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D2.6 Lessons Learned and Updated Requirements Report II

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Index:

1 Executive Summary

This deliverable provides an overview of the requirements engineering work performed in the second prototype cycle between M16 (December 2017) and M28 (November 2018).

The deliverable documents the Lessons Learned and changes in the requirements compared to the previous document in this series, *D2.5 Lessons Learned and Updated Requirements Report I*, including additions to the list of Innovations.

A final update of the COMPOSITION requirements engineering work will be provided as part of *D1.8 Final Progress Report for the Commission*.

1.1 Lessons Learned Overview

A total of 25 Lessons Learned has been reported in the second cycle. Compared with the list of requirements in D2.5, 22 requirements have been added, and 20 requirements have been rejected.

Many requirements have been updated without influencing their substance, and similarly, the essence of several requirements is unaffected, while the actual implementation has been adapted as an outcome of Lessons Learned, an overview of which is provided in Table 1.

Table 1: Lessons Learned per Work Package

WP	Number of Lessons Learned	Requirements (RQs) Affected
WP1	1	None
WP2	2	3 RQs rejected
WP3	4	3 RQs added, 1 updated, 2 rejected
WP4	5	15 RQs added
WP5	4	2 RQs added, 1 updated, 12 rejected
WP6	1	3 RQs rejected
WP7	2	2 RQs added
WP8	1	None
WP9	5	None

1.2 Requirement and Use Case Status

Good progress has been made since the issue of D2.5 in November 2017, with no requirements still in status Open, 47 requirements implemented, 71 now Part of Specification and 15 having passed the Quality Check. The latter category will be implemented to the extent possible within the project duration.

Use Case priority has not changed, but decisions have been made about their implementation based on the agreed priority. This has meant exclusion of one of the Tier2 Use Cases and many of the Tier3 Use Cases to ensure there is enough time left to implement the remaining Use Cases. Two Business Modelling Use Cases have been added as Subcases to existing inter-factory Use Cases.

1.3 Innovations

The existing Innovations have been reviewed and updated, and two new Innovations have been identified in this development cycle:

I-09 Blockchain-based Reputation and Trust Model

I-10 Real Time Multi-Protocol Event Broker

2 List of Abbreviations and Acronyms

Table 2: Abbreviations and Acronyms

Acronym or Abbreviation	Meaning
AMQP	Advanced Message Queuing Protocol
AMS	Agent Management Services
API	Application Programming Interface
DF	Directory Facilitator
DFM	Digital Factory Model
DoA	Description of Action
DSS	Decision Support System
EFFRA	European Factories of the Future Research Association
HMI	Human Machine Interface
IIMS	Integrated Information Management System
LL	Lesson Learned
MQTT	Message Queuing Telemetry Transport
PCBA	Printed Circuit Board Assembly
RPM	Revolutions Per Minute
RQ	Requirement
UC	Use Case
WP	Work Package

3 Introduction

The overall objectives of WP2 are to manage the agile requirement engineering, specification and design methodology and to coordinate the architecture design activities for the COMPOSITION platform. The specific objectives are:

- Produce a set of industrial use cases and story lines
- Perform an analysis of the use cases and discover the technological innovation potential using "innovation forms"
- Elicit the generic and specific functional requirements for the pilot applications
- Design the overall architecture based on the technical requirements and innovations
- Manage the iterative engineering of the requirements
- Collect Lessons Learned obtained during project progress results to generate change requests and adjustments to the initial requirements including emergent and obsolete requirements.

3.1 Purpose, Context and Scope of this Deliverable

This deliverable provides an overview of the requirements engineering work performed in the second prototype cycle between M16 (December 2017) and M28 (November 2018).

The deliverable documents the Lessons Learned and changes in the requirements compared to the previous document in this series, *D2.5 Lessons Learned and Updated Requirements Report I*, including additions to the list of Innovations.

A final update will be provided as part of *D1.8 Final Progress Report for the Commission*, which is due in M36 (August 2019).

3.2 Content and Structure of this Deliverable

Chapter 3 briefly reiterates the research and development methodology applied.

Chapter 4 lists the Lessons Learned and the change in requirements based on analysis of the Lessons. The content is organised per Work Package (WP).

Chapter 5 provides various statistical information on the present list of COMPOSITION requirements in the JIRA Repository, while Chapter 6 reports two Innovations introduced in the reporting period.

Appendix A contains the full, updated list of COMPOSITION requirements, and Appendix B provides details of presently identified COMPOSITION Innovations.

4 Research and Development Methodology

In COMPOSITION, requirements engineering is defined as a continuous iterative process, driven by a user-centred design approach, which is based on ISO 9241-210 "Ergonomics of human-system interaction" and on the Volere model recommended by Robertson & Robertson (Robertson et al, 1999).

Similarly, the methodologies and procedures adopted in the research work packages support an agile and evolutionary design and development process.

As one outcome of these undertakings, development experiences, Lessons Learned and other relevant knowledge are gained in each of the prototype cycles, the analysis of which leads to new and/or updated requirements in the JIRA repository.

Details of this process and of the associated structure for managing the innovation activities are described in *D2.2 Initial Requirements Specification*.

The COMPOSITION approach to Lessons Learned is described in the previous document in this series, *D2.5 Lessons Learned and Updated Requirements Report I.*

5 Lessons Learned and Requirements Engineering

This chapter contains the Lessons Learned collected between M16 and M27 (December 2017 through November 2018) and the subsequent analysis. To facilitate referring to individual Lessons Learned, they have been named LL followed by the relevant Work Package number and Lesson number (as they appear in the Confluence Wiki repository), e.g., LL-WP1-1. The process results in the identification of a series of improvement opportunities and the need for new, changed or rejected requirements (RQs).

The Lessons and the subsequent analysis are grouped per Work Package. The changes and updates to the requirements resulting from the Lessons Learned are listed and discussed for each Work Package.

A total of 25 Lessons Learned has been reported in the second cycle. Compared with the list of requirements in *D2.5 Lessons Learned and Updated Requirements Report I*, 22 requirements have been added, and 20 requirements have been rejected.

Many requirements have been updated, because Custom Labels have been added or changed, e.g., labels indicating which Task is involved as described below in Section 6.3. This has not affected the substance of these requirements.

Similarly, the essence of several requirements is unaffected, while the actual implementation has been adapted as an outcome of Lessons Learned. This is indicated with a [bracket] in the tables below.

The full list of requirements can be found in Appendix A.

5.1 Lessons Learned in WP1

WP1 is led by FIT, and the work involves the management of the COMPOSITION project. One Lessons Learned has been collected and verified from this WP.

Table 3: Lessons Learned in WP1

Org. LL ID	Experience and knowledge gained	Lesson Learned	RQs Affected
FIT LL-WP1-1	Although there is no confidential data or anything else worth stealing by external attackers, having a not properly secured system online allowed attackers exploring to misuse our computing power.	There are often reasons to attack software systems that the owner does not think of.	[COM-139]

5.1.1 Analysis of Lessons Learned

LL-WP1-1: The conclusion drawn from this unexpected experience is to never put systems online before they are properly secured, no matter what.

5.1.2 New/Updated/Rejected Requirements

This Lesson serves to emphasise the importance of COM-139 without necessitating an update of the requirement itself. No requirements were added or rejected in WP1.

5.2 Lessons Learned in WP2

Led by IN-JET, WP2 manages the requirements engineering process and architecture development. Two Lessons Learned have been collected and verified from this WP.

Table 4: Lessons Learned in WP2

Org. LL ID	Experience and knowledge gained	Lesson Learned	RQs Affected
IN-JET LL-WP2-1	Monitoring of progress of the User Requirements in the JIRA COMPOSITION project is to some extent a duplication of the work done and documented in the JIRA COMPOSITION Scrum project.	If the two JIRA projects can be linked in a sensible way, it will be possible to update the status of the User requirements based on the progress made in the Scrum project, thus saving time and effort.	(All indirectly)
ATL LL-WP2-2	The requirements and use cases described in the first stages of the project are not the final ones.	As the project progresses, the consortium develops a better understanding of the needs of the end users and of the tools that the technology providers will offer.	(Several indirectly)

5.2.1 Analysis of Lessons Learned

LL-WP2-1: A feasible way of doing this is by linking via the involved Use Cases, which exist as Epics in the Scrum project and as Custom labels for the Requirements in the COMPOSITION project. Linking the two manifestations of Use cases provides a reasonably consistent overview for concurrent updating of the status of the User requirements.

LL-WP2-2: A necessary step to take in projects such as COMPOSITION is to perform iterations for both requirements and use cases. Doing this provides a more complete view, and the final form that gets deployed adds more value for the involved partners.

5.2.2 New/Updated/Rejected Requirements

No requirements were added in WP2, while many were updated with new Custom Labels as described above. COM-147 was rejected as being a project issue, not a requirement. Two requirements not assigned to any WP were rejected, COM-126 as being Out of Scope, while COM-5 was withdrawn

5.3 Lessons Learned in WP3

WP3 works on modelling and simulation aspects of the solutions. CERTH is the WP Leader, and four Lessons Learned have been collected and verified from this WP.

Table 5: Lessons Learned in WP3

Org. LL ID	Experience and knowledge gained	Lesson Learned	RQs Affected
CERTH LL-WP3-1	An API was needed in order to enable storage, retrieval or deletion of system generated data from a common database by IIMS components.	Components using analysis data discovered a need for persistence of data.	COM-152, COM-153, COM-154
ATL LL-WP3-2	A thorough analysis of the needs of the end user and the conditions that exist on the shop floor. Also, the knowledge of the end users' processes, procedures and how they intend to use the component.	The end users have several requirements for the DSS and all the other COMPOSITION components, extending what is described in the DoA. Accurate definition of the end user requirements, before the development stage helped in the development of the DSS.	COM-92
ATL LL-WP3-3	Definition of the protocols needed for data communication throughout the COMPOSITION components. MQTT and HTTP chosen for their suitability. The protocols could not be used right away because the data format	The data follows the topic format provided by the DFM for both protocols. Problems with the implementation of the protocols and the message brokers. We solve them by constantly checking the broker for	[COM-93]

Org. LL ID	Experience and knowledge gained	Lesson Learned	RQs Affected
	changed many times, data unavailability, communication and server issues.	data and discovering how and what parameters affect the broker during communications. Some communication issues, solved by applying more resources.	
ATL LL-WP3-4	Development of the tools needed collaboration between perceived status of the shop floor and each use case. Through the development phase many aspects of the shop floor were studied and incorporated in the system.	The assets, procedures, people on the manufacturing environments shall be taken into consideration. The hierarchical structure which is provided by the DFM is used in the DSS for all the above. When an entity is not correctly mapped or something is described in the uses cases and does not exist in the DFM model, it is added in the tree form.	[COM-94]

5.3.1 Analysis of Lessons Learned

LL-WP3-1: A component that enables data exchanges among IIMS components and Data persistence store was not required in the initial technical design. The DFM API will implement this functionality using the API specification for the standard used in IIMS data messages.

LL-WP3-2: End users provided specific needs and insights for the DSS tool that were incorporated during the development phase.

LL-WP3-3: Test message topics are set in the message broker and the communication between the broker and the components is continuously tested.

LL-WP3-4: Understanding each use case creates new needs, and the models are constantly changing. Upon completion of all use cases a new model will be ready including the new findings.

5.3.2 New/Updated/Rejected Requirements

Requirements COM-152, COM-153 and COM-154 were added as a consequence of LL-WP3-1. The implementation of COM-93 and COM-94 was adapted as per LL-WP3-3 and LL-WP3-4. COM-92 was updated to reflect which Use Cases it applies to. COM-12 and COM-123 were rejected as Out of Scope.

5.4 Lessons Learned in WP4

Five Lessons Learned have been collected and verified in WP4, which is led by ATOS. The Work Package deals with security issues related to managing and exchanging of manufacturing data.

Table 6; Lessons Learned in WP4

Org. LL ID	Experience and knowledge gained	Lesson Learned	RQs Affected
CNET LL-WP4-1	In the open and dynamic COMPOSITION marketplace, agents need dynamic and continuous trust assessment for all involved entities exploiting both internal and external knowledge. This complements the Matchmaker rating.	We needed to add the reputation model to accommodate this.	COM-160 through COM-168
CNET LL-WP4-2	In the open and dynamic COMPOSITION marketplace, a system must be in place to verify the	The Security framework and blockchain implementation can be used to handle this.	COM-155, COM-156, COM-157

Org. LL ID	Experience and knowledge gained	Lesson Learned	RQs Affected
	sender of a message.		
ATL LL-WP4-3	The security Framework integrates all security in COMPOSITION for intra-factory users and marketplace stakeholders. COMPOSITION components also use the Security framework for authentication and authorisation.	During the development phase, there were two COMPOSITION users: persons or application. Both of them should be authenticated against the Security Framework.	[COM-139]
IN-JET LL-WP4-4	Agents in the marketplace must be able to store/retrieve messages on the blockchain.	APIs must be provided for this functionality.	COM-171
IN-JET LL-WP4-5	Agents must be able to publish their Public Key, and retrieve the Public Key of another agent.	APIs are needed for storing/retrieving public keys (different from the one for storing a message).	COM-172, COM-173

5.4.1 Analysis of Lessons Learned

LL-WP4-1: Several requirements resulted from this Lesson. The system may need additional components of this kind and must be open to extension.

LL-WP4-2: An integrated system allowing components to sign the messages they enter into the system and others to check the signature together with a PKI infrastructure is needed.

LL-WP4-3: Although all authentication is managed by Keycloak, different methods are used for the different security realms. Components are authenticated with trusted username and passwords, while users are authenticated during sign-in to the system. This Lesson Learned has influenced the implementation of COM-139, but not the RQ itself.

LL-WP4-4: Agents will be in charge of what to store on the blockchain, as is described in COM-171.

LL-WP4-5: The blockchain can be used for this. Details are defined in COM-172 and COM-173.

5.4.2 New/Updated/Rejected Requirements

COM-155, COM-156, COM-157, COM-160 through COM-168 and COM-171 through COM-173 were created based on Lessons Learned in WP4.

No requirements were rejected, while WP4 experiences affected the implementation of COM-15 and COM-139.

5.5 Lessons Learned in WP5

WP5 develops technologies for interoperability and data analysis. ISMB is the WP Leader, and four Lessons Learned have been collected and verified from this WP.

Table 7: Lessons Learned in WP5

Org. LL ID	Experience and knowledge gained	Lesson Learned	RQs Affected
FIT LL-WP5-1	While mock-ups and prototypes for UC-BSL-2 and UC-KLE-1 were developed, we realized that the existing requirement COM-34 (time frames for data pulls shall be freely configurable), which was documented for BSL at a workshop at Clonmel in 2016, is also required	Users have to be able to freely configure time frames for data pulls for their maintenance decision support. This is a common requirement and not limited to one pilot partner.	COM-34, COM-169, COM-170

Org. LL ID	Experience and knowledge gained	Lesson Learned	RQs Affected
	for Kleemann.		
ATL LL-WP5-2	Integration of HMIs will offer a better user experience to the users of the systems. It will also affect the sense of security and trust that COMPOSITION offers.	A uniform HMI at the disposal of the users facilitates direct interaction.	COM-108
ATL LL-WP5-3	User evaluation of HMI in both shop floors was performed, resulting in a need for changes.	Testing the HMIs for user attractiveness and experience on both shop floor for all use cases in an iterative process is necessary to achieve a useful result.	COM-108
NXW LL-WP5-4	Sensors equipped with a clock can provide the time instant when the observation happens	Analysis and correlation of data sensors can be facilitated by this additional piece of information	Several (directly and indirectly)

5.5.1 Analysis of Lessons Learned

LL-WP5-1: In some cases, it is required to have "hierarchically structured" requirements. It helps to keep track of their fulfilment. It may also help to spot requirements that should have a more general scope.

LL-WP5-2: While the design of HMIs provided a uniform experience, the common technical framework for HMIs was designed relatively late in the project. It helps to set up a common GUI structure.

LL-WP5-3: In the iterative process, the end users were asked to evaluate the developed HMIs, which were adapted according to the comments received.

LL-WP5-4: The time instant when an observation happens is a piece of information that shall be forwarded along the whole chain, from sensors to consumer components. Specific mechanisms to do this job are needed.

5.5.2 New/Updated/Rejected Requirements

As a result of LL-WP5-1, COM-34 was cloned as COM-170, while COM-169 was created to apply to the whole system.

The Lessons Learned in WP5 affected the implementation of COM-108, which was also updated to align Custom Labels.

Nine requirements were rejected as being Out of Scope: COM-26, COM-33, COM-65, COM-98, COM-99, COM-102, COM-112, COM-122 and COM-145.

Three requirements were rejected as Duplicates: COM-28, COM-115 and COM-119.

5.6 Lessons Learned in WP6

CNET leads WP6 in developing the collaborative ecosystem, and one Lesson Learned was reported in the second cycle. It is worth noting that some of the Lessons Learned reported in WP4 are also related to WP6.

Table 8: Lessons Learned in WP6

Org. LL ID	Experience and knowledge gained	Lesson Learned	RQs Affected
NXW LL-WP6-1	Marketplace Management Services needs to be initialised before they can be used by stakeholders	A "super-administrator" is needed to perform the initial setup	Several (directly and indirectly)

5.6.1 Analysis of Lessons Learned

LL-WP6-1: In some cases, it is required to have a special user with special permissions for configuring a SW component. It helps to manage administrative operations and setup of the component itself.

5.6.2 New/Updated/Rejected Requirements

Three requirements were rejected, COM-54 and COM-57 as being Out of Scope, while COM-66 was withdrawn.

5.7 Lessons Learned in WP7

Two Lessons Learned were collected from WP7 in the second cycle. The Work Package is responsible for integration of internal and external elements under the leadership of TNI-UCC.

Table 9: Lessons Learned in WP7

Org. LL ID	Experience and knowledge gained	Lesson Learned	RQs Affected
TNI-UCC LL-WP7-1	Cyber-attacks were highlighted as a concern by BSL in systems that are connected via the internet.	For operation to be allowed within factories sensing networks should be secure and any threats identified.	[COM-19]
TNI-UCC LL-WP7-2	To enable re-use, asset tracking tags need to be reconfigurable, so they can be re-assigned as items roll out of the production line.	The asset tracking tags that are secured to the tracked item need to have a method of identifying the item including serial numbers.	COM-158, COM-159

5.7.1 Analysis of Lessons Learned

LL-WP7-1: Cyber-attacks are of increasing concern everywhere, as exemplified in a manufacturing facility such as BSL where medical devices for human implant are being made. This potential threat will influence the way COM-19 is implemented, but not the substance of the high-level requirement, the Fit Criterion of which was already updated for specificity in the previous development cycle.

LL-WP7-2: In general, it is high-value items that need to be tracked. The item itself may have a high value, or the location of the item may impact a high-value process. Implementation of COM-158 additionally ensures identification and location of misplaced tracking devices.

5.7.2 New/Updated/Rejected Requirements

Two new requirements result from LL-WP7-2, COM-158 and COM-159.

No requirements were updated or rejected.

5.8 Lessons Learned in WP8

WP8 is in charge of reporting on the pilots and their evaluation, led by BSL. One Lesson Learned has been collected in the reporting period.

Table 10: Lessons Learned in WP8

Org. LL ID	Experience and knowledge gained	Lesson Learned	RQs Affected
ATL LL-WP8-1	It helps to maintain a close relationship with the pilot partners, so they can continuously evaluate progress. This process is additional to the main evaluation sessions, and it involves personnel directly involved in the requirements engineering process.	Regular teleconferences can make sure that the process is on the right track and that the developed tools will add value to the customer's process and/or portfolio of products.	-

5.8.1 Analysis of Lessons Learned

LL-WP8-1: Staying close to the potential customers enables a better understanding and helps ensuring that everyone is on the right track. This can be instrumental in bridging the well-known gap between the end users and the developers.

5.8.2 New/Updated/Rejected Requirements

No requirements were added, updated or rejected.

5.9 Lessons Learned in WP9

ATL leads WP9 in developing business models and coordinating dissemination and exploitation activities. Four Lessons Learned have been collected and verified from this WP.

Table 11: Lessons Learned in WP9

Org. LL ID	Experience and knowledge gained	Lesson Learned	RQs Affected
ATL LL-WP9-1	Clustering and collaboration with initiatives similar to the ongoing project gets better dissemination results.	Collaborative activities are translated into ability to reach larger audiences and reduction of required effort.	N/A
ATL LL-WP9-2	Iteration of the status of Intellectual Property Rights, IPR, is necessary.	Iterations may reveal that assets have changed form or ownership schema.	N/A
ATL LL-WP9-3	It is good to not setup Joint plans from the first steps, unless there is something really clear.	Partners do not need to provide joint exploitation plans, until there is enough level of understanding of the exploitable products and of the potential markets for them.	N/A
ATL LL-WP9-4	Exploitable assets need to be revised from the market point of view.	The technical solutions being developed in R&D projects like COMPOSITION need to be mapped with market needs.	N/A
ATL LL-WP9-5	Exploitation and Business Models workshops highlighted the need to consider potential clients at a level lower than Industry 4.0.	Some exploitable assets are suitable for more advanced/digitised potential clients than others.	N/A

5.9.1 Analysis of Lessons Learned

LL-WP9-1: Clustering and collaboration has been made easier with the support of the EFFRA CSA project, ConnectedFactories. This approach has led to knowledge sharing between projects and better dissemination results.

LL-WP9-2: It is important to establish an IPR registry early in the project. It is equally important to update this registry, as development progresses.

LL-WP9-3: This LL is much related to LL-WP9-2. As technical developments progress, it gets easier and safer to define interconnections and alliances that may lead to joint exploitation plans.

LL-WP9-4: It has been necessary to re-organise the exploitable assets from the point of view of potential clients in specific markets, in order to design the next steps of exploitation.

LL-WP9-5: The business models and the outreach strategies need to be adjusted to the respective target groups.

5.9.2 New/Updated/Rejected Requirements

No requirements were added, updated or deleted in WP9.

6 Status Update for COMPOSITION Requirements

The typical workflow for Volere requirements in the COMPOSITION JIRA is depicted in Figure 1.

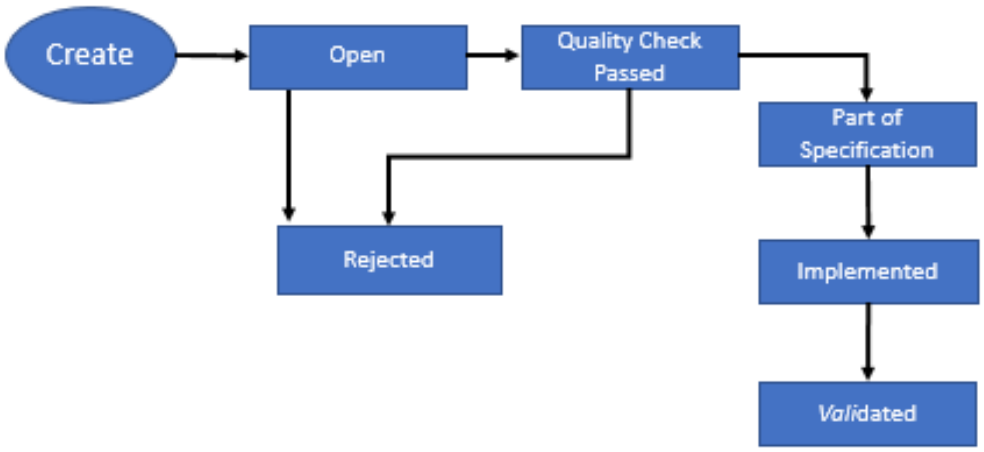


Figure 1: Typical JIRA workflow for COMPOSITION requirements

As of early December 2018, the JIRA repository contains 133 requirements, the status of which is depicted in Figure 2. Forty-seven requirements have been implemented, 71 are Part of Specification and 15 have passed Quality Check. The plan is to implement the latter category to the extent possible in the time remaining, while the group Part of Specification covers many requirements that have been partially implemented at this stage. Additionally, the repository contains 38 requirements that have been rejected, 22 as being Out of Scope, 11 as Duplicates and 5 that have been withdrawn.

The full list of requirements is attached in Appendix A.

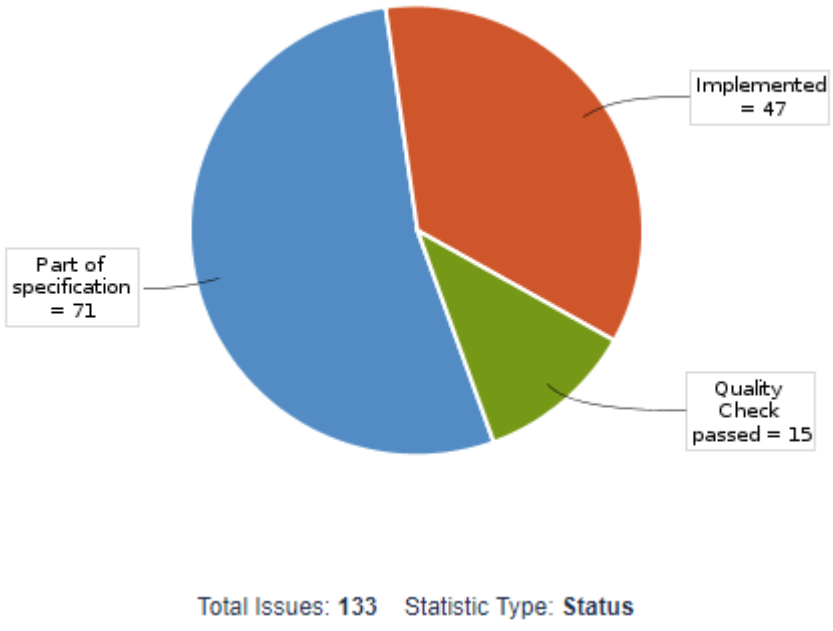


Figure 2: COMPOSITION Requirements by Status

6.1 Requirement Types

Of these 133 requirements, there are 2 Constraints and 2 Project Issues, while 93 requirements are functional, and 36 are non-functional with sub-types as follows:

- Operational – 25
- Performance – 3
- Security – 6
- Usability – 1
- Not defined – 1

6.2 Requirement and Use Case Priority

As detailed in *D2.5 Lessons Learned and Updated Requirements Report I*, requirement priority is aligned with the priority of the associated Use Cases. Priority of the Use Cases has not changed per se, but decisions have been made about their implementation based on the agreed priority. This has meant exclusion of one of the Tier2 Use Cases and many of the Tier3 Use Cases. These measures have been necessary to ensure finalising and demonstrating of the pilot applications within the project duration.

Two Business Modelling Use Cases have been added: UC-BM-1 which is a Subcase of UC-KLE-4 and UC-BM-6 which is a Subcase of UC-KLE-7. The Business Subcases will be implemented as part of the use cases they are derived form. The updated list can be seen in Table 12.

Table 12: Implementation of Use Cases

Tier	Use Case	Continue Implementation efforts?
Tier 1	UC-BSL-2 Predictive Maintenance	Yes
	UC-KLE-1 Maintenance Decision Support	Yes
	UC-KLE-4 Scrap metal collection and bidding process	Yes
	UC-ELDIA-1 Fill-level Notification – Contractual wood and recyclable materials management	Yes
Tier 2	UC-BSL-5 Equipment Monitoring and Line Visualisation	Yes
	UC-KLE-2 Delayed Process Step	No
	UC-BSL-3 Component Tracking	Yes
	UC-KLE-7 Ordering raw materials	Only simulate with software agents
	UC-ATL-3 Searching for recommended solutions	Yes
Tier 3	UC-KLE-3 Scrap Metal and Recyclable Waste Transportation	Yes
	UC-BSL-7 Automatic long term tracking of high value materials for physical security	Yes
	UC-BSL-4 Automatic Solder Paste Touch Up	No
	UC-ATL-1 Selling software/consultancy	No
	UC-ATL-2 Searching for solutions	No
	UC-ATL/NXW-1 Integrate external product into own solution	No
	UC-NXW-1 Decision support over marketplace	No
BM UCs	UC-BM-1 Waste notification, certificates and collection	Yes
	UC-BM-6 Contract fulfilment and supply chain management	Only simulate with software agents

6.3 Requirements per Work Package and Task

To further differentiate developer responsibility and provide an alternative type of overview, it was agreed to also indicate which task in the DoA each requirement belongs to. The distribution is shown in Table 13.

Table 13: Requirements per WP and Task

Work Package Total No. of RQs	Task	No. of RQs
WP2	T2.3	1
WP3	T3.2	9
	T3.3	8
27	T3.4	10
WP4	T4.1	9
	T4.2	6
	T4.4	2
19	T4.5	2
WP5	T5.1	11
	T5.2	3
	T5.3	16
	T5.4	9
48	T5.5	9
WP6	T6.1	1
	T6.2	24
	T6.4	5
37	T6.5	7
No WP		1

6.4 Components in COMPOSITION

One new component, Reputation & Trust Model, has been added to the COMPOSITION architecture, making a total of 24 entities as shown below. It is shown in red in the list and in the architectural view of the components and their interactions, see Figure 3. The new component is also an Innovation, as described in Chapter 7.

- Access Control
- Advanced Human Machine Interfaces
- Authentication
- Big Data Analytics
- BlockChain Connector
- Building Management System
- Data Collection System
- Deep Learning Toolkit
- Intrafactory Interoperability Layer
- Manufacturing Big Data Storage
- Manufacturing Decision Support System
- Market Event Broker
- Marketplace
- Marketplace UI

- MatchMaker
- Modelling
- Ontology
- Real Time Multi- Protocol Event Broker
- Reputation & Trust Model
- Requestor Agent
- Security Information and Event Management
- Service Catalog
- Simulation and Forecasting Tool
- Supplier Agent.

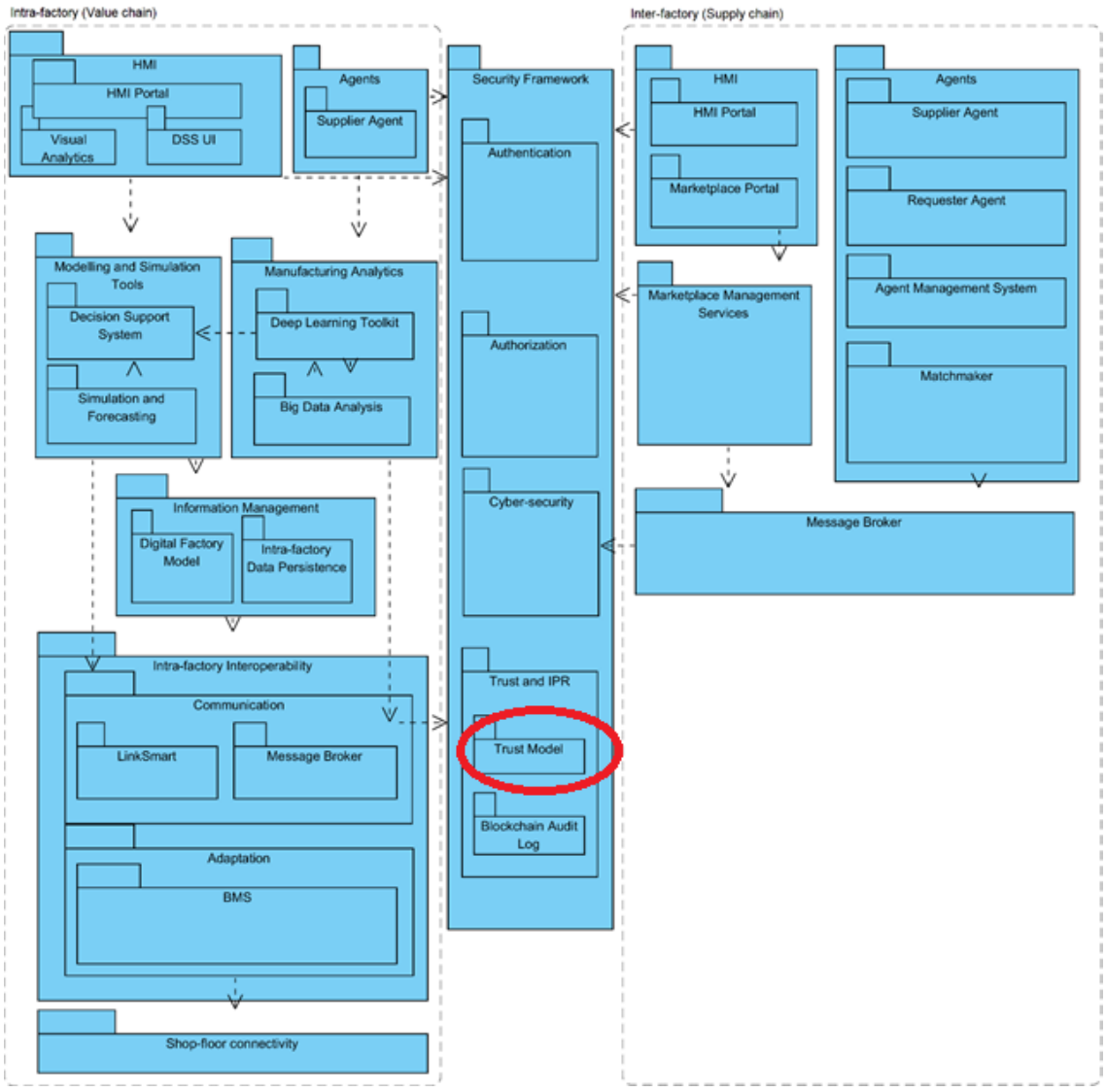


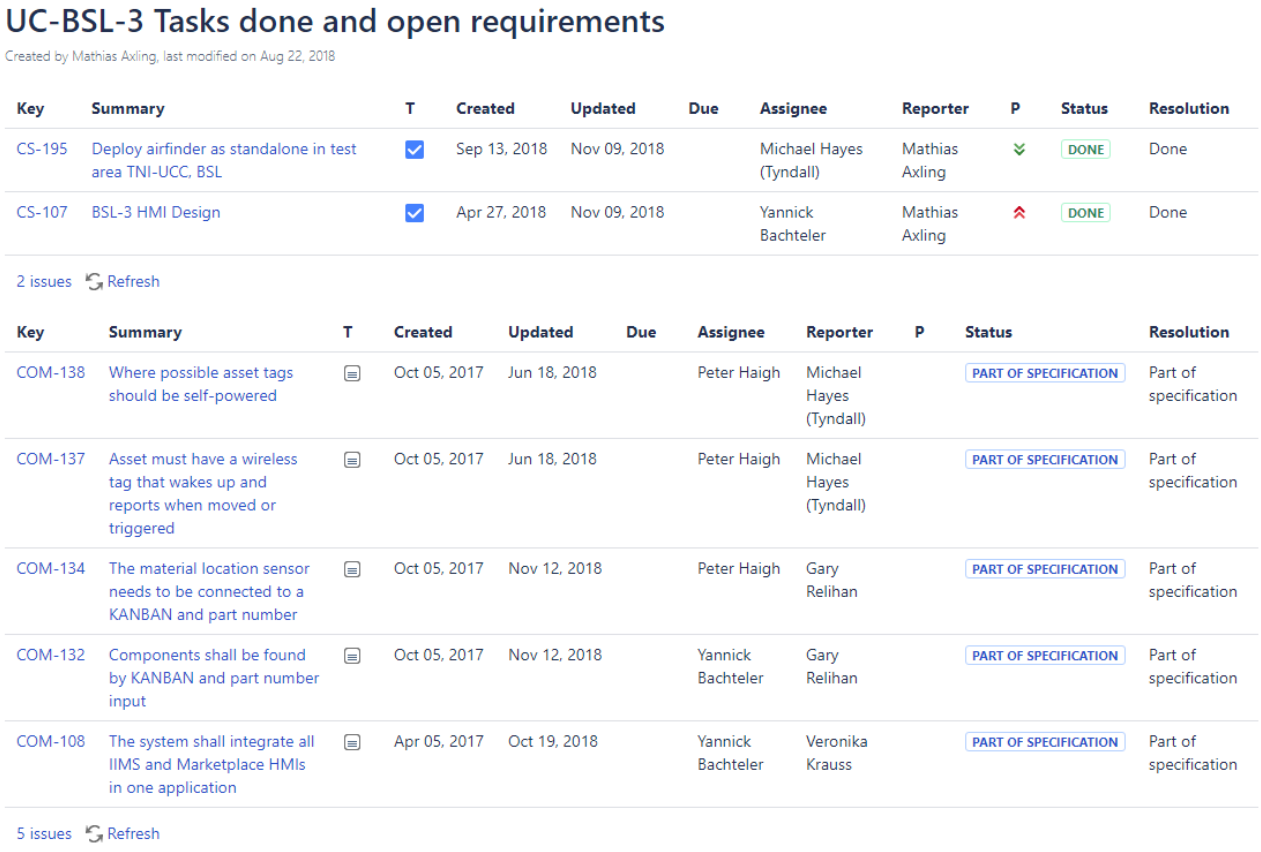
Figure 3: High-Level Functional View of Architecture

Figure 3 originates from *D2.4 The COMPOSITION Architecture Specification II*, where further architectural details are provided.

6.5 Associated JIRA Agile Requirements

As reported under Lessons Learned for WP2 (in Section 5.2), a convenient way of aligning the status of the User requirements in the JIRA COMPOSITION project with the more frequently updated entries in the JIRA Agile COMPOSITION Scrum project was devised and applied.

The alignment was achieved by linking the two JIRA projects through the associated Use Case(s), which are defined as Epics in the Scrum project and as Custom labels for the Requirements in the COMPOSITION project. An example depicting Tasks and Requirements for Use Case *UC-BSL-3 Component Tracking* is shown in Figure 4. The query compares finished tasks in the Scrum project with unresolved user requirements in the COMPOSITION project. These can thus be updated based on the progress made in the Scrum project, saving time and maintaining consistency.



UC-BSL-3 Tasks done and open requirements

Created by Mathias Axling, last modified on Aug 22, 2018

Key	Summary	T	Created	Updated	Due	Assignee	Reporter	P	Status	Resolution
CS-195	Deploy airfinder as standalone in test area TNI-UCC, BSL	☑	Sep 13, 2018	Nov 09, 2018		Michael Hayes (Tyndall)	Mathias Axling	⌄⌄	DONE	Done
CS-107	BSL-3 HMI Design	☑	Apr 27, 2018	Nov 09, 2018		Yannick Bachteler	Mathias Axling	⌃⌃	DONE	Done

2 issues Refresh

Key	Summary	T	Created	Updated	Due	Assignee	Reporter	P	Status	Resolution
COM-138	Where possible asset tags should be self-powered	≡	Oct 05, 2017	Jun 18, 2018		Peter Haigh	Michael Hayes (Tyndall)		PART OF SPECIFICATION	Part of specification
COM-137	Asset must have a wireless tag that wakes up and reports when moved or triggered	≡	Oct 05, 2017	Jun 18, 2018		Peter Haigh	Michael Hayes (Tyndall)		PART OF SPECIFICATION	Part of specification
COM-134	The material location sensor needs to be connected to a KANBAN and part number	≡	Oct 05, 2017	Nov 12, 2018		Peter Haigh	Gary Relihan		PART OF SPECIFICATION	Part of specification
COM-132	Components shall be found by KANBAN and part number input	≡	Oct 05, 2017	Nov 12, 2018		Yannick Bachteler	Gary Relihan		PART OF SPECIFICATION	Part of specification
COM-108	The system shall integrate all IIMS and Marketplace HMIs in one application	≡	Apr 05, 2017	Oct 19, 2018		Yannick Bachteler	Veronika Krauss		PART OF SPECIFICATION	Part of specification

5 issues Refresh

Figure 4: Linking of Tasks and User Requirements for UC-BSL-3

7 New Innovations in COMPOSITION

To ensure that the project has strong and continued focus on successful implementation of creative ideas, the COMPOSITION consortium has created a dedicated and strategic structure for managing the innovation activities. This process is described in *D2.2 Initial Requirements Specification.*

In the second prototype cycle, two new Innovations have been identified:

I-09 Blockchain-based Reputation and Trust Model

I-10 Real Time Multi-Protocol Event Broker

The existing Innovations have been reviewed, and most of them have been revised for precision. Specifically, the list of associated end user requirements has been updated to reflect that some of the original requirements have been rejected for various reasons. In the updated documents, only those requirements implemented or to be implemented are listed.

For two Innovations also their classification (Fulfilment of the DoA, Demoability, Exploitability and Usefulness in Pilot Applications) has been updated: in I-06, Usefulness in pilot applications has been changed from 5 to 4 and in I-07, Demoability has been changed from 3 to 4.

The new Innovations have been added to the COMPOSITION Innovation project in the JIRA installation hosted by IN-JET, and the existing entries have been updated as necessary.

A complete list of Innovations can be found in Appendix B.

8 Conclusion

This deliverable reports the Lessons Learned and changes in the requirements compared to the previous document in this series, *D2.5 Lessons Learned and Updated Requirements Report I*, including additions to the list of Innovations.

A total of 25 Lessons Learned has been reported in the second cycle. Compared with the list of requirements in D2.5, 22 requirements have been added, and 20 requirements have been rejected.

Good progress has been made since the issue of D2.5, with no requirements still in status Open, 47 requirements implemented, 71 now Part of Specification and 15 having passed the Quality Check. To the extent possible in the time remaining, the latter category will be made Part of Specification and subsequently implemented.

Use Case priority has not changed, but decisions have been made about their implementation based on the agreed priority. This has meant exclusion of one of the Tier2 Use Cases and many of the Tier3 Use Cases to ensure there is enough time left to implement the remaining Use Cases. Two Business Modelling Use Cases have been added as Subcases to existing inter-factory Use Cases.

Two Innovations have been identified in this development cycle, I-09 Blockchain-based Reputation and Trust Model and I-10 Real Time Multi-Protocol Event Broker.

A final update of the COMPOSITION requirements engineering work will be provided as part of *D1.8 Final Progress Report for the Commission*.

9 List of Figures and Tables

9.1 Figures

9.2 Tables

10 References

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

Appendix A – Updated List of Requirements

Key	Summary	Requirement Type	Priority	Status	WP
COM-173	Agents on the marketplace should be able to retrieve the public key of other agents from the blockchain	Functional	Major	Part of specification	WP4
COM-172	Agents on the marketplace should be able to publish their public key on the blockchain	Functional	Major	Part of specification	WP4
COM-171	Agents on the marketplace should be able to store/retrieve messages from the blockchain	Functional	Major	Part of specification	WP4
COM-170	Time frames for data pulls shall be freely configurable (KLE)	Non-Functional -> operational	Major	Implemented	WP5
COM-169	System shall allow user to freely configure time frames for data pulls.	Non-Functional -> operational	Major	Implemented	WP5
COM-168	'Bad' agents should not be able to leave the marketplace, and re-join as different agents	Functional	Major	Part of specification	WP4
COM-167	New agents should not be penalized	Functional	Major	Part of specification	WP4
COM-166	Reputation values must represent the evolution of the agent's behaviour	Functional	Major	Part of specification	WP4
COM-165	Involved agents must use the same aggregator operator	Functional	Major	Part of specification	WP4
COM-164	Agents should not be able to compute, or modify, their own reputation value	Functional	Major	Part of specification	WP4
COM-163	Reputation lifetime must be taken into account	Functional	Major	Part of specification	WP4
COM-162	Local reputations should be available to all the agents belonging to the marketplace, if needed	Functional	Major	Part of specification	WP4
COM-161	Incorrect reputation values should be detected (rater's credibility), when used	Functional	Major	Part of specification	WP4
COM-160	Reputation and ratings should discriminate agents' behaviour	Functional	Major	Part of specification	WP4
COM-159	It must be configurable which assets are to be tracked	Non-Functional -> security	Minor	Quality Check passed	WP4

Key	Summary	Requirement Type	Priority	Status	WP
COM-158	The system shall be able to create alerts whenever tracking devices are misplaced	Functional	Minor	Quality Check passed	WP4
COM-157	All message senders should publicise their public key	Functional	Major	Part of specification	WP6
COM-156	All messages received in the system should be verified	Functional	Major	Part of specification	WP6
COM-155	All messages sent in the system should be signed	Functional	Major	Part of specification	WP6
COM-154	DFM API should ensure that the data exchange will be based on the DFM schema	Functional	Major	Implemented	WP3
COM-153	DFM API should provide web services for data storing, retrieval or deletion	Functional	Major	Implemented	WP3
COM-152	IIMS components should be able to store/retrieve data to/from DFM instances	Functional	Major	Implemented	WP3
COM-151	System shall allow recording and searching of equipment issues	Functional	Medium	Part of specification	WP5
COM-150	The HMI shall enable Technician to view and search for past equipment issues	Functional	Medium	Quality Check passed	WP5
COM-149	COMPOSITION sensors' data should be described using common formats	Non-Functional -> usability	Medium	Implemented	WP3
COM-148	Matchmaker and Agents components should be able to access and manipulate Marketplace Ontology	Functional	Medium	Implemented	WP6
COM-147	ELDIA provides criteria for truck selection	Project Issue -> task	Major	Rejected - Withdrawn	
COM-146	The system shall allow the user to provide specifications for bidders for scrap metal	Non-Functional -> operational	Major	Part of specification	WP5
COM-145	The system shall enable to stop production	Functional	Nice to have	Rejected	WP5
COM-144	The line visualization shall compare the actual processed units to the target ones	Functional	Minor	Part of specification	WP5
COM-143	The system shall know how many assets are currently processed by machine	Functional	Minor	Part of specification	WP5
COM-142	The system shall know how many assets can be processed by machine and by time	Functional	Minor	Part of specification	WP5
COM-141	End users shall define the limits of attributes related to fan noise, RPM and power	Non-Functional	Major	Implemented	WP5

Key	Summary	Requirement Type	Priority	Status	WP
	consumption, which define when an alarm is raised				
COM-140	Fan alarms shall be raised if RPM, power consumption and noise of the fan exceed their limits	Functional	Major	Implemented	WP5
COM-139	All components with a public endpoint shall enforce authentication and authorization	Non-Functional -> security	Major	Part of specification	WP4
COM-138	Where possible asset tags should be self-powered	Functional	Medium	Part of specification	WP5
COM-137	Asset must have a wireless tag that wakes up and reports when moved or triggered	Functional	Medium	Part of specification	WP5
COM-136	The system shall also visualize up or down status of equipment which is currently not visualized in BSL systems	Functional	Medium	Rejected - Duplicate	
COM-135	The system shall visualize the state of all equipment on one screen: up or down	Functional	Medium	Part of specification	WP5
COM-134	The material location sensor needs to be connected to a KANBAN and part number	Functional	Medium	Part of specification	WP5
COM-133	The location of a component shall be visualized on a map with area names on it	Functional	Medium	Implemented	WP5
COM-132	Components shall be found by KANBAN and part number input	Functional	Medium	Implemented	WP5
COM-131	Comments and updates can be added to the equipment Downtime log	Functional	Minor	Quality Check passed	WP5
COM-130	Equipment issues can be reported manually	Functional	Minor	Quality Check passed	WP5
COM-129	System shall assist Technician in solving equipment issues	Functional	Medium	Quality Check passed	WP5
COM-128	Reminders for equipment resolution are issued	Functional	Minor	Quality Check passed	WP5
COM-127	Alarms/Notifications are forwarded to subscribers depending on their impact level	Functional	Minor	Quality Check passed	WP5
COM-126	IIMS is able to obtain relevant information from Asset Management System	Functional	Minor	Rejected - Out of Scope	
COM-125	Equipment Monitoring Screen is able to display predictive maintenance information for the machines where it is available	Functional	Medium	Implemented	WP5

Key	Summary	Requirement Type	Priority	Status	WP
COM-124	Users on the big visualisation screen are logged out automatically after defined time period and the view returns to the public overview screen	Functional	Medium	Quality Check passed	WP5
COM-123	To resolve an equipment issue a given set of conditions must be met	Functional	Medium	Rejected - Out of Scope	WP3
COM-122	Equipment status changes automatically based on light tower and alarm information	Functional	Medium	Rejected - Out of Scope	WP5
COM-121	A downtime log should be available for each equipment	Functional	Medium	Quality Check passed	WP5
COM-120	Notifications are sent to technicians	Functional	Medium	Quality Check passed	WP5
COM-119	Persons with a viable login can define their equipment subscriptions	Functional	Minor	Rejected	WP5
COM-118	System should allow only logged in users to create, edit and view comments related to downtime log	Functional	Medium	Quality Check passed	WP5
COM-117	Details about equipment can be accessed when equipment is selected on overview screen	Functional	Minor	Quality Check passed	WP5
COM-116	The equipment monitoring overview screen is able to show the flow of the product (PCBAs) through the lines in real time	Functional	Medium	Quality Check passed	WP5
COM-115	The equipment monitoring overview screen is able to show the relevant information on the equipment in real time	Functional	Minor	Rejected - Duplicate	WP5
COM-114	Equipment representation in IIMS can be adapted to line moves	Functional	Minor	Implemented	WP3
COM-113	The IIMS shall automatically send an NC report to a pre-defined list of recipients	Functional	Medium	Rejected - Out of Scope	
COM-112	The system shall visualize idle machines in KLE's production process	Functional	Medium	Rejected - Out of Scope	WP5
COM-111	The system shall provide an NC overview to the user	Functional	Medium	Rejected - Out of Scope	
COM-110	The NC monitoring visualisation screen should offer filter options to the user	Functional	Medium	Rejected - Out of Scope	
COM-108	The system shall integrate all IIMS and Marketplace HMIs in one application	Functional	Major	Part of specification	WP5
COM-107	The NC monitoring visualisation screen shall be operable from close range and far distance	Functional	Medium	Rejected - Out of Scope	

Key	Summary	Requirement Type	Priority	Status	WP
COM-106	The NC visualisation screen shall be usable on different screen sizes	Functional	Medium	Rejected - Out of Scope	
COM-105	The IIMS shall be able to generate alerts if the colour indication of a Production Unit changes to Red	Functional	Major	Rejected - Duplicate	
COM-104	The Non-Conformance Dashboard shall reflect the number of NCs as green, amber or red	Non-Functional -> look and feel	Medium	Rejected - Out of Scope	
COM-103	The IIMS shall be able to store and retrieve photos of NCs	Functional	Medium	Rejected - Out of Scope	
COM-102	The Non-Conformance Dashboard shall display NCs for each Production Unit	Functional	Medium	Rejected - Out of Scope	
COM-101	It must be possible to reset an alert when the necessary measures have been taken	Functional	Major	Part of specification	WP5
COM-100	Alerts shall be sent by email or SMS to predefined actors/roles	Functional	Major	Implemented	WP3
COM-99	An alert shall be displayed if the status of equipment or production unit changes	Functional	Major	Rejected - Out of Scope	WP5
COM-98	Time-to-failure limits for the measured parameters can be manually defined for the equipment in the production units	Functional	Major	Rejected - Out of Scope	WP5
COM-97	Visualization screen shall display status of machines in the production line	Functional	Major	Part of specification	WP5
COM-96	The IIMS system automatically advises the contractor of the time for scrap metal pick-up	Functional	Major	Part of specification	WP3
COM-95	DSS will analyse events, suggestions and measures	Functional	Major	Implemented	WP3
COM-94	Interfaces shall facilitate machine learning toolkit forecast	Non-Functional -> operational	Major	Rejected - Out of Scope	
COM-93	DSS will communicate/exchange the data	Functional	Major	Implemented	WP3
COM-92	Production of Simulated Data derived from Hypothetical Scenarios based on Current Trends	Non-Functional -> operational	Major	Implemented	WP3
COM-91	Supplying companies advertise their products/services in specific topic(s) within the ecosystem	Functional	Nice to have	Part of specification	WP6
COM-90	Ecosystem components should be deployed as Docker images	Non-Functional -> operational	Medium	Part of specification	WP6
COM-89	Matchmaker shall return a result within a reasonable time frame	Non-Functional	Major	Implemented	WP6

Key	Summary	Requirement Type	Priority	Status	WP
		-> performance			
COM-88	Different decision criteria for supplier selection are supported by the Matchmaker	Functional	Major	Implemented	WP6
COM-87	Different similarity algorithms and metrics shall be supported by the Matchmaker	Functional	Major	Implemented	WP6
COM-86	The Matchmaker shall apply both syntactic and semantic matching	Functional	Major	Implemented	WP6
COM-85	Service ontology has to describe manufacturing service capabilities in different levels of abstraction (e.g. process level, machine level, shop level and supplier level)	Functional	Major	Implemented	WP6
COM-84	COMPOSITION's IIMS shall be able to store and retrieve large amounts of data	Non-Functional -> operational	Major	Rejected - Withdrawn	
COM-83	Zooming functionality shall be supported by the visual analytics module	Functional	Major	Implemented	WP5
COM-82	Visualization presented to the user shall be synchronized	Functional	Major	Implemented	WP5
COM-81	The visual analytics module shall import data coming from the simulation and prediction engine	Functional	Major	Implemented	WP5
COM-80	Composition UIs shall be usable [-req to be deleted-]	Non-Functional -> usability	Major	Rejected - Withdrawn	
COM-79	The Decision Support System shall receive data via web-services and they shall be processed in real time	Functional	Major	Part of specification	WP3
COM-78	The Decision Support System shall import data coming from the simulation and prediction engine	Functional	Major	Part of specification	WP3
COM-77	The simulation and prediction engine shall apply machine learning techniques on production line's historical data	Functional	Major	Implemented	WP3
COM-76	Monitoring framework and DSS shall be able to display production line assets and equipment as they represented in DFM	Functional	Major	Part of specification	WP3
COM-75	Sensors from production line shall provide data to the simulation and forecasting tool	Functional	Major	Rejected - Duplicate	
COM-74	The simulation and prediction engine shall use historical data about production processes	Functional	Major	Implemented	WP3
COM-73	The simulation and prediction engine shall use data coming from sensors	Functional	Major	Implemented	WP3
COM-72	The simulation and prediction engine shall import process models and Digital Factory models	Functional	Major	Part of specification	WP3
COM-71	Simulation shall support also hypothetical scenarios for both production and	Functional	Major	Part of	WP3

Key	Summary	Requirement Type	Priority	Status	WP
	logistics chains			specification	
COM-70	Simulation data shall be exported for being visualized and explored	Functional	Major	Implemented	WP5
COM-69	COMPOSITION DFM has to be multi-scaled	Non-Functional -> operational	Major	Implemented	WP3
COM-68	Ontologies shall be implemented in OWL language	Non-Functional -> operational	Major	Implemented	WP6
COM-67	Business processes must be described using the BPMN standard	Non-Functional -> operational	Major	Part of specification	WP3
COM-66	Products/services offered via the ecosystem are COMPOSITION compatible	Non-Functional -> operational	Medium	Rejected - Withdrawn	
COM-65	The ranking component includes a machine learning system to continuously improve the recommendations it gives out.	Non-Functional -> usability	Nice to have	Rejected - Out of Scope	WP5
COM-64	The system provides an automatic ranking of the suppliers to the buyers, based on customers' satisfaction and feedback	Functional	Nice to have	Part of specification	WP6
COM-63	The system provides an automatic ranking of the suppliers to the buyers, based on the buyers' criteria.	Functional	Major	Part of specification	WP6
COM-62	COMPOSITION Marketplace supports participants services' description and potential matching of participants based on these services	Functional	Medium	Part of specification	WP6
COM-61	Suppliers' product/services shall be matched with a potential customers' needs/problems.	Non-Functional -> operational	Major	Part of specification	WP6
COM-60	Supplying companies register their products/services in specific topic(s) within the ecosystem.	Non-Functional -> operational	Major	Rejected - Duplicate	
COM-59	Supplying companies register their products/services in specific topic(s) within the ecosystem	Non-Functional -> operational	Major	Part of specification	WP6
COM-58	The needs and requirements of companies shall be registered/published within the ecosystem	Non-Functional -> operational	Major	Part of specification	WP6
COM-57	The contractor shall be able to create offers in the IIMS system	Functional	Minor	Rejected	WP6
COM-56	The IIMS system automatically informs the contractor the fill level of the metal scrap containers	Functional	Major	Part of specification	WP3
COM-55	The contractor shall inform the IIMS when the collection of a metal scrap container is completed	Functional	Major	Implemented	WP2

Key	Summary	Requirement Type	Priority	Status	WP
COM-54	Purchasing Manager maintains the list of approved contractors	Functional	Major	Rejected - Out of Scope	
COM-53	The Maintenance Manager shall receive information that the scrap metal container is full	Functional	Major	Part of specification	WP5
COM-52	The COMPOSITION Marketplace Management System shall enable stakeholders to visualize existing public, closed markets	Functional	Major	Part of specification	WP6
COM-51	The COMPOSITION Marketplace Management System shall enable stakeholders to define closed marketplaces	Functional	Major	Part of specification	WP6
COM-50	The COMPOSITION Marketplace Management System shall enable stakeholder to gain access to the COMPOSITION open marketplace	Functional	Major	Part of specification	WP6
COM-49	Agents may be part of an organization or group of agents	Functional	Major	Part of specification	WP6
COM-48	Agents shall be individually addressable	Functional	Major	Implemented	WP6
COM-47	Agent Communication Language shall have a standard and well-defined semantics	Non-Functional -> operational	Major	Implemented	WP6
COM-46	Agent Communication Language shall be based on messages	Non-Functional -> operational	Major	Implemented	WP6
COM-45	Agent Communication Language shall be agnostic to transport	Non-Functional -> operational	Major	Implemented	WP6
COM-44	Agents shall be writable in any programming language	Non-Functional -> operational	Major	Part of specification	WP6
COM-43	Message transport shall support several transport protocols	Non-Functional -> operational	Major	Part of specification	WP6
COM-42	AMS shall gracefully scale	Non-Functional -> performance	Major	Implemented	WP6
COM-41	AMS and DF shall be provided at the container (marketplace) level	Functional	Major	Implemented	WP6
COM-40	Message transport shall support authentication / encryption / access control	Non-Functional -> operational	Major	Part of specification	WP6
COM-39	Message transport shall be general purpose	Non-Functional -> operational	Major	Part of specification	WP6

Key	Summary	Requirement Type	Priority	Status	WP
COM-38	Message transport shall be scalable	Non-Functional -> performance	Major	Part of specification	WP6
COM-37	Redundancy shall be kept as low as possible	Non-Functional -> operational	Major	Part of specification	WP6
COM-36	Agent containers shall be natively distributed	Non-Functional -> operational	Major	Implemented	WP6
COM-35	Agents must not be forced to run in a single, pre-defined location	Non-Functional -> operational	Major	Implemented	WP6
COM-34	Time frames for data pulls shall be freely configurable (BSL)	Non-Functional -> operational	Major	Implemented	WP5
COM-33	Items from BSL's inventory shall be requested automatically	Non-Functional -> operational	Medium	Rejected – Out of Scope	WP5
COM-32	Data output format of Deep Learning Toolkit should be homogenized	Functional	Minor	Part of specification	WP5
COM-31	Data input format of Deep Learning Toolkit should be homogenized	Functional	Major	Part of specification	WP5
COM-30	Data classification report latency	Non-Functional -> operational	Medium	Part of specification	WP5
COM-29	Person in charge of the production process at BSL shall be contacted automatically if issues are detected	Functional	Major	Rejected - Duplicate	
COM-28	BSL's production data shall be observable in real time per machine	Functional	Major	Rejected - Duplicate	WP5
COM-27	Provide enough data for training artificial neural networks	Constraint -> assumption	Blocker	Part of specification	WP5
COM-26	Batches shall be identifiable in BSL's production line	Functional	Medium	Rejected - Out of Scope	WP5
COM-25	Items shall be trackable also when not located in BSL's production lines	Non-Functional -> operational	Medium	Implemented	WP5
COM-24	Items on the line should be trackable in real time in BSL's production process	Non-Functional -> operational	Medium	Rejected - Duplicate	
COM-23	Documentation of non conformance (NC) should be done automatically in BSL's	Non-Functional	Major	Rejected -	

Key	Summary	Requirement Type	Priority	Status	WP
	production process	-> operational		Duplicate	
COM-21	The IIMS shall integrate different heterogeneous data sources	Non-Functional -> operational	Major	Part of specification	WP5
COM-20	The system shall detect patterns in data, without the need to explicitly search for them	Functional	Major	Implemented	WP5
COM-19	The system shall be protected against cyber attacks	Non-Functional -> security	Major	Part of specification	WP4
COM-18	Data transactions shall be immutable	Non-Functional -> security	Major	Part of specification	WP4
COM-17	Data transactions shall be traceable	Non-Functional -> security	Major	Part of specification	WP4
COM-16	Only a specific group of receivers shall have access to data	Non-Functional -> security	Major	Part of specification	WP4
COM-15	The processes and stakeholders of the pilots shall be modelled	Project Issue	Major	Part of specification	WP3
COM-14	A common methodology and notation for modelling shall be established	Project Issue	Major	Implemented	WP3
COM-13	Optimal routes for collecting bin shall be recommended to KLE's worker	Functional	Minor	Part of specification	WP3
COM-12	The system shall simulate production processes	Functional	Major	Rejected - Out of Scope	WP3
COM-11	The system shall visualize bottlenecks in KLE's production process	Functional	Major	Rejected - Duplicate	
COM-10	The system shall monitor the status of KLE's polishing machine	Functional	Major	Implemented	WP3
COM-9	The system shall suggest to maintain machines before they break	Functional	Major	Implemented	WP3
COM-8	On request, information on fill level of the metal scrap container shall be provided	Functional	Major	Quality Check passed	WP5
COM-7	The employee shall be informed in which metal scrap container to dispose of the bin content	Functional	Major	Part of specification	WP3
COM-6	The employee shall be informed when a metal scrap bin is full	Functional	Major	Part of specification	WP5

Key	Summary	Requirement Type	Priority	Status	WP
COM-5	The offers for scrap metal shall be displayed for approval by the purchasing responsible	Functional	Major	Rejected - Withdrawn	
COM-4	Maintenance Data about machines shall be continuously collected	Functional	Major	Implemented	WP5
COM-3	COMPOSITION Marketplace(s) should have possibility of restricted access	Constraint -> stakeholders	Major	Part of specification	WP6
COM-2	The IIMS shall be able to forecast when the container is full	Functional	Major	Part of specification	WP3
COM-1	The fill level of metal scrap containers shall be monitored	Functional	Major	Part of specification	WP5

Appendix B – Innovations in COMPOSITION

This List contains all Innovations presently identified in COMPOSITION, including the new additions I-09 and I-10.

I-01 Supply Chain Blockchain

Description

The COMPOSITION architecture proposes to adapt and deploy a blockchain implementation as the central component of its log-oriented architecture. The log-oriented architecture will provide non-repudiation of transactions and distributed trust in the COMPOSITION marketplace for manufacturing and supply chains. In this context, the blockchain will be used to provide an audit trail for manufacturing and supply chain data, enabling both product data traceability and secure access for stakeholders. The blockchain shall be configurable for both public and consortium validation of blocks. Authentication in COMPOSITION marketplace shall be integrated with the blockchain.

Major functionalities

The following prioritised functionalities are enabled by the innovation:

Distributed trust in the agent marketplace

Decentralized log of agent transactions

Responsible WP

WP4

Innovation classification

Classify the innovation according to its dimensions:

Classification	Score
Fulfilment of the DOA	5
Demoability	3
Exploitability	4
Usefulness in pilot applications	3

Associated end user application requirements

COM-19: The system shall be protected against cyber attacks
COM-18: Data transactions shall be immutable
COM-17: Data transactions shall be traceable

I-02 Matchmaking Broker

Description

The Matchmaker, described in the Description of Action as the COMPOSITION Broker, will be responsible for connecting buyers and sellers of manufacturing services, raw materials and products towards building global supply chains. This will be achieved by applying both syntactic and semantic matching (both taxonomy-based and feature-based) in terms of manufacturing capabilities, in order to find the best possible supplier to fulfil a request for a service, raw materials or products involved in the supply chain. For measuring the similarity among offers and requests, well-established weighted similarity algorithms and metrics will be used and will be further extended if needed.

Different decision criteria for supplier selection according to several qualitative and quantitative factors will be considered (e.g., size of buyer's organization, cost, time, distance, due date, quality, price, technical capability, financial position, past performance, attitude, flexibility, etc.). The agent marketplace of COMPOSITION is not centralized as is the typical case. The Matchmaking Broker acts as a decentralized Directory Facilitator within the agent marketplace.

The Matchmaker offers the possibility to take into consideration matching by factors not known to the agents (buyer organization), e.g., externalities (environment, job markets, etc.) in the choice of supplier selection.

Special focus will be given in dealing with the trade-off between performance and quality of matching, in order to provide responses in a reasonable time while at the same time minimization of computational complexities will be targeted.

Major functionalities

The following prioritised functionalities are enabled by the innovation:

Matching buyers and suppliers using types of information not known to the agents, e.g. environmental rating of suppliers or ratings/past performance supplied by other parties.

Responsible WP

WP6, The Process Modelling and Monitoring Framework developed in WP3 will be used as input.

Innovation classification

Classify the innovation according to its dimensions:

Classification	Score
Fulfilment of the DOA	5
Demoability	4
Exploitability	4
Usefulness in pilot applications	4

Associated end user application requirements

COM-89 Matchmaker shall return a result within 5 seconds
COM-88 Different decision criteria for supplier selection are supported by the Matchmaker
COM-87 Various similarity algorithms and metrics shall be supported by the Matchmaker
COM-86 The Matchmaker shall apply both syntactic and semantic matching
COM-64 The system provides an automatic ranking of the suppliers to the buyers, based on customers' satisfaction and feedback

I-03 Manufacturing Decision Support System

Description

The Decision Support System (DSS) will combine information from the factory floor as well as from all stakeholders involved in the complete supply chain, interpreted by the semantic models produced in the COMPOSITION project. The aim of the DSS is to take a step forward towards a better understanding of the involved manufacturing processes and operations, the contribution of individual links of the supply chain, the effect of process monitoring in productivity, to facilitate communication and knowledge sharing among departments with different roles and responsibilities, the maintenance requirements and procedures and the detection of daily production details and flaws (ATL). Data will be processed combining big data analysis and deep learning. The data will be received using industry-standard web-services protocols (SOAP/REST) and formats (XML and JSON) and stored (if possible) in order to create a historical collection of data to be processed by the analysis tools. They will be coupled with the associated requests to certain parts of the supply chain, SOP (standard operating procedures) and response strategies, in order to offer feedback to the involved internal or external suppliers, in terms of actionable knowledge and recommendations, including maintenance operations and schedules.

Major functionalities

The following prioritised functionalities are enabled by the innovation:

Using the combination of several different technologies to visualize, analyse and forecast the performance of the factory and its supply chain.

Responsible WP

WP3

Innovation classification

Classify the innovation according to its dimensions:

Classification	Score
Fulfilment of the DOA	5
Demoability	5
Exploitability	4
Usefulness in pilot applications	5

Associated end user application requirements

COM-93 DSS will analyse data into a set of indicators and will provide a set of communications to other components
COM-92 Production of Simulated Data
COM-79 The Decision Support System shall receive data via web-services and they shall be processed in real time
COM-78 The Decision Support System shall import data coming from the simulation and prediction engine
COM-70 Simulation data shall be exported for being visualized and explored
COM-13 Optimal routes for collecting bin shall be recommended to KLE's worker
COM-9 The system shall suggest to maintain machines before they break
COM-7 The employee shall be informed in which metal scrap container to dispose of the bin content
COM-6 The employee shall be informed when a metal scrap bin is full

I-04 Dynamic Agent-based Marketplace

Description

Factories that are using the COMPOSITION system will be connected, creating a virtual market in support of the ecosystem of stakeholders. The COMPOSITION ecosystem is enabled by a dynamic interoperable agent-based marketplace, where each party is represented by one or more agents, endowed with sufficient autonomy to set up exchanges and to enable new economic collaboration models.

The goal is to improve the process of establishing and tailoring supply chains to dynamically changing product lines and open new collaboration opportunities for every involved stakeholder. This is an autonomous and distributed approach which will enable more efficient operation of already existing, consortia of companies contributing to a single manufacturing process, but it will also open up possibilities for new partners to attain new business on the basis of a matching mechanism for requested and offered products and services.

Major functionalities

The following prioritised functionalities are enabled by the innovation:

- *Open new business possibilities for external stakeholders, i.e. actors not yet part of a specified supply chain*
  - *Permits new partners to participate in existing supply chains*
- *Enables discovery of new stakeholders*
- *Stakeholders in existing supply chains can exchange services / data more effectively*
- *Collaboration and business interactions can be dynamically set up.*
- *Agents can autonomously perform transactions with other agents to optimise supply chains.*
  - *Automatic negotiation of terms of service for supply partners*
- *Provide a loosely coupled, decentralized agent marketplace where stakeholders are in control of their agent development and deployment.*

Responsible WP

WP6

Innovation classification

Classify the innovation according to its dimensions:

Classification	Score
Fulfilment of the DOA	5
Demoability	4
Exploitability	4
Usefulness in pilot applications	5

Associated end user application requirements

COM-91 Supplying companies advertise their products/services in specific topic(s) within the ecosystem
COM-90 Ecosystem components should be deployed as Docker images
COM-62 All types of companies (buyers and suppliers) shall be subscribed to specific topics in the ecosystem according to their interests and needs
COM-59 Supplying companies register their products/services in specific topic(s) within the ecosystem
COM-58 The needs and requirements of companies shall be registered/published within the ecosystem
COM-52 The COMPOSITION Marketplace Management System shall enable stakeholders to visualize existing public, closed markets
COM-51 The COMPOSITION Marketplace Management System shall enable stakeholders to define close

marketplaces
COM-50 The COMPOSITION Marketplace Management System shall enable stakeholder to gain access to the COMPOSITION open marketplace
COM-49 Agents might be part of an organization or group of agents
COM-48 Agents shall be individually addressable
COM-47 Agent Communication Language shall have a standard and well defined semantics
COM-46 Agent Communication Language shall be based on messages
COM-45 Agent Communication Language shall be agnostic to transport
COM-44 Agents shall be writable in any programming language
COM-42 AMS shall gracefully scale
COM-41 AMS and DF shall be provided at the container (marketplace) level
COM-37 Redundancy shall be kept as low as possible
COM-36 Agent containers shall be natively distributed
COM-35 Agents must not be forced to run in a single, pre-defined location
COM-3 Ecosystem: multiple marketplaces; participation by invitation only

I-05 Incorporation of Prediction and Forecast into Decision Support Toolkit

Description

Hypothetical scenarios based on current trends will be used to help on manufacturing processes optimisation (simulation – based optimisation) and make the simulation engine ready to export simulation data according to monitoring framework specifications. Furthermore, indicators, events and suggestions will be provided to the individual links in the supply chain. Metrics about the monitoring process, as well as communication of the data, among departments with different roles and responsibilities, such as the maintenance requirements and procedures and the detection of daily production details and flaws will be given. Moreover, the developed interfaces shall facilitate the machine learning toolkit in forecast and predictions. They shall be designed easing the exported, from them, data to be exploitable in the machine learning process.

Major functionalities

The following prioritised functionalities are enabled by the innovation:

Combine data analytics and rule engine to create a set of indicators and prescribed actions. The data analysis will exploit the various sources of data and will elaborate the machine learning toolkit into an intelligent decision support system.

Create a simulation engine based on BPMN flow and simulated data to visualise different scenarios and what-if analysis.

Produce actionable data to other components, like events or notifications.

Responsible WP

WP3

Innovation classification

Classify the innovation according to its dimensions:

Classification	Score
Fulfilment of the DOA	5
Demoability	4
Exploitability	4
Usefulness in pilot applications	5

Associated end user application requirements

COM-95 DSS will analyse events, suggestions and measures
COM-93 DSS will communicate/exchange the data
COM-92 Production of Simulated Data

I-06 Deep Learning Toolkit

Description

The Deep Learning Toolkit is a component that belongs to the COMPOSITION ecosystem and has a twofold nature. The first aspect is the intra-factory scenario, in which it is involved in the decision-making process at the shop-floor level, providing predictions leveraging on continuous learning algorithms. In order for this to happen, it uses three offline phases: training, validation and testing, of historical data from the very same shop-floor. The continuous learning phase happens online and is the one that is fully integrated with the intra-factory interoperability layer and the COMPOSITION ecosystem.

The second nature of the component belongs to the inter-factory scenario and it is based on providing predictions to the Agent-based marketplace. It provides a novel intelligence layer to the agent for trading in the most suitable conditions providing knowledge on the market future status with punctual predictions based on the historical analysis on the trading historical data.

Major functionalities

In the intra-factory scenarios, it will provide predictions to decision system designated components at the shop floor level, leveraging on continuous learning Artificial Neural Networks.

In the inter-factory scenarios, it will provide predictions to the intelligence segment of the agent, in the Agent-based Marketplace, providing data analytics on transactions and profiling the behaviour of opponent agents using re-enforcement learning techniques.

Responsible WP

WP5

Innovation classification

Classification	Score
Fulfilment of the DOA	5
Demoability	4
Exploitability	4
Usefulness in pilot applications	4

Associated end user application requirements

As main component in the requirement

COM-34 Time frames for data pulls shall be freely configurable (BSL)
COM-32 Data output format of Deep Learning Toolkit should be homogenized
COM-31 Data input format of Deep Learning Toolkit should be homogenized
COM-30 Data classification report latency
COM-27 Provide enough data for training artificial neural networks
COM-21 The IIMS shall integrate different heterogeneous data sources
COM-20 The system shall detect patterns in data, without the need to explicitly search for them
COM-8 On request, information on fill level of the metal scrap container shall be provided
COM-7 The employee shall be informed in which metal scrap container to dispose of the bin content
COM-6 The employee shall be informed when a metal scrap bin is full
COM-4 Maintenance Data about machines shall be continuously collected
COM-1 The fill level of metal scrap containers shall be monitored

Involved in the requirement

COM-83 Zooming functionality shall be supported by the visual analytics module
COM-82 Visualization presented to the user shall be synchronized
COM-81 The visual analytics module shall import data coming from the simulation and prediction engine
COM-65 The ranking component includes a machine learning system to continuously improve the recommendations it gives out
COM-64 The system provides an automatic ranking of the suppliers to the buyers, based on customers' satisfaction and feedback
COM-56 The IIMS system automatically informs the contractor the fill level of the metal scrap containers
COM-55 The contractor shall inform the IIMS when the collection of a metal scrap container is completed
COM-54 Purchasing Manager maintains the list of approved contractors
COM-53 The Maintenance Manager shall receive information that the scrap metal container is full

I-07 Process-Oriented Monitoring Framework

Description

The Process-Oriented Monitoring Framework will on one hand collect data from heterogeneous sensors available on shop floor, and on the other hand enrich data so that they are context-aware, which opens up more possibilities for later data processing. To achieve Process-Oriented Monitoring, sensor data will be first integrated onto a uniform data platform (e.g., LinkSmart IoT-Platform) for easy access. Then the production process will be modelled with Business Process Model and Notation (BPMN), which is a graphical representation standard for specifying business processes in a business process model. During production runtime, an instance of the process model will be created to represent each product in the production line. This process instance will be managed by a BPMN engine and it is synchronized with the real process with the help of sensor signals retrieved from the production line. In this way, sensor measurements can be annotated based on the active process activity as well as on a specific product. It enables investigation of production details such as performance in each production step as well as resources consumed for each product etc. Furthermore, context-aware reactions to certain (unusual) events or combination of events will also be possible.

Major functionalities

The following prioritised functionalities are enabled by the innovation:

Uniform data access, investigation of production details and context-aware reactions to certain (unusual) events or combination of events.

Responsible WP

WP3

Innovation classification

Classification	Score
Fulfilment of the DOA	5
Demoability	4
Exploitability	3
Usefulness in pilot applications	4

Associated end user application requirements

COM-25 Items shall be trackable asides BSL's production line
COM-10 The system shall monitor the status of KLE's polishing machine

I-08 Big Data Analysis Service

Description

Manufacturing in assembly lines consists of a collection of hundreds, thousands or millions of small discrete steps aligned in parallel production, management, maintenance and other processes. For each of those steps, automatized production processes or production lines produce small bits of data in the form of events. The events possess valuable information, but this information loses its value over time. Additionally, the data in the events usually are meaningless if they are not contextualized, either by other events, sensor data or process context. To extract most value of the data, it must be processed as it is produced – in other words, in real time and on demand. Therefore, we propose for the data-driven Big Data Analysis Stream Mining that makes use of Complex-Event Processing for the data management coming from the production facilities and opens it to embed analytic processes and algorithm. In this manner, the data is processed the moment it is produced, extracting maximum value, reducing latency, providing reactivity, providing context and avoiding the need for archiving data unnecessarily.

Major functionalities

The main functionalities provided by the Big Data Analysis Service are:

- Real-time Event Annotation
- Real-time Event Fusion
- Real-time Event Live Analysis
- Real-time Online Machine Learning Life Cycle Management
- Real-time Data Interoperability
- Real-time Data Endpoint and Protocol Routing

Responsible WP

WP5

Innovation classification

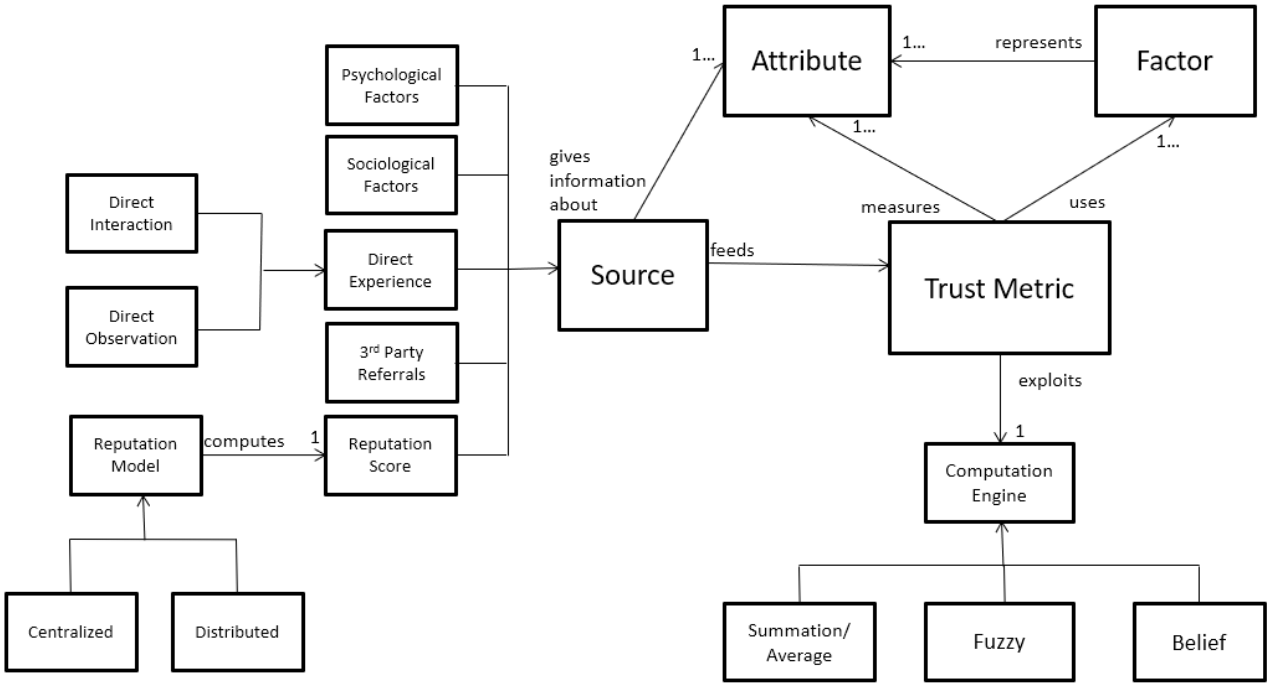
Classification	Score
Fulfilment of the DOA	5
Demoability	4
Exploitability	4
Usefulness in pilot applications	5

Associated end user application requirements

COM-94: Interfaces shall facilitate machine learning toolkit forecast
COM-27: Provide enough data for training artificial neural networks
COM-20: The system shall detect patterns in data, without the need to explicitly search for them

I-09 Blockchain-based Reputation and Trust Model

Description



In the COMPOSITION Reputation Model, the basic idea is to follow the selected reference model[1], in order to infer the basic requirements that should be satisfied, depending on the specific context of the project. Each agent of the marketplace must be able to provide a rating related to each single transaction, when they act as the requestor (trustor): these ratings could be integer values within a predefined interval for measured attributes (e.g., **trust**, **reputation**, quality of service provided, seller reliability, **critical level of the refined information**) processed through computation engines (e.g., summation, average, fuzzy, belief, continuous/discrete).

- Dynamic and continuous trust assessment for all involved entities exploiting both internal and external knowledge
- Speed-up decision making phase
- Reputation models fit very well in open, or semi-open, environment
  - new member could join
  - actual member could leave, and re-join after leaving
- Reputation values and 3rd party referrals could be stored into the blockchain [2] (in case of distributed model)
  - easy to track possible fake and malicious behaviours
- Computed trust values can take into account specific information specifically related to COMPOSITION
  - Critical level of the information received
  - Quality of the provided information
  - Context effectiveness in the related service
  - Time constraints

COMPOSITION is relying on blockchain technologies as the central component of its log-oriented architecture. This technology will be used for implementing a secure, trusted and automated information exchange related to supply chain data. Considering the distributed nature of blockchain and, more in general, of the COMPOSITION infrastructure, it makes sense to rely on a distributed Reputation Model: each

[1] S. Vavilis, M. Petković and N. Zannone, "A reference model for reputation systems," Decision Support Systems, vol. 61, pp. 147-154, 2014.

agent will compute his own reputation values and will be in charge to provide these values to the other entities.

The Reputation and Trust Model is further described in *D4.2 Design of the Security Framework II*.

Major functionalities

The main functionalities provided by the Reputation and Trust Model are:

- Dynamic and continuous trust assessment for all involved entities in the marketplace exploiting both internal and external knowledge
- Adoption of the blockchain for reputation distribution; all the agents will have a global view of every interaction related to each agent of the marketplace in a secure, trusted and automated manner.

Responsible WP

WP4; (WP6)

Innovation classification

Classification	Score
Fulfilment of the DOA	4
Demoability	3
Exploitability	3
Usefulness in pilot applications	3

Associated end user application requirements

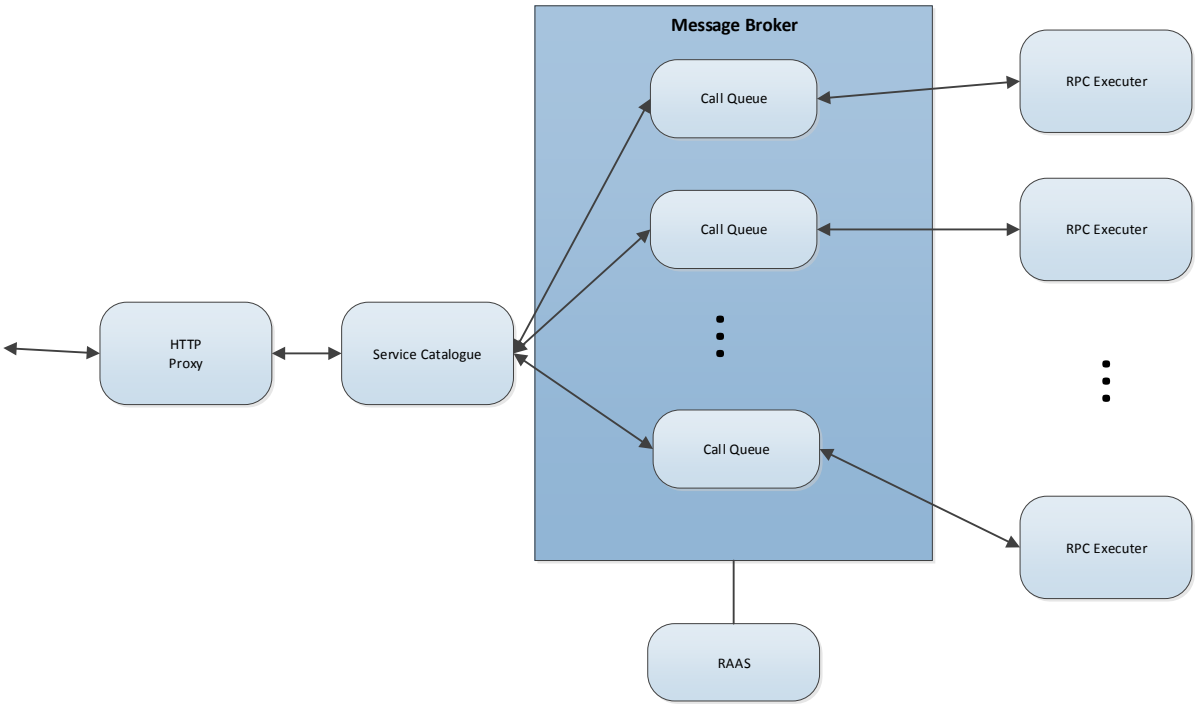
COM-168 ‘Bad’ agents should not be able to leave the marketplace, and re-join as different agents
COM-167 New agents should not be penalized
COM-166 Reputation values must represent the evolution of the agent’s behaviour
COM-165 Involved agents must use the same aggregator operator
COM-164 Agents should not be able to compute, or modify, their own reputation value
COM-163 Reputation lifetime must be taken into account
COM-162 Local reputations should be available to all the agents belonging to the marketplace, if needed
COM-161 Incorrect reputation values should be detected (rater's credibility), when used
COM-160 Reputation and ratings should discriminate agents' behaviour

I-10 Real Time Multi-Protocol Event Broker

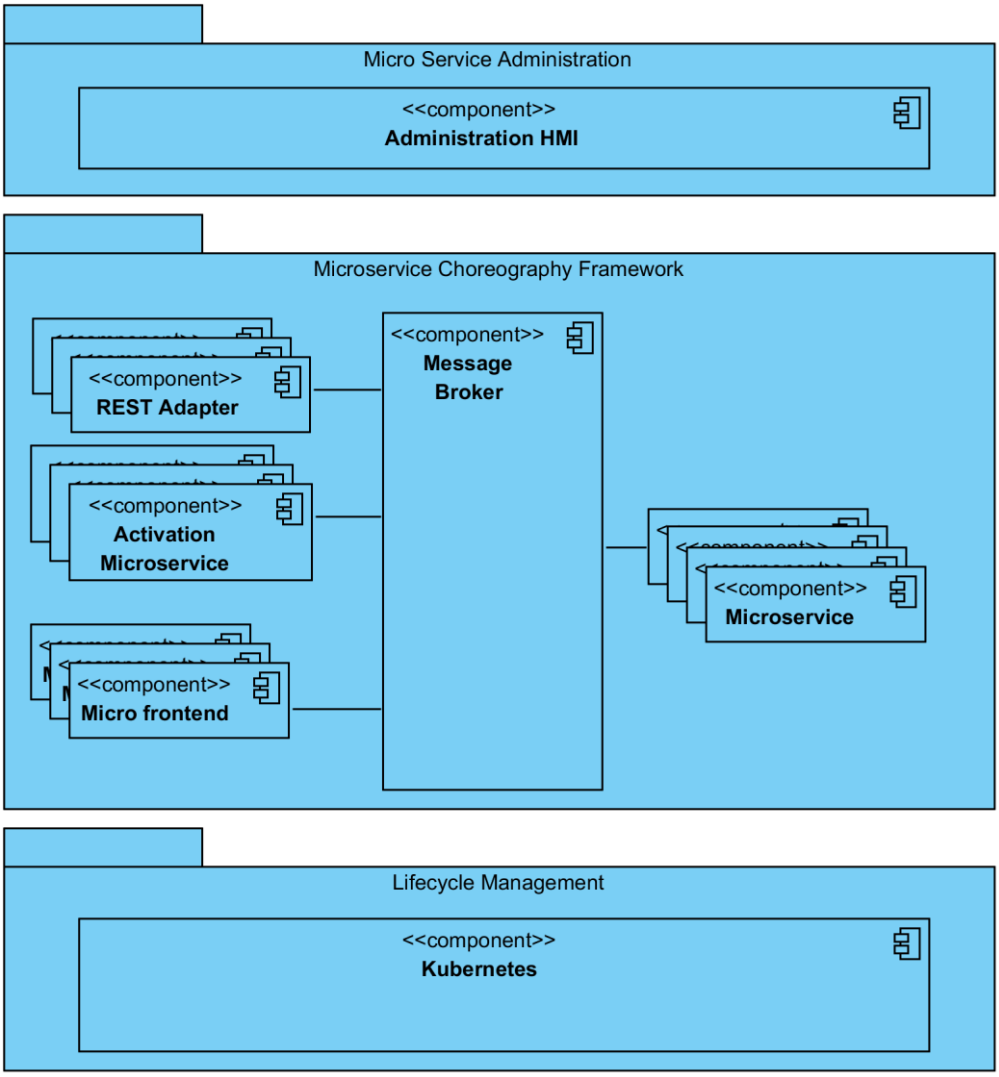
Description

The Real-time Event Broker of COMPOSITION is the central communication hub in both intra- and inter-factory scenarios. Authentication and authorisation for the entire platform is managed in a uniform manner via the RAAS extension to the message broker. COMPOSITION components use either messaging (using MQTT or AMQP) or REST APIs. Routing the REST calls through the broker makes the most use of the integrated identity management and blockchain integration in COMPOSITION and introduces a level of decoupling of components, logical addressing of services and centralised management. When the broker is used for inter-component communication, logical addressing of components can be used – a component identifier instead of a network address and port – decoupling components and providing a consistent way to address and find them for other components.

We have developed a transparent adapter for the request-response communication for HTTP REST services in COMPOSITION, corresponding to the SOAP tunnelling described in (Milagro, F. A. (2008). “SOAP tunnel through a P2P network of physical devices.” Internet of Things Workshop. Sophia Antopolis: Internet of Things Workshop, Sophia Antopolis.). It routes HTTP requests through an HTTP Proxy and resolves the base URL to a queue where the HTTP request is put. Clients (the REST services) may subscribe to the requests directed at them and return the response without exposing any public HTTP ports. This provides decoupling of services, logical addressing of services, discovery and an integrated security solution for HTTP, MQTT and AMQP communication. The core implementation mechanism, RabbitMQ already provides the mechanisms for RPC (Remote Procedure Call) style request-response messaging, including facilities for sending responses directly to the client channel without a client queue.



The REST Adapter is the first prototype and a special case of an infrastructure and framework for activating micro services using the Message Broker for activation choreography. On the publisher side, there is the activation micro services, where the REST accepts an HTTP call and sends this to a configured exchange to be put on a work queue. This message contains all the information from the HTTP call. However, this type of message could also be activated from, e.g., a timer, file system trigger or email, by activation (or choreography) micro services. On the subscriber side, the REST Executer is but one type of micro service that could be configured to process messages from a queue and return the results.



If the messages are standardised and the Message Broker communication details are hidden/virtualised/abstracted in a framework, the micro services may be written, managed and orchestrated using a simple web IDE, very similar to, e.g., Azure Functions[2] or AWS Lambda[3]. However, the framework would not be tied to any specific cloud infrastructure. Kubernetes or Docker Swarm can be used to handle the infrastructure for micro service container lifecycles, load balancing and scaling.

It is our belief that a lightweight, standardised micro service framework that can be deployed on any cloud platform or physical servers would be a significant addition to the platform and an exploitable asset in the area of I4.0.

Major functionalities

The main functionalities provide by the Real-time Event Broker are:

- Real-time brokering
- Keycloak integrated security (which works across broker federations)
- Transparent adapter for the request-response communication
- Micro services execution framework
- Micro services for real-time translation and annotation.

[2] https://azure.microsoft.com/en-us/services/functions/
[3] https://aws.amazon.com/lambda/

Responsible WP

WP6; (WP4)

Innovation classification

Classification	Score
Fulfilment of the DOA	3
Demoability	3
Exploitability	5
Usefulness in pilot applications	4

Associated end user application requirements

COM-139 All components with a public endpoint shall enforce authentication and authorization
COM-43 Message transport shall be general purpose
COM-39 Message transport shall be general purpose
COM-38 Message transport shall be scalable
COM-16 Only a specific group of receivers shall have access to data