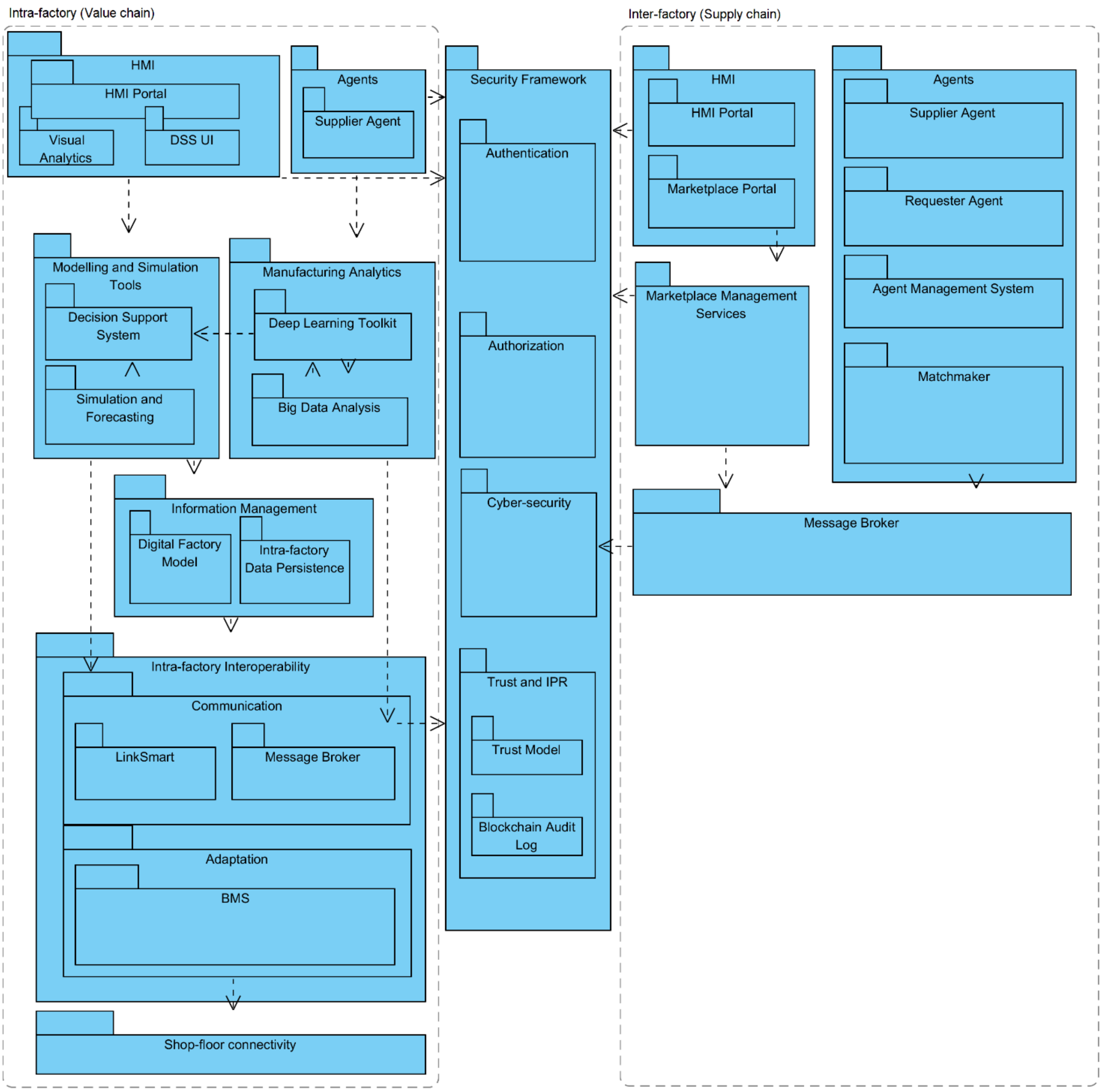

Figure 3: High-level functional view of COMPOSITION architecture

Agent Marketplace

The COMPOSITION Agent Marketplace is the container of the COMPOSITION agents. Agents within the Marketplace may implement market-specific services (such as the white pages or the MatchMaker), or they can act on behalf of industry stakeholders participating in the Marketplace. Required communication infrastructure is provided by a suitable message broker (namely the Marketplace Event Broker), which provides message delivery services to all other components through a well-known, publish-subscribe, interaction paradigm. A well-defined set of messages in JSON format exists, defining the different communications between interacting agents.

As stated in deliverable D2.4, there are two main categories of agents that can be defined a priori, depending on the kind of provided services:

- Marketplace agents
- Stakeholder agents.

The former category groups all the agents providing services that are crucial for the marketplace to operate. In COMPOSITION the most important one is the Agent Management Service (AMS). According to FIPA specifications[1] an AMS is a mandatory component of every agent platform, and only one AMS should exist in every platform. It offers the white pages service to other agents on the platform by maintaining a directory of the agent identifiers currently active.

The latter complementary category, groups agents developed and deployed by the marketplace stakeholders to take part in supply chain formation rounds.

The role of the AMS is crucial for the correct functioning of the whole marketplace. Prior to any operations, any agent must register itself to the AMS to get a valid unique identifier that will be used in all future transactions.

The AMS interacts with:

- RabbitMQ broker, in order to exchange messages with other agents using AMQP as transport protocol
- MatchMaker, in order to update the list of all the agents currently active on the marketplace, as well as with the services they offer. Moreover, requestor agents do not directly communicate with the MatchMaker but, they rely on the AMS for retrieving the list of suppliers that might be interested in or capable of replying to a certain offer
- Requestor and Supplier agents, so that they can get their unique identifier. Requestor agents retrieve the list of the suppliers possibly interested in a certain bidding process by calling a specific AMS's API. In order to update their status on the marketplace, requestor and supplier agents always need to inject this information to the AMS.

Security Framework

The COMPOSITION Security Framework is composed of the following components and model which have been reported in *"D4.2 Design of the Security Framework II".* The following is a brief description of the current components:

- **Authentication – Keycloak:** Component responsible for providing the authentication mechanisms for users, applications, services and devices. Supports the following standard authentication protocols:
    - OAuth 2.0: Industry-standard protocol for authorization. Makes heavy use of the JSON Web Token (JWT) set of standards
    - Open ID Connect (OIDC): Authentication protocol based on OAuth 2.0. Unlike OAuth 2.0 OIDC is an authentication and authorization protocol
    - SAML 2.0: Authentication protocol similar to OIDC, but older, that relies on the exchange of XML documents between the authentication server and the application.

  It also supports most common social networks which allows delegating authentication to a semi-trusted and respected entity where the user already has an account. Most common social networks are supported, like Google, Facebook, Twitter, Github, LinkedIn, Microsoft and StackOverflow

  For more information related to this component refer to section 4.2 in *"D4.2 Design of the Security Framework II"*.

- **Authorization – EPICA:** Component responsible for providing authorization mechanisms to COMPOSITION architecture. This component is based on XACML v3.0 that provides an attribute-based access control mechanism. It provides the means to define authorization policies used to protect resources; any request to access a protected resource will first be evaluated against the defined policies and the evaluation result will be enforced depending on the outcome.

  For more information related to this component refer to *"D4.2 Design of the Security Framework II"* - Section 4.3.

- **Message Broker Auth-Authz Service – RAAS:** Component responsible for providing authentication and authorization to COMPOSITION Message Broker (RabbitMQ) overriding built-in mechanisms. The usage of this service allows the use of centralized Authentication and Authorization COMPOSITION components described above.

[1] http://www.fipa.org/specs/fipa00023/SC00023K.pdf

For more information related to this component refer to *"D4.2 Design of the Security Framework II"* - Section 4.1.

- **XL-SIEM: XL-SIEM** (Cross-Layer SIEM) provides the capabilities of a Security Information and Event Management (SIEM) solution with the advantage of being capable of handling large volumes of data and raise security alerts from a business perspective thanks to the analysis and event processing in a Storm cluster. The main XL-SIEM functionalities can be summarized in the following points:
  - Real-time collection and analysis of security events
  - Prioritization, filtering and normalization of the data gathered from different sources
  - Consolidation and correlation of the security events to carry out a risk assessment and generation of alarms and reports.

  XL-SIEM makes use of components called Cyber-Agents responsible for catching security events and transmit them to XL -SIEM to be analysed. They are installed on the systems that need to be secured and their configuration may differ from one installation to another depending on the events to be monitored.
  For more information related to this component refer to "D4.2 Design of the Security Framework II" - Section 4.4.

- **Blockchain PKI:** Component responsible for providing access to public keys needed for validating the signature of flowing messages in COMPOSITION.

  This component is described in detail in *"D4.3 The COMPOSITION Blockchain"*.

- **Reputation Model:** Model developed in COMPOSITION for the trustworthiness of information exchanged in the manufacturing ecosystem based on the context of data. Each agent of the marketplace will be able to provide a rating related to each single transaction, when they act as the requestor. These will be aggregated with the previous ratings associated with the same provider.

  This model is described in *"D4.2 Design of the Security Framework II"*.

Big Data Analytics

The Big Data Analytics developed in the COMPOSITION project is detailed in *"D5.1 Big data mining and analytics tools I"*. The Big Data Analytics service is provided by the LinkSmart® Learning Service (LS). The LS is a Stream Mining service that provides means to manage real-time data for several purposes. In the first place, the LS provides a set of tools that collects, annotates, filters, aggregates, or caches the real-time data incoming from the production facilities. This set of tools makes it possible to build applications on top of real-time data. Secondly, the LS provides a set of APIs to manage the real-time data lifecycle for continuous learning. Thirdly, the LS can process the live data to provide complex analysis, creating real-time results for alerting or informing about important conditions in the factory that may not be seen at first glance. Finally, the LS will adapt to production needs during the production process. In the pilots, the LS will be responsible for collecting live data coming from the broker for fusion, aggregation, annotation and redistribution to several other components. The Big Data Analytics component is shown in Figure 4.

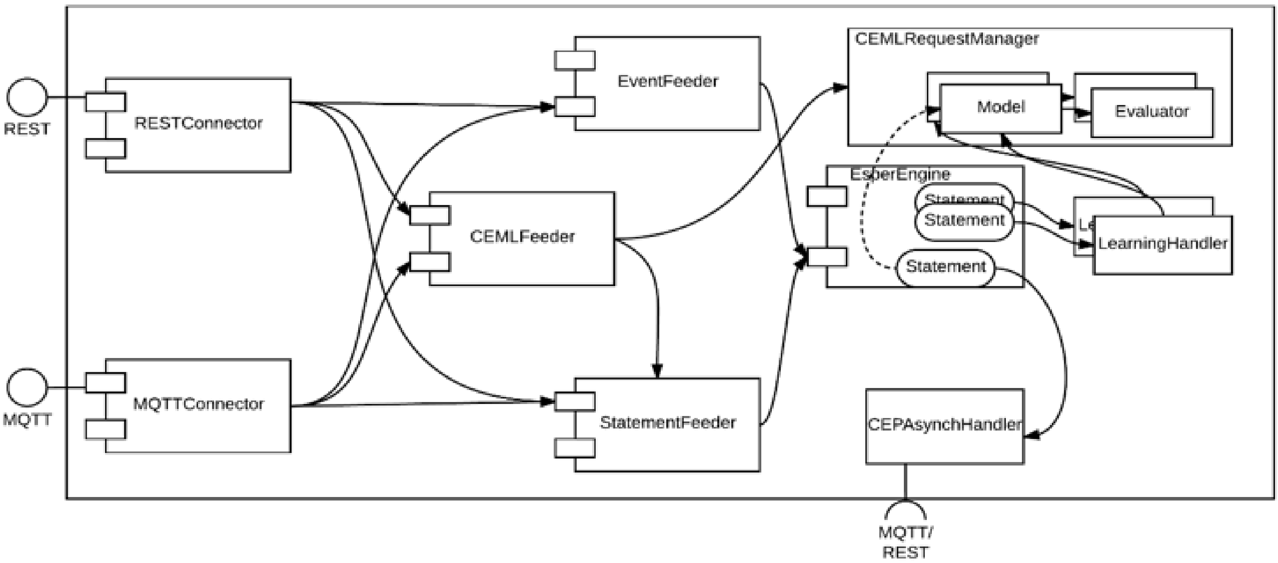

Figure 4: Big data analytics component

BlockChain API

COMPOSITION will use blockchain technology to provide a log of transactions that will ensure the integrity and non-repudiation of messages, e.g., agent negotiation and contracts in the marketplace or material/shipment tracking in the factory. The blockchain API is the component that interfaces COMPOSITION, implements the COMPOSITION specific functionality and interacts with a blockchain implementation. Multichain, an open source product implementing the Bitcoin protocol with some additions, has been selected as the blockchain implementation. Multichain is relatively easy to configure and deploy, not dependent on an underlying "currency" to function, very versatile and free to use as deployed by COMPOSITION. The agents use the API to store public keys, business interactions and reputation values in a shared immutable ledger for later verification. This component is described in detail in "D4.3 The COMPOSITION Blockchain".

Commissioning System

The role of the Commissioning System is to configure sensor set-up, e.g., PLC register mappings and hardware and software identifiers, when deploying the COMPOSITION IIMS and re-configuring or installing new sensors. The information about the deployed equipment is stored in the Digital Factory Model instance for the factory and distributed to the involved components by the Commissioning System.

Deep Learning Toolkit

Machine learning is the branch of computer science concerned with the development of algorithms and techniques to allow systems to learn from training and previous experiences without task-specific programming. As algorithms are evolving, their time efficiency and resource consumption is progressively decreasing and the number of possible fields in which machine learning is applicable is becoming almost endless.

The Deep Learning toolkit represents a point of intelligence aggregation in the COMPOSITION ecosystem providing predictions and forecasts about relevant indicators, such as predictive maintenance and raw material market price estimations. The Artificial Neural Networks are the base of the toolkit prediction approach. The computational models of these networks are inspired by the biological neurons in an animal brain. They are comprised of a large number of highly interconnected processing elements (neurons), typically organized in layers, linked together to solve specific problems.

The real power of Artificial Neural Networks will not be achieved by claiming intellectual propriety of algorithms or frameworks, that are in fact released as open source and progressively updated by the community. On the contrary, the true power of prediction accuracy is in the data ownership.

Regarding the development and deployment of the toolkit, it is worth mentioning that the aim is not to create a Swiss knife tool for every application, but a tailored solution that fits a complex ecosystem from its roots to its leaves. After outlining these scenarios, it is easy to understand why the Deep Learning Toolkit will have as many declinations as the use cases in which it will be deployed, working at both intra-factory and inter-factory levels. Each solution will be specifically developed for the actions required and will be based on historical data availability.

During the training activity of the networks, the most appropriate models are selected and configured for optimal predictions about each use case. This process consists of iterating multiple times through the input dataset. During each training step, the optimal parameters are determined for a given combination of model hyper-parameters, by minimizing prediction error over the training set. The success rate of predictions is drastically dependent of the amount of data provided by the end-user partners in each of the scenarios. In fact, there is a linear dependency between the model complexity and the amount of data required: the deeper and more complex the model, the larger a training set is required.

The Deep Learning Toolkit is going to be deployed in an already trained form continuously refining its training by analysing small batches of live data.

Intrafactory Interoperability Layer

In COMPOSITION intra-factory use cases there is a need of a centralized approach to integrate data from multiple sources and support flexible components integration. These tasks are carried out by the Intrafactory Interoperability Layer, which has three main functions:

- Granting a data agnostic layer to exchange heterogeneous contents through common interfaces
- Securing the messaging system using the services provided by the COMPOSITION security framework
- Ensuring the conformity between communications among interconnected components.

Real-time communications are managed by the RabbitMQ message broker, a highly-scalable implementation of the lightweight TCP/IP-based MQTT protocol. The SSL cryptographic protocol and Keycloak virtual layer have been adopted to provide authentication, authorization and to secure the broker connections. Moreover, all the exchanged messages are signed with the JSON Web Signature (JWS) to demonstrate the authenticity of the sender and to ensure data integrity.

The LinkSmart© Service Catalog allows seeking information about services that are authorized to communicate through the Intrafactory Interoperability Layer. The Catalog provides a JSON-based RESTful API to access service information like publication topics and JWS public keys.

Furthermore, the Building Management System (BMS) provides a seamless interconnection among all the heterogeneous physical sensor systems in the factory and the software modules in the upper layer (data processing, decision support, etc.). This component gathers data read from the sensors, installed in the local environment and interconnected through different field buses and protocols, and organizes it into a uniform Data Model. The RabbitMQ broker mediates communication between the BMS and the other components of the COMPOSITION environment.

This component provides a model for interconnecting the COMPOSITION ecosystem in the intra-factory scenario. It also ensures the conformity between communications among interconnected components.

Manufacturing Decision Support System

The Decision Support System should be designed to accommodate the needs in a manufacturing environment. The DSS integrates Digital Factory Models with sensor data, and other information and knowledge about the products, manufacturing, planning, simulation, communication and controls at all levels of planning and manufacturing. Raw data from sensors in the factory are collected and transformed according to the Digital Factory Model Schema. Processed data are accessed by the DSS through the DFM API. Accessing and processing the transformed data is easier and DSS implementation can be applied without the complicated need of transforming data in a suitable format.

Designing a DSS data and algorithm specification should be considered. Data specifications derive from the DFM API. The algorithms suitable to be applied in a DSS in a manufacturing environment are both data mining algorithms to retrieve suitable data from a repository and decision-making algorithms for the decision-making process. The most used data mining algorithms are classification trees, generic algorithms, support vector machine and Naïve Bayes. Various combinations and modifications of the above algorithms are considered for designing the data mining part of the DSS. Additionally, Non-deterministic Finite-state Automata (NFA) could be used in the decision-making process. The automata can be expanded during the process. Originally, the DSS can implement a rule engine based on Finite State Machines, where the rules applied are defined based on the use cases. The initial rules can be used during a period to train data and then NFAs and non-deterministic algorithms can be implemented for the decision-making process with the collaboration of the Simulation and Forecasting Toolkit. The results of the SFT are sent to the DSS and the Visual Analytics Toolkit for predictions and monitoring.

The DSS also provides the suitable manufacturing KPIs on the shopfloors. Rules are applied to incoming data and they provide the knowledge for maintenance procedures. The KPIs extracted by the data are shown on the HMIs and provide knowledge at a glance to the decision makers. In this state of development of the Manufacturing Decision Support System, the provided KPIs are: Mean Time to Repair – MTTR, Mean Time Between Failures – MTBF, count of recommendations and a measurement of the user's feedback through a mobile application. Messages are coming to the DSS, through the MQTT broker or HTTP RESTful services.

Market Event Broker

The Market Event Broker is the instance of the message broker used in the COMPOSITION Marketplace (see deliverable *D6.2 "Real-Time event broker II*"). It interacts with most components and is the hub through which marketplace agents communicate. However, this is through the standard AMQP protocol and needs no special configuration or development of the broker itself. The broker is tightly integrated with the security framework, which provides identity and access management for all brokers in the COMPOSITION system (federated or clustered).

MatchMaker

The Matchmaker is one of the core components of the COMPOSITION Marketplace. This component aims to match requestor and supplier agents participating in the Marketplace based on different selection criteria. Furthermore, the Matchmaker component is used by agents to match requests and offers between the agents. The Matchmaker's functionality is exclusively depending on the Collaborative Manufacturing Services Ontology. The Matchmaker infers new knowledge by applying rules on the knowledge which is stored in the Ontology.

The Ruled-based Matchmaker has been developed in Java and is offered through RESTful web services. A set of rules (Jena rules) has been created to support matchmaking between services (requested and offered). It also supports offer and request matching based on price, quantity, delivery time and company ranking.

Internally, the Matchmaker component offers a complete semantic framework to the Marketplace. An Ontology store is used for storing the Ontology's individuals. An Ontology Querying Engine which applies SPARQL queries to Ontology story is offered through RESTful web services. The Marketplace agents are able to read or store individuals to Ontology Store by using this comment. The Ruled-based Matchmaker is the third component.

The Matchmaker will be used in pilot cases related to bidding processes, raw material provision and searching for solutions inside the Marketplace.

A Docker image for the Matchmaker component, which contains the complete semantic framework of the Marketplace has been created and deployed in the COMPOSITION Inter-factory Portainer ready for usage by the agents.

Real-Time Multi-Protocol Event Broker

The Real-Time Multi-Protocol Event Broker is an instance of the message broker used in the COMPOSITION IIMS (see *D6.2 "Real-Time event broker II*"). As the hub for all message-based communication, it interacts with most components in the IIMS. However, this is through the standard MQTT protocol and needs no special configuration or development. The broker is tightly integrated with the security framework, which provides identity and access management for all brokers in COMPOSITION system (federated or clustered).

Requestor Agent

The Requestor Agent is the agent exploited by a factory to request the execution of an existing supply chain or to initiate a new supply chain. Due to the dynamics of exchanges pursued in COMPOSITION, there is no actual distinction between the two processes, i.e., for any supply need a new chain is formed and a new execution of the chain is triggered. The Requestor Agent may act according to several negotiation protocols, which can possibly be supported only by a subset of the agents active on a specific marketplace instance.

Simulation and forecasting tool

The Simulation and Forecasting Tool component is part of the high-level platform of the COMPOSITION, Integrated Information Management System. The main purpose of the Simulation and Forecasting Tool is to simulate process models and provide forecasts of events whose actual outcomes have not yet been observed.

Its main interactions are the Digital Factory Model, the Data persistence storage, the Decision Support System (DSS) and the Visual Analytics tool. The Simulation and Forecasting Tool provides predictions by applying a wide variety of algorithms. The DSS will be use the produced data to suggest solutions and actions.

A first analysis of pilot site data related to BSL, KLE and ELDIA use cases has been completed. Algorithms related to Descriptive statistics, linear regression analysis, Markov models, Genetic algorithms for optimization, trend analysis, Density-Based Spatial Clustering and Correlation heat maps have been developed in Python programming language and applied to related data and use cases. The first results have been evaluated.

More precisely, for the KLEEMANN Maintenance Decision Support use case, a Probabilities of Future Faults (PoFF) algorithm has been developed alongside the vibrometers real-time analysis. Methods such as Tonnage-Route Genetic Algorithm (T-RGA), Markov chain models, statistics and trend analysis have been implemented for the ELDIA use case. Algorithms such as Correlation Heatmaps in Real Time, Density-Based Spatial Clustering and Correlation of Applications with Noise (DBSCAN) and Local Outlier Factor (LOF) have been applied and tested for the BSL Predictive Maintenance use case.

Supplier Agent

The Supplier Agent is the counterpart of the Requestor Agent in the COMPOSITION marketplace. It is usually adopted by actual suppliers to respond to supply requests coming from other stakeholders in the marketplace. Factories transforming goods typically employ at least one Requestor Agent to get prime goods and one supplier agent to sell intermediate products to other factories.

5.3 Use cases and component usage and implementation

The different Use Cases to be implemented at the pilot sites require different components of the COMPOSITION platform, and therefore the necessary information, including restrictions and prerequisites, must be provided through the combined efforts of the pilot partners and the technical partners.

To analyse and describe the impact of each component on each of the UCs, an assessment framework has been used, as shown in Table 5. The first and second columns refer to the use case and component, respectively. The component usage (third column) can be: 1) direct, when the UC uses this component, 2) indirect, when the UC uses this component through another component and 3) no usage, when the UC does not use the component at all. The fourth column describes the required effort on a scale from 1 to 5 and shows how difficult it is to incorporate the component into the use case. The assigned value is related to the complexity of integrating the component into the infrastructure of the shopfloor, and not to person months. The fifth column refers to the restrictions and barriers identified. The last column refers to the prerequisites of each component.

Table 5: Use cases and component usage and implementation

Use Case	Component name	Component usage	Effort Required (1-5)	Restrictions	Prerequisites
UC-KLE-1	Manufacturing Decision Support System	Direct	2	Interoperability, Data format	Wi-Fi
	Intrafactory Interoperability Layer	Indirect	4	Not known	-
	Simulation and forecasting tool	From DSS	1	Historical and live data	-

Use Case	Component name	Component usage	Effort Required (1-5)	Restrictions	Prerequisites
	Visual Analytics Tool	Direct/integrated with DSS	2	Interoperability, Data format, Live data from sensors	SFT input, Live data from sensors
UC-KLE-3	Simulation and forecasting tool	From DSS	1	Internal routes data and sensors live data	Fill-level sensors data
	Intrafactory Interoperability Layer	Indirect	4	None known	-
UC-KLE-4	Matchmaker	Agents UI	1	Messages by agents	
	Simulation and forecasting tool	Agents UI	1	Fill-level sensor data	-
	LinkSmart® IoT Learning Agent	Indirect	2	Fill-level sensor data	Working KLE data feeding of the BMS; Running Broker; Security framework;
	Agent Marketplace	Direct	3	Data format, communication protocols	RabbitMQ broker, MySQL database, Security framework
	Requestor Agent	Direct	2	Data format, communication protocols	Marketplace infrastructure
	Supplier Agent	Direct	2	Data format, communication protocols	Marketplace infrastructure
	Intrafactory Interoperability Layer	Indirect	4	Interoperability, Data format	Live data from sensors
UC-KLE-7	Matchmaker	Agents UI	1	Messages by agents	
UC-ELDIA-1	Agent Marketplace	Direct	3	Data format, communication protocols	RabbitMQ broker, MySQL database, Security framework
	Requestor Agent	Direct	2	Data format, communication protocols	Marketplace infrastructure
	Supplier Agent	Direct	2	Data format,	Marketplace

Use Case	Component name	Component usage	Effort Required (1-5)	Restrictions	Prerequisites
				communication protocols	infrastructure
	Visual Analytics	Direct	2	Messages by agents, data formats, communication protocols	SFT and DLT output, ELDIA historical data, fill-level sensors live data
	Simulation and forecasting tool	Agents UI	1	Live and historical data	Fill-level sensor data and ELDIA historical data
	Deep Learning Toolkit	Indirect	2	Nevertheless, the few datapoints available, an already trained model is deployed on the server and serves as an endpoint for prediction for the applicable goods (paper, plastic, wood, scrap-metal)	Live and historical data
UC-BSL-2	Simulation and forecasting tool	From DSS	1	Live data	Acoustic sensors live data
	Deep Learning Toolkit	Indirect	2	None known	Live and historical sensor data
	LinkSmart® IoT Learning Agent	Indirect	4	Live data	Working BSL data feeding of the BMS; Running Broker; Security framework; DLT running
	Intrafactory Interoperability Layer	Indirect	4	Interoperability, Data format	Live data from sensors
	Manufacturing Decision support	Direct	2	Interoperability, Data format	WIFI, docker host
UC-BSL-5	Intrafactory Interoperability Layer	Indirect	4	None known	-
	Manufacturing Decision	Direct	3	Data format	Docker host with

Use Case	**Component name**	**Component usage**	**Effort Required (1-5)**	**Restrictions**	**Prerequisites**
	support				connectivity
UC-BSL-3	Manufacturing Decision support	Direct	2	Interoperability, Data format	WIFI, docker host / Live data from sensors
UC-ATL-3	Matchmaker	Agents UI	1	Messages by agents	Ontology concepts related to software solutions etc

6 Preparation Actions for the Implementation of Use Cases

Preparation actions are broken into two parts, i.e., value chain scenarios and supply chain scenarios. Figure 5 presents the hierarchy of the value chain and supply chain scenarios, which is a result of the reviewer recommendations during the first review of COMPOSITION. In the second year of the project and after various of meetings with KLEEMANN's Production Manager, the Production Supervisor and CERTH researchers, it was decided that UC-KLE-2 will not be further developed, since it is not offering any added value to the pilot partner. Also, it was decided to combine UC-BSL-7 and UC-BSL-3 in the same use case as they are quite similar, and UC-BSL-4 has been excluded. Likewise, it was decided to exclude the lower-priority uses cases involving NXW, and to implement only UC-ATL-3, thus excluding UC-ATL-1 and UC-ATL-2.

In the preparation actions, the following deliverables are utilized to assist the implementation of the UCs: 1) *"D7.4 Test, installation and operation plan template I"* and *"D7.5 Test, Installation and Operation Plan Template II"*, which provide a preliminary test, installation and operation plan for each of the defined use cases and *"D7.6On site Readiness Assessment of Use Cases based on Existing Sensor Infrastructure I"* and *"D7.7 On-Site Readiness Assessment of Use Cases Based on Existing Sensor Infrastructure II",* which assess the readiness of the COMPOSITION industrial use case sites for potential integration of wired and wireless sensors.

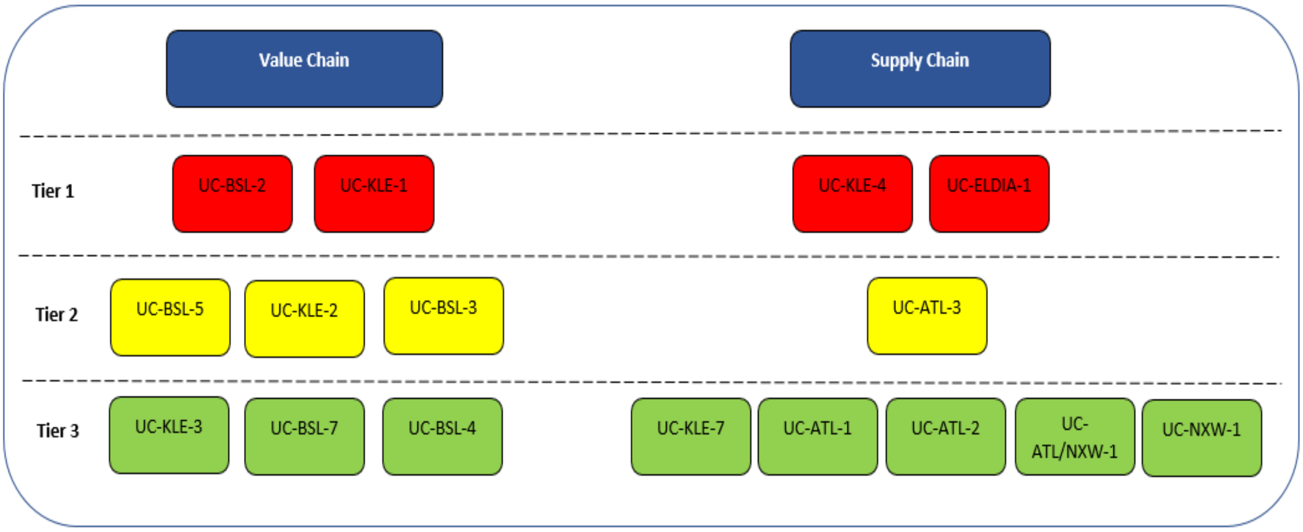

Figure 5: Hierarchy of value chain and supply chain UCs

For each use case detailed in the following section, the description includes four subsections: the components and technologies used, the involved actors and their responsibilities, the risks of conducting the pilot and the success criteria and metrics. Since the security framework and it´s components are horizontal, they are involved in all use cases and hence they are described only in the first intra-factory and inter-factory use case.

Before discussing the UCs, the four pilot partners and their involvement in COMPOSITION are described below.

Boston Scientific Ltd

Boston Scientific is one of the largest medical device companies in the world with over 23,000 employees worldwide. Boston Scientific Limited (BSL) in Clonmel, Ireland is the largest in terms of Value of Production in the Boston Scientific network of plants. BSL will run the Value Chain/Intra-factory pilot in the COMPOSITION project. The BSL pilot will implement specific elements of the COMPOSITION solution to realise the future Front End solution for implantable Printed Circuit Board Assemblies (PCBAs).

KLEEMANN

KLEEMANN operates both in the field of manufacturing and trading of complete lift systems. The head offices are based in Kilkis, Northern Greece, with offices and subsidiaries in 15 territories serving more than 100 countries worldwide. The range of products includes domestic and commercial lift systems, as well as car parking and multi-storey building lift systems. In COMPOSITION, KLEEMANN is involved in the Value

Chain/Intra-Factory Pilot, where the maintenance department participates and is responsible for UC-KLE-1 and UC-KLE-3. For the Supply Chain/Inter-factory Pilot, which will be deployed at the KLEEMANN plant in Kilkis and part of it jointly at ELDIA's recycling facilities in Thessaloniki, two departments will be involved; the maintenance department and the purchasing department will be responsible for UC-KLE 4. The purchasing department will also be responsible for UC-KLE 7.

ELDIA

ELDIA is the largest waste management company in Northern Greece and one of the leading dealers of recycled materials in Greece. ELDIA offers services providing solutions to solid waste management and disposal issues of industrial and commercial enterprises, local government, or organizations of the broader public sector. ELDIA undertakes the screening of all commercial and industrial waste in order to recover materials (paper, wood, plastics, metal, pallets, and glass) and promote the recycling industries. The principle under which ELDIA operates and handles waste is in line with what COMPOSITION will apply at the latest stages of the ecosystem development. The ELDIA pilot aims to remove all reusable material from the waste stream and to reduce the amount of waste that is disposed of at the Sanitary Landfill. Parts of the Supply Chain/Inter-factory Pilot will be deployed jointly at the KLEEMANN plant in Kilkis and at ELDIA's recycling facilities in Thessaloniki.

ATLANTIS

ATLANTIS Engineering is an SME whose main activities include the support of daily production activities in different factories with simple and advanced manufacturing systems, the organisation and computerisation of maintenance departments, the customised maintenance consulting and training, and asset life cycle optimisation. ATLANTIS has long standing experience in the industrial manufacturing domain. The expertise of the company is mainly in decision support for the management and optimisation of production activities and assets' life-cycle, in the design, interconnection and implementation of models and protocols for the manufacturing sector, and in the streamlining of the various maintenance related processes (predictive, condition-based, and reactive). Parts of the Supply Chain/Inter-factory Pilot will be deployed by ATLANTIS for software upgrade and deployment.

6.1 Value Chain (intra-factory) scenarios

6.1.1 Tier 1 Use Cases: Very high overall priority

6.1.1.1 UC-BSL-2 Predictive Maintenance

Initially the use of sensors that can 'listen' and monitor performance (temperature, vibrations, power consumption) on and near fans (blowers) in reflow ovens were investigated. After some analysis it was found that acoustic sensing yielded the best results in detecting fan failures. The 'signature data' from the acoustic sensors can give early indication that a fan will fail in the near future. This will then be communicated to relevant personnel via email and displayed on large visualization screens in the factory. This early warning enables preventative maintenance to be scheduled, which can result in significant savings both in terms of disruption to production and avoiding loss of materials. The Rhythmia reflow oven was selected as the production oven for the sensors.

Figure 6: Position of sensors in BSL reflow oven

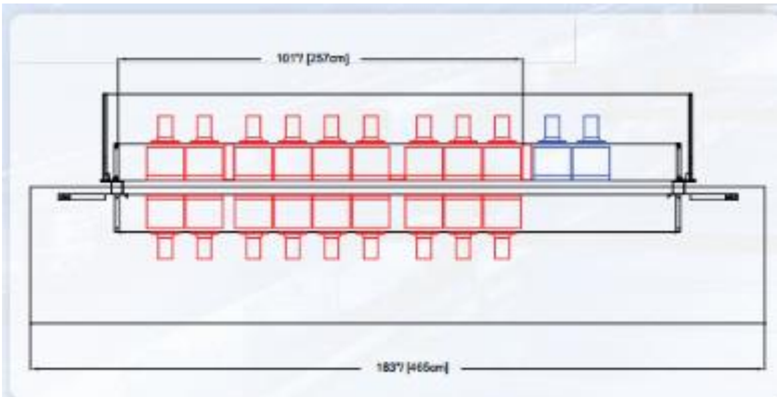

Figure 7: Layout of fans (blowers) in reflow oven

6.1.1.1.1 Components and technologies used

- Security Framework:

  Authentication – Keycloak: provides authentication mechanisms

  Authorization – EPICA: provides authorization mechanisms

  Message Broker Auth-Authz Service – RAAS: enable authentication and authorization to message broker (RabbitMQ)

  XL-SIEM and Cyber-Agents: catch and analyze security events

- The Deep Learning Toolkit component is expected to distribute the probability of a failure of the reflow oven within a fixed time frame in the future, based on the continuous input stream from the sensors. In specific, data from BSL and the Brady re-flow oven has been used for creating the first lab scale set-up. Once deployed, it will process live data streams provided by the Big Data Analytics component, producing meaningful predictions and updating them whenever enough information is processed and a new prediction is available. Due to the change of production oven at partner BSL, the oven now used in use case UC-BSL-2 Predictive Maintenance is Rhythmia.

- The Intrafactory Interoperability Layer provides extraction of live data from ovens' sensors making them available to other components involved in this use case.

- The Digital Factory Model will be used to model static and dynamic data related to this use case.

- The Simulation and Forecasting Tool provides predictions about outliers relative to normal fan operation.
- Decision Support System

  Assess information from multiple sources to issue alerts or alarms when necessary. DSS also uses prediction values coming from the DLT and the Learning Agent (LA). The predictions provided to the DSS can be inserted as values to the DSS Rule Engine. There, the rules are often initialized by the input data and provide shopfloor maintenance staff with viable suggestions. Interacting with information provided by components in the background it visualizes results to the users with different data access and authorization levels. The visualization process is done on the main dashboard of the application and in a simplified version on a mobile application that allows the user to give feedback on the suggestions.
- Real-Time Multi-Protocol Event Broker

  Publish/subscribe-based communication of sensor data and predictions between components. It is indirectly used by the participating components.

6.1.1.1.2 Actors involved and responsibilities

TNI-UCC supplied the expertise and hardware for the acoustic sensors using commercially available parts. In parallel TNI-UCC continued to review existing and emerging technology, their capabilities and inter-operability with existing infrastructure. The 1st generation sensors were based on a Raspberry PI platform and were mains powered. TNI-UCC is continuing to investigate technologies such as energy harvesting to develop power management solutions to self-power the sensors and eliminate battery replacement in a 2nd generation design (or at least extend battery life significantly). Some options have been identified and a paper study initiated.

The sensor data is gathered by the BMS provided by NXW, which is part of the Intrafactory Interoperability Layer. It then reshapes this information following the OGC Sensor Things Data Format and exposes it using the MQTT protocol. This data is then used in the DSS to enable predictive maintenance regimes also using data from existing infrastructure (e.g., power consumption of individual fans).

A user interface will then be used to notify BSL’s Process Technicians and Technician Supervisors about fan performance and impending fan failures.

6.1.1.1.3 Risks for conducting the pilot

One of the risks associated with UC-BSL-2 is people solely relying on the COMPOSITION IIMS. If people rely on the system completely and the system performs poorly, this may lead to motors completely failing, the oven going down causing production to stop. This would increase non-recoverable product and production downtime. Also, available sensorial data may not be sufficient for predictive algorithms to provide an acceptable prediction. Another risk could be the inadequate definition of response strategies. Finally, users may not be willing to use the COMPOSITION tools.

6.1.1.1.4 Success criteria and metrics

There is currently no reliable way to detect the failure of a fan motor. Fan motors are usually replaced if a technician notices that the temperature does not stabilize or if they hear a high-pitched noise when they walk past the oven. Replacing the motor too late may lead to the part failing and stopping the production process. Replacing the motor too early means the useful lifetime is reduced and the total cost of owner ship increases. This use case would allow for the detection of the optimum process performance and provide instant notification to relevant personnel. This would prevent the manufacturing process from being disrupted, reduce scrap and reduce the cost/efforts of maintenance. The potential cost of non-recoverable oven alarm resulting in non-conforming product being scrapped is estimated as $32,000. Other success criteria include the stability and reliability of the system, the intuitive and user-friendly HMIs and finally the outcomes of predictive maintenance that result in time/cost savings.

6.1.1.2 UC-KLE-1 Maintenance Decision Support

In UC-KLE-1, the goal of the COMPOSITION system is to identify/forecast problems in the machines and then to inform the Maintenance Manager, making proper suggestions and work orders for machine maintenance. In D7.6, it was stated that two sensors would be installed on two Bossi motors, one on an internal motor and one on an external motor. During the development and installation process of the external sensor, KLEEMANN's safety department identified safety issues concerning the installation of the internal sensor. Due to the hostile environment inside the BOSSI machine, even for a sensor enclosed in a steel case, the life expectancy of the device was estimated to be less than a month. To test the system behaviour with more than one sensor and to compare behaviour between sensors the second sensor was added on an external motor. The installed sensors on the BOSSI machine are generating a set of vibration data, which together with the data from the CMMS, are analysed in order to provide an early indication that the outside motors are close to breakdown. This notification is expected to assist the decision making of the maintenance planner and maintenance manager and help them better organise maintenance tasks. This is expected to reduce the overall down-time from failures, to provide cost savings from improved process monitoring, to reduce cycle-times from process monitoring, to reduce scrap and repair costs and to improve the quality of manufacturing.

Two vibration sensors have been installed on two external Bossi machine motors. The sensors were enclosed in a plastic case. The plastic cases have been tied with tie-wraps on the Bossi motors' circuit enclosures. The sensors are powered by micro-USB wires which are connected to the Bossi power supply. The communication is carried out via Wi-Fi. An SSID and password was given by KLEEMANN's IT to connect the sensors, who also arranged for a static IP to facilitate remote firmware updates. See Figure 8 below.

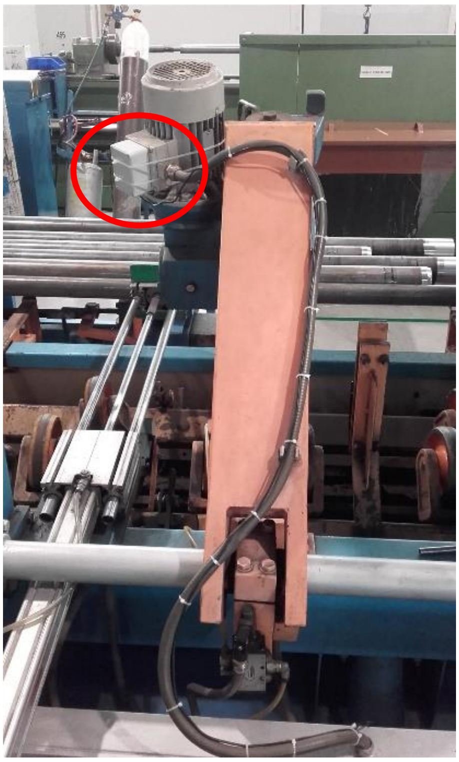

Figure 8: Vibration Sensor installed on Bossi Motor

6.1.1.2.1 Components and technologies used

- Security Framework (same as UC-BSL-2, see Section 6.1.1.1.1)
- The Digital Factory Model will be used to model static and dynamic data related to this use case
- The Simulation and Forecasting Tool will provide predictions about future malfunctions. Probabilities of different types of faults based on historical data and abnormal vibrations detection on real-time data
- Visual analytics tool will display the vibrometer analysis
- Intrafactory Interoperability Layer and BMS provide extraction of live data from vibration sensors making them available to other components involved in this use case

- Vibration sensors are installed at Bossi machine. Figure 8shows the actual sensor position of the first test
- Real-Time Multi-Protocol Event Broker

  Publish/subscribe-based communication of sensor data and predictions between components. It is indirectly used by the participating components.
- Decision Support System

  The DSS imports data from CMMS, sensors and COMPOSITION components. Also, it imports live data from the already applied vibrometer sensors. The DSS receives the predictions of the SFT and exploits them in the Rule Engine, along with the live vibrometer data. It exports data to the mobile feedback application and visualises information to users, with different diagrams for live data and KPIs.

6.1.1.2.2 Actors involved and responsibilities

There are two types of actors involved in this UC. From the factory side there are the maintenance technicians (electrical, electronic, mechanical, and hydraulic), the maintenance planner, the maintenance supervisor and the maintenance manager. From the COMPOSITION side, component-wise, CERTH provided the vibration sensors that fed NXW BMS with live data. Such data is then exposed to a set of consumers that are: the Simulation and Forecasting Tool, the Deep Learning Toolkit and the Decision Support System at the end of the chain.

6.1.1.2.3 Risks for conducting the pilot

The risks associated with UC-KLE-1 are the lack of qualified personnel, inadequate or difficult user interface, poor performance of the COMPOSITION system and changes in the maintenance timetable. Also, connectivity issues may affect the speed of data acquisition. Another potential risk is if not all users are logged into the system. If triggers of preventive maintenance schedule are not well defined and if HMIs are not well received by personnel, problems may be caused when implementing the pilot.

6.1.1.2.4 Success criteria and metrics

Success criteria for this UC are the minimization of downtimes, the proper notifications to responsible persons and the reduction of mean time to repair.

6.1.2 Tier 2 Use Cases: High overall priority

6.1.2.1 UC-BSL-5 Equipment Monitoring and Line Visualisation

This use case will provide real-time monitoring of equipment performance on the PCBA line in a visual format. It will show live and relevant information on the equipment (Equipment name, status (red, green, yellow), BSL equipment ID), products on the line (actual and target), and flow of the PCBA's visually through the lines on a 'factory map' on a big visualization screen. This will be done by manipulating existing data from BSL machine/systems. It will be displayed on large visualization screens where logged-in users can retrieve the history and performance of the equipment, previous failure modes, production and production compared to build plans. Comments can be entered and retrieved from the system. Persons who have login for the 'Equipment monitoring and line visualization system' will have the option to 'subscribe' to the equipment and will receive updates to this equipment. Alerts will then be sent out to relevant personnel when a machine changes status. This line visualization screen will also be used to display aspects of UC-BSL-2 (Predictive Maintenance) and UC-BSL-3 (Component tracking).

6.1.2.1.1 Components and technologies used

- Security Framework (same as UC-BSL-2, see Section 6.1.1.1.1)
- The Digital Factory Model will be used to model static data and BSL processes related to this use case
- Intrafactory Interoperability Layer
- Decision Support System

BSL exposes data from lighthouses to the DSS which combines them to visualise the health status of the machines in an intuitive HMI

- Real-Time Multi-Protocol Event Broker

  Publish/subscribe-based communication of sensor data and predictions between components. It is indirectly used by the participating components.

6.1.2.1.2 Actors involved and responsibilities

Equipment Monitoring and Line Visualization would be used by a range of people on the BSL factory floor. Product builders, area supervisors, quality engineers, lean engineers and process owners would be interested in using the system to keep track of equipment issues and status.

6.1.2.1.3 Risks for conducting the pilot

Risks for UC-BSL-5 include false alarms of equipment status, inadequate or over-complicated user interface and late notification to relevant personnel. Also, BSL data may not be available in time in the agreed format. Connectivity issues is another risk that affects performance. Finally, KPIs may not be easily understood by the personnel.

6.1.2.1.4 Success criteria and metrics

There is currently no way to reliably track equipment up-/downtime and the production hour's lost due to equipment issues. This system will reduce equipment downtime as a result of instant notification to relevant personnel leading to increased output/efficiency. It has the potential to aid as a planning tool for new investments based on historical data about up-/downtime. BSL will implement this onto the PCBA front end, and if successful it has the potential to run across all production lines.

Potential success criteria include the success of the systemin providing the health status of the equipment, the user friendly and usable HMIs and the use of system results to facilitate the supervisors in their everyday tasks.

6.1.2.2 UC-BSL-3 Component Tracking

6.1.2.2.1 Components and technologies used

Use of wireless sensors that can be attached to component reels, fixtures, jigs, sub-assembly trays, etc. so their location can be determined within a factory. The direct (material value) losses and indirect (time lost in production) losses in a factory can be considerable if such assets cannot be found quickly.

As for the Predictive Maintenance use case, TNI-UCC supplied the expertise and hardware for the wireless sensors using commercially available parts, including examining existing and emerging technologies, their capabilities and interoperability with existing infrastructure. For the 1st generation an off-the-shelf BLE-based tracking system was selected from a number of candidate technologies. This technology fulfilled many of the requirements from BSL as well as being suited for energy harvesting modification. TNI-UCC investigated energy harvesting technologies to develop power management solutions to self-power the sensors and eliminate battery replacement in a 2nd generation design. This utilized off-the-shelf photovoltaic cells with a bespoke designed Multi Point Power Tracking circuit and is deployed in the test site.

Based on studies to date as described in *"D7.6 On-Site Readiness Assessment of Use Cases Based on Existing Sensor Infrastructure I"* the partners decided to focus on two technologies for the Real Time Location System (RTLS), namely BLE (Bluetooth Low Energy) and UWB (Ultra-Wideband). After further work it was found that the UWB technology was not mature enough for implementation within the timeline of the COMPOSITION project. A BLE system was implemented, and as described in D7.6, this deployment takes place in a prototyping area as a proof-of-concept tracking demonstration within the factory environment. This is the first time that electronic tracking of assets has been attempted at BSL. Some examples of material that could be tracked are shown below.

Figure 9: Examples of Trays to Track

- Security Framework (same as UC-BSL-2, see Section 6.1.1.1.1)
- The Digital Factory Model will be used to model static data and BSL processes related to this use case
- Intrafactory Interoperability Layer
- Decision Support System
  Visualisation of events and provision of notifications to the suitable personnel.

6.1.2.2.2 Actors involved and responsibilities

TNI-UCC has worked closely with BSL to make decisions on technologies selected, infrastructure required in lab and then production environment, scalability needs, etc. Whilst initially a stand-alone system the vision continues to be for the data to be visualized and captured in the COMPOSITION IIMS, particularly as part of UC-BSL-5 Equipment Monitoring and Line Visualisation. The goal of this system is to give product builders, material handlers and quality engineer's constant access to the location of containers/subassemblies which have deviated from their normal production path.

6.1.2.2.3 Risks for conducting the pilot

The risks associated with UC-BSL-3 are inadequate or over-complicated user interface, poor performance of the COMPOSITION system and late/inadequate notification to relevant personnel. Connectivity issues that affect asset tracking and failure of tracking valuable material are also considered as potential risks.

6.1.2.2.4 Success criteria and metrics

The use of the asset tracking platform reduces losses. Material worth an estimated $50,000 to 100,000 is unaccounted for every year, and approximately 14.5 manufacturing days lost per year awaiting replacement material. The target for this use case is to get a 50% reduction in both cost and time associated with the loss of components.

6.1.3 Tier 3 Use Cases: Medium overall priority

6.1.3.1 UC-KLE-3 Scrap Metal and Recyclable Waste Transportation

In this UC the purpose is to optimize the collection of scrap metal and recyclable waste through the early (real-time) notification of bin and container fill levels and the suggestion of optimal routes within the factory. For this use case, five prototype fill-level sensors were installed in two types of bins: two bins containing scrap metal and three sets of four bins containing recyclable materials (plastic, paper, aluminum and cardboard), a total of fourteen bins. The prototypes were enclosed in a plastic case and the sensors were enclosed in 3d printed cases. Special constructions were manufactured by KLEEMANN in order to install the sensors on the bins, as seen in Figure 10, Figure 11, Figure 12, Figure 13 and Figure 14 below.

Figure 10: Fill sensors on set of recycle bins 1

Figure 11: Fill sensors on set of recycle bins 2

Figure 12: Fill sensors on set of recycle bins 3

Figure 13: Fill sensor on scrap metal bin 1

Figure 14: Fill sensor on scrap metal bin 2

6.1.3.1.1 Components and technologies used

- Security Framework (same as UC-BSL-2, see Section 6.1.1.1.1)
- The Digital Factory Model will be used to model static and dynamic data related to this use case
- The Simulation and Forecasting Tool will provide suggestions related to the optimal route for waste transportation and post them to DFM
- Fill-level sensors are used in KLE bins for bin monitoring
- Intrafactory Interoperability Layer and BMS provide extraction of live data from fill-level sensors making them available to other components involved in this use case
- DSS will use data from DFM and will send messages to workers about full bins
- Real-Time Multi-Protocol Event Broker

  Publish/subscribe-based communication

6.1.3.1.2 Actors involved and responsibilities

The actor involved in this UC is the worker who drives the forklift and empties the bins into the containers. Moreover, indirectly, all the COMPOSITION partners responsible for the hardware and software components involved in this use case must be mentioned.

6.1.3.1.3 Risks for conducting the pilot

Risks associated with this UC are the false monitoring of fill levels of scrap metal and recyclable waste and the wrong suggestion of routes.

6.1.3.1.4 Success criteria and metrics

The success criteria identified in this UC are the minimization of transport time and costs through the proposition of optimal routes for collecting bins.

6.2 Supply Chain (inter-factory) scenarios

6.2.1 Tier 1 Use Cases: Very high overall priority

6.2.1.1 UC-KLE-4 Scrap metal collection and bidding process

The goal of UC-KLE 4 is the automated notification that the scrap metal container is full. This will lead to the optimization of the transportation of scrap metal and the selection of the best offer from the bidders. All fill level sensors installed on KLEEMANN’s bins are communicating using LoRa wireless network. A LoRa base station (LORANK 8) was installed in a suitable location within the factory, to ensure coverage for all the sensors and access to an active Ethernet socket (Figure 15). The outdoor installation of the base station demanded the construction of a plastic enclosure capable of protecting the base station from rain and dust. An existing plastic enclosure was modified by KLEEMANN according to CERTH’s directions and was installed in the aforementioned location. KLEEMANN’s IT department integrated the base station in the company’s local network and provided access on the Internet.

Figure 15: Installed gateway (KLEEMANN)

One outdoor fill level sensor was installed on a scrap metal bin (Figure 16). Scrap metal is being tossed and collected from the bin by heavy machinery, so a steel enclosure had to be manufactured for the protection of the device. Also, a steel mounting structure had to be developed in order to deploy the sensor on the bin. The steel case was attached on the mounting structure with an interface that allowed alternate angles of measurement from the sensor. KLEEMANN’s special constructions department manufactured both the steel enclosure and the steel mounting structure and installed them according to CERTH's directions.

Figure 16: Outdoor fill-level sensor installed (KLEEMANN)

6.2.1.1.1 Components and technologies used

- Security Framework:

  Authentication – Keycloak: provides authentication mechanisms

  Authorization – EPICA: provides authorization mechanisms

  Message Broker Auth-Authz Service – RAAS: enable authentication and authorization to message broker (RabbitMQ)

  XL-SIEM and Cyber-Agents: catch and analyze security events

  Blockchain PKI: enable public key sharing for message signature validation:

  Reputation Model
- COMPOSITION Marketplace Agents are necessary to guarantee the correct information flow between the different companies' agents, both Requestor and Supplier.
- Requestor and Supplier agents are required for negotiations and notifications between the different parties involved in any transaction.
- The Matchmaker and Collaborative Manufacturing Services Ontology will be used to match KLE agent with waste management companies' agents. Moreover, they will evaluate the available offers and will match the KLE request with the best one.
- Fill-level sensors will be used in KLE bins for bin monitoring
- Intrafactory Interoperability Layer and BMS provide extraction of live data from fill-level sensors making them available to other components involved in this use case
- Real-Time Multi-Protocol Event Broker
- Publish/subscribe-based communication of fill level sensor data.
- Market Event Broker
- The marketplace agents will communicate via the broker using the agent protocol.

6.2.1.1.2 Actors involved and responsibilities

The involved actors in UC-KLE-4 are waste management companies, the maintenance manager and the purchasing manager.

The COMPOSITION Marketplace sends a notification to KLE about the fill level of the scrap metal bins. Based on the specific criteria and requirements that have been set about the bidding, the bidding process starts autonomously (it is started by KLE Requestor agent), and waste management companies are alerted, through their agent (Supplier agent) in the COMPOSITION Marketplace. After offers have been evaluated, the most suitable candidates are presented by the Requestor agent to the maintenance and purchasing manager who, in turn, will decide the best candidate and approve it. All the waste management companies are notified by the COMPOSITION system about the outcome of the bidding process.

6.2.1.1.3 Risks for conducting the pilot

Identified risks for conducting the pilot are the notification of the selected company only, the absence of pick-up notification, the overlapping of the selected date with another pick-up process, the late notification for pickup date, late payments and late pick up.

6.2.1.1.4 Success criteria and metrics

The success criteria identified in this UC are the notification of all selected and not selected companies, the automatic proposition of the best offer, on-time payments, improvements in reaction time, reduction of operational costs.

6.2.1.2 UC-ELDIA-1 Fill-level Notification – Contractual wood and recyclable materials management

The goal of UC-ELDIA-1 is to receive an automatic notification about the container fill level, in order to optimize its logistics services and improve the wood and recyclable materials management. As in UC-KLE-4, a LoRa base station (LORANK 8) was installed in a suitable location on ELDIA's premises, to ensure coverage for all the sensors and access to an active Ethernet socket (Figure 17). Also, an outdoor fill- sensor was installed on a container that receives any type of solid waste (wood, metal, paper, plastic etc.) (Figure 18).

Figure 17: Installed gateway (ELDIA)

Figure 18:Outdoor fill-level sensor installed (ELDIA)

6.2.1.2.1 Components and technologies used

- Security Framework (same as UC-KLE-4, see Section 6.2.1.1.1)
- The Deep Learning Toolkit will distribute the latest prediction about the price per ton at which specific commercial partners are likely to accept to buy/sell recycled material within fixed timeframe in the future. This information in the form of predictions will be intended to support the agents' intelligence in order to improve the decision system that is in charge of accept/emit commercial offers about scrap metal.
- COMPOSITION Marketplace Agents are necessary to guarantee the correct information flow between the different companies' agents, both Requestor and Supplier
- Requestor and Supplier agents are required to allow negotiations and notifications between the different parties involved in any transaction
- Fill-level sensors will be used in KLE bins for bins' monitoring
- Intrafactory Interoperability Layer and BMS provide extraction of live data from fill-level sensors making them available to other components involved in this use case
- The Simulation and Forecasting Tool will apply a generic algorithm providing trend analysis on bins fill level, time series forecasting and Markov chain methodology for tonnage prediction, statistics, etc.
- Visual Analytics will visualize SFT output in an effective and interactive way to the ELDIA user, enhancing the decision making for ELDIA resource allocation and planning
- Real-Time Multi-Protocol Event Broker

  Publish/subscribe-based communication of fill-level sensor data
- Market Event Broker

  The marketplace agents will communicate via the broker using the agent protocol and data sharing between KLE and ELDIA will be set up using the broker and the integrated security framework.

6.2.1.2.2 Actors involved and responsibilities

Notification of fill level is sent from KLEEMAN to ELDIA using the Marketplace. This involves the use of the agents (Requestor and Supplier) to ensure a correct information flow and the participation of ELDIA's Logistics Manager, Driver and Accounting department.

6.2.1.2.3 Risks for conducting the pilot

Identified risks in this use case include the absence of pick-up notification, late notification for pickup date, late pick up and thus late payments.

6.2.1.2.4 Success criteria and metrics

Success criteria are related to automatic proposition of optimal pick up, on-time payments, improvements in reaction time and reduction of operational costs.

6.2.2 Tier 2 Use Cases: High overall priority

6.2.2.1 UC-ATL-3Searching for recommended solutions

The goal of UC-ATL-3is to allow potential buyers to search within the COMPOSITION ecosystem for recommended solutions/suggestions for their needs/inquiries. The demand side will trust the recommendations coming for an ecosystem with built-in trust, safety and verification mechanisms.

6.2.2.1.1 Components and technologies used

- Security Framework (same as UC-KLE-4, see Section 6.2.1.1.1)
- The Matchmaker and Collaborative Manufacturing Services Ontology will be used to match customers with available solutions
- Marketplace Ontology
- Requestor
- Supplier
- Marketplace

6.2.2.1.2 Actors involved and responsibilities

The involved actors are potential customers' purchase department and/or technical/IT team members. From the suppliers' side, the Sales Engineer, as well as the Technical Support Engineer are involved.

6.2.2.1.3 Risks for conducting the pilot

There is not enough data for the system to generate recommendations.

Buyers do not use the system that much.

COMPOSITION fails to be considered a trusted environment.

6.2.2.1.4 Success criteria and metrics

The system generates recommendations for all inquiries.

COMPOSITION is perceived as a trusted advisor by both buyers and sellers.

The system is stable and fast (generates recommendations within a few minutes, after all information of demand side are provided as input).

6.2.3 Tier 3 Use Cases: Medium overall priority

6.2.3.1 UC-KLE-7 Ordering raw materials

The goal of this UC is to automate the supply chain processes in order to get high quality raw materials at the best price, delivered on time and to establish good customer-supplier relationship.

6.2.3.1.1 Components and technologies used

- Security Framework (same as UC-KLE-4, see Section 6.2.1.1.1)
- The Matchmaker and Collaborative Manufacturing Services Ontology will be used to match customers with available raw material providers
- Market Event Broker

  The marketplace agents will communicate via the broker using the agent protocol.

6.2.3.1.2 Actors involved and responsibilities

The actors involved in this UC are the purchasing manager and the raw material suppliers.

6.2.3.1.3 Risks for conducting the pilot

The risks associated to UC-KLE-7 are delivery of the wrong raw materials, delayed delivery and the offering of poor quality of raw materials.

6.2.3.1.4 Success criteria and metrics

The success criteria for this UC are related to on-time delivery of the right raw materials, the automated order placement for high-quality materials at the best price and the reduction of supply chain costs.

7 Conclusion

This deliverable provides a methodology for planning the deployment of COMPOSITION on the shopfloor. It describes how, when and by whom pilot planning is going to take place. Each use case has been analysed regarding the components used, the involved actors, the associated risks and the success criteria. This document updates the pilot planning and preparation actions described in D8.1, taking into account the methodologies and evaluation activities derived from *"D8.7 Evaluation Framework"*. Finally, the concluding table "Pilot planning on the shopfloors and preparation actions" developed in D8.1 is updated below.

Table 6: Pilot plans on the shopfloor and preparation actions

Value Chain Use Cases						
Use Case	**Use Case Stages**	**Components & technologies**	**Actors**	**Risks**	**Success criteria & metrics**	**Time scheduling**
UC-BSL-2	3. Deployment - Commissioning	1.Simulation and forecasting tool 2.Deep Learning Toolkit 3.Intrafactory Interoperability Layer 4.Manufacturing Decision support 5. Real Time Multi-Protocol Event Broker 6. Learning Agent	1.TNI-UCC 2.FIT 3.ISMB 4.BSL 5. ATL	1.Poor performance of the Composition system 2.Available sensorial data are not sufficient or qualitative inadequate for predictive algorithms to provide a good enough prediction. 3.Response strategies are not well defined. 4.Users are not willing to use the COMPOSITION tools.	1. Detection of the optimum process performance 2. Instant notification to relevant personnel 3. Prevent the manufacturing process from being disrupted 4. Reduce scrap 5. Reduce the cost/efforts of maintenance 6. The system is stable and reliable. 7.HMIs are intuitive and user friendly. 8.Results on predictive maintenance result to time/cost savings.	
UC-KLE-1	3. Deployment - Commissioning	1.Manufacturing Decision Support System 2.Intrafactory Interoperability Layer 3.Simulation and forecasting tool 4.Real-Time Multi-Protocol	1.Maintenance planner 2.Maintenance manager 3.Research partners 4.Technical partners	1.Lack of qualified personnel 2.Poor performance of the COMPOSITION system 3.Inadequate or difficult user interface, 4. Changes in	1.Downtime minimization 2.Proper notifications sent to responsible persons 3.Reduce mean time to repair 4.Use of system results to reduction of break	January2018 (First tests of sensors have been performed by CERTH and KLEEMANN at KLEEMANN's shopfloor)

		Event Broker 5. Visual Analytics Toolkit		maintenance timetable 5.Connectivity issues affect the speed of data acquisition. 6.Not all users are logged into the system. 7.Triggers of Preventive maintenance schedule are not well defined. 8.HMIs are not well received by personnel.	down time	
UC-BSL-5	1.Design-Preparation	1.Real-Time Multi-Protocol Event Broker 2.Manufacturing Decision Support System 3. Intrafactory Interoperability Layer		1. False alarms of equipment status 2. Inadequate or difficult user interface 3. Late notification to relevant personnel 4.BSL data are not made available in time in the agreed format. 5.Connectivity issues affect performance. 6.KPIs are not easily understood by the personnel.	1. Provides method to track up-/downtime which is not currently available 2. Reduce equipment downtime as a result of instant notification to relevant personnel 3. Increased output/efficiency 4. Provides a planning tool for new investments based on historical data 5.System succeeds in providing the health status of the equipment. 6.HMI is user friendly and usable. 7.Use of system results for facilitation of the supervisors' everyday tasks.	
UC-BSL-3	3. Deployment - Commissioning	1.Intrafactory Interoperability Layer 2.Manufacturing Decision	1.TNI-UCC 2.BSL	1. Inadequate or difficult user interface 2. Poor performance of	1. Reduction in cost associated with the loss of components 2. Reduction in	

		support		the COMPOSITION system 3. Late/ inadequate notification to relevant personnel.	time/effort associated with loss of components 3.Connectivity issues affect asset tracking. 4.Asset tracking platform fails to track valuable material.	
UC-KLE-3	3. Deployment - Commissioning	1.Simulation and forecasting tool 2.Intrafactory Interoperability Layer 3.Real-Time Multi-Protocol Event Broker	1.Worker 2.Research partners 3.Technical partners	1.False monitoring of fill levels of scrap metal and recyclable waste bins 2. Wrong suggestion of routes.	1.Minimization of transport time and costs	Start July 2018(Sensors are being tested on a regular level by CERTH and KLEEMANN at KLEEMANN’s shopfloor)
Supply Chain Use Cases						
UC-KLE-4	3. Deployment - Commissioning	1.Matchmaker 2.Simulation and forecasting tool 3.Agent Marketplace 4.Requester Agent 5.Supplier Agent 6.Real-Time Multi-Protocol Event Broker 7.Market Event Broker 8.Intrafactory Interoperability Layer	1.Waste management companies 2.Maintenance manager 3.Purchasing manager.	1.Notification of the selected company only 2.Absence of pick-up notification 3.Overlapping of the selected date with another pick-up process 4.Late notification for pickup date 5.Llate payments 6.Late pick up	1.Notification of all selected and not selected companies 2.Automatic proposition of the best offer 3.On-time payments 4.Improvements in reaction time 5.Reduction of operational costs	January 2018 (First tests of sensors have been performed by CERTH and KLEEMANN at KLEEMANN’s shopfloor)
UC-ELDIA-1	3. Deployment - Commissioning	1.Real-Time Multi-Protocol Event Broker 2.Market Event Broker 3.Deep Learning Toolkit	1.Logistics manager, 2. Driver, 3. Accounting department	1.Absence of pick-up notification 2.Late notification for pickup date 3.Llate payments 4.Late pick up 5.Available historical data are not sufficient or qualitative inadequate for	1.Automatic proposition of optimal pick up 2.On-time payments 3. Improvements in reaction time 4. Reduction of operational costs	Tests started in March 2018

				predictive algorithms to provide a good enough prediction.		
UC-ATL-3	1.Design-Preparation	1.Matchmaker 2.Marketplace Ontology 3.Requester 4.Supplier 5.Marketplace	1. Purchasing department 2. Sales Engineer 3. Technical Support Engineer.	1. Not enough data to generate recommendations. 2. Buyers don’t use the system. 3. COMPOSITION not considered as a trusted environment	1. System generates recommendations. 2. COMPOSITION is perceived as a trusted advisor. 3. The system is stable and fast.	
UC-KLE-7	1.Design-Preparation	1.Matchmaker 2.Market Event Broker	1.Purchasing manager 2.Raw material suppliers	1.Wrong raw materials delivery 2.Delayed delivery 3.Proposition of bad quality raw materials	1.On-time delivery of the right raw materials 2.Automated order placement of high-quality materials on the best price 3. Reduction of supply chain costs	Not yet defined

8 List of Figures and Tables

8.1 Figures

8.2 Tables

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