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(Grant Agreement No 723145)

D8.4 Supply chain pilot II

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Index:

1 Executive Summary

The present document is a deliverable of the COMPOSITION project, which is funded by the European Commission's Horizon 2020 Research and Innovation programme, reporting the final results of the activities carried out in Task 8.3 Inter-factory Supply Chain Centric Pilot of WP8. The supply chain centric pilot is one of the key aspects of COMPOSITION ecosystem. It is based on the initial system installation and preparation actions and the actual testing of the IIMS at KLEEMANN's (KLE) and ELDIA's shop floors. Two additional use-cases are presented in this report, including partners ATLANTIS (ATL) from the industrial manufacturing software domain and NEXTWORKS (NXW) from the IT and Telecommunications sector. The key component of the supply chain is the COMPOSITION marketplace, where pilot partners can offer or request specific goods and services.

This deliverable provides a description of the developments of the supply chain use cases, which promise to add value from a technology, impact and exploitability point of view. The current status and outcomes of "UC – KLE 4 Scrap Metal Collection and Bidding Process" and "UC – ELDIA 1 Fill Level Notification – Contractual Recyclable Material Management", are updated. UC-KLE-4 and UC-ELDIA-1 demonstrate that the sensors are successfully working as expected in the pilots' operational environments. The other two use cases "UC-KLE-7 Ordering Raw Materials" and "UC-ATL/NXW Searching for Software Solutions", are similar to UC-KLE-4 since common tools and processes are deployed (simulated bidding process for UC-KLE-7 and matchmaking for UC-ATL/NXW). A set of supply chain key performance indicators is provided based on the supply-chain operations reference model (SCOR). On-site technology (including sensors and gateways) is well accepted from both key supply chain pilots KLEEMANN and ELDIA. Furthermore, the HMI evaluation for the supply chain use cases is presented. Finally, supply chain risks that may occur during the implementation of the inter-factory use cases are identified from both pilot and technical partners and methods to manage and mitigate them are presented. The deliverable concludes by presenting the steps beyond COMPOSITION project, showing how the results of supply chain centric pilot could be exploited to support decision-making.

This deliverable summarises the outcomes of the inter-factory supply chain pilot. It demonstrates how the pilot preparation material of T8.1 is used and how common technological developments are used for the demonstration of the pilot testing. Overall, both the "real world" and the simulated results and processes that have been produced and demonstrated through the inter-factory use cases, show that the COMPOSITION platform for supply chain management, could be effectively deployed beyond the project by focusing on real – time monitoring, developing and analysing KPIs and supply chain risks and testing the IIMS in several marketplaces.

Deliverable *"D8.4 Supply chain pilot II"* documents the final actions that are implemented and the related risks for the supply chain use cases. D8.4 is part of Milestone (MS) 14 "Final iteration of platform deployed and evaluated" and Task 8.3 "Inter-factory Supply Chain Centric Pilot". The document updates *"D8.3 Supply chain pilot I"*.

2 Abbreviations and Acronyms

Table 1: Abbreviations and acronyms used in the deliverable

Acronym	Definition
ANN	Automated Neural Network
BMS	Building Management System
CXL	Composition Exchange Language
DFM	Digital factory Model
DLT	Deep Learning Toolkit
EC	European Commission
ERP	Enterprise Resource Planning
HMIs	Human Machine Interfaces
IIMS	Integrated Information Management System
KPIs	Key Performance Indicators
LA	Learning Agent
LoRA	Long Range
MS	Milestone
PPE	Personal Protective Equipment
SCOR	Supply Chain Operations Reference

3 Introduction

3.1 Purpose, context and scope of this deliverable

The purpose of this deliverable is to present and demonstrate the work carried out and the results of Task 8.3 Inter-factory Supply Chain Centric Pilot that is implemented under WP8 - Industrial Pilots and Evaluation. The document includes information about the current status and outcomes of the industrial supply chain pilots. It presents and updates the set-up and deployment status of the use cases, that are being implemented as demonstrators of the COMPOSITION platform. The key performance indicators (KPIs) of each use case are also provided. Finally, this document focuses on the evaluation of the developments of the COMPOSITION platform regarding the supply chain. This is performed by the assessment of the operation of sensors, human machine interfaces (HMIs) and related pilot and technological risks.

This deliverable is the second and last iteration of *D8.3 "Supply chain pilot I"*, which was the first report about Task 8.3 Inter-factory Supply Chain Centric Pilot. The main updates of the Supply Chain Centric Pilot developments, which are illustrated in this report, are the following:

- Description of the developments of two additional use cases which are under the supply chain pilot i.e. "UC-ATL/NXW Searching for recommended solutions" and "UC-KLE-7 Ordering Raw Materials"
- Further developments and updates on UC – KLE 4 and UC – ELDIA 1
- Visual analytics platform provided for the optimization of waste management procedures
- A simulated ecosystem is set-up for the needs of UC-KLE-7.

3.2 Content and structure of this deliverable

The content of this deliverable is structured as follows:

Section 4 presents the status, outcomes and KPIs of the inter-factory use cases. In Section 5 a description of the evaluation of the supply chain pilots is provided. This section includes a description of the on-site technology, the human machine interfaces (HMIs), the supply chain risks and the assessment of the installed sensors. In Section 6, the conclusions of the final demonstrations are provided.

4 Inter-factory Supply Chain Pilots: set-up and demonstration

In this section a description of the supply chain (inter-factory) use cases is provided. UC – KLE 4 "Scrap Metal Collection and Bidding Process" and "UC – ELDIA 1 Fill Level Notification – Contractual Recyclable Material Management" are the highest priority inter-factory use cases. The other two use cases that are under the supply chain pilot are "UC-ATL/NXW Searching for recommended solutions" and "UC-KLE-7 Ordering Raw Materials". The main focus of this deliverable is the documentation of the current status and outcomes of these four use cases. For UC – KLE 4 and UC – ELDIA 1 that are related to bins fill level notification, a fill level monitoring sensor has been developed. This sensor provides data to the simulation and prediction tool in order to enable the estimation of the date in which the bin will be full. More information about the simulation and prediction tool is available on *D3.6 Computational Modelling, Simulation and Prediction of Logistics I*. For UC-ATL/NXW and UC-KLE-7, an integrated solution is developed in the COMPOSITION ecosystem that provides the functionality to search for services and goods. KLEEMANN, ELDIA, ATL, NXW or other prospective companies are able to enter the marketplace and offer or request specific goods (raw materials) and services (software solutions). More information can be found in "*D6.10 COMPOSITION Brokering and Matchmaking components II".*

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

The goal of UC-KLE 4 is to optimize scrap metal collection and bidding process in order to achieve better scrap metal prices, minimize costs and receive fast and efficient services. This will be implemented through the automated fill level notification to KLEEMANN and to possible bidders that are registered to the COMPOSITION platform. When the fill level reaches the predefined fill level threshold (e.g. 80%), the action is transferred out of the shopfloor, where KLEEMANN's marketplace agent generates an automated bidding process. By the end of the bidding process, the matchmaker evaluates the offers and suggests the best one to KLEEMANN's agent. The final decision is made by the purchasing manager, who accepts the suggested offer or examines other available offers. Finally, the selected waste management company is informed by the system and the scrap metal collection process is completed as soon as the scrap metal is collected. Figure 1 below, shows the information data flow.

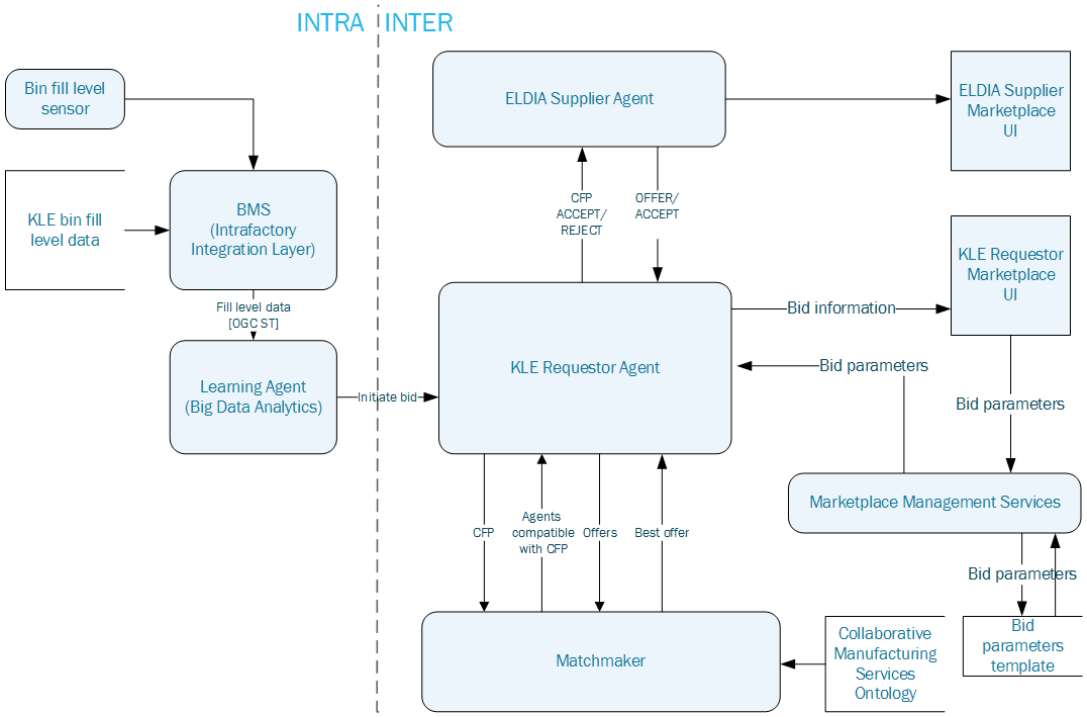

Figure 1: UC-KLE-4 Information Data Flow

4.1.1 Current status

As of March 2018 (M19), an ultrasonic sensor is installed at KLEEMANN's site on the scrap metal container. A protective case for the sensor is constructed at KLEEMANN's special construction's factory. An additional case for the gateway is purchased and installed at KLEEMANN's shopfloor, around 150 meters away from the sensor. It has to be mentioned that there were no existing sensors at KLEEMANN's equipment and facilities. Figure 2 shows the architecture of the sensors network for both KLEEMANN's and ELDIA's use cases.

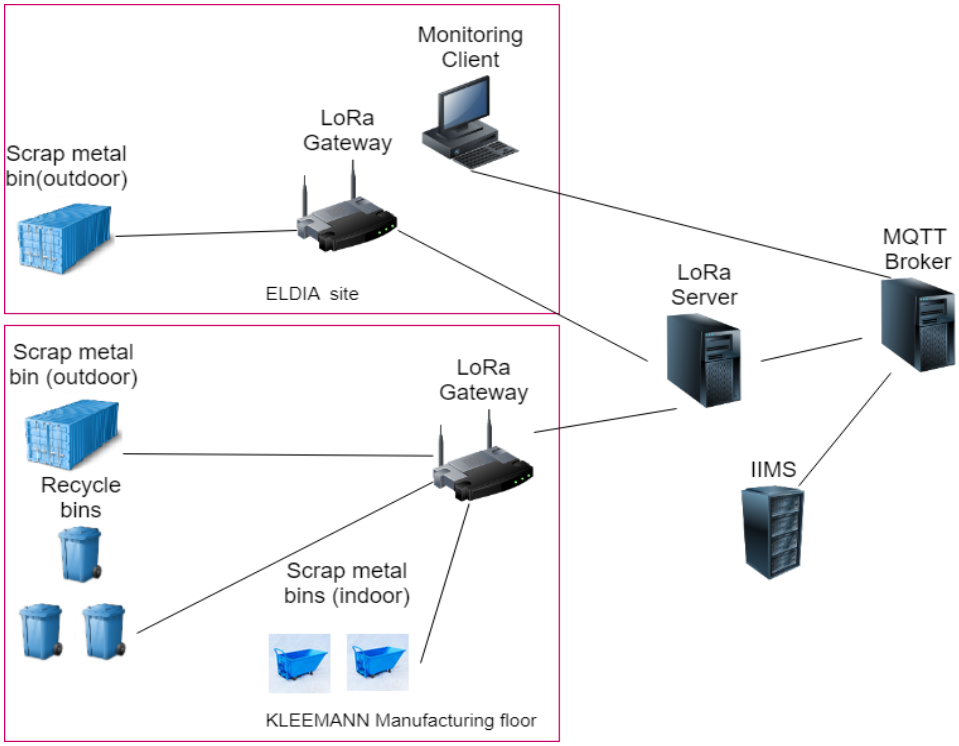

Figure 2: UC-KLE-4 and UC-ELDIA-1 Sensors Network Architecture

The photos below show the installed sensor (Figure 3) and the gateway (Figure 4) in their actual position at KLEEMANN's factory.

Figure 3: UC-KLE-4 sensor's position

Figure 4: UC-KLE-4 gateway's position

In addition, a scrap metal dataset is generated by the company's ERP system. The ERP maintains a database including information about the produced scrap metal and the price of it. This set of data is extracted from ERP in excel as a report file. In 2018 around 1,000 tons of scrap metal were produced with an average price of € 120 - 150/ ton.

4.1.2 Outcomes

As already described, UC-KLE 4 starts with the fill level monitoring using the aforementioned fill level sensor's measurements in KLEEMANN factory's scrap metal bin. This is achieved through on-site observations at KLEEMANN's factory and crosschecking with CERTH's fill level sensors' data. Fill level measurements are documented in an assessment table, which is presented in section 5.4 of this deliverable. The part of bidding process is successfully tested between KLEEMANN and ELDIA in a simulated scenario. The use of COMPOSITION Marketplace and its UIs for the online bidding process were tested and validated from both sides (requester/KLEEMANN and supplier/ELDIA). Moreover, the functionality of matchmaking scenarios and the suggestions of the best available offers were validated through some simple test cases. The aforementioned experiments in the online bidding process demonstrate the connection of the COMPOSITION IIMS components (sensors, shop-floor connectors etc.) with the COMPOSITION Ecosystem services (online bidding process), and the capability of COMPOSITION platform to handle supply chain complexities and support decision-making. However, a large-scale use case of a real-world ecosystem of hundreds or thousands of participants and services in the COMPOSITION marketplace, it was not possible to be tested due to the limited number of end users that participated in the project.

4.2 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. The primary goal of this use case is to be able to receive notifications of the fill level of various containers installed at ELDIA's customers' facilities, thus facilitating the logistics service and improving the reaction time of replacing full containers. ELDIA ERP maintains a database including information about the date of pick up, type, weight and prices of various recyclable materials. This information becomes available to the project's technical and research partners for further analysis in order to enable possible estimations of the fill level of various containers.

4.2.1 Current status

As of May 2018 (M21), an ultrasonic sensor is installed at ELDIA's site on the scrap metal container. A protective case for the sensor was ordered and constructed by KLEEMANN. The gateway is purchased and installed at ELDIA's office facilities, around 50 meters away from the sensor. It should be mentioned that there were no existing sensors at ELDIA's equipment and facilities. The photos below show the installed sensor (Figure 5) and gateway (Figure 6) in their actual position at ELDIA's facilities.

Figure 5: UC-ELDIA-1 sensor position

Figure 6: UC-ELDIA-1 gateway's position

4.2.2 Outcomes

As already described, UC-ELDIA 1 starts with the fill level monitoring using the aforementioned fill level sensor's measurements at ELDIA's scrap metal container. This is achieved through on-site observations at ELDIA's container and crosschecking with CERTH's fill level data. Fill level measurements are documented in an assessment table, which is presented in section 5.4 of this deliverable.

Visual Analytics Platform for Optimization of Waste Management Procedures

A Visual Analytic tool is available for ELDIA end-users in this use case. This interactive tool provides many functionalities as it visualizes SFT and DLT outcomes in order to be used by ELDIA staff. The key features supported by the tool are:

- ✓ **Monitoring** of containers **fill level** based on **IoT sensors**
- ✓ **Analysis** of the containers **fill level trend**
- ✓ **Forecasting** about **the tonnage of wastes** that is going **to be transported** by a waste management company
- ✓ **Calculator** for **optimal pair** of **routes** and **tonnage** should be transported
- ✓ **Price forecasting** for **various** waste types/materials
- ✓ **Statistical analysis** and **visualization** for better data exploration

Some indicative screenshots of the COMPOSITION VA tool that is used by ELDIA for waste management optimization and planning are listed below:

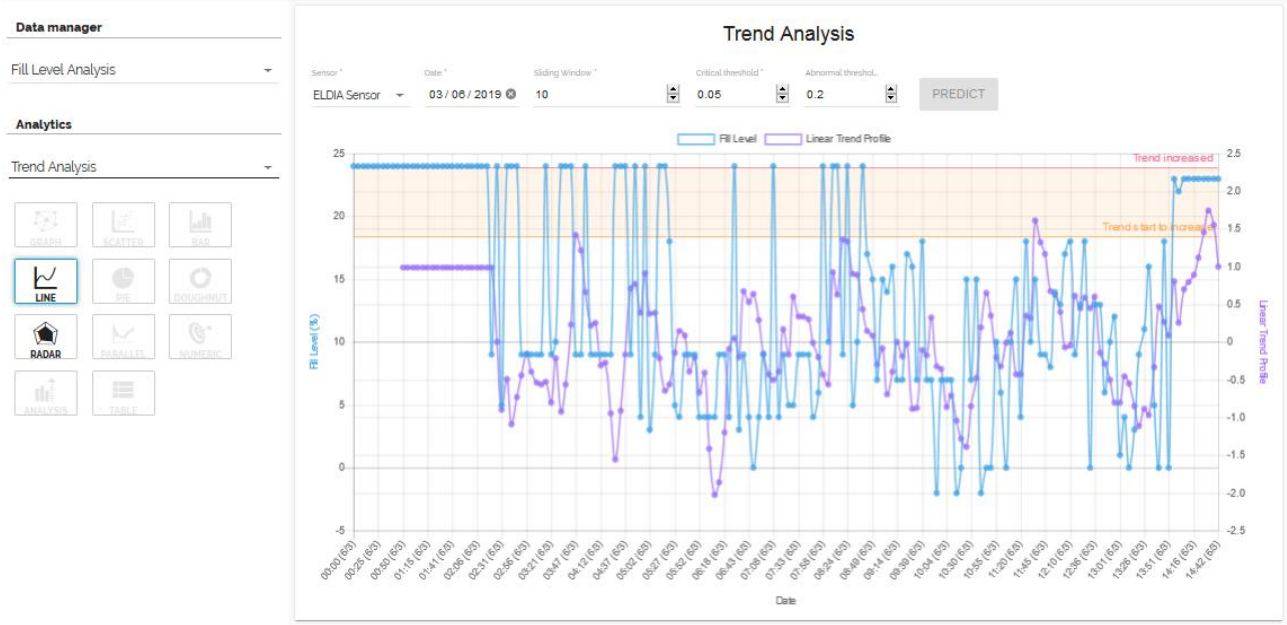

Figure 7: Fill Level Sensors Data Trend Analysis

In Figure 7, the end-user is able to choose the fill level sensor that wants to get an analysis, the type of analysis and the available type of graph for visualization based on the selected analysis. In the screenshot, the user is able to explore both the fill level percentage for a complete day and the trend analysis output for the same period. By monitoring the trend of the fill level, the user is able to define aggressively increased trends for a specific bin and give a higher priority to collect this bin from a customer.

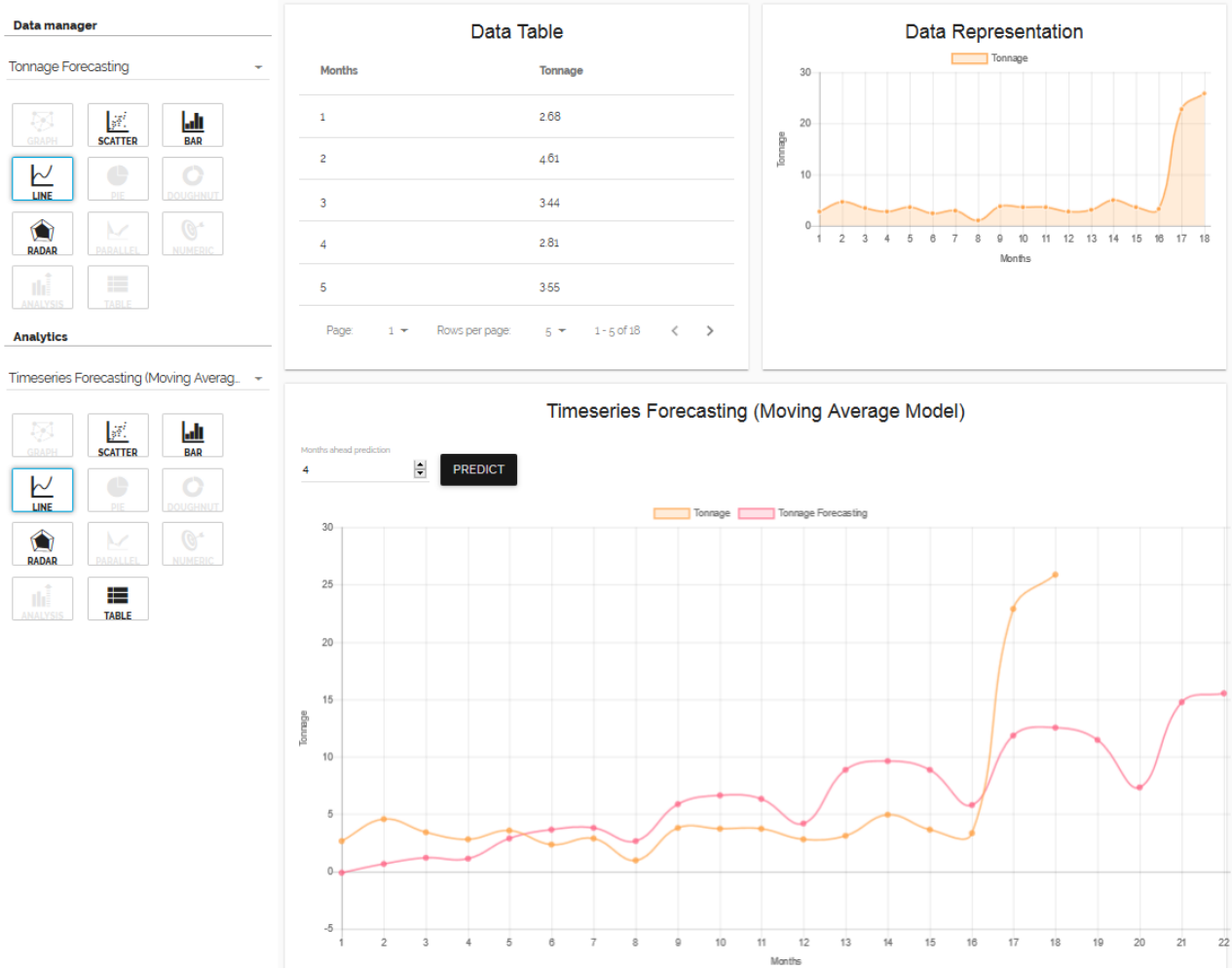

Figure 8: Tonnage Timeseries Forecasting

In Figure 8 the end-user is able to load data regarding the transportation of a specific material, to choose the type of analysis and the available type of graph for visualization based on the selected analysis. In the screenshot, the user is able to explore the tonnage that has been transported during the uploaded period of data alongside with the prediction of the tonnage that is going to be transported in the next 4 months (the period of the ahead prediction that has been selected by the user through the UI). This prediction enhances the decision making by enabling a better resource allocation and planning for the end-user.

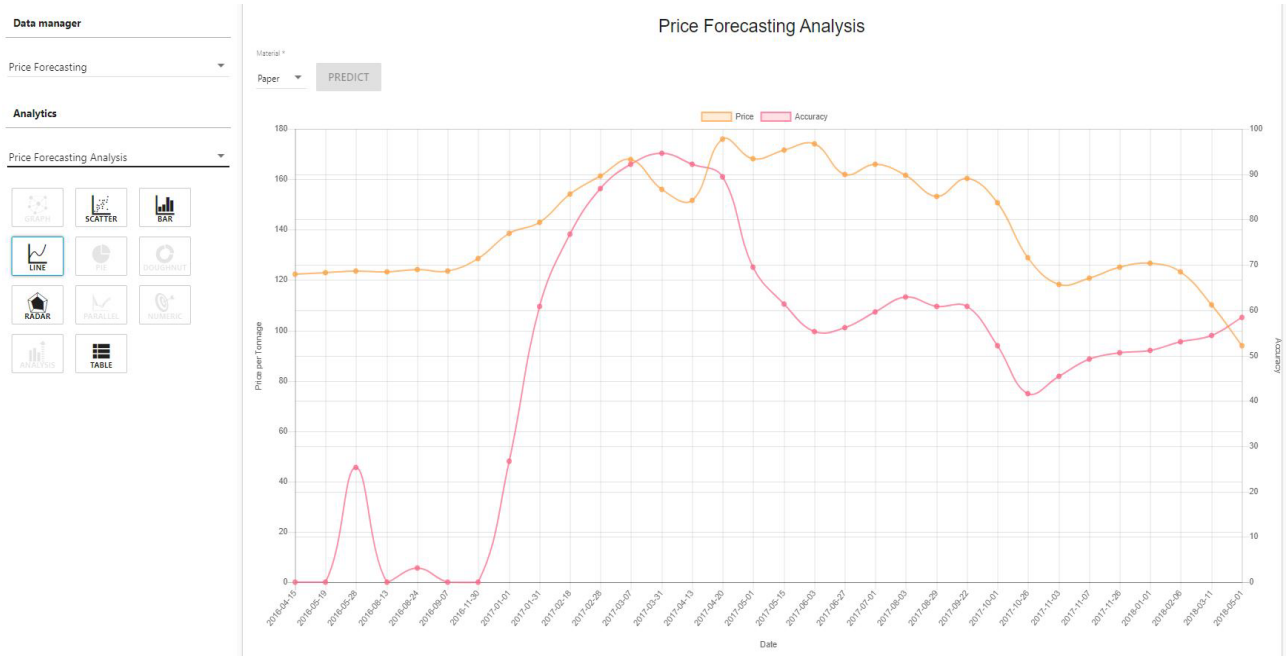

Figure 9: Price Forecasting

In Figure 9, a screenshot for the price forecasting is available. In this case, the end-user can select the material that he wants to receive a price prediction and the available graph for visualization as well. The user is able to see the prediction values for a selected period and the accuracy of these predictions. This is another tool for waste management procedures' optimization and decision support.

4.3 UC-KLE-7 Ordering Raw Materials

The use case is almost similar with UC KLE-4. KLEEMANN agent initializes a bidding process for raw materials. The goal of the purchasing manager of KLEEMANN, who is represented by the corresponding agent, is to get high quality raw materials on the best price and delivered on time. The goal of raw material suppliers is to provide high quality products and to establish good customer relationship.

As there are no real Marketplace and a participant (pilot partner), who offers raw materials a simulated ecosystem was set up for the needs of this use case. Besides the components (Marketplace, Matchmaker, Security Framework) which are independent of use cases some Agents to represent simulated raw material companies were set up. Then a procedure similar to KLE-4 and bidding process took place.

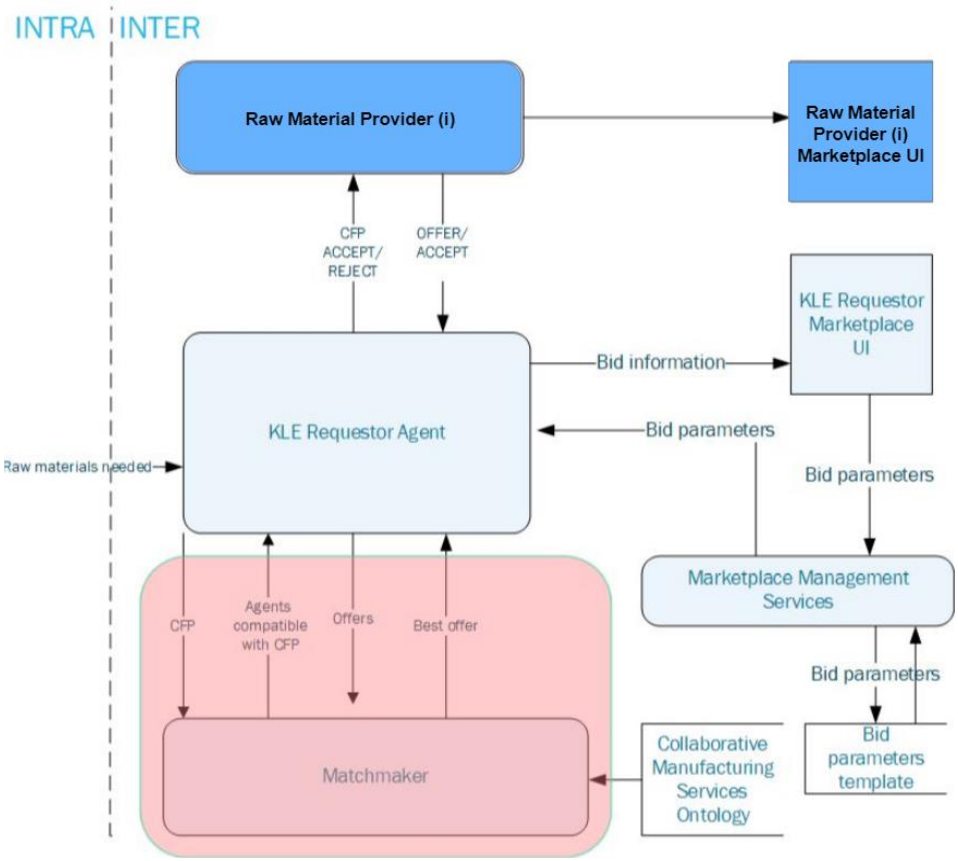

Figure 10: UC-KLE-7 Information Data Flow

In order to evaluate the provided offers for raw materials the Marketplace/Matchmaker takes into consideration various criteria as KLEEMANN purchasing department indicates them. The criteria are presented below:

- Price (service, transportation and insurance)
- Delivery time
- Payment terms (credit)
- Business ranking
- Certificate
- Delivery methods (optional)
- Payment methods (optional)

The COMPOSITION Matchmaker applies an Automated Criteria Weighting algorithm in order to assign weights on criteria based on the ordered criteria list by the user (requester agent). Then, it applies Best Score Algorithm alongside with semantic rules for evaluating the offers and returns the best available one as the suggested offer to the requester. Figure 11 below from *D6.10 COMPOSITION Brokering and Matchmaking components II* illustrates the offer evaluation process for UC-KLE-7 related to raw materials.

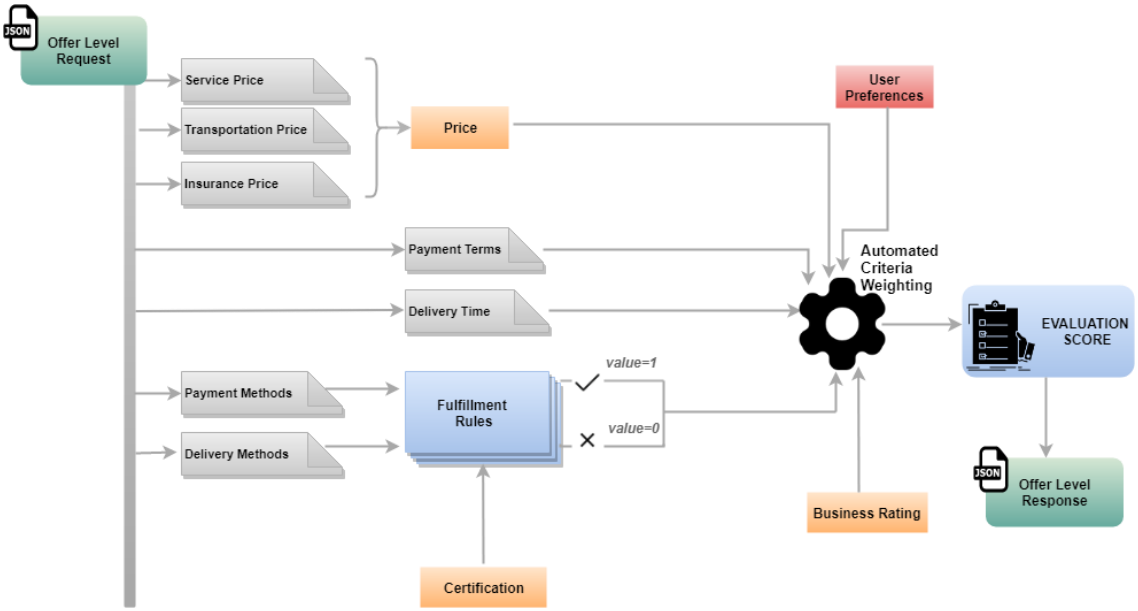

Figure 11: Raw Material Offers Evaluation Process

4.4 UC-ATL/NXW Searching for Software Solutions

In this use case, ATLANTIS or NXW which are SMEs that provide software solutions related to the manufacturing domain are able to advertise their solutions, products and consultancy services to the COMPOSITION eco-system. As soon as a potential client has a problem or requests software solution via the ecosystem, the agent is able to match the requester with ATLANTIS or NXW or a company from the same domain by using Matchmaker capabilities. In contrast with use cases such as UC-KLE-4 and UC-KLE-7, this scenario stops in the first level of matching services such as software solutions or consultancy demand communication between clients and providers and it is not so easy to be handled by an automated bidding process.

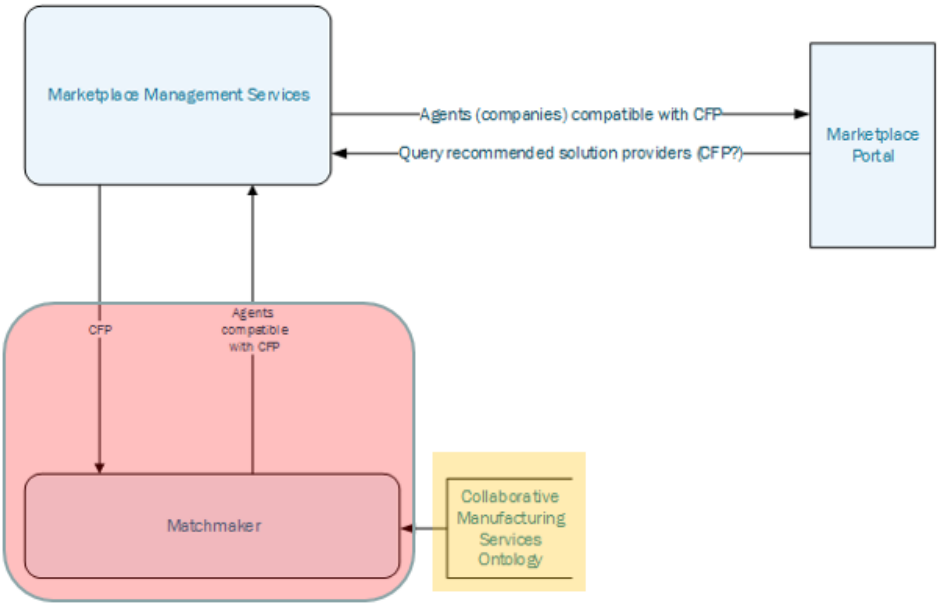

Figure 12: UC-ATL/NXW Information Data Flow

Besides the components (Marketplace, Matchmaker, and Security Framework), which are independent of use cases, ATL and NXW Agents were setup and some Agents to represent simulated companies as well in order to execute some scenarios and test the functionality. The requests process is similar with UC-KLE-4. The

returned result of the request is a list of companies, which offer the requested service. The returned list is in ranked order by Matchmaker based on the ecosystem's reputation/rating of the agents/companies. Supply chain end-users like software houses have pretty similar reasons for joining the ecosystem, since all of them are interested in exchanging software solutions. The following picture depicts the service and goods that are searchable through the COMPOSITION ecosystem:

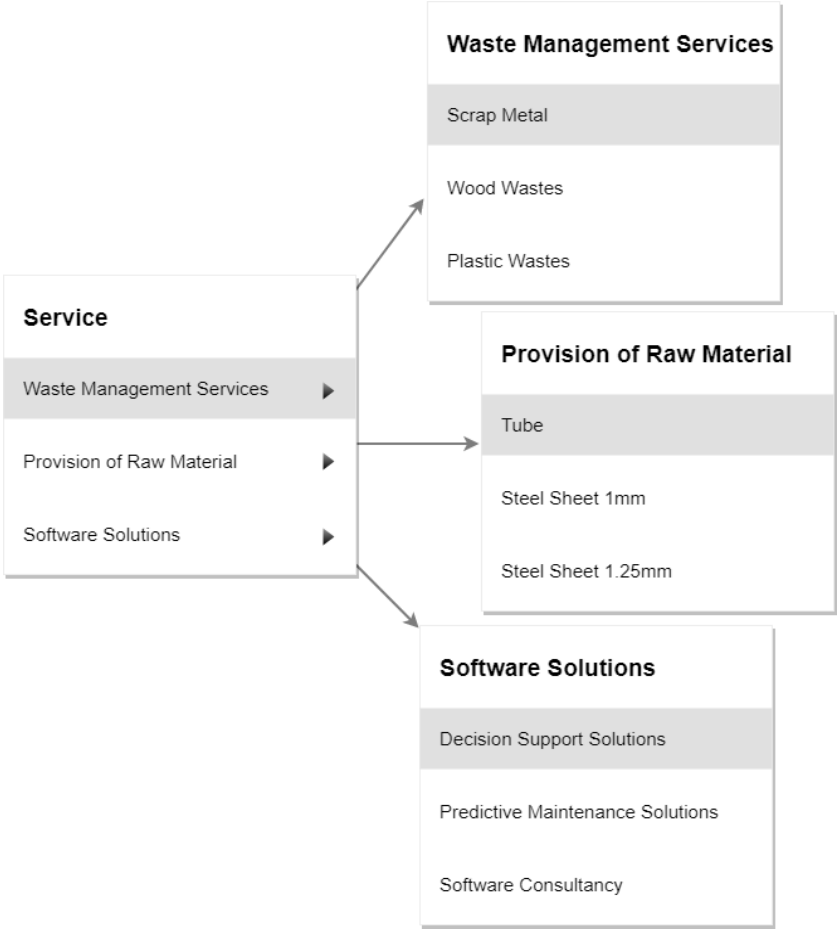

Figure 13: COMPOSITION Ecosystem Searchable Services and Goods

4.5 Supply chain KPIs

In this section the key performance indicators (KPIs) of each inter-factory use case will be presented based on the supply-chain operations reference model (SCOR). The SCOR model is considered to be the first cross-industry framework for evaluating and improving supply-chain performance and management (Stewart, 1997). It consists of more than 250 metrics which are categorized in five performance attributes: reliability, responsiveness, agility, costs and asset management efficiency. Reliability, responsiveness and agility are customer-oriented, while costs and asset management efficiency are internally focused (APICS, 2018). The purpose of using this model, is to identify the indicators required for the successful implementation of each use case. The KPIs were selected based on the end goals of each use case. The following table describes the SCOR attributes (see APICS, 2018) and presents the KPIs for each attribute as identified by the pilot partners. Since there is no real marketplace for UC-KLE-7 and UC-ATL/NXW, the KPIs in Table 2 refer only to UC-KLE-4 and UC-ELDIA 1.

Table 2: Supply chain KPIs

SCOR attribute	Description	KPIs	Inter-factory use case
Reliability	The ability to perform tasks as expected. Reliability focuses on the predictability of the outcome of a process. Typical metrics for the reliability attribute include: On-time, the right quantity, the right quality.	On-time Pickup On-time payments Collection quality (referring to content-material) On-time Pickup Accurate notifications Correct content	UC-KLE 4 UC-ELDIA 1
Responsiveness	The speed at which tasks are performed. The speed at which a supply chain provides products to the customer. Examples include cycle-time metrics.	Reaction time to invitation for pick-up	UC-ELDIA 1
Agility	The ability to respond to external influences, the ability to respond to marketplace changes to gain or maintain competitive advantage. SCOR Agility metrics include Flexibility and Adaptability.	Ability to sub-contract (in case of extreme number of notifications for pick-up or any unforeseen factors)	UC-ELDIA 1
Costs	The cost of operating the supply chain processes. This includes labour costs, material costs, management and transportation costs. A typical cost metric is Cost of Goods Sold.	Cost of material Transportation costs General expenses Price per load Warehousing costs (double-handling cost)	UC-ELDIA 1 UC-KLE 4
Asset Management Efficiency (Assets)	The ability to efficiently utilize assets. Asset management strategies in a supply chain include inventory reduction and in-sourcing vs. outsourcing. Metrics include: Inventory days of supply and capacity utilization.	Utilization of own trucks vs outsourcing Utilization of own containers vs outsourcing Number of pick-us per truck Number of pick-ups per week	UC-ELDIA 1 UC-KLE 4

The use of KPIs is very important for both KLEEMANN and ELDIA, to measure their performance and improve their operations based on specific points of reference. Monitoring KPIs and acting properly and immediately will help the supply chain pilots visualize their performance. For example, when a KPI (e.g. on-time pickup) fluctuates, the manager through the COMPOSITION IIMS is able to monitor the delay in real-time and take specific measures to overcome the delay, such as switching to a local waste management company.

5 Supply Chain Pilot Evaluation

5.1 On-site technology

Regarding the technology infrastructure, it has to be noted that there were no existing sensors on the waste bins. For UC-KLE-4 and UC-ELDIA-1, a fill level monitoring ultrasonic sensor was developed. The sensor provides data to the simulation and prediction tool in order to enable the estimation of the date in which the bin will be full. More specifically, it captures raw measurements of distance of the waste heap from the deployment point. Data is transferred via the LoRa low power protocol to the LoRa Gateway. The gateway is connected to the internet via Ethernet or Wi-Fi. Finally, the Building Management System (BMS) component of the project will be the destination platform.

Overall, the installed on-site technology is well accepted from both companies with supply chain use cases and so far, it has not been affecting day to day operations.

More information about the sensor infrastructure and the on-site technology can be found in deliverables *"D3.7 Computational Modelling, Simulation and Prediction of Logistics II"* led by CERTH and *"D7.7 On-Site Readiness Assessment of Use Cases Based on Existing Sensor Infrastructure II"* led by TNI-UCC.

5.2 Human Machine Interfaces (HMIs)

Evaluation sessions were conducted at KLEEMANN's premises in Kilkis in June 2018. It was planned by FIT and ATL and the most suitable personnel from KLE participated in the sessions. The evaluation has focused on the HMIs of the INTER-factory UC-KLE-4 Scrap metal collection process and bidding process and was conducted as a cognitive walkthrough. At this stage, participants were guided through the evaluation by a list of commonly used tasks. More details about the evaluation process can be found in *D8.8 Final evaluation of the COMPOSITION IIMS platform*.

From the HMI perspective, UC-KLE-4 and UC-KLE-7 are related. While UC-KLE-4 is focused on selling waste by running a bidding process, UC-KLE-7 focuses on buying. However, the HMI design for UC-KLE-7 will rely on UC-KLE-4, since similar elements and steps are required.

Generally, the HMI was well received providing most of the necessary information needed for the scrap metal fill level and bidding process. The participants' suggestions underlined the need for more criteria in the bidding process and some changes in the visual elements of the HMIs. The HMIs for UC-KLE-7 and UC-ATL/NXW are not implemented in the scope of this project. These use cases are simulated by software agents only. In meetings with ELDIA it was discovered, that the HMI created for UC-KLE-4, satisfies most of the requirements of UC-ELDIA-1. Figure 14, shows an example of the latest state of fill level notification regarding UC-KLE-4. UC-KLE-4 HMI monitors the fill level of container.

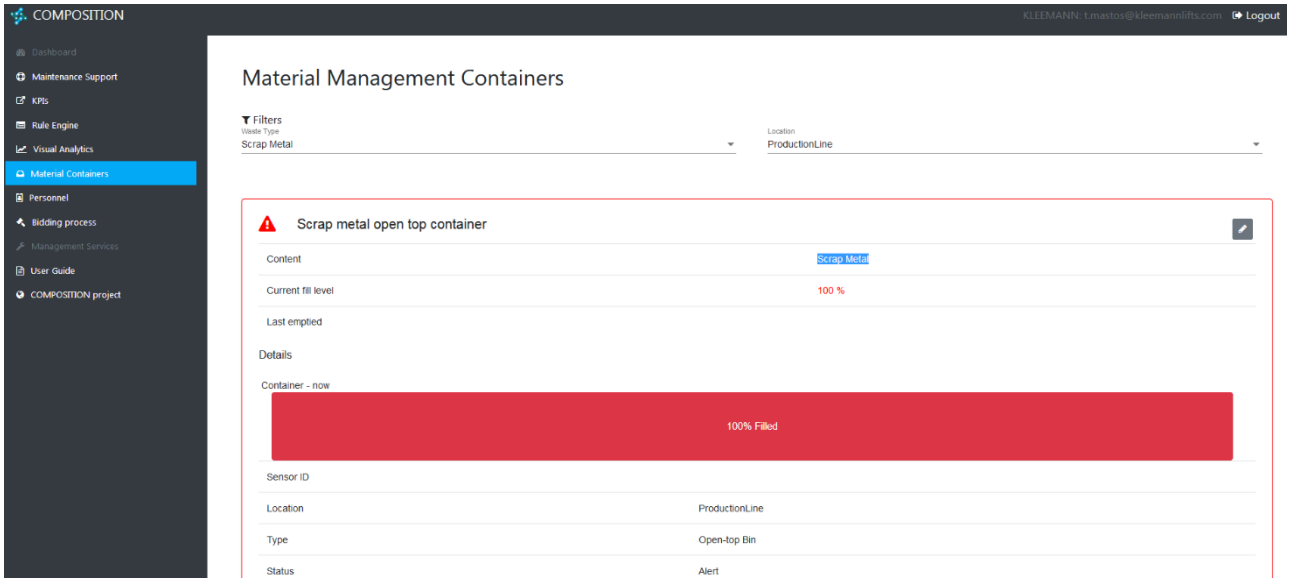

Figure 14: Details of open top container's fill level

Figure 15, shows an example of the Bidding Process Management HMI. As observed, the user is able to filter by status, waste type and contractor.

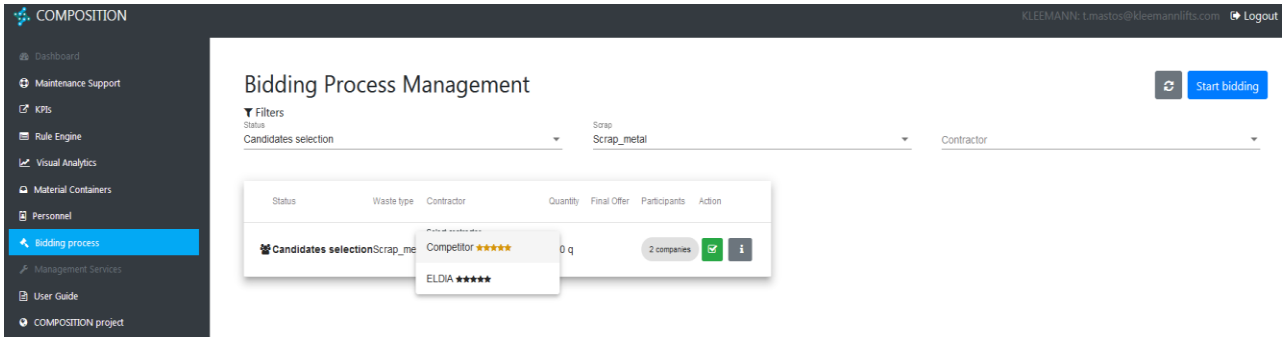

Figure 15: Screenshot of the Bidding Process Management HMI

In a later state of the project, during the Cork plenary meeting, an evaluation session took place. At this point, all different HMIs were incorporated into a single view, with the use of a web – component. Project partners FIT, In-JeT, KLE, BSL participated in the second evaluation session. The HMI had already improved since the first evaluation session. Partners measured the acceptance of the HMIs, the successful unification of different application under a single common menu view, as well as ease of use, clarity and other KPIs concerning the Human Machine Interfaces. More details about the use-cases' HMIs and updates, is included in "*D5.6 Human-Machine-Interfaces for direct interaction with the factory II"*.

5.3 Supply chain risks

In this section supply chain risks that may occur during the implementation of the inter-factory use cases are identified and methods to manage and mitigate them are presented. This process is documented in the following risk assessment tables. Two main types of risks are identified by the consortium.

1. Pilot risks: risks associated to the end-user
2. Technology risks: risks associated to technology failures that may result in breakdowns

Table 3: Risk Matrix

		Severity			
		NEGLIGIBLE small/unimportant; not likely to have a major effect on the operation of the event / no bodily injury to requiring minor first aid injury	MARGINAL minimal importance; has an effect on the operation of event but will not affect the event outcome / requires medical treatment	CRITICAL serious/important; will affect the operation of the event in a negative way / suffers serious injuries or medical treatment of minors	CATASTROPHIC maximum importance; could result in disaster/death; WILL affect the operation of the event in a negative way / death, dismemberment or serious injury to minors
Probability	LOW This risk has rarely been a problem and never occurred at a college event of this nature	LOW (**1**)	MEDIUM (**4**)	MEDIUM (**6**)	HIGH (**10**)

	MEDIUM This risk will MOST LIKELY occur at this event	LOW (**2**)	MEDIUM (**5**)	HIGH (**8**)	EXTREME (**11**)
	HIGH This risk WILL occur at this event, possibly multiple times, and has occurred in the past	MEDIUM (**3**)	HIGH (**7**)	HIGH (**9**)	EXTREME (**12**)

Table 4: Explanation of Risk Ranking

Explanation of Risk Ranking		
LOW	MEDIUM	If the consequences to this event/activity are LOW / MEDIUM, your group should be OK to proceed with this event/activity. It is advised that if the activity is MEDIUM, risk mitigation efforts should be made.
HIGH		If the consequences to this event/activity are HIGH, it is advised that you seek additional event planning support.
EXTREME		If the consequences to this event/activity are EXTREME, it is advised that you **do not hold** this event without prior consultation with Risk Management.

5.3.1 Pilot risks

Table 5: End-user risks

List All Activities/Use Case *Your activity name*	**Associated Risk(s)** *Risk(s) associated with the activity*	**Severity** *Level of impact*	**Probability** *The chances of that risk happening*	**Risk Score** *Risk score, found by combining impact and probability on the risk matrix*	**Method(s) to Manage/Mitigate the Risk** *A list of methods you will use to minimize the chances of the risk happening and/or the resulting damages of the risk*
Installation of sensor on open top scrap metal container (UC-KLE-4)	1. Interrupt collection process 2. Injury to installers 3. Interfere with the normal operation of recycling waste collection	1. Marginal 2. Critical 3. Critical	1. Low 2. Low 3. Medium	1. Medium (4) 2. Medium (6) 3. High (8)	1. Arrange a specific time for installation that does not interrupt the collection process. 2. Ensure and inspect that all work is performed

					based on company's health and safety policy and procedures and that personal protective equipment (PPE) is used. 3. Educate forklift operators on how to collect recycling waste without obstructing the normal operation and without damaging the sensor case
Scrap metal collection (UC-KLE-4)	1.Wrong fill level notification of scrap metal	1. Critical	1. Medium	1. High (8)	1.Check the fill level and report the failure of the system to provide accurate data. The report should be communicated to the technical team responsible for the notification.
Bidding process (UC-KLE-4)	1. Wrong notifications (a-Only the selected company was notified, b-the pick-up notification for waste was not delivered, c-The arranged date overlaps with another pick-up process, d-Late notification for pickup date) 2. Late payment 3. Late pick up	1. Critical 2. Critical 3. Critical	1. High 2. High 3. High	1. High (9) 2. High (9) 3. High (9)	1.Thorough check – audit of the bidding process. Confirm transactions via telephone or e-mail and notify selected and not selected companies 2. Inform the scrap metal company about the late payment via telephone and request for payment 3. Inform the scrap metal company about the late pick-up via telephone and request pick-up
Bidding process (UC-KLE-7)	1.Wrong raw materials arrive in the factory with delays 2. Wrong notifications (neither the best price	1. Critical 2. Critical	1. High 2. High	1. High (9) 2. High (9)	1. Inform the supplier and/or distributor about the arrival of wrong materials

	nor the quality of the raw materials has been achieved through the IIMS)				via telephone and request for the right raw materials. Ensure that the right raw materials arrive at the factory and the wrong raw materials are returned. 2. Thorough check – audit of the bidding process. Confirm transactions via telephone or e-mail and notify selected and not selected companies. If prices and quality are not the agreed ones, return the raw materials to the supplier and request the agreed ones.
Installation of sensor on an open top container (UC-ELDIA-1)	1. Damage Sensor Case 2. Interrupt loading process 3. Injury to installers (technicians)	1.Critical 2.Marginal 3.Critical	1.Low 2.Low 3.Low	1.Medium (6) 2.Medium (4) 3.Medium (6)	1.Educate participants regarding the sensor activity. The sensor case is mounted on the container, so extra attention needs to be paid. 2.Educate forklift and loader operators in order to avoid loading from the sensor's position. 3.Ensure all company's health and safety policies are implemented.
Notification of fill level and optimal route choice (UC-ELDIA-1)	1. Incorrect notification of fill-level 2. Incorrect choice of optional route 3. Misunderstandings with customers	1. Critical 2. Critical 3. Critical	1. Medium 2. Medium 3. Low	1.High (8) 2.High (8) 3.Medium (6)	1.Educate container loaders for proper and equal filling of container. 2.Educate Logistics manager to double check fill level readings 3.Explain the methodology to customers.

Searching for Software Solutions (UC-ATL/NXW)	1.Wrong output from the external solution (with respect to what expected) 2. Wrong connectors with COMPOSITION ecosystem 3. No data available	1. Critical 2. Critical 3. Marginal	1. Low 2. Low 3. Medium	1.Medium (6) 2. Medium (6) 3. Medium (5)	1. Prepare preliminary test phase, in order to ensure that the output is right 2. Check that the connectors are compliant with COMPOSITION interfaces 3. Continuous monitoring of the data

5.3.2 Technology risks

Table 6: Technology risks

List All Components *Your activity name*	**Associated Use case(s)** *Use case(s) associated with the activity*	**Associated Risk(s)** *Risk(s) associated with the activity*	**Severity** *Level of impact*	**Probability** *The chances of that risk happening*	**Risk Score** *Risk score, found by combining impact and probability on the risk matrix*	**Method(s) to Manage/Mitigate the Risk** *A list of methods you will use to minimize the chances of the risk happening and/or the resulting damages of the risk*
COMPOSITION Virtual Marketplace provides ranking of suppliers	1. ALL	1.COMPOSITION Virtual Marketplace does not provide ranking. 2. The ranking provided by the COMPOSITION Virtual Marketplace is biased.	1. Critical 2. Critical	1. Low 2. Low	1. Medium (6) 2. Medium (6)	1. COMPOSITION Virtual Marketplace takes into account criteria posed by the Requester. 2. COMPOSITION Virtual Marketplace has security features embedded using blockchain based technology to avoid non authorized access and intervention.
COMPOSITION Security Framework	1. ALL	1. Unauthorized access (malicious or accidental) 2. Misuse of information (or	1.Critical 2.Critical 3.Critical 4.Critical	1. Low 2. Low 3. Low 4. Low 5. Low	1.Medium (6) 2.Medium (6)	1. COMPOSITION Security Framework provides strong

		privilege) by an authorized user 3. Data leakage or unintentional exposure of information 4. Loss of data 5. Disruption of service or productivity	5.Catastrophic		3.Medium (6) 4.Medium (6) 5.High (10)	authorization mechanisms based on EPICA 2. Continuous learning about the data and information management 3. Authentication and authorization management using Keycloak and EPICA 4. Data replication policies 5. Distributed architecture with backup instances running
COMPOSITION Shop Floor Connectivity / BMS	1.UC-KLE all	1.Data is not available due to connectivity problems 2.Data from shop-floor is incomplete 3.Broker is down 4. Sensors are not working or get damaged due to environmental factors	1. Critical 2. Critical 3. Critical 4. Critical	1. Medium 2. Low 3. Medium 4. Medium	1. High (8) 2. Medium (6) 3. High (8) 4. High (8)	1. Connectivity must be constantly monitored; notifications must be sent in case of downservice 2. An initial trial phase is performed to test the robustness of the system. Diagnostic software messages user when data is present but not complete/valid. 3. Broker connectivity must be monitored 4. Cases have been created in order to protect sensors. Sensors are tested in lab and after that they deployed to the pilots' sites for further testing before

						the permanent installation.
COMPOSITION data persistence	1.UC-KLE all	1.Storage queries request excessive amount of data with a single call 2.After production server's reboot BMS or DFM storage components stop and new data are not stored to the data bases anymore 3. Data from shop floors comes in different formats	1.Critical 2.Critical 3.Critical	1.High 2.Medium 3.Medium	1. High (8) 2. High (9) 3. High (8)	1.Queries results must be limited by the data persistence component 2. Use of Portainer for Docker containers deployment and Set Restart Policy to Unless Stopped. This is to make sure containers restart after a system reboot 4. Data strictly follows the database schema which is defined.
COMPOSITION Virtual Marketplace Matchmaking Processes	1. UC-ATL/NXW 2. UC-KLE 4 3. UC-KLE 7	COMPOSITION Marketplace does not suggest the correct list of possible suppliers or the best available offer	1.Critical	1.Low	1.Medium	1.COMPOSITION Matchmaker takes into account different qualitative and quantitative criteria in order to perform effective matching. Moreover, many automated tests have been applied and integration tests with the agents as well.
Design of HMI for Marketplace Management Portal	1.All	1.Interface is not understood by the user and tasks cannot be fulfilled 2. Different HMIs for the different COMPOSITION applications	1.Critical 2.Critical	1.Low 2.Low	1.Medium (6) 2.Medium (6)	1.Evaluate the HMIs with end users to make sure it is understandable, and educate users who are working with the HMI. 2.Design a web component

						which includes all the common element in the menus of the different application and implement it as a common menu in all of them.
IoT Learning Agent	1.UC-ELDIA 1	1.The agent does not process and deliver the data to DLT and front-ends 2.The agent does not forward the data	1.Marginal 2.Marginal	1.Medium 2.Medium	1.Medium (5) 2.Medium (5)	1. In case of a crash the service is automatically restarted according to a Docker restart policy. The service is closely monitored using Nagios so corrective measures can be applied quickly if necessary. 2.Same as (1).
COMPOSITION Cloud Servers	1.UC-KLEall 2.UC-ATL/NXW	1. Servers are unreachable due to technical issues 2. Servers are unreachable for scheduled maintenance 3. Data is lost due to server failure 4. Data is stolen due to security breach 5.Servers unreachable due to third party (owner) disapproval	1.Critical 2.Marginal 3.Critical 4.Critical 5. Critical	1.Low 2.Medium 3.Medium 4.Low 5.Low	1.Medium (6) 2.Medium (5) 3.High (8) 4.Medium (6) 5.Medium (6)	1. Services are running on Amazon Web Services EC2 instances which ensures high availability. 2. Inform all stakeholders about scheduled updates, possible schedule updates during off-peak hours to minimize the operational effects. 3. Daily backups of the data are performed and can be used for a quick data recovery. 4. Utilize state of the art security mechanisms, deploy security

						patches automatically, adopt common security practices in all aspects of the system from infrastructure to end-user services. 5. Comply with the owner's requests based on the acceptance during installation, signing in etc.
Deep Learning Toolkit for price prediction	1.UC-ELDIA-1 2.UC-KLE-4 3.UC-KLE-7	1. Predicted trends are not accurate 2. Input of wrong data for monthly reports	1. Marginal 2. Critical	1. Medium 2. Low	1. Medium (5) 2. Medium (6)	1. Predictions will improve over time 2. There is no unrolling functions in ANNs. Next input might require data compensation
Message exchange between agents	1. UC-KLE-4 2. UC-KLE-7 3. UC-ATL/NXW	1. Requester Agent fails during negotiation/message exchange 2. Supplier Agent fails during negotiation/ message exchange 3. The message is not CXL-compliant 4. The marketplace infrastructure fails during negotiation/ message exchange	1. Critical 2. Critical 3. Critical 4. Critical	1. Low 2. Low 3. Low 4. Low	1. Medium (6) 2. Medium (6) 3. Medium (6) 4. Medium (6)	1. Stop current negotiation, restarting it when agent will be back online. 2. Withdraw from current negotiations. 3. Always check the message against CXL before sending it out. Do not accept CXL-not-compliant messages. 4. Stop all the current negotiations. Provide high availability and redundancy for Agent Management System.
Start new negotiation process	1. UC-KLE-4 2. UC-KLE-7	1. Requester/Supplier Agent fails before starting negotiation, after	1. Critical	1. Low	1. Medium (6)	1.Store the IIMS input in a backup system.

		IIMS input has been received				
Agent registration on marketplace	1. UC-KLE-4 2. UC-ELDIA-1, 3. UC-KLE-7 4. UC-ATL/NXW	1. White pages service fails before registering agent 2. Registration request has a wrong format	1. Critical 2. Marginal	1. Low 2. Low	1. Medium (6) 2. Medium (4)	1. Provide fail over mechanisms for White pages service. 2. Always stick to standard request before sending it out.
Matchmaking results from the COMPOSITION Marketplace	1. UC-KLE-4 2. UC-KLE-7 3. UC-ATL/NXW	1. Requesters fail to correctly register their needs and requirements to the ecosystem to specific topics 2. Suppliers fail to correctly register their products and services to the ecosystem to specific topics	1. Critical 2. Critical	1. Medium 2. Low	1.High (8) 2.Medium (6)	1. Requesters are asked to follow specific topics, connected to the COMPOSITION ontology framework. 2. Suppliers register their products and services according to the COMPOSITION ontology framework.
Visualization of Analysis results	1.UC-KLE-1 2.UC-ELDIA-1	1.SFT and DLT results are not visualized in an effective way for the end-users 2.Visual analytics are not interact with end-users in real-time	1. Critical 2. Critical	1. Low 2. Low	1. Medium (6) 2. Medium (6)	1. The Visual Analytic tool support different types of advanced visualizations in order to meet different user requirements and present in different ways the SFT and DLT outputs 2. The VA tool is a completely online tool able to support analysis and visualizations on demand. The user is able to select type of analysis, type of visualization, data resource and in some

						times to set parameters

5.4 Synchronization between reality and simulation

The challenge of synchronising the digital and physical world while simultaneously addressing the security and IPR protection requirements still exists. In this phase of the project, where the platform is still under development, pilot partners can evaluate the status and operation of sensors through on-site observations. In collaboration with technology partners, an assessment table is developed in order to document the results of the test studies regarding the evaluation of the installed sensors on the pilot's shopfloor. The table consists of 6 columns including information on the date, time, level of scrap metal (photo), on-site estimation from one pilot's employee, the sensor fill level as shown in the technical partner's lab, and the difference between the estimated level and the sensor level. The sensors are evaluated through iterative on-site testing by the same employee (one from KLEEMANN and one from ELDIA).

Overall, the sensors provide accurate measures, which are very close to the on-site observation measures. Indicative results from KLEEMANN's and ELDIA's shopfloors are presented in the following tables. The comparison between on-site observations and sensor fill level data, demonstrates the robustness of the measurements since all of them are quite close (from 0% to 5%). However, a limitation of the above measurements is that the sample of observations in both companies is very small due to project time limitations and more data is needed to provide more accurate results.

Table 7: UC-KLE 4 sensor assessment

Date	Time	Photo	On-site estimated fill level	Sensor fill level	Difference
20/08/2019	14:00		95%	100%	5%

Table 8: UC-ELDIA 1 sensor assessment

Date	Time	Photo	On-site estimated fill level	Sensor fill level	Difference
21/08/2019	10:30		60%	63%	3%

6 Conclusion

This deliverable is the result of the ongoing process, which describes the actions taken regarding the implementation of supply chain use cases. It represents the final deployment status of Task 8.3 “Inter-factory Supply Chain Centric Pilot” of WP8. Regarding the set up and demonstration of UC-KLE-4 and ELDIA-1, the sensors have been successfully installed and are running at KLEEMANN’s and ELDIA’s shopfloors. The development of two more supply chain use cases is also presented. UC-KLE-7 and UC-ATL/NXW are based on similar processes to UC-KLE-4. Since there is no real marketplace, UC-KLE-7 is based on a simulated ecosystem and UC-ATL/NXW stops at the first level of matching services such as software solutions. The data is successfully transferred from both supply chain pilots to COMPOSITION’s related components. Finally, a list of supply chain KPIs is identified by the end-users. This list provides indicative KPIs and may be extended after the end of the project.

Regarding the supply chain pilot evaluation, the installed on-site technology is well accepted from both supply chain pilots. The HMI for UC-KLE-4 is well received providing most of the necessary information needed for the scrap metal fill level and bidding process. The pilot and technology risks are identified and methods to mitigate them are presented, as recommended in the second project review by the EC. The low differences between on-site observations and sensor fill level data, demonstrate the robustness of the measurements. Finally, it is observed that metal swarf, may cause implications to the measurements of ultrasonic sensors.

Based on the supply chain analysis performed in the previous sections, this deliverable concludes on a number of next steps beyond COMPOSITION, that could be effectively deployed in order to successfully use the COMPOSITION platform and exploit the results of the project. These steps are:

1) Focus on the real – time monitoring of fill levels and test the bidding process with existing supply chain partners
2) KPIs will be further discussed and developed with help from supply chain partners and technical partners in order to improve the system’s performance and the overall supply chain management performance
3) The supply chain risks along with mitigation methods will be continuously reviewed and updated
4) Continuous testing and demonstration of the COMPOSITION platform to different marketplaces (e.g. e-factory) in order to evaluate the supply chain functionalities.

7 List of Figures and Tables

7.1 Figures

7.2 Tables

8 References

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