Ecosystem for COllaborative Manufacturing PrOceSses – Intra- and Interfactory Integration and AutomaTION
(Grant Agreement No 723145)

D2.1 Industrial Use Cases for an Integrated Information Management System

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1 Executive Summary

The COMPOSITION project has two main goals: To integrate data along the value chain inside a factory into one integrated information management system (IIMS), and to create a (semi-)automatic ecosystem, which extends the local IIMS concept to a holistic and collaborative system incorporating and inter-linking both the *Supply* and the *Value Chains*. Six use case pilots will be implemented to demonstrate and evaluate the COMPOSITION eco-system based on two different approaches: Value-Chain/Intra-Factory and Supply-Chain/Inter-Factory approach.

Two pilots will focus on the Value-Chain/Intra-Factory approach:

- **Boston Scientific Ltd, Ireland (BSL)**

  Boston Scientific Limited (Clonmel) is the largest plant in the Boston Scientific group. It is the sole manufacturer of Pulse Generators (Pacemakers, Implantable Cardiac Defibrillators (ICDs) in the network. Boston Scientific aims to leverage COMPOSITION tools and technologies to tackle real knowledge gaps within their business. These can enable disruption of its current method of manufacturing and enable it to continue to be the prime manufacturer of pacemakers and ICDs.

- **Kleemann Hellas, Greece (KLE)**

  Kleemann operates both in the manufacturing and the trading of Complete Lift Systems field. The range of products includes domestic and commercial lift systems, including car parking and multi-storey building lift systems. Three departments from the Kleemann plant will be involved in the COMPOSITION pilot: the car slide (intra-factory application), the piston-cylinder and the power the unit department (inter-factory application). KLE is also part of the Supply Chain/Inter-Factory approach will be deployed jointly at the Kleemann plant in Kilkis and at ELDIA's recycling facilities in Thessaloniki.

Four pilots will focus on the Supply-Chain/Inter-Factory approach:

- **Kleemann Hellas, Greece** (described above)

- **ELDIA, Greece (ELDIA)**

  ELDIA is the largest waste management company in Northern Greece. ELDIA's activities cover the entire range of solid waste management of municipal, industrial, and commercial sectors. In particular, the collection, transportation, sorting, processing of waste and recovery of recyclable materials. 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.

- **ATLANTIS, Greece (ATL)**

  ATLANTIS Engineering is an SME with various activities. ATLANTIS has long standing experience in the industrial manufacturing domain. The expertise of the company is mainly in the 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). The Supply Chain/Inter-factory Pilot will be deployed by ATLANTIS for software upgrade and deployment.

- **Nextworks, Italy (NXW)**

  Nextworks, located in Pisa (Italy), is a dynamic SME that was created in 2002. The current development of the Symphony platform focuses on service decomposition and distribution over a wide area, in a truly flexible IoT approach. Nextworks will play the role of technology and service provider in the value chain and in the supply chain of the Kleemann use case, specifically for factory premises and production line monitoring and management. Decisional processes inside the production line will also be supported, enhancing their functionality using professional analysis tools offered by the COMPOSITION marketplace. Nextworks will contribute to the design and development phases of the COMPOSITION project, providing the common technological platform in support of the value chain and supply chain pilot and use cases.

Scenario workshops with all six pilot sites were conducted in order to firstly understand the current situation and secondly to identify how and where the COMPOSITION eco system can be used to optimise

manufacturing and logistics processes. This activity resulted in a number of intra-factory and inter-factory industrial scenarios for the pilots (COMPOSITION To-Be scenarios) and use case which are described in this deliverable.

The Value Chain/Intra-Factory To-Be scenarios and use cases focus on applying business intelligence to provide improved coordination mechanisms of collaborative manufacturing processes. The Intra-Factory scenarios will demonstrate value added services that address fundamental challenges in the pilot organisations by matching requirements to capabilities for internal and external processes and addressing emerging issues. The scenarios will aim at boosting collaborative manufacturing and Intra-Factory interoperability in marketplaces to the next level of knowledge management, agility, reliability, security, responsiveness, and cost-efficiency. The Intra-Factory To-Be scenarios and their related use cases are entitled as follows:

Scenario INTRA-1: Non-Conformance Monitoring

- UC-BSL-1 NC Monitoring

Scenario INTRA-2: Predictive Maintenance

- UC-BSL-2 Predictive Maintenance
- UC-KLE-1 Maintenance decision support

Scenario INTRA-3: Material Management

- UC-BSL-3 Component Tracking
- US-KLE-2 Delayed Process Step
- UC-KLE-3: Scrap metal and recyclable waste transportation (from bins to container)

Scenario INTRA-4: Automatic Data Conversion

- UC-BSL-4 Automatic Solder Paste Touch Up.

The To-Be use cases and scenarios based on the supply chain approach focus on the lacks of long-term performance both for the companies and for the entire chain. This is due to the manual management of all procedures and the absence of any real-time data that could be of use for optimizing the management of the supply chain. Lack of automation mainly impedes the data collection and analysis. Furthermore, an issue that customers face when they are trying to look for a solution is that they might do not know exactly how to find one, how to get the details they need and how to handle the information available from solution providers. ´They do not have access to a broader base of evaluators of collaborations and results of certain providers. COMPOSITION will provide an automatic way to offer software and consultancy through the ecosystem. The following To-Be scenarios and use cases for Inter-factory have been identified:

Scenario INTER-1: Scrap Metal Management

- UC-KLE-4 Scrap metal collection process
- UC-KLE-5 Scrap metal bidding process
- UC-KLE-6 Determining price for scrap metal with ELDIA acting as logistician.

Scenario INTER-2: Recyclable Material Management

- UC-ELDIA-1 Fill-level notification – Contractual recyclable material management
- UC-ELDIA-2 Fill-level notification – Contractual wood waste management

Scenario INTER-3: Supply Chain Management

- UC-KLE-7 Ordering raw materials

Scenario INTER-4: Software Distribution

- UC-ATL-1 Selling software/consultancy
- UC-ATL-2 Searching for solutions
- UC-ATL-3 Searching for recommended solutions

Scenario INTER-5: System connection over marketplace

- UC-ATL/NXW-1 Integrate external product into own solution – Exposing service output for external application
- UC-NXW-1 Decision support over marketplace.

The use cases include a description of the actors, their roles and goals, the pre-conditions for the use case, the use case trigger, post-condition success/failure, description of the steps in the use case, and where applicable extensions and sub variations. Most use cases have also been visualised using UML diagrams.

Based on the scenarios and use cases presented in this deliverable, a number of user requirements has been elicited and documented in *D2.2 Initial Requirements Report*. Due to the iterative approach of the development work in the project, the scenarios and use cases may be further revised. The user requirement engineering work to come will reflect such revisions (to be documented in the forthcoming WP2 deliverables).

2 Abbreviations and Acronyms

Table 1: Abbreviations and acronyms used in the deliverable

Acronym	Meaning
API	Application Programming Interface
ASIC	Application Specific Integrated Circuit
ATL	ATLANTIS
BMS	Building Management System
CMMS	Computerised Maintenance Management System
DoA	Description of Action
DSS	Decision Support System
EFQM	European Foundation for Quality Management
ERP	Enterprise Resource Planning
FE	Front End
FoF	Factory of the Future
IC	Integrated Circuit
ICD	Implantable Cardiac Defibrillator
IIMS	Integrated Information Management System
JIT	Just In Time
KLE	KLEMANN
MES	Manufacturing Execution System
MRB	Material Review Board
NC	Non-Conforming
NXW	NEXTWORKS
PB	Product Builder
PCB	Printed Circuit Board
PCBA	Printed Circuit Board Assembly
PG	Pulse Generator
PU	Production Unit
SAP	SAP Production Planning System
SMT	Surface Mount Technology
SPD	Solder Paste Deposit
SPI	Solder Paste Inspection
ToS	Terms of Services
UC	Use Case
UPH	Units Per Hour
UV	Under Volume
WIP	Work-In-Process

3 Introduction

The COMPOSITION project has two main goals: The first goal is to integrate data along the value chain inside a factory into one Integrated Information Management System (IIMS) combining physical world, simulation, planning and forecasting data to enhance re-configurability, scalability and optimisation of resources and processes inside the factory. The second goal is to create a (semi-)automatic ecosystem, which extends the local IIMS concept to a holistic and collaborative system incorporating and inter-linking both the *Supply* and the *Value Chains*. By building on well-known paradigms, such as marketplace emulation (in a way similar to the current mobile app markets), the COMPOSITION system extends the factory IIMS into a holistic and collaborative IIMS incorporating the entire *Supply* and *Value Chain,* providing the necessary tools to compare production indicators within and between manufacturing facilities.

Sharing products and production data with other actors in the supply chain (sub-manufacturers, suppliers) seldom occurs and, when this happens it is generally on an ad-hoc basis. Where specific systems have been developed in actual factories, they are often bespoke, non-transparent, inflexible, and provide few if any client-side feedback. Tracking information along the supply chain is getting increasingly important because nowadays products are no longer produced in a single manufacturing plant. Instead, they are sent from one factory to another and possibly back again, according to the production process needs and phases. Additionally, there may be many ‘factories within factories’ with various manufacturing cells developing sub-assemblies or undertaking task such as preparation, coating, packaging, etc. Whilst tracking inside companies already occurs, although in a somewhat limited scale, crossing company borders is almost unknown and, even tracking within factory borders or between different production cells can be difficult. In most cases, moreover, the currently available tracking facilities are almost operating off-line or in batch, with no possibility of getting real-time information on involved processes.

Suitable tools to track production efficiency (scrap, re-work, available capacity, resources, and energy consumption) are missing or lacking features in most enterprises. Modern manufacturing facilities are complex, with a growing variability in terms of product mix, product families, unique variations, one-offs, varying batch sizes, parallel production paths, etc. Given the proliferation of similar parts, and the constant reduction of time allocated to the manufacturing lifecycle, plants are increasingly forced to acquire the agility to meet the demands for such increased re-configurability. Traditional assets, like machines, now increasingly tend to belong to several different production pathways, making optimization of their usage even more difficult. Visibility to non-scheduled production, rework and scrap is often lacking, and a significant contribution in the efficient operation of the production systems is reliant on the tacit knowledge of the operators and production associates, which, in turn, is difficult to optimize and systemize. Thus, the demand for accurate tools comparing production indicators is undeniable.

3.1 Overview of the COMPOSITION IIMS platform

Data and services have become the key factor in manufacturing processes. The necessity of reacting to dynamically changing market demands is ever more important. One major problem in the manufacturing domain is to connect supply chain data and services between enterprises and to connect value chain data within a factory, so that it can meaningfully support decision-making. COMPOSITION will create a digital automation framework – the COMPOSITION Integrated Information Management System – that optimises the manufacturing processes by exploiting existing data, knowledge, and tools to increase productivity and dynamically adapt to changing market requirements.

COMPOSITION will implement, demonstrate, and validate the system in two multi-sided pilots that show the modularity, scalability, and re-configurability of the platform across multiple application domains. The first pilot in the biomedical device domain, the Value Chain Pilot, focuses on the integrated information management system in a multi-sided manufacturing process. The second pilot, the Supply Chain Pilot, concentrates on the interaction between different companies using the COMPOSITION ecosystem with the agent-based marketplace for collaboration.

3.2 Purpose, context, and scope of this deliverable

The overall purpose of this deliverable is to present the set of industrial To Be use cases for the COMPOSITION Integrated Information Management System which will be deployed by the pilots in the project.

The use cases have derived from a scenario thinking process which involved dedicated workshops with the pilots and other relevant partners. User scenarios are useful tools from with relevant industrial use cases and user requirements can be derived. The primary objective of activities in this task (T2.1) has been to identify specific needs and improvements in the value and supply chains respectively, which motivate the COMPOSITION concepts and planned innovations in decision support and factory management systems, at both intra-factory and inter-factory levels. Analyses have been carried out based on a common use case description methodology (template), in order to obtain a coherently “processable” list of involved actors, stakeholders, expected roles, workflows, and interfaces. Visual modelling of the use cases has been used where appropriate.

3.3 Content and structure of this deliverable

Some basic background information about the five COMPOSITION pilots is provided in Section 4 in order to provide an understanding of their present state of play, needs and challenges in the context of COMPOSITION.

The scenarios and use cases have been developed in close cooperation with the COMPOSITION pilots in order to ensure that the scenarios and use cases reflect the needs and challenges which are envisioned by COMPOSITION. Hence dedicated workshops working with the scenarios were conducted and the approach to these is described in Section 5.

In Section 6, the scenarios for the Intra-Factory Value-Chain pilots and the COMPOSITION Integrated Information Management Systems (IIMS) are presented, and Sections 7-11 present the future To-Be use cases that are based on the scenarios.

Similarly, Section 11 describes the scenarios for Inter-Factory Supply Chain pilots, and Sections 12-16 describe the To-Be use cases.

Section 17 explains how the developed scenarios and use cases shall be interpreted in the context of the underlying business ecosystems for the purpose of gathering the requirements.

4 Description of the pilot domains

This section will provide a brief background description of the five pilot partners in COMPOSITION. The Intra-factory pilots, which consists of use cases mainly from Boston Scientific Limited, however there are some from Kleemann and Nextworks which have both Intra- and Inter scenario use-cases. The remaining two pilots, ELDIA and ATLANTIS, are represented in the Inter-factory scenarios.

4.1 Boston Scientific Ltd, Ireland

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.

BSL manufactures Pulse Generators (Pacemakers, Implantable Cardiac Defibrillators). Currently the manufacturing process is a ‘non-intelligent’ fragmented process. Manufacturing is performed in production steps which have little or no upstream/downstream communication other than Manufacturing Execution system (MES) traceability, which verifies completion of the previous process step through review of traceable information, and some localized intelligent systems which can determine that the correct product recipe is active and that the equipment set is at production status. Real-time monitoring of equipment sets is not possible; equipment sets do not perform autonomous decision making and there is no communication between equipment sets or the ability to identify trends/processing issues which may impact downstream processes. Reporting of process yield/ equipment metrics is performed offline using software systems which extract and correlate the data from BSL’s MES system.

The future state of the manufacturing processed is envisaged to be a fully integrated intelligent framework which uses an over-riding software management system to allow real-time monitoring of equipment performance/ process performance and has the ability to make autonomous decisions (adjust equipment settings/ stop production on identification of trends/ alert when equipment or process goes into alarm state). The future manufacturing line will utilize intelligent software management systems to monitor required metrics, determine build sequence per build plan, recognise incoming product and perform seamless changeover of production recipes and provide a visualization of agreed and required performance metrics.

The BSL pilot will implement specific elements of the COMPOSITION solution to realise the future Front End single line solution. The layout of the future Front End single line solution for implantable Printed Circuit Board Assembly (PCBAs) is visualised in Figure 1.

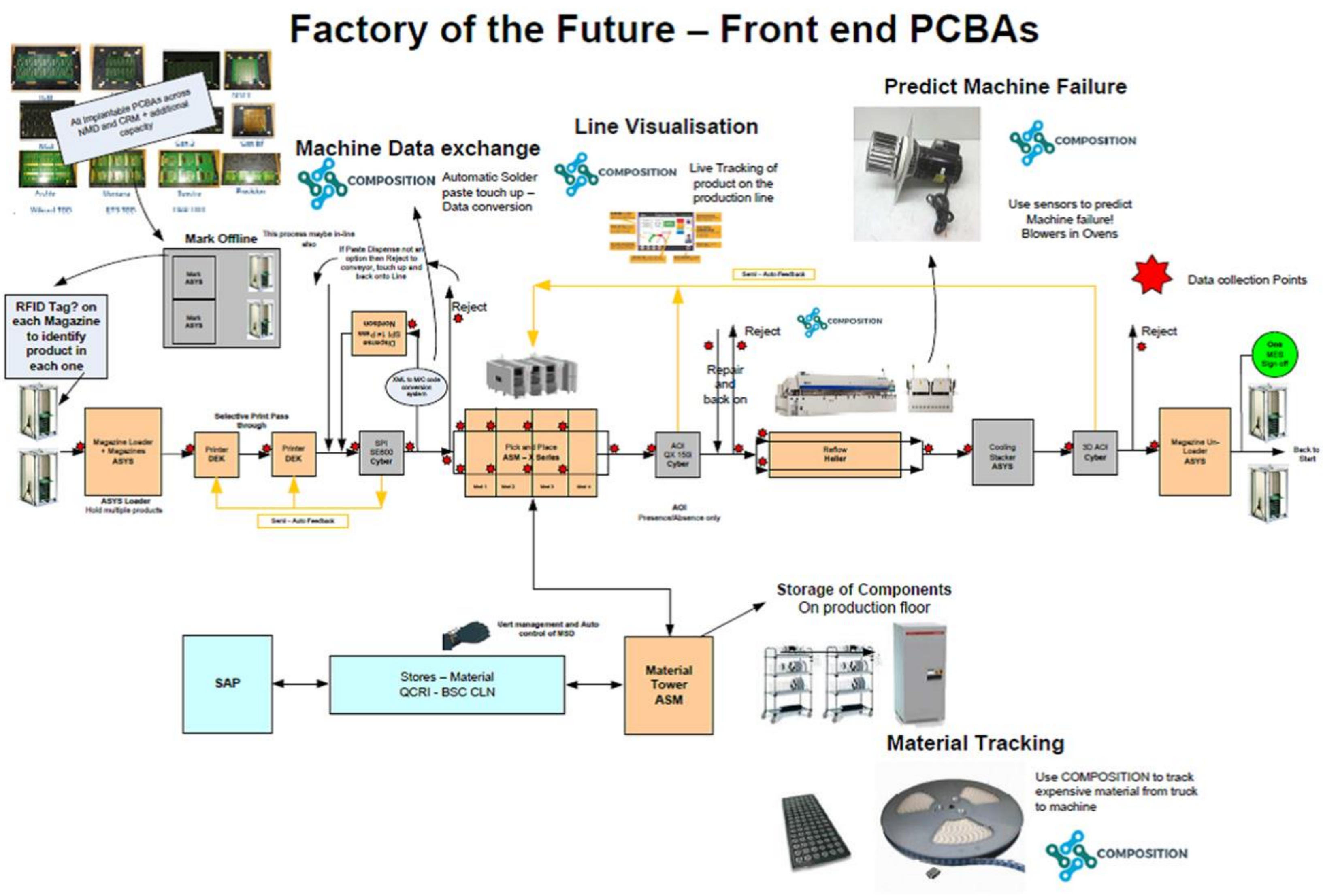


Figure 1: PCBA Front End single line solution for implantable PCBAs

4.2 Kleemann Hellas, Greece

Kleemann operates both in the manufacturing and the trading of complete lift systems field. The head offices are based in Kilkis, Northern Greece, with offices and subsidiaries in 10 territories serving more than 90 countries worldwide.

The range of products includes domestic and commercial lift systems, including car parking and multi-storey building lift systems.

Figure 2: The Kleemann Factory Complex in Kilkis

For the Value Chain/Intra-Factory Pilot, two departments will be involved; the maintenance department will be responsible for UC-KLE 1 and UC-KLE 3 and the piston-cylinder unit will be responsible for UC-KLE 2. 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 from the Greek plant will be involved; the maintenance department and the purchasing department will be responsible for UC-KLE 4, UC-KLE 5 and UC-KLE 6. The purchasing department will also be responsible for UC-KLE 7.

4.3 ELDIA, Greece

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.

Figure 3: ELDIA's recycling facilities

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.

4.4 ATLANTIS, Greece

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 the 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).

The Supply Chain/Inter-factory Pilot will be deployed by ATLANTIS for software upgrade and deployment.

4.5 Nextworks, Italy

Nextworks, located in Pisa, Italy, is a dynamic SME that operates in the IT and Telecommunications sectors. Nextworks has long-term experience and proved skills in the frameworks of IoT, wireless, access and transport networks, digital video encoding and transport, control and automation, design and development of complex software systems on both traditional and embedded platforms.

Nextworks' role is two-fold: as a pilot in the Supply Chain / intra-factory domain, and as technology and service provider in both the value chain and the supply chain of the Kleemann use case, specifically for factory premises and production line monitoring and management. These services will be provided based on information collected both from the field (production line and BMS), and where possible from other stakeholders' ERP systems. Decisional processes inside the production line will also be supported, enhancing their functionality using professional analysis tools offered by the COMPOSITION marketplace.

5 Methodology

As described in task T2.1, a modified version of the IDON technique was proposed as the methodology for creating scenarios. User workshops would be conducted with both internal and external expert stakeholders. The result of applying the IDON method is a set of scenarios that all point to alternative use cases within a given user domain and at a given point in time. All scenarios will have the same frame of reference and – ideally – be equally likely to happen.

However, the proposed approach and methodology were re-evaluated as IDON is generally used to predict uncertain futures, usually with a significant time frame (10-15 years). Instead, it was decided to ground the scenarios more firmly in the actual present challenges, needs and opportunities faced by the COMPOSITION user partners who represent the five COMPOSITION pilots. By focusing on meeting actual current needs of the pilots, an exploitation perspective becomes more integral to the use cases.

The approach used still followed the standard procedure used in scenario thinking. Thus, the first step was to identify and understand the current situation of each of the pilots, and then to identify their needs and constraints, which is described in the different scenarios. Based on the scenarios a number of use cases have been defined which illustrate the solution(s) proposed by COMPOSITION. From the use cases, a number of user requirements will be elicited and documented in *D2.2 Initial Requirements Report*.

Two separate workshops were held: one for the single Intra-Factory pilot (BSL) and one for the four Inter-Factory pilots (KLE, ELDIA, ATL and NXW).

5.1 Organisation of the Intra-Factory Scenario Workshop

To get a better understanding of the manufacturing processes and environment at BSL, where the intra-factory/value chain pilot will be hosted, a workshop was held in Clonmel on November 17-18, 2016.The workshop was organised by IN-JET with the participation of three project members and users from BSL, as well as representatives from partners FIT and TNI-UCC. To set the stage, a 2-hour guided tour of the manufacturing and planning facilities in Clonmel was carried out in the beginning of the workshop. This gave a good insight into the activities in the production line and gave partners a better understanding of the context.

The workshop started with a general introduction to the possible impact foreseen from the projects results together with a discussion of the definition of an “Intra-Factory ecosystem” in the context of the BSL factory. The DoA has already identified several scenarios and the following INTRA-scenarios were discussed in the context of the BSL pilot:

- INTRA-1 Non-Conformance Monitoring
- INTRA-2 Predictive Maintenance
- INTRA-3 Material Management
- INTRA-4 Automatic Data Conversion.

The scenarios were useful as a reference point because they triggered discussions and different perspectives on how the elements of the scenarios were related to the BSL pilot’s needs and challenges. As a result, the four scenarios for BSL were finally selected to form the basis for the development of specific use cases for the BSL pilot.

During the workshop, it transpired that two scenarios could also be applied to the KLE pilot, namely INTRA-2 and INTRA-3.

The four Intra-Factory scenarios are described in Section 6.

For each of these four scenarios, the participants then outlined and discussed specific use cases aligned with the desire and interest of the BSL and KLE users. Four use cases have been developed for BSL and three use cases have been developed for KLE. The discussions also included an initial listing of actors and data interfaces. After the workshop, the use cases were detailed and finalised by the pilot partner.

The Intra-Factory use cases are presented in Sections 7 to 10.

5.2 Organisation of the Inter-Factory Scenario Workshop

In a similar way and for the same purpose, a scenario workshop was held in Kilkis, Greece, on December 5-7, 2016. The workshop, chaired by IN-JET, took place in connection with a Consortium Meeting, and therefore most of the partners were also able to participate in the workshop. Guided tours of the Kleemann (KLE) and ELDIA facilities in the area provided insights into the business processes that will be addressed in the inter-factory pilots pertaining to KLE and ELDIA as well as the intra-factory scenarios at KLE.

During the workshop, a high-level view of and interrelation between scenarios, use cases and requirements was presented, followed by a general introduction to the possible impact foreseen from the project results together with a discussion of the definition of an "Inter-Factory ecosystem", the concept of business models and other relevant terms.

To reach an understanding of the future of COMPOSITION's To-Be scenarios, the workshop went through what the situations (scenarios) are today for end-user partners KLE, ELDIA, ATL and NXW were then selected, followed by depiction and discussion of To-Be scenarios, and use cases expected to result from the implementation of the COMPOSITION solution.

As detailed in Section 11, five Inter-Factory To-Be scenarios each with a number of associated use cases were defined:

- INTER-1 Scrap: Metal Management
- INTER-2: Recyclable Material Management
- INTER-3: Supply Chain Management
- INTER-4: Software Distribution
- INTER-5: System Connection Over Marketplace

Based on the chosen scenarios, workshop participants discussed the main elements the resulting use cases should contain. Following the workshop, the use cases were written and distributed to partners for commenting to ensure that the final versions were in agreement with what was discussed during the workshop. The eleven Inter-Factory use cases are described in detail in Section 12 to 16.

6 INTRA-Factory Scenarios

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

The Intra-factory scenarios will demonstrate value added services that address fundamental challenges in the pilot organisations by matching requirements to capabilities for internal and external processes and addressing emerging issues. The scenarios will aim at boosting collaborative manufacturing and intra-factory interoperability in marketplaces to the next level of knowledge management, agility, reliability, security, responsiveness, and cost-efficiency.

In close dialogue with the pilot owners, four Intra-factory scenarios were defined:

- Scenario INTRA-1: Non-Conformance Monitoring
- Scenario INTRA-2: Predictive Maintenance
- Scenario INTRA-3: Material Management
- Scenario INTRA-4: Automatic Data Conversion

The scenarios are primarily related to the BSL pilot and secondly to the KLE pilot. Based on the scenarios, a number of use cases have been defined which will be implemented and demonstrated during the trials in the Clonmel Factory of the Future Front End PCBAs (see also Figure 1).

In addition, real-time material tracking will be utilized and material will be traced from inventory control to production release. This ensures material is always located and controlled within the manufacturing area. Also consumption will be verified in order to release proper quantity and identify possible discrepancies/ manufacturing issues.
The scenarios are described in detail in the following subsections.

6.1 Scenario INTRA-1: Non-conformance monitoring

This scenario is related to the BSL Value Chain pilot.

6.1.1 Background and challenges today (As-Is)

Currently, there are a number of challenges with respect to Non-Conformance (NC). NC appears when a component or product is failing an automated test or a visual inspection. NCs are always reported by an operator and manually transferred to the quality technicians for inspection! The Operator signs-off NC against position in line / work step:

- Each step is numbered
- Failure has a reason: drop down list for certain defect for classification (might not be precise), comments for failure description

Next, the NC is transferred to the Material Review Board (MRB) for further investigation. MRB is an offline process where material which hasn't been processed per the required Manufacturing requirements is segregated and reviewed by an expert panel for perceived non-conformance against design/validation or other supporting rationale to determine disposition of the product. Product will then either be dispositioned and allowed to continue processing or scrapped if the non-conformance introduces an unacceptable risk.

It is important to quickly determine the cause of the NC and whether it is a systemic fault in one of the Production Units (PU). In other words, early detection of failures is important as it is a potential cost saver. The total costs related to detection of failures in the field versus in production amounts to at least 3-4 times the cost of the manufactured par (support, failure investigation, part replacement, hospital care for affected patients). However, the present system only identifies NCs reported the previous day and there is thus a need to optimise the identification and reporting of NC.

The To-Be scenario shall describe the ability to track all PCBAs visually on the Factory Floor, and include the following elements:

- A picture of the non-conforming part (this would be very useful to document the NC).

- The responsible supervisor should receive a notification (email, etc.)

BSL will try and implement this onto the new FOF PCBA FE; if successful roll across other lines.

6.1.2 COMPOSITION Non-Conformance Monitoring (To-Be)

Early detection of non-conformance is achieved via interaction with the COMPOSITION IIMS. Whenever a NC is detected, either by automated tests or by human inspection, it is reported and recorded in the IIMS by the process technician. At the same time, the software application captures a real-time image of the perceived non-conformance from sensors specific to the particular production unit in the production line attached to the report. The non-conforming part or component is uniquely identified in the system.

The components of the COMPOSITION Non-Conformance Monitoring System are shown in Figure 4.

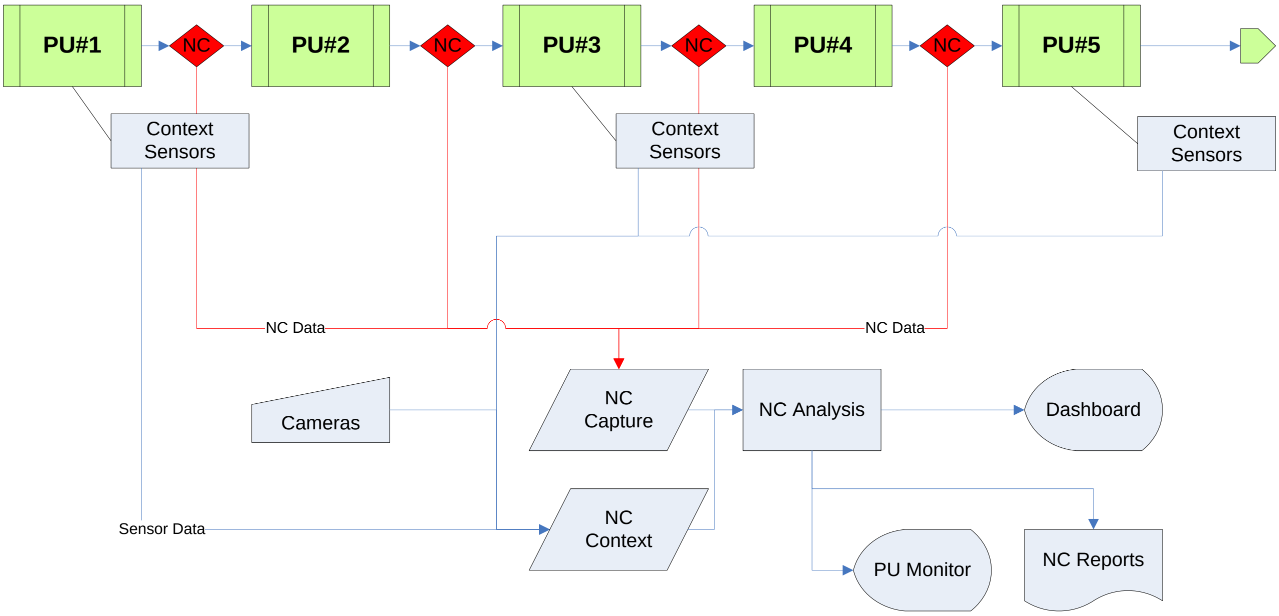


Figure 4: COMPOSITION Non-Conformance Monitoring System

Reports with statistical information can be extracted on a regular basis or on demand, facilitating the identification of potential improvements in the process or systemic faults in one of the PUs.

The information is processed and the NC is visualised in the Non-Conformance Dashboard in (near) real time. Depending on pre-defined thresholds, the corresponding PU on the dashboard will change from green through yellow to red as the number of NCs increases. When red, the core team is alerted (by email or text), allowing timely intervention.

When the process technician has signed off the NC, it is immediately presented to the MRB. The Non-Conformance Dashboard is the key interface between the staff and the IIMS. Current information on NCs and related PUs is displayed, and the quality technician or MRB staff can obtain further details about the nature of the problem as necessary for decision support regarding the non-conforming component.

The implementation of the COMPOSITION Non-Conformance Monitoring System is shown in Figure 5 on the next page.

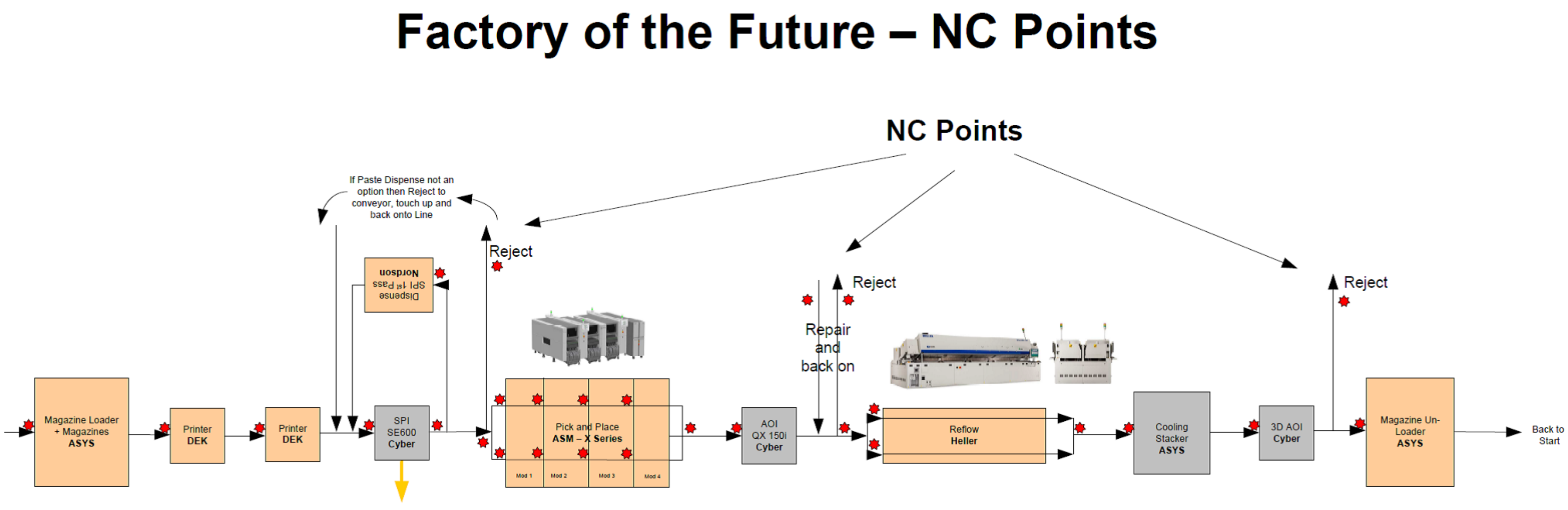


Figure 5: COMPOSITION Non-Conformance Monitoring System implemented in Factory of the Future

Based on the scenario description, three To-Be use cases for the BSL pilot related to Non-Conformance Monitoring have been developed and are described in Section 7.

6.2 Scenario INTRA-2: Predictive maintenance

This scenario is related to BSL Value Chain, and KLE and NXW Supply Chain.

6.2.1 Background and challenges (As-Is)

The INTRA scenarios for the predictive maintenance are of course different depending on the factories.

BSL has defined the following challenges:

- Machine downtime may be better managed if there is prediction of failure of critical components. For example, laser monitors, paste stores, fridges, levels and temperature of solvents, sensors for blowers in oven, time to change pumps, etc.
- Needs to know the optimal time for replacing parts in terms of cost and downtime
- Affects Total Cost of Ownership for specific production units
- Prediction of when Laser welders/Spot welders are going to fail is a massive improvement
- Implement sensors into the Blowers on the new reflow ovens to try and predict failure using sensors.

Kleemann experiences the following challenges regarding the management of maintenance services:

- The software Kleemann uses (CMMS-AIMMS), is partly efficient, including a lot of required paperwork to collect all the necessary information and data for supporting the maintenance services.
- CMMS holds information about machines i.e. how often does it break? When was the last maintenance? When should the next maintenance be done? However, all these information and data are stored manually to the system from the maintenance planner who is responsible for the management of CMMS.
- Manual measurements are performed by the technicians who then write it down to the maintenance special forms. Then all this paperwork is gathered by the maintenance planner who registers all these data in CMMS.
- Also, the suggestion of predictive maintenance is performed manually. For example, the maintenance planner sets a date for the maintenance of forklifts, based on the working hours (8/day). But a forklift may not be in motion for 8 hours and not for every day. Also, it could be broken earlier than the set date causing problems and delays in the production lines and in the logistics department (warehouses).
- Costs and inefficient operations occur. Two examples are given below to better demonstrate the cost and inefficiency problems.
    - Abrasive stones are parts of polishing machines. They are designed to be used for the piston's surface polishing. A stone in a good condition is processing pistons in 30 minutes, whereas when damaged it takes 60 minutes and produces more scrap. Another example is coolant grades. The maintenance department does not know the exact time to replace the coolant grade causing damage to the equipment.
    - The time required for all the paperwork is estimated to 30-45 minutes for the technician and two full days for the maintenance planner (16 man hours) to update the AIMMS and organize the files.

NXW decision support is based on the KLE challenges above.

6.2.2 COMPOSITION Predictive Maintenance scenario (To-Be)

The COMPOSITION IIMS collects information about actual performance (real-time) and history of performance. Data is captured at machine level (laser power, soldering paste, fans, mechanical conveyers, etc.).

The actual status is compared to static data models (performance specs, history, costs) about the optimum process performance and algorithms can predict the likely point in time where critical components in the machine or process may fail thus causing the manufacturing process to be disrupted or products to be scrapped. Based on historic performance the prediction of failures can further be improved using different machine learning technologies. The COMPOSITION Early Failure Prediction System is shown in Figure 6.

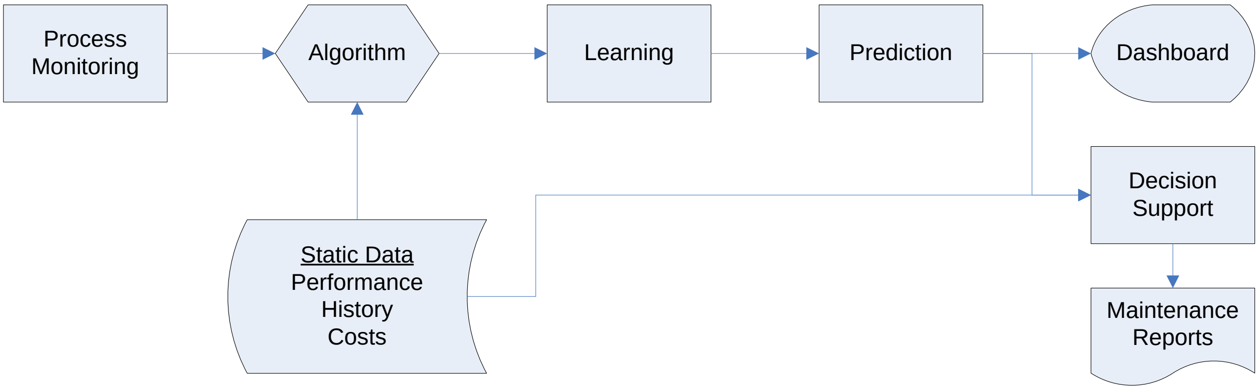


Figure 6 COMPOSITION Predictive Maintenance System

The predictions are presented to the operator to support their decision about when and what to replace before failure occurs. The operator will view a selection of critical components and their estimated time of failure as shown in Figure 7.

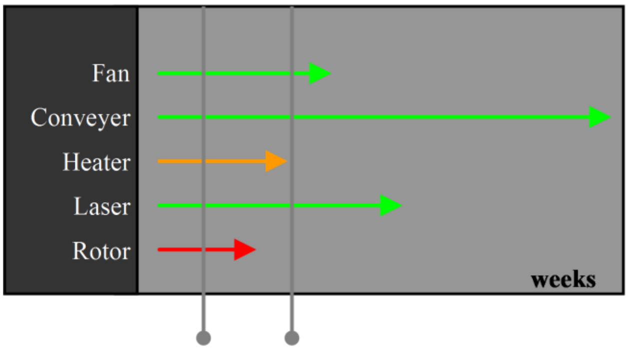


Figure 7: Replacement Decision Support

Replacing a machine part means unnecessary costs to the manufacturing process. Replacing it too late may lead to the part failing and stopping the production process. Replacing the part too early means its useful lifetime is reduced and the total cost of owner ship increases. The optimum time of replacement is also influenced by the time it will take to replace the part. A fast exchange will minimise downtime. Other parts will also influence the decision. Several parts may be easier to replace together (e.g. the parts are in all the same physical place but access is difficult) whereas other parts may be replaced easily.

The prediction will present the operator with decision support as exemplified in Figure 7 where each part has a predicted remaining lifetime measured in months. The Rotor is about to need replacement, but the Fan can last a long time.

Choosing the left-hand time-line indicates that it would make sense to replace the Rotor in the coming month. However, it would not be cost effective to replace the fan, which has a remaining lifetime of 8 months. But the Heater is located next to the Rotor in the heart of the production unit and the Heater needs to be replaced in the coming two months. If the cost of the Heater is minor, it may be economically wiser to replace it at the same time as the Rotor.

The prediction will have certain margins of error. Assuming that the cost of downtime is significantly higher than the cost of the replaced components, it may be economically more attractive to postpone the replacement of the Rotor until the time indicated by the right-hand time line, which may even be a scheduled down-time. At this point it will be wise to replace the Rotor, the Heater, and the Fan all together. There is a calculated risk that the Rotor may fail before that time, but this must be balanced against the potential gains of delaying the down-time.

The Laser will be the next part needing replacement, but since it is a minor operation and a high-valued part, this part will be monitored individually for replacement.

Finally, replacing the Conveyer is a major task and it is not necessary to be concerned with this part at present.

The COMPOSITION IMMS will help the pilots to efficiently and effectively manage machine downtimes and failures based on the prediction of failures of critical components. Information such as levels and temperature of solvents, vibration of machines, etc., will be provided in the IMMS. Prediction of the Blower motors within the Heller Ovens are very important to BSL from a quality and cost perspective. Potential cost of a non-recoverable oven alarm (motor/blower failure) resulting in non-conforming product being scrapped is estimated as $60K

Two To-Be use cases have been identified for Predictive Maintenance in Section 8.

6.3 Scenario INTRA-3: Material management

This scenario relates to BSL and KLE pilots.

6.3.1 Background and challenges (As-Is)

BSL experience the following challenges in management of material flows in the manufacturing process:

- Inventory mismanagement (location, misplaced, quality, quantity, mislabelled, obsolescence)
- Are there clusters of components missing; find out if vendors are short-shipping deliveries
- Batch processing causing missing or misplaced batches
- Production stop due to delay of getting components from inventory to the Production Units (PU)
- Monitor the parts on the machine – when it runs low sends signal to tower – PB collects. Tower topped up by Material Handler
- Track expensive material from stores to product use
- Implement sensors onto BSLs most expensive components and track throughput factory using sensors

Last year, BSL recorded $900k worth of scrap due to missing or damaged material. The causes of this loss are many, but mostly known.

The number of components delivered on reels is not always in conformity with the nominal specs; mostly there are fewer components than what is indicated and paid for. Components are also lost or damaged during reels' replacement, or simply misplaced during set-up.

Delays in bringing components from inventory to the Production Units (PU) occur because components suddenly run out or the inventory staff is not readily at hand or busy. This causes the production to stop until the needed components are present. Work in progress downstream is then stored; waiting for the process to continue.

Batch processing in e.g. cleaning or burn-in requires operators to assemble products in batches (in baskets or trays). Sometimes some of these baskets or trays get misplaced or moved to other positions in the plant without a record.

Many of these scenarios can be described as 'physical security' issues in the context that material, devices, fixtures, baskets etc. that are subject to undergoing movement are lost, misplaced, wasted through mis-feeds, miscounted, short shipped, etc. Apart from the direct financial impact (value of the material/asset) there are other significant indirect financial impacts due to machines unexpectedly being short of components, test fixtures going missing and disrupting production, etc. The use of ICT to track such assets can help reduce many of such misplacements and can also potentially narrow down the time and location where anomalies arise creating a greater level of vigilance amongst operators.

6.3.2 COMPOSITION Material Management Scenario (To-Be)

Improved material management is obtained by having the COMPOSITION IIMS keeping track of various aspects of the material flow through the factory, analysing the flow and presenting the results for operators on real-time dashboard and in the form of periodic or on-demand reports. This is shown in Figure 8.

An Input/output analysis is performed on selected (high-value) components. The IIMS collects data on the usage of the components from the MES and compares it to the inventory pulls of the same components extracted from the SAP. The Input/output analysis will compensate from timing differences and may present the results over pre-defined periods such as weeks, months, and quarters or over batches or shifts, according to the availability and granularity of data. Intermediate data can also be shown on the Material Management Dashboard for real-time follow-up by operators.

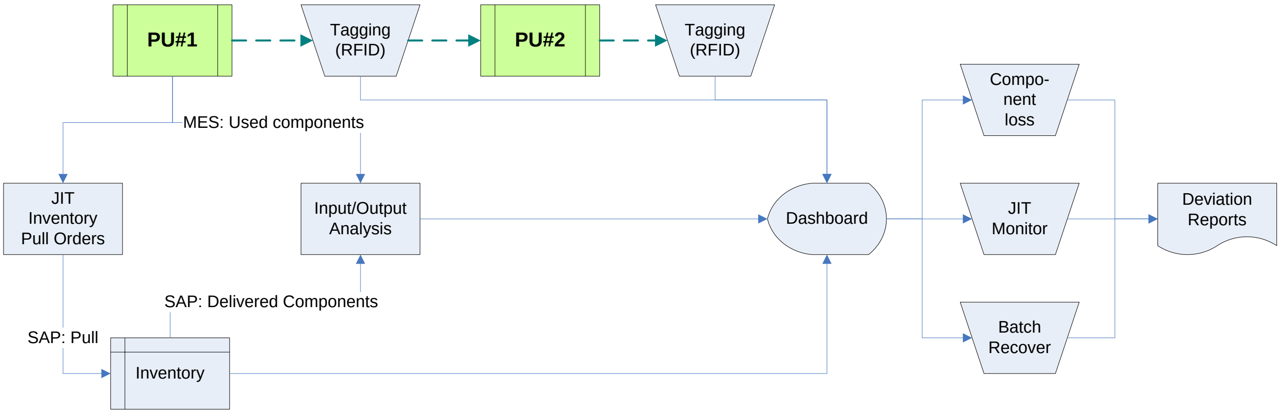


Figure 8: The COMPOSITION Material Management System

An internal JIT (Just-in-Time) system can be established by monitoring individual components in the Input/output analysis and predict when changes in reels are needed. The JIT Inventory Pull system can then issue future pull orders hours before the reels need to be replaced thus allowing the material handlers to better plan inventory pulls to the PUs.

Moreover, a Batch Tracking System will be created where operators can tag each tray or reel with products in process when they are manually transferred from one PU to another. The IIMS records the previous and next PU, the batch numbers, and other data pertinent to the products in process. The tagging allows operators, material handlers, supervisors, and others to immediately identify batches found in the production halls and bring them to the appropriate place. Using long range communication technologies, it may also be possible to query the location of a missing batch. The data can be shown to users on the Material Management Dashboard.

The Material Management Dashboard is the key interface between operators and the IIMS. Information from the various subsystems is shown here and the operator can dig into the information and obtain further details as necessary for decision support. Reports with statistical information can be extracted on a regular basis or on demand. These reports can be used to identify areas of improvements in either the process or the manual handling. It can also be used to show possible systemic deviations from specific Production Units or from specific sub-suppliers.

Finally, the following functionalities and procedures would simplify overall waste management tasks:

- Install open top containers on a permanent basis for the collection of various materials (wood, metal, plastics etc.). This will help keep the site cleaner and reduce storage space.
- Install sensors on the containers in order to get information of its filling level.
- Establish a filling threshold e.g., 75% and 90%, for each container and generate a signal that the container is almost full and should be emptied within 24 hours.
- The signal activates the Logistics Department, which arranges for the substitution of the full container with an empty one.

6.4 Scenario INTRA-4: Automatic data conversion

This scenario relates to the BSL pilot.

6.4.1 Background and challenges (As-Is)

Currently during Solder Paste Inspection (SPI) if a Solder Paste Deposit (SPD) on a Printed Circuit Board (PCB) fails for Under Volume (UV) the machine instructs the PB (Product Builder) on what pad has failed. The PB will then add solder paste to the pad and the PCB will be re-inspected. This process continues until the SPI gives a passing result (see Figure 9).

6.4.2 COMPOSITION Automatic Data Conversion Scenario (To-Be)

The future line should operate as follows:

The rejected PCB will be re-directed to the Dispense system. The dispense system will then automatically dispense the correct amount of paste onto the relevant pad location

The problem at this current moment is that the SPI and Dispense machines do not communicate to each other. The SPI does export an XML file. However, the Dispense system is not configured to receive this file

COMPOSITION should create an intermediate step between both machines for automatic data conversion. A system that can take the XML, convert it to the right program and able to tell the dispense machine what Pad to top up.

The dispense input file will be decided by the Dispense vendor.

Figure 9 below illustrates the process today (As-Is) and the envision future with COMPOSITION (To-Be).

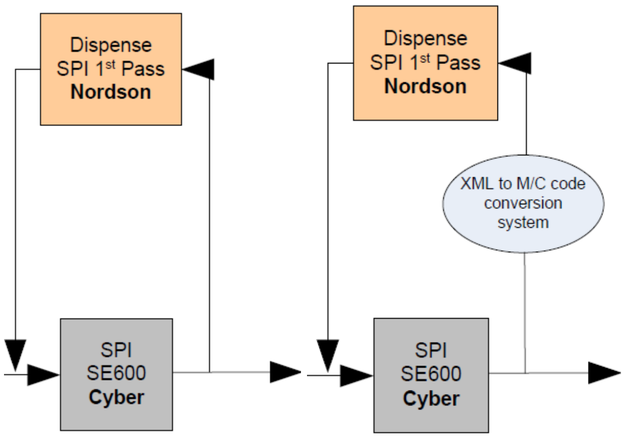


Figure 9: Automatic Data Conversion As-Is (left) vs. To-Be (right)

7 INTRA-Factory-1 Use Cases: Non-Conformance Monitoring

Based on the scenario: INTRA-1: Non-Conformance Monitoring, 1 use case was developed. It is presented here. The use case involves the BSL pilot:

- UC-BSL-1 NC Monitoring

The following actors involved in the use cases have been identified:

- Process Technician (BSL): The purpose of the Process Technician is to keep equipment running at all times. Another function is to maintain and calibrate equipment and ensure that spares are on hand at all times. These people are also involved in process improvements and ensure metric target such as yields and UPH are achieved
- Area Supervisor (BSL): The purpose of the Area Supervisor is that they are the 1st point of contact for all PBs on the production floor. They are responsible for the area for ensuring that the committed build plan for the month is achieved.
- Material Review Board (MRB) Staff (BSL): Investigates the NC in more detail.
- Product Builder (BSL): Responsible for keeping the product flowing.
- Quality Technician (BSL): Acts as 1st point of call for NCs and makes decisions on how to proceed.
- Visualisation Screen (BSL): Displays an overview of the status of the production line or factory.

7.1 UC-BSL-1 NC Monitoring

Table 2: UC-BSL-1 NC Monitoring

ID	**UC-BSL-1**	
Name	**NC Monitoring**	
Actors	• Product Builder: • Quality Technician • Process Technician • Area Supervisor • MRB Staff • Visualisation Screen	
Actor goals	The goal of the Product Builder, Quality Technician, Process Technician, Area Supervisor and MRB Staff is to become aware of NCs as soon as they are detected and to have easy access to all relevant information on the NCs. The goal of the Visualisation Screen is to alert other actors in case of a NC and display all relevant information on the NC in a structured way.	
Pre-conditions	NCs occur when the inspection systems in the line deliver a file that states that the product is in NC	
Trigger	A product is rejected from a station.	
Post-conditions success	NC is available in the Visualisation Screen	
Post-conditions fail	NC is not available in the Visualisation Screen	
Description	**Step**	**Action**

	1	If a product gets rejected from the station an alert is shown on the Visualisation Screen
	2	The system takes picture of the defect
	3	A notification is sent to Quality Technician, Process Technician, and Area Supervisor – The XML file from the machine will contain the defect information
	4	The Product Builder or Quality Technician puts the product into NC.
	5	The NC is available on the Visualisation Screen.
	6	The product then moves to the MRB storage
	7	The MRB Staff will make decision on Pass or Scrap
	8	The NC information on the Visualisation Screen is updated to reflect the MRB decision.
Extensions	**Step**	**Branching Action**
		n/a
Sub variations	**Step**	**Branching Action**
		n/a

8 INTRA-Factory-2 Use Cases: Predictive Maintenance

Based on the scenario: INTRA-Factory-2: Predictive Maintenance, 2 use cases were developed. They are presented here. The use cases involve the BSL and KLE pilot:

- UC-BSL-2 Predictive Maintenance
- UC-KLE-1 Maintenance decision support.

The following actors involved in the UC-BSL-2 use case have been identified:

- Process Technician (BSL): The purpose of the Process Technician is to keep equipment running at all times. Another function is to maintain and calibrate equipment and ensure that spares are on hand at all times. These people are also involved in process improvements and ensure metric target such as yields and UPH are achieved
- Technician (electrical, electronic, mechanical, and hydraulic), (KLE): A technician works in the maintenance department of KLE. The technician receives the work orders for preventive maintenance from the previous day from the maintenance planner. When an unexpected failure/breakdown occurs, the technician receives the work order during the day (reactive maintenance). A technician’s task is to perform maintenance either predictive or reactive where and when needed.
- Technician supervisor (BSL): The purpose of the Technician supervisor is to ensure that the technicians are clear on their roles and responsibilities and ensuring machine uptime is as high as possible
- Maintenance planner (KLE): The maintenance planner is responsible for the management of CMMS (data input, updating and planning) and for the maintenance programming (work orders, keep record of maintenance special forms, warehouse, safety stock). S/he completes all daily maintenance requests and reports and any unfinished work of the maintenance management. S/he is also responsible for all maintenance supplies. Most importantly, s/he gives feedback to the maintenance manager.
- Maintenance manager (KLE): The maintenance manager is responsible for managing the maintenance department.
- Visualisation Screen (BSL): Displays an overview of the status of the production line or factory.

8.1 UC-BSL-2 Predictive Maintenance

Table 3: UC-BSL-2 Predictive Maintenance

ID	**UC-BSL-2**
Name	**Maintenance Monitoring**
Actors	• Process Technician • Visualisation Screen • Technician Supervisor
Actor goals	The Process Technician’s and Technician Supervisor’s goal is to have access to fan performance data and to be notified of impending fan failure. The goal of the visualisation screen is to display fan performance data as well as an alarm when this data reaches levels which indicate impending fan failure.
Pre-conditions	Fan parameters such as noise and current change as it reaches the end of its lifetime.

Trigger	A sensor shows that noise/ampere etc. has increased in the motor	
Post-conditions success	The fan is changed or planned to be changed	
Post-conditions fail	The fan is not replaced and not planned to be replaced	
Description	**Step**	**Action**
	1	The fan parameter measurements are displayed on the factory Visualisation Screen
	2	The parameters are compared against pre-set limits
	3	If the limits are exceeded an alarm about exceeded fan limits is displayed on the Visualisation Screen
	4	The Process Technician and Technician Supervisor are notified
	5	The Process Technician decides with the rest of the team whether to change the fan at this point or to change it later
	6	Once changed the Process Technician resets the alarm and system continues monitoring
Extensions	**Step**	**Branching Action**
		n/a
Sub variations	**Step**	**Branching Action**
		n/a

8.2 UC-KLE-1 Maintenance Decision Support

The following actors involved in the UC-KLE-1 use case have been identified:

- Process Technician (BSL): The purpose of the Process Technician is to keep equipment running at all times. Another function is to maintain and calibrate equipment and ensure that spares are on hand at all times. These people are also involved in process improvements and ensure metric target such as yields and UPH are achieved
- Area Supervisor (BSL): The purpose of the Area Supervisor is that they are the 1st point of contact for all PBs on the production floor. They are responsible for the area for ensuring that the committed build plan for the month is achieved.
- Technician (electrical, electronic, mechanical, and hydraulic), (KLE): A technician works in the maintenance department of KLE. The technician receives the work orders for preventive maintenance from the previous day from the maintenance planner. When an unexpected failure/breakdown occurs, the technician receives the work order during the day (reactive maintenance). A technician’s task is to perform maintenance either predictive or reactive where and when needed.
- Technician supervisor (BSL): The purpose of the Technician supervisor is to ensure that the technicians are clear on their roles and responsibilities and ensuring machine uptime is as high as possible
- Maintenance planner (KLE): The maintenance planner is responsible for the management of CMMS (data input, updating and planning) and for the maintenance programming (work orders, keep record of maintenance special forms, warehouse, safety stock). S/he completes all daily maintenance requests and reports and any unfinished work of the maintenance management. S/he is also responsible for all maintenance supplies. Most importantly, s/he gives feedback to the maintenance manager.

- Maintenance manager (KLE): The maintenance manager is responsible for managing the maintenance department.

Table 4: UC-KLE-1 Maintenance Decision Support

ID	**UC-KLE-1**	
Name	**Maintenance Decision Support**	
Diagrams	Two models of the above use case have been visualised (model A and B) in Figure 11 and Figure 12 below.	
Actors	• Technician (electrical, electronic, mechanical, and hydraulic), KLE. • Maintenance planner (KLE) • Maintenance manager (KLE): The maintenance manager is responsible for managing the maintenance department. • BMS (NXW)	
Actor goals	The goal of all actors is to optimize maintenance services and procedures. More specifically the goal of the: • Technician is to reduce machine failures/breakdowns. The technician receives work order for fixing the machines. • BMS system is to collect data from the machine continuously, and sends them to COMPOSITION system • Maintenance planner is to minimize the required paperwork. • Maintenance manager is to get the best decision about maintenance based on COMPOSITION system's suggestions. Another goal is to reduce machine failures/breakdowns, costs, and the mean time to repair (MTTR).	
Pre-conditions	BMS collects and sends data to the COMPOSITION system continuously. COMPOSITION system needs historical data to perform analysis.	
Trigger	COMPOSITION system performs analysis in both data coming from BMS as well as in historical data in a periodic manner. When the result of this analysis diverges from a pre-defined threshold, the process of suggesting proper actions for maintenance to the Maintenance Manager as well as the Maintenance Planner is triggered.	
Post-conditions success	COMPOSITION system is to identify/forecast problems in the machines and then to inform the Maintenance Manager by also making proper suggestions about machine maintenance and work order for fixing the machines. • Maintenance manager and maintenance planner are properly notified. • The COMPOSITION system suggests proper corrective actions. • All maintenance services are automated. • Production lines will minimize downtimes.	
Post-conditions fail	• Wrong suggestions provided by the system. Wrong data are stored in IIMS, due to sensors' failure. • Late or early notification of maintenance manager and maintenance planner. • The notification for maintenance is not delivered.	
Description	**Step**	**Action**
	1	The status of machines is monitored by the BMS. COMPOSITION system retrieves data from the BMS continuously.
	2	COMPOSITION system stores information about machines
	3	Analysis is performed by the COMPOSITION system using machine learning techniques applied on both real-time data coming from sensors as well as on historical data.

	4	COMPOSITION system makes suggestions for machine maintenance based on the results of the analysis.
	5	COMPOSITION system sends notifications to maintenance manager and maintenance planner.
	Step	**Extension Action**
	1	The status of polishing machines is monitored by the BMS COMPOSITION system receives continuously real-time data from BMS about status of polishing
	2	COMPOSITION system stores information about polishing machines
	3	Analysis is performed by the COMPOSITION system using machine learning techniques applied on both real-time data coming from sensors as well as on historical data
	4	COMPOSITION system makes suggestions if a threshold of degradation is reached
	5	COMPOSITION system sends a notification to Maintenance Manager
	Step	**Branching Action**
		n/a
Sub variations	**Step**	**Branching Action**
		n/a

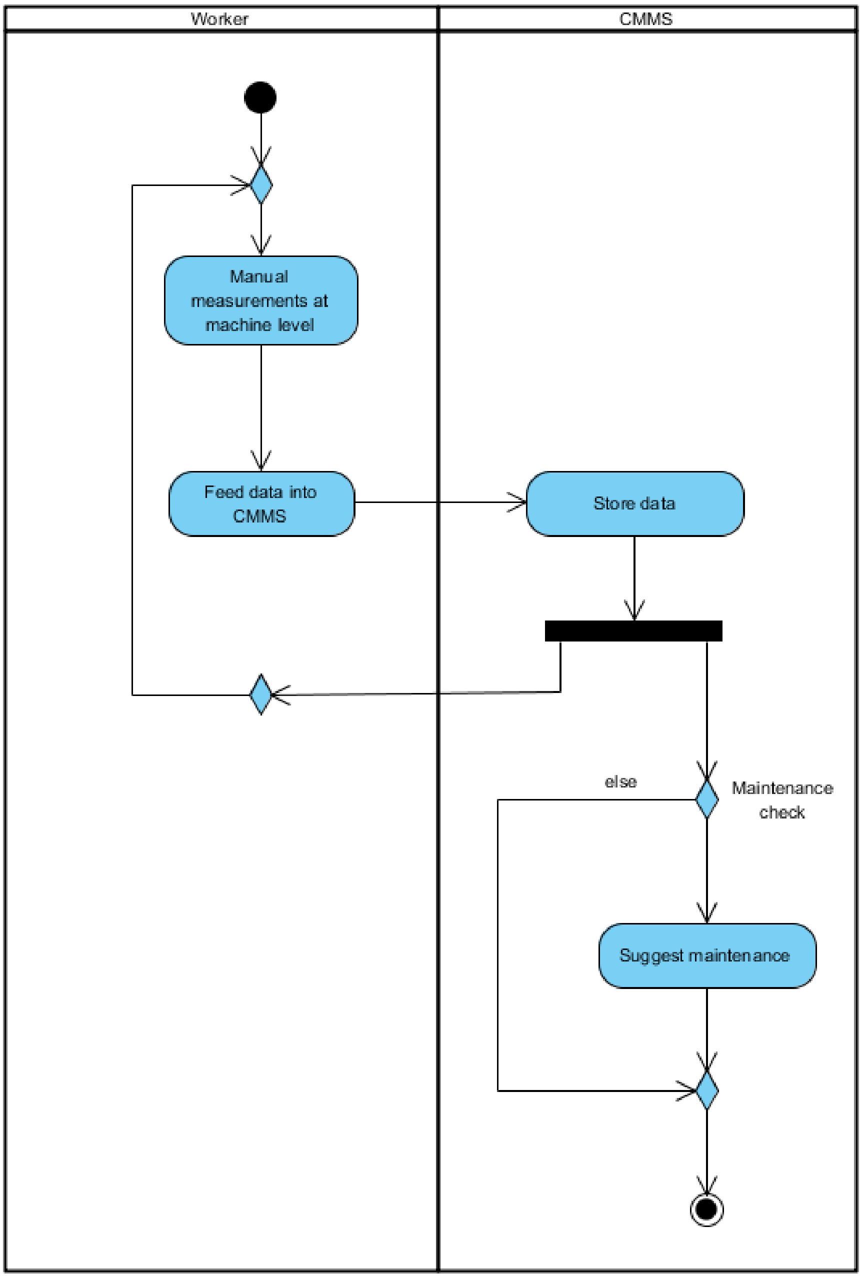


Figure 10: Maintenance Decision Support (As-Is)

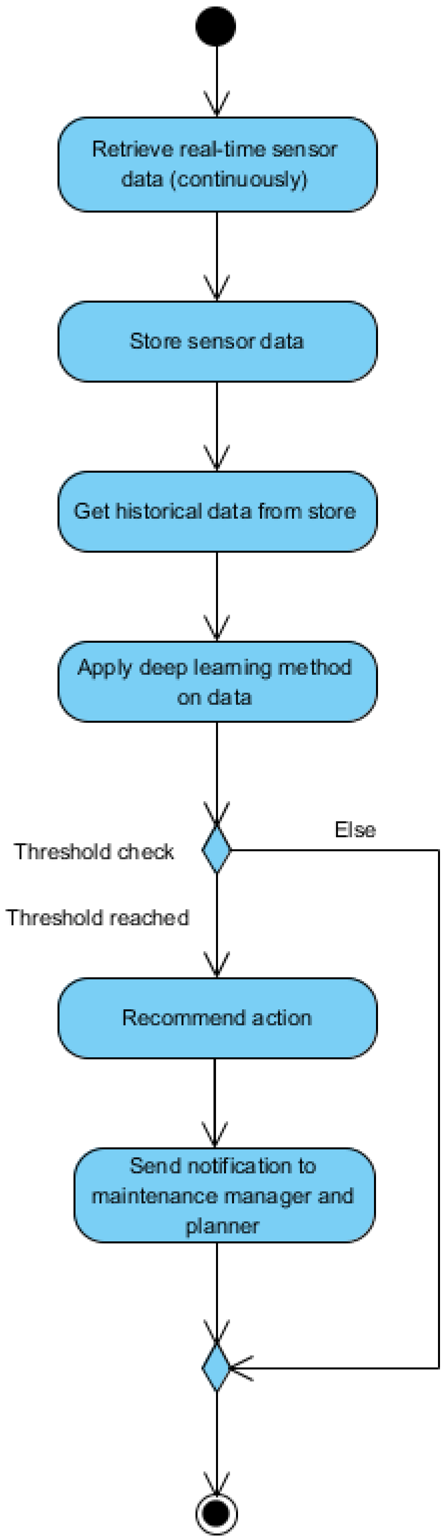


Figure 11: Maintenance Decision Support (To-Be) - Model A

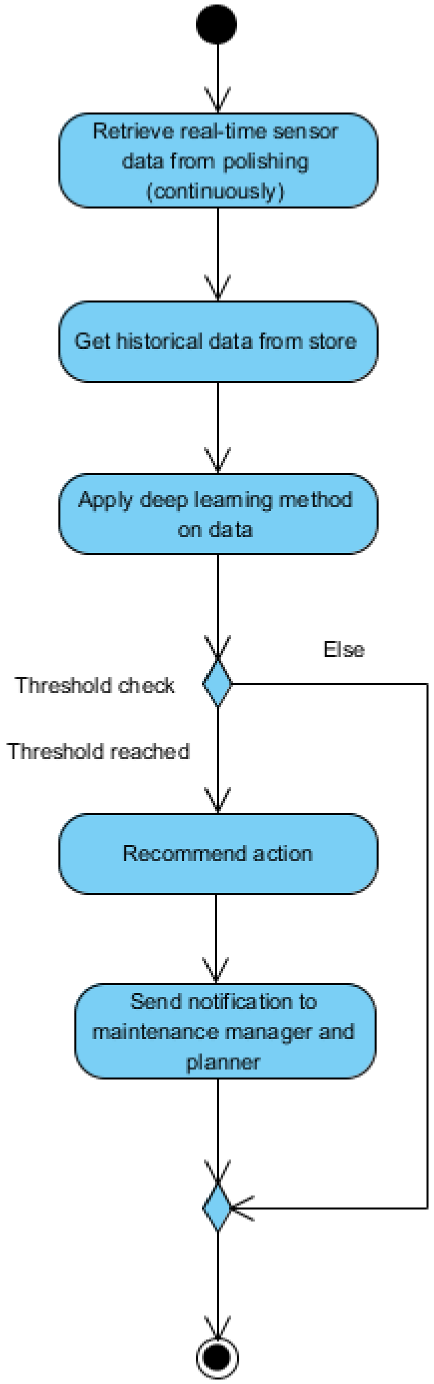


Figure 12: Maintenance Decision Support (To-Be) - Model B

9 INTRA-Factory-3 Use Cases: Material Management

Based on the scenario: INTRA-Factory-3: Material Management, 3 use cases were developed. They are presented here. The use cases involve the BSL and KLE pilot:

- UC-BSL-3 Component Tracking
- UC-KLE-2 Delayed process step
- UC-KLE-3: Scrap metal and recyclable waste transportation (from bins to container).

The following actors involved in the use cases have been identified:

- Visualisation Screen (BSL): Displays an overview of the status of the production line or factory.
- Production Manager (KLE): The production manager is a human responsible for the management, supervision, and control of the production processes. His duties, among others, include 1) the planning and organisation of production schedules 2) the monitoring of product standards and 3) the reviewing of workers' performance. He also ensures that the production is cost effective and he decides what resources are required
- Worker (KLE): A Worker is an individual working in the maintenance department of KLE. He is responsible for the detection of fill levels of scrap metal and recyclable waste bins.

9.1 UC-BSL-3 Component Tracking

Table 5: UC-BSL-3 Component Tracking

ID	**UC-BSL-3**	
Name	**Component Tracking**	
Actors	• Visualisation Screen	
Actor goals	The goal of the Visualisation Screen is to display all components with their location.	
Pre-conditions	Components are delivered to the back door of BSL, are moved through the factory and are finally consumed by the Pick and Place machine on the production floor	
Trigger	An expensive component enters or moves within the factory.	
Post-conditions success	Components are tracked and a database is updated with the new data obtained from the tracking. All components should be visible on the Visualisation Screen.	
Post-conditions fail	Components could not be tracked and go missing. Database is not updated correctly. Components not visible on the Visualisation Screen.	
Description	**Step**	**Action**
	1	Sensors detect a component has entered the factory or moved within the factory.
	2	The sensors send component location data to the system.
	3	The system updates a database with the component location data and the time the data was obtained.
	4	The current component location data is visualised on the Visualisation Screen.
Extensions	**Step**	**Branching Action**

		n/a
Sub variations	**Step**	**Branching Action**
		n/a

9.2 UC-KLE-2 Delayed Process Step

Table 6: UC-KLE-2 Delayed Process Step

ID	**UC-KLE-2**	
Name	**Delayed process step (application in the piston roughing and polishing step)**	
Diagrams	See Figure 13 and Figure 14 below.	
Actors	• Production Manager • Sensor • Out-put-system (COMPOSITION)	
Actor goals	• Production Manager adjusts process to erase bottlenecks based on COMPOSITION system's suggestions	
Pre-conditions	COMPOSITION system needs production's historical data to perform forecasts for bottlenecks	
Trigger	Prediction for delayed process step leading to bottleneck	
Post-conditions success	• Production Manager is notified for possible bottlenecks • Adjustment of production process to erase bottlenecks	
Post-conditions fail	• Production Manager is not notified in time • False alarms for bottle necks • Wrong suggestions for erasing bottlenecks	
Description	**Step**	**Action**
	1	COMPOSITION retrieves continuously real-time data from sensors related to various production steps
	2	COMPOSITION analyses the data and forecasts bottlenecks
	3	COMPOSITION visualizes the problem
	4	COMPOSITION makes suggestions for erasing bottlenecks based on simulation
	5	COMPOSITION sends notification to Production Manager
	6	Production Manager adjusts production process to erase bottlenecks
Extensions	**Step**	**Branching Action**
		n/a
Sub variations	**Step**	**Branching Action**
		n/a

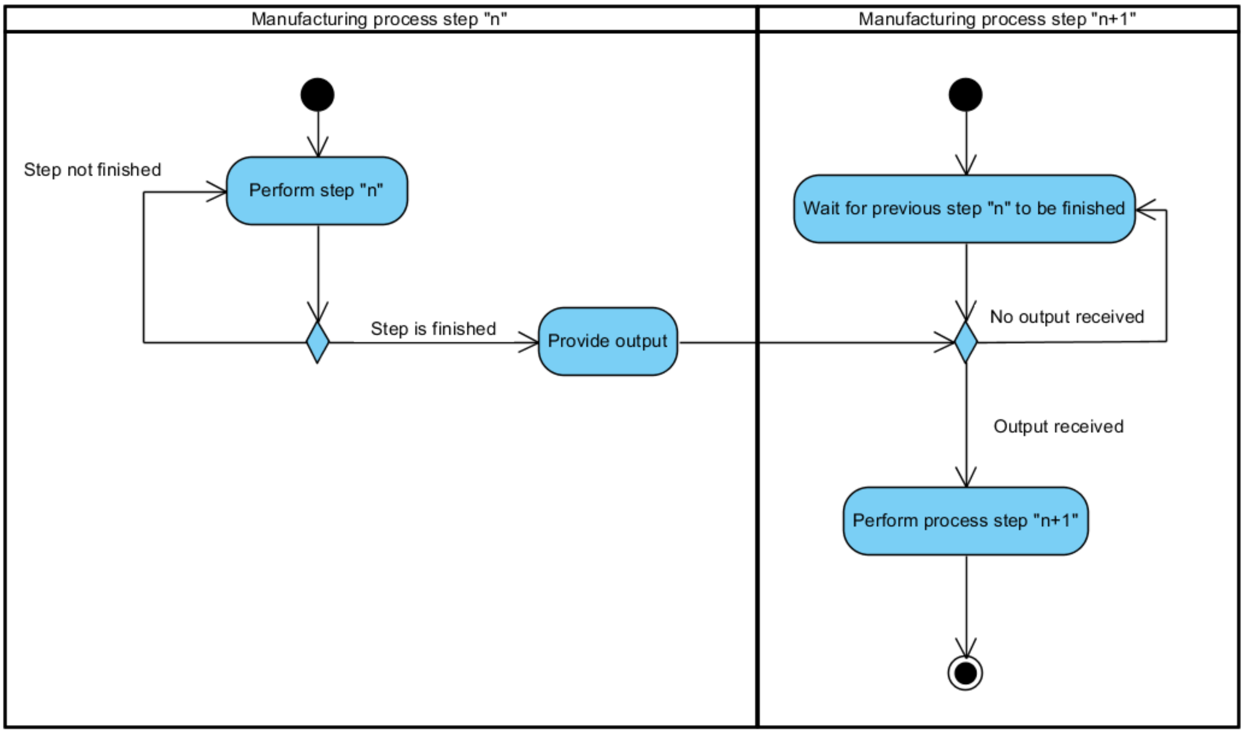


Figure 13: UC-KLE-2 Delayed process step (As-Is)

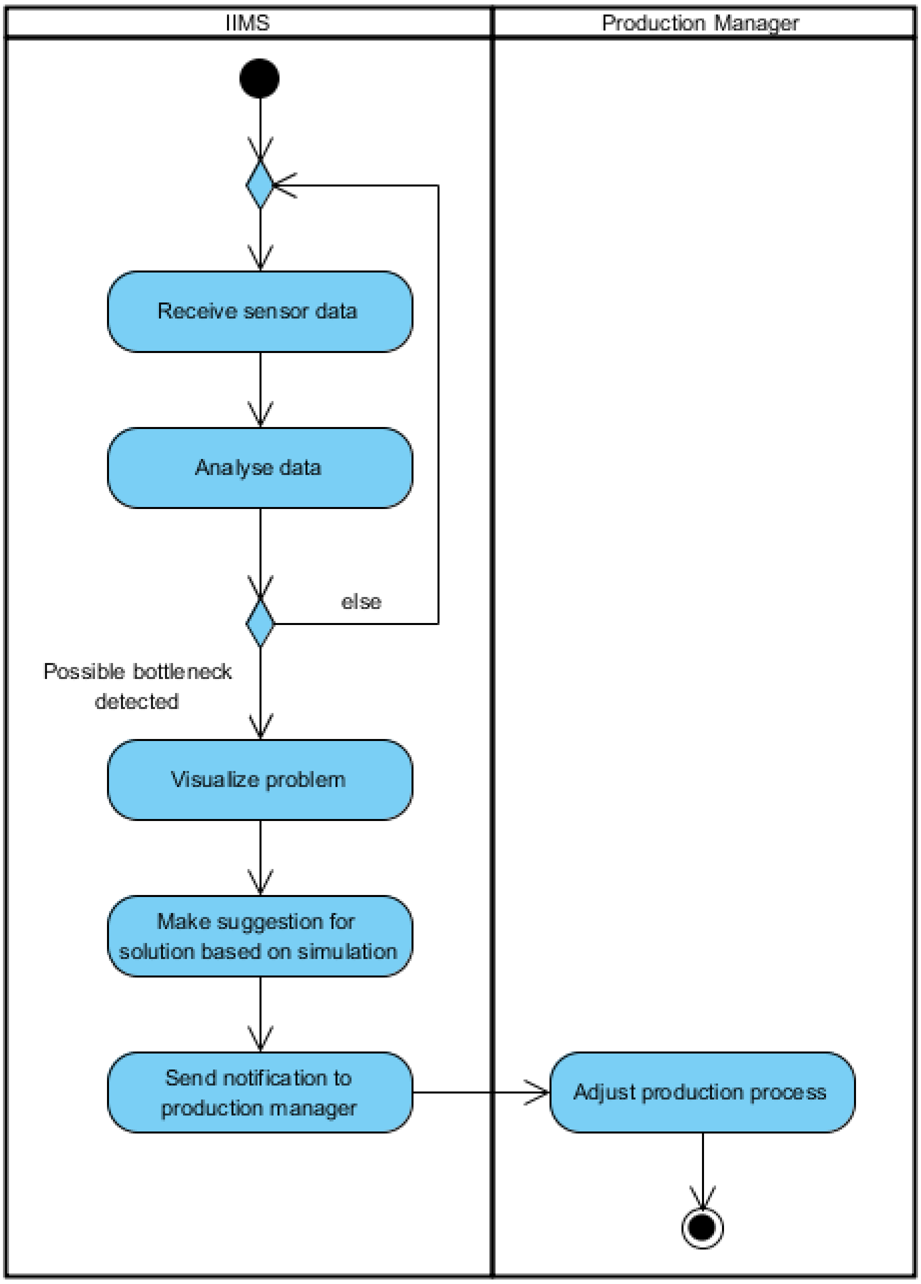


Figure 14: UC-KLE-2 Delayed process step (To-Be)

9.3 UC-KLE-3 Scrap Metal and Recyclable Waste Transportation (from Bins to Container)

In Kleemann, a worker from the maintenance department is responsible for the detection of fill levels of scrap metal and recyclable waste bins. Based on his experience, the worker estimates a specific time for pick-up of the bins and transportation to the container. The worker does not know the exact time the container is full. For example, he picks up scrap metal from piston cylinder plant every 3 days and transports it to the factory's open top container. The container might be full and then the worker will dispose the scrap metal in another place causing space problems. This procedure is not optimized, because orders do not have the same volume every day and different quantities of scrap are produced. This increases fuel consumption and sometimes traffic with other forklifts or trucks within the factory.

Table 7: UC-KLE-3 Scrap Metal and Recyclable Waste Transportation

<table>
<tr><th>ID</th><th colspan="2">UC-KLE-3</th></tr>
<tr><th>Name</th><th colspan="2">Scrap metal and recyclable waste transportation</th></tr>
<tr><td>Diagrams</td><td colspan="2">See Figure 15 and Figure 16 below.</td></tr>
<tr><td>Actors</td><td colspan="2">• Worker (KLE)</td></tr>
<tr><td>Actor goals</td><td colspan="2">Choose the best route (minimize total distance from bins to container)</td></tr>
<tr><td>Pre-conditions</td><td colspan="2">Scrap metal and recyclable waste is produced and filled into bins and containers.</td></tr>
<tr><td>Trigger</td><td colspan="2">Bin and container fill levels are over a set of predefined thresholds.</td></tr>
<tr><td>Post-conditions success</td><td colspan="2">• The worker is informed about fill levels of scrap metal and recyclable waste bins.
• The optimal route for collecting bins is proposed to the worker by the COMPOSITION system</td></tr>
<tr><td>Post-conditions fail</td><td colspan="2">• Fill levels of scrap metal and recyclable waste bins are not monitored correctly
• COMPOSITION system suggests routes that are not optimal</td></tr>
<tr><td rowspan="5">Description</td><td>Step</td><td>Action</td></tr>
<tr><td>1</td><td>COMPOSITION monitors fill levels of scrap metal and recyclable waste bins in a periodic manner and checks if they are over a set of predefined thresholds</td></tr>
<tr><td>2</td><td>COMPOSITION proposes the optimal route for collecting bins</td></tr>
<tr><td>3</td><td>Composition system informs worker to start collecting the bins by also visualising the optimal route to be followed</td></tr>
<tr><td>4</td><td>KLE worker empties bins based on COMPOSITION system's suggestions</td></tr>
<tr><td rowspan="2">Extensions</td><td>Step</td><td>Branching Action</td></tr>
<tr><td></td><td>n/a</td></tr>
<tr><td rowspan="2">Sub variations</td><td>Step</td><td>Branching Action</td></tr>
<tr><td></td><td>n/a</td></tr>
</table>

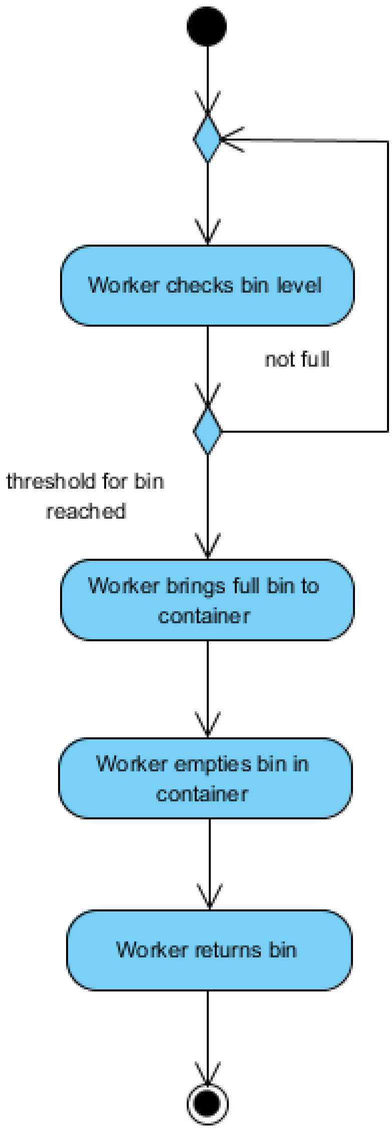


Figure 15: UC-KLE-3 Scrap metal and recyclable waste transportation (from bins to container) (As-Is)

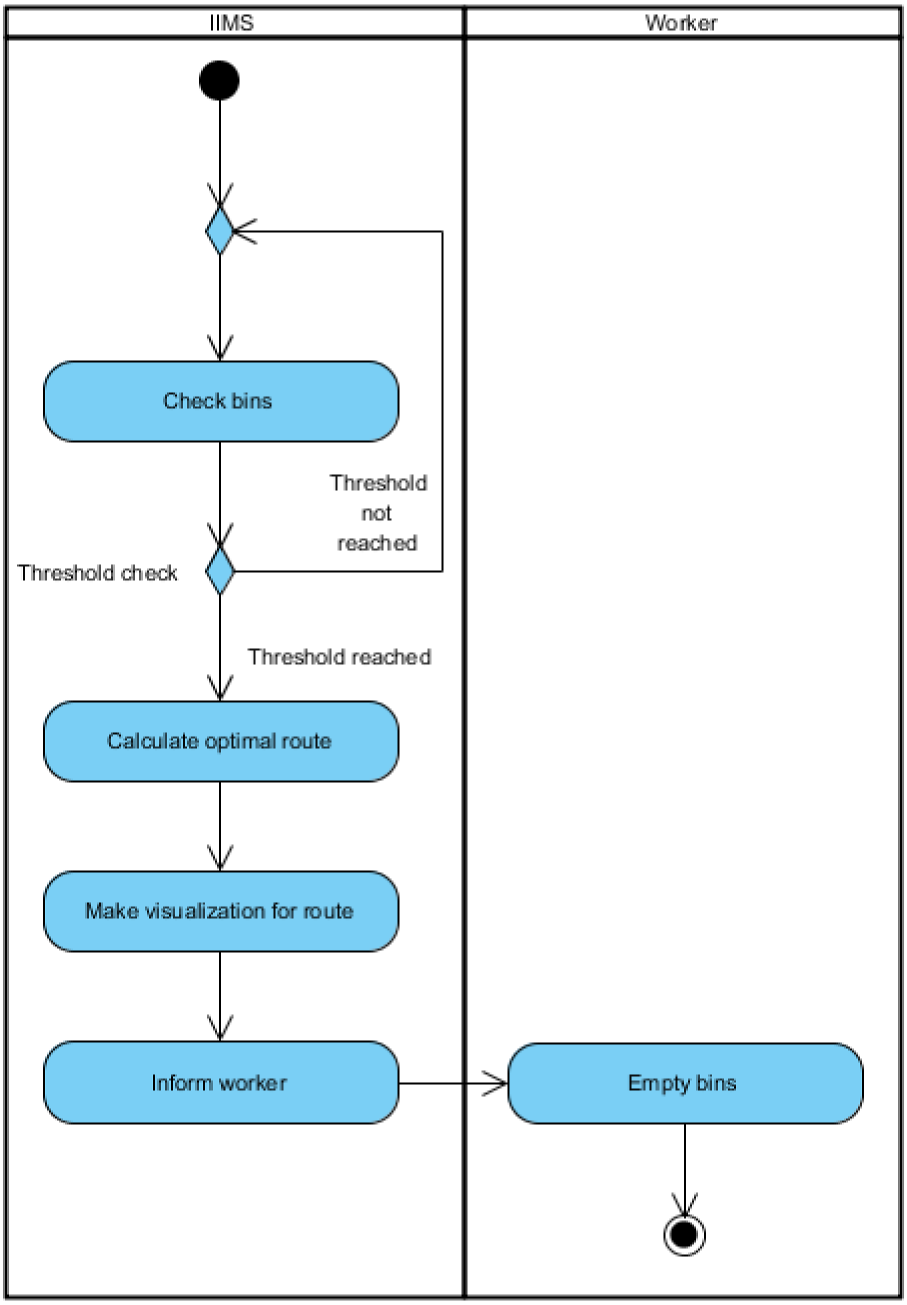


Figure 16: UC-KLE-3 Scrap metal and recyclable waste transportation (from bins to container) (To-Be)

10 INTRA-Factory-4 Use Case: Automatic Data Conversion

Based on the scenario: INTRA-Factory-4: Automatic Data Conversion, one use case related to the BSL pilot was developed:

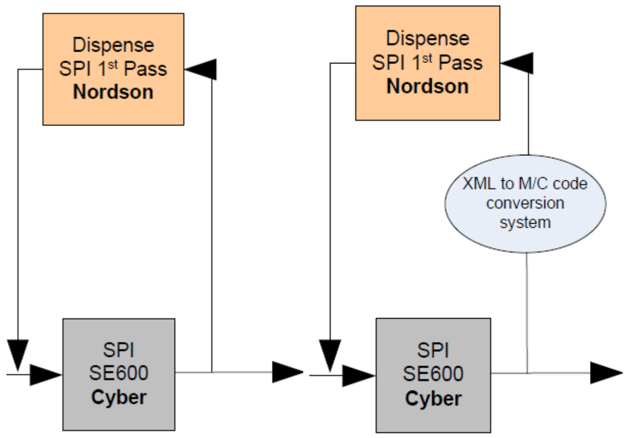
- UC-BSL-4 Automatic Solder Paste Touch Up.

The following actors are involved in the use case:

- Solder Paste Inspection (SPI) (BSL): Inspects solder paste on the PCBA.
- Dispense system (BSL): Dispenses solder paste onto specific locations (solder pads) on the PCBA.

10.1 UC-BSL-4 Automatic Solder Paste Touch Up

Table 8: UC-BSL-4 Automatic Solder Paste Touch Up

ID	**UC-BSL-4**
Name	**Automatic solder paste touch up**
Diagrams	 Figure 9 above.
Actors	• SPI • Dispense System
Actor goals	The goal of both actors is to reduce NCs using automatic solder paste -up. More specifically, the goal of the • SPI is to automatically send information about the solder paste volume on each pad to the dispense system. • Dispense System is to top up the correct solder pads using information received from the SPI
Pre-conditions	Solder paste failures occur on the SMT line because of printer defects.
Trigger	The SPI machine produces a failed product
Post-conditions success	The dispense system knows exactly what solder paste deposits fails for Under volume and dispenses the right material before going through SPI again
Post-conditions fail	The wrong information is sent for the SPI to dispense machine and tops up the wrong location on the PCBA
Description	Step | Action

	1	The SPI fails a PCBA for e.g. Circuit 1 Pad 2 on C3.
	2	The SPI directs the PCBA to the Dispense System
	3	The SPI al this time sends a signal and correct file to the Dispense System to tell that system what location needs additional solder paste
	4	The Dispense System tops up the particular pad and sends the PCBA back through SPI. This process continues until the SPI gives a passing result
Extensions	Step	Branching Action
		n/a
Sub variations	Step	Branching Action
		n/a

11 INTER-Factory Scenarios

As the manufacturing eco system grows in complexity involving a multitude of stakeholders in decentralized production and supply chains, the efficient use of technologies for product data management is vital. There is competitive advantage to be gained from sustainable manufacturing based on open and transparent supply chains.

The Inter-factory scenarios will demonstrate an ecosystem for enabling participating actors to exchange data (e.g., requests / offers) deemed as relevant for identified production needs. Involved parties will have the ability to (semi-) automatically enter a virtual, agent-based, marketplace where needs, captured by the factory IIMS and expressed through a shared, high-level, and machine-understandable format will be matched with offers, described in the same language. By mimicking real market exchanges, suitable trade-offs between needs with their relative constraints, and offers will be reached exploiting automatic negotiation, auctions, and controlled constraint relaxation / masking. An innovative log-oriented architecture will be demonstrated to promote trust and guarantee non-repudiation of data and transactions. Every party in the marketplace will be represented by a suitable software agent which will be able to both gather needs and constraints from the factory-side IIMS, and to interact with similar software entities in the COMPOSITION marketplace.

In dialogue with the pilot owners, the following five Inter-factory scenarios related to pilots KLE, ELDIA, ATL and NXW have been identified:

- Scenario INTER-1: Scrap Metal Management
- Scenario INTER-2: Recyclable material Management
- Scenario INTER-3: Supply Chain Management
- Scenario INTER-4: Software Distribution
- Scenario INTER-5: System connection over marketplace.

The main focus areas for the Inter-factory scenarios and use cases include: metal scrap handling, solid waste collection, supply chain management, and software purchase.

<u>Metal scrap handling</u>

When KLE approaches ELDIA with a quantity of scrap metal to dispose, ELDIA follows these steps:

- Find out what the approximate tonnage of the material for disposal is.
- Get a detailed description of the size of the scrap material.
- Determine the distance between KLE and ELDIA sites.
- Determine the means of collection and transportation of the material.
- Determine the marketability of the material at that time.
- Find out the price per ton as listed in the steel industry reports.

After collecting and evaluating the above-mentioned information, ELDIA then proposes to KLE either a price per ton of transportation and handling of the material, or a price per ton for the purchase of the material by ELDIA and at the same time the transportation and handling cost for KLE. The first method is the most common one in the Greek market right now. Following the order acknowledgment by KLE, ELDIA will then arrange for the collection and transportation of the material, follow up with the payment of KLE's invoice, and sell the material to the steel mill or steel trader with the better price.

<u>Solid waste collection</u>

ELDIA is currently collecting KLE's broken wooden pallets which cannot be reused. ELDIA has made an agreement with KLE based upon the assumption that the maximum load that could be transported is 70 cubic meters, which is the total capacity of 2 open top containers of 35 cubic meters each.

ELDIA has established a transportation cost for the service, and a processing fee for the wood shredding. Depending on the demand of the wood chips from the cement industry to be utilized as alternative source of energy, and the price set for the sale of the material, the processing fee ranges from €0 to €15 per ton.

The wooden pallets are being stacked up at KLE's property and when KLE collects 300-350 pallets, they notify ELDIA via phone and within 24 hours ELDIA arranges for a truck with grabble mechanism and two containers to go and pick them up. A weight ticket is issued at their truck scale and accompanies the load. The entire load returns to ELDIA premises, and the moving documents along with the weight ticket go to the Accounting Department to complete the billing process.

The wooden pallets are unloaded at a designated area and are shredded by special equipment. The process is completely different when it applies to other waste streams such as metal scrap and various plastics. The main reason is that these materials are loose and they cannot be stacked up properly. Therefore, the usage of an open top container for their collection is mandatory on a permanent basis.

The same process applies to the plastics collection.

Supply chain management

Supply chain management can be defined as *"the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole"* (Mentzer et al., 2001, p. 18).

In the case of KLE and ELDIA, the supply chain that is identified in the two previous paragraphs lacks the long-term performance both for each company and for the entire chain. This is due to the manual management (by phone) of all procedures and the absence of any real-time data that could be of use for optimizing the management of the supply chain. Lack of automation mainly impedes the data collection and analysis.

An example is shown in Figure 17 below to describe the supply chain flows between KLE and ELDIA. Scrap metal is produced from KLE plants (1). The most common procedure to dispose scrap metal is 2a, in which ELDIA purchases scrap metal from KLE and then sells it to a scrap metal supplier (3). 2a box produces 2a scrap metal flow and financial transaction. The less common procedure is 2b where ELDIA provides transportation services to KLE. In this case ELDIA is paid from KLE and transports scrap metal to a metal trader. Then the metal trader sells scrap to supplier and pays KLE (2c). 2b box produces 2b scrap metal flow. 2c box produces 2c financial transaction to box 1 and 2c scrap metal flow and financial transaction to box 3.

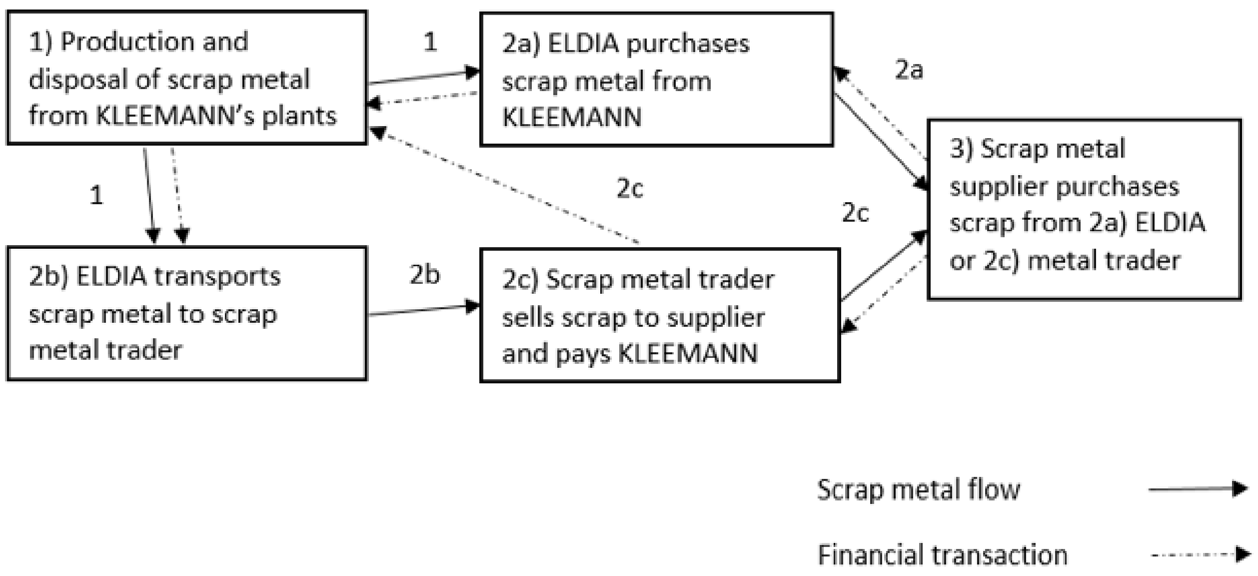


Figure 17: Supply chain flows between Kleemann and ELDIA

Software purchase

The COMPOSITION will provide an automatic way to offer software and consultancy through the ecosystem. For the project participant ATL and for other software providers that want to offer and sell their products throughout the IIMS, it is a great opportunity to reduce the costs (communication and travel), as well as the invested time of the sales department to find new customers. Even with highly experienced sales department, there are difficulties in reaching agreements with new potential clients. Thus, using COMPOSITION, savings of high importance will be achieved for the company, further development and maintenance of the competitive level can be attained.

The details regarding ATL's software and services are presented in details in chapter 15 INTER-Factory-4 Use Cases: Software Distribution. In praxis, this AS-IS cases can be described as follows.

The main challenge when ATL (or any other software provider) wants to sell software products or even consulting services, is that the sales department spends a lot of time to find new potential clients doing it manually, looking throughout companies' advertising campaigns, different companies' websites, and their products, in order to spot the ones that need this kind of software/constancy. The clients may need to be contacted many times repeatedly by phone or mail, until they establish an agreement and sign a contract.

Furthermore, an issue that customers face when they are trying to look for a solution is that they might do not know exactly how to find one, how to get the details they need and how to handle the information available from solution providers. This can push them to make an agreement with the well-known solution provider, even though there are other equally, or more, suitable solutions available. Moreover, they seek for recommendations through their already established channels, thus limiting the possibilities to finding alternative suppliers. They do not have access to a broader base of evaluators of collaborations and results of certain providers.

The scenarios and the accompanying use cases that have been developed are described in the following sections.

11.1 Scenario INTER-1: Scrap Metal Management

This scenario is related to the KLE pilot.

11.1.1 Background and challenges (As-Is)

A scrap metal collection team of KLE manually monitors the level of scrap metal bins in all factories every day. When bins are full, the worker responsible for waste management transports the scrap metal from bins to an open top container. Then he informs the maintenance manager, who then collects offers from scrap metal recycling companies that have official state license from a pre-defined list that is annually updated. The maintenance manager consults the purchasing manager and together they identify the offers and select the best one based on price and health and safety issues (regarding the way of collection). The next step is to inform the selected company and arrange a pick-up date. The whole procedure is made by phone which is inefficient and expensive.

Early and automated detection of scrap metal bin levels is very important. Scrap metal is profitable for KLE. In 2014, 705.25 tons of iron scrap (sheet metal) was sold to scrap metal companies with a cash value of € 126.623,45. The total costs are mainly related to time spent on phone calls and delays due to late detection. Costs are also related to inefficient routes within the factories during the detection procedure.

The key challenge KLE needs to face here is to record what is unknown until now and optimize, through statistical analysis, the scrap metal management procedures. The unknown variables that will be useful for analysis through the COMPOSITION IIMS are: level of scrap metal bins, weight, height, scrap metal price (obtain historical data), duration of the whole procedure, average distance of scrap metal companies' tracks.

The first step in the bidding process deals with identifying the specifications of the scrap metal. KLE develops the specifications for the bidding process and is then looking for bids. All the scrap metal details are outlined in the documentation that includes reports regarding the quantity and types of scrap . After the details of the scrap metal have been developed, KLE requests for bids. This involves sending out invitations to bid on scrap metal and calling contractors to notify them for the opportunity. In some cases, KLE requests bids from a pre-selected list of contractors. In other situations, KLE looks for other contractors to find better offers. In the next step, KLE sets a deadline to the contractors on when the last bids will be accepted. Once that deadline is reached, KLE begins reviewing the bids. The length of time that it takes to review the bids could vary depending on the number of bids received. After the bids, have been thoroughly reviewed, KLE awards the contract to one bidder. In all cases, the bidder with the highest bid wins. The three criterions to award the contract are price, health, and safety.

11.1.2 COMPOSITION Scrap Metal Management scenario (To-Be)

Early and automated detection of scrap metal levels will be achieved via interaction with the COMPOSITION IIMS. Whenever a desired level (50%, 75% or 90%) is detected by the bin sensors, it will be reported and recorded in the IIMS automatically. The system will automatically collect and compare data about the current amount of scrap per bin in each factory. Scrap metal recycling companies will put their offers to the system. Selected and rejected companies will be notified automatically about the final decision. KLE arranges a pick-up date and time in agreement with the selected scrap metal recycling company.

Getting accurate information about the bin levels during the day will now be possible and KLE will stop sending staff out to manually detect scrap metal levels at each bin. Real time data will help optimize scrap metal management procedures.

The system will automatically collect and compare data about the current amount of scrap per bin in each factory. Scrap metal recycling companies will be contacted automatically by the COMPOSITION system, or they will receive continuous information on the current scrap metal level. In response to such an interaction, they will put their offers to the system. Selected and rejected companies will be automatically notified about the final decision. KLE will then arrange a pick-up date and time in agreement with the selected scrap metal recycling company; such an arrangement will be automatized as much as possible.

The COMPOSITION system will automatize many of the steps in the As-Is scenario above. Once identified the scrap metal specification and set-up the bidding specifications, KLE inserts the bid details in the COMPOSITION system. The system registers the new bid request and contacts the waste management companies for getting bids on scrap metal. Companies contacted by the system typically belong to a selected subset of contractors. However, in some cases the bid could be open, e.g. to find better offers. When the system contacts contractors for bidding, a deadline is provided on when the last bid will be accepted. Once the deadline is reached the COMPOSITION system will select the best (or n-best) offer according to the bidding process criteria (entered when the process started) and present it to the relevant manager (this automation will reduce the time required for processing bids by an order of magnitude or more). Upon human approval, bidders will be informed about the outcomes of their bids. The three criterions to award the contract will still be price, health and safety.

11.2 Scenario INTER-2: Recyclable materials management

This scenario is related to the ELDIA pilot.

11.2.1 Background and challenges (As-Is)

The challenge of the Recyclable Materials scenario is to demonstrate techniques for reducing handling time of metal, wood, and plastics waste in order to avoid materials taking up storage space, hindering material circulation and increasing the costs of handling. A further aim is to improve procedures with collaborators for the actual recycling of the material in order to reduce storage space.

The process of handling recyclable waste materials is complicated and depends on many factors affecting the entire service. Hence, there are many telephone calls between ELDIA and KLE and many different people at different departments are involved. A priori, the pilot users KLE and ELDIA have highlighted the following challenges to be overcome by deploying the COMPOSITION platform:

- Control of the volume of recyclable materials from the production (mass, weight, material, etc.) is weak
- Sensors are needed to accurately measure the filling levels of recycling containers
- Collaboration between actors in the process of managing waste could be improved
- Recycling Materials Procedures lacks automation
- Reduction of man-hour cost for handling waste are required
- Better prices for non-hazardous waste materials should be possible
- Reduction of overall costs of disposal for hazardous material should be achieved.

11.2.2 COMPOSITION Recycle Material Management Scenario (To-Be)

The scenario will demonstrate how the COMPOSITION System will optimise existing logistics processes in the management of solid waste.

The scenario is based on the following functionalities and procedures, which will simplify the overall waste management task for all actors involved:

- By locating an available truck in the vicinity of the factory (through the GPS system), the substitution could take place with a minimum of delay.
- At the same time, the recycler contacts its network in order to get a price for the material in question.
- The generation of metal waste should be associated with future production plans, in order to forecast the approximate amount of waste at certain points in the future.
- With this information, the recycler can contact its network in order to sell the material before it leaves the factory.
- The accounting department automatically issues the transportation manifests including the category of material, weight, etc. and simultaneously notifies the recycler's logistics and accounting departments of the future transport.

11.3 Scenario INTER-3: Supply chain management

This scenario relates to the KLE pilot.

11.3.1 Background and challenges (As-Is)

Over the past years, one of the most important problems regarding the management of supply chains is the connection of supply chain data and services among all supply chain members so that it can meaningfully support decision-making. Even though KLE uses an advanced ERP, the company experiences a difficulty regarding the time spent in the whole purchasing procedure. The purchasing department contacts suppliers (existing or potential) to receive offers by phone or e-mail. This is cost consuming in human resources, time, and communication. The digital automation of all the required data through the COMPOSITION system will optimize the supply chain processes and will ultimately increase productivity. It will also provide the opportunity for other new suppliers to actively interact with other members of the supply chain by providing services to improve cycle time, cost, flexibility, or resource usage.

11.3.2 COMPOSITION Supply Chain Management Scenario (To-Be)

Currently, the coordination chain is interrupted. Interaction is needed with suppliers' warehouse and service availability. Information required for, e.g. follow up of production, number and lot sizes, cost-effectiveness, and maintenance, will be provided for fast and easy mapping, follow up, deeper analysis and decision making.

The IIMS Decision Support System will dynamically assess all data and suggest alternative scenarios which will allow for optimal solutions to e.g. optimum and synchronized spare parts levels in the warehouses of multiple production sites (DoA).

KLE's purchasing department looks for raw material suppliers to buy black, stainless and/or galvanized steel. The purchasing department puts the order into the ERP and checks for suppliers that have availability of the requested product. The purchasing manager decides which supplier is the best, based on multiple criteria (see pre-conditions in UC-KLE-7 in section 14.1) and places the order by phone.

11.4 Scenario INTER-4: Software Distribution

This scenario relates to the ATL pilot.

11.4.1 Background and challenges (As-Is)

ATLS Engineering offers software, consulting and training products and services. As most software, SMEs, ATL attracts and keeps its clientele with the ability to offer not only a good solution from the software point of view, but also accompanying consulting services, customer support and customization. To achieve that, many resources need to be dedicated from the sales and customer support departments. The reputation of the company is being slowly built up with satisfied customers, suite of existing clients and mouth-to-mouth advertisement playing key roles.

Two in-house developed types of software solutions can be offered, the Computerized Maintenance Management System (AIMMS) and the Decision Support System (mainDSS). AIMMS can support every company strategy in a structured manner, addressing efficiently the most demanding maintenance department procedures as well as minimizing the required paperwork. Moreover, it is the tool to reliably collect all necessary information and data to support efficiency, productivity, and energy consumption reduction. Additionally, upon request, AIMMS can be extended with modules to receive automatically notifications and alarms from the shop floor, and in turn provide automatically all necessary information and data to the maintenance team. Other add-ons that can be offered are the work schedule automatic prioritization module or the connection to external systems that exist in a specific client (e.g. information from fleet management system). With the in-house mainDSS software that ATL offers to every company which wants to know its weaknesses and strengths and it offers the software to monitor its progress, to realize its position in the market with regards to asset management. mainDSS has been awarded a Eurostars and an SME Instrument project and has been thus recognized as an innovative software for the assessment of the performance of the maintenance department and for the support towards effective Asset Management. Another DSS can be considered, IamDSS, which accounts for Intelligent Asset Management Decision Support System, handling data from external systems to the maintenance department.

Even though ATL sales and consulting team members are of high expertise, they have a difficulty in reaching the agreement with new potential clients in the sense that sales department usually needs to repeatedly contact potential customers before they reach the agreement. It is cost consuming in human resources, communication and travel and it takes a lot of time and effort.

The goal using the COMPOSITION ecosystem is that ATL will be able to offer its software products in an automatic way. This means cost reduction, due to the less needed time and involvement of the sales department, to which the cost for communications and travel needed to be added. Moreover, the resources saved will be put to better use, as they can be redirected to customer support and pursue of new clients. This will allow the company to grow, to offer better services, to have more satisfied clients and to strengthen its position in the maintenance and asset management sector.

The involvement of ATL in the ecosystem would allow them to build a wide database of companies interested in asset management and, thus, potentially to the other products that they offer. Additionally, it is anticipated that the ecosystem will provide qualitative ranking and evaluation of suppliers and customers. A qualitative ranking will allow ATL to be competitive/comparable to big players (or even to reach their level) and not to be lost within the ecosystem, because of the SME size. The evaluation of the customers will provide information and ranking and it will facilitate decision making regarding which potential clients to pursue. Targeting and selecting potential future customers is a tedious task that requires commitment from the sales and marketing department. Having, via the ecosystem, information on companies that are already interested in the maintenance sector will be a valuable tool.

Finally, often when ATL wants to sell software products or consulting services, the sales department manually tries to find and contact potential customers before the sales department agrees on the contract with a customer**.**

11.4.2 COMPOSITION Software Distribution Scenario (To-Be)

In relation to the inter-factory use case, ATL can provide "maintenance", "asset management" and "spare part availability" software and/or services via the ecosystem. For maintenance, the product is a Computerised Maintenance Management System, CMMS, called AIMMS. The software as well as its updates can be provided, i.e. in annual maintenance contracts (software maintenance) or additional modules. Furthermore, via the ecosystem, mainDSS, software for Asset Management, can be offered. It analyses CMMS data and data from the ambient environment of the specific industry to derive recommendations for leveraging maintenance performance and physical asset management. It offers proposals/suggestions for ameliorating identified shortcomings.

In the same sense, ATL could provide consulting services for the organisation of the maintenance department or operation, customised for the production process used in a specific industry. They can do a requirement and environment analysis to propose a plan to attain certain targets, KPIs. The same goes for the Physical Asset Management, where the used tools and methodologies can be broader, including Total Productive Maintenance (TPM), EFQM models and any other procedure requested by the client.

11.5 Scenario INTER-5: System Connection to Marketplace

This scenario is related to the NXW and ATL pilots.

11.5.1 Background and challenges (As-Is)

Nextworks has recently started a business and technology line towards process and infrastructure automation for small/mid-size factories, the Symphony Building Management System. NXW intends to use its digital platform for smart residential environments towards factories, leveraging on a cloud-based and highly distributed system. The current Nextworks product for Building Management System (BMS) and Home Automation is a stand-alone service-oriented middleware that integrates many communications, demotics and entertainment subsystems into a unified IP-based platform. It can support company needs for on-field data gathering process, both from environment and machines, to support efficiency, productivity and energy consumption reduction as well. Additionally, BMS can be extended to allow the interfacing with already existing ERP systems, with modules to provide all necessary information and data for the monitoring automatically.

Current production line processes are handled by the historical knowledge gained from workers over the years, so they don't involve any external software support system, or are helped by any stored collection of data, gathered from the previous machine cycles. Moreover, the know-how related to these processes is not methodically analysed or formalized into specific procedures, but simply repeated basing on the worker experience.

At the moment ATL often wants to build a solution that interfaces external product. This leads to the development of interfaces to product and its integration into solution. This current (As-Is) status could be advanced greatly via the COMPOSITION ecosystem that can set and define its standards that will be followed by ATL when they build and develop a solution or a product. Furthermore, the COMPOSITION will be a good system for ATL to offer and advertise their development of solution

11.5.2 COMPOSITION System Connection to Marketplace Scenario (To-Be)

The scenario will demonstrate how the COMPOSITION System will support decision processes in the production line over the marketplace.

The scenario describes how a worker makes a decision during the execution of a process; something which was used to be done based on the worker's experience. The BMS (in combination with the ERP system) is in charge to continuously collect and store data, in order to make them available for analysis. The marketplace will allow the selection of the most suitable tool for that purpose, and so (after data processing) a decision can be suggested.

As a solution provider, ATLANTIS will build a solution that interfaces external system. This means that the solution will be developed and it will be built according to the COMPOSITION interfaces standards. This leads to the possibility of external products being exchanged by other products that have to meet COMPOSITION standards as well. Furthermore, this To-Be scenario can be extended with one more sub-variation step where a potential client/buyer of a solution asks via the ecosystem for the development of a COMPOSITION compatible solution (see UC-ATL/NXW-1 Integrate External Product into Own Solution for details)

12 INTER-Factory-1 Use Case: Scrap Metal Management

Three use cases have been developed based on the scenario INTER-1 Scrap Metal Management. The use cases are related to the KLE pilot. The last use case, UC-KLE-6, also involves ELDIA as an actor:

- UC-KLE-4 Scrap metal collection process
- UC-KLE-5 Scrap metal bidding process
- UC-KLE-6 Determining price for scrap metal with ELDIA acting as logistician.

The following actors are involved in one or more of the use cases:

- Worker (KLE): The Worker works at the maintenance department of KLE. Usually, he receives his tasks verbally once a day in the morning from the maintenance department manager. A worker's task is to check on the fill level of the scrap containers. He does this frequently every 2 hours. He is also responsible for the transportation of the scrap to the KLE's open top scrap metal containers.
- Waste management companies: Waste management companies are legal entities that provide industrial and hazardous waste services. Usually, the maintenance manager calls waste management companies, when scrap bins are full and gets an offer.
- Maintenance manager (KLE): The maintenance manager is responsible for managing the maintenance department. Currently, the maintenance manager receives offers for the scrap metal and consults the purchasing manager to select the best one. After the purchasing manager selects the best offer, the maintenance manager arranges the pick-up date.
- Purchasing manager (KLE): Purchasing manager works in the purchasing department. He is responsible for the final selection of the waste management company. He is also responsible for the raw material orders.
- Sales Manager (ELDIA): The Sales Manager is an individual in charge of receiving price information from the steel industry and steel dealers, and conveys the best offer to KLE, or other similar parties.
- Logistics manager (ELDIA): The Logistics Manager is an individual in charge of monitoring the truck routes according to the customers' orders.
- Driver (ELDIA): The Driver executes the orders given from the Logistics Department in order to service the customers' needs.
- Accounting Department (ELDIA): The Department responsible for handling all invoicing and payments.

12.1 Use Case: UC-KLE-4 Scrap metal collection process

Table 9: UC-KLE-4 UC-KLE-4 Scrap metal collection process

ID	**UC-KLE-4**
Name	**Scrap metal collection process**
Diagrams	See Figure 18 and Figure 19 below.
Actors	• Waste management companies - Scrap metal collectors • Scrap metal recycling companies • Maintenance manager (KLE) • Purchasing manager (KLE) • Sales Manager (ELDIA)
Actor goals	The goal of all actors is to optimize scrap metal collection process. More specifically the goal for the: • Waste management companies is to optimize the transportation for the scrap metal collection. • The maintenance manager and the purchasing manager get the

	best price and reduce costs at the minimum.	
Pre-conditions	Scrap metal is produced and transported to a scrap metal container	
Trigger	Automated notification from the COMPOSITION system that the scrap metal container is full	
Post-conditions success	• All not selected companies were notified • The company with the best offer was automatically selected	
Post-conditions fail	• Only the selected company was notified • The pick-up notification for waste was not delivered • The arranged date overlaps with another pick-up process • Late notification for pickup date, which disturbs KLE's procedures	
Description	Step	**Action**
	1	COMPOSITION automatically sends notification to selected waste management companies about the scrap bins fill level
	2	Waste management companies send their offers exploiting the COMPOSITION System
	3	The COMPOSITION System evaluates all the offers and selects the most suitable candidates (1 to 3)
	4	The maintenance and purchasing managers (KLE) select the best candidate and approve it
	5	COMPOSITION System notifies waste management companies, both selected and not selected.
	6	COMPOSITION System proposes selection of possible pick-up arrangements (already negotiated with waste company)
	7	KLE Manager select the most suitable one (or let COMPOSITION do it autonomously)
Extensions	**Step**	**Branching Action**
		n/a
Sub variations	**Step**	**Branching Action**
	1a	Instead of current fill levels, forecasted amount of scrap metal is sent
	4a	Notification is sent by the system on the waste management companies' side.

The laser and punching machines are equipped with a scrap container. On the scrap container, a unit is mounted with sensors. This unit provides information of the scrap level in the scrap container. This information is transmitted to the IIMS system.

On the IIMS a forecast algorithm is processing the data from the sensors and provides information of the scrap filling level and a prognosis on, when it is full and should be collected by the Worker.

When the scrap container is full, the Worker is notified by the IIMS on his Smartphone with information on which scrap container he is going to collect and which open top solid-waste containers he is going to deliver the scrap to. When the job is done, the Worker confirms this on his Smartphone, and the IIMS is updated. The worker is informed about the fill level of the entire laser and punching machines scrap containers on his Smartphone. This part is handled in 9.3 in UC-KLE-3.

The fill level of the solid-waste container is also measured with sensors, and the information is transmitted to the IIMS system. On the IIMS a forecast algorithm is processing the data from the sensors and provides information of the filling level and a prognosis on, when it will be full.

The Maintenance Manager receives information of the forecast and the fill level of the solid-waste container.

The Maintenance Manager requests offers from the waste management companies, and the Purchasing Manager approves the offers. The Purchasing Manager maintains the list with approved waste management companies.

The Purchasing Manager provides the Maintenance Manager with the request for offer with information on the raw material.

It is possible for the COMPOSITION system to automatically inform selected approved waste management companies, about the current filling level of the solid-waste container and when it is full and should be collected. The waste management company can confirm the request for collection and inform the requester (system) when the collection has been completed. The waste management company can send offers for the specific solid-waste container through the COMPOSITION system. At the requester side, the Maintenance Manager can select/approve a given offer (or pre-defined agreement) given that the Purchasing Manager has approved it.

The Maintenance Manager can either let the COMPOSITION system automatically request the collection date/time or might impose a manual date/time.

The IIMS is updated with information on raw material the solid-waste container contains (weight/material type etc.) and the waste management companies uses this to prepare the offer.

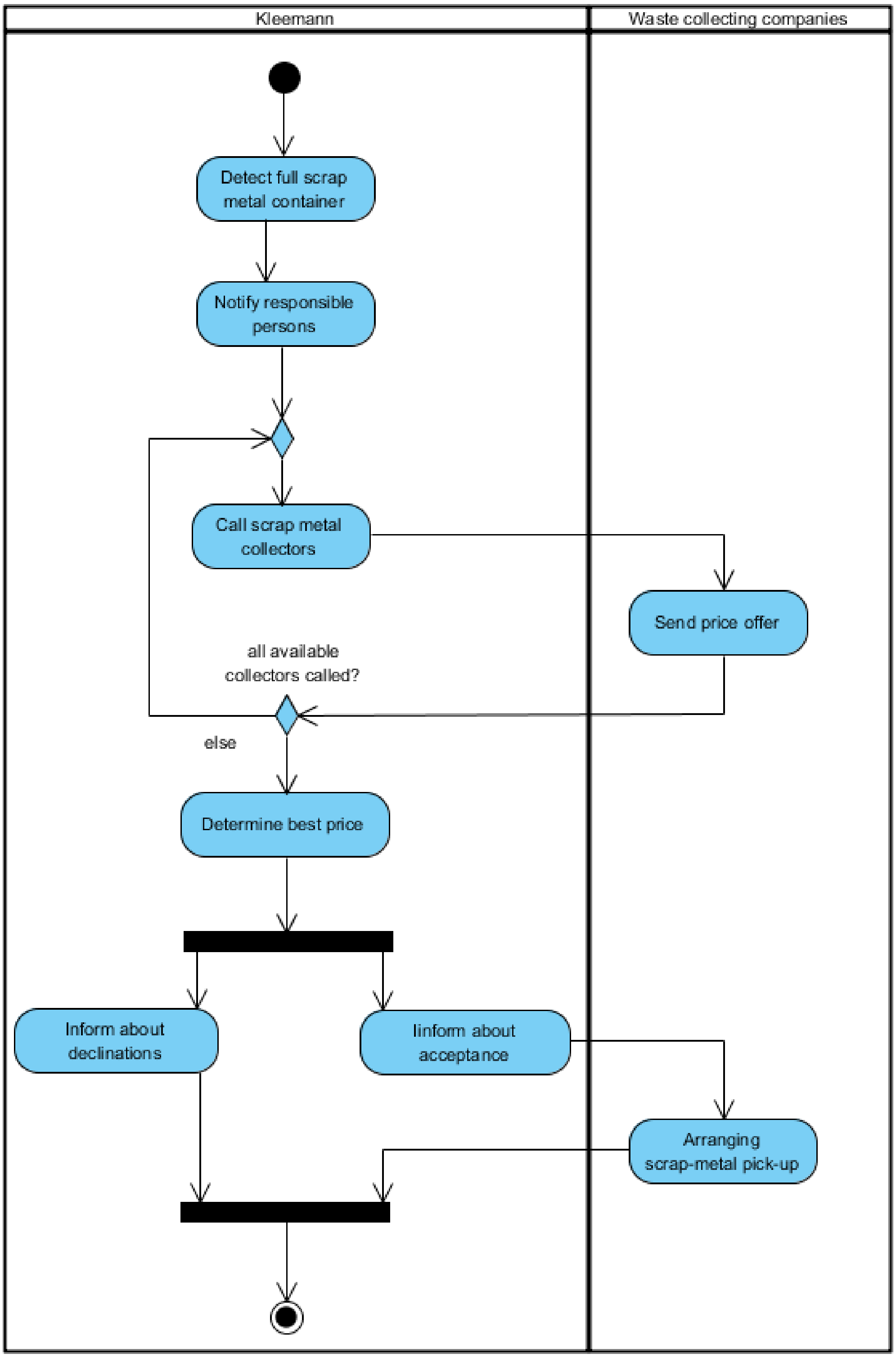


Figure 18: UC-KLE-4 Scrap metal collection process (As-Is)

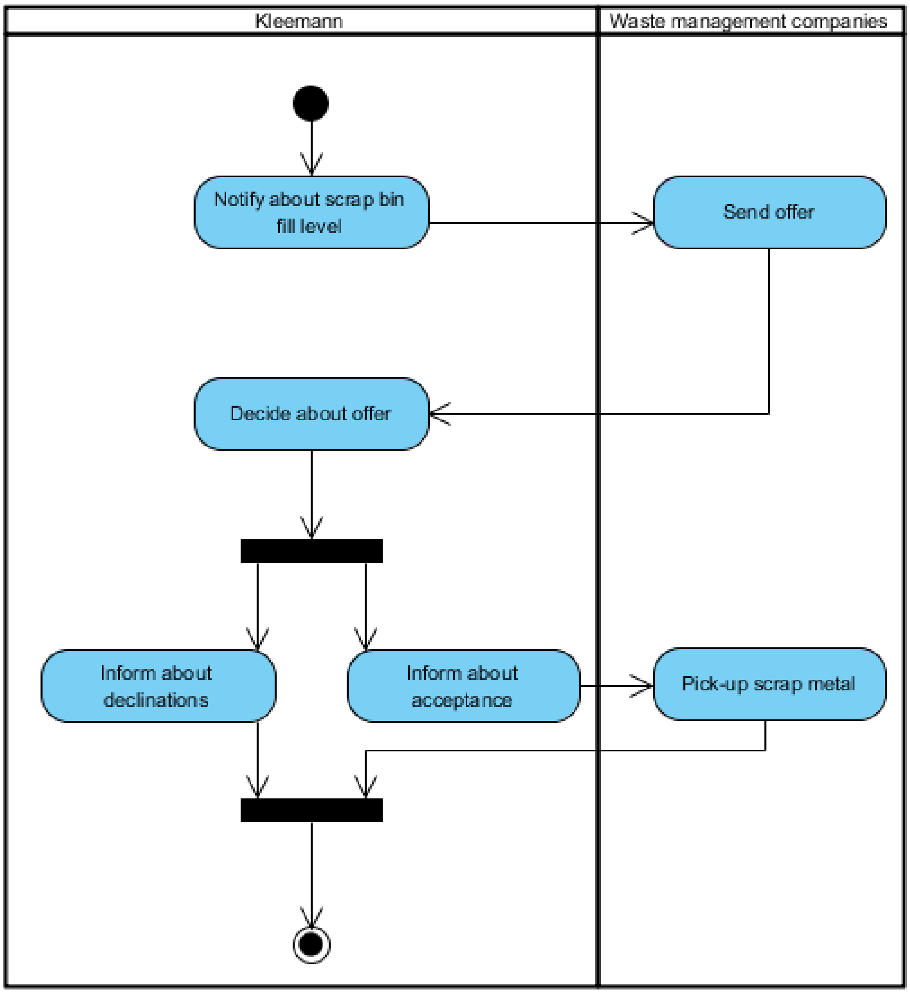


Figure 19: UC-KLE-4 Scrap metal collection process (To-Be)

12.2 Use Case: UC-KLE-5 Scrap metal bidding process

Table 10: UC-KLE-5 Scrap metal bidding process

ID	**UC-KLE-5**
Name	**Scrap metal bidding process**
Diagrams	See Figure 20 below.
Actors	• Waste management companies - Scrap metal collectors • COMPOSITION (System) • Maintenance Manager (KLE) • Purchasing Manager (KLE) • Sales Manager(ELDIA)
Actor goals	The goal of all actors is to optimize scrap metal collection process. More specifically the goal for the: • Maintenance manager and the purchasing manager are to get the best price and reduce costs in the minimum.
Pre-conditions	Scrap metal is produced and transported to a scrap metal container
Trigger	Forecasted availability of scrap metals that need to be collected within the next X days.

Post-conditions success	• All not selected companies were notified • The company with the highest price was automatically selected	
Post-conditions fail	• Only the selected company was notified. • The pick-up notification for waste was not delivered. • Waste management companies sent their offers too late. • The arranged date overlaps with another pick-up process.	
Description	**Step**	**Action**
	1	KLE wants to have (new) contractor for metal
	2	KLE uses the COMPOSITION system to call for offers
	3	Offers come in by waste management companies
	4	KLE uses the COMPOSITION system to approve the best offer
	5	The COMPOSITION system notifies winners and losers of the waste management companies
Extensions	**Step**	**Branching Action**
		n/a
Sub variations	**Step**	**Branching Action**
		n/a

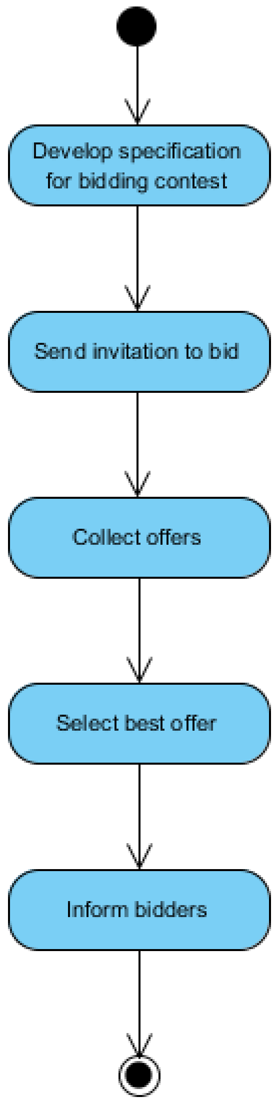


Figure 20: UC-KLE-5 Scrap metal bidding process (To-Be)

12.3 Use Case: UC-KLE-6 Determining price for scrap metal with ELDIA acting as Logistician

Table 11: UC-KLE-6 Determining price for scrap metal with ELDIA acting as Logistician

ID	**UC-KLE-6**
Name	**Determining price for scrap metal with ELDIA acting as logistician**
Diagrams	See Figure 22 below.
Actors	• Maintenance manager (KLE) • Purchasing manager (KLE) • Sales Manager (ELDIA) • Logistics manager (ELDIA) • Driver (ELDIA) • Accounting Department (ELDIA)
Actor goals	• The goal of maintenance manager and the purchasing manager is to get the best price. • The goal of the Sales Manager is to get the best price, thus convey

	the best offer to KLE. • The goal of the Logistics Manager is, upon KLE confirmation, to arrange for immediate pick up. • The goal of the Driver is, upon Logistics Manager order, to immediately pick up the scrap metal container. • The goal of the accounting department is to receive and make payments as fast as possible.	
Pre-conditions	Scrap metal is produced and transported to a scrap metal container Waste management company has the personnel and the necessary equipment to perform the task	
Trigger	Get better scrap metal price, minimize costs Provide a fast and efficient service	
Post-conditions success	• The company with the highest price was automatically selected • On-time payment • Improvement in reaction time	
Post-conditions fail	• Late payment • Late pick up	
Description	**Step**	**Action**
	1	Forecasted volumess of scrap metal is sent to ELDIA
	2	The estimated and/or forecasted weight of scrap is sent to ELDIA
	3	ELDIA requests for price offers for exact tonnage of scrap (possibly using the COMPOSITION System)
	4	ELDIA Customers place concrete offers (possibly using the COMPOSITION System, see use case UC-KLE-5)
	5	ELDIA selects customers (possibly using the COMPOSITION System)
	6	ELDIA Informs KLE about price by exploiting the COMPOSITION system
	7	KLE confirms, automatically or manually
	8	Customers pays ELDIA
	9	ELDIA pays KLE
	10	ELDIA transports scrap from KLE to customers
Extensions	**Step**	**Branching Action**
		n/a
Sub variations	**Step**	**Branching Action**
		n/a

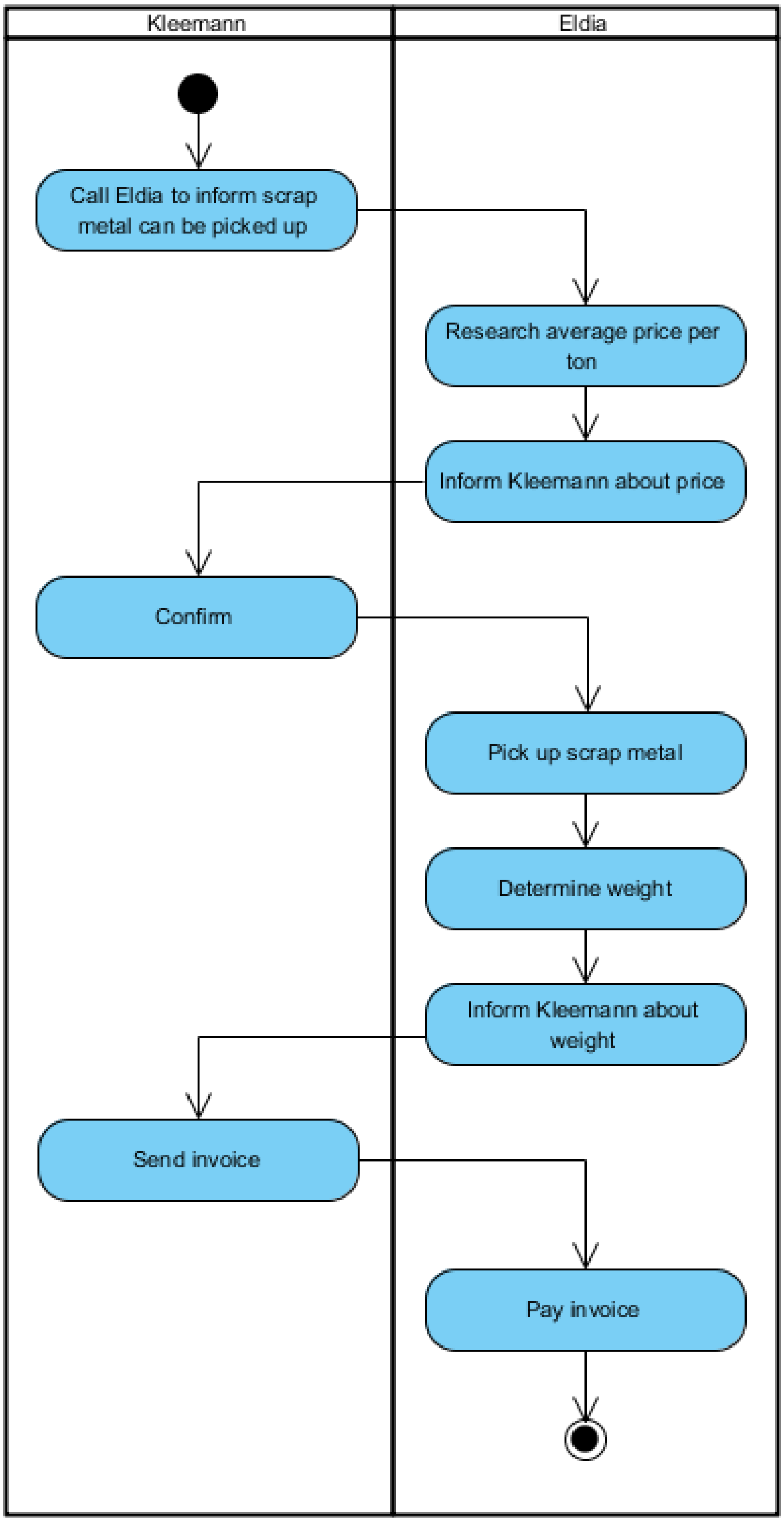


Figure 21: UC-KLE-6 Determining price for scrap metal with ELDIA acting as Logistician (As-Is)

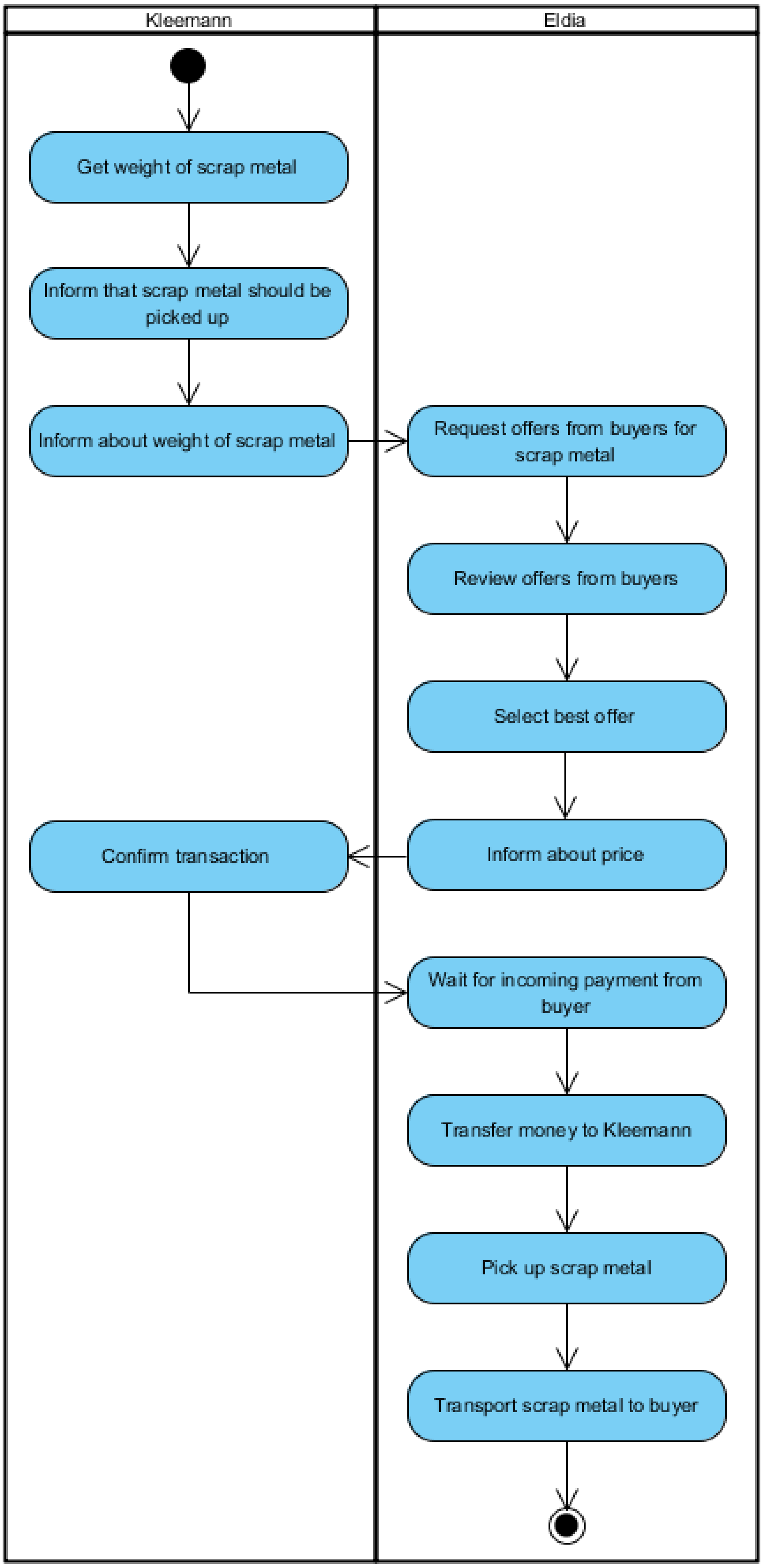


Figure 22: UC-KLE-6 Determining price for scrap metal with ELDIA acting as Logistician (To-Be)

13 INTER-Factory-2 Use Cases: Recyclable Material Management

Two use cases have been developed for the ELDIA pilot based on the scenario INTER-Factory-2 Recyclable Material Management:

- UC-ELDIA-1 Fill-level notification – Contractual recyclable material management
- UC-ELDIA-2 Fill-level notification – Contractual wood waste management.

The following actors are involved in the use cases:

- Worker (KLE): A Worker is an individual who works in the maintenance department of KLE. Usually, he receives his tasks verbally once a day in the morning from the maintenance department manager. A worker's task is to check on the fill level of the wood containers. He does this frequently every 2 hours.
- Waste management companies: Waste management companies are legal entities that provide industrial and non-hazardous waste services. The maintenance manager calls waste management companies, when wood bins are full.
- Maintenance manager (KLE): The maintenance manager is responsible for managing the maintenance department. The manager receives offers for the wood and selects the best one.
- Sales Manager (ELDIA): The Sales Manager is an individual in charge of receiving price information from the steel industry and steel dealers and of conveying the best offer to KLE.
- Logistics manager (ELDIA): The Logistics Manager is an individual in charge of monitoring the truck routes according to the customers' orders.
- Driver(ELDIA): The Driver executes the orders given from the Logistics Department in order to service the customers' needs.
- Accounting Department (ELDIA): The Department responsible for handing all invoicing and payments

13.1 UC-ELDIA-1 Fill-level notification – Contractual Recyclable materials (paper, plastics) recyclable waste management

Table 12: UC-ELDIA-1 Fill-level Notification – Contractual solid recyclable waste management

ID	**UC-ELDIA-1**
Name	**Fill-level Notification – Contractual solid recyclable waste management**
Diagrams	See Figure 23 below.
Actors	• Worker (KLE) • Logistics Manager (ELDIA) • Driver (ELDIA) • Accounting Department (ELDIA)
Actor goals	• Fill-level notifications received in due time • Reduce cost • Time efficiency • Better service. • Faster payment
Pre-conditions	• Recyclable materials are produced • The recycler (ELDIA) has the staff and the means to collect them.

Trigger	Automated notification about the container fill level	
Post-conditions success	• The contacted company is automatically notified. • The driver is automatically notified • Service Efficiency	
Post-conditions fail	The Logistics department is not receiving the message from the sensor	
Description	**Step**	**Action**
	1	Notification of fill level to ELDIA
	2	Logistics Manager (ELDIA) notifies Driver (ELDIA)
	3	Driver (ELDIA) picks up container
	4	Accounting Department (ELDIA) makes the payment
Extensions	**Step**	**Branching Action**
		n/a
Sub variations	**Step**	**Branching Action**
		n/a

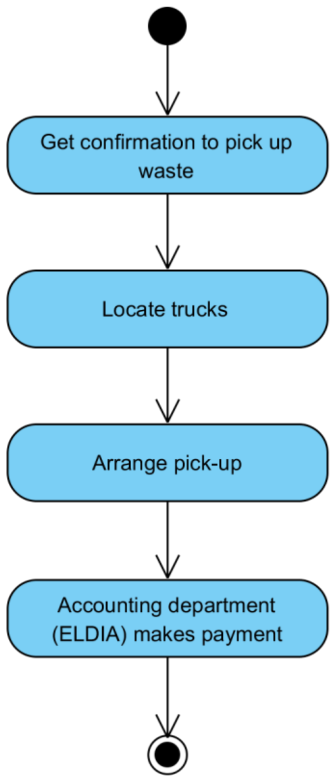


Figure 23: UC-ELDIA-1 Fill-level notification – Contractual Recyclable materials (paper, plastics) recyclable waste management (To-Be)

13.2 UC-ELDIA-2 Fill-level notification – Contractual wood waste management

Table 13: UC-ELDIA-2 Fill-level Notification – Contractual wood waste management

ID	**UC-ELDIA-2**	
Name	**Fill-level Notification – Contractual wood waste management**	
Diagrams	See Figure 25 below.	
Actors	• Worker (KLE) • Waste management companies • COMPOSITION (System) • Maintenance manager (KLE) • Logistics Manager (ELDIA) • Driver(ELDIA)	
Actor goals	• Worker (KLE) observe wood levels in real time • Optimize wood collection process both for KLE and ELDIA • More efficient service (ELDIA)	
Pre-conditions	• Wood is produced • Worker from KLE finds out wood container is full • ELDIA has personnel and equipment to perform the service	
Trigger	Wood bin fill level reaches a threshold.	
Post-conditions success	• Wood levels are observed automatically and in a systematic way (in real time) • ELDIA's reaction time is improved • ELDIA's efficiency is improved	
Post-conditions fail	• Wood levels are observed manually and by sample (not in real time) • Sensors or cameras installed do not function properly.	
Description	**Step**	**Action**
	1	Notification from the sensor of the wood bin fill level will be send to contract partner (ELDIA)
	2	Waste management companies determine pick ups considering the location of their trucks if picking up makes sense
	3	Pick up is arranged through the GPS tracking system in the trucks
Extensions	**Step**	**Branching Action**
		n/a
Sub variations	**Step**	**Branching Action**
		n/a

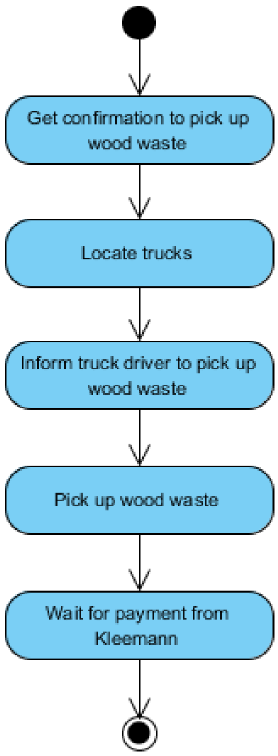


Figure 24: UC-ELDIA-2 Fill-level notification – Contractual wood waste management (As-Is)

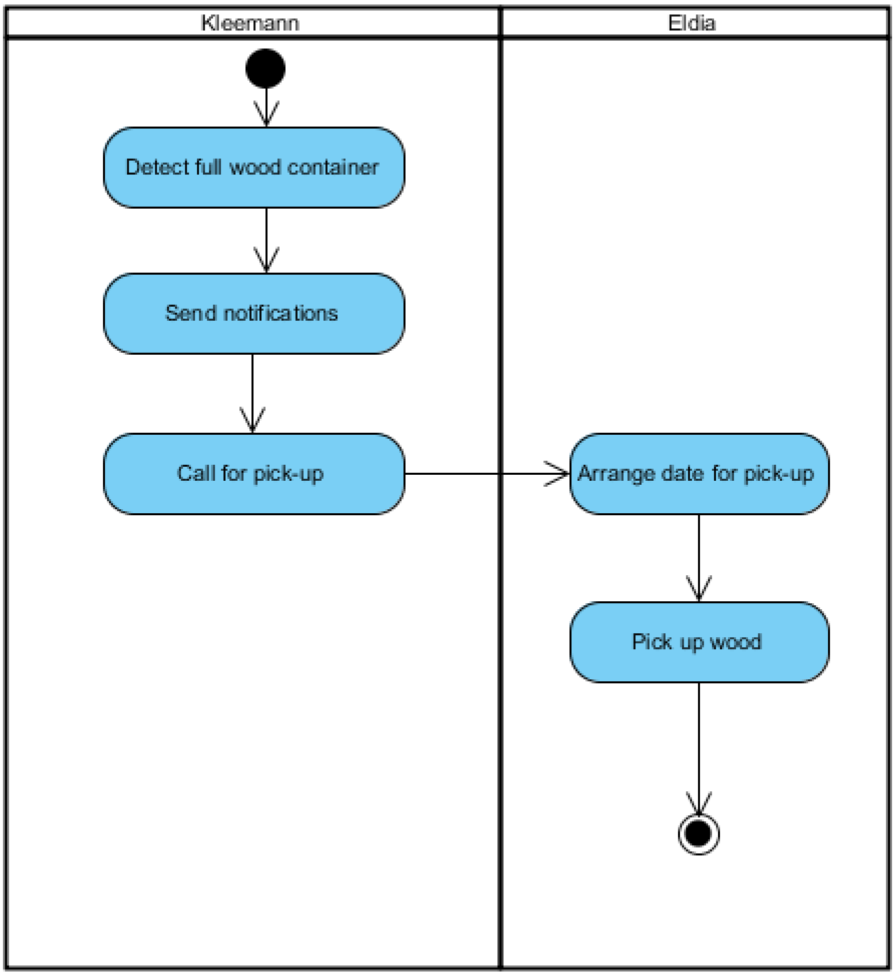


Figure 25: UC-ELDIA-2 Fill-level notification – Contractual wood waste management (To-Be)

14 INTER-Factory-3 Use Case: Supply Chain Management

Based on the scenario Supply Chain Management, one use case for the KLE pilot has been developed: UC-KLE-7 Ordering raw materials.

The actors involved in the use case are:

- Purchasing manager: A purchasing manager is an individual who works in the purchasing department of KLE. His tasks include the monitoring of ERP and the continuous communication with all production lines. A purchasing manager's task is to check on the orders and production level of all factories.
- Raw material suppliers: Raw material suppliers are suppliers that provide raw material. Raw material suppliers are informed by the purchasing manager of KLE that KLE needs raw materials and gives offers. The suppliers' task is to deliver orders on time.

14.1 UC-KLE-7 Ordering raw materials

Table 14: UC-KLE-7 Ordering raw materials

ID	**UC-KLE-7**
Name	Ordering raw materials
Diagrams	See Figure 26 and Figure 27 below.
Actors	• Purchasing manager (KLE) • COMPOSITION (System) • Raw material suppliers (KLE
Actor goals	The goal of raw material suppliers is to provide high quality products and to establish good customer relationship The goal of the purchasing manager is to get high quality raw materials on the best price delivered on time.
Pre-conditions	Raw materials and ready products are needed to produce lifts. KLEEMANN's purchasing department looks for raw material suppliers to buy raw materials (stainless steel, galvanized steel etc.). The purchasing department takes into account and compares among different suppliers the following criteria: a) Product specifications b) Quantity of product c) Type of product d) Order delivery e) Certifications required for each product/raw material (ISO, insurance certificate etc.) f) Insurance certificate g) Guarantees h) Raw material suppliers size (number of employees) i) Suppliers under predefined clauses. j) Turnover k) Payment terms l) Total costs (transportation, price, insurance etc.)

	m) Possible discounts if orders arrive late or don't arrive n) Monthly/yearly consumption of materials. Suppliers send their offers. The purchasing manager decides which supplier is the best, based on the aforementioned criteria and places the order by phone.	
Trigger	Automated notification from IIMS that raw materials and ready products are needed.	
Post-conditions success	• The right raw materials arrive on time in the factory. • The IIMS ensures that it places an order of high quality materials on the best price.	
Post-conditions fail	• Wrong raw materials arrive in the factory with delays • Neither the best price nor the quality of the raw materials has been achieved through the IIMS	
Description	**Step**	**Action**
	1	KLE announces electronically, through the COMPOSITION system that it looks for raw material suppliers
	2	Raw materials Suppliers submit offers to KLE through COMPOSITION
	3	KLE receives a limited set of candidate deals (offers+ToS = Terms of Services) from the COMPOSITION system and the Purchasing Manager approves the “best” one.
Extensions	**Step**	**Branching Action**
		n/a
Sub variations	**Step**	**Branching Action**
		n/a

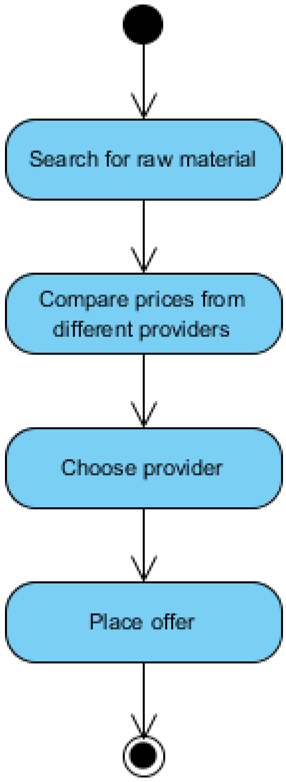


Figure 26: UC-KLE-7 Ordering raw materials (As-Is)

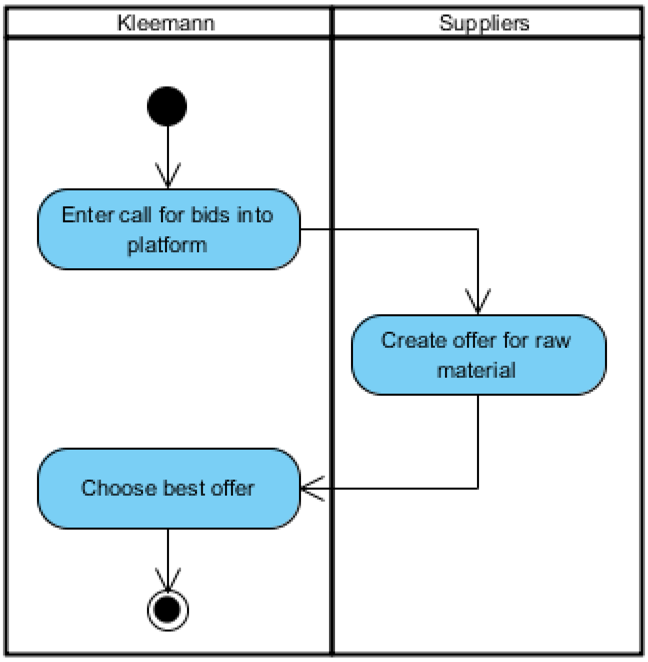


Figure 27: UC-KLE-7 Ordering raw materials (To-Be)

15 INTER-Factory-4 Use Cases: Software Distribution

Three use cases for the ATL pilot have been developed. They are based on the scenario INTER-4 Software Distribution:

- UC-ATL-1 Selling software/consultancy
- UC-ATL-2 Searching for solutions
- UC-ATL-3 Searching for recommended solutions.

The following actors are involved in the use cases:

- Chief Sales Officer (CSO) (ATL)oversees the organisation and supervision of the entire sales department and its daily activities, overseeing all sales-related activities including account management, operations, customer support and advertising. CSO provides guidance, direction, and resources to the sales department and is accountable for the overall sales department performance, the achievement of sales department goals and targets, and its alignment to the business strategy.
- Sales Engineers (ATL) are using their technical knowledge along with sales skills to provide advice and support on a range of products, for which they have a high level of expertise. They have extensive knowledge of the products' parts and functions and they understand the scientific processes that make these products work.
- Chief Marketing Officer (CMO) (ATL) is responsible for marketing activities, strategy and vision in the company and he/she keeps careful track of all actions, successes and measuring marketing outcomes. He/she is responsible for developing a feasible marketing plan for the department, to plan and organize marketing functions and operations (product development, branding, communications etc.) and to oversee the day-to-day implementation.
- Marketing Manager (ATL) is handling the marketing and he/she is responsible for several services and products. He/she sets the budget for specific marketing plans, promotional campaigns, develops price strategies, plans advertising, initiates market research studies and meets with clients to provide marketing advice. These actions are performed in accordance to the strategy of the company, and in collaboration with the CMO, CEO (Chief Executive Officer), CSO and CTO (Chief Technical Officer). The marketing manager oversees the staff that develops advertising and serves as link between the client and promotion agency. The goal is to establish brand, increase market exposure and capture sales.
- Digital Marketing Manager (ATL) is tracking conversion rates, making improvements, usability, design, content, and conversion to the company's website developing and managing digital marketing campaigns. He/she oversees the social media strategy for the company, manages online brand and product campaigns to raise brand awareness and evaluates customer research, market conditions and competitor data.
- Chief Technical Officer (CTO) (ATL) is responsible for planning the technical developments and for the smooth operation of the technical department (in the case of Atlantis, of the IT department). He/she is in collaboration with the CSO, CEO and CMO. The CTO coordinates the technical support manager and thus, the technical support engineers.
- Technical Support Manager (ATL) is responsible for running and managing the company's technical support department, primarily involved in the team to respond quickly and efficiently to incoming technical support issues, via telephone, email, and the company's website and support ticketing system, and that all issues are documented and resolved ASAP. He/she is in close collaboration with the CTO.
- Technical Support Engineer (ATL) is responsible for research, diagnose, troubleshoot and identification of a solutions for a specific problem that client has. He/she resolves customer issues and provides technical support via phone, web, email, chat, and other channels. Furthermore, the Technical Support Engineer is accurately and timely reporting and documenting the knowledge in the form of knowledge base tech notes and articles.

15.1 UC-ATL-1 Selling software/Consultancy

Table 15: UC-ATL-1 Selling software/consultancy

ID	**UC-ATL-1**	
Name	**Selling software/consultancy**	
Diagrams	See Figure 28, Figure 29 and Figure 30 below.	
Actors	• Chief Sales Officer • Chief Marketing Officer • Digital Marketing Manger • Sales Engineer • Technical Support Manager	
Actor goals	Increase product/consultancy sales	
Pre-conditions	Atlantis advertises features of product/consultancy to eco-system	
Trigger	Potential client has a problem and requests software solution via the ecosystem	
Post-conditions success	ATL is matched with the potential client. They agree on a contract.	
Post-conditions fail	• Potential client is matched with wrong kind of sellers and vice-versa. • There is no rating in suggestions from the system to the potential clients. There is no rating in suggestions from the system to ATL. • Not selected companies (software providers like ATL) are not notified.	
Description	**Step**	**Action**
	1	Potential customer advertises needs to ecosystem
	2	Ecosystem matches customers' needs and features regarding software product/consultancy and provides for example a top 5 list of better matches
	3	Ecosystem pre-negotiates ToS / prices automatically on the basis of the customer (and ATL) specifications
	4	Seller (ATL) and buyer (KLE) approve one among the different proposed deals and agree to sign a contract.
Extensions	**Step**	**Branching Action**
	1	Potential customers are subscribed to a specific topic.
	2	Potential customers meet certain criteria of ATL for the specific product/consultancy.
	3	Ecosystem matches potential customers regarding software product/consultancy with ATL. Ecosystem provides ranking of potential customers to ATL.
	4	ATL contacts potential customers via the ecosystem and sends advertisement of product/consultancy.
	5	Interested potential customers get back to ATL.
	6	Interaction leads to collaboration, e.g. contract.
Sub variations	**Step**	**Branching Action**
	1	Notification is sent using e-mail or specific COMPOSITION APP
	2	Notification is sent using e-mail to users with specific roles, e.g. accounting department of buyer/seller.

	3	Satisfied seller/buyer leaves positive feedback or fills ready questionnaire to assess the interaction/collaboration.
	4	Satisfied seller/buyer invites other companies to join the COMPOSITION ecosystem (in return for discount?).

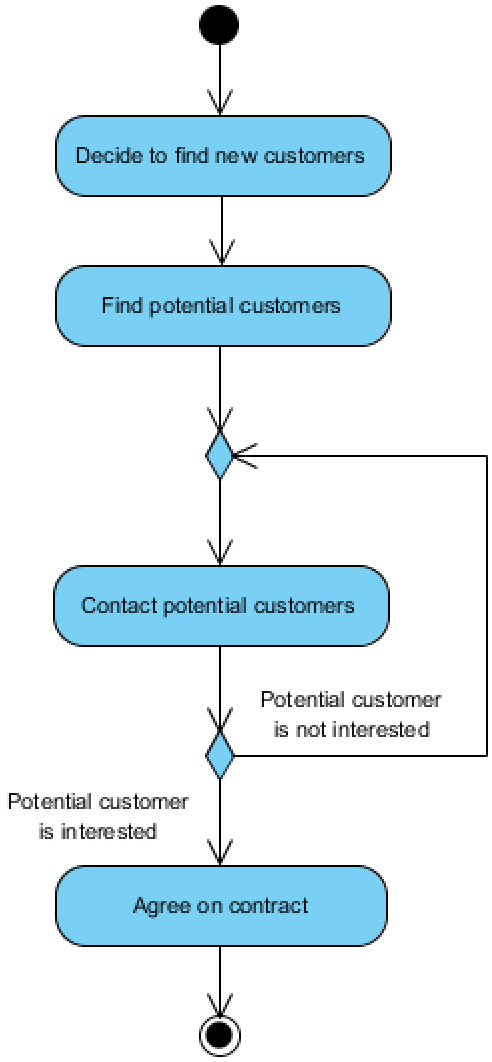


Figure 28: Selling software/Consultancy (As-Is)

Below, two models for push (Figure 29) and pull (Figure 30) are visualised respectively.

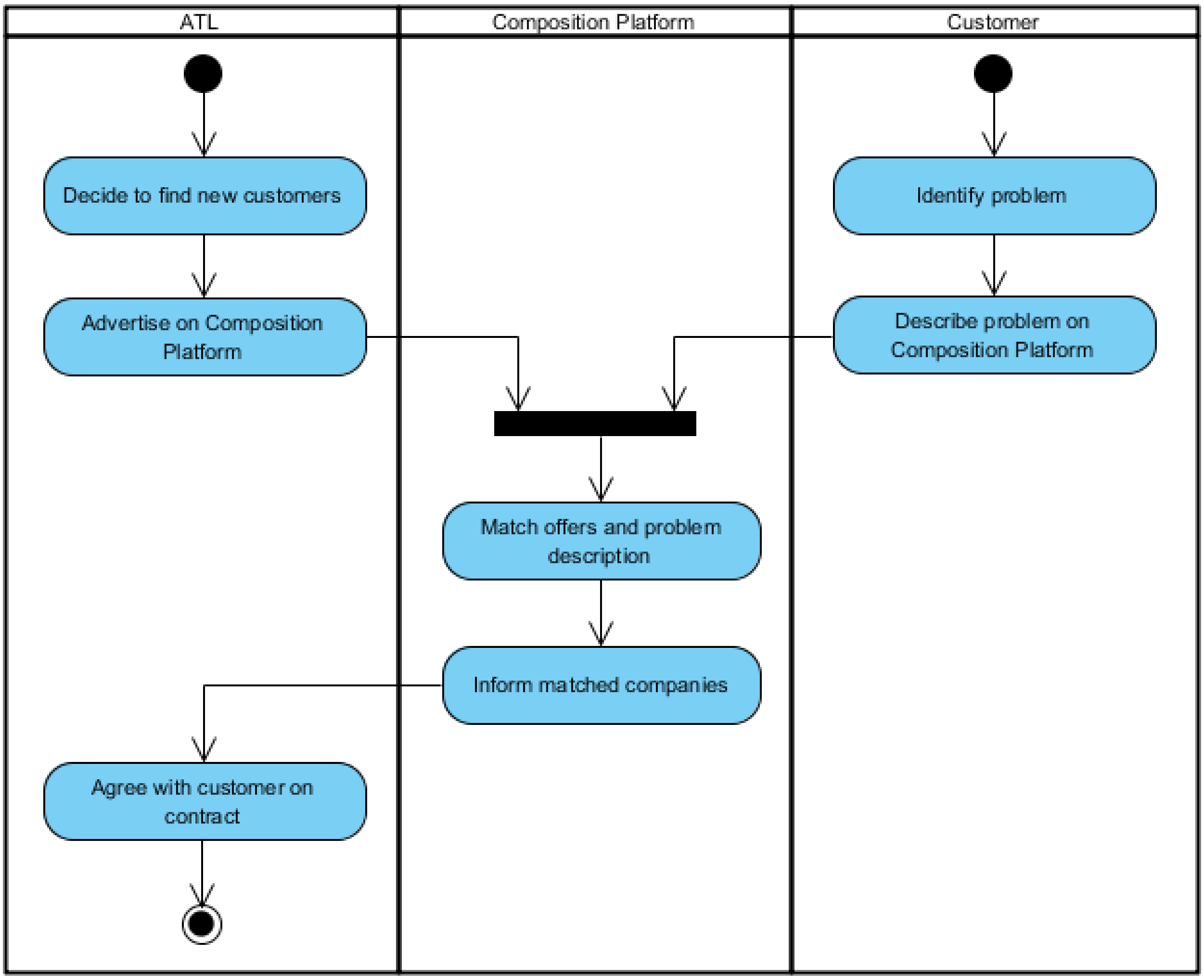


Figure 29: Selling software/Consultancy - model A ext. push (To-Be)

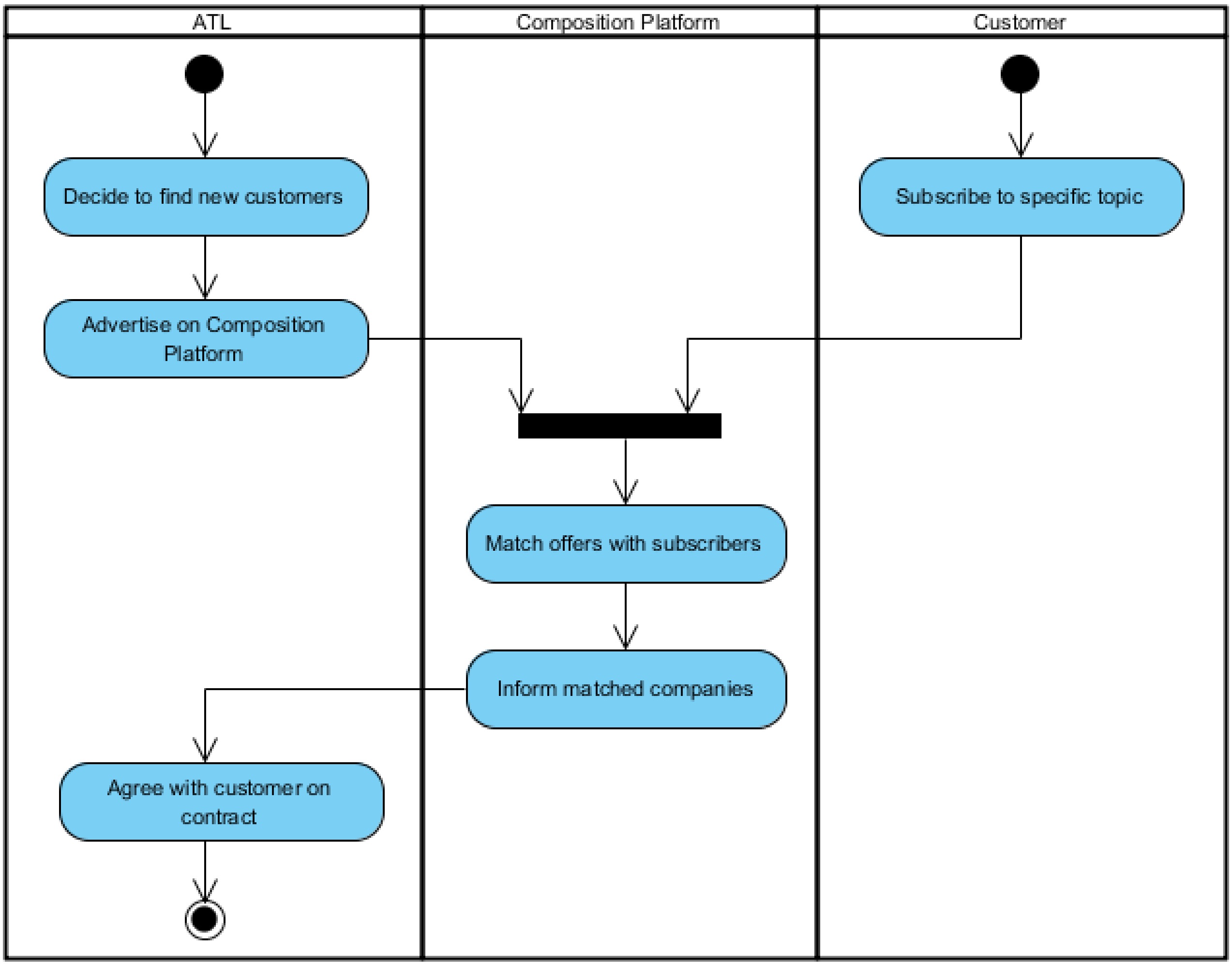


Figure 30: Selling software/Consultancy - model B ext. pull (To-Be)

15.2 UC-ATL-2 Searching for solutions

Table 16: UC-ATL-2 Searching for solutions

ID	**UC-ATL-2**
Name	**Searching for solutions**
Diagrams	See Figure 31 and Figure 32 below.
Actors	• Potential customers • Sales Engineer • Technical Support Manager (TSM • CSO
Actor goals	• Customer/Buyer wants to find solutions • CSO and Sales Engineer wants to increase sales • TSM wants to facilitate the provision of services
Pre-conditions	• Customer needs a software solution. • Customer needs to collaborate with a recommended seller. • Customer has subscribed to topic(s) to get information from solution providers (means of contact learn to handle information system tool).
Trigger	Customers look for software solution and/or solution providers in the ecosystem.

Post-conditions success	• Customers selects solution provider based on information in ecosystem e.g. ranking of providers. This raises chances for more unknown providers.	
Post-conditions fail	• Not enough ranking for potential-new clients to read because clients who have already a contract didn't fill the ranking sheet. • Non-useful/suitable solutions proposed by the ecosystem.	
Description	**Step**	**Action**
	1	Customers search for solution providers in ecosystem
	2	Customers get recommendations via the ecosystem
	3	Customers select solution provider based on information in ecosystem
Extensions	**Step**	**Branching Action**
	1	UC-ATL-1 extension scenario
Sub variations	**Step**	**Branching Action**
	1	Improve/train customer team members to have better subscribe to topics.
	2	Notification for change of ranking?
	3	Notification for advertising, link to UC-ATL-1

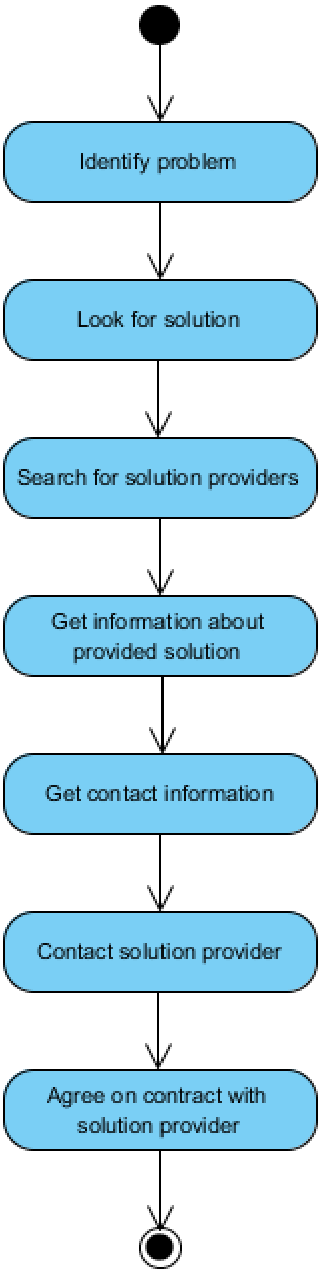


Figure 31: Searching for solutions (As-Is)

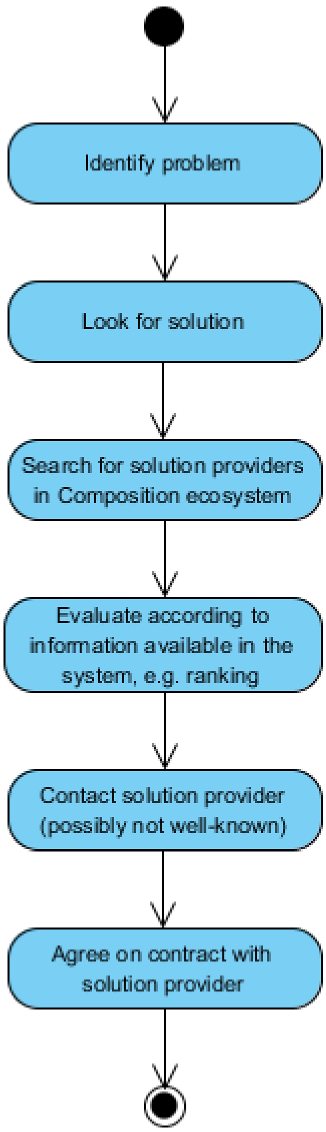


Figure 32: UC-ATL-2 Searching for solutions (To-Be)

15.3 UC-ATL-3 Searching for recommended solutions

Table 17: UC-ATL-3 Searching for recommended solutions

ID	**UC-ATL-3**
Name	**Searching for recommended solutions**
Diagrams	See Figure 33 to Figure 36 below.
Actors	• Potential customers' purchase department and/or technical/IT team members • Sales Engineer • Technical Support Engineer
Actor goals	Customer wants recommended solution providers.
Pre-conditions	• Customer looks for solution in the ecosystem. • Sellers (like ATL) of the desired type of solution must be available and evaluated in the ecosystem. • Nice to have sellers with good ranking available.

Trigger	Customer checks ecosystem for ranking of companies (like ATL).	
Post-conditions success	Customer contacts seller(s) (e.g. ATL and other similar companies to receive offers).	
Post-conditions fail	• The customer does not know how to look into the ecosystem for what they need. • No available sellers of the desired type are available in the system.	
Description	**Step**	**Action**
	1	Customer looks for solution
	2	Customer gets recommendation for e.g. top 5 companies.
	3	Customer checks ecosystem for one or more company's ranking (e.g. ATL).
	4	Customer contacts company (ATL).
Extensions	**Step**	**Branching Action**
	1	Customer is happy with Atlantis's solution.
	2	Atlantis asks customers to give a good recommendation in the ecosystem.
	3	Customer gets ATL good ranking/recommendation in ecosystem.
Sub variations	**Step**	**Branching Action**
	1	Customer gives feedback in a short questionnaire after interaction with a company in the ecosystem.
	2	Customer receives a reward for it.

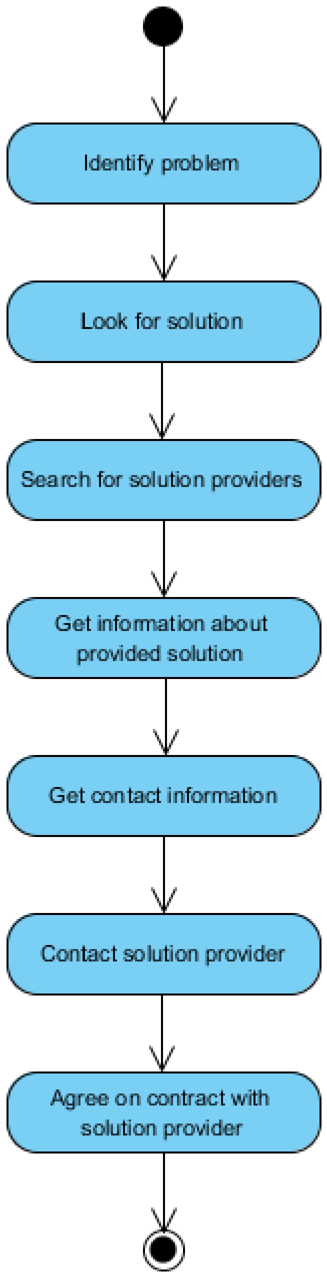


Figure 33: Searching for recommended solutions - Model A (As-Is)

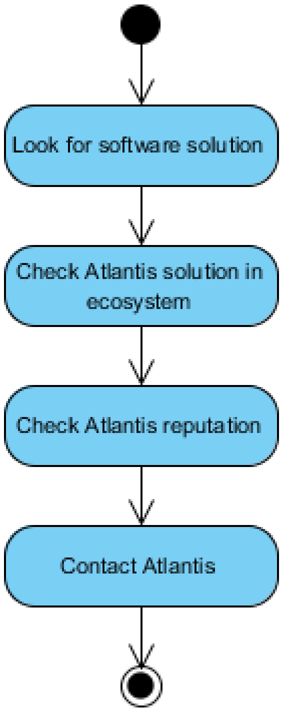


Figure 34: Searching for recommended solutions - Model A (To-Be)

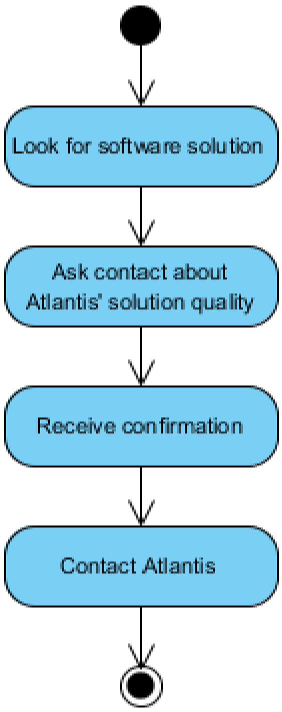


Figure 35: Searching for recommended solutions – Model B (As-Is)

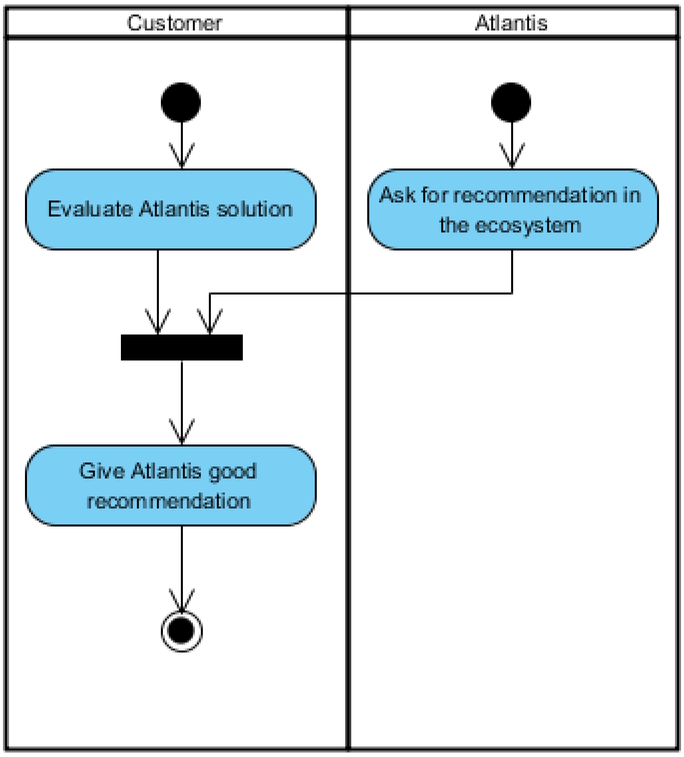


Figure 36: Searching for recommended solutions Model B - sub (ranking request) (To-Be)

16 INTER-Factory-5 Use Cases: System Connection over Marketplace

Two use cases have been developed based on the scenario INTER-5 System Connection over Marketplace. The first use case is related to two pilots, ATL and NXW, and as such is a joint use cases. The second use case is related to NXW:

- UC-ATL/NXW-1 Integrate External Product into Own Solution
- UC-NXW-1 Decision Support over Marketplace.

The following actors are involved:

- NXW/ATL (as solution provider): acts as a solution provider that want to build a solution using some devices
- Clients: ask via the ecosystem for the development of a COMPOSITION compatible solution
- Chief Sales Officer (CSO) (ATL/NXW) is in charge of the organisation and supervision of the entire sales department and its daily activities, overseeing all sales-related activities including account management, operations, customer support and advertising. CSO provides guidance, direction, and resources to the sales department and is accountable for the overall sales department performance, the achievement of sales department goals and targets, and its alignment to the business's strategy.
- Chief Technical Officer (CTO) (ATL/NXW) is responsible for planning the technical developments and for the smooth operation of the technical department (in the case of Atlantis, of the IT department). He/she is in collaboration with the CSO, CEO and CMO. The CTO coordinates the technical support manager and thus, the technical support engineers.
- Technical Support Manager (ATL/NXW) is responsible for running and managing the company's technical support department, primarily involved in the team to respond quickly and efficiently to incoming technical support issues, via telephone, email, and the company's website and support ticketing system, and that all issues are documented and resolved ASAP. He/she is in close collaboration with the CTO.
- Technical Support Engineer (ATL/NXW) is responsible for research, diagnose, troubleshoot and identification of a solutions for a specific problem that client has. He/she resolves customer issues and provides technical support via phone, web, email, chat, and other channels. Furthermore, the Technical Support Engineer is accurately and timely reporting and documenting the knowledge in the form of knowledge base tech notes and articles.
- Building Management System (BMS) (ATL/NXW): The Build Management System installed into the factory premises, which continuously collects data from the environment
- Enterprise Resource Planning (ERP) system (ATL/NXW): The ERP system installed into the factory premises, which continuously collects data from the environment.
- Worker (KLE): A Worker is an individual who works in the production line department of KLE. Usually, he receives his tasks verbally once a day and controls its machine settings to configure it correctly for the assigned task.

16.1 UC-ATL/NXW-1 Integrate External Product into Own Solution

As solution providers ATL and NXW often want to build solutions that use some devices, hence both develop interfaces to devices which can be integrated into solutions.

Table 18: UC-ATL/NXW-1 Integrate External Product into Own Solution

ID	**UC-ATL/NXW-1**
Name	**Integrate external product into own solution – exposing service output for external application**
Diagrams	See Figure 37 and Figure 38 below.

Actors	• NXW / ATL (as solution provider) • Clients • CSO • CTO • Technical Support Manager • Technical Support Engineer • External application	
Actor goals	• Integration of developed product by ATL / NXW to the COMPOSITION interface standards are goals for all actors above • NXW to provide a service based on data internal to customer premises • NXW to provide a service that uses Composition IIMS to retrieve data • External application to meet COMPOSITION interface • External application to use the information exposed from NXW services, through COMPOSITION	
Pre-conditions	Developed solution which is built according to COMPOSITION standards – a service based on data internal to customer premises	
Trigger	Development of solution that the developing company wants to offer/advertise via the ecosystem e.g. an external application which wants to use the output of the NXW service	
Post-conditions success	The developed solution is "COMPOSITION compatible". Which means an external application for example can use the NXW service output through the interface.	
Post-conditions fail	• The developed solution is not "COMPOSITION compatible" • Stakeholders report the developed solution as not "COMPOSITION compatible" to the ecosystem, e.g. the external product cannot use the NXW service output through the interface.	
Description	**Step**	**Description**
	1	ATL builds solution based on COMPOSITION standards that can interface with other external systems that are also COMPOSITION compatible. Then e.g. NXW provides a service based on data internal to customer's premises such as sensors
	2	External product can be exchanged/connected to other products that meet the COMPOSITION standards, which are provided through COMPOSITION IIMS, the interface is used to retrieve the internal data
Extensions	**Step**	**Branching actions**
	1	NXW provides a service based on data internal to customer premises (e.g. sensors)
	2	COMPOSITION IIMS provides interfaces to retrieve the internal data
	3	An external application wants to use the output of the NXW service
	4	The NXW service exposes its output to the application using COMPOSITION interfaces
	5	The external application, compliant with COMPOSITION interfaces, gets access to the NXW output
	6	ATL/NXW builds solution based on COMPOSITION standards that can interface with other external systems that are also COMPOSITION compatible.
	7	External product can be exchanged/connected to other products that meet the COMPOSITION standards.

Sub variations	Step	Extensions
		A potential client/buyer asks via the ecosystem for the development of a COMPOSITION compatible solutions.

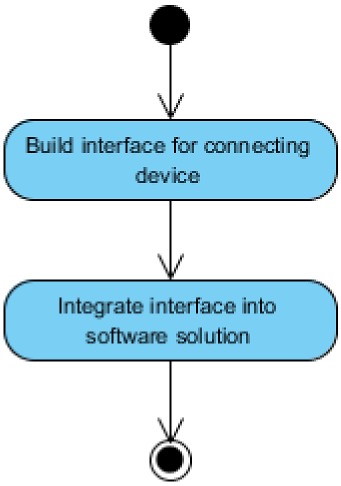


Figure 37: UC-ATL/NXW-1 Integrate external product into own solution (As-Is)

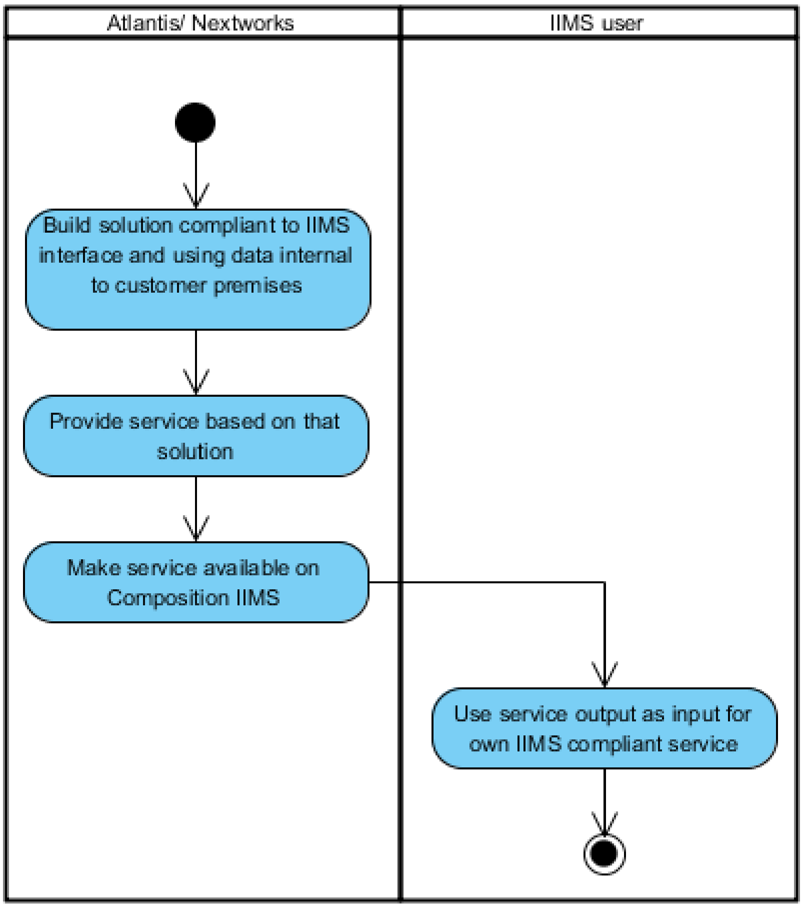


Figure 38: UC-ATL/NXW-1 Integrate external product into own solution (To-Be)

16.2 UC-NXW-1 Decision Support over Marketplace

Table 19: UC-NXW-1 Decision support over marketplace

ID	**UC-NXW-1**	
Name	**Decision support over marketplace**	
Diagrams	See Figure 39 and Figure 40 below.	
Actors	• BMS • ERP system • Purchasing manager (KLE) • Worker(KLE) External analysis tool	
Actors Goals	Enhance the decisional process with the analysis of data history	
Pre-conditions	Create a data history archive, enhance the data analysis with machine learning	
Trigger	Every time a production machine needs to be configured to refine tis process	
Post conditions success	The product has the expected size, quality, shape, etc.	
Post conditions fail	The product has not the expected size, quality, shape, etc.	
Description	**Step**	**Action**
	1	BMS system collects and stores data from a production process continuously
	2	COMPOSITION system stores an historical of these inputs and outputs
	3	KLE requests for analysis tool
	4	COMPOSITION system exposes the request on the marketplace
	5	COMPOSITION presents available tools to KLE
	6	KLE selects the best tool
	7	Analysis tool accesses to KLE data through COMPOSITION
	8	Analysis tool runs its algorithms
	9	Analysis tool suggests a decision to worker (KLE) through COMPOSITION
	10	Worker configures the machine
Extensions	**Step**	**Branching Action**
		n/a
Sub variations	**Step**	**Branching Action**
		n/a

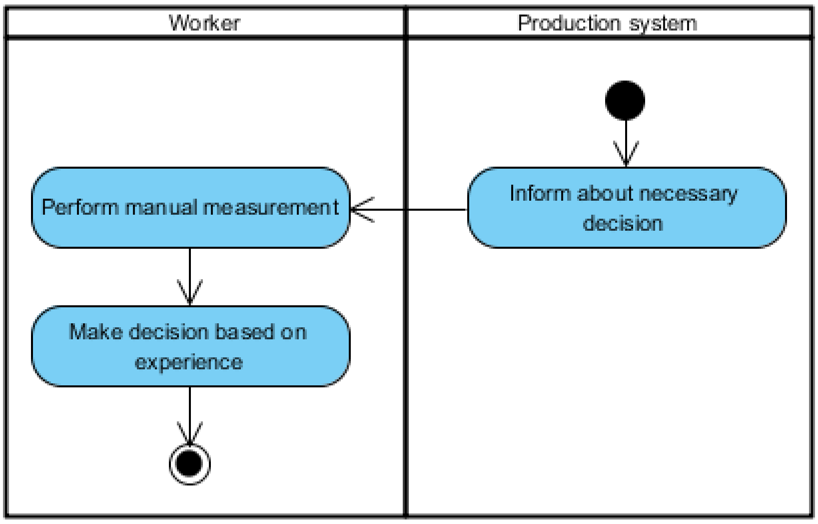


Figure 39: UC-NXW-1 Decision support over marketplace (As-Is)

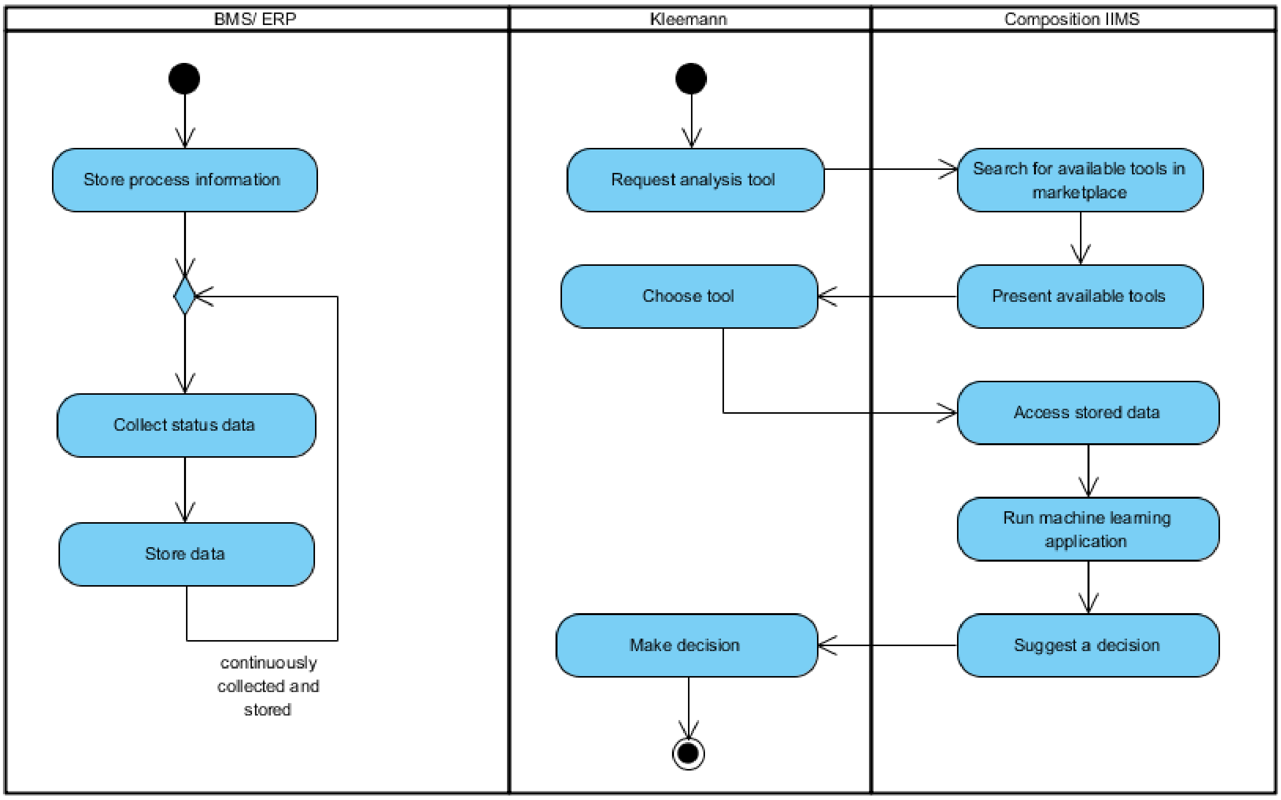


Figure 40: UC-NXW-1 Decision support over marketplace (To-Be)

17 Scenario Interpretation – Planning the Requirements

An essential property of the User-Centred Design Procedure is that it should be adapted to the specific requirements of the individual project. This chapter gives an overview on how the standard procedure has been instantiated and adapted to the COMPOSITION project.

17.1 Initial vision scenario

A scenario is an acknowledged way of communicating the vision of a particular system, as well as to explain and document requirements.

Creating scenarios of end user behaviour and interaction with platform functionality is an extremely useful instrument for identifying key technological, security, socioeconomic and business drivers for future end user requirements. The scenarios provide a vision framework for the subsequent iterative requirement engineering phase.

The scenarios developed in this document provide top-level user requirements in the form of vision scenarios of future use of the COMPOSITION platform in the selected domains. The next step produces technically oriented storylines focusing on the deployment and use of the COMPOSITION platform. These storylines address technical questions referring to the platform and its components. The deliverable also summarises the future developments foreseen by the experts and the significance this will have for the development of the COMPOSITION applications beyond the project. The future scenarios describe end user activities as well as application functionalities, and thus, bridge the gap to the formulation of technical user requirements.

17.2 Derivation of technical scenarios

From the main vision scenario, more technical scenarios may be derived that could be used to elicit requirements for the future COMPOSITION platform. The technical scenarios are tentative, trying to capture the context of use for a certain user role and to illustrate how the COMPOSITION platform might support them. Such technical context scenarios illustrate the benefits and functionality of a system for certain user groups with their typical tasks and goals (Dzida, 1999). They describe the users' view of the usage of a system within the current context of work and the envisaged improvement of tasks. Scenarios normally do not explicate details of interaction, which is left for a later stage when mock-ups are available. These technical scenarios were elaborated for different work of context aspects and specific to the problems and questions within all technical work packages.

It is important to note that the technical scenarios were meant as means for discussion with users. The scenarios do not contain requirements, but help the users and experts to generate the requirements.

17.3 Requirements derivation

The main task after the completion of scenarios and use cases is the consolidation of the information gathered from the discussions. The output of the discussions and interviews are user statements. The analysis of the original users' statements in the respective workshops leads to the elicitation of requirements at different levels of detail and their aggregation in a structured way.

First, all user statements shall be extracted from the discussion protocols and statements referring to the more global constraints were separated. The second step is the first classification of the statements relating explicitly or implicitly to the functionality that the COMPOSITION platform might provide. Such user feedback to technical scenarios may relate to various aspects of the system and its use, and have been classified according the Volere scheme (Robertson and Robertson, 1999).

The initial set of user requirements will be documented in *D2.2 Initial Requirements Specification* and will become accessible for all users and also traceable for evaluation of design solutions.

18 List of Figures and Tables

18.1 Figures

18.2 Tables

19 References

Dzida, W. Developing Scenario-based Requirements and Testing them for Minimum Quality. HCI, Erlbaum.

Robertson, S. Robertson, J.R. (1999): Mastering the requirement process. Addison Wesley, London, ACM Press Books.