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

D2.2 Initial Requirements Specification

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1 Executive Summary

This deliverable documents initial user requirements and derived system requirements elicited from the scenarios and use cases detailed in *D2.1 Industrial Use Cases for an Integrated Information Management System*. It also lays the foundation for the Innovations expected to materialise from the project work. The main focus will be on end user requirements, ensuring that the development work results in solutions that address real-world problems and challenges.

Scenarios and use cases have been derived from user workshops that were arranged to determine the context of use for the intra-factory and inter-factory settings, respectively. This early user involvement was pursued to ensure that user requirements are based on actual end users' views and expectations of COMPOSITION services.

The document describes the methodologies, procedures and results of the process of requirements engineering that has been commenced for COMPOSITION. In the project, 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).

The next step in the requirements engineering process includes quality checking and assignment of the initial requirements to decide whether they will be included in the final specification. New requirements may emerge from this process, while existing requirements may be reformulated to enhance clarity and accuracy.

The implemented iterative process continues throughout the project, involving collection and analysis of Lessons Learned and updating of existing and addition of new requirements. The outcome of this process will be documented in subsequent deliverables *D2.5 Lessons Learned and Updated Requirements Report I* and *D2.6 Lessons Learned and Updated Requirements Report II*.

A joint repository based on the JIRA Issue Tracking tool has been created for COMPOSITION requirements, and the first round of entries includes 62 functional requirements and 38 non-functional requirements, most of which are operational. All requirements are associated with one or more of 18 identified system components.

To ensure that the project has a strong and continued focus on successful implementation of creative ideas, the COMPOSITION consortium applies a dedicated and strategic structure for managing innovation activities. An Innovation Form has been devised for a unified and simple way of documenting any innovative aspects of the COMPOSITION Integrated Information Management System. To enable systematic follow-up of identified innovations, a corresponding JIRA repository has been established. Initially, five Innovations have been described, relating to components in the requirements repository.

2 Introduction

The aim of the COMPOSITION project is to create a digital automation framework, the COMPOSITION Integrated Information Management System, that optimises manufacturing and business processes by exploiting existing data, knowledge and tools to increase productivity and adapt dynamically to changing market requirements. This technology acts as the technical operating system for business connections between factories and their suppliers.

Furthermore, COMPOSITION opens a new space for third party entities to actively interact in the supply chain, e.g., by providing services to improve cycle time, cost, flexibility or resource usage. In addition to the supply chain improvements, also processes inside the company will be addressed and optimised.

2.1 Purpose, context and scope of this deliverable

This deliverable documents the initial end user requirements and derived system requirements elicited from the scenarios and use cases detailed in *D2.1 Industrial Use Cases for an Integrated Information Management System*. The document also lays the foundation for the Innovations expected to materialise from the project work. End user requirements are emphasised to ensure that the development work results in solutions that address real-world problems and challenges.

Requirements engineering involves a process of discovery, analysis, validation and formalisation of requirements. In COMPOSITION, the following types of requirements will be taken into consideration:

- Functional requirements
- Operational requirements
    - Performance requirements
    - Usability requirements
    - Security requirements
    - Business requirements
    - Ethical requirement

The iterative process will continue throughout the project and involves collection and analysis of Lessons Learned and pertinent fine-tuning of existing and addition of new requirements. The outcome of this process will be documented in future deliverables *D2.5 Lessons Learned and Updated Requirements Report I* and *D2.6 Lessons Learned and Updated Requirements Report II*.

2.2 Content and structure of this deliverable

Section 3 describes the applied methods and principles of user-centred development.

Section 4 presents an overview of the design process and its basis in user workshops and subsequent requirements derivation.

In Section 5 the Innovation methodology and procedure are briefly outlined, and some initial innovations are listed.

A brief conclusion is provided in Section 6, while Appendices A and B contain the initial List of COMPOSITION requirements and Innovations, respectively.

3 Methods and Principles of User-Centred Development

Requirements are descriptions of how a system should behave, in terms of functional requirements describing what the system should do and non-functional requirements describing how the system works. These requirements include application domain information, constraints on the system's operations and specifications of system properties and attributes. This deliverable is the result of the first iteration of the requirements engineering process for the COMPOSITION project. Requirements engineering is a continuous iterative process driven by the adopted user-centred design (UCD) approach and not a stage or a phase in the project. Because It is unlikely that all aspects of a problem are identified and analysed at the outset, the user-centred design process outlined in this document will be applied throughout the project. Consequently, this deliverable documents the initially elicited requirements, while future iterations of the process will extend, update and adapt this list of requirements.

The general approach to requirements gathering and processing involves the following activities in the COMPOSITION project:

- Elicitation: Discovering, extracting and learning about needs of stakeholders. This includes gaining insight into current manufacturing and business processes, both inside factories and in supply chains, to identify problems and deficiencies in the existing systems and to discover opportunities and general objectives. Conducting user workshops with end users are part of this activity
- Negotiation and agreement: To establish priorities and to determine the subset of requirements that will be included in the different prototype implementations
- Specification: Requirements expressed in a more precise way, sometimes as a documentation of the external behaviour of the system
- Verification/Validation: Determining the consistency, completeness and suitability of the requirements. This may involve static testing, prototyping or other techniques, to be referenced in *D8.7 Evaluation Framework*
- Evolution and management: The requirements are modified to include corrections and to address objectives emerging from requirements added to the repository in subsequent iterations. Requirement management means tackling those modifications and additions in a consistent way to ensure traceability and to preserve inherent interdependencies.

In many cases, these activities are performed in parallel, guided by the project's user-centred design approach as this is the characteristics of the ISO 9241-210 standard.

3.1 The ISO 9241-210 standard

The ISO 9241-210 (ISO, 2010) "Ergonomics of human-system interaction" provides guidance on user-centred design activities throughout the life cycle of computer-based interactive systems. The ISO standard uses the term 'human-centred design' where the term 'user-centred design' is used in COMPOSITION. These terms can be understood as being synonymous, and only the term user-centred design will be used in this deliverable, as this is the term used in the COMPOSITION Description of Action.

Essential principles in the UCD process are:

- Multi-disciplinary design
- Iteration of design solutions
- A clear understanding of users, tasks and environments
- Active involvement of users and user-centred evaluation.

The multi-disciplinary design is ensured by the expertise of the COMPOSITION team, which includes manufacturing and business specialists, computer scientists and usability engineers and designers.

The iterative nature of the COMPOSITION design approach allows advancing from requirements specification to implemented prototypes, from experience and evaluation of these prototypes to improved specifications and improved prototypes. In COMPOSITION two main cycles are planned for the project lifetime, aiming at validating and evaluating prototypes of individual components and their integration in the complete system, both for the value chain and the supply chain.

One of the core tasks of user-centred design is to negotiate and facilitate communication across the well-known user-developer gap while acknowledging the different forms of expression and different requirements on each side. Evolutionary or iterative approaches have been shown to reduce this gap (Clark et al, 1989).

The user-centred design process reflects an iterative process with no sharp start and end points: Eliciting the ‘context of use’ requires intensive and sustained user involvement for the duration of the process, and the requirements elicitation will continue in conjunction with the definition of the design and the specification of the architecture. There are four essential user-centred activities recommended in ISO 9241-210:

- Understanding and specifying the context of use
- Specifying organisational and user requirements
- Producing design solutions
- Evaluating the design.

3.2 The Volere model

The ISO 9241-210 standard does not prescribe specific methods to achieve the above-mentioned goals. Practical experience from other R&D projects, involving some of the COMPOSITION partners, paved the way for the decision to follow a use case and scenario driven approach based on information emerging from on-site user workshops. This approach is also in line with the descriptions in the Document of Action.

To facilitate specification of requirements the Volere process recommended by Robertson & Robertson will be used (Robertson et al, 1999). This process ensures the consideration of important aspects of requirements specification in a systematic and practical way. Subsequent sections provide more detailed information about the process applied in COMPOSITION for requirements elicitation. This includes a description of the main characteristics of the requirements, which will be based on the Volere Template described in more detail in Section 4.4. The Volere model allows the definition of functional and non-functional requirements, and of global constraints that may the solutions or the project. The emphasis on sound rationales and measurable fit criteria for the requirements substantiates their applicability and testability.

3.3 Sources of requirements

Derivation of requirements must be based on pertinent sources of information. Conducting field studies is a standard method for obtaining such information, e.g., by doing interviews or arranging workshops with users representing the target user groups of an envisioned service. Typical usage scenarios and use cases for the service under development can be derived from these field studies, thus providing the foundation for elicitation of requirements.

3.3.1 User workshops

User workshops in general provide a suitable forum for collecting information on user needs and expectations of a service to be developed. They provide an interactive setting for discussion among workshop participants, revealing individual opinions and attitudes with a potential for sketching and agreeing on possible solutions. Therefore, workshops with end user participation were conducted at the beginning of the COMPOSITION project for the purpose of gaining insight into the challenges and everyday problems to be addressed by means of the project outcomes.

3.3.2 Scenarios

The aim of scenarios is to capture and illustrate features of a system, thus demonstrating its usefulness and benefits for the prospective end users. Scenarios can be used for various purposes and at different stages of a project. Particularly in the early stages of the design phase, comparing existing procedures with envisioned future scenarios can be a useful method for understanding and agreeing on user requirements and derivative system requirements. They describe end user activities as well as application functionalities, thus facilitating the formulation of essential technical requirements. In COMPOSITION, the agreed scenarios and associated industrial use cases will serve as the main source for the systematic formalisation of user requirements and derivation of system requirements in the initial requirements specification phase.

4 User-Centred Design Process in COMPOSITION

To ensure consistent enhancement of usability, the user-centred design approach in COMPOSITION continually examines user needs, with direct feedback of the findings into the development cycle. Each iteration follows the following broad pattern:

- User requirements engineering and refinement
- Architecture design specification and refinement
- Enabling technologies research to implement architecture
- Prototype development, system integration and testing
- Piloting in selected industrial, use case oriented business applications
- Conformance testing, usability evaluation and user validation
- Lessons Learned and change analysis.

The substantially different needs of all stakeholders are to be considered, whether they relate to the intra-factory value chain domain or the inter-factory supply chain domain, with some end users involved in both.

4.1 User workshops, scenarios and use cases

Two user workshops were conducted at the BSL and KLE premises, respectively. These workshops included tours of the facilities, for the latter also a tour at ELDIA. The participants subsequently discussed future scenarios and derived use cases for the project development work.

The nature of identified vison scenarios is evidently tentative and future-oriented, as they must attempt to capture successfully the perceived prospective user/system interactions. However, they help illustrate user requirements by examining intended developments in real-life situations. The scenarios defined in COMPOSITION therefore serve as a basis for discussion among consortium partners, allowing further refinement of project goals and corresponding system requirements. The scenarios are also a primary source of user requirements.

The workshops are described in more detail in deliverable *D2.1 Industrial Use Cases for an Integrated Information Management System*.

4.2 Requirement derivation

As a consolidated outcome of the workshops, an initial set of requirements will be elicited from these scenarios and derived use cases (To-Be use cases). If necessary, the requirements will be adapted in the course of the project, and new requirements will be added based on user feedback, e.g., from user evaluation of the prototypes.

The extracted requirements relate to various aspects of the COMPOSITION services. They will be classified according to the Volere template (Robertson et al., 1999) depicted in Section 4.4. Two main types of requirements will be defined: Functional requirements describing what the system should do, and non-functional requirements describing how the system works. The initial set of user requirements can be found in Appendix A in Section 9 of this deliverable.

4.3 Requirements engineering

To ensure a systematic approach to managing the requirements engineering process as prescribed in the Volere model, it was decided to create a shared repository using the JIRA Issue Tracking Tool[1]. With this tool, hosted by FIT, it is possible to implement and track the Volere workflow for all COMPOSITION requirements.

A visual interpretation of the requirements engineering process is shown in Figure 1. As outlined in Section 4, this process involves requirement elicitation, analysis, specification, validation and feedback for the next iteration. Requirement management is supported by the workflow implemented in the JIRA tool (see Figure 3 in Section 4.6), which allows tracing individual requirements and tracking their progress. The Lessons Learned collected in each cycle and the subsequent change analysis lead to refining of existing requirements as well as addition of new requirements.

[1] http://www.atlassian.com/software/jira

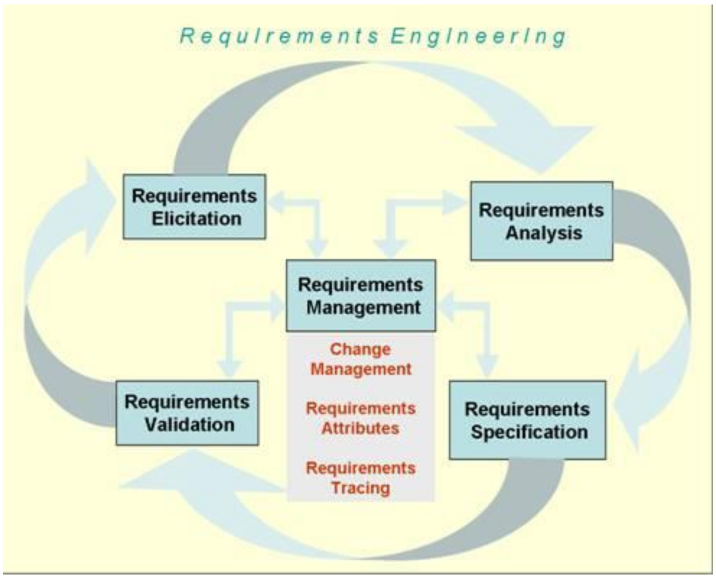

Figure 1: The Requirements engineering process

4.4 The Volere requirement template

The Volere template has been configured for use for requirements specification in COMPOSITION, see the example in Figure 2. The most important fields are described in Table 1.

Table 1: Important fields in the COMPOSITION Volere template

Field	Description
Summary	Clear and brief one-sentence description of the intent of the requirement
Requirement Type/ Sub-type	Functional/Non-functional/Constraint, etc.
Component/s	To which component(s) does this requirement belong? See Section 4.5
Source	Where did this requirement originate? E.g., the DoA, a use case description, a workshop, etc.
Priority	Priority defines the relevance of the requirement in relation to the other requirements, depending on the source, the component, etc. Scale: Blocker, Critical, Major, Medium, Minor, Trivial, Nice to have
Rationale	Why is the requirement important? What contributions does it make to the product's purpose?
Fit Criterion	This field describes how to determine if a requirement is met. The Fit Criterion must be *measurable* for testing/verification that the requirement is fulfilled
Custom Labels	Custom labels are mainly intended for filtering purposes. User requirements typically have at least one label defining which use case(s) it is part of.
Description	This field is used to further clarify or elaborate interpretation of the Summary

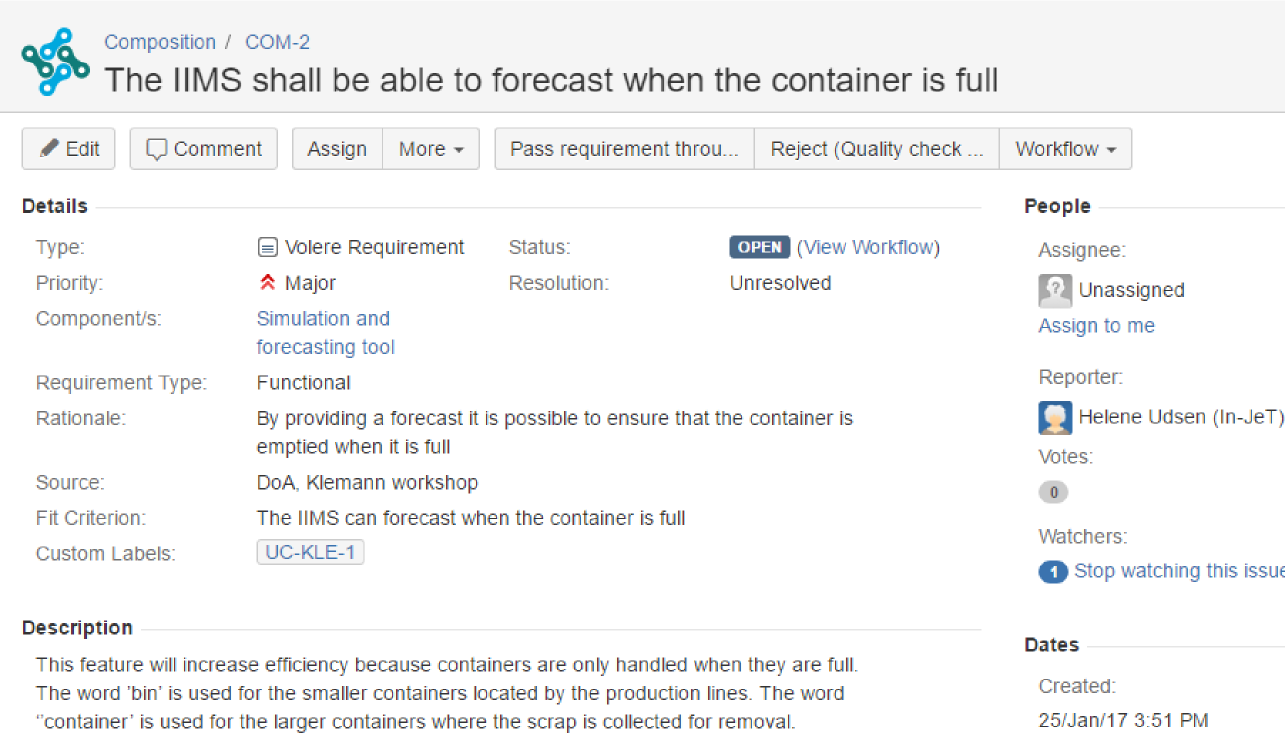

Figure 2: The COMPOSITION Volere template

4.5 Components in COMPOSITION

Defining the *component* associated with each requirement is important to help structure requirements and to get a clearer picture of the technical developments to be achieved. The associated component defines which Work Package (WP) is involved, and hence determines to whom the requirement is assigned for resolution, typically the WP Leader.

The following Components have been identified at this point:

- Access Control
- Advanced Human Machine Interfaces
- Authentication
- Big Data Analytics
- BlockChain Connector
- Deep Learning Toolkit
- Intrafactory Interoperability Layer
- Manufacturing Big Data Storage
- Manufacturing Decision Support System
- Market Event Broker
- MatchMaker
- Modelling
- Ontology
- Real Time Multi Protocol Event Broker
- Requestor Agent
- Security Information and Event Management
- Simulation and Forecasting Tool
- Supplier Agent

4.6 The requirement specification workflow

The typical workflow for requirement specification in COMPOSITION comprises five stages, as shown in Figure 3. Upon creation, the requirement is in the 'Open' stage. The requirement will then be quality checked by the Assignee, or by a different person with sufficient technical insight, if this Assignee is also the Reporter.

In the latter case, the requirement will be re-assigned to the WP Leader, when it has passed the Quality Check.

A requirement can fail to pass the quality gateway for two reasons:

- A requirement can be incomplete. Some fields may have meaningless entries like 'TBD'
- A requirement can be ambiguous; certain terms are not clearly specified.

When passed, the Assignee decides whether a requirement will become part of the specification or if it must be further revised or possibly rejected.

Requirements with status 'Part of Specification' will then be implemented and validated; for user requirements, validation usually involves end users.

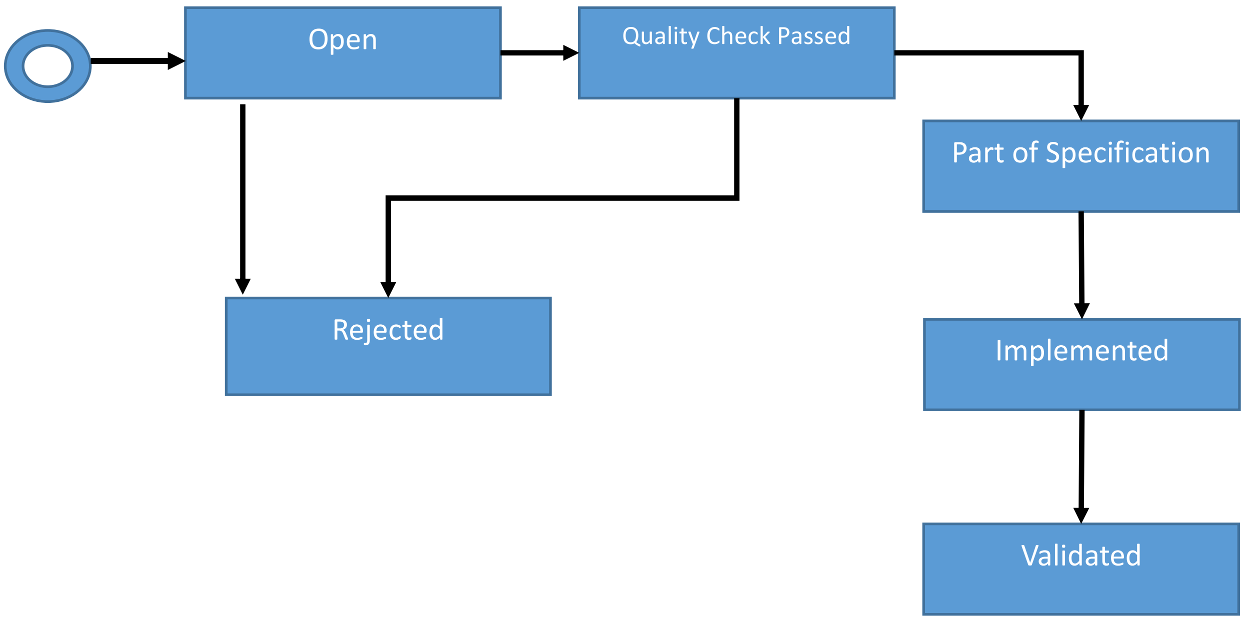

Figure 3: The typical requirement specification workflow in JIRA

Quality checked requirements can be rejected for two reasons:

- A requirement can be a duplicate of another requirement
- A requirement can be out of scope for the project.

4.7 Requirement types and distribution

The JIRA repository currently contains 104 requirements. Of these, 62 are Functional requirements, 38 are Non-functional, 2 are Constraints and 2 are Project issues. Table 2 shows the distribution of Non-functional requirements by sub-type:

Table 2: Non-functional requirements by sub-type

Type	Count
Non-functional - Operational	30
Non-functional - Performance	3
Non-functional - Usability	1
Non-functional - Security	4

Table 3: Requirements by priority

Priority	Count
Blocker	1
Critical	3
Major	93
Medium	3
Minor	2
Trivial	0
Nice to have	2

Most of these initial requirements are prioritised as Major, reflecting that the focus at this early stage is on specifying functional and non-functional requirements of high impact for the technical development, though these priorities may change in alignment with the overall implementation process.

Table 4: Requirements by Component

Component	Count[2]
Access Control	3
Advanced Human Machine Interfaces	13
Authentication	17
Big Data Analytics	8
BlockChain Connector	18
Deep Learning Toolkit	6
Intrafactory Interoperability Layer	5
Manufacturing Big Data Storage	9
Manufacturing Decision Support System	29
Market Event Broker	16
MatchMaker	22
Modelling	5
Ontology	3
Real Time Multi Protocol Event Broker	1
Requestor Agent	20
Security Information and Event Management	6
Simulation and Forecasting Tool	23
Supplier Agent	18

The requirements have been assigned to one or more of the Use Cases described in *D2.1 Industrial Use Cases for an Integrated Information Management System*. The distribution per use case is shown in Figure 4, the main purpose of which is to show the relatively even distribution between the use cases covered in the initial requirements. As for the components, requirements may be associated with more than one use case.

[2] Requirements may be associated with more than one component

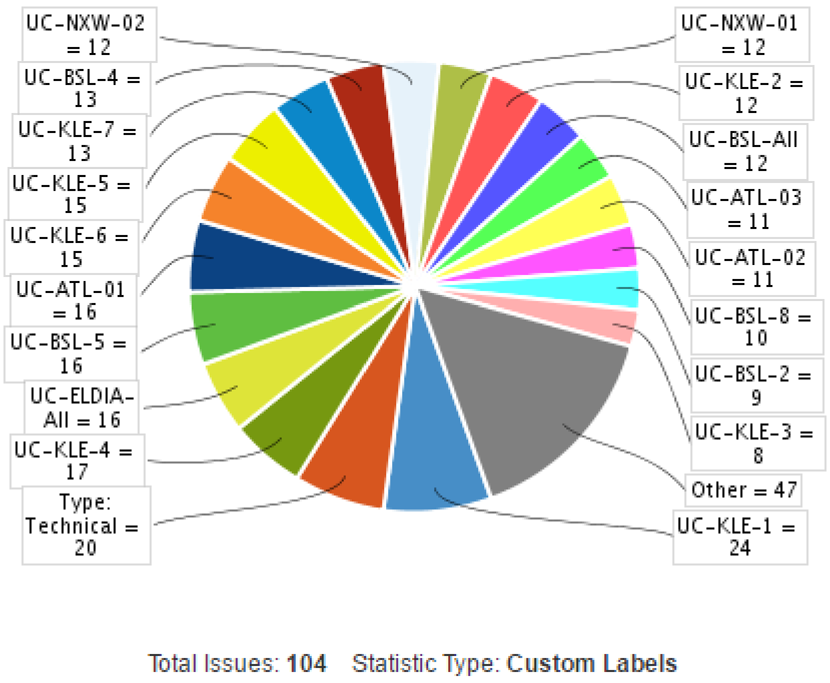

Figure 4: Requirements per Use Case

4.8 Functional requirements

Functional requirements can be defined as “identifying what the system should do”, i.e., the “functions” of the system under analysis. The initial list includes 62 functional requirements, distributed over the intra-factory and inter-factory solutions.

The components with the highest number of associated requirements are again the Manufacturing Decision Support System, the Simulation and Forecasting Tool and the MatchMaker. The numbers are depicted in the chart in Figure 5.

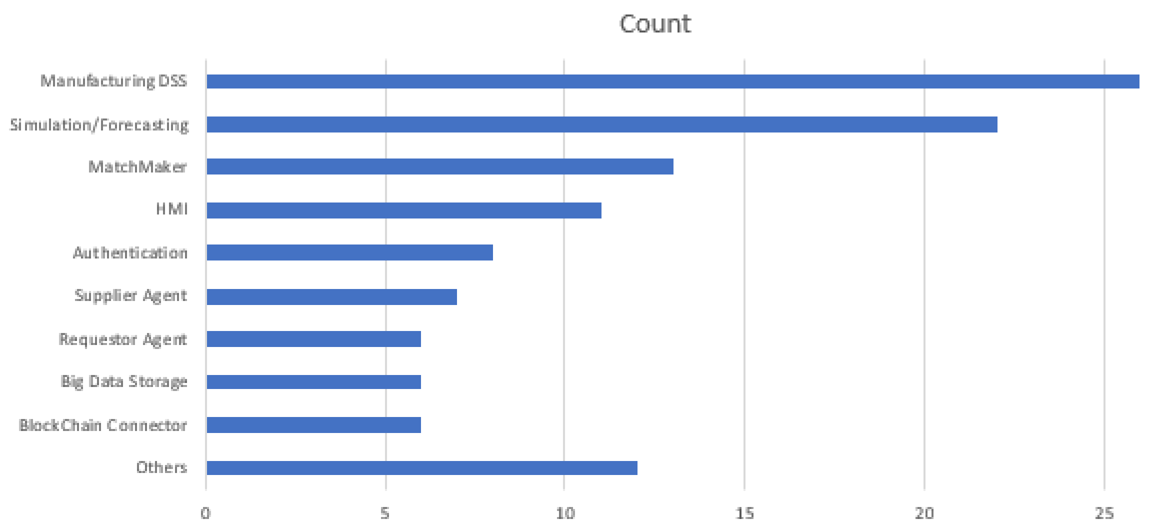

Figure 5: Number of functional requirements by component

The overall picture is similar to the distribution for all requirements (Table 4), and the most specified components are also reflected by the Innovations described in Sections 5 and 10.

4.9 Non-functional requirements

Non-functional requirements describe how the system works, i.e., they specify the constraints in terms of attractiveness, usability, performance, security and reliability under which functions described by the functional requirements shall operate. The Volere template facilitates the definition of several sub-types for non-functional requirements as detailed below.

4.9.1 Operational requirements

Operational requirements cover the demands defined by the intended operating environment, addressing how the users will operate the system, including interfaces and interoperability with other systems. Operational requirements establish how well and under what conditions the system must perform.

The initial list includes 30 operational requirements.

4.9.2 Performance requirements

Performance requirements cover a wide variety of simple or complex characteristics related to system performance, generally measured in terms of quantity, quality, coverage, timeliness, etc.

The initial list includes 3 performance requirements.

4.9.3 Usability requirements

Usability requirements derive from the specific needs of the intended end users, to be adapted to align with feedback from user evaluation of the various prototypes,

The initial list includes 1 usability requirement.

4.9.4 Security requirements

In the scope of information systems, the following security properties are relevant: confidentiality, integrity, availability, authenticity, accountability, non-repudiation and reliability as defined in the ISO/IEC 13335 standard (ISO, 2004).

The COMPOSITION project will use Privacy and Data Protection by Design methodologies everywhere in the design and development process.

The initial list includes 4 security requirements.

4.9.5 Business requirements

When satisfied, business requirements meet objectives, i.e., provide value. Business requirements exist within the business environment and must be discovered. Discovery necessarily involves stakeholders.

When available, deliverables *D9.8 Market Segmentation and Potential of COMPOSITION in European Industry* and *D9.9 Sustainable Business Models for IIMS in Manufacturing Industries* will be vehicles for elicitation of business requirements.

4.9.6 Ethical requirements

Ethical requirements include issues of privacy, trust, data protection and intellectual properties, etc. Ethical aspects may have to be considered for protection of data and personal information where humans are involved.

5 Innovations

The COMPOSITION technological innovation approach has the objective of creating a digital automation framework (the COMPOSITION IIMS) that optimises the manufacturing processes by exploiting existing data, knowledge and tools to increase productivity and dynamically adapt to changing market requirements.

From the use cases the technical teams will define a set of "Innovations" that will help them deliver the use case applications in an efficient and timely manner. The innovation management process uses *Innovation Forms* to capture innovative features of the platform, see below. These features are further decomposed into "Functionalities", which are typically defined as simpler and implementable elements of the platform.

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, led by the Innovation Manager. More details of the methodology and procedures can be found in *D1.1 Project Quality Control Plan 1*.

To supervise this process and reinforce alignment with the technological objectives of the project, a simple workflow has been associated with the JIRA Innovation project illustrated in Section 5.2.

5.1 The Innovation Form

The Form shown below has been created to formalise the innovations.

COMPOSITION

Ecosystem for Collaborative Manufacturing Processes

Innovation form I-01

1 Innovation name

2 Description

3 Major functionalities

Define features that can be used to show/visualise the innovation to users and its general applicability as part of a demonstrator. The following prioritised functionalities are enabled by the innovation:

4 Responsible WP

Identify the work package(s) responsible for development and implementation:

5 Innovation classification

Classify the innovation according to its dimensions:

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

6 Associated end user application requirements

List end user requirements for the COMPOSITION application that will be implemented using the innovation:

Figure 6: COMPOSITION Innovation form

The Form defines major functionalities enabled by the Innovation and classifies it according to 4 dimensions, i.e., Fulfilment of the Description of Action, Demoability, Exploitability and Usefulness in pilot applications. Finally, the Form lists the associated end user application requirements.

5.2 Managing Innovations in JIRA

To manage the Innovations in COMPOSITION, a project has been created in IN-JET's JIRA installation. An example of an Innovation entry, reproducing the content of the Innovation Form, is shown in Figure 7.

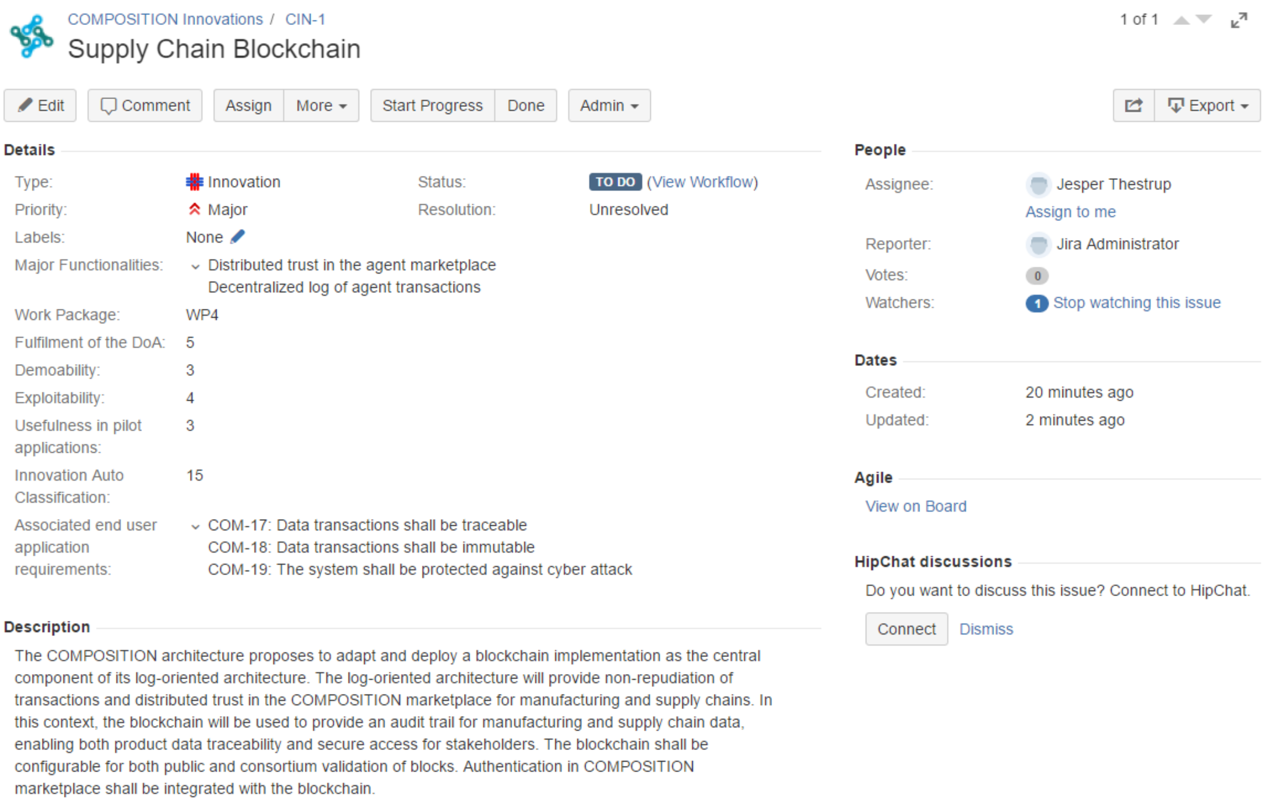

Figure 7: COMPOSITION Innovation in JIRA

A very simple workflow for COMPOSITION Innovations has been incorporated, as shown in Figure 8.

Figure 8: COMPOSITION innovation workflow

5.3 Initial Innovations in COMPOSITION

As an outcome of the requirements specified and the system components described in previous sections, 5 initial Innovations have been documented:

I-01 Supply Chain Blockchain

I-02 Matchmaking Broker

I-03 Manufacturing Decision Support System

I-04 Dynamic Agent-based Marketplace

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

Details of these Innovations can be found in Appendix B in Section 10.

6 Conclusion and Next Steps

Scenarios and use cases have been developed from user workshops that were arranged to determine the context of use for the intra-factory and inter-factory settings, respectively. The early user involvement has enabled the elicitation of end user requirements and derived system requirements based on actual end users' views and expectations of COMPOSITION services.

The COMPOSITION project implements a user-centred development process based on ISO 9241-210 and the Volere model.

The next major step in the user-centred development process is to determine the impact of the requirements on each COMPOSITION component. To accomplish this, all initial requirements must be quality checked and assigned to the component leads, who subsequently decide if the requirements become part of the specification. New requirements may emerge from this process, while existing requirements may be reformulated to enhance clarity and accuracy.

Adopting an iterative approach means that the initial set of requirements will be continuously expanded, updated and refined, particularly in connection with user evaluation of the COMPOSITION prototypes. This will be documented in subsequent deliverables *D2.5 Lessons Learned and Updated Requirements Report I* and *D2.6 Lessons Learned and Updated Requirements Report II*.

7 List of Figures and Tables

7.1 Figures

7.2 Tables

8 References

(Clark et al, 1989) Clark, P. G.; Lobsitz, R. M., Shields, J. D. (1989): Documenting the evolution of an information system. IEEE Software, pp. 1819-1826.

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(ISO, 2010) ISO 9241-210:2010: Ergonomics of human-system interaction -- Part 210: Human-centred design for interactive system

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

9 Appendix A: Initial List of COMPOSITION Requirements

Table 5: List of Requirements

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
Issue key	Summary	Custom field (Requirement Type)	Custom field (Requirement Priority)	Custom field (Rationale)	Custom field (Fit Criterion)
COM-105	The IIMS shall be able to generate alerts if the colour indication of a Production Unit changes to Red	Functional	Major	Alerting predefined actors/roles will allow timely intervention	Alerts are generated when colour indication changes to Red
COM-104	The Non-Conformance Dashboard shall reflect the number of NCs as green, amber or red.	Functional	Major	Monitoring and signalling the number of NCs will allow timely intervention	As the number of NCs increases, the colour changes from Green through Amber to Red
COM-103	The IIMS shall be able to store and retrieve photos of NCs	Functional	Major	Deviations documented during production can be reviewed and revisited to help discover systematic errors occurring over time	Photos of NCs can be stored in and retrieved from the system
COM-102	The Non-Conformance Dashboard shall display NCs for each Production Unit	Functional	Major	Non-Conformances can be spotted and corrected in a timely fashion	NCs are displayed on the dashboard with indication of the relevant Production Unit
COM-101	It must be possible to reset an equipment alert, when the necessary measures have been taken	Functional	Major	When the malfunction has been corrected, this must be reflected on the visualization screen	Equipment alerts can be reset
COM-100	The equipment alert shall be sent by email or SMS to predefined actors/roles	Functional	Major	The predefined actors will be specifically notified that equipment maintenance is required	Predefined actors are alerted by email or SMS
COM-99	An alert shall be displayed if the measured values for the equipment	Functional	Major	Monitoring of measurements from the	An alert for the involved equipment is

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
	exceed the defined limits			equipment compared to pre-defined limits allows timely scheduling of maintenance	displayed to signal that maintenance is require
COM-98	Limits for the measured parameters can be defined for the equipment in the production units	Functional	Major	By setting the parameters for the fan noise level, fan speed and fan amperage, the visualization screen can generate an alert if the values exceed the limits	The parameter limits for the equipment can be entered in the system
COM-97	Visualization screen shall display status of equipment in the production units	Functional	Major	By using a Factory visualization screen to display the status of equipment in production units in real time, timely intervention can be performed if to minimize processing downtime	The status of equipment in the production units is displayed
COM-96	The IIMS system automatically advises the contractor of the time for scrap metal pick-up	Functional	Major	Contractor can schedule his own internal tasks and plan for container pick-up.	The IIMS system calculates the time for pick-up of scrap metal and informs the selected contractor
COM-95	DSS will analyse events, suggestions and measures	Functional	Major	DSS will provide events, suggestions for the individual links and measures about the process monitoring.	Data will be analysed by DSS into a set of indicators
COM-94	Interfaces shall facilitate machine learning toolkit forecast	Non-Functional -> operational	Major	The interfaces will be developed facilitating the	Big data from all components and

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				machine learning toolkit in forecast and predictions.	interfaces will be exploited for the machine learning toolkit.
COM-93	DSS will communicate/exchange the data	Functional	Major	DSS will communicate/exchange data among departments/components with different roles and responsibilities.	A set of communications to other components will be provided by DSS.
COM-92	Production of Simulated Data	Non-Functional -> operational	Major	DSS will produce hypothetical scenarios based on current trends.	The DSS provides scenarios models and data via web services which help in manufacturing processes optimisation.
COM-91	Supplying companies advertise their products/services in specific topic(s) within the ecosystem.	Non-Functional -> operational	Major	Supplying companies advertise products/services to potential customers.	The products/services of a supplier are advertised within the ecosystem.
COM-90	Ecosystem components should be deployed as Docker images.	Non-Functional -> operational	Major	Past experience shows that using Docker gives ease of deployment and simpler integration of heterogenous components. Exact configuration of target platform can be performed by the partner developing the component and setup is easy for other partners.	Components are available as docker images.

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				Many third-party components are also available as docker images.	
COM-89	Matchmaker shall return a result within a reasonable time frame	Non-Functional -> performance	Major	The Matchmaker should respond within a reasonable time frame	The Matchmaker responds within a reasonable time frame (e.g. 5 seconds)
COM-88	Different decision criteria for supplier selection are supported by the Matchmaker	Functional	Major	Different decision criteria have to be supported by the Matchmaker towards finding the best possible solution for a specific request	The Matchmaker supports various decision criteria for supplier selection
COM-87	Various similarity algorithms and metrics shall be supported by the Matchmaker	Functional	Major	Different similarity metrics and algorithms have to be supported by the Matchmaker towards finding the best possible solution for a specific request	The Matchmaker supports various similarity algorithms and metrics
COM-86	The Matchmaker shall apply both syntactic and semantic matching	Functional	Major	Different matching techniques have to be supported by the Matchmaker towards finding the best possible solution for a specific request	The Matchmaker applies both syntactic and semantic matching
COM-85	Service ontology has to be multi-scaled				The Service ontology supports unambiguous description
COM-84	COMPOSITION's IIMS shall be able	Non-Functional ->	Major	The system is based on	IIMS supports storage

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
	to store and retrieve large amounts of data	operational		store and retrieve large amounts of data	and retrieval of large amount of data
COM-83	Zooming functionality shall be supported by the visual analytics module	Functional	Major	Facilitating user interaction when dealing with very small/large content to be visualized.	User can zoom in/out in the different visualizations offered
COM-82	Visualization presented to the user shall be synchronized	Functional	Major	Users will have a better understanding of different events related to the production and logistics chain or whatever information is presented to them through the visual analytics module, if all visualizations are synchronized.	All visualizations presented to the user are synchronized
COM-81	The visual analytics module shall import data coming from the simulation and prediction engine	Functional	Major	The results of simulation and prediction shall be properly visualized through the visual analytics module	Data coming from the simulation and prediction engine are properly imported into the visual analytics module
COM-80	Composition UIs shall be usable	Non-Functional -> usability	Major	The interaction of the actors with the COMPOSITION system will be easier and more efficient if UIs are user-friendly	New users shall be able to navigate through the different forms/pages quickly (e.g. 2-3 sec)
COM-79	The Decision Support System shall receive data via web-services and they shall be processed in real time	Functional	Major	DSS needs to support a unified manner such as through web-services for	DSS receives data from the different COMPOSITION

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				receiving data. Moreover, these data have to be processed in real time to enable fast decisions by the DSS.	components via web-services and these data are processed in real time.
COM-78	The Decision Support System shall import data coming from the simulation and prediction engine	Functional	Major	The results of simulation and prediction have to be taken into account by the DSS to make proper suggestions.	Data coming from the simulation and prediction engine are properly imported into the DSS
COM-77	The simulation and prediction engine shall apply machine learning techniques on production line's historical data	Functional	Major	The interfaces will be developed facilitating the machine learning toolkit in forecast and predictions.	The use of machine learning techniques on historical data
COM-76	Simulation tool shall be able to simulate and display production line assets and equipment as they represented in DFM	Functional	Major	Mechanical equipment and other assets are important parts of the production line and they are represented at DFM. A thorough simulation of the production line should be able to involve them.	The existence of the functionality to support the simulation of mechanical equipment and other assets.
COM-75	Sensors from production line shall provide data to the simulation and forecasting tool	Functional	Major	In order to make proper simulations and predictions using sensors data, the installed sensors should provide data to Simulation and forecasting tool	Sensors' data are available to Simulation and forecasting tool
COM-74	The simulation and prediction	Functional	Major	In order to make proper	Historical data about

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
	engine shall use historical data about production processes			simulations and predictions, the simulation and prediction engine has to use also historical data about production process.	production process are also used by simulation and prediction engine
COM-73	The simulation and prediction engine shall use data coming from sensors	Functional	Major	In order to make proper simulations and predictions, the simulation and prediction engine has to use also up-to-date data coming from the sensing layer.	Up-to-date data from the sensor layer are also used by the simulation and prediction engine.
COM-72	The simulation and prediction engine shall import process models and Digital Factory models	Functional	Major	In order to simulate the behaviour of the computational models, both of process and Digital Factory models, the simulation engine has to support their import	Both process models and Digital Factory Models are properly imported into the simulation and prediction engine
COM-71	Simulation shall support also hypothetical scenarios for both production and logistics chains	Functional	Major	Hypothetical scenarios shall be tested in both production and logistics chains based on current trends in market or given action plans	Different hypothetical scenarios can be defined and tested in the simulation and forecasting engine
COM-70	Simulation data shall be exported for being visualized and explored	Functional	Major	Simulation data shall be properly exported in order to be used by the DSS as well as the visual analytics module.	Simulation data can be visualized and explored through the visual analytics module as well as imported into the DSS.

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
COM-69	COMPOSITION DFM has to be multi-scaled	Non-Functional -> operational	Major	The DFM has to provide all necessary means for the direct manipulation of the overall Digital Factory.	The DFMs can describe in detail the corresponding machines, end-users, and processes.
COM-68	Ontologies shall be implemented in .owl format	Non-Functional -> operational	Major	Owl format is very popular; it is supported by open-source tools (e.g. Protégé, etc.) and APIs (e.g. Jena, etc.) and enables semantic rules and queries to be applied.	All the developed semantic models are implemented within ontologies in .owl format
COM-67	Business processes must be described using the BPMN standard	Non-Functional -> operational	Major	Business processes must be defined in machine-readable format that supports also easy visualization	There are corresponding BPMN files for all
COM-66	Products/services offered via the ecosystem are COMPOSITION compatible.	Non-Functional -> operational	Medium	Products/services offered via the ecosystem are COMPOSITION compatible, according to a set of adopted standards.	Products/services offered via the ecosystem are COMPOSITION compatible, according to a set of adopted standards.
COM-65	The ranking component includes a machine learning system to continuously improve the recommendations it gives out.	Functional	Nice to have	Customers get ranking about solution providers based on information in ecosystem about customer satisfaction. The system gets feedback: i) from potential customers on whether they want to	The categorisation of suppliers of different products/services will be optimised within the ecosystem based machine learning algorithms.

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				receive the advertisements on specific topic(s), ii) from the suppliers on the effectiveness of the advertising campaign, as well as iii) to who it should advertise, depending also on who is registered in specific topics. This feedback helps the system learn and optimise.	
COM-64	The system provides an automatic ranking of the suppliers to the buyers, based on customers' satisfaction and feedback.	Functional	Nice to have	Customers get ranking about solution providers based on information in ecosystem about customer satisfaction. This raises chances for more unknown suppliers.	Suppliers of different products/services will be automatically categorised within the ecosystem based on customers' satisfaction
COM-63	The system provides an automatic ranking of the suppliers to the buyers, based on the buyers' criteria.	Functional	Major	Customers get ranking about solution providers based on information in ecosystem. The ranking of suppliers is done in an automatic way, based on defined criteria.	Suppliers of products/services will be automatically ranked according to a set of predefined available criteria that exist in the ecosystem and that the potential customer sets in an automatic way.
COM-62	All types of companies (buyers and suppliers) shall be subscribed to specific topics in the ecosystem	Functional	Medium	By subscription to a specific topic of interests, information is available to	Potential customers and suppliers subscribe to specific topics within

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
	according to their interests and needs			the ecosystem which will automatically match customers' interests with various suppliers' offers and vice versa.	the ecosystem.
COM-61	Suppliers' product/services shall be matched with a potential customers' needs/problems.	Functional	Critical	By advertising supplier's products/services information is available to be automatically matched with registered customer's needs/problems.	Suppliers' product/services are automatically matched with a potential customers' needs/problems.
COM-60	Supplying companies register their products/services in specific topic(s) within the ecosystem.	Non-Functional -> operational	Major	Supplying companies register products/services to potential customers.	The products/services of a supplier are registered within the ecosystem.
COM-59	Supplying companies register their products/services in specific topic(s) within the ecosystem.	Non-Functional -> operational	Critical	Suppliers register their products/services to the ecosystem and this information is available to specific topic(s).	The products/services of a supplier can be published/registered in specific topics with a predefined manner within the ecosystem.
COM-58	The needs and requirements of companies shall be registered/published within the ecosystem.	Non-Functional -> operational	Critical	Companies register their needs and requirements to the ecosystem and this information is available to specific topic(s).	The necessary categories and topics exist in the ecosystem, so that the companies can publish their needs within COMPOSITION.
COM-57	The contractor can create offers in the IIMS system	Functional	Major	The contractor receives information on the content of the metal scrap container. He	The contractor can create, modify and delete offers in the IIMS system

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				prepares the offer and creates the it in the IIMS system	
COM-56	The IIMS system automatically informs the contractor the fill level of the metal scrap containers	Functional	Major	The contractor can plan when to collect the metal scrap container by knowing the fill level of it.	The contractor is informed by the IIMS system of 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	Functional	Major	When the contractor has collected the metal scrap container and delivered a new empty back, he confirm this by updating the IIMS system.	The contractor can access the IIMS system and update the status of the collection activity
COM-54	Purchasing Manager maintains the list of approved contractors	Functional	Major	He is responsible for the final selection of the waste management company, as he has all information and knowledge about the companies selected as contractors. He is also responsible for the raw material orders	The Purchasing Manager can create, maintain, delete and edit the list of approved contractors
COM-53	The Maintenance Manager shall receive information that the metal scrap container is full	Functional	Major	By automatically measure the scrap container's filling level the Maintenance Manager receives information when it is full. The maintenance manager arranges with the	The Maintenance Manager receives information from the IIMS system that the metal scrap container is full

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				contractor the pick-up time	
COM-52	The COMPOSITION Marketplace Management System shall enable stakeholders to visualize existing public, closed markets	Functional	Major	Stakeholders shall be able to explore closed, but public marketplaces and require access/participation to those they are interested in.	Through a suitable UI an open marketplace stakeholder can request access to a public, closed, marketplace
COM-51	The COMPOSITION Marketplace Management System shall enable stakeholders to define closed marketplaces	Functional	Major	Some stakeholder might want to form a closed marketplace with a restricted subset of other market participants	A stakeholder part of the COMPOSITION open marketplace can define a closed marketplace and invite other stakeholders to join.
COM-50	The COMPOSITION Marketplace Management System shall enable stakeholder to gain access to the COMPOSITION open marketplace	Functional	Major	Any stakeholder wanting to enter the COMPOSITION open marketplace shall be able to gain necessary credentials / configurations needed for its agent to join the marketplace	External stakeholder can get access credentials and configuration information to enable their own agents to join the COMPOSITION open marketplace
COM-49	Agents might be part of an organization or group of agents	Functional	Major	Agents might want to form groups for accomplishing specific tasks, and or mimicking traditional supply chains.	Agents groups actually appear on the marketplace
COM-48	Agents shall be individually addressable	Functional	Major	Every agent in the market shall be individually	Every agent on a marketplace as a

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				addressable to support both identification/tracing and peer-to-peer communication	unique agent address identifier (AID)
COM-47	Agent Communication Language shall have a standard and well defined semantics	Non-Functional -> operational	Major	Every agent in the marketplace shall be able to effectively interpret exchanged messages.	A shared, standard (e.g., stemming from FIPA ACL) language is used for communication between agents
COM-46	Agent Communication Language shall be based on messages	Non-Functional -> operational	Major	To preserve independence from implementation technology and to support flexible information exchange between agents, message-based interaction shall be preferred over other alternatives, e.g., remote procedure call.	Conversation between agents are based on messages
COM-45	Agent Communication Language shall be agnostic to transport	Non-Functional -> operational	Major	For agents to be able to communicate independently from the technology they are developed with, the messages exchanged shall be technology independent, and should not imply any language-specific "operational	Agent Communication Language is completely independent from the technology used to implement single agents

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				semantics".	
COM-44	Agents shall be writable in any programming language	Non-Functional -> operational	Major	As any stakeholder will be enabled to develop and tune its own marketplace agent, it is straightforward to foresee that different stakeholder will exploit different technology stacks and consequently will develop their own agents in different programming languages.	Agents are developed using more than one programming language
COM-43	Message transport shall support several transport protocols	Non-Functional -> operational	Major	Since agents can be developed in many, different programming languages, it is mandatory to ensure support to several communication protocols that can be used to deliver agent messages.	More than 3 different transport protocols are supported / deployed on the marketplace event broker
COM-42	AMS shall gracefully scale	Non-Functional -> performance	Major	Agency Management Services, i.e., the marketplace white pages, shall gracefully scale to markets involving hundreds of agents, with consistent performance and low latency.	The AMS is able to withstand several requests per second and an almost constant latency

Key	**Summary**	**Requirement Type**	**Priority**	**Rationale**	**Fit Criterion**
COM-41	AMS and DF shall be provided at the container (marketplace) level	Functional	Major	Every distributed container (or COMPOSITION marketplace, see definitions in shall provide services for agent identification / location and for service discovery.	AMS and/or DF are available in a marketplace
COM-40	Message transport shall support authentication / encryption / access control	Non-Functional -> operational	Major	Communication between agents shall never be disclosed to other agents / entities belonging to the market (unless required by the specific interaction being in place)	Agent communication is performed over an encrypted channel. Access control is in place.
COM-39	Message transport shall be general purpose	Non-Functional -> operational	Major	The message transport leveraged by the marketplace shall be able to transport at the same time both peer to peer messages between agents, shall support multicast / group communication and shall be able to handle high-speed/high-cardinality data flows between agents (e.g., to share data between factories)	The Market Event Broker is able to handle high-speed / high cardinality data streams. It supports several protocols / access mechanisms to enable agents developed with different technologies to communicate with each other.
COM-38	Message transport shall be scalable	Non-Functional -> performance	Major	Communication in the marketplace shall seamlessly scale to support hundreds of	The Market Event Broker is able to handle conversations for a high number of

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				agents	agents
COM-37	Redundancy shall be kept as low as possible	Non-Functional -> operational	Major	To support high-performance data exchange and to gracefully scale to a possibly high number of market players the number of redundant infrastructure components (e.g., so-called container nodes) shall be reduced at the minimum.	Virtually no redundant / duplicate components shall be part of a deployed marketplace (this does not include replication for failure protection)
COM-36	Agent containers shall be natively distributed	Non-Functional -> operational	Major	The Agent container concept (with its mappings to marketplace definitions) shall be natively distributed to support: (a) distribute deployment of stakeholder agents, (b) effective scaling, (c) resistance to single component failures	All implemented and deployed Agent containers are completely decentralized and they are defined as a set of intelligent agents interacting through the same, shared broker (can be a cluster) and referring to shared platform services such as the DF and the AMS.
COM-35	Agents must not be forced to run in a single, pre-defined location	Non-Functional -> operational	Major	Ideally any stakeholder shall be able to run its own agents exploiting its preferred ICT infrastructure / facilities. there should be no constraints on	Agents belonging to a single marketplace are hosted on different physical / virtual machines or they run in separate containers (e.g., Docker)

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				contributing agent code to a specific location / actor, with related "disclosure" and "protection" issues	
COM-34	Time frames for data pulls shall be freely configurable (BSL)	Non-Functional -> operational	Major	Allows for dedicated analysis of past and real-time production data	Time frames are freely configurable from 15 minutes up to years
COM-33	Items from BSL's inventory shall be reordered automatically	Non-Functional -> operational	Major	Prevention of production delay due to out of stock items	Items which numbers are below a certain threshold are reordered automatically
COM-32	Data output from Deep Learning Toolkit	Functional	Minor	Data output format and transmission mechanism to read data reports from the Deep Learning Toolkit should be commonly agreed.	Successful modules interoperability.
COM-31	Data input to Deep Learning Toolkit	Functional	Major	Data input format and transmission mechanism to feed data stream to the Deep Learning Toolkit should be commonly agreed.	Successful modules interoperability.
COM-30	Data classification report latency				The time span between the periodic processing of two consecutive batches of live input data can be as long as 24 hours, depending on specific tasks and

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
					configuration. Other Composition modules interacting with Deep Learning Toolkit should be resilient to this maximum delay.
COM-29	Managers in charge of the production process at BSL shall be contacted automatically if issues are detected	Non-Functional -> operational	Major	Shorter response times if there is a critical issue, e.g. broken machines	Responsible managers are contacted automatically
COM-28	BSL's production data shall be observable in real time per machine	Functional	Major	Allows to detect issues and potential defective machines in real time. Additionally, the managers can observe the current production compared to the goal	Production data can be monitored in real time per machine
COM-27	Provide enough data for training artificial neural networks	Constraint -> assumption	Blocker	In order to be modelled and validated, the artificial neural networks managed by the Deep Learning Toolkit needs to receive enough pertinent data for the tackled problem. The amount of data changed based on the use case scenario addressed.	The requirement will be considered fulfilled when provided data will allow a preliminary validation accuracy of at least 95%.
COM-26	Batches shall be identifiable in BSL's production line	Non-Functional -> operational	Major	Identifiable batches allow to determine at which step the batch has been, what it's issues are and	All batches are identifiable with a unique ID

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				where it is in the production process	
COM-25	Items shall be trackable asides BSL's production line	Non-Functional -> operational	Major	Tracking of items asides the production line allows for faster return of manually moved items into the production process	Items are trackable asides the production line
COM-24	Items on the line should be trackable in real time in BSL's production process	Non-Functional -> operational	Major	Allows for the detection of bottle necks or retrieving lost parts	All items on the line are trackable
COM-23	Documentation of defective parts should be done automatically in BSL's production process	Non-Functional -> operational	Major	The automated documentation of defective parts shortens reaction time if critical issues appear	All defective parts are automatically documented
COM-21	The IIMS shall integrate different heterogeneous data sources	Non-Functional -> operational	Major	IIMS features are based on different heterogeneous data sources.	Data from at least 5 heterogeneous sources is fed into the IIMS:
COM-20	The system shall detect patterns in data, without the need to explicitly search for them	Functional	Major	Finding patterns for which one does not have to formulate searches is an added value to traditional data analysis.	The system detects patterns in data for which no search query was formulated
COM-19	The system shall be protected against cyber attacks	Non-Functional -> security	Major	Prerequisite for establishing trust of end user for using their data inside the Composition platform	An independent security expert does not find ways to get illegal access to the platform or data from the platform.
COM-18	Data transactions shall be	Non-Functional ->	Major	Data transfer	No past data transfer

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
	immutable	security		immutability is a key enabler for trust in the system.	can be manipulated,
COM-17	Data transactions shall be traceable	Non-Functional -> security	Major	Data traceability is a key enabler for trust in the system.	Every data past transfer can be traced,
COM-16	Only a specific group of receivers shall have access to data	Non-Functional -> security	Major	Confidentiality and integrity of all data needs to be guaranteed.	Only individuals who are specified by the data owner have access to data.
COM-15	The processes and stakeholders of the pilots shall be modelled	Project Issue	Major	This is a prerequisite for the forecasting, simulation and decision support features	All processes and stakeholders of the pilots, which are relevant for the forecasting, simulation and decision support features of Composition, are modelled
COM-14	A common methodology and notation for modelling shall be established	Project Issue	Major	This is a prerequisite to model processes and stakeholders by different partners	A common methodology and notation for modelling is specified.
COM-13	Optimal routes for collecting bin shall be recommended to KLE's worker	Functional	Minor	The routes for collecting bins shall be optimized.	The system recommends 1-3 optimal routes for collecting bins.
COM-12	The system shall simulate KLE's production process	Functional	Major	Simulating different variations of the production process helps find the optimal variation with the smallest bottle	The system simulates all variations of KLE's production process.

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				necks	
COM-11	The system visualizes bottle necks in KLE/BSL's production process	Functional	Major	Identification and visualization of bottle necks is the first step for removing bottle necks.	The system visualizes all bottle necks in both, KLE's and BSL's production process.
COM-10	The system shall monitor the status of KLE's polishing machine	Functional	Major	Maintenance of KLE's polishing machine shall be improved by predicting maintenance times BEFORE something is broken. The prediction needs to continuously analyse the status of the polishing stones which again needs to be collected from the machines.	All data which is needed for predicting maintenance of KLE's polishing machine is continuously collected.
COM-9	The system shall suggest to maintain machines before they break	Functional	Major	Predictive maintenance enables optimized maintenance time by reducing unnecessary maintenance checks and by fixing first flaws before they are extended to bigger problems.	The system suggests machine maintenance at the optimized time.
COM-8	On request, information on fill level of the metal scrap container shall be provided	Functional	Major	This information is required for optimising collection and removal of metal scrap	The IIMS system can provide information on the fill level of each metal scrap container on request.
COM-7	The employee shall be informed in which metal scrap container to	Functional	Major	To avoid unnecessary delays or production	The employee is informed in which

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
	dispose of the bin content			stops, it is important that bins are removed when they are full	metal scrap container to dispose of the bin content
COM-6	The employee shall be informed when a metal scrap bin is full	Functional	Major	The fill level of the metal scrap bin is measured automatically, and when full, the employee is advised to collect the scrap	The employee is informed when a metal scrap bin is full
COM-5	The offers for scrap metal shall be displayed for approval by the purchasing responsible	Functional	Major	The purchasing responsible is responsible for the final selection of the contractor and approval of the offer	The offers are displayed for approval by the purchasing responsible
COM-4	Maintenance Data about machines shall be continuously collected	Functional	Major	Machine maintenance shall be improved by predicting maintenance times BEFORE something is broken. The prediction needs to continuously analyse data which again needs to be collected from the machines.	All data which is needed for predicting machine maintenance is continuously collected.
COM-3	Ecosystem: multiple marketplaces; participation by invitation only	Constraint -> stakeholders	Major	Platform management, as well as negotiation, trust and information security in a completely open ecosystem/marketplace is perceived as problematic. Perceived lack of control and trust may hinder the exploitation of the	There should be a way to control access to and participation in a COMPOSITION marketplace. Where relevant, component design should take this requirement into account.

Key	Summary	Requirement Type	Priority	Rationale	Fit Criterion
				system. To aid acceptance of the platform by end users, closed marketplaces with controlled access are suggested.	
COM-2	The IIMS shall be able to forecast when the container is full	Functional	Major	By providing a forecast it is possible to ensure that the container is emptied when it is full	The IIMS can forecast when the container is full
COM-1	The fill level of metal scrap containers shall be monitored	Functional	Major	By automatically measuring the fill level, information is available as to when it is necessary to collect the scrap	The fill level of the metal scrap container is continually monitored
	Summary	Custom field (Requirement Type)	Custom field (Requirement Priority)		Custom field (Fit Criterion)

10 Appendix B: Initial List of Innovations

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

List end user requirements for the COMPOSITION application that will be implemented using the innovation:

COM-17: Data transactions shall be traceable

COM-18: Data transactions shall be immutable

COM-19: The system shall be protected against cyber attacks

I-02 Matchmaking Broker

Description

The COMPOSITION Broker that 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, et c) 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-64: The system provides an automatic ranking of the suppliers to the buyers, based on customers' satisfaction and feedback.

COM-86: The Matchmaker shall apply both syntactic and semantic matching

COM-87: Various similarity algorithms and metrics shall be supported by the Matchmaker

COM-88: Different decision criteria for supplier selection are supported by the Matchmaker

COM-89: Matchmaker shall return a result within 5 seconds

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 an 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-80 The UIs should be user-friendly

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-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-23 Documentation of defective parts should be done automatically in BSL's production process

COM-13 Optimal routes for collecting bin shall be recommended to KLE's worker

COM-12 The system shall simulate KLE's production process

COM-9 The system shall suggest to maintain machines before they break

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-5 The offers for scrap metal shall be displayed for approval by the purchasing responsible

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 dynamic agent-based marketplace enables the COMPOSITION ecosystem by an 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 request / offer matching mechanism.

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-66 Products/services offered via the ecosystem are COMPOSITION compatible.

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-33 Items from BSL's inventory shall be reordered automatically

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 – Manufacturing Modelling and Simulation

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-94: Interfaces shall facilitate machine learning toolkit forecast

COM-93: DSS will communicate/exchange the data

COM-92: Production of Simulated Data