MAESTRI

Total Resource and Energy Efficiency
Management System for Process Industries

Deliverable 1.7

Lessons Learned and Updated Requirements Report 3

Date: 15/01/2019

WP1 Requirements Engineering

T1.5 Evolutionary Requirements Elicitation

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Executive Summary

The requirements elicitation in MAESTRI is carried out applying a user-centred approach (see D1.4 Initial Requirements Report for details). Based on the existing requirements we updated the status and also introduced use case descriptions in order to better describe the context in which requirements will be used.

Due to confidentiality issues we only included general descriptions of use cases for main pillars such as management and operator dashboards or the usage of ecoPROSYS. But this should provide support to better understand how the MAESTRI platform can be applied in real-world scenarios.

D1.7 Lessons Learned and Updated Requirements Report 3 is the final deliverable of WP1.

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1 Introduction

1.1 Purpose, context and scope of this deliverable

The purpose of this deliverable is to give an overview of lessons learned, requirement updates and refinements considering the time between M27 and M38. It is based on the user requirements for the MAESTRI consortium which was presented in D1.4, D1.5 and D1.6. According to a Lessons Learned from the previous deliverable D1.6 we extended the requirements work in such a way that we also include use cases to better reflect the relations between requirements and give context to both business users as well as developers.

1.2 Deliverable Organization

This deliverable is organized as follows:

- Chapter 2 presents lessons learned.
- Chapter 3 contains an updated list of requirements.
- Chapter 4 contains a list of use case descriptions.

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2 Lessons Learned (LL)

This section presents MAESTRI's definition of a lesson learned, the MAESTRI Lessons Learned (LL) process, the LL verification criteria, the categories a LL can be related to. Moreover, it lists the current lessons learned so far per work package.

2.1 What are Lessons Learned?

Lessons Learned belong to a project culture committed to Knowledge Management. Lessons are learned during project RTD work, during testing and integration, as a part of the validation of project prototypes and during literature search and technology watch. Further sources for LL are Dissemination and Exploitation activities, as a part of the process for commercialization of the project prototype. Lessons can thus be learned throughout the project work. As such, Lessons Learned constitute both individual and organisational knowledge and understanding gained by experience, either negative (missed targets, solutions that do not work as expected, wrong choice of technology) or positive (easier implementation than expected, faster response time, more interoperable devices than expected).

Lessons Learned help support project goals in the RTD work of:

- Promoting recurrence of successful outcomes
- Precluding the recurrence of unsuccessful outcomes.

In order to implement a workable Lessons Learned process, we need first to define what we understand by the term "lesson". We use the following characterisation for a lesson:

- It must be significant in terms of the project progress and ability to meet its goal
- It must be valid, i.e., the experience gained must be repeatable and/or must be linked to at least one activity or phase of the project
- It must be applicable to the MAESTRI project
- It may contain or address pertinent info
- It may provide information of interest for existing stakeholders but also for future potential users of separate items/findings of the project.

Not all experiences will qualify as being Lessons Learned and it is important that reported Lessons Learned not merely restate existing information, and/or existing experiences *not* related to the MAESTRI work.

The documentation of the MAESTRI Lessons Learned Process can be found in D1.6

2.2 List of current Lessons Learned

This section lists the current lessons learned related to each work package for M27-38. The previous deliverable D1.6 contains the set of Lessons Learned for M1-M26.

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2.2.1 WP5 Lessons Learned

Category	Experience and knowledge gained	Lesson learned	Analysis
PRO	It should be considered in early stages of front-end tool deployment ways to use strategies to integrate so-called "black boxes", this is, solvers, that received inputs and data, and delivers results towards results database or dashboards.	This could speed-up the deployment process, accelerated by proofs of concept also to involve more the Pilot Teams of the Demonstrator Companies. Furthermore, this could facilitate, by standardization (of communication formats for data I/O) the implementation to be more modular and straightforward, rather than full vertical integration with direct access to raw-data or "data lake".	This aspect is seen as transverse in all MAESTRI demo cases.

2.2.2 WP6 Lessons Learned

Category	Experience and knowledge gained	Lesson learned	Analysis
PRO	When defining the performance indicators for a given process area, and associated to new assessment tools that require always even minor behaviour transformation process, is fundamental to involve different profile persons for different hierarchical roles, starting from the full engagement of top management, good articulation with middle management and, last but not least, a very transparent inputs collection of important process parameters from the shop-floor area.	A full engagement towards the new assessment methods and tools should be facilitated, by providing a clearer explanation in what manner the new tools and information can support decision and awareness for multiple profile roles. Furthermore, the indicators should be articulated in-between the management structure (bottom-up for awareness and top-down for policy deployment regarding goals and	These aspects could be seen in a transverse way in all MAESTRI pilots, and so they should be transposed to the MAESTRI Total Efficiency Framework deployment guide.

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		master objectives). Not all the indicators are "KPI", this is, important indicators to be always followed-up in dashboards, rather to be analysed on demand (when something goes wrong or efficiency deviation) as "observation parameters" for example.	
VAL	Purpose of the Problem Solving workshop is to find a relevant solution to the selected problem. This problem has to be important for the company, possible to solve by the factory team, but not too much complicated.	There is a need to support the company in a selection of appropriate problem for a problem solving workshop purpose.	Highly complex problem can cause that workshop team will not be able to complete the analyses until the end of the workshop. In addition, it might be demotivating for them and in a result, they will not be interested into solving problems in the future. On the other hand – it is not possible to solve problems which are not directly dependent on the factory team. When suppliers or third parties are affected by the problem then it is necessary for their support to solve problems effectively.
VAL	Problem Solving workshop focuses more on methodology and less on information on how to build a project team, work rules, communication and dealing with problems.	Problem Solving workshop should contain information about the role of the leader, the role of each team members, as well as the owner of the area and supporting departments.	If solving the problems have to be a process instead of one single event, employees should know how to work as a team and how to communicate in order to solve problems quickly and effectively.
VAL	Problem solving methodology needs	Use as many relevant data as	Based on the imprecise data and

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	relevant data and information. Often employees are based on their assumptions about the scale of the problem and not on hard data.	possible. If data are not available, then it is necessary to start to collect them and then initiate problem solving analysis.	information about the scale of the problem wrong decisions and corrective actions can be taken by employees. On the other hand, when employees do not have data, they are not able to set success criteria which tell them whether the problem was solved effectively or not.
VAL	Engagement of key managers in the workshop and then problem solving implementation is crucial. When the key manager is involved in a problem solving process – the analyses go smoothly and the results are satisfying.	Invite key manager(s) for problem solving workshop.	Key managers should know the methodology of the problem solving and motivate employees to use it. Managers should know how to assess the effectiveness of the problem solving and celebrate the success. In addition, employees expect support from the managers and the appropriate allocation of time and financial resources.
VAL	Employees are not aware of how important it is to make regular reflection process thus, they rarely improve their management processes or the improvements are only superficial.	It is needed to make employees aware of what a reflection process is and what benefits it can bring.	Employees often assume that once established, the way of working should continue without any changes. An Effective Management System can only be effective if the company reflects on what went well and what went wrong with both the results and the processes. Then they discover that improvements can be implemented in the management system that will

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			improve their performance in a wider perspective.
VAL	The engagement of top management in the reflection process is crucial.	Invite key manager(s) for Reflection Process workshops.	Top management gives an example of commitment and immediately verifies the ideas of employees. Management is able to take a quick decision which of improvement ideas will be implemented. On the other hand, top management can see the discrepancies in the perception of the same aspects and processes by management and employees.
VAL	Reflection Process should not be a single event. Reflection Process should be repeated regularly for different processes.	Build awareness across company's employees that Reflection Process is one of the Effective Management System elements that continuously should improve processes and results. Organize Reflection Process sessions regularly.	Reflection Process sessions should be organized regularly and not only at the end of management system implementation but also at particular stages of the implementation of the management system and further. In addition, each Reflection Process session should end with the creation of an action plan, which will contribute to the improvement of processes and results of company's Management System.

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2.2.3 WP8 Lessons Learned

Category	Experience and knowledge gained	Lesson learned	Analysis
VAL	External professionals could multiply the dissemination and exploitation potentials of project results	In many industries and companies, - especially SMEs - R&D, Optimisation of industrial processes as well as implementation of effective management systems are often outsourced to external experts such as engineers working as sole traders or freelance professionals.	Targeting professionals and experts is an effective strategy to a broader diffusion of MAESTRI results. One professional may have a role in more than one company (e.g. the case of energy managers – e.g. in Italian SMEs it is common to have this role externalised. One energy manager usually keeps this role in more than one company). Professionals are interested in participating to specific training activities about the MAESTRI approach. This increases their opportunities to provide more valuable consulting services to their customer companies and, in parallel, allows the MAESTRI Consortium to expose companies to the results and potentially to exploitation opportunities. In this sense, professionals can be considered multiplier and 'trojan horses' for MAESTRI results.
VAL	Physical events are more important than social media in terms of visibility	Apart the organic research in search engines such as Google, the main source of website visitors is the direct access. Around 25%	Likely, visitors having the MAESTRI URL received it at physical events such as workshops, conferences, fairs in which MAESTRI was

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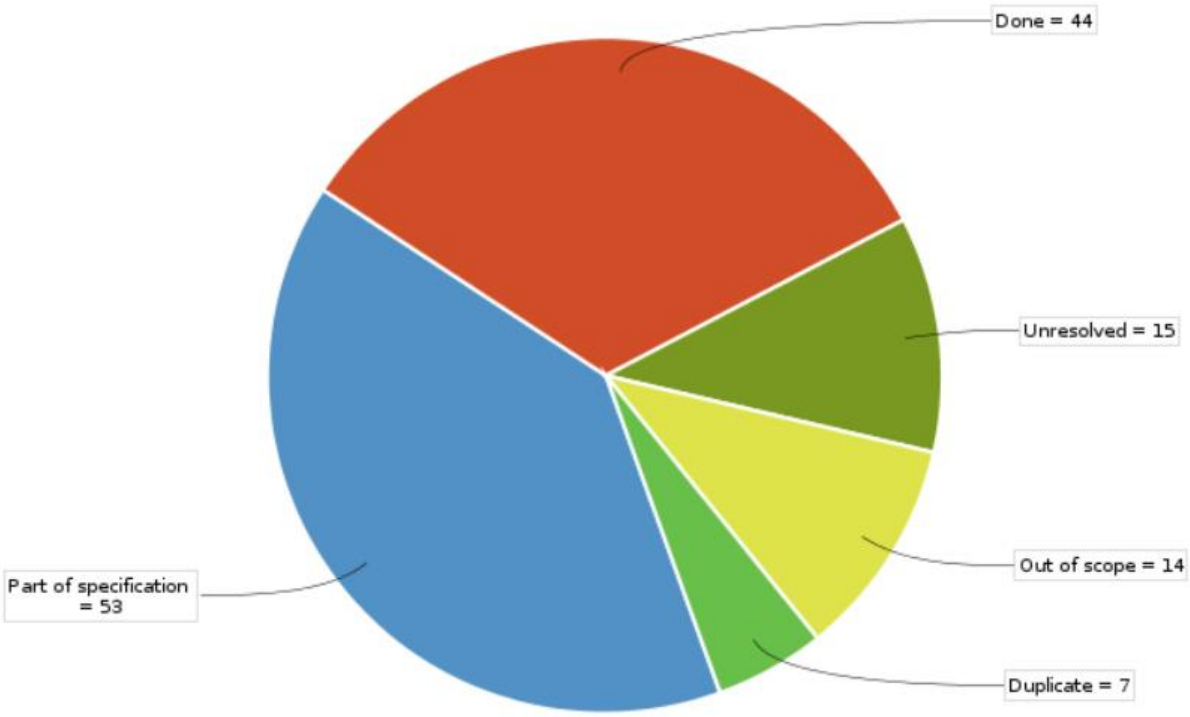
		of visitors knew directly the MAESTRI website url.	presented or where dissemination materials have been distributed. Social media represent the minor sources of visitors.

3 Updated Requirements List

The following graph shows the resolution for the list of requirements as they have been listed in deliverable D1.6 with their updated status:



	Issues	%
Part of specification	53	39%
Done	44	33%
Unresolved	15	11%
Out of scope	14	10%
Duplicate	7	5%

The requirements currently being "Part of specification" do not only contain implementation requirements but also process related requirements that will be validated later so they are supposed to be closed at the end of the project.

All MAESTRI requirements being "Part of specification" are listed in the following table.

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Requirement Key	Summary	Fit Criterion	Requirement Type
MAES-68	MAESTRI IoT platform must provide API to allow ecoPROSYS to calculate the eco-efficiency output	Relevant data for eco-efficiency assessment are accessible through at least one of the interfaces provided by MAESTRI IoT platform (e.g. REST API, MQTT, or other interfaces), as soon as it is made available from relevant data sources.	Functional
MAES-83	Effect of an elementary flow variation in all other elementary flows should be predicted	Functional	
MAES-73	Necessary data for MAESTRI Platform: Emissions to Air	Air outputs represent the releases to the environment of gaseous or particulates from a point or diffuse source of any stage of business case, after passing through emission control devices, if applicable.	Non-Functional -> operational
MAES-58	Develop models to identify and simulate appropriate consumption patterns and waste flows, leading to optimisation of materials and energy use via cost-saving optimization approach	A forecast of the expected consumption patterns and waste flows is displayed.	Functional
MAES-57	Managers can evaluate, through scenario analysis, the expected costs and perform simple payback analysis, considering the cost reduction and/or reduction of waste/missuses of resources	A forecast of the expected costs and a simple payback is displayed.	Functional
MAES-59	Real time metering, must be adopted to monitor energy and resource flows by adopting the Internet of Things (IoT) concept	The data collection is automated, so that the energy and resource consumption as well as other process related activities will be monitored in real time (or near real-time).	Functional
MAES-45	Visual mapping tools	MAESTRI, via DSS (see task 5.2), will encompass Visual Analytics engine presenting different state-related views of the production operations, supporting comparative assessment of material and resource management, enabling managers to visualise the entire process as well as each unit process and the respective inputs and outputs. Moreover, managers will be able to map the process (process design).	Functional
MAES-56	Perform and evaluate Life Cycle Costing Analysis and Value Modelling	MAESTRI Platform provides a function for Life Cycle Costing Analysis and Value Modelling.	Functional

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MAES-77	Necessary data for MAESTRI Platform: Intermediate Products	Products or substance outputs from a process that are received as input by a subsequent unit process within the business case, enabling managers to keep track of the intermediate products.	Non-Functional -> operational
MAES-52	Prioritize options to support decisions for improvement measure (both cost-saving and efficiency improvements)	The major inefficiencies are identified and results are available, therefore the priority of each improvement action can be determined.	Functional
MAES-70	Necessary data for MAESTRI Platform: Material flows and costs	Actual materials that make up the final product for a particular process (primary materials) and materials that are used in the processing of a product for a particular process. Materials may be non-renewable (i.e., materials extracted from nature that are non-renewable or stock resources such as coal), renewable, or flow resources such as water. Quantification, at each stage of the process system, of "what adds value" (AV) and "what does not add value" (NVA) to a product or service.	Non-Functional -> operational
MAES-82	Environmental performance evaluation should be used for simulation	The view of the company and the way it understands the production system should be included in scenarios simulation.	Functional
MAES-80	Necessary data for MAESTRI Platform: Maintenance Activities and Costs	Maintenance activities schedule and costs related to any process and/or equipment or infrastructure used in a process within the business case.	Non-Functional -> operational
MAES-79	Necessary data for M MAESTRI Platform: Labour cost	Direct and indirect (benefits and payroll taxes) labour costs	Non-Functional -> operational
MAES-78	Necessary data for MAESTRI Platform: Equipment data and cost	Includes data on equipment used in the different processes within the business case, working related costs, including amortization, opportunity cost, etc.	Non-Functional -> operational
MAES-76	Necessary data for MAESTRI Platform: Wastes	Represents the mass of a product or material, either solids or liquids, that are deposited as hazardous or non-hazardous waste, either before or after treatment (e.g., incineration, composting), recovery, or recycling processes. Quantity/volume of waste as well as route/treatment.	Non-Functional -> operational
MAES-75	Necessary data for MAESTRI Platform: Emissions to soil	Soil emissions represent discharges chemical substances that are considered pollutants to soil from point or diffuse sources of any stage of business case.	Non-Functional -> operational
MAES-74	Necessary data for MAESTRI Platform: Emissions to water	Water outputs represent liquid surface and groundwater discharges, from point or diffuse sources of any stage of	Non-Functional -> operational

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		business case, after passing through any water treatment devices.	
MAES-55	Definition of the Life Cycle Costing Analysis and Value Modelling approaches	Costs and value is evaluated for all process stages in the processes under research assessment	Non-Functional -> operational
MAES-29	Relationship between process variables and material properties need to be understood in order to support individualization of products to customer needs.	For 80% of the process variables used in the production process it is known how changes to material properties would influence the output qualities.	Non-Functional -> operational
MAES-28	Reorder amount of raw material needs to be calculated automatically in order to reduce miscalculations	Calculating the reorder amount of raw material can be automated and the algorithm can be specified to match the company´s need.	Functional
MAES-48	Definition of the simulation models for assessing scenarios	For each scenario, the efficiency and eco-efficiency performance has been quantified, these results allow the company to foresee the overall performance regarding a certain scenario.	Non-Functional -> operational
MAES-72	Necessary data for MAESTRI Platform: Water flows and costs	Water consumed and/or generated by any process within the business case, including effluents. Quantification, at each stage of the process system, of "what adds value" (AV) and "what does not add value" (NVA) to a product or service.	Non-Functional -> operational
MAES-71	Necessary data for MAESTRI Platform: Energy flows and costs	Process energy and pre-combustion energy (i.e., energy expended to extract, process, refine, and deliver a usable fuel for combustion) consumed and/or generated by any process in the business case. Quantification, at each stage of the process system, of "what adds value" (AV) and "what does not add value" (NVA) to a product or service.	Non-Functional -> operational
MAES-66	MAESTRI Platform encompasses a methodology for modelling industrial processes, which includes resources and energy efficiency related aspects	Managers are able to perform model the process and consequently are able to perform optimization simulations	Non-Functional -> operational
MAES-49	The production manager gets a prediction the best scenario in order to enhance overall efficiency and eco-efficiency	A forecast of the expected efficiency and eco-efficiency performance for different scenarios is displayed.	Functional
MAES-50	Definition of the optimization models for energy and resources efficiency	The adoption of an optimization tool, will enable fast generation of optimized scenarios for improvement, since improvement scenario design optimization can be very time-	Non-Functional -> operational

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		consuming and unmanageable task on a trial-error basis	
MAES-51	The production manager to perform optimization simulations and optimized scenarios for materials and energy consumption, via overall efficiency and cost-saving targets	A forecast of the expected optimized scenarios is displayed.	Functional
MAES-62	The production manager is able to monitor, analyse and mine eco-efficiency performance data in order to assess environmental and economic performance (assess overall eco-efficiency performance using ecoPROSYS)	MAESTRI is able to analyse monitored data and to identify major environmental and economic impacts regarding energy and resource consumption.	
MAES-67	Plant managers can use the MAESTRI Platform in order to create an overall efficiency index and company eco-efficiency profile	The user can evaluate on a monthly basis the efficiency performance and company eco-efficiency profile.	Non-Functional -> operational
MAES-65	A clear approach needs to be outlined in order to define the value added and non-value added fraction, for each energy and resource flow in order to assess overall resource and energy efficiency	The MAESTRI Platform is available and can be used to Quantify the NVA of each stage of the process system	Non-Functional -> operational
MAES-46	Define the information and contents for the environmental footprint	The environmental footprint of each product belonging to a given set of products can be determined.	Non-Functional -> operational
MAES-30	Plant managers can use the Total Efficiency Platform in order to select KPIs to appear on the dashboard	The user selects a given set of KPIs using the Total Efficiency Platform and have them displayed on the Total Efficiency dashboard on the shop floor: KPI evolution and deviation from the target values.	Functional
MAES-27	Plant managers communicate with shift and sector supervisors in order to spread the knowledge on how to enhance efficiency and eco-efficiency performance	Plant managers organize 6 workshops per year to communicate best practices on how to enhance efficiency and eco-efficiency performance.	Functional
MAES-23	The plant manager has access to methods and tools in order to identify consumption patterns and make forecasts	Methods and tools for consumption patterns identification as well as for energy and resources efficiency forecasting are available.	Functional

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MAES-18	Product data can be monitored in order to determine a product's environmental footprint.	The environmental footprint of each product belonging to a given set of products can be determined.	Functional
MAES-7	The production manager gets a prediction of short term customer demands in order to enable an efficient production planning	A forecast of the expected customer demands for different types of products in the short term is displayed.	Functional
MAES-16	The production process designer can get information about the different production steps in order to evaluate options for process/installation changes	The production process designer gets enough information about the current situation in order to estimate the possible success of process/installation changes and enable a calculation of the expected payback period of the investment, and expected eco-efficiency and efficiency performance	Functional
MAES-15	The supply chain manager is able to analyse historical data about problems the supply chain in order to get decision support for future planning	Relevant historical data related to the supply-chain are collected.	
MAES-22	The sector manager can access the Total Efficiency Platform in order to monitor a production line's efficiency and eco-efficiency	The Total Efficiency Platform is available and can be used to monitor a production line's efficiency and eco-efficiency.	Functional
MAES-25	Plant managers can use the Total Efficiency Platform in order to simulate the effect of higher efficiency and eco-efficiency performance	Plant managers can simulate the effect of a higher efficiency and eco-efficiency performance on their plant through the Total Efficiency Platform.	Functional
MAES-24	The board can use the Total Efficiency Platform in order to define sustainability targets.	The user can define sustainability targets using the Total Efficiency Platform.	
MAES-60	MAESTRI platform needs to be defined in order to maximize the improvements in a single plant or across multiple companies, and enable more integrated and cross-sectorial interactions	A holistic approach will enable process monitoring and optimization, as well as focus on an integrated and cross-sectorial interaction that can have a greater impact within the process industry.	Non-Functional -> operational
MAES-47	The board and managers are able to define the company's sustainability targets	For each company or site/plant a set of environmental and economic aspects and KPI has been identified and quantified, these allow the definition of the company's sustainability targets.	Non-Functional -> operational
MAES-43	Define the structure and contents for the standard efficiency and eco-efficiency reports	For each section of the standard PDF report a set of indicators and performance aspects has been identified and, these allow proper communication of the company processes in terms of	Non-Functional -> operational

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		efficiency and eco-efficiency performance.	
MAES-32	Energy consumption must be monitored based on the process steps in order to find potential optimization steps.	Process energy consumed is monitored for all process stages in the processes under assessment.	Non-Functional -> operational
MAES-44	A manager can export a standard efficiency and eco-efficiency report	MAESTRI provides an export function for a standard eco-efficiency and efficiency PDF report	Functional

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4 Use Case Descriptions

This section presents MAESTRI's use cases to give the reader an understanding how the MAESTRI platform can be used in real-world scenarios. Due to confidentiality issues the use cases are rather broad but still should transport the ideas of using the MAESTRI platform.

4.1 ecoPROSYS Use Case

ID	ecoPROSYS_Use_Case_01	
Name	Produce eco-efficiency reports using the ecoPROSYS software and monitor KEPIs.	
Diagrams		
Actors	Manager, Environmental Engineer (EE), IoT Platform, ecoPROSYS Developer (ED), ecoPROSYS Software.	
Actors Goals	Evaluation a production system performance in terms of eco-efficiency. Use ecoPROSYS disaggregated results to assist in a given process of decision making.	
Pre-conditions	Inventory data is available for a given time period or product. Environmental Engineer is aware of ISO 14040, 14044 and 14045. Valid ecoPROSYS registered account.	
Trigger	Manager requests to see an eco-efficiency report to have more information for a given process of decision making.	
Post-conditions success	Manager gets an eco-efficiency assessment report with useful insights.	
Post-conditions fail	Manager does not get an eco-efficiency assessment report with useful insights.	
Description	**Step**	**Action**
	1	Manager requests a new eco-efficiency report.
	2	EE logins into ecoPROSYS.
	3	EE creates a new Evaluation defining the scope and goal for the final report.
	4	EE creates a new Configuration for each inventory intended (one for each product or one for each time period to be analysed).
	5	Inside each Configuration, EE defines as many Activities as processes are present in the Production System.
	6	Associated to each Activity, EE defines Impact Aspects (that are associated to different Aspect Groups).
	7	Associated to each Activity, EE defines Value Aspects.

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	8	After having the inventories configured, EE proceeds with the creation / computation of as many Assessments as desired (testing different methods).
	9	EE chooses what Configuration to use, an LCIA weighting method (to get a Single Score – Influence), an Impact method (if needed) and a Damage assessing method (if asked by ecoPROSYS).
	10	EE analyses the Assessment results.
	11	EE proceeds forward to the report by clicking "New Report".
	12	EE chooses which Configurations to use in the report.
	13	For each Configuration chosen, EE chooses which associated assessment to use in the report.
	14	If comparison metrics are available, EE chooses which eco-efficiency impact indicators and value indicator to use.
	15	EE reviews the report and updates the information on the original modals if need.
	16	EE writes the interpretations on the end of report.
	17	EE prints the reports and delivers it to the Manager.
Extensions	**Step**	**Branching Action**
	1	EE may define KEPIs to display on the dashboard for accessing the EEPA tab, available on each Configuration cards.
	2	EE defines a KEPI that will be shown on the Dashboard, for any entry displayed on the EEPA table.
	3	ED integrates KEPIs monitoring with the IoT Platform for real-time monitoring.
Sub variations	**Step**	**Branching Action**
	1	EE creates a new Configuration for each new inventory intended as well as a new Assessment.
	2	EE creates a new report whenever something in changed on a Configuration or Assessment to account for those changes in the report.
	3	EE creates a new Assessment whenever something in changed on a Configuration to account for those changes in the report.

4.2 Management Dashboard Use Case

ID	**MAESTRI-Management Dashboard-UC1**
Name	Document raw material preparation process
Diagrams	
Actors	Production worker, shift supervisor
Actors Goals	Communicate the status of raw material preparation and document problems observed during preparation, aiming to avoid those problems in the future and thus increase the efficiency.
Pre-conditions	A specific batch is planned for a given production line.
Trigger	The production worker gets the production plan for a given production line, including raw material requirements.
Postconditions success	The raw material preparation results are documented and correctly stored by MAESTRI.
Postconditions fail	The raw material preparation results are not correctly stored.

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Description	**Step**	**Action**
	1	The production worker fetches the required raw material and puts it in front of the production line.
	2	The production worker opens the MAESTRI dashboard and navigates to the raw material preparation area. Then the production worker selects the given production line and sets the status for this line as "raw material to be checked".
	3	The MAESTRI dashboard indicates that the raw material for the given line is ready to be checked.
	4	The shift supervisor notices this change on the dashboard and checks if the raw material was prepared correctly in front of the production line.
	5	The shift supervisor uses the MAESTRI dashboard to insert the results of the raw material check.
	6	The MAESTRI dashboard indicates for the given production line that the raw material was prepared and checked and thus production of the batch can be started.
Extensions	**Step**	**Branching Action**
	4.b	In case that raw material was not prepared correctly, the shift supervisor will correct the mistakes.
	5.b	In case that raw material was not prepared correctly, the shift supervisor notes down the problems observed as well as their probable causes.
	6.b	In case that raw material was not prepared correctly, the problems observed are displayed by the MAESTRI dashboard in a raw materials preparation report.
Sub variations	**Step**	**Branching Action**

ID	**MAESTRI-Management Dashboard-UC2**	
Name	Document planned and actual arrival times of lorries	
Diagrams		
Actors	Production worker	
Actors Goals	Communication of planned arrival times. Documentation of delays observed for further analysis to avoid inefficiencies in the future.	
Pre-conditions	Product shipment is assigned to a specific lorry.	
Trigger	The production worker gets information about the planned arrival time for a lorry.	
Postconditions success	Planned and actual arrival time are saved in the dashboard.	
Postconditions fail	Planned and actual arrival time are not saved in the dashboard.	
Description	**Step**	**Action**
	1	The production worker enters the "lorry plan" area of the dashboard and notes down the planned arrival time of a specific lorry.
	2	The MAESTRI dashboard displays the planned arrival time for the lorry and highlights the status as planned.
	3	The lorry arrives.
	4	The production worker notes down the actual arrival time in the dashboard.
	5	The MAESTRI dashboard displays the planned and actual arrival time for the lorry.

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Extensions	**Step**	**Branching Action**
	2.b	If the planned arrival time is overdue then the MAESTRI dashboard highlights the lorry's status as "delayed".
	5.b	In case that the actual arrival of the lorry was delayed, this observed problem is displayed by the MAESTRI dashboard in a "delayed lorries report".
Sub variations	**Step**	**Branching Action**

ID	**MAESTRI-Management Dashboard-UC3**	
Name	Document final product packaging check results	
Diagrams		
Actors	Shift supervisor	
Actors Goals	Document the condition of product packaging before shipment. In case of problems, allow further analysis to avoid such problems in the future.	
Pre-conditions	The production of a batch was finished and the product was packaged.	
Trigger	Product is ready for shipment.	
Postconditions success	The results of the packaging check are stored by MAESTRI for future analysis.	
Postconditions fail	The results of the packaging check are not available/stored.	
Description	**Step**	**Action**
	1	The MAESTRI dashboard indicates that the batch was finished and the product was packaged.
	2	The shift supervisor inspects the packaging quality for the batch.
	3	The shift supervisor enters the "packaging check" area of the dashboard and notes down the number of (not) okay packaging.
	4	The results of the packaging check are stored in MAESTRI dashboard for future analysis.
Extensions	**Step**	**Branching Action**
	3.b	If the packaging is not okay, the shift supervisor notes down the description of flaws and (if known) the causes of the problems observed.
	4.b	If packaging was not okay, the observed problems are displayed by MAESTRI in a packaging problems report.
Sub variations	**Step**	**Branching Action**

ID	**MAESTRI-Management Dashboard-UC4**
Name	Document batch runtime deviations

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Diagrams		
Actors	Production worker	
Actors Goals	Document batch runtime deviations and their causes for further analysis regarding improvement potentials for future batches.	
Pre-conditions	Batch is finished.	
Trigger	A deviation from the expected batch runtime was observed.	
Postconditions success	The deviation of the batch runtime and the (probable) cause is documented successfully for further analysis.	
Postconditions fail	Batch runtime deviation was not saved properly.	
Description	**Step**	**Action**
	1	The production worker opens the MAESTRI dashboard and navigates into the batch runtime deviations section.
	2	The production worker inserts the type of and the cause for the deviation observed during the batch runtime.
	3	The MAESTRI dashboard displays the type of deviation and the cause for the deviation for the given finished batch in a runtime deviations report.
Extensions	**Step**	**Branching Action**
Sub variations	**Step**	**Branching Action**

ID	**MAESTRI-Management Dashboard-UC5**	
Name	Document suggestions for the quality management	
Diagrams		
Actors	Production worker	
Actors Goals	Note down suggestions for the quality management, aiming to improve the efficiency of the production in the future.	
Pre-conditions	Batch is finished.	
Trigger	Production worker has observed improvement potentials during the production of a batch that could be leveraged to improve the efficiency of the production of similar batches in the future.	
Postconditions success	Suggestions have been saved successfully and can be accessed by quality management.	
Postconditions fail	Suggestions are not saved in the system successfully or are not accessible by quality management.	
Description	**Step**	**Action**
	1	The production worker opens the MAESTRI dashboard and navigates to the "suggestions for quality management" area.
	2	The production worker notes down the suggestions based on the observations during the batch production in the MAESTRI dashboard.
	3	The MAESTRI dashboard displays the suggestion in the report for the quality management for future reference.
Extensions	**Step**	**Branching Action**

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Sub variations	Step	Branching Action

ID	MAESTRI-Management Dashboard-UC6	
Name	Get information about off-spec batches	
Diagrams		
Actors	Production worker	
Actors Goals	Get information about amount of waste and causes for off-spec batches, aiming to learn what went wrong and how to avoid off-spec batches and thus waste in the future.	
Pre-conditions	The MAESTRI dashboard has access to data about off-spec batches.	
Trigger	The production worker wants to get information about off-spec batches.	
Postconditions success	All off-spec batches are displayed by the dashboard correctly.	
Postconditions fail	Off-spec batches are not displayed correctly.	
Description	Step	Action
	1	The MAESTRI dashboard displays the number of off-spec batches on the main screen.
	2	The production worker navigates from the main screen to the off-spec batches area of the dashboard.
	3	The MAESTRI dashboard displays detailed information about the off-spec batches with amount of waste and the causes for failure.
Extensions	Step	Branching Action
Sub variations	Step	Branching Action

ID	MAESTRI-Management Dashboard-UC7	
Name	Document status changes of a batch	
Diagrams		
Actors	Production worker	
Actors Goals	Communicate current status as well as status changes of batches. Document the runtime of each production stage to enable further efficiency analysis in the future.	
Pre-conditions	Batch is assigned to production line and production line is available.	
Trigger	The production worker wants to document status changes of the batch.	
Postconditions success	Current production status is displayed correctly for all production lines.	
Postconditions fail	Current production status is not displayed correctly.	
Description	Step	Action
	1	The MAESTRI dashboard displays planned batches for a given production line with batch number and planned production start time.

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	2	The production worker starts the next planned batch on a given production line. The start of the batch is documented by the worker via the MAESTRI dashboard.
	3	The MAESTRI dashboard displays the batch status as running on the production line, and displays the actual start time instead of the planned.
	4	After completion of the running batch, the production worker stops the batch and documents this via the dashboard.
	5	The MAESTRI dashboard changes the batch status to finished and displays the actual end time. At this point the batch is ready for packaging.
	6	After packaging was finished, the production worker selects the finished batch in the dashboard and sets the status to packaged/finished.
	7	The MAESTRI dashboard displays the actual start & end times for each stage of the finished batch.
Extensions	**Step**	**Branching Action**
	3b	In case of a two-step production process: After completion of the batch in the first stage of the given line, the production worker documents that the production of the batch is now in the second stage.
	3c	In case of a two-step production process: The MAESTRI dashboard displays the batch status as finished for the first stage and as running for the second stage. The time of the stage change is also displayed.
Sub variations	**Step**	**Branching Action**

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4.3 Operators Dashboard Use Case

ID	Operators_Dashboard_Use_Case_01	
Name	Operators dashboards presentation in shop floor,	
Diagrams		
Actors	Operator, Line Manager, MAESTRI Platform = MAESTRI Front-end Application? IoT Platform Wall Display (platform visual "interface", i.e. dashboard), Production Machines, ERP System, ERP connector, Dashboard	
Actors Goals	Observe line performance in real time (near-to-real time) Get a notification when the pre-defined thresholds are surpassed	
Pre-conditions	Line is running, Parts are being produced, IoT Platform is running, collecting data of cycle time of injection, Total cycle time (and respective time for each cycle phase), machine on/off state and downtime, number of injected parts and rejected parts are monitored, and information is recorded and send to IoT platform A threshold is set for maximum cycle time (and respective time for each cycle phase) by Line Manager, Thresholds for rejected parts per shift and downtime are set,	
Trigger	1- Machine is turned on, 2- Threshold for downtime is reached (alarmist situation) 3- Threshold for rejected parts per shift is reached (alarmist situation) 4- Threshold for cycle time is reached (alarmist situation)	
Postconditions success	Operator gets real information in screen regarding line performance, Operator gets a notification on reached threshold for the defined parameters,	
Postconditions fail	Operator does not get real information in screen regarding line performance, The threshold for one or more pre-defined parameters is reached, operator does not get a notification,	
Description	**Step**	**Action**
	1	The operator starts the machine on and initiates the production line
	2	The ERP connector gets defined threshold values for alarmistic situations from the ERP,
	3	The ERP connector periodically gets data from the ERP about the number of rejected parts for the current shift,
	4	The IoT Platform takes the on/off state, duration of on/off times and the cycle time data from the Machines
	5	The wall display shows a dashboard for each machine containing machine on/off state, duration of on/off state, rejected parts for the current shift,
	6	The dashboard shown on the wall display is continuously updated with new data from the machines, according to the refresh rates defined in the KPIs list,
Extensions	**Step**	**Branching Action**
	a.1	The threshold for maximum downtime in one or more machines is reached,
	a.2	The dashboard visualized on the wall display shows a red warning light to highlight the event at step a.1.

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	b.1	The threshold for rejected parts per shift is reached,
	b.2	The MAESTRI Front-end Application displays a red warning light in the wall display,
	c.1	The threshold for cycle time is reached,
	c.2	The system displays a red warning light in the wall display specific to the machine,
Sub variations	**Step**	**Branching Action**

4.4 Production Scheduling Support Use Case

ID	**MAESTRI-Production-Scheduling-Support-UC1**	
Name	Get suggested production scheduling for current day	
Diagrams		
Actors	Production control operator	
Actors Goals	The production control operator wants to get decision support in defining an efficient production schedule for the current day	
Pre-conditions	MAESTRI application has access to the following data: • Production orders for the current day • Resource requirements for each product • Available resources • Historical batch scheduling log data	
Trigger	The production control operator starts a shift and has to do the batch scheduling	
Postconditions success	MAESTRI application provides meaningful suggestions that help the operator to do the batch scheduling	
Postconditions fail	MAESTRI provides suggestions that are not feasible/good from the operator's point of view	
Description	**Step**	**Action**
	1	The production control operator opens the list of production orders for the current day. It displays for each product the overall amount to be produced during the day.
	2	Via the MAESTRI GUI, the operator selects the option "get production scheduling suggestions".
	3	MAESTRI searches the historical batch log data for "similar days" in the past that could serve as template for the current day, meaning that the use of production resources on the "historical day" is similar to the requirements for production resources by the current day's production orders.
	4	MAESTRI displays a ranking of the similar days, which are possible template schedules for the current day, based on two criteria: • Similarity of resource requirements, meaning that the adaptation of the historical schedule to align it to the current day's production orders will require an acceptable amount of work. • Efficiency, meaning that the historical schedule is efficient regarding energy and resource consumption.
	5	The operator compares MAESTRI's suggestions, and then selects the template that is most appropriate for the current day.
	6	MAESTRI displays a graphical "timetable" representation of the historical production schedule that was selected by the operator. MAESTRI visualizes the differences between historical and current day, i.e. it shows how much more or less is needed for each product when comparing the current day's requirements to the historical schedule.

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	7	The operator moves and replaces batches in the schedule until it is in line with the requirements of the current day's production orders.
	8	The operator does the actual batch scheduling, i.e. the operator distributes the batches on the different production lines and starts them according to the template created using the MAESTRI application.
	9	At the end of the day, MAESTRI displays an overview of the actual performance indicator values for the current day, so that the operator gets feedback about how efficient the current day's scheduling has actually been.
Extensions	**Step**	**Branching Action**
Sub variations	**Step**	**Branching Action**

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