European Connected Factory Platform for Agile Manufacturing

European Factory Platform

WP9: Implementation of Embedded Pilots and Validations

D9.4: Experimental Support through Pilot Validations

Vs: 1.0

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Short Abstract

The deliverable describes the implementation and validation of developed solutions in the Aerospace Pilot.

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Document Status

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History

See Annexe A.

Status

This deliverable is subject to final acceptance by the European Commission.

Further Information

www.efpf.org

Disclaimer

Project Partners:

Executive Summary

The purpose of this document is to document the experimental phase of the solutions implemented by the three pilot projects, focusing on the implementation experience and lessons learned.

Therefore, this document briefly presents the developed solutions from the pilots and complements them with the experiments from the Open Call.

The COVID-19 crisis influenced the implementation and testing phase. Some companies were not reachable during the second and third waves in Germany and other European countries. For this reason, the EU Commission was notified of a delay of four months in WP9 for all pilot solutions and a corresponding addendum was created.

Table of Contents

0 Introduction

0.1 EFPF Project Overview

EFPF – European Connected Factory Platform for Agile Manufacturing – is a project funded by the H2020 Framework Programme of the European Commission under Grant Agreement 825075 and conducted from January 2019 until December 2022. It engages 30 partners (Users, Technology Providers, Consultants and Research Institutes) from 11 countries with a total budget of 16M€. Further information can be found at www.efpf.org.

To foster the growth of a pan-European platform ecosystem that enables the transition from "analogue-first" mass production to "digital twins" and lot-size-one manufacturing, the EFPF project will design, build, and operate a federated digital manufacturing platform. The platform will be bootstrapped by interlinking four base platforms from the FoF-11-2016 cluster funded by the European Commission early on. This will inform the design of the EFPF Data Spine and the associated toolsets to fully connect the existing user communities of the four base platforms. The federated EFPF platform will also be offered to new users through a unified Portal with value-added features such as single sign-on (SSO) and user access management functionalities to hide the complexity of dealing with different platforms and solution providers.

0.2 Deliverable Purpose and Scope

The purpose of this deliverable, "D9.4 Experimental Support through Pilot Validations", is to document the activities in the project with a focus on experiences during the implementation and the lessons learned from the developed solutions in all three EFPF pilots and the 20 Open Call Experiments.

0.3 Target Audience

The deliverable is declared public; therefore, its content can be used to raise expert awareness among a wider audience.

0.4 Deliverable Context

This document is one of the cornerstones for achieving the project aims. Its relationship to other documents is as follows:

- Description of Action (DOA): Provides the foundation for the actual research and technological content of EFPF. Notably, the Description of Action includes the overall project work plan.
- Project Handbook (D1.1): Provides the foundation for the practical work in the project throughout its duration and helps to ensure that the project partners follow the same well-defined procedures and practices in terms of information sharing.
- Deliverables D9.1, D9.2 and D9.3: Description of all three pilots in detail.

0.5 Document Structure

This deliverable is broken down into the following sections:

- **Section 0:** Introduction: An introduction to this deliverable, including a general overview of the project, and an outline of the purpose, scope, context, status, and target audience of the deliverable at hand.
- **Section 1:** Aerospace Pilot: Gives a short overview of the Aerospace Pilot, the realised user stories and the lessons learned.
- **Section 2:** Furniture Pilot: Gives a short overview of the Furniture Pilot, the realised user stories and the lessons learned.
- **Section 3:** Circular Economy Pilot: Gives a short overview of the Circular Economy Pilot, the realised user stories and the lessons learned.
- **Section 4:** Open Call Experiments: Gives a short overview of the Open Call support activities and the lessons learned.
- **Annexes:**
  - **Annexe A**: Document History

0.6 Document Status

This document is listed in the Description of Action as "public".

0.7 Document Dependencies

This document has no preceding documents or further iterations.

0.8 Glossary and Abbreviations

A definition of standard terms related to EFPF and a list of abbreviations are available at https://www.EFPF.org/glossary.

0.9 External Annexes and Supporting Documents

Annexes and Supporting Documents:

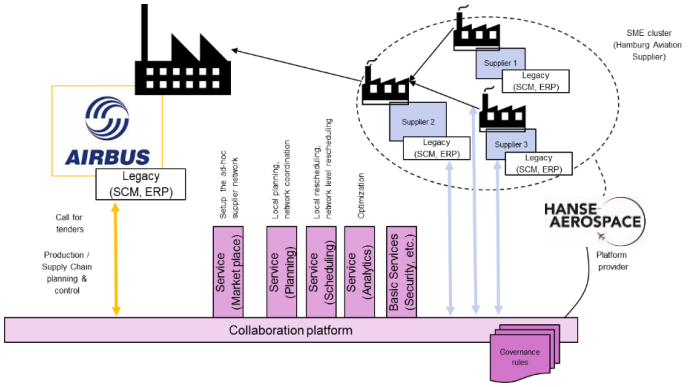
- No external annexes or documents are available

0.10 Reading Notes

- None

1 Aerospace Pilot (ASP)

1.1 Short Pilot Description



In aerospace manufacturing, highly customised commercial aircraft products often require precise solutions developed by small but innovative high-tech companies. The customer demands, e.g., for novel cabin features, must be developed and produced quickly with OEMs and high-tech SMEs' close collaboration. This typically requires an ad-hoc production/supply network, which is currently best served via a local cluster around the OEM. As soon as the parties are geographically separated, the OEM and the innovative SMEs (organised in industrial clusters) need ICT solutions (technical platform, novel governance approaches, coordination tools and services) to simplify the ad-hoc setup and management of collaborative production in the agile network and to manage the IPR, etc.

The Aerospace Pilot in the EFPF project addresses the ad-hoc setup of a production network involving local SME suppliers represented by the Hanse-Aerospace (HAW) association. This pilot focuses on realising two high-level scenarios:

- OEMs like Airbus are interested in rapidly integrating SME innovations into existing aircraft programs and building agile supply chains. Existing Airbus tools and platforms need complementary solutions for integrating SMEs directly into the supply chain. These solutions, such as tender decomposition, match-making, team building and smart contracting, can be provided by the EFPF platform
- SME clusters like Hanse-Aerospace and its member companies expect mature digital manufacturing tools for supporting agile collaborations between SMEs, shop floor connectivity and data analysis. EFPF can provide a unified interface to distributed tools to address the diverse digitalisation needs of SMEs in the aerospace sector

1.2 Experiences from Aerospace Pilot Experimentation

In the Aerospace Pilot, four epics and 13 user stories were defined in total. The focus of the user stories has shifted somewhat after Airbus left the project consortium. Originally, functionalities for exchanging data and information between SMEs and Airbus as OEM were to be developed and implemented. This was abandoned in favour of digitalisation solutions at the shop floor level in the participating SMEs. The planned processes initially for the use of product catalogues and for the bundling of purchasing quantities in terms of tenders and purchasing consortia were modified to the effect that they now take place between the participating SMEs and no longer with Airbus, as access to the Airbus IT systems was no longer possible with the departure of this partner. As a result, user stories have been developed that meet the SMEs' needs much better than if the substantial restrictions imposed by the OEM had to be considered. User stories (US) in the aerospace pilot are implemented in four different companies, and they are combined in four epics. An epic is a

big chunk of work with one common objective, e.g., a business function or requirement. One epic can be broken down into several user stories. All of them are shown in the following Table 1.

US ID	US Title	3DI	AAM	IAI	WOM
Epic 1: Joint Purchase and Offer Products					
US1.1	Place products and services in the catalogue and offer them	X	X	X	X
US1.2	Finding suppliers for specific products and services on an ad-hoc basis	X	X	X	X
US1.3	Find partners for joint purchase of consumables	X	X	X	X
US1.4	Finding partners for joint purchase of (raw) materials and products with high MOQ	X		X	X
Epic 2: Tender and Bid Management					
US2.1	Tender of material that has reached the expiry date	X			
US2.2	Tender for Maintenance Services		X		
Epic 3: Parameter Monitoring in Production and Maintenance					
US3.1	Automated environmental monitoring of process-relevant parameters			X	X
US3.2	Tracking of Trolleys		X		
US3.3	Visual Detection of PPE			X	
US3.4	Stock Level Monitoring	X			
Epic 4: Supply Chain Management					
US4.1	Increase Supply Chain Transparency			X	
US4.2	Secured Logistics Chain			X	
US4.3	Material Track and Trace during the lifecycle			X	

Table 1: Epics and User Stories (US) and Implementation Partners

The table below gives a comprehensive overview of the EFPF solutions used in the Aerospace Pilot implementation of the user stories mentioned before:

No.	Solution	EFPF Components Covered	Tools and Services Covered
S 1a	Solution 1a: Production Optimisation (Predictive Maintenance)	Data Spine, Industreweb Collect, SSO, Secure Data storage	FCGMT, Analytics Tools (to be clarified), Risk Tool
S 3	Solution 3: Workflow and Service Automation Platform		WASP
S 4	Solution 4: Matchmaking Service	Catalogue Service, Federated Search	Business Opportunities

S 5	Solution 5: Efficient Resources Management Solutions (Visual Detection)	Data Spine – Message Bus, SDSS, SDK	Industreweb Collect, Factory Connector, AI Vision Service (FC component)
S 6	Solution 6: Workplace Environment Monitoring	TSMatch Gateway, Data Spine, SSO	FCGMT, Analytics Tools, Event Reactor
S 7	Solution 7: Tendering & Bid Management		Business Opportunities
S 8	Solution 8: Almende Risk Analysis & Management Tool	Data Spine	Risk Tool
S 9	Solution 9: Catalogue Service	Data Spine	Product Catalogue Service
S 12	Solution 12: Blockchain Application	blockchain, security framework	DAML

Table 2: Overview of EFPF solutions used in the Aerospace Pilot and related components and tools

The detailed description of each epic and user story was done in deliverable D9.1. In the following sections, a short overview is provided with a focus on lessons learned.

1.2.1 ASP-Epic 1: Joint Purchase and Offer Products

1.2.1.1 US-ASP1.1: Place products and services in the product catalogue and offer them to users

1.2.1.1.1 Short Description

Many small and medium-sized companies have only limited financial resources available for marketing measures. The highest priority is assigned to day-to-day business, which leads to the fact that few or only small personnel resources are used for visibility and marketing. As a result, SMEs are often sparsely found online or not found at all on the relevant portals, and their business depends on personal recommendations.

A solution is needed to help small and medium-sized companies increase their visibility with minor financial and labour efforts. The aim is to draw the attention of potential customers to the company's product portfolio and provide the possibility to offer its products and services via a product catalogue so that company’s visibility is generally increased.

Partners involved in this user story were from the user side HAW, 3DI, WOM, AAM and IAI. As technical partner, SRDC was responsible for the technical development. The Product Catalogue service tool from the partner SRDC was used. A detailed description can be found in D9.1.

1.2.1.1.2 Testing, Evaluation and Experimenting

Validation of the Product Catalogue was done by all four Aerospace partner companies considering the above-defined requirements and further usability aspects. In different iteration steps the companies 3DI and IAI uploaded some of their offered products into the catalogue, whereas simple and complex products were considered. In regards to offered services, the validation was done from AAM and WOM, whereas both have uploaded typical services. Each finding was reported in a comprehensive form using screenshots with markings and comments to the developers. Whenever necessary short video calls were made additionally to discuss the findings and possible corrections. Afterwards the corrections were implemented so that they meet the formerly defined requirements correctly. As an example, some screenshots show the validation work as follows (refer to Figure 1 and Figure 2).

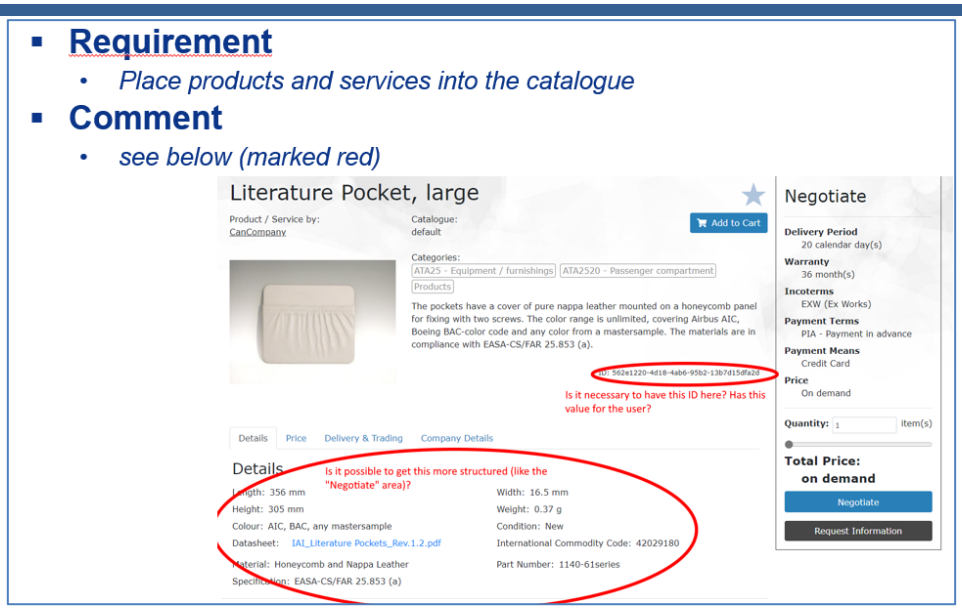


Figure 1: Illustration of way of working in regards to user feedback: screenshots with direct notes and markings

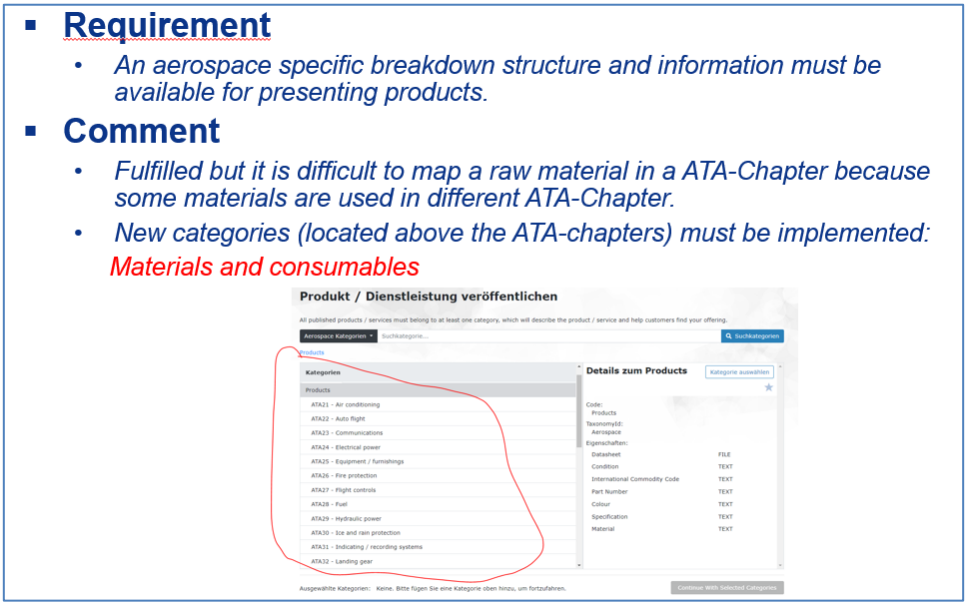


Figure 2: Illustration of way of working in regards to user feedback: screenshots with additional description of specific finding and proposal for improvement

Please note that only some exemplary screenshots are shown here. If required, several documents can be provided for further demonstration of validation work.

1.2.1.1.3 Lessons Learned and Outlook

The Product Catalogue and the service catalogue are very well developed. The basic shop functions are fully available. Products and services can be easily offered on the platform. In the B2B sector - especially in aviation - online shops are not widespread. Especially SMEs, which serve the very specialised areas of the supply chain in the aviation sector, have so far rarely used such possibilities. Via the EFPF platform, an easy entry into this marketing segment would now also be possible for these companies without major technical or financial hurdles.

For the outlook, it would be interesting to work with the integration of the payment system "Stripe"[1]. Certain functions such as contract management and the rating system can only be meaningfully validated and further developed once a certain number of transactions have been fully carried out on the platform. The user-friendliness must be measured against current standards offered by the major consumer platforms. The users from the business sector are in the end also private consumers and used to these standards. Continuous improvements are necessary here and are implemented on an ongoing basis in cooperation with developers. Generally, more added value could be achieved by several future developments and implementations, e.g.:

- There are several ways to load products and services into the catalogue. On the one hand, this can be done step by step for individual products and services. On the other hand, there is the possibility of uploading many products and services at once via an Excel table to be filled in. Although the latter option makes it much easier to use the catalogue, further improvements can be made here if tools are developed that can automatically read in and upload such data. One possibility here would be to examine the extent to which the so-called HyCoDER tool currently being developed by the Fraunhofer IPT could be used. This tool (Hybrid Configurable Data Extraction and Restructuring System) is designed to process various input files consisting of lists (e.g., article lists) from different sources that differ in format, content, and organization, and would ease the bulk uploading of products and services.
- One goal should be to open the platform to locally used ERP/CRM systems used by users. To this end, it would be necessary to investigate which standard ERP/CRM systems are used to develop flexible interfaces. This would further increase the incentive to use the platform.
- At the same time as the above-mentioned connection to ERP/CRM systems, another goal could be to consider the ATA Spec 2000[2] data communication standard for communication between parties involved. Here, a connection to the so-called ARINC/SITA network would have to be examined, via which many Process Order Management processes (Purchase Order Placement/Order Acknowledgement/Invoicing, etc.) between aviation companies are already handled today. The digitalization of the European aviation supply chain could thus be extensively advanced.
- If process order management is handled entirely via the platform, it makes sense to implement functions for the direct tracing and tracking of shipments. Here one could imagine connecting to existing logistics networks to avoid the use of different platforms for tracking and tracing and offer this service for all common forwarders (Fedex/DHL/UPS/K&N etc.) from one user interface.
- Taking also into account developed solutions for EFPF, a connection of the "Secured Supply Chain" solution could be established as well to establish further networking between the developed solutions. More relevant functions could be implemented and offered from one source (please refer also to chapter 0 for the developed solution for the secured logistic chain).

[1] https://stripe.com/en-gb-us

[2] ATA SPEC 2000 is an international standard created by the Air Transport Association (ATA) to optimize exchanges, communications and information flows within the aeronautics industry

1.2.1.2 US-ASP1.2: Finding suppliers for specific products and services on an ad-hoc basis

1.2.1.2.1 Short Description

One of SME's strength (amongst others) over competitors that are significantly larger is flexibility and speed in responding to customer requests. The faster customer inquiries can be answered and the quicker components can be manufactured after order receipt, the more successful the supplier is. This is where agile supply chains are needed to help requested suppliers respond quickly to customer requests.

Thus, it is important for the supplier's success to find partners and suppliers for a variety of specific products and services, so that there is the full overall view of available suppliers on the market without the need of huge research efforts. This is to make sure that the supplier can work with the best products (price/lead-time/quality) and suppliers (reliability/communication/quality).

Partners involved in this user story were from the user side HAW, 3DI, WOM, AAM and IAI. As technical partners SRDC and C2K were responsible for the technical development.

1.2.1.2.2 Testing, Evaluation and Experimenting

Validations of the Product Catalogue Service and the Business Opportunity Tool were done from INNOVINT, AAM, 3DI and WOM under consideration of the above-defined requirements and further usability acceptance criteria by publishing different opportunities. Different products and services have been searched for. Also, different opportunities have been established in the Business Opportunity Tool. Each finding was reported in a comprehensive form by means of screenshots with markings and comments to the developers. Whenever necessary short video calls were made additionally to discuss the findings and possible corrections. Afterwards the corrections were implemented so that they meet the formerly defined requirements correctly. As an example, some screenshots show the validation work (please refer to Figure 3, Figure 4 and Figure 5).

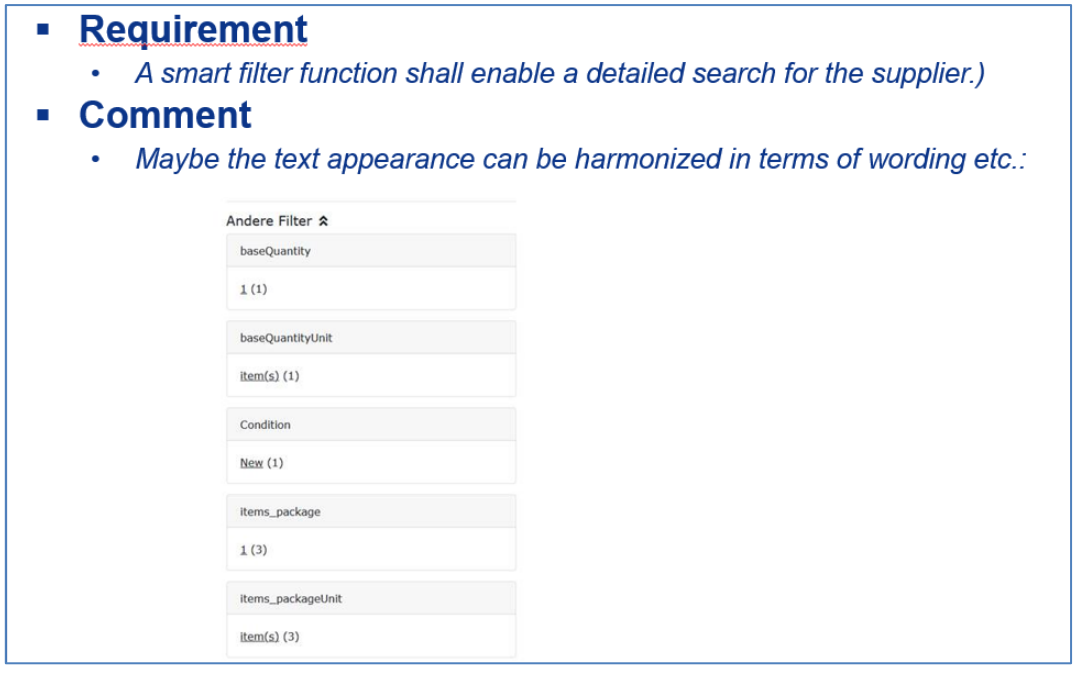


Figure 3: Feedback for the Product Catalogue Service by means of screenshots specific comments.

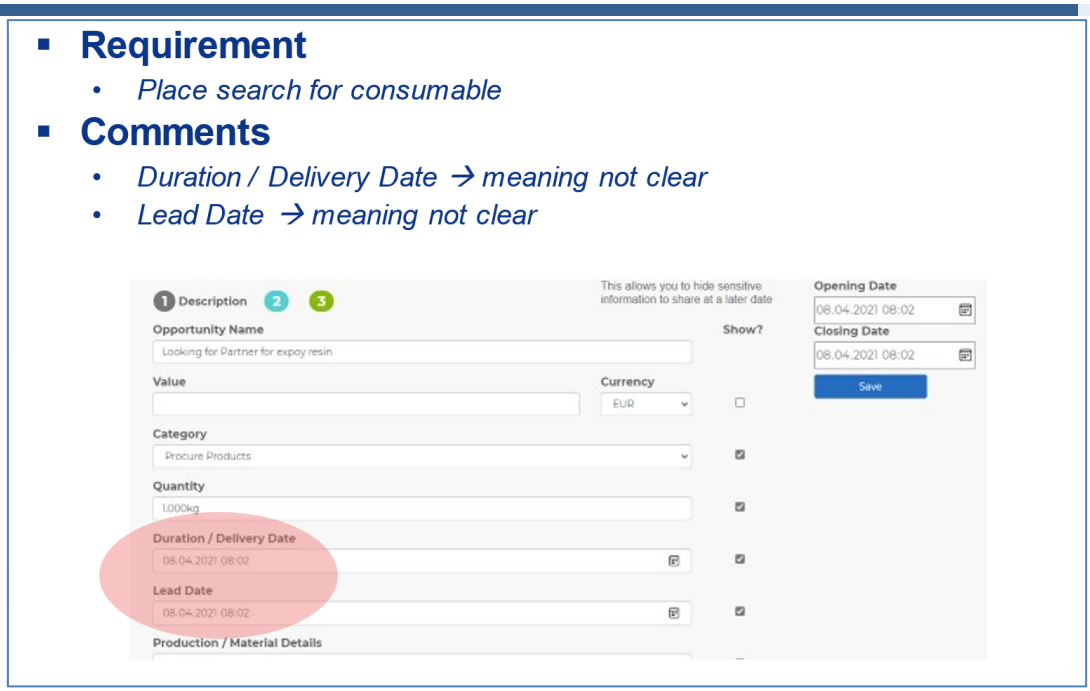


Figure 4: Feedback for the Business Opportunity Tool by means of screenshots with markings and additional comments.

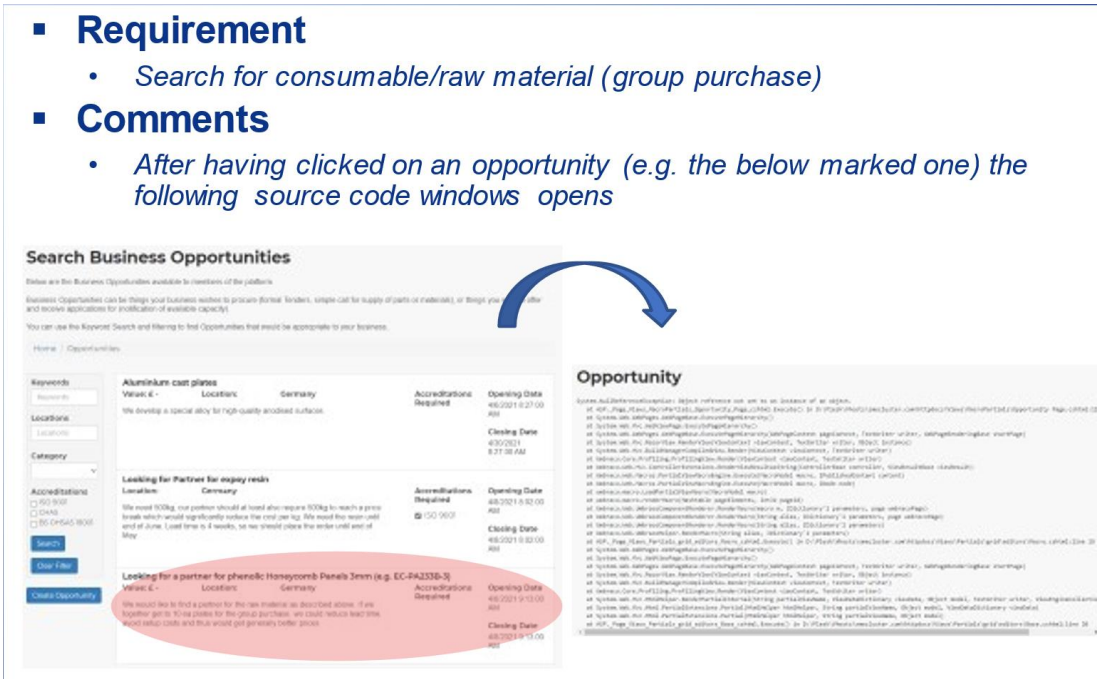


Figure 5: Feedback for the Business Opportunity Tool by means of screenshots with markings and additional comments.

Please note that only some exemplary screenshots are shown here. If required, several documents can be provided for further demonstration of validation work.

1.2.1.2.3 Lessons Learned and Outlook

Once again in the process of development during several iterations steps it turned out that the better the cooperation between technical and user partners is, the better is the result of the developed solution. Reason for this is that the technical partners need a solid

understanding of the real world, and in turn the user partners need a solid understanding of what is technically possible.

Stronger networking of small and medium-sized enterprises in Europe for the exchange of products and services will provide clear competitive advantages for the companies involved. A cooperative approach is not widespread in this group of companies. One reason is the fear of losing one's own market advantages, because one always must open the company slightly to other stakeholders. More significant, however, is the fact that it takes a lot of effort for small and medium-sized enterprises to identify suitable partners, products, or services. A digital platform that offers easy access to such data can significantly lower the threshold for cooperation.

For the further development of the platform, we expect further improvement and expansion of the functions. User-friendliness is crucial for user acceptance and should be kept in mind. Users will continue to provide feedback on the developments on the platform.

1.2.1.3 US-ASP1.3: Find partners for joint purchase of consumables

1.2.1.3.1 Short Description

Many companies only need a limited quantity/number of products, and due to the small order, it is usually not possible to achieve favourable purchase prices. By bundling quantities/units of products, correspondingly better purchasing conditions can be achieved, which can partly be passed on to the partners.

Partners involved in this user story were from the user side HAW, 3DI, WOM, AAM and IAI. As technical partners SRDC and C2K were responsible for the technical development.

1.2.1.3.2 Testing, Evaluation and Experimentation

Validation of this Business Opportunity Solution was done from IAI, AAM, 3DI and WOM under consideration of the above-defined requirements and further usability acceptance criteria by publishing different opportunities. The validation was carried out against the previously defined criteria, the screenshots below show examples from the validation process.

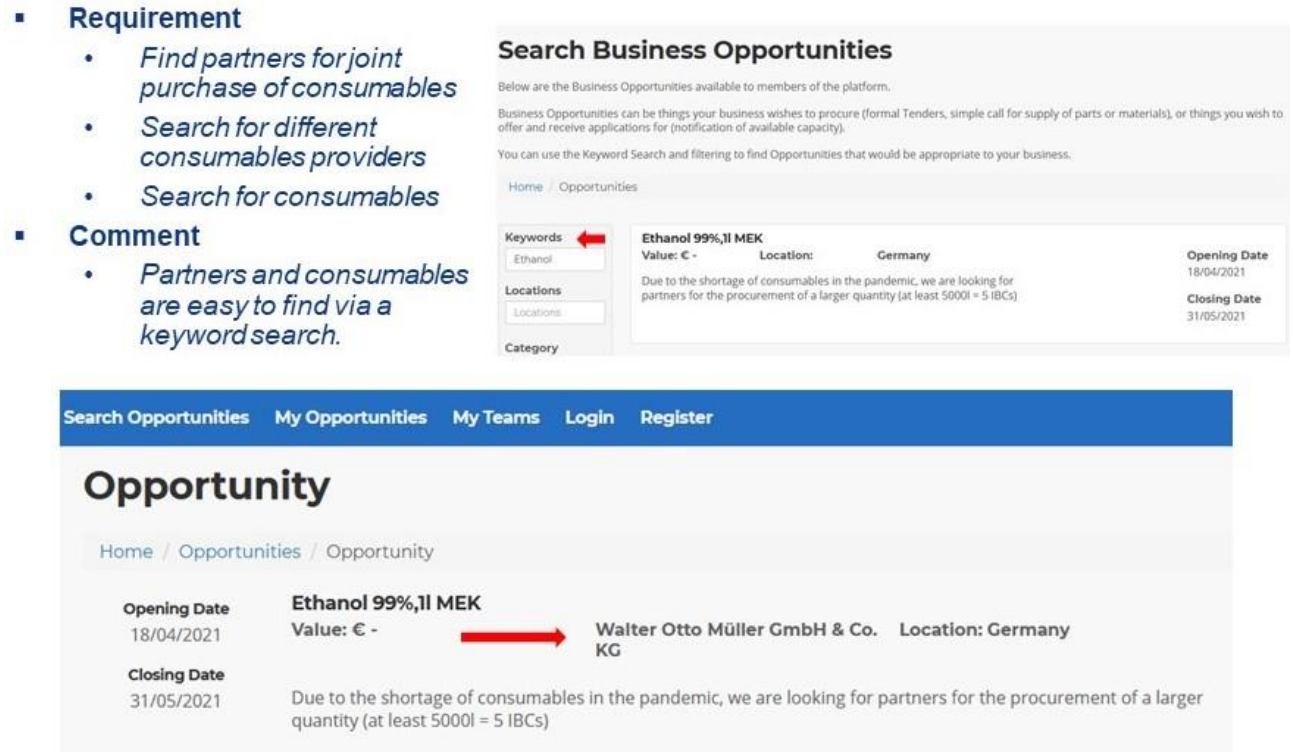


Figure 6: Validation of the Business Opportunity Solution regarding keyword search

- **Requirement**
  - *Find partners for joint purchase of consumables*
  - *Search also time-related*
- **Comment**
  - *Various date fields for search and narrowing are implemented (e.g. delivery date, lead date).*

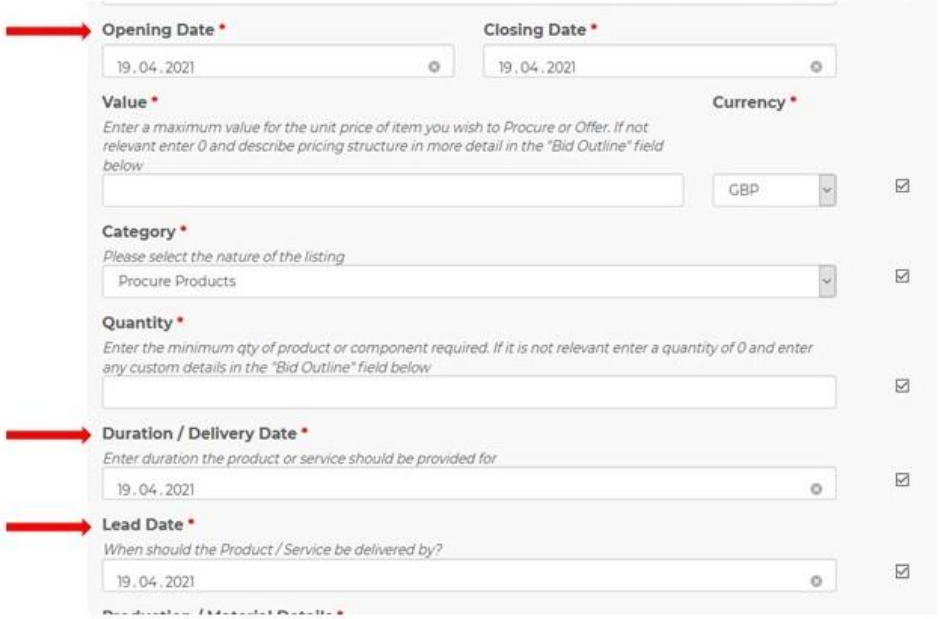
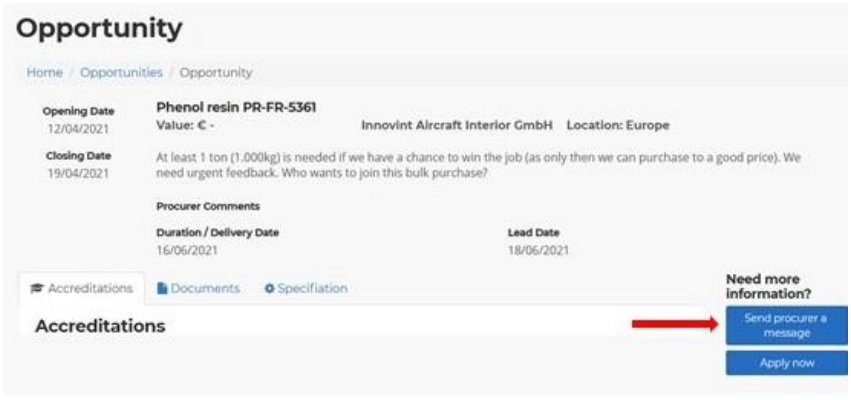


Figure 7: Validation of the Business Opportunity Solution regarding date search

- **Requirement**
  - *Find partners for joint purchase of consumables*
  - *Get contact details or the possibility to get into contact with potential partner companies (send invitation)*
- **Comment**
  - *A system for sending messages and invitations is implemented.*



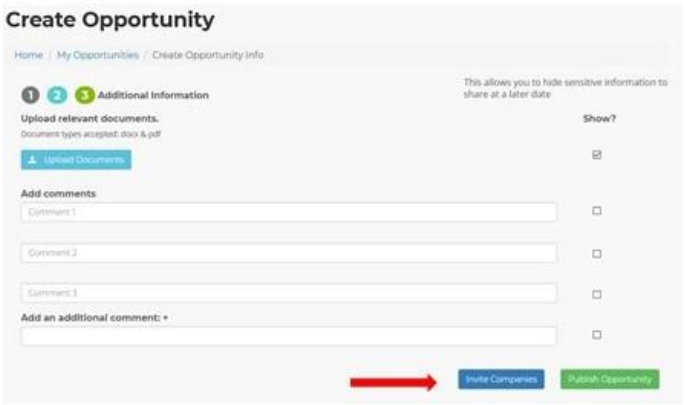


Figure 8: Validation of the Business Opportunity Solution regarding message system

- **Requirement**
  - *Find partners for joint purchase of consumables*
  - *Place search inquiries for consumables*
- **Comment**
  - *Search queries for consumables can be freely formulated and placed.*

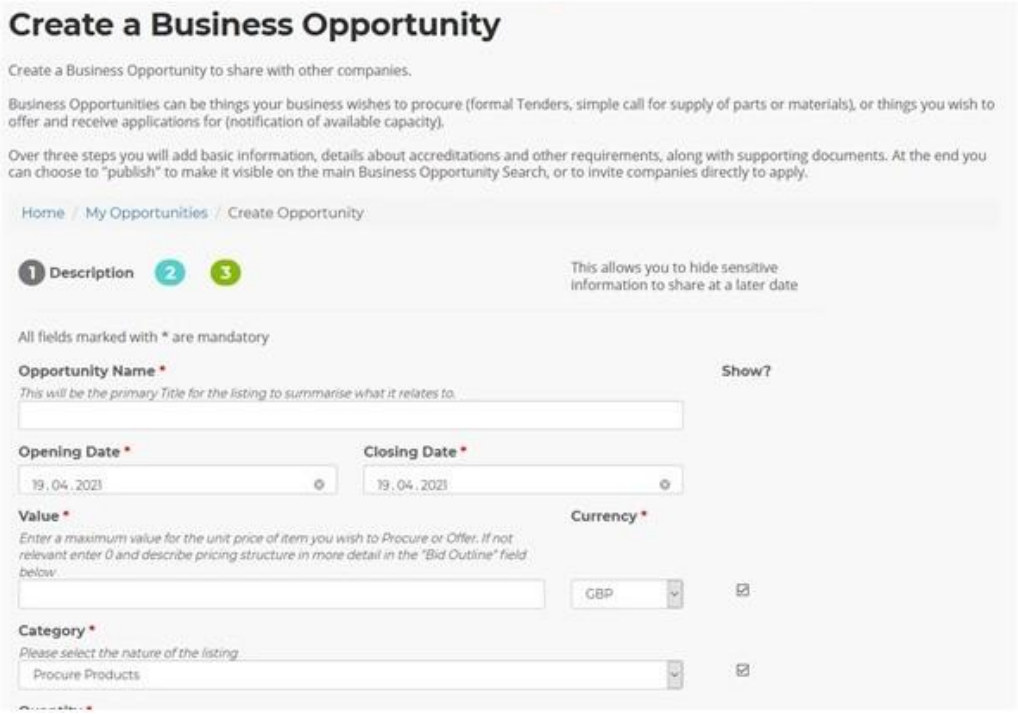


Figure 9: Validation of the Business Opportunity Solution regarding search queries

- **Requirement**
  - *Find partners for joint purchase of consumables*
  - *Have a dashboard with summarizing information about search inquiries*
- **Comment**
  - *Search queries for consumables and raw materials can be freely formulated and placed. In addition, further information or documents can be attached.*

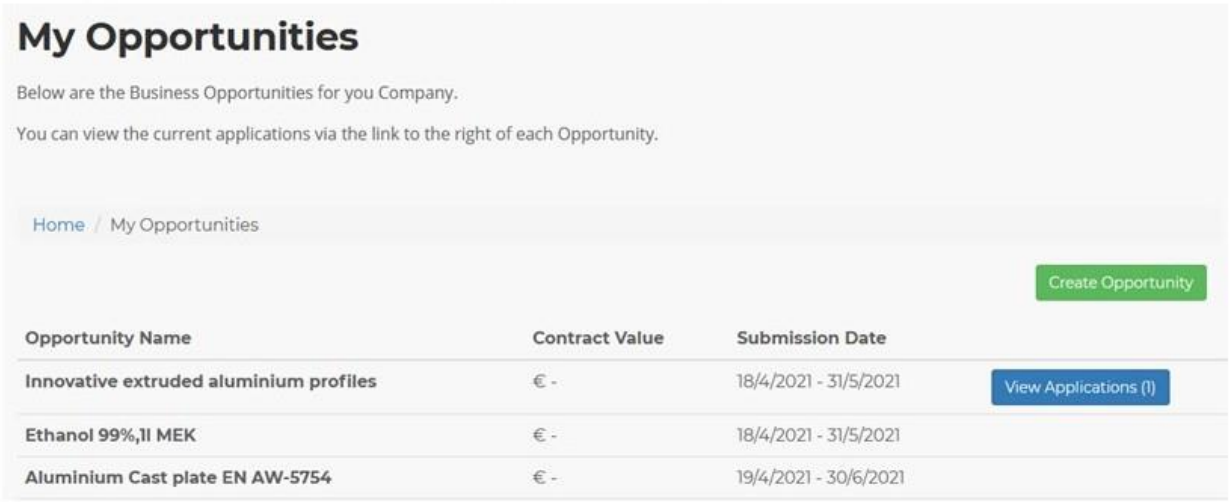


Figure 10: Validation of the Business Opportunity Solution regarding dashboard

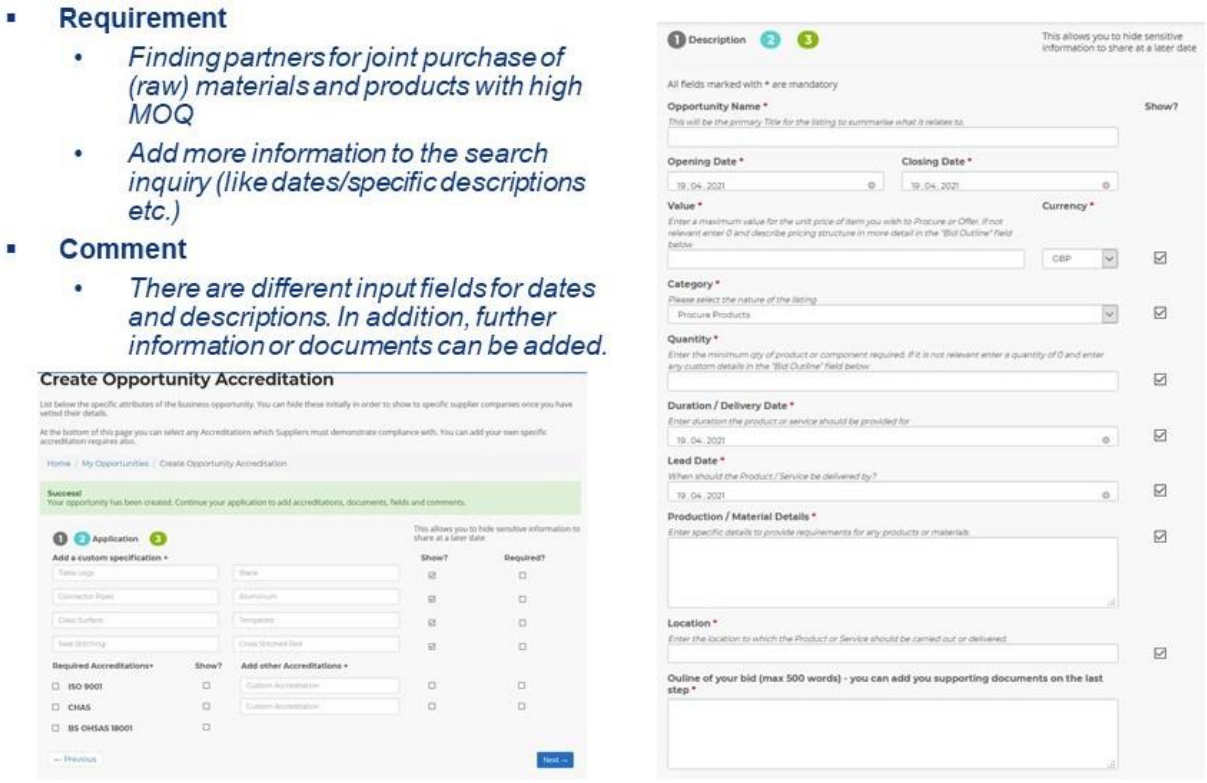


Figure 11: Validation of the Business Opportunity Solution regarding adding documents

1.2.1.3.3 Lessons Learned and Outlook

Undoubtedly, it will be of great benefit to SMEs in Europe if ad hoc cooperation related to specific purposes, such as joint purchasing, can be arranged easily and simply via a digital platform.

Networking among each other is not very well developed, especially in the SME sector. In addition, digitisation is often not yet very far advanced in the companies. The first digitisation measures mainly address internal company processes - B2B processes are presumably the exception. There is great potential here to significantly strengthen the own position in the global competitive environment.

Based on the validation and following outlook in the last deliverable, it was planned to integrate the Business Opportunity Tool with other tools like the product catalogue service. A very meaningful integration was done accordingly: As soon as the search for a product or service in the product catalogue service does not lead to any results, via an integrated button (refer to Figure 12, blue button on the right side) the Business Opportunity Tool is directly accessible, so that it can be used to look for purchasing partners or whether the product or service is available on this platform.

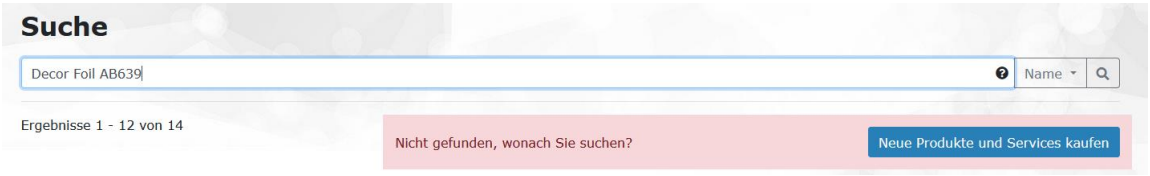


Figure 12: Link from Business Opportunity Tool to Product Catalogue Service

By integrating the tools, application scenarios are conceivable in the future that currently cannot be mapped in the real economy, at least not via an open and standard platform, such as for example combining a product search with a tender to be able to fulfil a high minimum order quantity.

1.2.1.4 US-ASP1.4: Finding partners for joint purchase of (raw) materials and products with high Minimum Order Quantity (MOQ)

1.2.1.4.1 Short Description

Small and medium-sized companies have often found their niche in the production of small series. In the aviation industry, such small series are usually stretched out over months or years, so that effectively one no longer even must speak of a small series, but of a lot size one manufacturing. This becomes a problem especially when products requested by customers can only be manufactured with materials that have a certain minimum order quantity (MOQ). In some cases, it is possible to purchase only the required quantity, but due to the order below MOQ certain setup costs become valid. Although this all does not prevent the requested product from being offered, the price is often no longer in line with the market due to the minimum quantity to be considered, which far exceeds the requirement, so that the order is not won in the end.

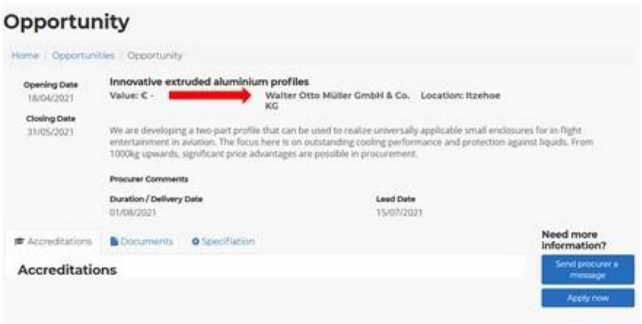
Based on this, the interest of the offering company is to find partners for the joint purchase of (raw) material and products with high MOQ. In this way, high setup costs or high purchase quantities can be avoided, so that competitive prices can be offered. This increases the probability of winning an order.

Partners involved in this user story were from the user side HAW, WOM, 3DI and IAI. As technical partners SRDC and C2K were responsible for the technical development.

1.2.1.4.2 Testing, Evaluation and Experimentation

Validation of this Business Opportunity Solution was done from all partners under consideration of the above-defined requirements and further usability acceptance criteria by publishing different opportunities.

- **Requirement**
  - *Finding partners for joint purchase of (raw) materials and products with high MOQ*
  - *Search for different (raw) material and products providers*
  - *Search for (raw) material and products*
- **Comment**
  - *Partners and raw material and products are easy to find via a keyword search.*



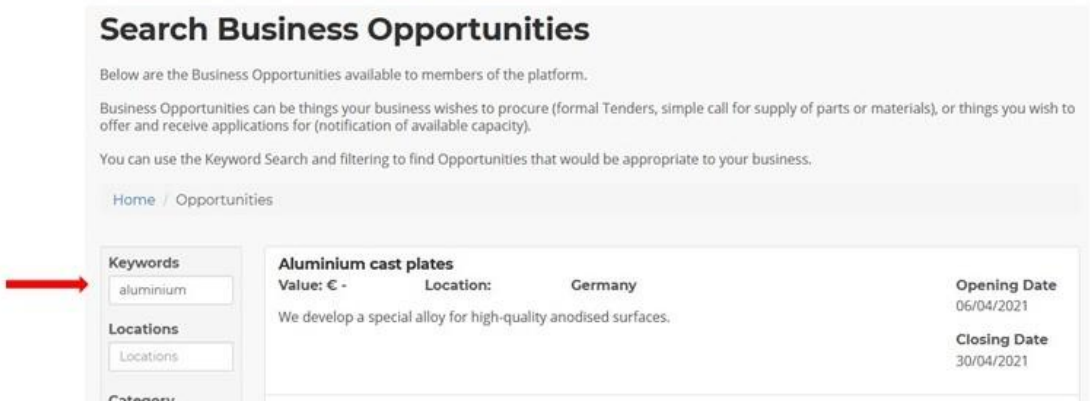


Figure 13: Validation of the Business Opportunity Solution regarding material search

- **Requirement**
  - *Finding partners for joint purchase of (raw) materials and products with high MOQ*
  - *Search also time-related*
- **Comment**
  - *Various date fields for search and narrowing are implemented (e.g. delivery date, lead date).*

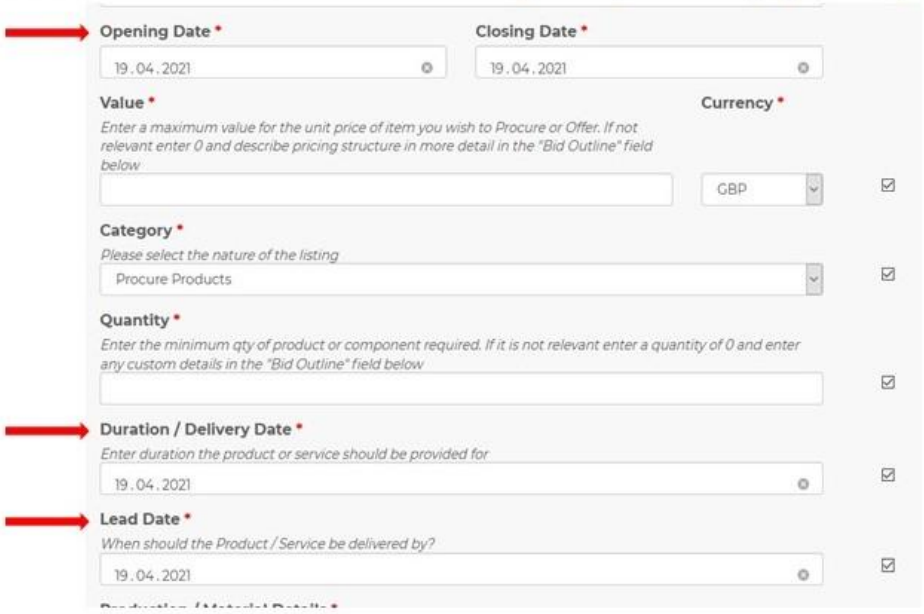


Figure 14: Validation of the Business Opportunity Solution regarding time related search

- **Requirement**
  - *Finding partners for joint purchase of (raw) materials and products with high MOQ*
  - *Get contact details or the possibility to get into contact with potential partner companies (send invitation)*
- **Comment**
  - *A system for sending messages and invitations is implemented.*

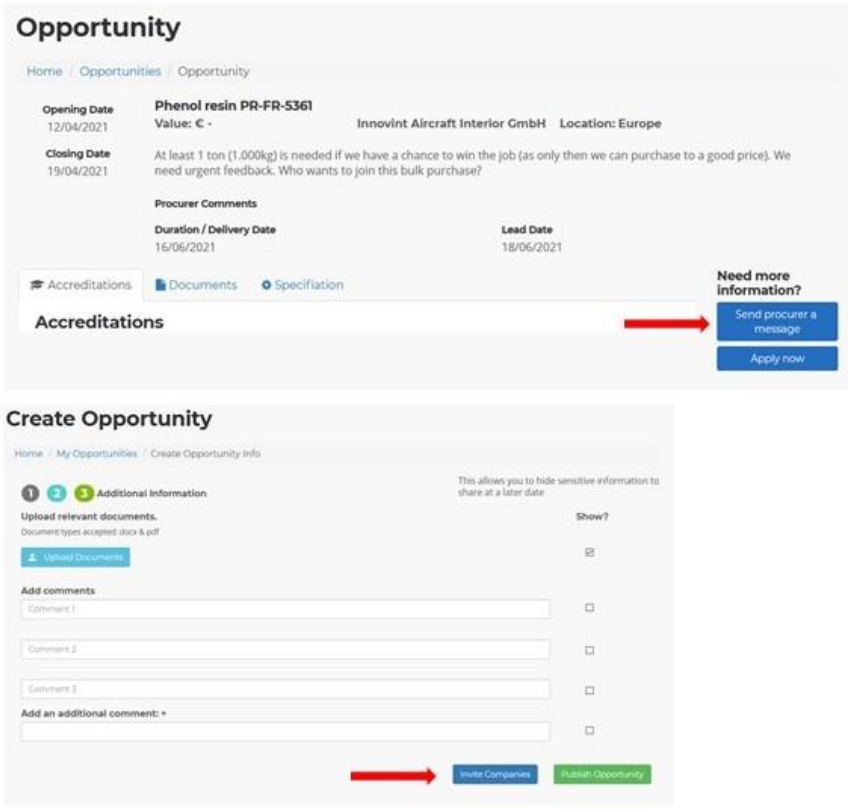


Figure 15: Validation of the Business Opportunity Solution regarding internal messages

- **Requirement**
  - *Finding partners for joint purchase of (raw) materials and products with high MOQ*
  - *Place search inquiries for raw materials and products*
- **Comment**
  - *Search queries for raw materials and products can be freely formulated and placed.*

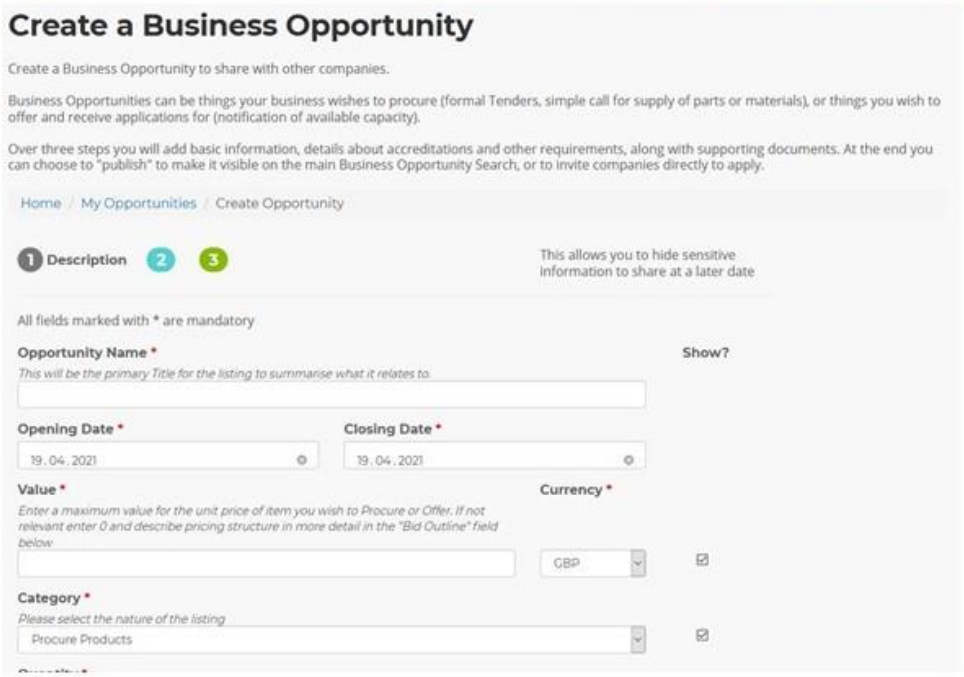
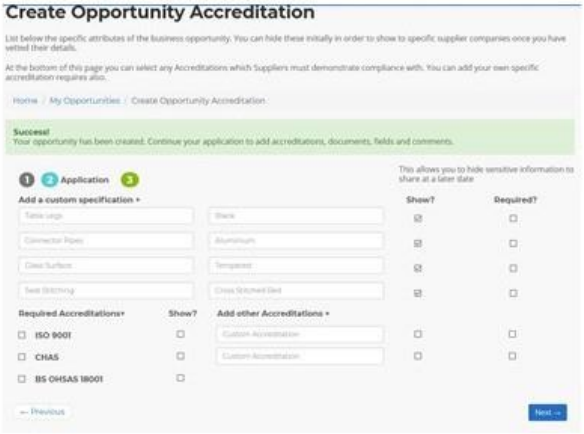


Figure 16: Validation of the Business Opportunity Solution regarding raw material search

- **Requirement**
  - *Finding partners for joint purchase of (raw) materials and products with high MOQ*
  - *Add more information to the search inquiry (like dates/specific descriptions etc.)*
- **Comment**
  - *There are different input fields for dates and descriptions. In addition, further information or documents can be added.*



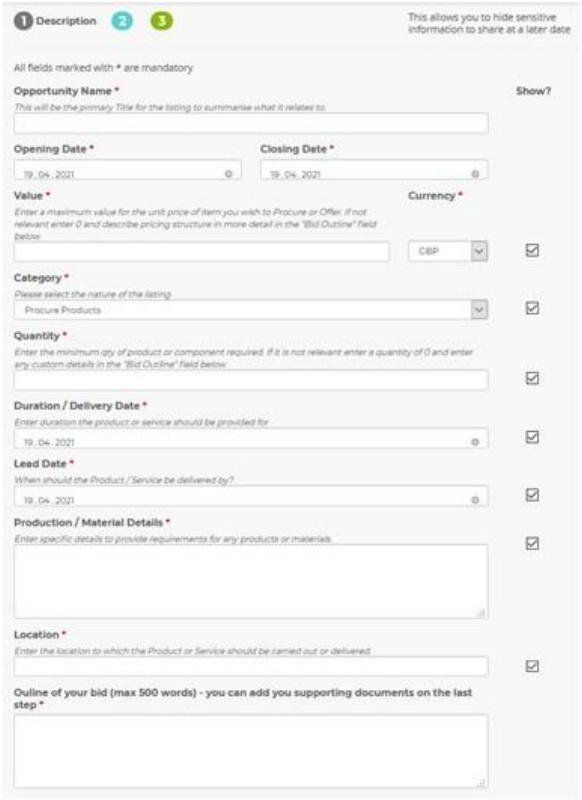


Figure 17: Validation of the Business Opportunity Solution regarding detailed material description

- **Requirement**
  - *Finding partners for joint purchase of (raw) materials and products with high MOQ*
  - *Have a dashboard with summarizing information about search inquiries*
- **Comment**
  - *Search queries for consumables and raw materials can be freely formulated and placed. In addition, further information or documents can be attached.*

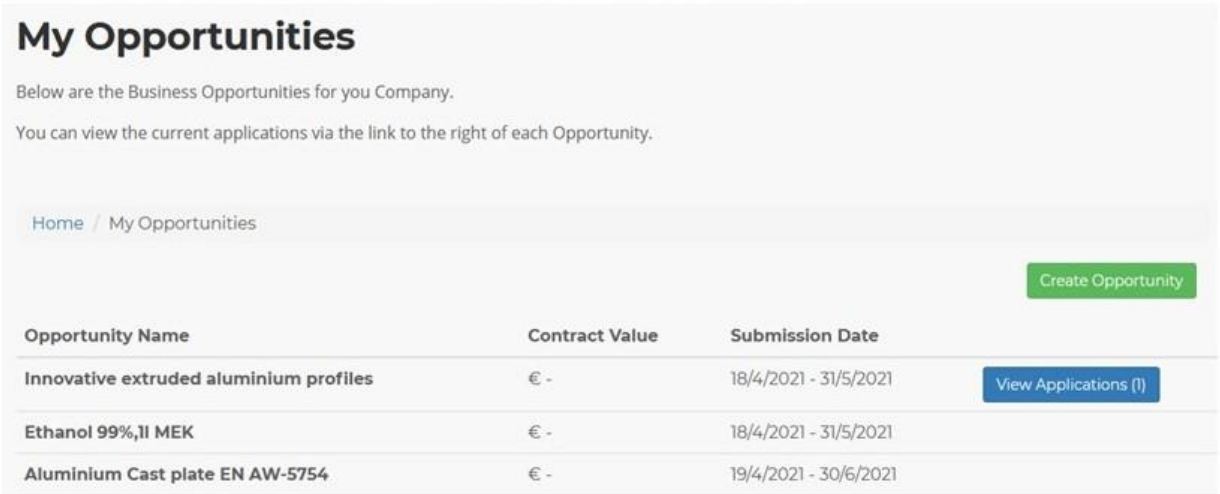


Figure 18: Validation of the Business Opportunity Solution regarding dashboard with search results

1.2.1.4.3 Testing, Evaluation and Experimentation

Validations of the Product Catalogue Service and the Business Opportunity Tool were done from INNOVINT and 3DI under consideration of the above-defined requirements and further usability acceptance criteria by publishing different opportunities.

Different products and services have been searched for. Also, different opportunities have been established in the Business Opportunity Tool. Each finding was reported in a comprehensive form by means of screenshots with markings and comments to the developers. Whenever necessary short video calls were made additionally to discuss the findings and possible corrections. Afterwards the corrections were implemented so that they meet the formerly defined requirements correctly. For exemplary screenshots for this proceeding please refer to 1.2.2.1.2.

1.2.1.4.4 Lessons Learned and Outlook

During the development and realisation of the Business Opportunity Tool, it became apparent that it had already reached a very high level of development with the last deliverable. On the one hand, this speaks for the very good cooperation and clear communication between the requirement originators and the technical partner, but also for the high level of expertise of the latter.

Although minor breakdowns occurred again and again during the experimental phase (see Figure 19), these were always quickly resolved so that the tool was able to work operationally again.

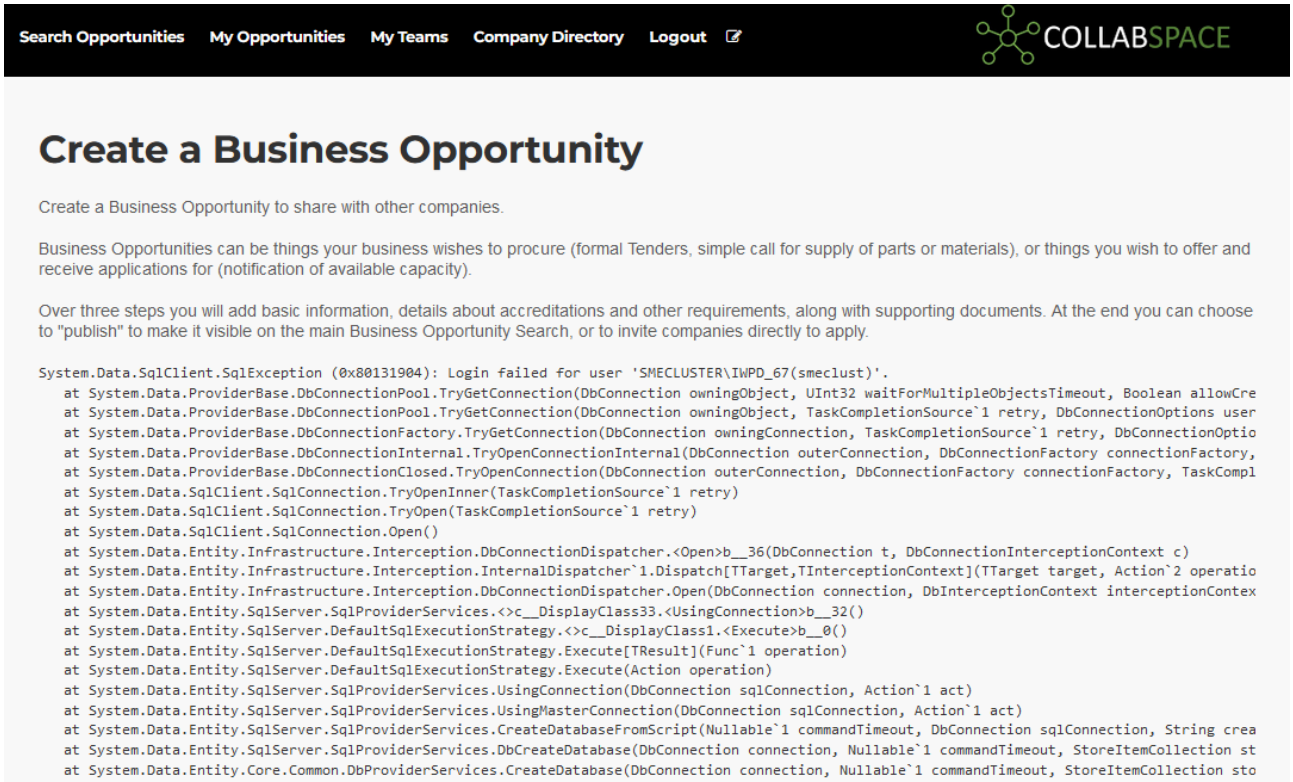


Figure 19: Minor failure during experimentation phase

That said, it can be stated at this point that no further adjustments are necessary.

1.2.2 ASP-Epic 2: Tender and Bid Management

1.2.2.1 US-ASP2.1: Tender of material that has reached the expiry date

1.2.2.1.1 Short Description

As a purchasing manager, I want to create a tender for a specific material that will reach the expiry date in the following weeks and days because after this date, it is not usable for high-quality products in the aviation industry.

Companies are often confronted with short-time changes respective materials to be used for their products. Reasons are changing requirements made by the customers or new regulations regarding the usage of dangerous materials made by the European Chemical Agency (ECHA[3]) which updates the REACH-guidelines twice a year. In some cases, this leads to material excess, long-time-storage of materials or in worst case to materials in stock who reach the expiry date and therefore become scrap. To prevent the material from being thrown away, tenders should be made in the opportunities tool so that other companies who need this material can buy this material.

1.2.2.1.2 Testing, Evaluation and Experimentation

The validation was done by 3DI. All defined requirements were tested. The results are shown in Figure 20. Some examples for screenshots are shown in the following figures.

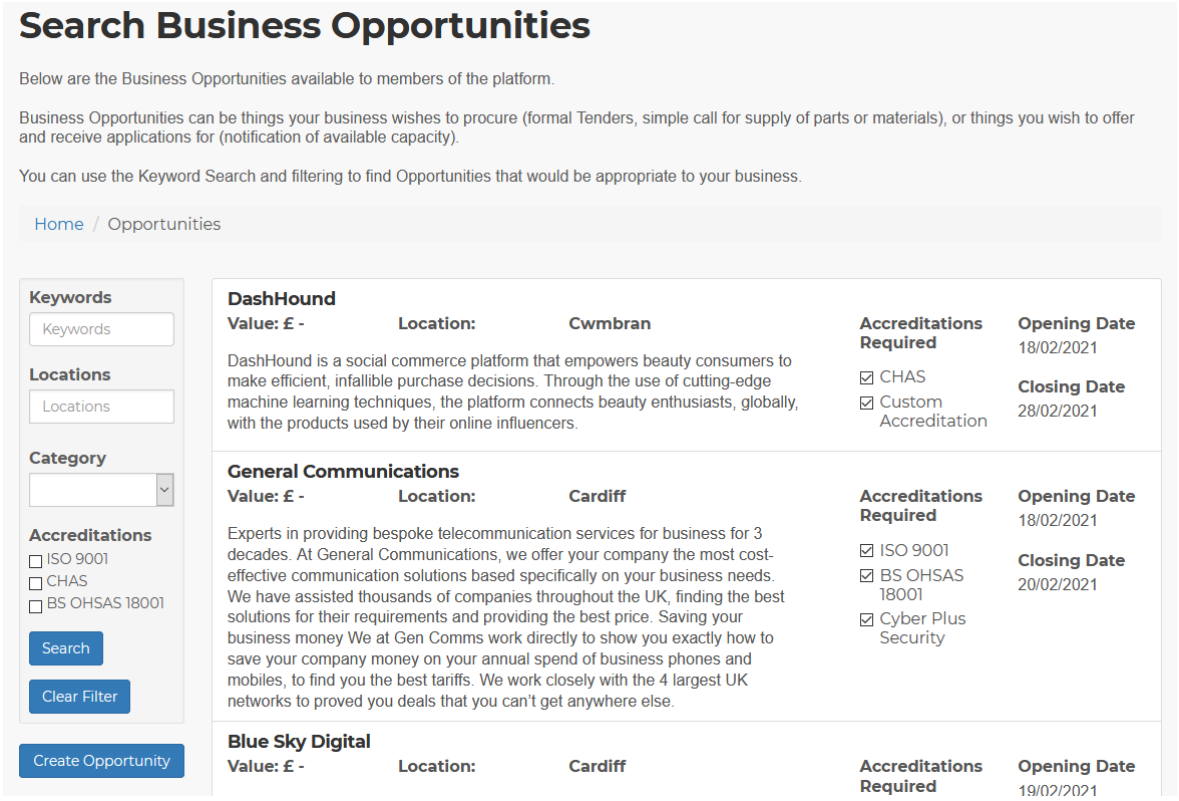


Figure 20: Search for Opportunities

[3] https://echa.europa.eu/

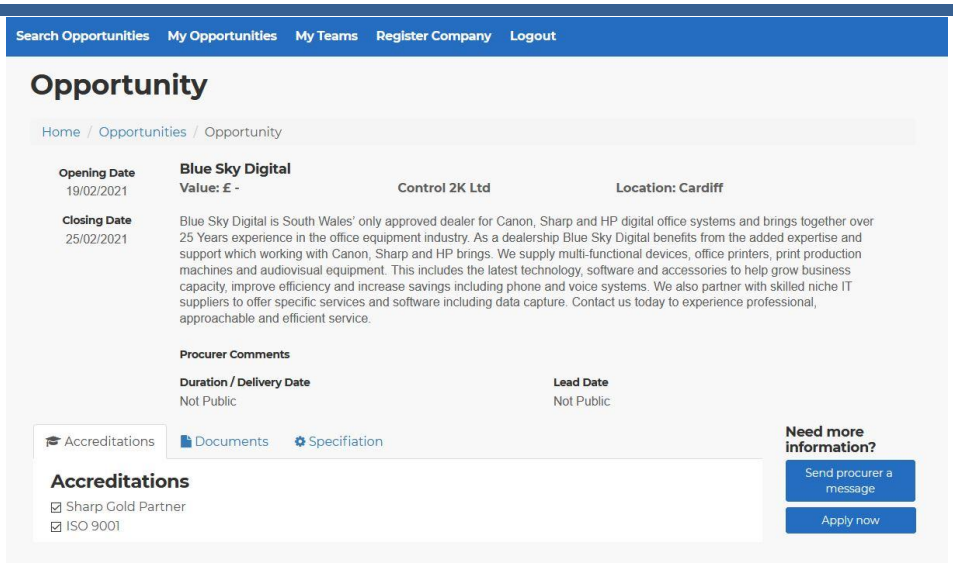


Figure 21: Getting in contact with other companies via Opportunity tool

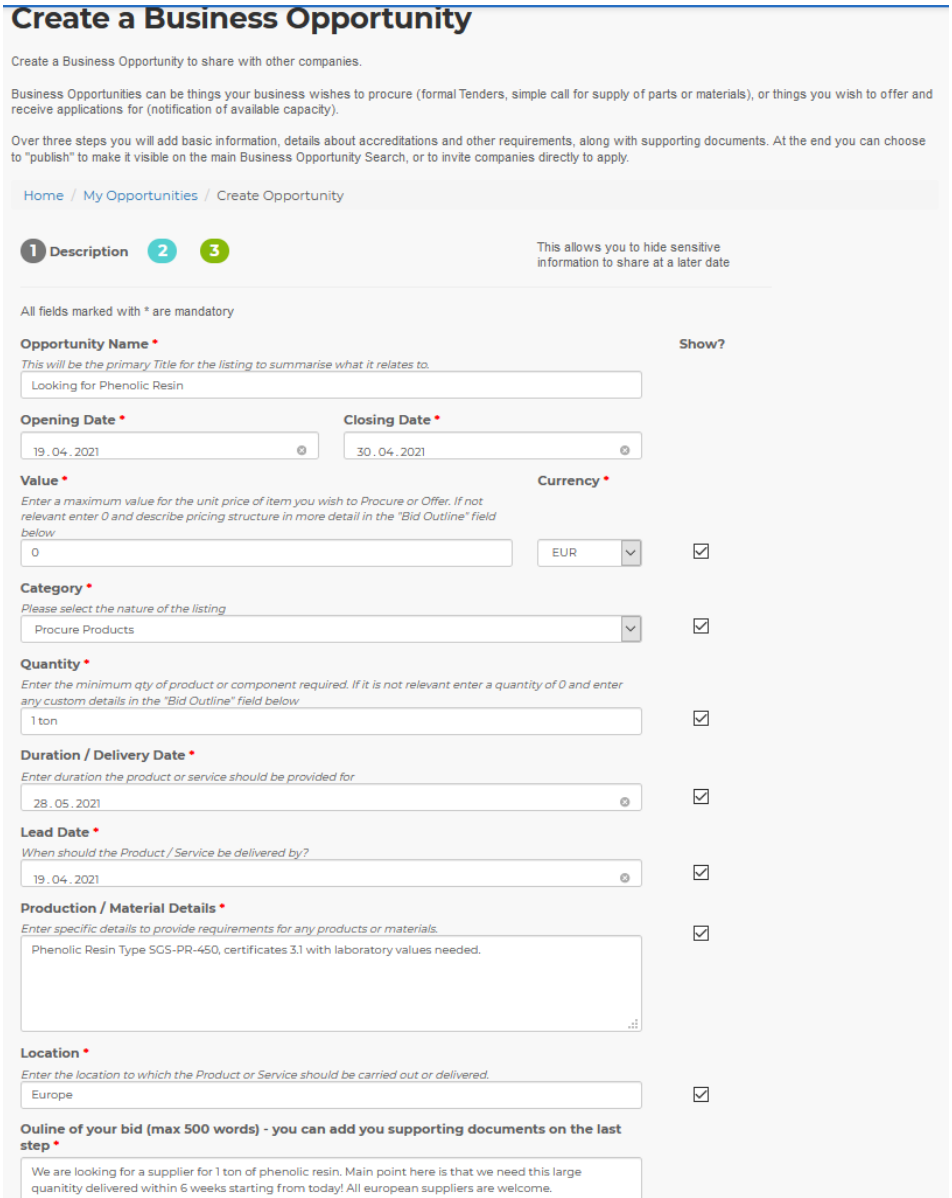


Figure 22: Creating business opportunities

1.2.2.1.3 Lessons Learned and Outlook

Essentially, the same applies here as already written under 1.2.1.4.4.

In addition, it should be mentioned that the Business Opportunity Tool is now directly accessible via the EFPF portal with single sign on (SSO) functionality (see Figure 23).

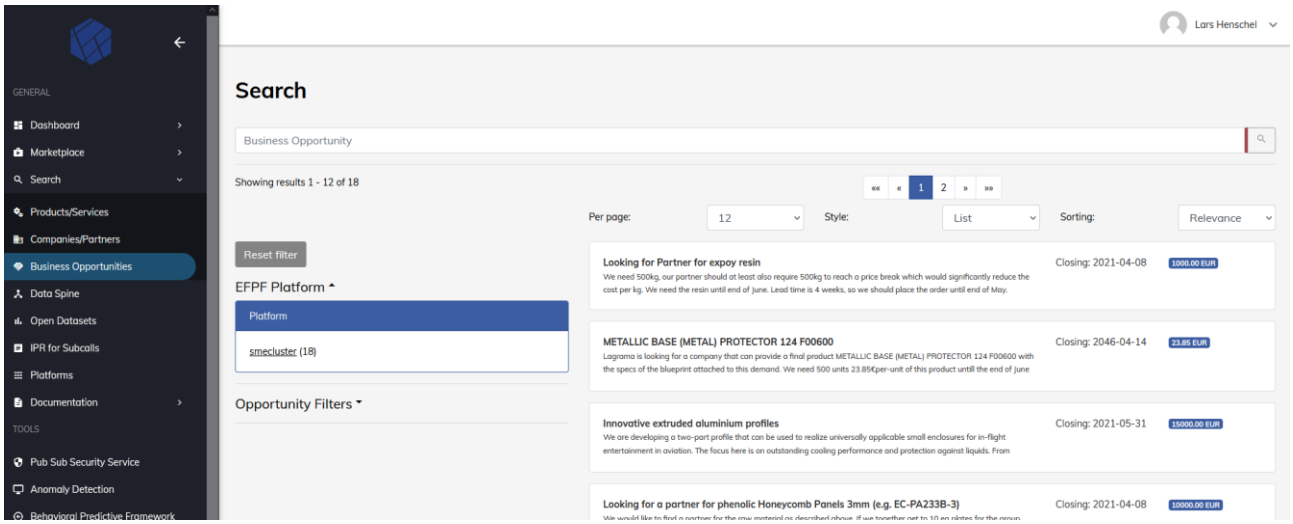


Figure 23: Business Opportunity Tool reachable directly though EFPF main portal

This again shows the consistent implementation of the findings from the previous deliverable. Thus, the complete integration into the EFPF portal has now been completed for the Business Opportunity Tool.

1.2.2.2 US-ASP2.2: Tender for Maintenance Services

1.2.2.2.1 Short Description

As a sales manager I want to sell services to customers with participation of sub-suppliers because not all service can be delivered by my company.

For some years now, there has been a reduction in the number of suppliers in maintenance at large OEMs. AAM is one of the selected suppliers in this segment, which can still be directly contracted by the customer. Nevertheless, the operators/users have the wish or the operational requirements to continue to have activities carried out by the original supplier. In these cases, AAM acts as an intermediary between the customer and the downstream suppliers and assumes the coordination and purchasing functions.

1.2.2.2.2 Testing, Evaluation and Experimentation

The examination of the specifications for the maintenance requests was carried out by AAM under the defined requirements and other usability aspects. In different iteration steps, AAM loaded some of the required services into the tool, whereby only precisely defined services were considered here. There are many similar maintenance services, but due to the large number of pieces of equipment, it is only possible to request a specific service to a limited extent. The prerequisite here is that the provider clearly knows the requested equipment, e.g., drilling machine: here there are simple hand-guided devices or also large drilling machines that are subject to completely different test regulations. Regarding the services offered, validation was carried out by AAM, whereby typical, simple services were uploaded. In various meetings, the needs were concretely discussed with the developers. If necessary, additional meetings (telephone or Videocalls) were held to discuss the problems found and

possible corrections. The corrections were then implemented in such a way that they fulfilled the previously defined requirements.

1.2.2.2.3 Lessons Learned and Outlook

In the description of the processes, we assumed that the developers had the necessary prior knowledge. Unfortunately, this turned out to be a mistake during the project. In the future, we will have to choose a different approach, as outsiders cannot clearly understand our requirements. This means that we must describe our programming requirements even more clearly, as there were different perceptions of processes.

1.2.3 ASP-Epic 3: Parameter Monitoring in Production and Maintenance

1.2.3.1 US-ASP3.1: Automated Environmental Monitoring of Parameters

1.2.3.1.1 Short Description

Many SMEs lack fundamental digitization. In order not to forget them in the global digitization race, solutions are also needed that connect existing machines and devices to digital networks without large investments, and thus make their parameters readable and evaluable to increase the efficiency of production processes. Such solutions, which tie in with low-digitized infrastructures, are needed so that SMEs are not left behind.

In this specific use case, the capturing of relevant shop floor information from the real world is demonstrated. The data are linked together and are made available in the EFPF portal through digital information and communication technologies.

Overall goal is to ensure that specific parameters in specific production machines and production environment are kept. WOM requires control of temperature and humidity in their manufacturing area to assure to ensure consistent quality, especially regarding component tolerances. In aviation, the large OEMs such as Airbus and Boing set detailed production specifications for suppliers. In some cases, certain production steps are only permitted under very specific and monitored environmental conditions. For example, aerospace paints may only be processed within a certain temperature range.

IAI needs to survey raw material that is stored in a freezer to avoid scrapping in case of too high temperature. In the second use case the vacuum of the vacuum forming machine will be controlled, so that immediate actions can be taken once the pressure is too high.

In all three cases the goal is to secure the stability and quality of manufacturing processes by monitoring the relevant parameters and provide alarms in case defined thresholds are underrun or exceeded. Overall goals are to make sure that:

- products are manufactured in acc. with relevant process specifications,
- rejects and waste are reduced,
- failures can be detected early and intervene actions can be taken if necessary.
- Record history data as proof for correct functioning of the system even when unattended.

Partners involved in this user story were from the user side WOM and IAI. As technical partners FOR and NXT were responsible for the technical development.

1.2.3.1.2 Testing, Evaluation and Experimentation

Validation of the solutions was done from IAI and WOM under consideration of the above-defined requirements and further usability aspects. Both companies set the relevant threshold in the Symphony GUI to a value where the alarms a triggered. The correct function of the alarm system has then been tested. It turned out the all required functions worked as expected.

WOM was testing the monitoring on the shop floor. Measured values for temperature and humidity were recorded under real production conditions. As the validation was carried out under real conditions on the shop-floor, a quick and permanent exchange with the developers via Skype chat was necessary. The validation was carried out against the

previously defined criteria, the screenshots below show examples from the validation process.

The monitoring was also exposed to changing conditions in different areas of the production. The measurements with the sensors were compared with analogue and digital measuring equipment. The accuracy of the hardware used is surprisingly high and completely enough in practice. In general, there are always areas in manufacturing processes where the monitoring and documentation of environmental parameters is technically required. Temperature is one of the most important parameters. For example, lacquers and other chemicals are specified for storage in a certain temperature range. Only under these defined conditions do manufacturers guarantee consistent quality. Safety aspects also play a role, as chemicals can change under certain environmental conditions and release hazardous degradation products, for example. In this respect, the installed solution has a great added value for industrial practice.

- **Requirement**
  - *Monitor process parameters like temperature, pressure/underpressure etc.*
- **Comment**
  - *Different sensors were used in the validation process (pressure, temperature, humidity). The screenshot shows the example of a temperature sensor.*

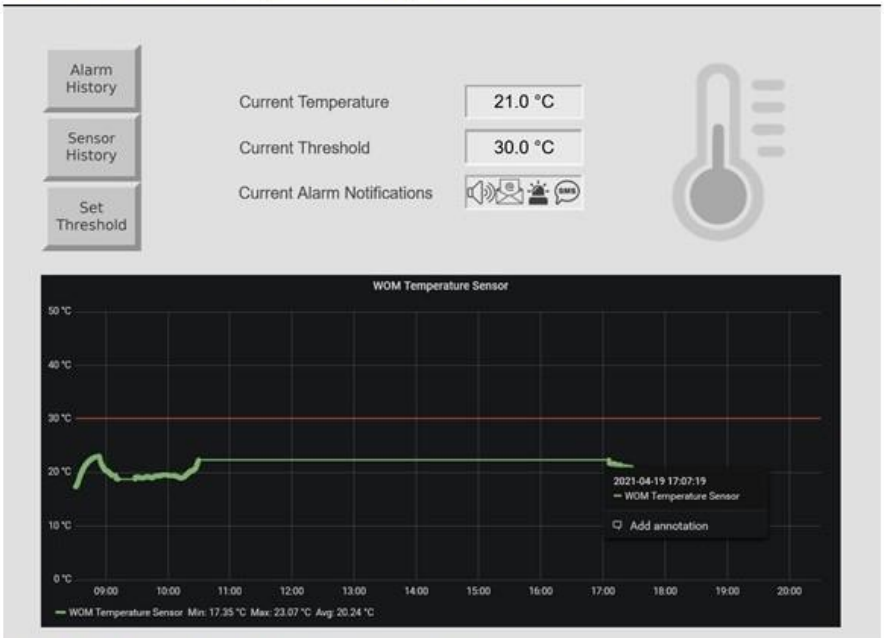


Figure 24: Validation of the Environmental Monitoring Solution regarding process parameters

- **Requirement**
  - *Provide alarm in different appearances (e.g. lights/SMS/Email) if parameters are out of defined tolerances.*
  - *Email and SMS as alarm indication devices shall be put in place to give direct feedback about the monitoring status to staff in the backoffice.*
  - *Email and SMS as alarm indication devices shall be put in place to give direct feedback about the monitoring status to staff at home, when the company is not occupied (e.g. at night).*
- **Comment**
  - *Acoustic and visual alarms are implemented - as well as e-mail notification.*

Figure 25: Validation of the Environmental Monitoring Solution alarms

- **Requirement**
  - *Record the defined parameters over time and enable easy data access.*
  - *The montoring system shall record relevant data and provide them to EFPF data spine.*
- **Comment**
  - *The sensor history and a separate alarm history are stored on the platform.*
  - *The data are permantly stored in the EFPF data spine.*

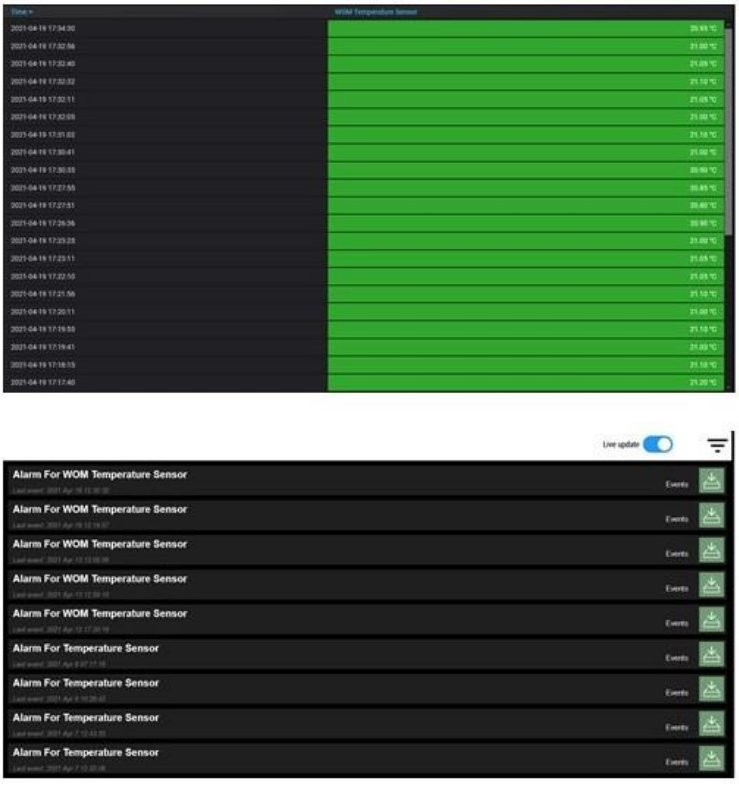


Figure 26: Validation of the Environmental Monitoring Solution regarding process parameter monitoring

- **Requirement**
  - *The monitoring system shall amongst others consist of control computers with corresponding intelligent software and interface modules, relevant relays and actuators, and different status indication devices.*
  - *The required technical equipment shall be state-of-the-art.*
  - *The required technical equipment shall be easily available and consider standard parts where possible.*
- **Comment**
  - *The system consists of several modules that can flexibly connect alarm systems and sensors. The technology reflects the current IT-standards.*

Figure 27: Validation of the Environmental Monitoring Solution regarding technical equipment

- **Requirement**
  - *LED lamps (green/red) and a sounder as general indication devices shall be installed direct at the specific implementation locations (freezer/vacuum machine) to give direct feedback about the monitoring status to staff in the workshop.*
  - *For the temperature use case: the green LED lamp shall be always powered on indicating the correct status of the temperature.*
  - *For the vacuum use case: the green LED lamp shall be powered only when the machine starts running and when then the monitored parameters are correct.*
  - *The monitoring system shall control the LED lamps and sounder as well as the Email and SMS automatically without needed manual input.*
- **Comment**
  - *An industry standard signal lantern with acoustic alarm is implemented. The signaling is programmed according to the requirements.*
  - *Physical alarms and notifications are carried out automatically.*

Figure 28: Validation of the Environmental Monitoring Solution regarding siren for alarms

- **Requirement**
  - *The monitored data shall be presented in a GUI with maximized usability and ergonomic handling.*
  - *The monitored data shall be presented in a graph with the option two zoom in/zoom out and to look into specific areas more detailed.*
- **Comment**
  - *A comfortable GUI with zoom function is available and fully functional.*

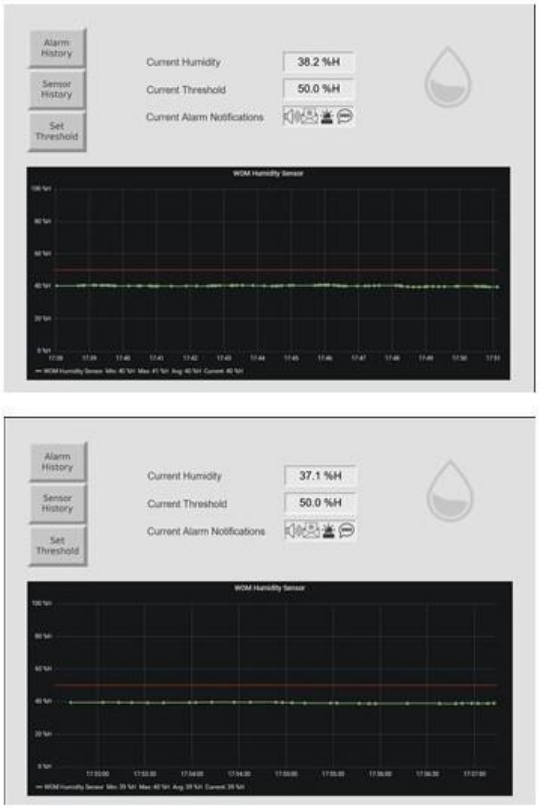


Figure 29: Validation of the Environmental Monitoring Solution regarding dashboard

- **Requirement**
  - *It shall be possible to set the thresholds (values for triggering the alarms) via the EFPF portal (GUI).*
  - *After having set a new threshold a separate request for confirmation shall pop up.*
  - *After having confirmed a new threshold the changes shall apply to the monitoring system without delay.*
- **Comment**
  - *The threshold limit for the different sensors can be changed at any time via the GUI and is adopted without delay. A safety query prevents accidental changes to critical measured values.*

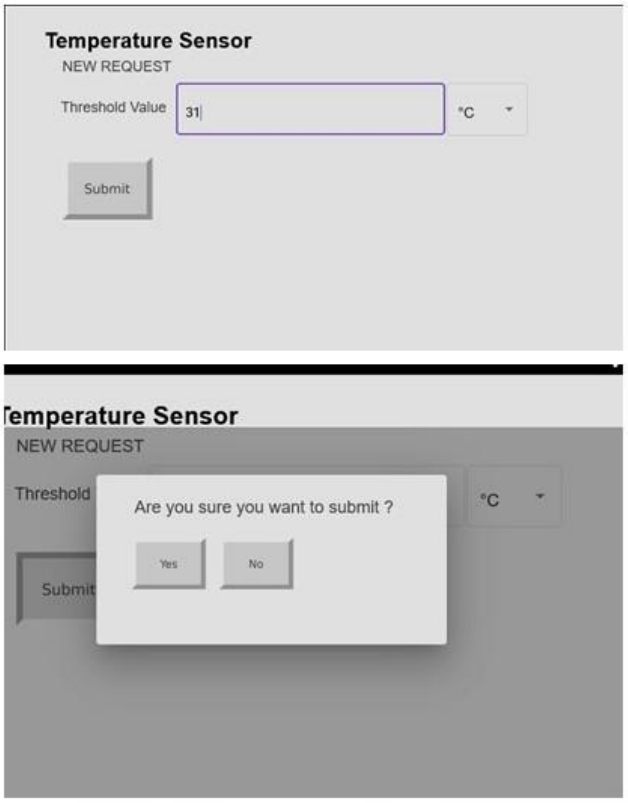


Figure 30: Validation of the Environmental Monitoring Solution regarding threshold change

1.2.3.1.3 Lessons Learned and Outlook

The great advantage of the developed solution is its high flexibility. Even if the implementations shown are limited to pressure/temperature and humidity sensors, many other applications are possible with only minimal adjustments to the existing solution. Thus, in addition to other environmental values such as air pollution and light, more technical parameters such as gases, vibrations, liquid leaks, accelerations, current flows and so on can be monitored. There are almost no limits here. In this respect, not two specific solutions were developed here for the two partners WOM and IAI, but rather the foundation was laid for countless other use cases that can be offered via the EFPF portal.

Here, too, the special circumstances relating to the global pandemic situation made work difficult for the partners during the development and implementation phases. For example, it was not possible for the technical partners to visit the user partners on site. However, this hurdle was overcome by regular and ad-hoc phone calls via messenger services such as Skype, as well as by taking and sending pictures and videos. This ensured that all partners were clear about the necessary technical environmental conditions.

Nevertheless, not all difficulties could be solved without delay. For example, the devices to be configured were sent to the technical partners, which were set up in their own laboratory environments, often only in the home office due to various restrictions in the countries. This complicated the configuration in that respect that the correct programming could not always be done immediately, resulting in unplanned iterations. Nevertheless, thanks to the commitment of the partners to each other and to the technical implementations, solutions were developed that were in no way inferior to those that would have been developed under simpler conditions.

In regards to the solutions itself the following impressions occurred at the user partners:

Now, the system is still very complex. It consists of numerous hardware components. Three small industrial computers are required to record a measured value such as temperature. Maybe we can think about whether it is possible to reduce the number of computers which would decrease the cost for the needed hardware.

Setting up and integrating the hardware requires technical experience at the user level. As the electrical cabinets were wired and installed at the users' premises, certain skills of the staff and the willingness of the managing directors were needed (especially in terms of insurance), which both might complicate the installation for future companies. However, this is not a general disadvantage, as valuable experience was gained by both partners, so that the trouble-shooting on hardware side is eased. We could think for future implementations whether the whole electrical cabinets as hardware kits are pre-configured from the technical partners, to avoid these activities at potential customers. These hardware kits must comply with industry standards (IP protection class, electric security, IT security, rack or rail mounting, fail-safety). They had then only to install the cabinets to the existing shop floor infrastructure. If this is guided with an applicable technical installation document, which explains which hardware will be delivered, how it is installed and connected, which infrastructure should be available etc. potential customers would get a clear picture of the overall solution. This would increase the general attractiveness of the solution itself.

In terms of the software troubleshooting this is not possible now without help from the developers. Consequently, this requires ongoing ad-hoc support from the technical partners, if required.

One function in the GUI that was missing was the export of the data, which should be implemented. In regards to the data storage it must be ensured that measured values are

stored securely over a defined period. If data acquisition fails, the user must be alerted or notified. Otherwise, critical processes will remain unobserved.

During the test phase, it was noticeable that access to the monitoring was of course only possible when the portal was functioning without disruptions. Since there was continuous further development of the platform during the project, there were occasional malfunctions and errors. In addition to the reliability and stability of the hardware used, a corresponding stability of the web platform is also necessary and must be considered for productive practical use.

Since monitored environmental factors such as temperature and humidity are simple. Since monitored environmental factors such as temperature and humidity are simple data structures, convenience functions such as the above-mentioned export and various options for display and output would be desirable - for example, a temperature curve in a defined period in printable form as an A4 sheet.

Conceivable and probably quite easy to implement would also be simple analysis functions within the database, such as a search for the lowest or highest value in a certain period or a query for an accumulation of certain measured values in a defined period, to be able to easily recognise anomalies even without an analysis algorithm.

Moving a monitoring tool to the online space is an advantage here, as the tool's functional scope can be changed and improved without having to update locally installed software and test it against different system platforms.

Even with inconspicuous and abstract data sets such as environmental parameters from a production facility, the aspect of data security should not be ignored. Solutions available on the global market for various manufacturing aspects also often mean that data can flow out of the company's own sphere of influence and rights and possibly be used to the disadvantage of the companies involved. Therefore, preference should be given to a European secure solution.

1.2.3.2 US-ASP3.2: Trolley Tracking

1.2.3.2.1 Short Description

AAM takes care of various transport trailers (trolleys) with which various jigs (devices) are transported for its customers. These transports are carried out between the Airbus locations Hamburg (Germany), Toulouse, St. Nazaire (France) and Mobile/Alabama (USA). The trolleys are only used for internal transport and are transported by ship to the respective location.

AAM has been commissioned to carry out a monthly visual inspection of these trolleys about damage and, if necessary, to carry out repair work immediately. For this purpose, corresponding protocols are drawn up, which must be quickly and easily accessible.

Every three months, the chassis of the trolleys are inspected following German accident prevention regulations (DGUV) and once a year, a technical inspection (TÜV) with an inspection sticker is carried out. Subsequently, the trolleys are released for further use.

This inspection is essential because although the trolleys are used on private property in Germany and France, in the USA they are transported/pulled on public roads from the port to the customer's premises and must, therefore, be technically safe.

1.2.3.2.2 Testing, Evaluation and Experimentation

The validation of the solution for this use case was carried out by AAM taking into account the defined requirements. We paid particular attention to the ease of use and quick learnability of the tool for the user.

One can go through the individual steps based on the process created to generate the corresponding information. This tool was combined with existing trackers on the various trolleys to know earlier when a trolley is in our geo-zone (Hamburg) to make the appropriate preparations. The planned functions are given.

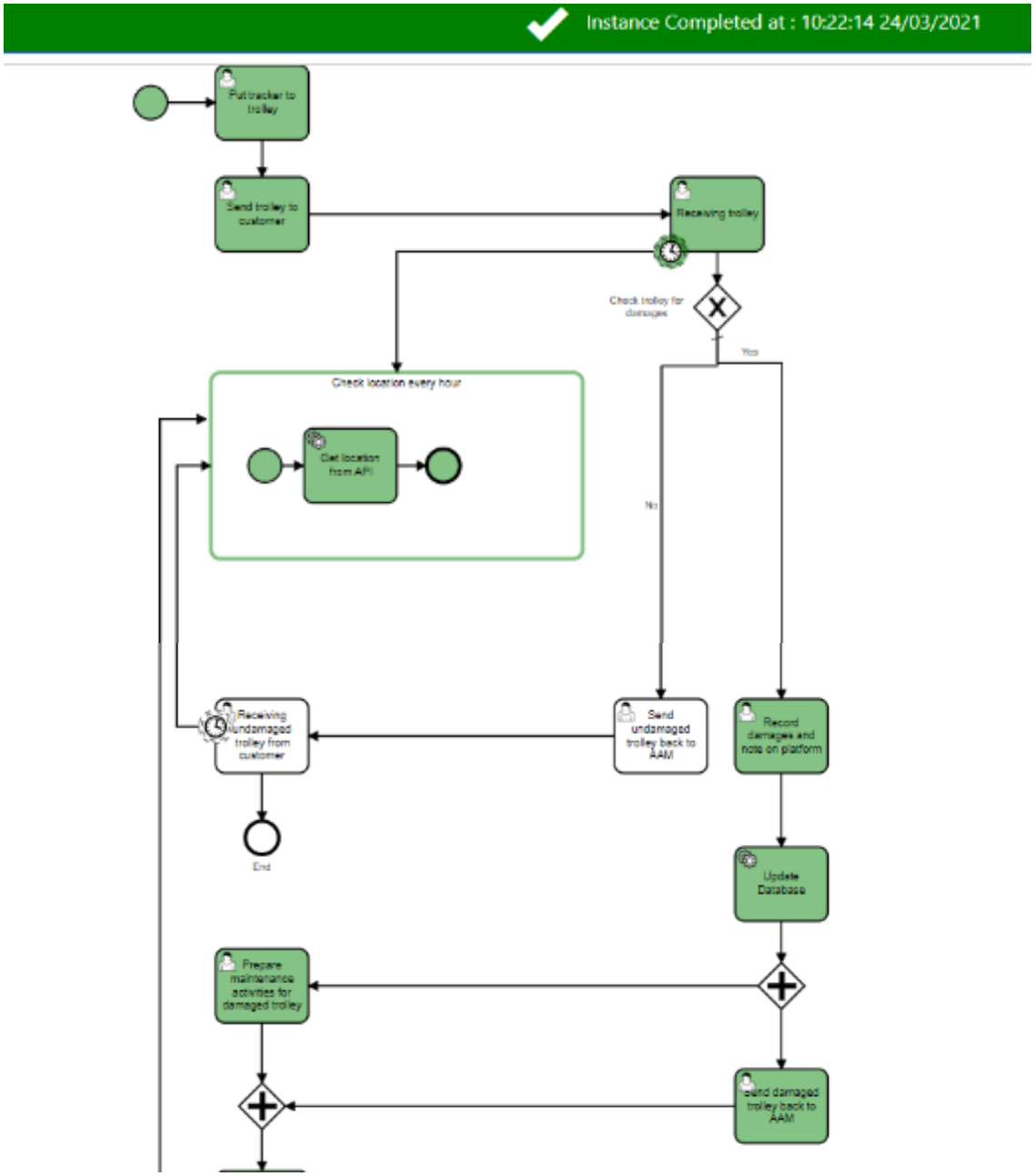


Figure 31: Screenshot Trolley Tracking Workflow for US 3.2 (part 1 of 2)

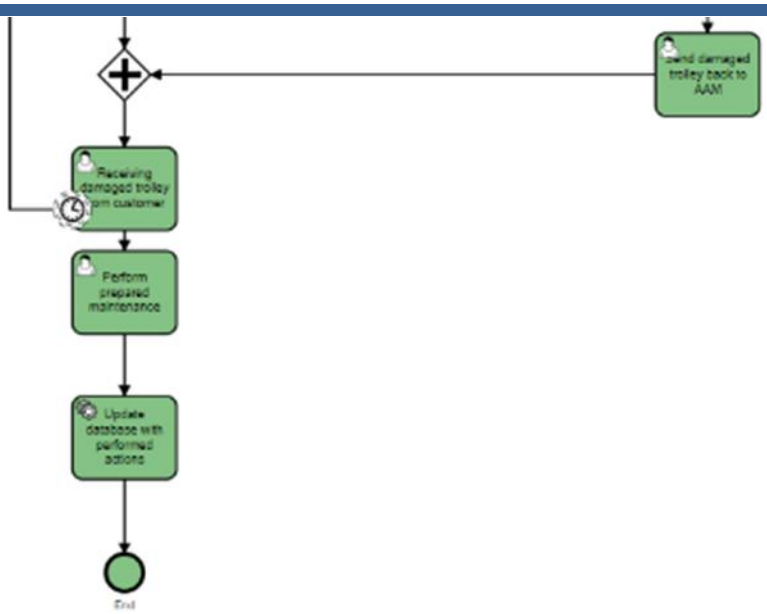


Figure 32: Screenshot Trolley Tracking Workflow for US 3.2 (part 2 of 2)

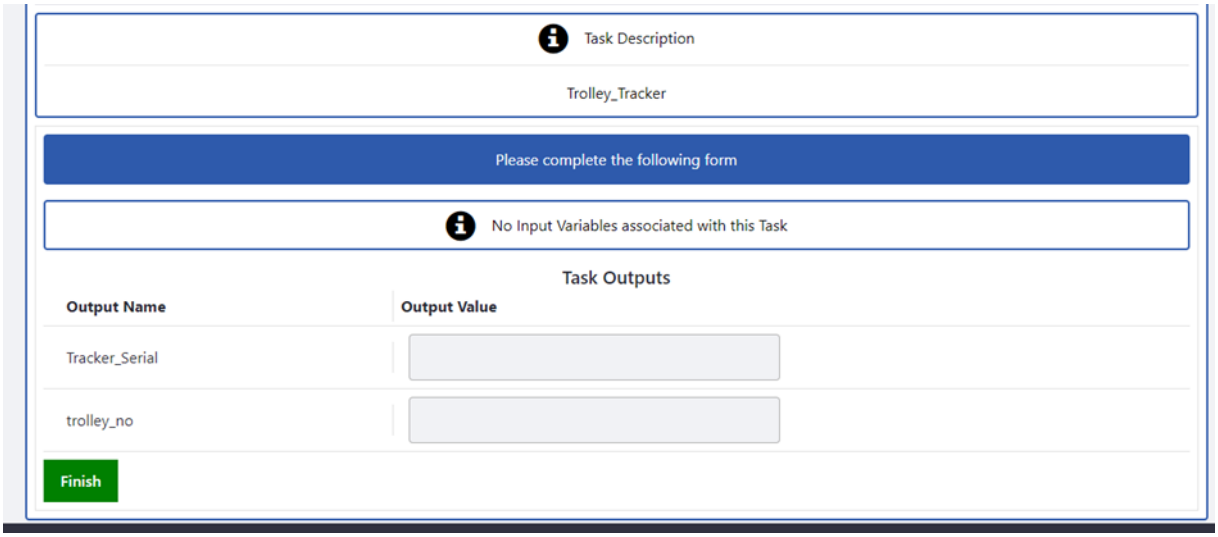


Figure 33: Screenshot Trolley Tracking for US 3.2

1.2.3.2.3 Lessons Learned and Outlook

AAM has clearly established requirements for programming to be described even more clearly, as there were different perceptions of processes.

The company will continue to push this tool to reduce the weaknesses that currently exist and, above all, to obtain an acceptable user value.

The large number of partners with whom AAM had worked or even just exchanged information has been a great enrichment of knowledge. It is not always the project-related information, but also the exchange with companies on other topics, from which one can then also view one's own processes differently and possibly also change them. In the future, AM Allied Maintenance will continue to apply for EU projects with several participants.

In future projects, the specifications in relation to the requirements must be clearly formulate and explained to the partners so that the partner or developer has a clear understanding of the task and the workflows.

1.2.3.3 US-ASP3.3: Visual Detection of Personal Protection Equipment (PPE)

1.2.3.3.1 Short Description

This use case deals with the integration of machine learning into the daily operations of manufacturing companies. The project partners C2K and IAI want to demonstrate what is possible with software intelligence. The goal being to increase manufacturing process reliability and efficiency, as well as implementing automated health and safety compliance.

With its large variety of different manufacturing processes and products Innovint has its own spray booth facility (shown in Figure 34 and Figure 35).

Figure 34: Spray booth at Innovint. The curtain on the left- and right-hand side is closed before the paint job starts

Figure 35: Spray booth at Innovint: shown is the extraction system, wherein parts are painted.

In this use case, a tool for automatic detection of the wearing of face masks should be implemented that orchestrates the various systems used in the spray booth. This includes

reading an air pressure sensor, sounding a siren, illuminating status lamps, activating / deactivating a pneumatic valve, and activating/deactivating an electrical contact which power the extraction.

The solution shall detect that the employee has put on the protective mask and give him direct feedback about the detection status via status LED mounted directly near the camera. It shall then check whether the correct air pressure is available, and the pneumatic spray valve shall be opened accordingly. At the same time the extraction system shall be turned on and a lamp, installed in front of the painting booth, shall indicate the status “Work in progress”.

In turn, the system shall turn all systems off (or setting timer to do so after a defined period) once the employee has taken off the PPE.

1.2.3.3.2 Testing, Evaluation and Experimentation

The implemented solution was regularly used in everyday operations. The goal was to increase manufacturing process reliability and efficiency and implement automated health and safety compliance surveillance. All these goals were achieved. The technical solutions have been harmoniously integrated into the entire process flow, which promotes usability and user-friendliness. The recognition of the mask or the fact that it is not being worn generally works very reliably.

However, it has also been shown that there are weak points in the hardware used. For example, one I/O module failed several times. The ICP Digital Card EIP-2055 lost its settings and configurations again and again, which led to necessary restarts. Since this also happened during the painting process, and thus the compressed air was cut off, the new technology was not used for limited periods of time. The manufacturers of the respective devices were contacted and solutions were sought. The most promising solution was to program regular restarts of the card, which led to the needed stable running of the system.

Furthermore, it was not possible to achieve reliable results with the built-in air pressure sensor. It was failing to deliver a constant 0mA reading where it should have been a minimum of 4mA. Measurements were taken by IAI staff to check whether the sensor was the problem or whether it was the analogue card itself to which the sensor cables are connected. In the end, the sensor had to be replaced and the manufacturer sent a replacement without complications.

In the meantime, the system is running reliably again.

1.2.3.3.3 Lessons Learned and Outlook

As written before, the implementation of the solution required intensive software development, but also know-how of the on-site staff at IAI during the installation of the hardware. Due to the pandemic situation, the initial installation had to be done by IAI itself and with the help of C2K through remote support. As both partners had a high interest in the success of this implementation, everything could nevertheless be implemented as it would have happened under normal conditions (including visits). Even during the recurring difficulties caused by hardware failures, solutions were found as quickly as possible to ensure the functioning of the system. During this close cooperation between both partners, further potential for improvement was identified.

For example, the installation of a sensor to measure the air quality is currently being planned to further increase and secure the quality of the painting results. Dust/particle inclusions in paintwork cost time and money. These paint defects caused by air contamination can be

significantly reduced. The decisive role here is played by suitable and well-maintained filters; in IAI case, it is also a question of other factors that cannot be influenced, since the paint booth is not a purely professional one. To achieve a reduction of possible rework due to trapped particles, a particle sensor will be installed in the paint booth that measures the number of particles present. As right from the beginning it is not clear what number of particles tends to have a negative impact on the final paint job result, a kind of "training" must take place here. Once a paint job was done, the results is noted with date and time. Over time, one gets to the number of particles above which the painting result is not good with a certain probability, so that rework must be carried out. The software will then not allow to start the paint job (it will not open the air pressure valve) if there are too many particles in the air, so that rework is avoided. Figure 36 shows the relevant updated workflow:

As a further improvement the generated data in the spray booth shall be visualized for IAI in the EFPF in a “Dashboard HMI”. The goal here is to optimize the production planning, detect early anomalies within the system and to control the duration of the employees’ exposure to paint vapours. For that reason, different data and time stamps shall be used:

- **Occupation of spray booth ("Workload")**
  - Data to be used: time from Mask-On detection to Extraction powered off
  - Different options to illustrate the data (e.g. it should be at least possible to change the view in terms of daily/weekly/monthly/yearly view, and to select the relevant time).
- **Occupational health and safety / Staff exposure time**
  - Data to be used: time from mask-on detection to mask-off detection
  - Different options to illustrate the data (e.g. it should be at least possible to change the view in terms of daily/weekly/monthly/yearly view, and to select the relevant time).
- **Predictive maintenance for the filter of the extraction system**
  - Data to be used: extraction powered on to extraction powered off.
  - Visible in HMI: Service life of the filter (extraction powered on).
  - It should be possible to set a threshold (hours), so with that due we get a notice/email once the filter needs to be changed.

Figure 37 shows exemplary a possible visualization of the new Spray Booth Dashboard HMI.

Also, it is planned to visualize the air quality during a paint job based on the new air quality sensor. This is already running in the development laboratory. For the later implementation in the real production environment the challenge is to install it in an electrical safe manner as normally explosion-proof equipment is needed. Figure 38 shows exemplary measuring results for three different particle sizes:

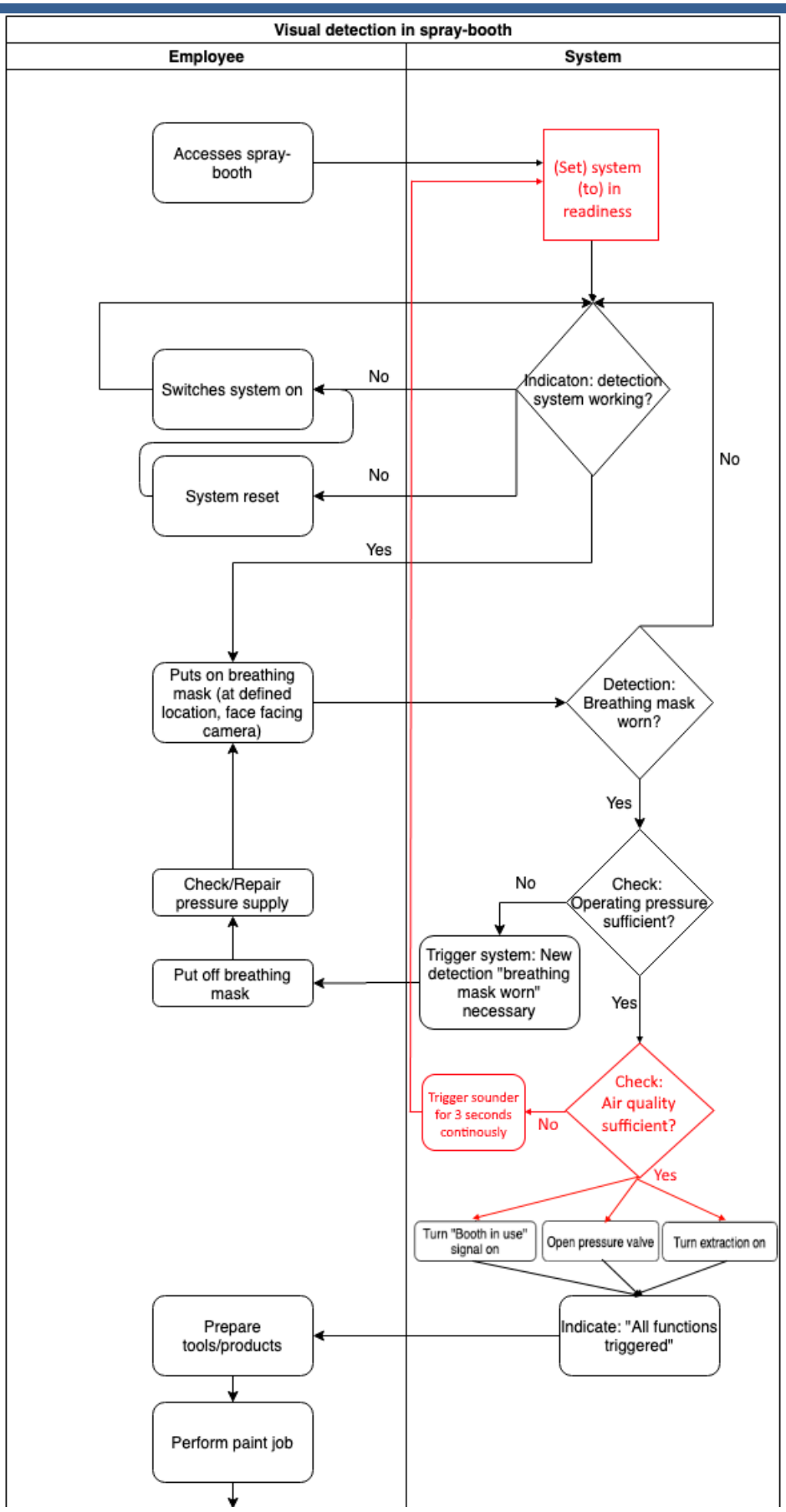


Figure 36: Updated workflow

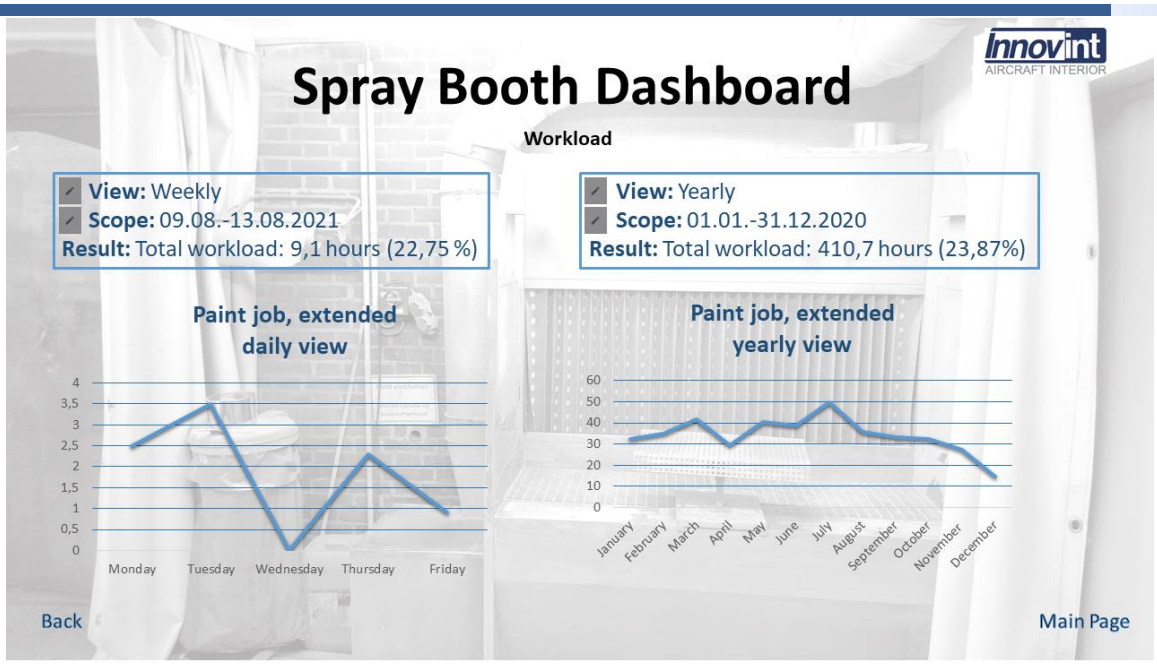


Figure 37: Exemplary HMI visualization for the spray booth

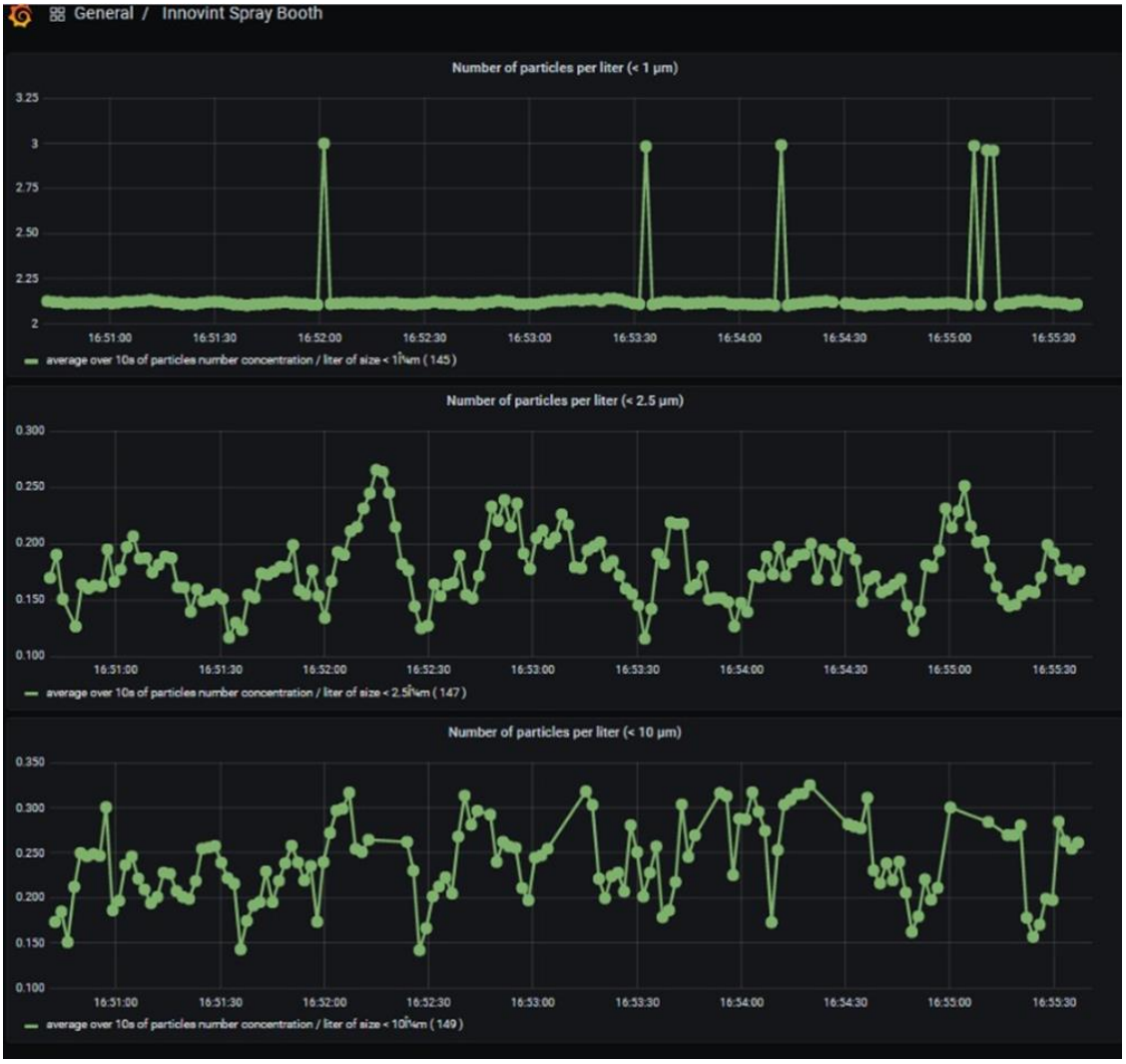


Figure 38: Graphs of the development environment for the air quality sensor

For later industrial applications in EFF customer companies of similar use cases there should be manuals available that helps the companies to understand what the solution generally provides, by use of which tools and required hardware/infrastructure it is done and how a route to implementation of such a solution generally looks like. Also, the customer should state which qualifications are available among its staff, and how the willingness of internal support is generally. From the experience IAI as user made during the process, it is favourable to do much of the implementation work on its own, as then trouble shooting is much easier as relevant know-how is directly available.

Although a very specific use case was developed, there are multiple other similar applications possible. First, the software could be trained to other PPE than IAI uses, which opens the solution already to a wider market. Second, the generic solution to detect things in different environments allows for example the monitoring of areas where staff with specific characteristics are present. This would lead to the necessity to anonymize data directly in the camera, so that relevant privacy data regulations are not harmed.

1.2.3.4 US-ASP3.4: Stock Level Monitoring

1.2.3.4.1 Short Description

As a production manager I want to know when the stock runs out for specific parts. The continuous measurement of box content in a shelf is necessary and a signal shall be generated if a minimum stock level is reached.

1.2.3.4.2 Testing, Evaluation and Experimentation

The validation of the factory connector tool was done from 3DI and C2K and Almende under consideration of the defined requirements.

The connection of factory connector via Internet/Data spine to C2K worked without any problems. The electrical cabinet was combined with an analogue weight sensor which sends voltage signals whose strength depend on the applied weight. The weight signals are sent to the ROAM-tool and were checked whether the values are fallen below the defined threshold values.

During installation the first weight sensor was destroyed by an unknown reason. This was noticed by negative weight values and a sensor whose temperature raised up to more than 50°C. To continue testing an adjustable voltage device was installed to simulate the sensor.

After the values were fallen under the defined thresholds e-mails arrived at defined addresses in the distribution list.

Threshold levels and other criteria which lead to an email-notification can be programmed by the users of the ROAM-tool. New recipes for notifications can be created as described in the following figures.

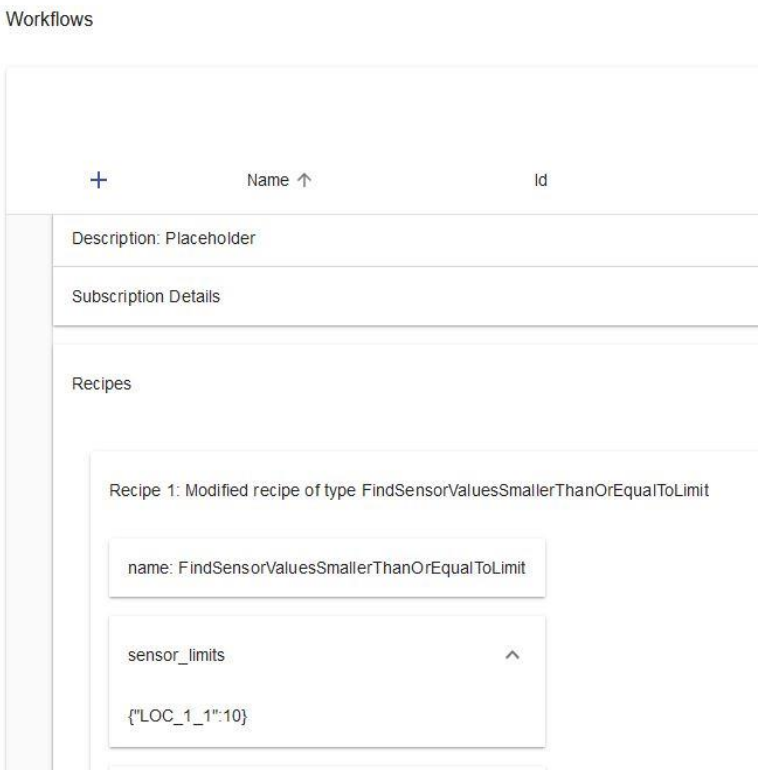


Figure 39: Threshold recipe detail for an email-notification when sensor signals fall below 10kg

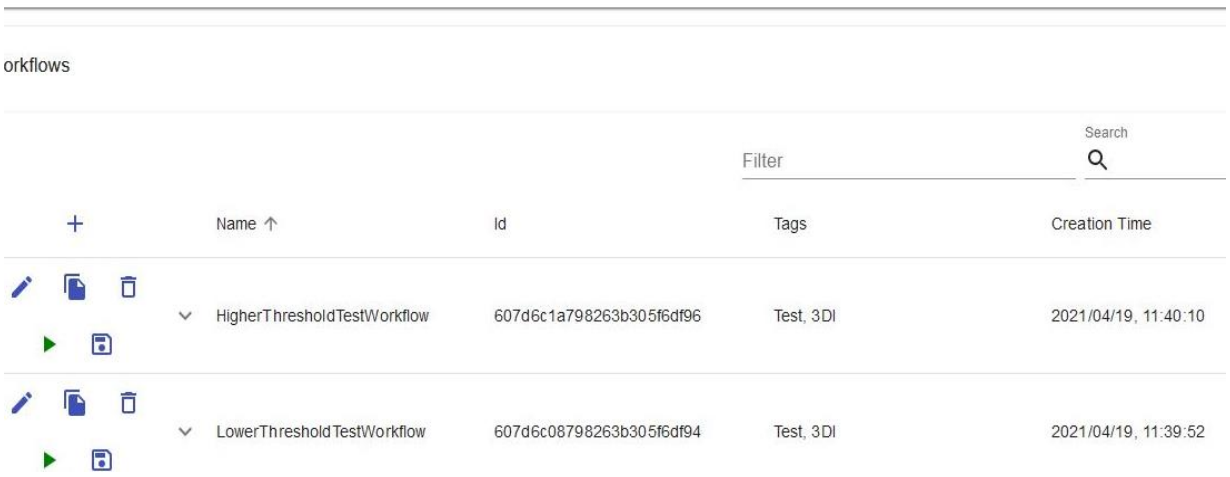


Figure 40: Adjustable recipes defining different threshold levels

Figure 41: Factory connector

Figure 42: Weight sensor

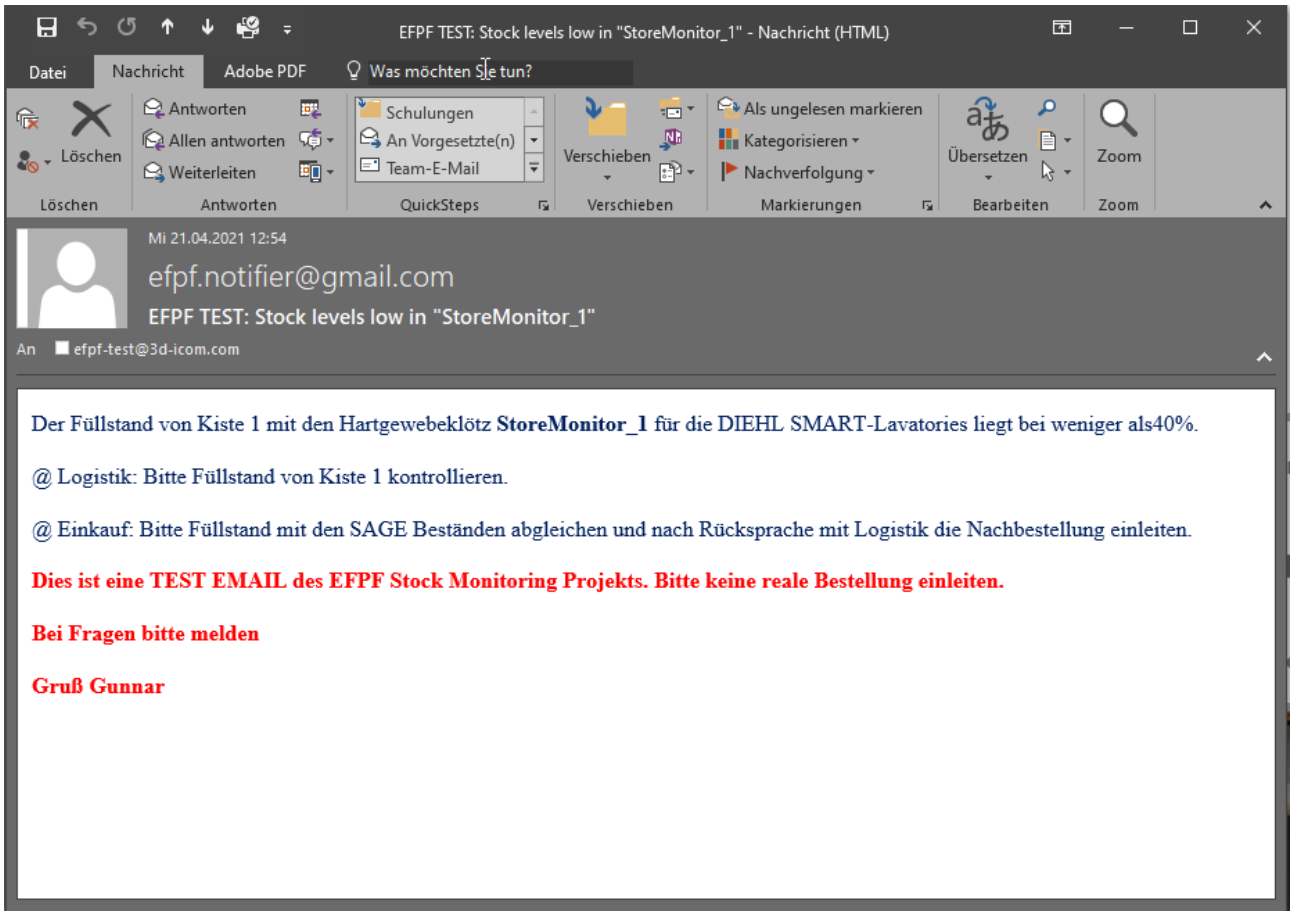


Figure 43: Notification (Example)

1.2.3.4.3 Lessons Learned and Outlook

If an analogue weight sensor is used an additional power supply of 5V must be observed.

A circuit diagram for the complete solution should be enclosed, when going to an industrialisation of the product. A further development regarding a wireless solution would be expedient and desirable. An automated ordering function / connectivity to product catalogue service like Product Catalogue Service or the ERP-System would be helpful.

1.2.4 ASP-Epic 4: Supply Chain Management

1.2.4.1 US-ASP4.1: Increase Supply Chain Transparency

1.2.4.1.1 Short Description

Due to low digitalisation in aerospace supply chains, there is generally low transparency in at the same time. Often regular information about production status is only provided upon delivery. If supplier does not inform manually in time about delivery delays or other problems during manufacturing process the whole production planning at the customer production plant might get mixed up leading to additional efforts and delivery delays towards own customers. A lot of SME does not have appropriate ERP systems, which on top makes monitoring of orders more difficult.

To support SME in tracking orders, reduce delays and be informed about possible problems at an early stage an applicable tool is developed, which includes automatic reminder when dates are slipped. Overall goal is to have a better view on the status of ordered products and services, so that manufacturing capacities can be optimized to ensure efficient use of available resources and to have actual data about the status of the product or service available.

Partners involved in this user story were from the user side HAW and IAI. As technical partner ICE was responsible for the technical development.

1.2.4.1.2 Testing, Evaluation and Experimentation

Based on the validation and the lessons learned from the previous deliverable, the WASP tool was further optimized accordingly. Partner ICE iteratively implemented new functions in the backend as well as in the frontend, which were then tested by the partners HAW and IAI. To provide structured feedback from a user and requirement perspective, the tried and tested method of presentations with screenshots and comments was used again. The next Figure 44 and Figure 45 show examples of this feedback:

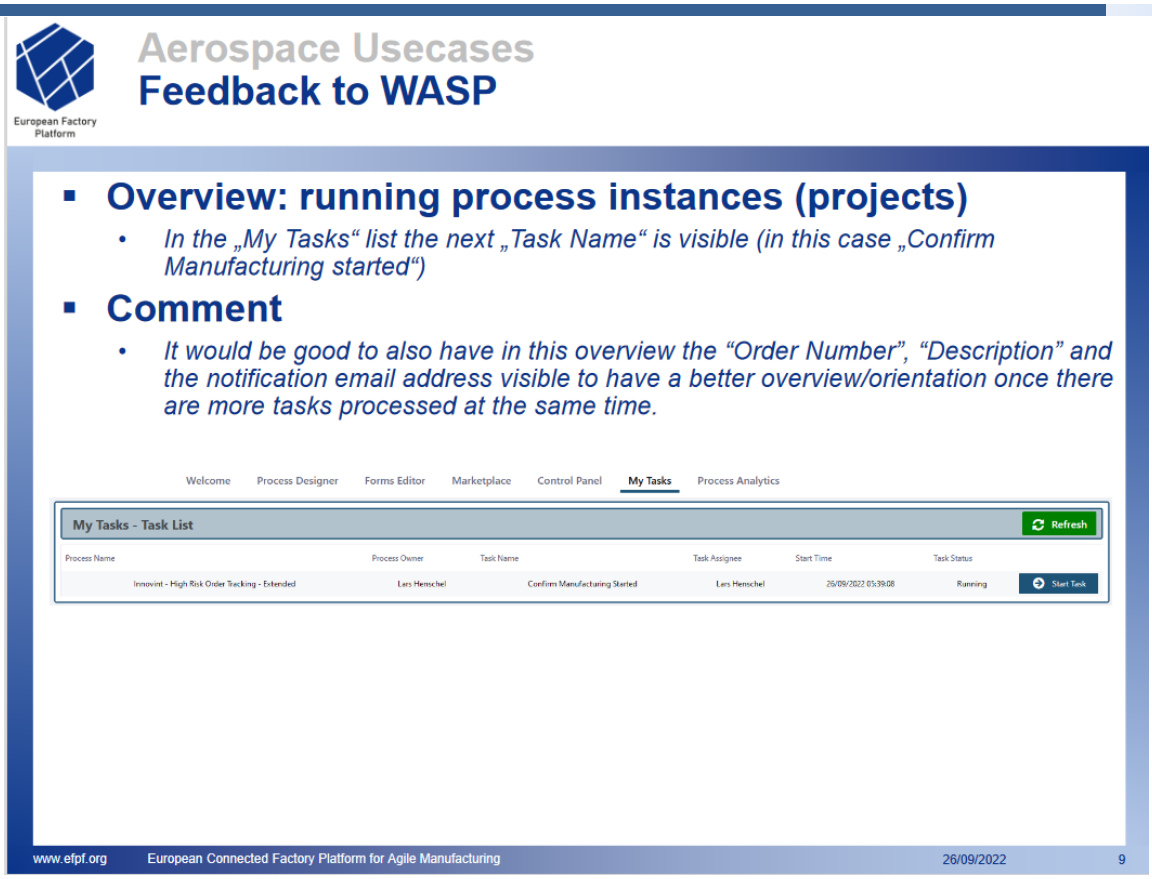


Figure 44: Feedback for the WASP tool by means of screenshots and comments

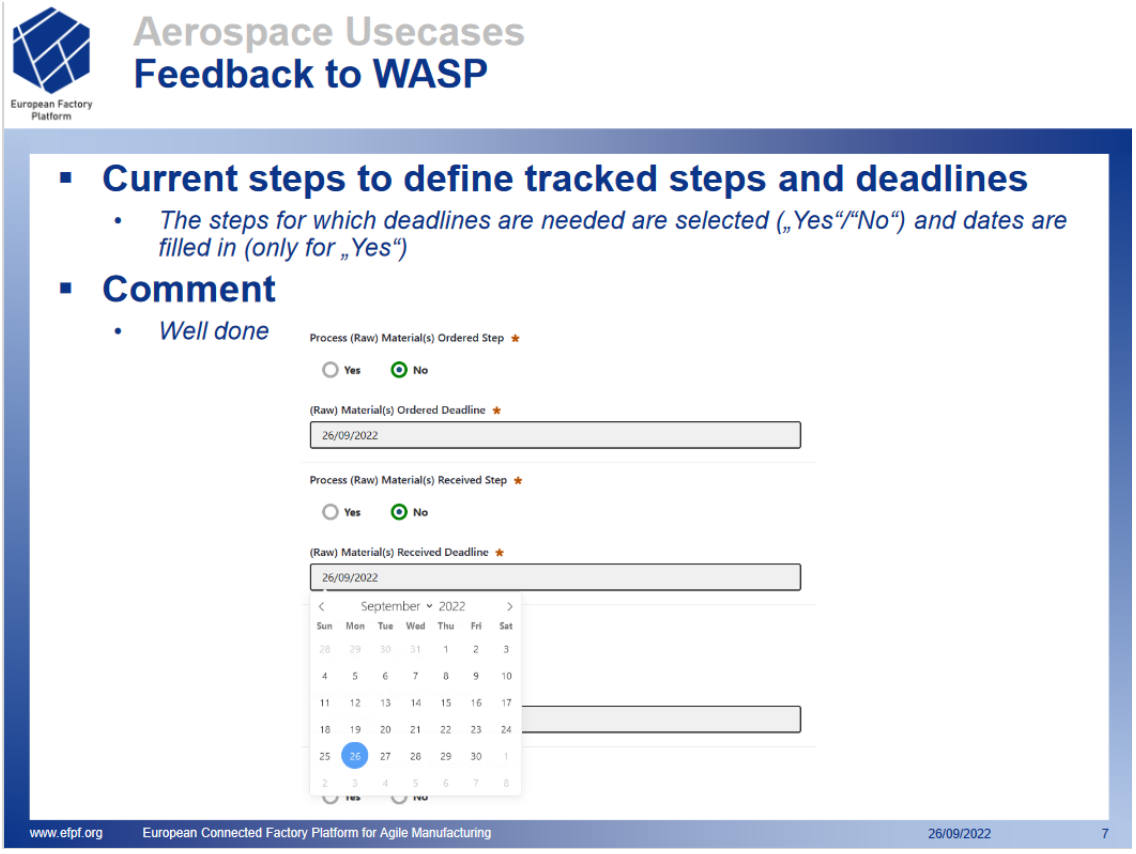


Figure 45: Feedback for the WASP Tool by means of screenshots and comments

Following that various measures and functions have been implemented to optimize usability. For example, basic main processes have been defined (Low Risk Order Tracking and High-Risk Order Tracking) from which the number of steps to be tracked can be selected. These can now be used by users without having to enter the process creation themselves. Both include a first step in which the various data about the order to be tracked is entered. This data includes Order Number, Part Description and Notification Email Address. In the further course, the steps "Raw Material Ordered", "Raw Material Received", "Manufacturing Started", "Manufacturing Completed", "Quality Inspection Done", "Product Ready for Pick Up" as well as "Incoming Inspection" can be selected, which are relevant for the order tracking. In this way, orders can be tracked very precisely or rather roughly, depending on their criticality.

The following Figure 46 describes the added input fields for initially creating an order tracking process:

Figure 46: Input fields for starting an order tracking process with the fields Order Number, Part Description and Notification Email Address

Based on the various available pre-defined steps for an order tracking process now the user can choose which of them is applicable for the current tracking. For every step the user is now choosing between "Yes" and "No". In case "Yes" for a step is defined, the due date must be entered. Therefore, a little calendar field was added, which makes it easy to orientate and select the specific dates. Figure 47 show this proceeding:

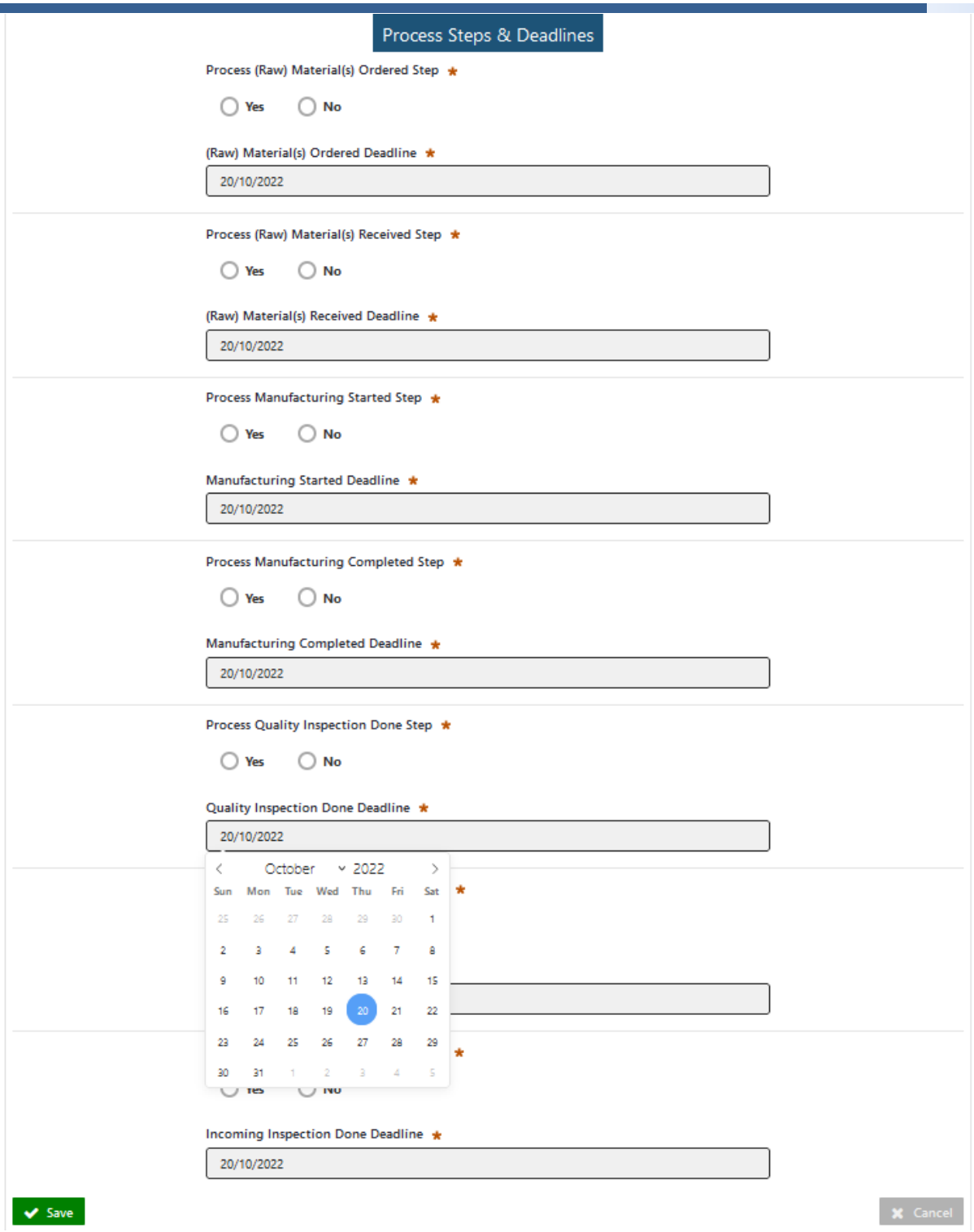


Figure 47: Choose applicable tracking steps and define due dates based on calendar input

For suppliers, that are also registered in the EFPF, relevant steps with needed action from their sides are visible in the "My Task View". Figure 48 shows an example for the step "Manufacturing Completed", which is visible in the IAI My Task View, as this task has been assigned to the email address which is already registered in the WASP tool:

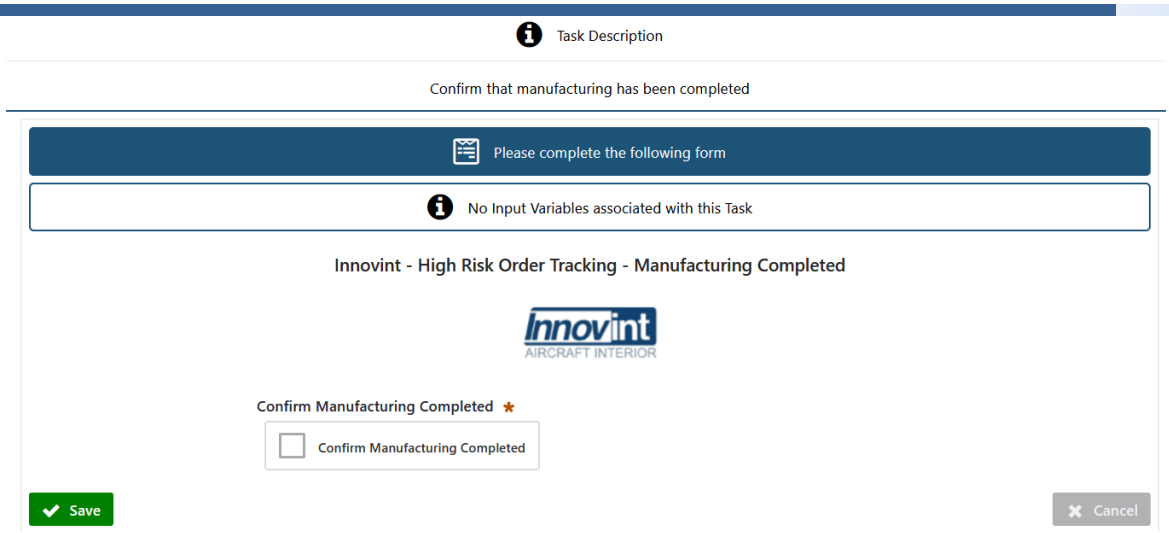


Figure 48: Input field (in this example for the step "Manufacturing Completed") in the WASP view (this is only visible once the step is assigned to the applicable user)

Additionally, the email reminding function has been optimized. Once a date is due, automatically reminder emails are sent out. Figure 49 shows such an email exemplary:

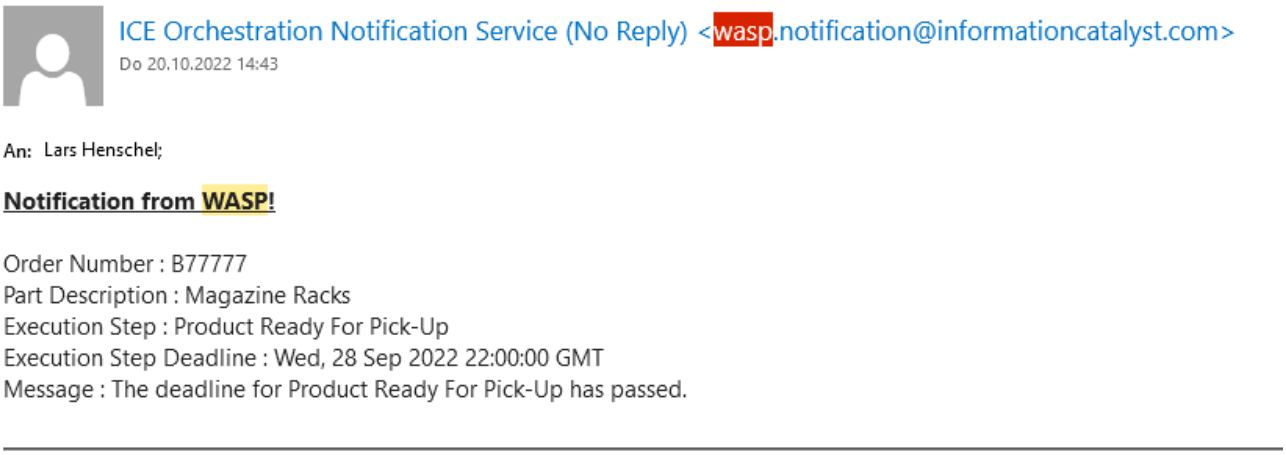


Figure 49: Example of a reminder email for the step "Product Ready for Pick-Up"

In this regard, also the content of the emails has been optimized. Now the order number as well as the Part Description are included, which both give the recipient descriptive information so that it is no longer necessary to search for the Part Number and Description, which are hidden behind the order number, in your own system.

By means of the Process Instance View the status of an Order can be seen graphically presented. This gives a comprehensive overview with only few clicks. Additionally, a function has been implemented, that now allows to send ad-hoc email reminders out of this flow chart. This helps to remind suppliers of the due dates, and there is no other software needed to use (e.g. Microsoft Outlook) as the email is automatically generated out of the WASP tool. Refer to Figure 50, which shows the implemented function:

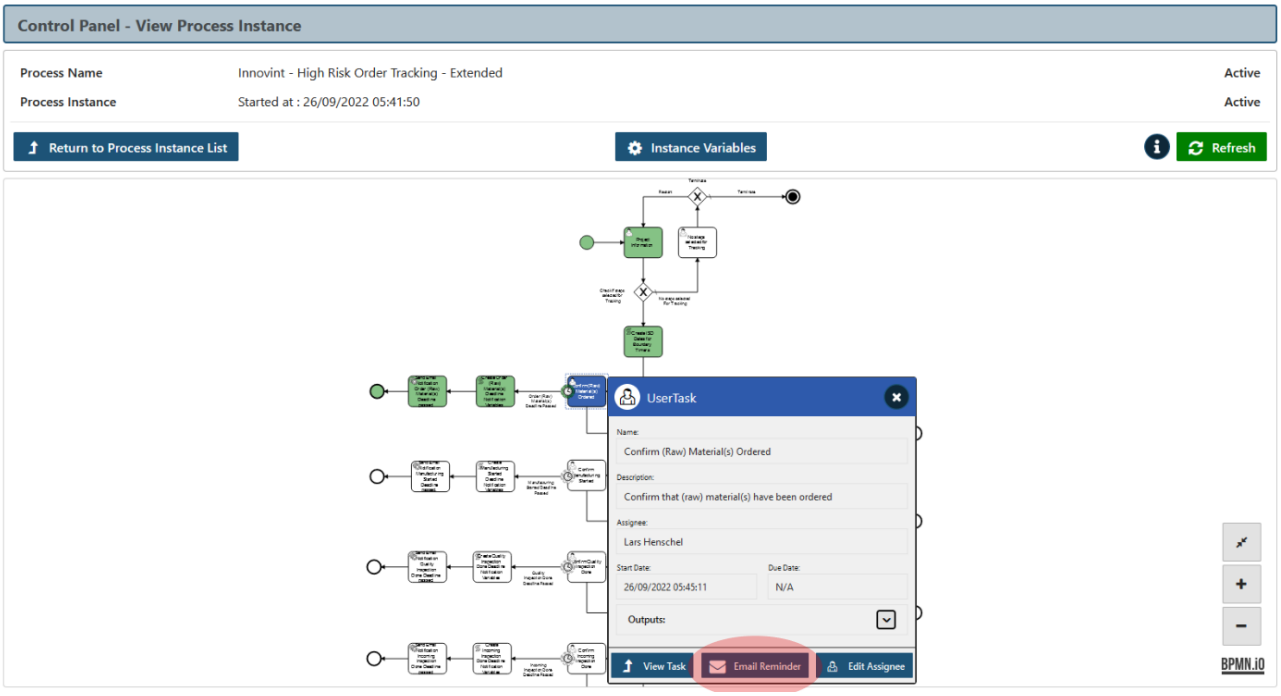


Figure 50: Ad-Hoc Email reminder function in the process instance view for specific orders

Although there was extensive progress done, still some functions must be implemented. As one example in the My Task overview the Order Number, Description and the notification email address will be visible to have a better overview/orientation once there are more tasks processed at the same time.

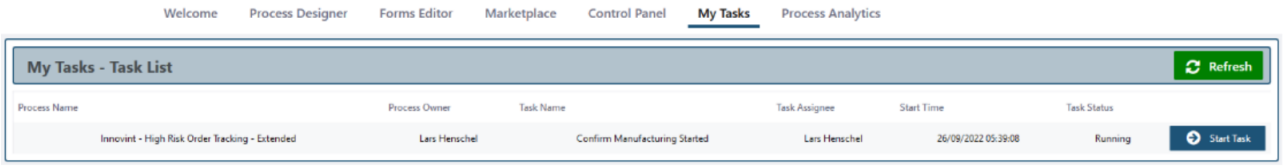


Figure 51: My task overview that will be optimized

Furthermore, a button in the reminder email will be included, so that suppliers can directly confirm the actual status of the order process based on this link. With that change also, the wording in the reminder email will be completed: the sentence "Please confirm by clicking on the following link that the step has been performed and you are in line with the production schedule: [LINK]" will be added.

1.2.4.1.3 Lessons Learned

In general, it has been shown that with the WASP tool, ICE has developed an extremely flexible tool that can be used for a wide variety of applications. With the input of HAW and IAI it could be built up to a strong addition for the EFPF. The user requirements are well implemented and the tool is suitable for the intended purpose.

It also became clear that the advantage of an extremely flexible tool leads to challenges when it must be adapted and further developed for specific use cases. This leads to the fact that it cannot directly meet the specific applications in all aspects. An example of this is the technical wording, which can nevertheless be adapted with a little more effort. Here it shows up however that despite these difficulties the WASP Tool is so flexibly programmed that also these restrictions existing at the beginning can be eliminated in individual applications.

This flexibility also allows both very well trained and less well-trained users to use the tool. Thus, it is possible for technically skilled users to define their own processes and steps for order tracking and apply them directly without the involvement of the programmers themselves.

In conclusion, the WASP tool for increasing supply chain transparency complements the EFPF in a very important way, namely the capability to control supply chains more closely, which in the end leads to earlier identification and reduction of delays, and ultimately to more customer satisfaction.

1.2.4.2 US-ASP4.2: Secured Logistic Chain

1.2.4.2.1 Short Description

Companies that have access to and are responsible for handling and preparation of air cargo can apply for the Known Consignor status described in Regulation (EU) 185/2010.

With this certification the consignor invests in the security of its supply chain by taking certain measures to increase security. This way it is relieved of the need to have its goods controlled, and avoids potential delays and additional screening costs before being stored in the aircraft.

Up to now there is no comprehensive solution available for logistic chains that ensures that freight/packages have not been manipulated on the way to the air carrier. Rather, a variety of different steps and tools are currently used in this logistics chains, with only the partners directly involved ever having control over the measures to be followed.

To support the tamper-proof storage of information in this logistics chain latest blockchain technologies shall be used to develop a solution that ensures compliance and proper monitoring of the relevant requirements. The goal is to ensure that wherever a transfer of freight/packages between persons/ companies takes place, that the freight/packages are the same and have not been manipulated and relevant persons are identified/authorized and their data are recorded.

1.2.4.2.2 Testing, Evaluation and Experimentation

Here, too, the user side was constantly testing so that optimisation potential could be worked out. As always, the proven method of iterative feedback and resulting improvements was used. The result is a further optimised back end based on the previous DAML tool, which is presented in the following figures. The deployment for the use on smartphones has also started.

First figures show some extracts from the desktop version, whereas the description of functionalities is more important than the user interface. After them some figure will show the functionalities on the smartphone apps. Figure 52 shows the landing page of the tool:

Figure 52: Landing page for the Secured Logistic Chain Tool

By clicking on “Create Order” a new order can be created. It consists of part number, description and a delivery address as seen in following Figure 53:

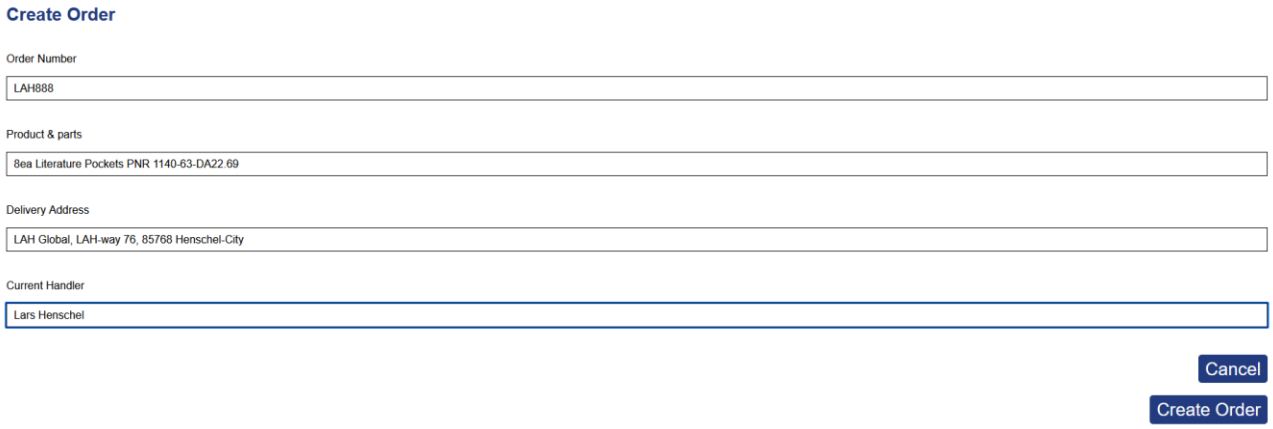


Figure 53: Create Order page

Once all data are entered, the order is created with a click on “Create Order”. A little window pops up and confirms the creation:

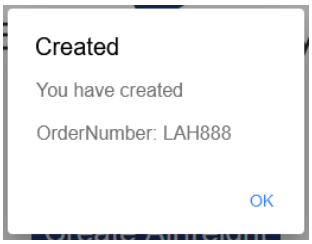


Figure 54: Confirmation of created order

Different orders can be entered the tool. Once the shipping shall start, relevant order can be selected after having clicked on the “Create Airfreight” button on the landing page. The following window opens (Figure 55):

Figure 55: Menu page after having clicked on "Create Airfreight" on the landing page

Here the applicable order can be selected and the summary is shown (refer to Figure 56):

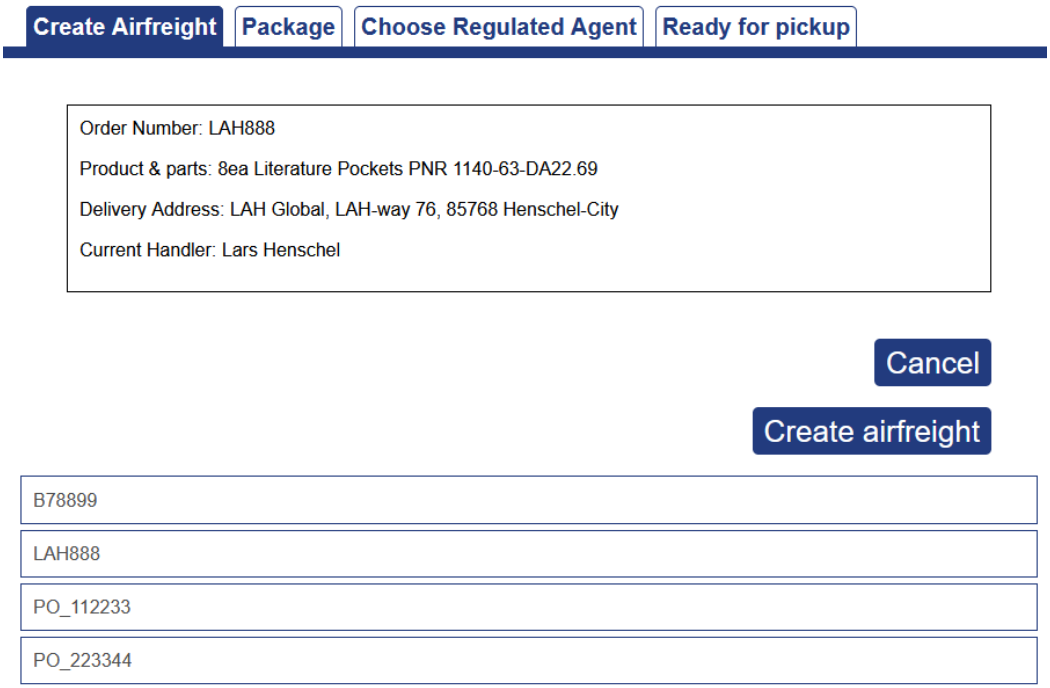


Figure 56: Summary of selected order after selection

With a click on “Create Airfreight” the shipping process is initiated and a little window confirms the update of the order status (Figure 57):

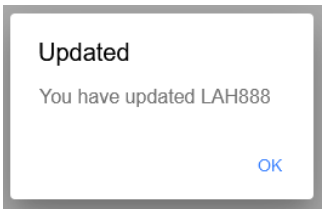


Figure 57: Confirmation of order update

The order is now shown in the “Package” register (Figure 58) and a click on it opens the fields “Dimensions” and “Weight”, which then can be filled in. Additionally, a photo can be uploaded to prove the sealed package:

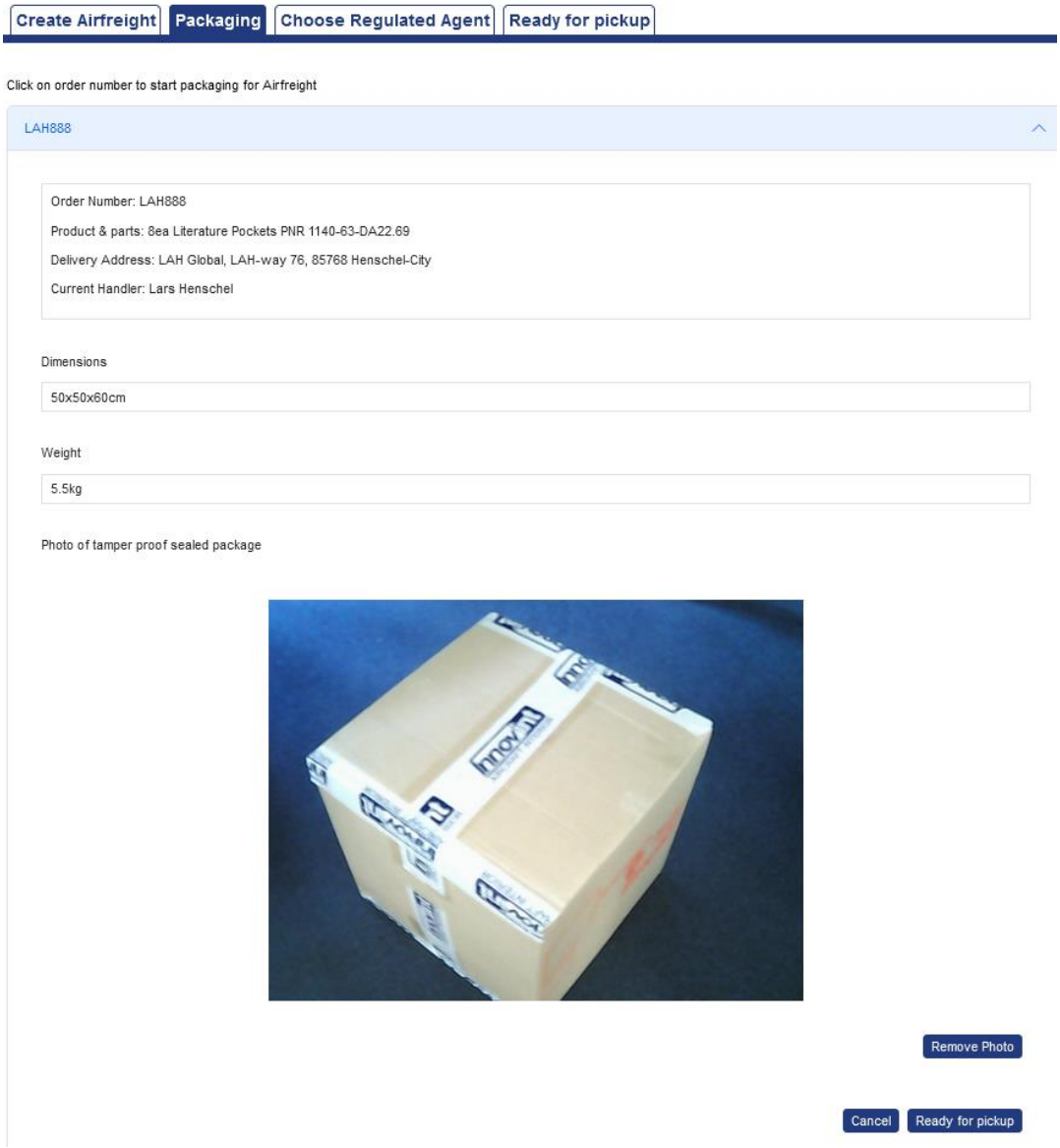


Figure 58: Order is now visible under register "Package", fields “Dimensions” and “Weight”, photo was uploaded

With a click on “Ready for pickup” a little window again confirms the update of the order and it is visible in the register “Choose Regulated Agent”. After selecting the relevant order, the carrier and additional carrier related information are loaded (refer to Figure 59):

Figure 59: "Choose Regulated Agent" menu with relevant data of order and filled in information regarding the carrier

An easy control mechanism to assure the regulated agent-status of the carrier will be implemented. With a click on “Send notification email” the carrier is pre-informed about the package and therewith notified for pickup (Figure 60).

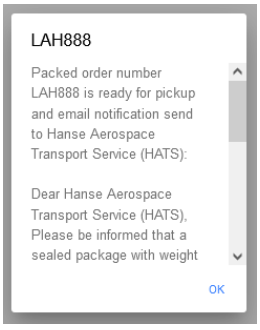


Figure 60: Notification email text

A little window again confirms the update of the order and the order appears in the register “Ready for pickup” with relevant information (Figure 61):

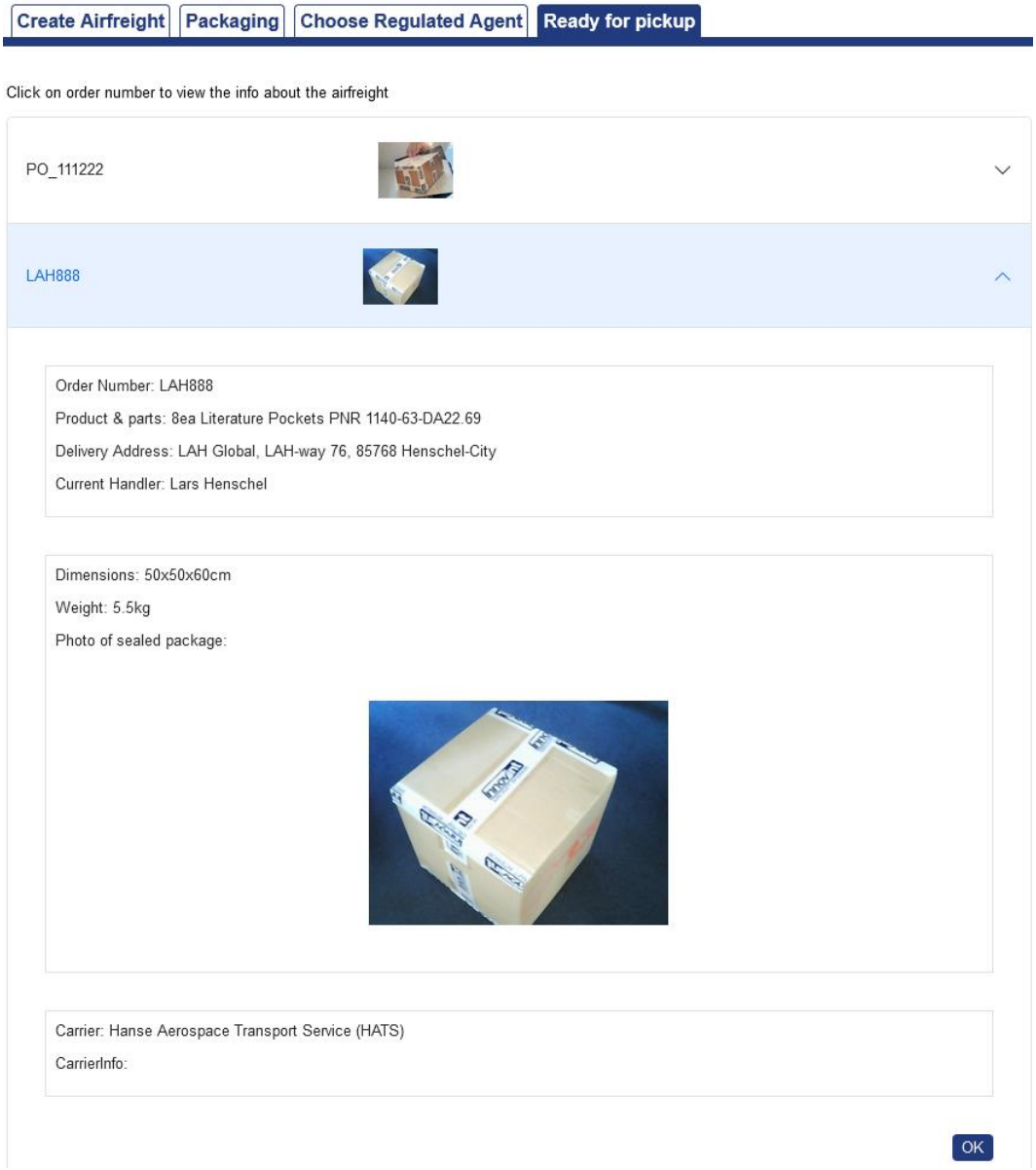


Figure 61: Register "Ready for pickup"

The following figures show an extract of the next step to demonstrate the availability of the app on a smartphone. This next step is the handover of the package to the carrier:

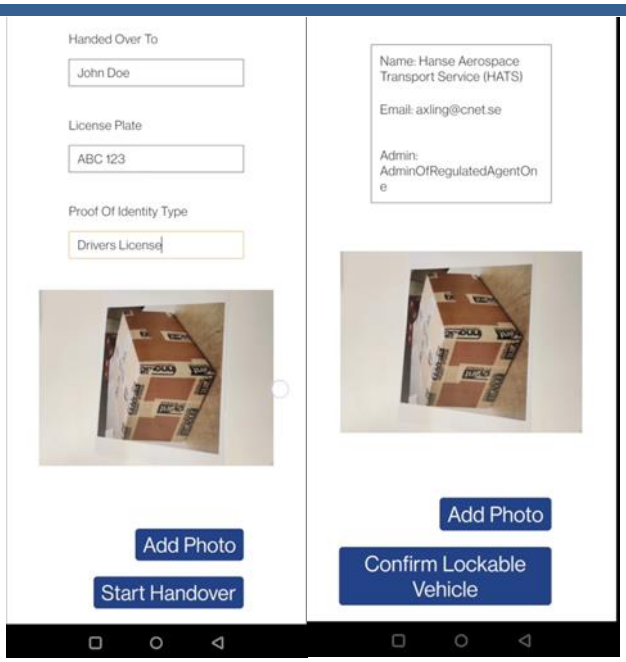


Figure 62: Handover of the package to the carrier

Different task must be done during handover. For example, the name of the carrier staff, the license plate number of his car and with which document he identified himself are to be recorded, which all can be done in the app. A further important point is the needed active confirmation that the used transporter is a lockable car.

To make sure that all further carriers, resp. recipients of the package, can take it over and to ensure the integrity of it, a QR code with relevant information (certificate) is generated in this step, which must be scanned during handover steps in the logistic chain accordingly (Figure 63).

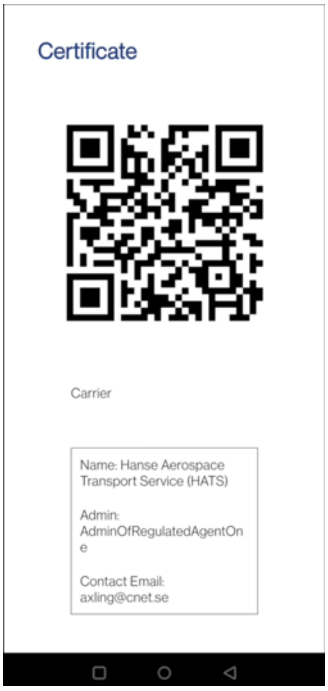


Figure 63: Certificate to ensure integrity of the package and involved persons.

1.2.4.2.3 Lessons Learned and Outlook

It became obvious during the development of this use case that there is no comparable app so far. Discussions with companies specialising in this type of logistics chain have shown that there are no higher-level or monitoring programmes that ensure the entire integrity of the logistics chain from within a single programme. In this respect, the development of this application, even if not yet completed, is a further step towards improving security in aviation.

In general, although not fully shown in this report, a large part of the functionalities is available in the back end. The task for the next few weeks is to fully map these functionalities into intuitive user interfaces. Here, too, a significant part is already available, so that the app will be available with all functions and a very good user interface by the end of the project.

1.2.4.3 US-ASP4.3: Material Track & Trace During Lifecycle

1.2.4.3.1 Short Description

As a quality management employee, my goal is to identify other affected products when a manufacturer of a material used in them reports material defects, so that reliable track and tracing is possible and follow-up actions can be initiated accordingly (e.g. inform other customers).

As a quality management employee, my goal is to identify other affected products when a customer reports defect in a supplied product, so that reliable track and tracing is possible and follow-up actions can be initiated accordingly (e.g., inform other customers).

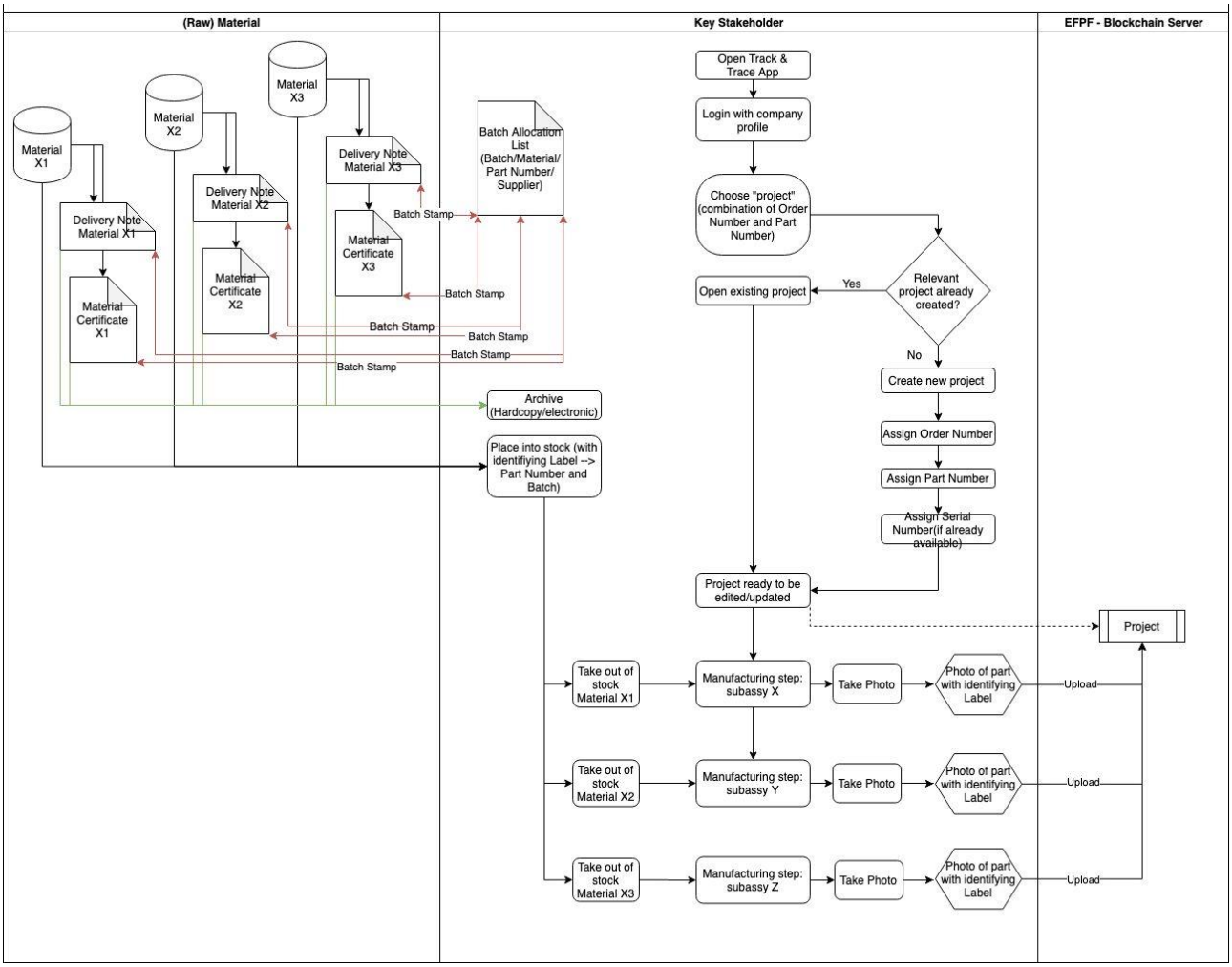


Figure 64: Workflow for US4.3

1.2.4.3.2 Testing, Evaluation and Experimentation

As with the previous application, an iterative approach was taken for further development. IAI tested the current versions, commented on them and sent them to CNET so that improvements could be implemented step by step. The result is an optimised frontend based on the previous DAML tool, which is explained step by step in the following illustrations.

As with the previous use case, no on-site installations were necessary here, and so cooperation was not restricted by the Corona situation. Figure 65 shows the landing page of the tool:

Figure 65: Landing page of the Material Track and Trace Tool

Once the user clicks on “Projects” and on the next menu page on “+New Project” the following page opens and relevant information can be filled in:

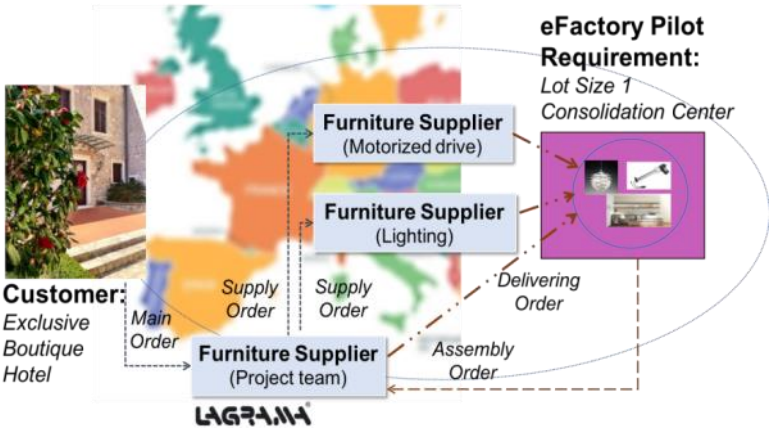
Figure 66: Creation of a new project

1.2.4.3.3 Lessons Learned and Outlook

The tool runs very well and gives a good opportunity to fulfil the requirements of a documentation of all changes on a product during its life cycle. The most important issue was the connection to the EFPF portal. Sometimes during the testing phase the portal was not available and the tool could not run. A very good and frequent communication between developers and user is necessary.

2 Furniture Pilot (FUP)

2.1 Short Pilot Description



The need to find new customer segments to increase turnover pushes furniture manufacturers to diversify both production systems and supply chains. The traditional clients of the Home Furnishing segment, who buy from a catalogue with different options to personalise the furniture, coexist with new clients from the Contract segment (hotels, offices, etc.) that demand an essential service of furnishing and decoration. Sometimes this service is provided entirely by a third party (decorator, interior designer), and sometimes it must be provided by the furniture manufacturer who accepts the order.

This new form of business requires substantial modification of "traditional" supply chains since now. It must be the furniture manufacturer that seeks other suppliers of functional or decorative elements (e.g., lighting and textiles) or someone in charge of the complete installation of the project. The production process is also affected since, in this case, it is oriented towards the manufacture of unique products that deviate from the company's catalogue. These unique products are manufactured in unit-sized lots, customized for a specific project.

The furniture pilot in EFPF envisions creating a *Lot Size 1 Consolidation Centre* to control small scale stocking and consolidation points for furniture manufacturers. LAGRAMA is an industrial company founded in 1982 that produces home furniture, located in Vinaròs (Spain) which mainly sells in Spain but is starting to export to other countries such as Italy or the United States of America. It has specialized in custom furniture and the manufacture of lot size 1, offering a wide variety of models and colours, making each piece of furniture a unique piece for the consumer. The supply network of products that are not manufactured in the company (lighting, textiles, etc.) is defined from scratch for each customer order. This need for establishing an agile network of collaborators (or connected factories) in the Furniture Manufacturing sector requires advanced tools. These tools range from facilitating search, selection and evaluation of suppliers, monitoring of distributed manufacturing processes, coordination of deliveries, and planning of internal and external activities and new business models for collaborative manufacturing.

Therefore, this pilot focuses on LAGRAMA as a prominent manufacturer/supplier and responsible for receiving and realising customer orders and coordinating various suppliers to produce the furnishing and decoration for rooms in a small Boutique hotel. LAGRAMA is also expected to coordinate the installation all these elements, so a *Lot-Size-1 Consolidation Centre* is envisioned at LAGRAMA or near the installation point.

EFPF is expected to improve the efficiency of supply chain creation and operations based on the provisioning of digital tools and secure information exchange channels. The EFPF platform will facilitate the selection of the appropriate suppliers, the coordination of the

production and service phases between suppliers and the monitoring of the execution of the entire project. Besides this, all devices (such as sensors, systems etc.) are validated in the AIDIMME facilities physically before transferring them to the actual industrial environment in LAGRAMA, as well as the EFPF solutions which are validated by AIDIMME which is continuously in contact with LAGRAMA technicians and technical developers providing continuous feedback on detected errors and providing close technical support.

2.2 Experiences from Furniture Pilot Experimentation

In the Furniture Pilot in total 4 epics and 18 user stories were defined in. The user stories (US) organized by Epics are summarized in the Table 3 below shows.

US ID	US Title
Epic 1: Search for products, services or supply partners to meet production objectives	
US1.1	Send and receive orders
US1.2	Search of products/services
US1.3	Request for quotation of customised product
US1.4	Exchange product catalogue
US1.5	Customer analytics
Epic 2: Publish tenders and special supply requests inviting groups of companies to participate	
US2.1	Invitation to join collaboration platform
US2.2	Tender publication & bid assessment
US2.3	Product request
Epic 3: Monitor production processes to get a schedule for planning activities	
US3.1	Production optimization
US3.2	Production process monitoring in a supply chain
US3.3	High-level production overview
US3.4	Predictive maintenance
US3.5	Waste collection optimization
Epic 4: Monitor delivery processes, both incoming and outgoing, to get a schedule of activities	
US4.1	Delivery process monitoring
US4.2	Local reception of goods
US4.3	Delivery Schedule
US4.4	Replace logistics provider to meet just-in-time delivery
US4.5	Set up logistics supplier in the new country

Table 3: Epics and User Stories (US) in the Furniture Pilot

The Table 4: Overview of EFPF solutions used in the Furniture Pilot and related components and tools below provides a comprehensive overview of the EFPF solutions used in the Furniture Pilot implementation of the user stories aforementioned:

No	Solution	EFPF Components Covered	Tools and Services Covered
S 1a	Solution 1a: Production Optimisation (Predictive Maintenance)	EFPF Portal Data Spine – Message Bus, Data Spine – Integration Flow Engine, EFPF Security Portal (EFS), Service Registry	Industreweb Collect Factory Connector, Pub Sub Security Service, Anomaly Data Solution (ADS), Predictive Maintenance Tool, Deep Learning Toolkit (DLT), ROAM Risk Tool, Secure Data storage
S 1b	Solution 1b: Production Optimisation (Operator Error)	Data Spine – Message Bus, EFPF Security Portal (EFS), Service Registry	Industreweb Collect Factory Connector, Pub Sub Security Service, Industreweb Display
S 2	Solution 2: Bin Fill Level Monitoring	EFPF Portal Data Spine – Message Bus, Data Spine – Integration Flow Engine, EFPF Security Portal (EFS), Service Registry	Visual and Data Analytics Tool, Symphony HAL, Symphony Event Reactor
S 3	Solution 3: Workflow and Service Automation Platform	EFPF Portal Data Spine – EFPF Security Portal (EFS), Service Registry	WASP
S 7	Solution 7: Tendering & Bid Management	EFPF Portal, Data Spine - EFPF Security Portal (EFS), Service Registry	Business Opportunities Service, Federated Search
S 8	Solution 8: Almende Risk Analysis & Management Tool	EFPF Portal, Data Spine – Message Bus, Data Spine – Integration Flow Engine, EFPF Security Portal (EFS), Service Registry	ROAM Risk Tool
S 9	Solution 9: Catalogue Service	EFPF Portal, Data Spine – EFPF Security Portal (EFS), Service Registry	Product Catalogue Service
S 10	Solution 10: Business Network Intelligence	EFPF Portal, Data Spine - Message Bus, EFPF Security Portal (EFS)	iQluster SDK Business Intelligence App
S 11	Solution 11: Data Analytics	EFPF Portal, Data Spine – Message Bus, Integration Flow Engine, EFPF Security Portal (EFS), Service Registry	Visual and Data Analytics Tool, Deep Learning Toolkit
S 13	Solution 13: Online Bidding Process	EFPF Portal, Data Spine – Integration Flow Engine, EFPF Security Portal (EFS), Service Registry	Matchmaker, Agents, Marketplace

Table 4: Overview of EFPF solutions used in the Furniture Pilot and related components and tools

2.2.1 FUP-Epic 1: Search for products, services or supply partners to meet production objectives

2.2.1.1 US-FUP1.1: Send and Receive Orders

2.2.1.1.1 Short description

The production manager is interested in managing orders from customers to improve the efficiency of the supply process.

2.2.1.1.2 Testing and Evaluation

Orders of raw materials (e.g., wooden board) can be placed to meet production requirements.

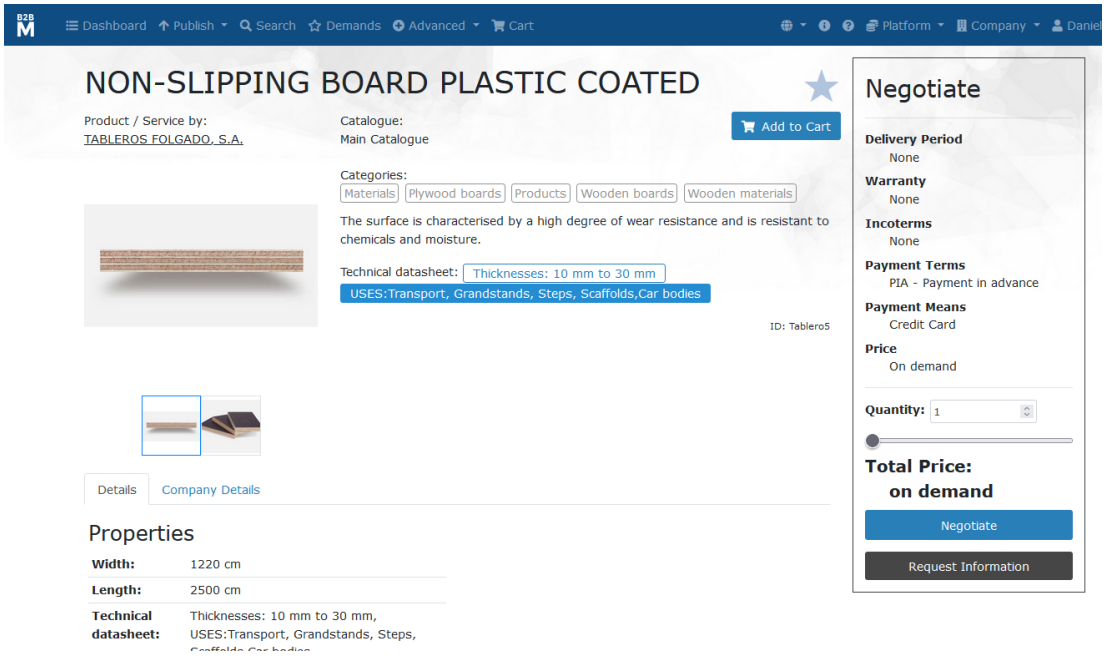


Figure 67: Detail of raw material to be requested

The terms provided by the producer can be inspected by the customers, so they can proceed with a ‘counteroffer’ if necessary. The conditions can be evaluated so the buyer can react with new ones through a negotiation process. The system remarks the changes for better readability and identification.

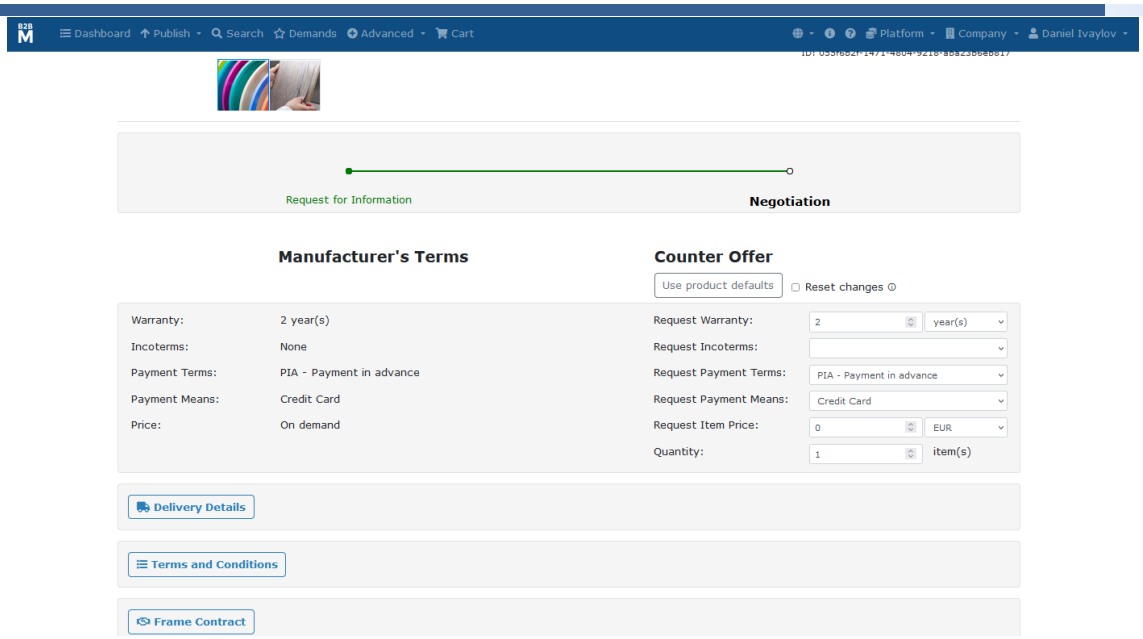


Figure 68: Negotiation between two parties

The buyer (LAGRAMA in this case) can also fill the delivery details to receive the requested goods. The parties can create a frame contract so the customers can apply the same terms that both parts when repeating the same purchases. Notes and additional files can also be attached to the requests.

Both customers and buyer can inspect all the collaboration steps including responses and comments. The process can iterate or be finished by accepting or cancelling. After this, the collaboration can be rated.

All details about the validation of this functionality can be found in D9.2.

2.2.1.1.3 Lessons Learned and Outlook

The management of orders between industrial companies in the same business ecosystem becomes very valuable. It can be stated that, from previous experience, industrial users need to feel very confident with the overall platform to make an intensive use of it. This means that aspects such as stability and robustness need to be emphasized.

An important added value of the platform is the availability of a REST API to retrieve the information in a structured format, what enables the integration with ERP and specific business software.

A payment gateway has been recently implemented, and the previous features are then even more relevant for making use of these functionalities.

2.2.1.2 US-FUP1.2: Search of Products and Services

2.2.1.2.1 Short Description

The purchasing manager needs to search for products and services before defining the supply chain for specific production objectives.

2.2.1.2.2 Testing and Evaluation

Users can search products and services at any moment in the catalogue service. This search can be filtered by name and categories as well as advanced filters. The system also provides the autocomplete function that improves the user experience.

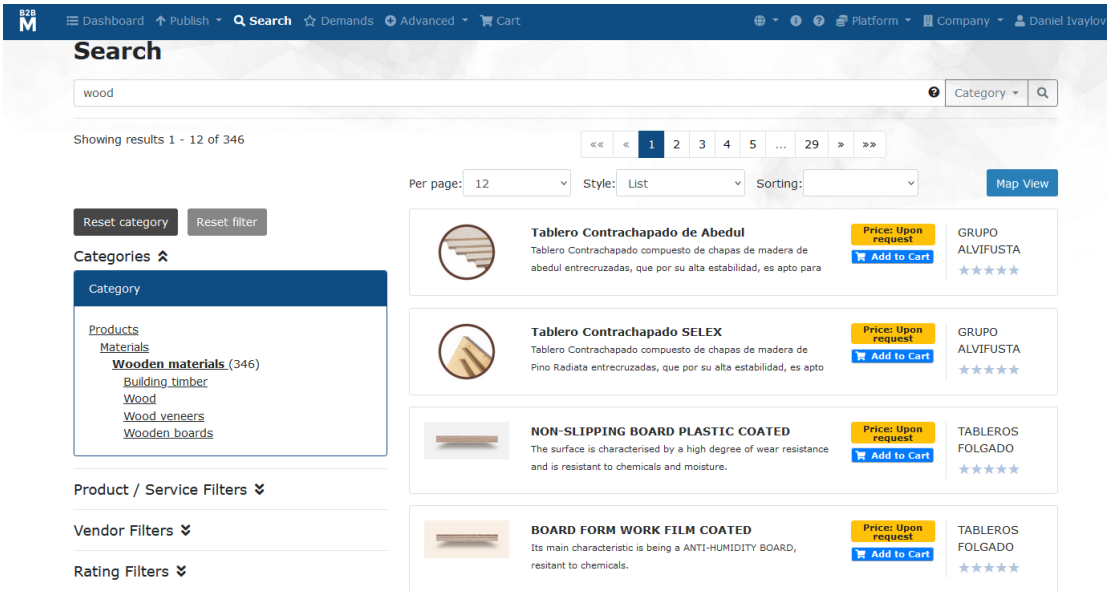


Figure 69: Search of wooden materials in catalogue service

Details of any product or service can be inspected at any moment. All the information available about items depend on the taxonomies integrated in the service, which in the EFPF instance are eClass, Aerospace and Furniture Sector.

All details about this functionality can be found in D9.2.

2.2.1.2.3 Lessons Learned and Outlook

The search capabilities are especially valuable in a digital platform oriented to catalogue management. Buyers can find items fulfilling specific criteria while sellers can present its goods in a manner that they could be easily accessible and adequately characterized. Text-based search, browsing and filtering provide a pleasant user experience. The more relevant aspect to be improved is, as in previous experimentation, the filtering mechanism, that con provide a better use experience.

2.2.1.3 US-FUP1.3: Request for Quotation of Customised Product

2.2.1.3.1 Short Description

The purchase manager wants to send requests for quotation of customized items to assess the adequacy of the companies involved in the supply chain.

2.2.1.3.2 Testing and Evaluation

This functionality was validated not in the prices scope but in the information shared between seller and buyer through the catalogue service. Requests may involve product characteristics, specifications, or just more product information.

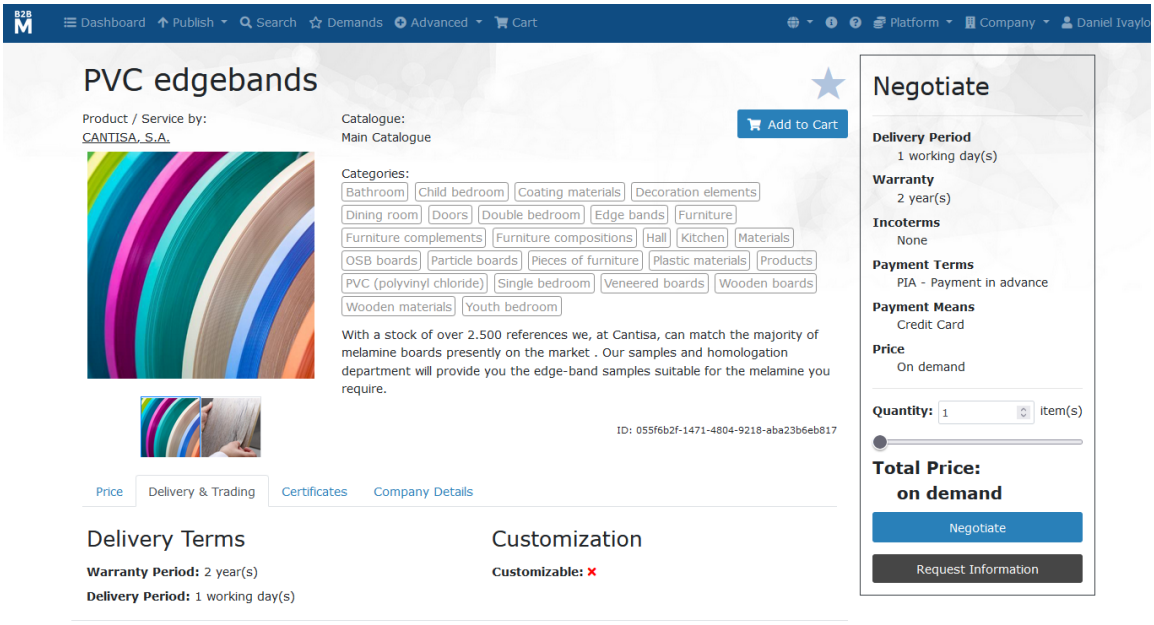


Figure 70: MDF board for supply to be requested

Buyers can write notes and attach files indicating needs of the product if needed to be customized.

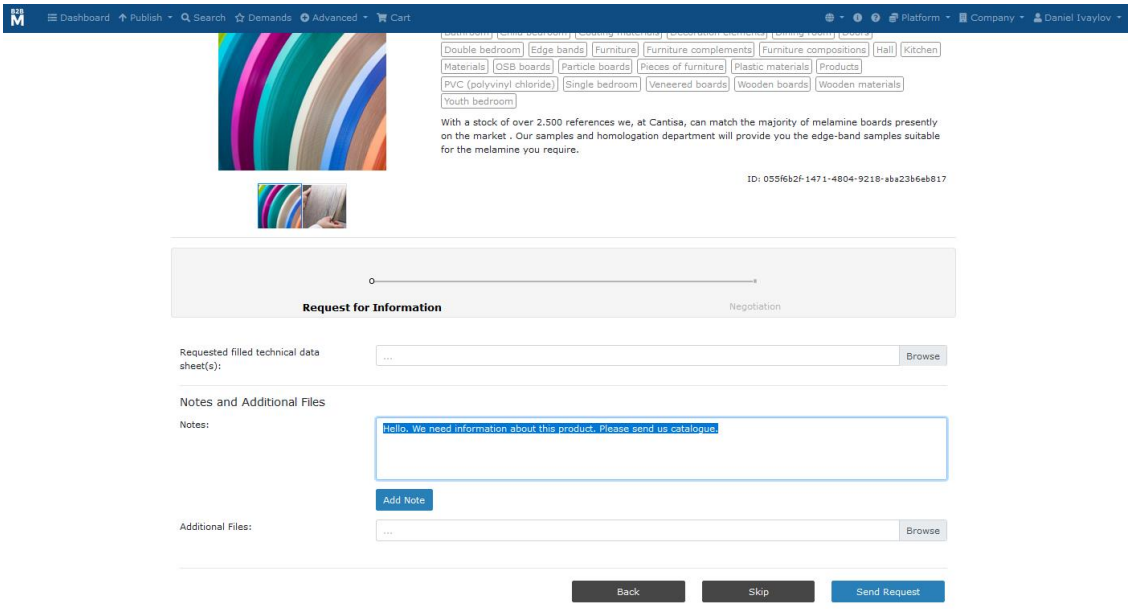


Figure 71: Request for information process

The suppliers can inspect the requests to respond, with the option of adding new pictures to provide more information to the buyers. The process can be iterated by asking for new information. This process finished when the user navigates to the next step, which is the negotiation stage already covered in *US1: Send and receive orders*.

2.2.1.3.3 Lessons Learned and Outlook

As already concluded from previous experimentations, the management of quotations is a more relevant functionality for industrial partners than the order placement, so the first one does not imply a formal agreement between parties, allowing a more flexible way of proceeding while finding the most appropriate suppliers.

2.2.1.4 US-FUP1.4: Exchange Product Catalogue

2.2.1.4.1 Short Description

The sales manager wants to exchange the catalogue of products and services to share with other platform members and detect opportunities to improve the configuration of the supply chain.

2.2.1.4.2 Testing and Evaluation

The export function is available in the dashboard of the catalogue service. The users can select which catalogues to export generating a zip file containing an excel file per each product or service category and the collection of associated pictures.

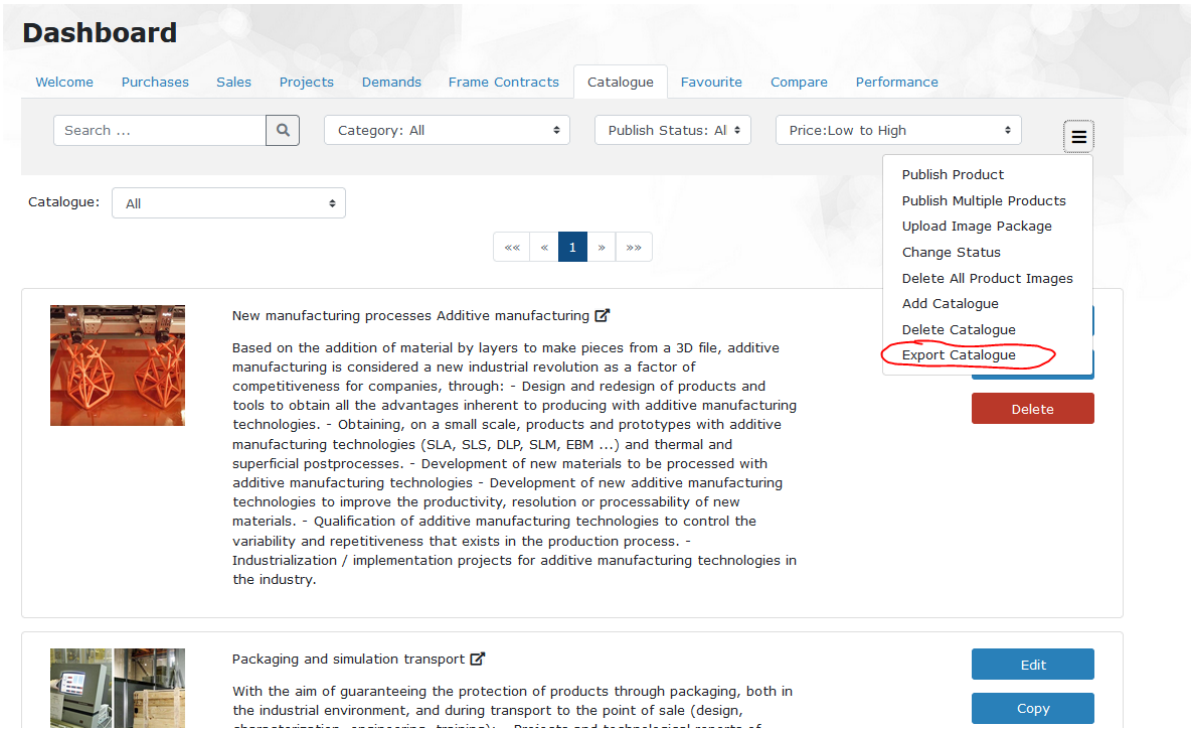


Figure 72: Export catalogue option

The service also provides a store button to visit the complete list of products and services provided by a company. The users can request a catalogue exchange also including some statements after launching the request

The import of catalogue information into systems already deployed in the company has not been covered so it was out of the scope of the catalogue service. It is up to the companies interested in importing the catalogue data the implementation of some tool to feed its local system with the data exported from the catalogue service.

2.2.1.4.3 Lessons Learned and Outlook

The catalogue exchange is not a critical functionality for most furniture industrial users. Just a small fraction of companies is interested in getting the information from their suppliers' catalogues and integrating it with its local systems. In any case the implementation of this functionality is greatly supported by the availability of the export mechanism provided by the catalogue service.

2.2.1.5 US-FUP1.5: Customer Analytics

2.2.1.5.1 Short Description

The sales and production manager want to condense information about customers to arrange more business relationships with them.

2.2.1.5.2 Testing and Evaluation

Even considering that LAGRAMA manages a Google API that includes valuable data about the behaviour of the users in the company web site, the company does not sell furniture directly to final consumers but retailers, and there is not enough data to develop analytical tools that could be used to reliably predict customer behaviour. Furthermore, the functionality that could provide any solution implemented to this end is already extensively provided by current API.

2.2.1.5.3 Lessons Learned and Outlook

Not applicable

2.2.2 FUP-Epic 2: Publish tenders and special supply requests inviting groups of companies to participate

2.2.2.1 US-FUP2.1: Invitation to join collaboration platform

2.2.2.1.1 Short Description

The production manager wants to manage contacts in an organized manner so that selected companies could be invited to participate in a supply chain.

2.2.2.1.2 Testing and Evaluation

The experimentation of this functionality assumes that the company selected by LAGRAMA to cover some production need is not registered in the platform yet. The catalogue service provides this functionality and sends an email to the invited party containing a link to join the platform through the registration process. The administrators can then validate the new company, and this can start collaborating in the platform. The 'project' feature provides an organized mechanism to manage the suppliers involved in some production objective. This process was extensively explained in D9.2.

2.2.2.1.3 Lessons Learned and Outlook

The invitation functionality is a basic feature that has been successfully covered. The negotiation groups also improve orders and requests in a very custom fashion, so they can be defined according to production objectives, and this is highly appreciated by users.

2.2.2.2 US-FUP2.2: Tender publication and tender bid assessment

2.2.2.2.1 Short Description

The purchasing manager wants to publish a tender to get proposals to cover the supply of different product parts.

2.2.2.2.2 Testing and Evaluation

So, the publication and assessment of bids was extensively illustrated in D9.2, the current description is just focused on the detected improvement opportunities and problems found from the user perspective in the last period of experimentation.

Supply tenders can be published in the Business Opportunity & Team Formation Tool. One of the most relevant problems found was the unavailability of editing and deleting opportunities. This was successfully solved.

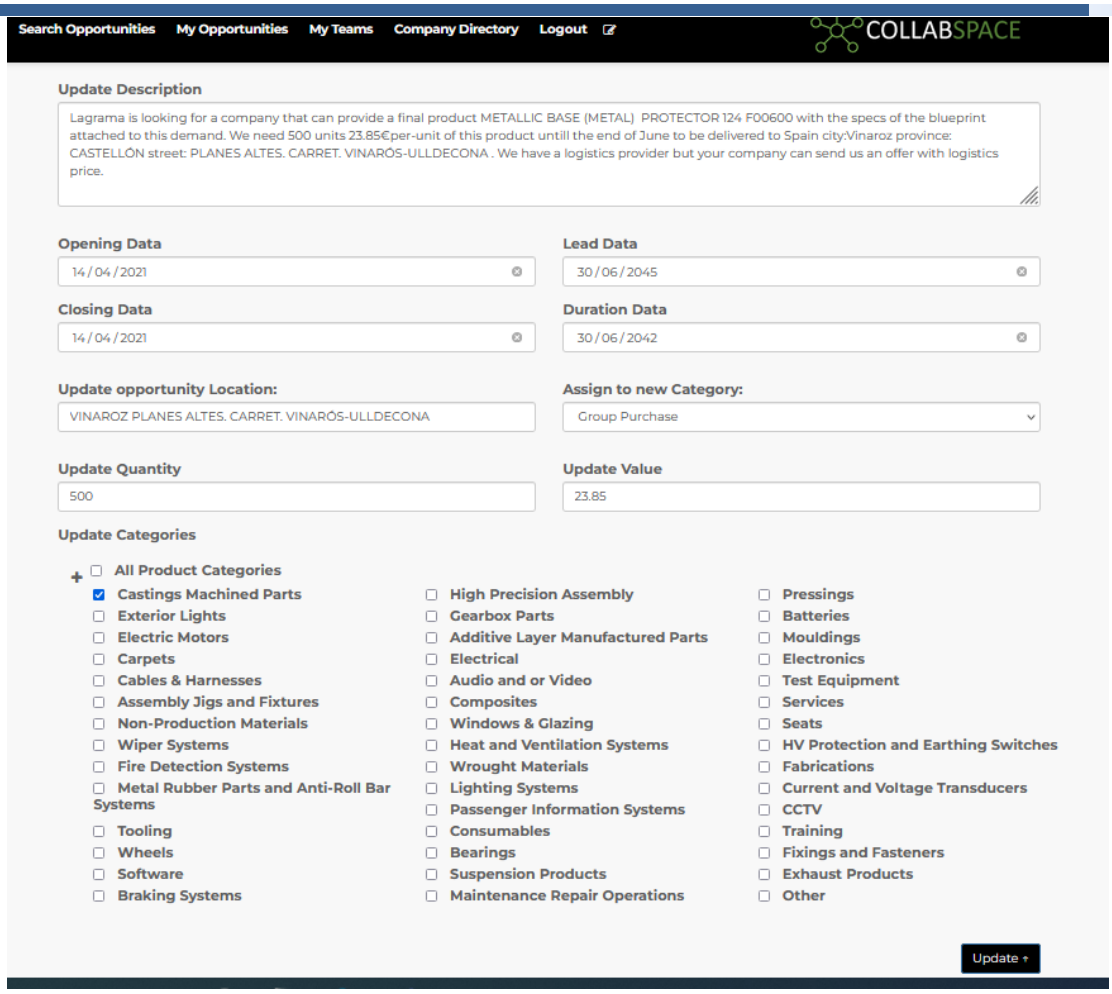


Figure 73: Edition of opportunity

Furthermore, the search function that did not work properly in previous experimentation has been fixed.

In this regard, it has been detected that the behaviour of filters is not as expected so this is as aspect that may potentially be improved.

Companies can be invited in the tool to take part in the tender process. LAGRAMA as requester can add additional information, such as PDF documents and text describing the demand just before inviting partners. These partners receive an email containing a link to the business opportunity to explore its details. In this regard, it should be noted that the email sending did not work as expected so this is an issue to be addressed by the tool. LAGRAMA can also inspect the data of the companies that apply for some opportunity. The most agile way to negotiate with the companies is creating a *new 'team', that provides a* chat space to exchange messages and documents.

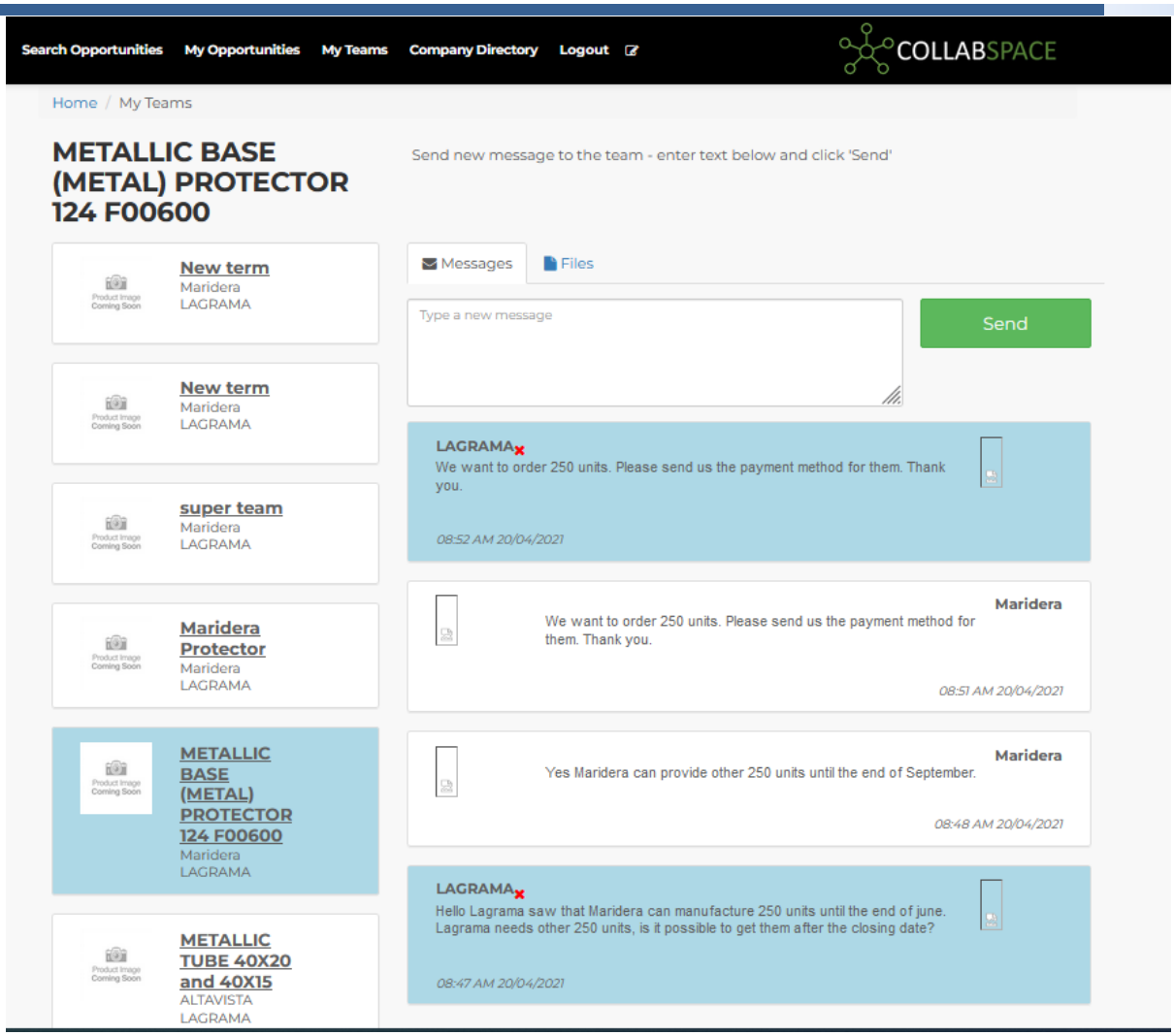


Figure 74: Chat functionality in a team

2.2.2.2.3 Lessons Learned and Outlook

The tender bid management was a highlighted requirement when defining the different user stories so to reach the customer needs in a dynamic market is crucial. The team's functionality enables partnering to make cheaper acquisitions while the management of tenders and bids allows to request the supply of products, materials or services of any kind indicating the needs and keeping a track of these activities, what leads to a gain of awareness about new opportunities by taking part in other production collaboration auctions.

2.2.2.3 US-FUP2.3: Product request

2.2.2.3.1 Short Description

The purchasing manager wants to publish a product demand to get product offers that fulfil the expected technical and quality requirements.

2.2.2.3.2 Testing and Evaluation

Users in the Business Opportunity & Team Formation Tool can publish business opportunities and set the type to 'procure product', adding the additional details and documents if considered. The requester can include additional parameters such as the quantity, the delivery address, materials and overall description. The company creates the opportunity accreditation and once the opportunity has been published, this is available all the companies in the cluster so candidates can find it through the search capability.

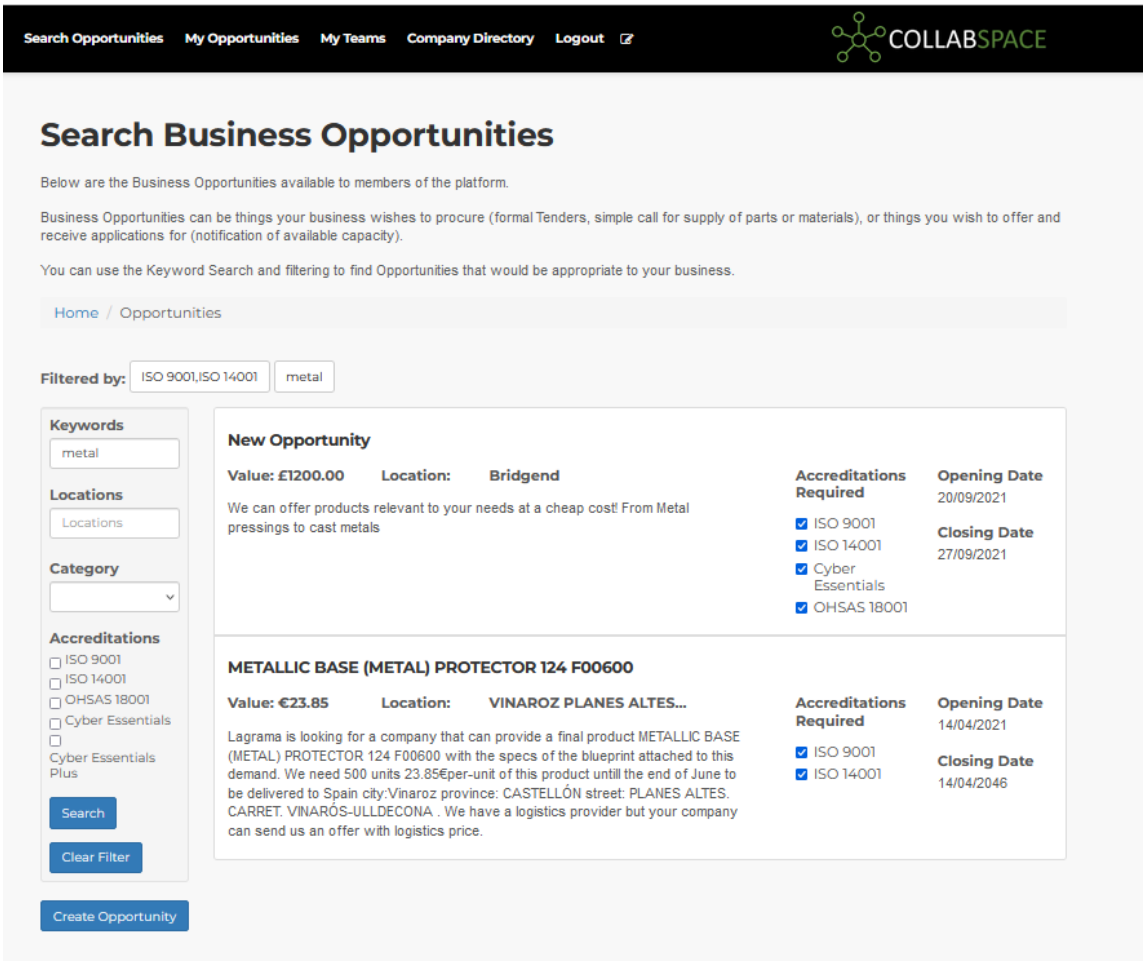


Figure 75: Search for opportunities

The interested companies can send a message with all the details that could be considered helpful for the user and attach any document to support the application. The companies can communicate with each other.

As previously commented, the most agile way to negotiate with each applicant is by creating teams. They can be inspected by the requester who can communicate with the selected provider through the chat function provided by the tool.

A detailed user experimentation of this product request functionality can be found in D9.2, so in this release the focus is on what has been improved in the tool.

2.2.2.3.3 Lessons Learned and Outlook

Most of lessons learned from the previous user story apply to this one so they are quite similar in the end. However, besides the previous ones, the capability for industrial users to request the supply of personalized items enriches the variety of offerings provided by the EFPF solutions to the industry scope. Therefore, this becomes a very potent tool for the supply process.

2.2.3 FUP-Epic 3: Monitor production processes to get a schedule for planning activities

2.2.3.1 US-FUP3.1: Production optimisation

2.2.3.1.1 Short Description

The production manager wants to speed up the production to reduce the time to serve the customer.

2.2.3.1.2 Testing and Evaluation

This main objective in this user story is to improve the efficiency of the edge banding machine at LAGRAMA by displaying clear instructions to the operator about how to proceed with the pieces to avoid mistakes in the classification process and detect any machine operation error.

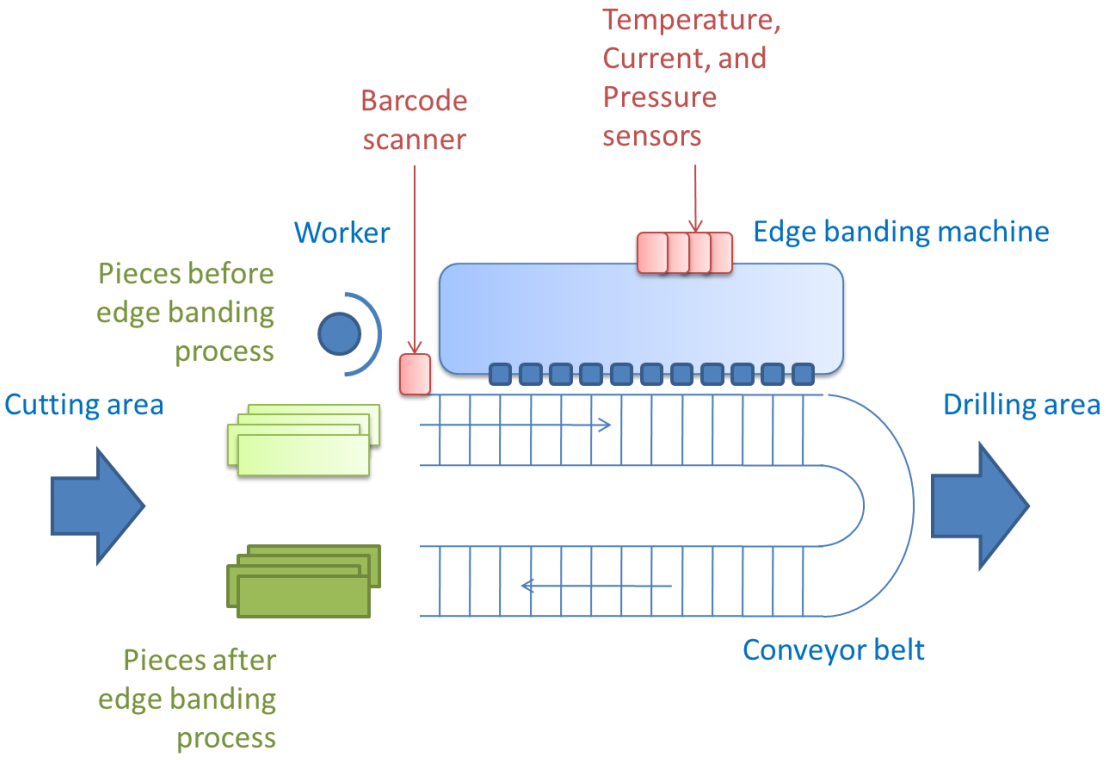


Figure 76: Layout of the preliminary placement of the devices

The barcode label attached to each piece is scanned with a camera connected to the Industreweb Factory, which allows the Factory Connector to query the ERP and retrieve the information about the scanned piece. The instructions associated to such piece are then displayed on a screen to the worker.

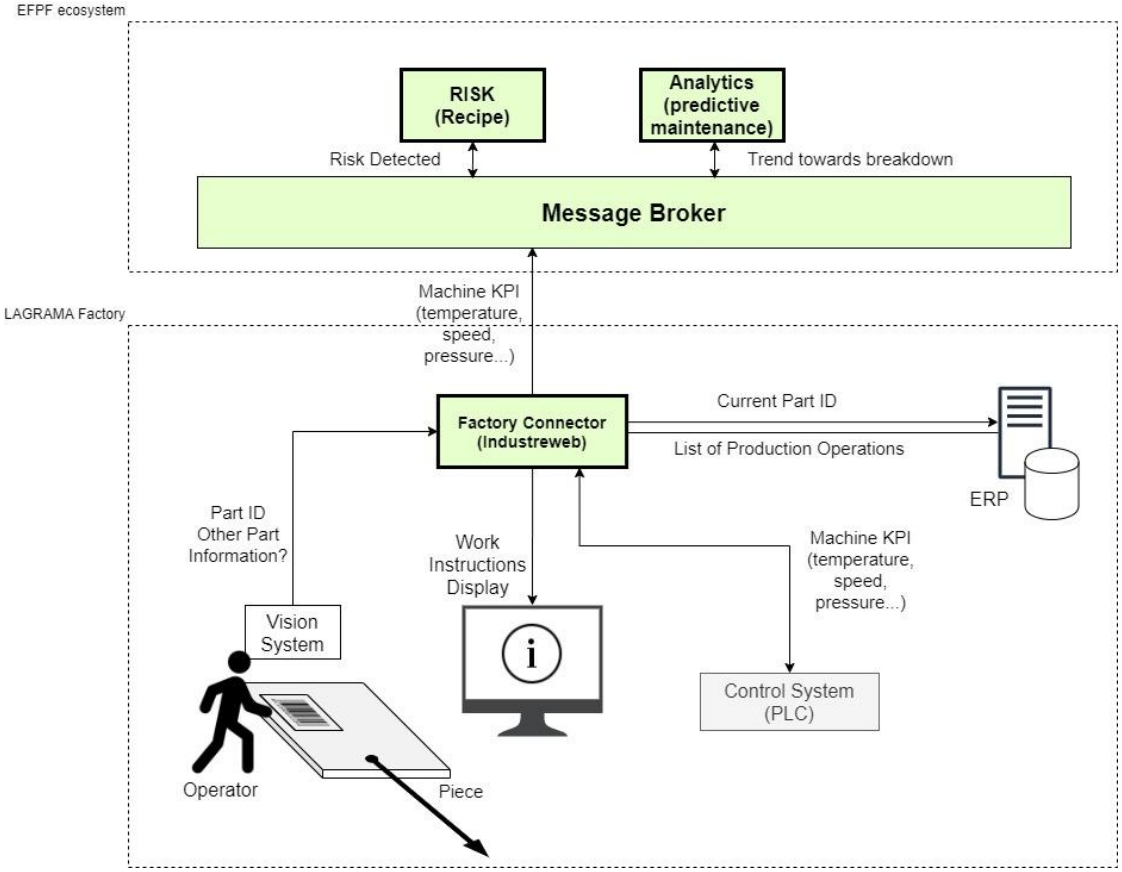


Figure 77: Elements involved in the deployment for factory connectivity

These components were integrated into an electrical panel placed inside a cabinet near the edge banding machine.

Figure 78: Camera for pieces' label scanning in edge banding machine of LAGRAMA

A successful recognition of the barcodes was achieved through the code of the PLC after some configuration tasks.

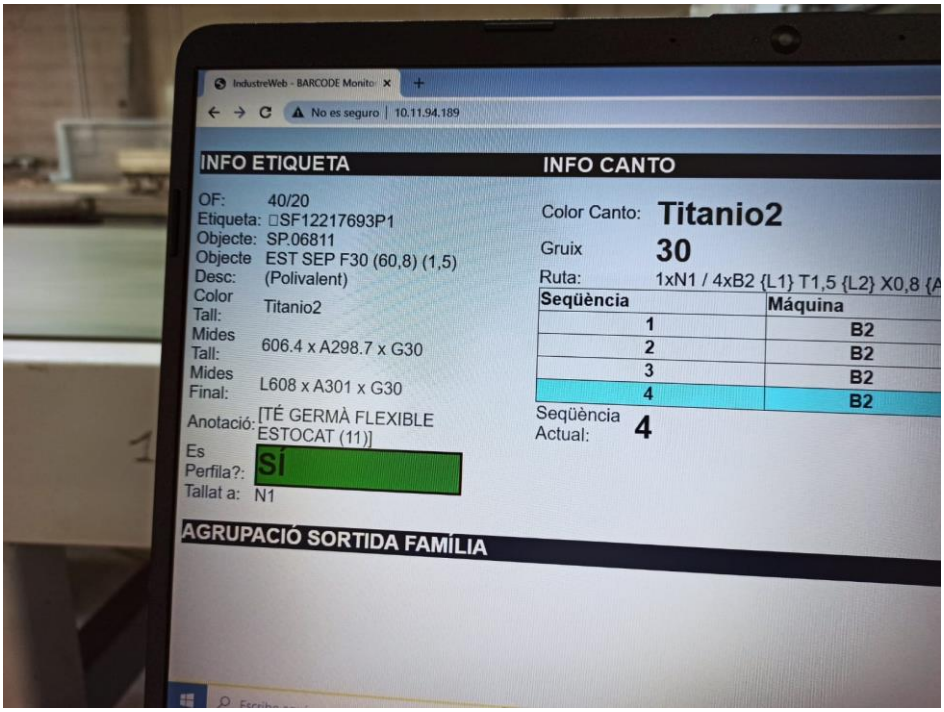


Figure 79: Detail of the display showing instructions to the operator

The maximum range of the camera was calculated, as well as possible orientation of the labels in the pieces. This information was used to determine the position of the scanner in the production line as well as the recommended position of the labels.

Further details about the role of all the components involved in the factory connectivity scope, the barcode information and the workflow can be found in D9.2.

Given the particularities of the edge banding machine operation, the deployed system did not provide the whole functionality as expected, so label reading was skipped too often. After many testing activities, it was concluded that the selected camera does not provide a high ratio of detection at some distances and mainly when the labels are located with variable orientations, what hinders a proper label recognition ratio.

2.2.3.1.3 Lessons Learned and Outlook

A great effort from both technical partners and LAGRAMA has been required to implement and adopt the solutions involved in this user story.

Despite the effort put on the definition, deployment, configuration and testing of this solution, and considering the final detection ratio less than expected, the effort was well worthwhile considering the knowledge gathered during the whole experimentation. To some extent, the solution provided for the production optimisation increases the workers' productivity at the edge banding machine.

2.2.3.2 US-FUP3.2: Production Process Monitoring in a Supply Chain

2.2.3.2.1 Short Description

The sales, production or purchasing managers want to monitor the production process of goods, detecting problems during production and keeping a history of them for future reference.

2.2.3.2.2 Testing and Evaluation

The previous experimentation of the WASP tool was performed in several rounds. The first one covered a generic production process of LAGRAMA, while the second one covered a concrete production example. As a short reminder, these are the steps followed per each round:

- To detect the tasks of the selected process
- To evaluate the scope of the task (external/internal), the type of completion (user/automatic) and the dependencies with other tasks
- To define and validate the process modelled in BPMN
- To define the process diagram in WASP
- To edit each task according to if this is user or automatic, creating the corresponding user assignments when needed
- To execute the whole process through the WASP process engine
- To validate the step-by-step operation of the process execution

It should be noted that the complexity of the process selected for the second round, even this is a short excerpt of the one performed in the factory, required the definition of several sub-processes that encapsulate other tasks.

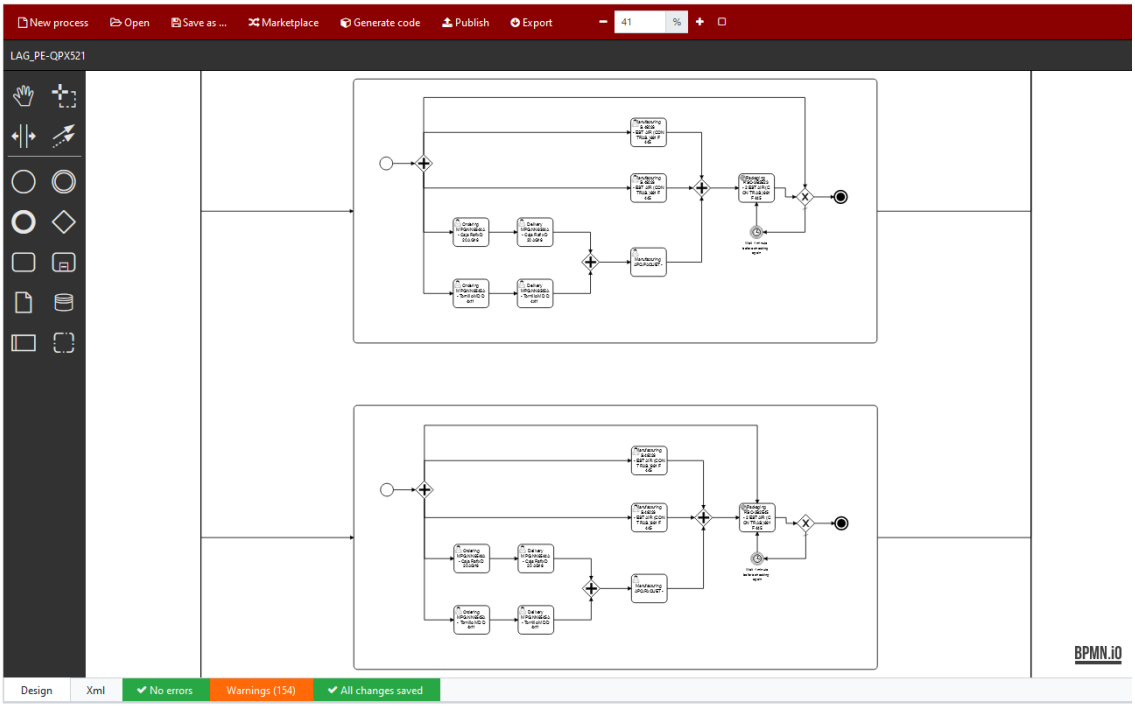


Figure 80: Detail of subprocesses in PE-QPX521 process of LAGRAMA modelled in WASP

The selected process includes both manual tasks to be completed by users (e.g..: ordering, manufacturing tasks) and automated tasks whose completion can be automatically detected from a web service endpoint (e.g.: packaging).

These packaging activities have been defined as automated because of the availability of an API that queries an ad-hoc repository that stores the status of these activities. Once the first experimentation with this sample API was performed, an API to get the status of these tasks from the ERP was implemented by LAGRAMA. However, for security reasons, this API could not be published to be accessible from outside the company and could not be deployed in production.

All details about the processes considered on each round and the experimentation through WASP can be found in D9.2.

2.2.3.2.3 Lessons Learned and Outlook

During the experimentation different opportunities for improvement were detected by the users. These improvements have been progressively implemented leading to a more usable interface and navigation experience, mainly in the process design section.

Aside from the above, the evaluation of the integration with an ERP or other enterprise system to automate those tasks whose completion can be automatically detected has led to valuable conclusions. The complexity of the industrial processes in LAGRAMA (which can be considered as representative in furniture sector) implies a very significant effort to define all the tasks and dependencies involved and to establish the web service communication for those automated tasks. Also, many companies may miss such endpoints what additionally involves its implementation after evaluating the feasibility based on the information available in the ERP.

All the same, the WASP tool provides a potential advantage for any industrial SMEs to manage processes of affordable scope, so the experimentation has led to improvement requests that has been implemented achieving an improved usability and user experience.

2.2.3.3 US-FUP3.3: High-Level Production Overview

2.2.3.3.1 Short Description

The managing director wants to get a high-level overview of the enterprise processes to gather overall information about production and delivery processes avoiding details.

2.2.3.3.2 Testing and Evaluation

This user story is closely related to the previous one, *US10: Production process monitoring in a supply chain* which is also covered by the WASP tool. Indeed, the height of the process visualization and management directly depends on the level of granularity represented when the process is defined.

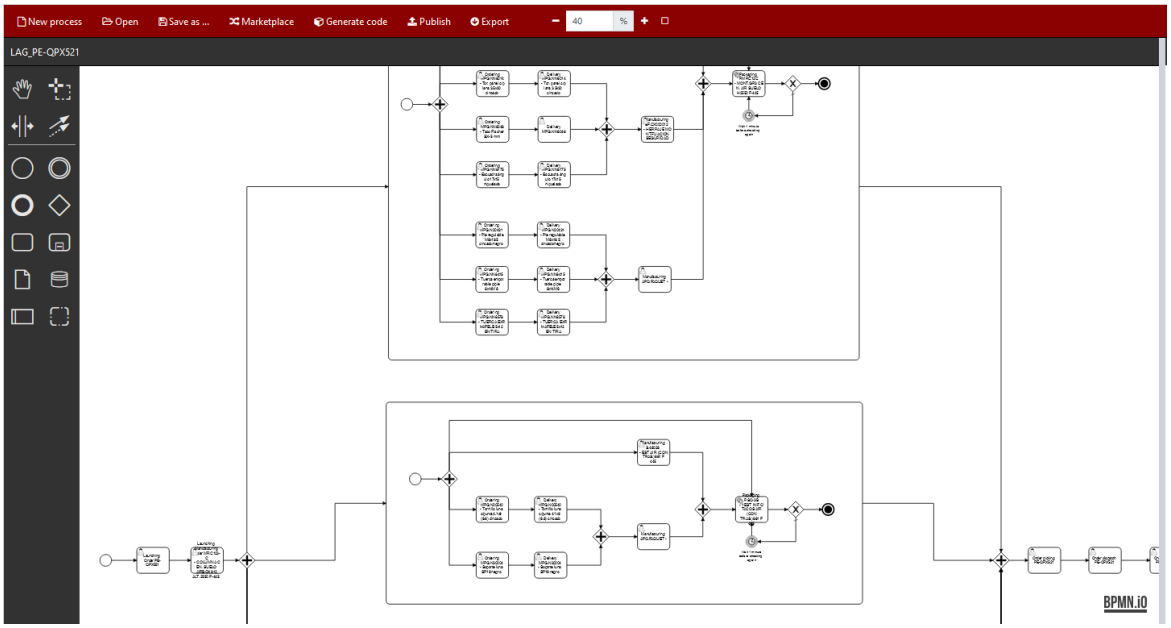


Figure 81: Overall visualization of PE-QPX521 process of LAGRAMA modelled in WASP

Therefore, the experimentation mainly matches the one from the previous user story which is also documented in detail in D9.2.

2.2.3.3.3 Lessons Learned and Outlook

As stated above, the level of visualization depends on the granularity of the process defined. In this regard, higher-level tasks can be defined instead of more specific ones. Moreover, the WASP tool can be managed to focus on those activities that are more relevant from the user perspective.

Apart from the above, when a high-level overview is needed it should be considered the availability of API endpoints or users from the parties involved in the process. If the process contains tasks to be performed by external parties and they cannot automate them, the users assigned to such activities need to take part of the WASP tool as a member to interact with the workflow. If the party could implement such endpoints to automate the tasks, this needs to provide them to LAGRAMA to keep the track of the process completion. Therefore, the WASP solution is quite flexible to face these situations, and this becomes very valuable in the targeted industrial sector.

2.2.3.4 US-FUP3.4: Predictive Maintenance

2.2.3.4.1 Short Description

The production manager wants to monitor the machine operation and perform data analysis to detect abnormal working conditions and take preventive actions.

2.2.3.4.2 Testing and Evaluation

The main objective of this user story is the evaluation of risks through predictive maintenance to prevent machine breakdowns and reduce the impact when they occur. The machine data is captured by sensors placed in different points of the machine. They are 10 temperature probes (lately reduced to 8), 9 power consumption sensors and 6 air pressure sensors.

The sensors are connected to an interface board on the Industreweb Factory Connector that publishes them to the EFPF Data Broker. An evaluation rig was defined and deployed during the first experimentation, which was transferred to LAGRAMA by technicians of AIDIMME for a preliminary connectivity test. The electrical cabinet was built to host all the required hardware.

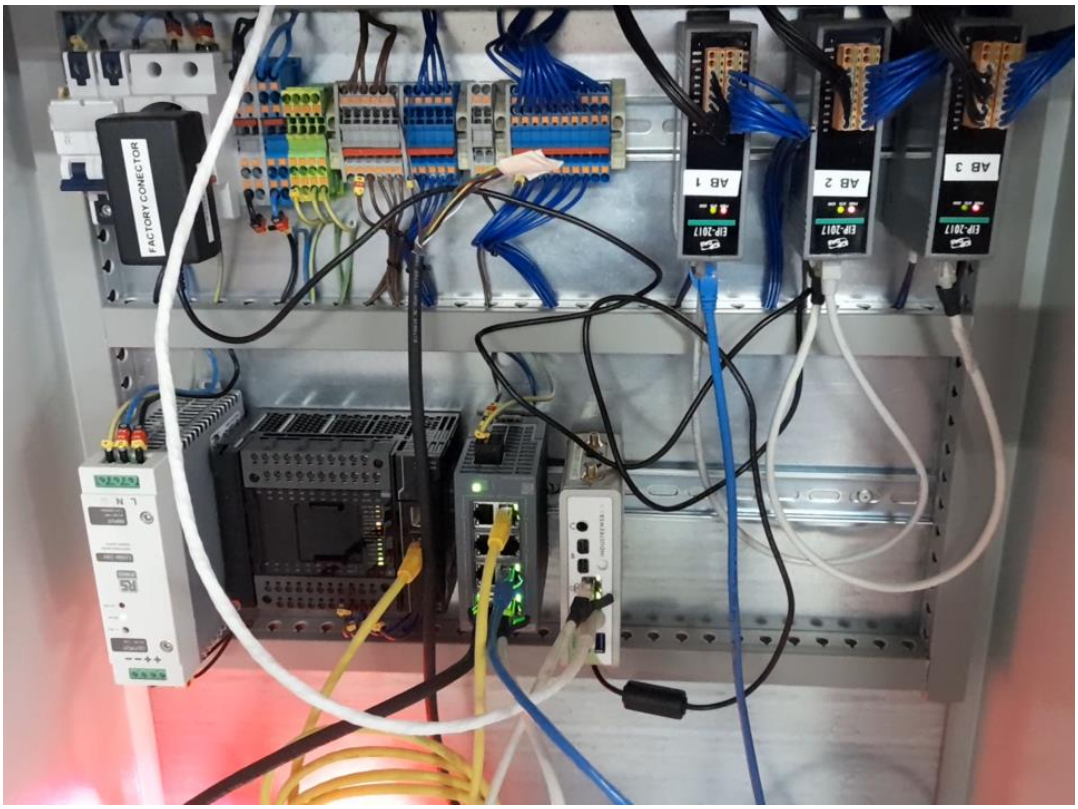


Figure 82: Interior of the electrical cabinet

As it was reported in the previous experimentation, some problems were detected and the number of available sensors was reduced to 16 (10 for temperature, none for pressure and 6 for electric current) due to problems in the placement of the sensors and the calibration of those machine parts where they were placed.

The collection of data of the edge banding machine was achieved, publishing information every 10 seconds. For predictive maintenance, 3 main tools have been experimented. This experimentation, that was reported in D9.2, has continued.

The Anomaly Detection Service enables the detection of problems during the machine operation by using machine learning algorithms. This learning process requires several months of machine operation to provide reliable data. The thresholds that represent the correct operation of the machine have been tuned several times during the experimentation. During the actual working time no special issues have been detected.

The Risk, Opportunity, Analysis and Monitoring (ROAM) processes data streams into metrics providing a visualization that enables insights into costs, risks and opportunities, sending warning emails to users. The default recipes have been eventually adjusted to adapt the tool to the LAGRAMA production environment.

The Deep Learning Toolkit (DLT) is used to predict machine failures by consuming the sensor data. The tool labels these data as right or wrong depending on thresholds and process them through a neural network for training. Unlike the solutions above, DLT provides a real-time prediction about the machine's behaviour in the short term. It keeps a confidence score that depends on the training process, resulting in improved results as more sensor data is collected and processed.

2.2.3.4.3 Lessons Learned and Outlook

To monitor the machine operation becomes especially important when producing in batches. With the predictive maintenance solution, LAGRAMA can prevent some parts of the machine from being damaged, so this leads to a decrease in productivity, losses and bad reputation if deliveries are late. In the daily experimentation has been detected that the machine learning model requires significant time, but abnormal values can be detected outside the ranges defined in the different parameters. From business perspective, being able to get warnings for maintenance review when some machine failure risk is detected provides a huge value.

2.2.3.5 US-FUP3.5: Waste Collection Optimisation

2.2.3.5.1 Short Description

The production manager wants to monitor the fill level of the outdoor waste bins to optimize the waste collection procedure.

2.2.3.5.2 Testing and Evaluation

The waste collection optimisation aims at detecting the fill level of waste bins outdoor the manufacturing plant optionally supporting the calculation of the optimal route to perform the emptying process. This is achieved by placing distance sensors on top of the waste bins to monitor the fill level providing real-time notifications. The experimentation of this solution required the evaluation of the destination environment, the selection, ordering, preparation and deployment of hardware components, the deployment of the factory connector (Symphony HAL) and connection to the EFPF Data Spine, the creation of dashboards for real-time monitoring connected to the Data Spine and the configuration of the notification service (Symphony Event Reactor).

In the case of LAGRAMA just one metal container has been used for the experimentation. The technical partners provided instructions to LAGRAMA on preparing and making the proper connections of the components inside the sensor box which is placed on the top of the pole. The LoRa gateway, the component in charge of transmitting the signal from the sensors to the LoRa server to publish the data making available to other components was configured. LAGRAMA requested the construction of the metallic pole to place the sensor box on top, as well as solved problems related to the Wi-Fi network reachability. All these issues have been reported in D9.2.

Figure 83: Detail of the metallic pole to keep the sensor box

The LAGRAMA dashboard of the Fill Level Monitoring solution presents a clear visualization of the fill level of the containers under monitoring.

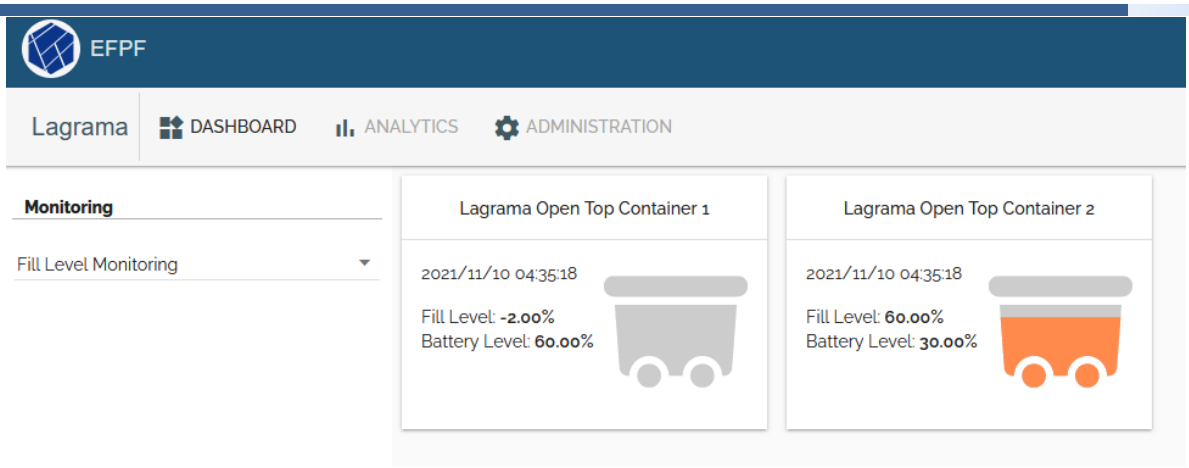


Figure 84: User interface of the bin fill level monitoring dashboard for LAGRAMA

A notification system warns users about any surplus detected in the level of the waste containers by email. The tool also enables the analysis of trends by inspecting the expected behaviour of the filling, offering several types of visualization.

Figure 85: Fill level Trend Analysis UI

2.2.3.5.3 Lessons Learned and Outlook

As concluded in the first period of experimentation, the Fill Level Monitoring tool prevents the workers from checking the status of the waste containers. This increases efficiency and workers' safety. It should be highlighted that the technical documentation initially provided has been significantly improved during the experimentation. During the validation process, some problems in the 2nd sensor were detected so just a single container validation has been performed. Furthermore, an inclement weather period caused damaged to the pole deployment, so the system stopped working for some weeks. Also, during the latest experimentation, the sensor box ran out of batteries that were replaced. Therefore, the user interface of the tool often prompted data that was not aligned to the situation at each moment. Besides this, it can be stated that the solution has been very much appreciated by LAGRAMA to manage the outdoor wastes in the factory.

2.2.4 FUP-Epic 4: Monitor delivery processes, both incoming and outgoing, to get a schedule of activities

2.2.4.1 US-FUP4.1: Delivery Process Monitoring

2.2.4.1.1 Short Description

The sales manager wants to monitor the delivery process of the produced goods to the customer to detect problems during delivery and customer reception, keeping history for future reference.

2.2.4.1.2 Testing and Evaluation

This user story aims at monitoring the activities related to the delivery of goods produced by LAGRAMA with the support of the DApp tool, a mobile application that enables the tracking of the delivery process by implementing the Blockchain approach. The process workflow is defined through the backend, where the actors involved in the process (LAGRAMA as furniture manufacturer, the carrier, the assembler and the customer) are defined.

QR codes are used to identify the packages and the tool can be configured to identify themselves through the fingerprint or codes, which guarantees the overall reliability of the delivery process. As reported during the first experimentation, the user authorization was avoided to speed up the evaluation by users. The first tests of the DApp resulted in the detection of some bugs that have been fixed through the different versions of the tool.

All details about the workflow using the DApp can be found in D9.2, including pictures and detailed descriptions.

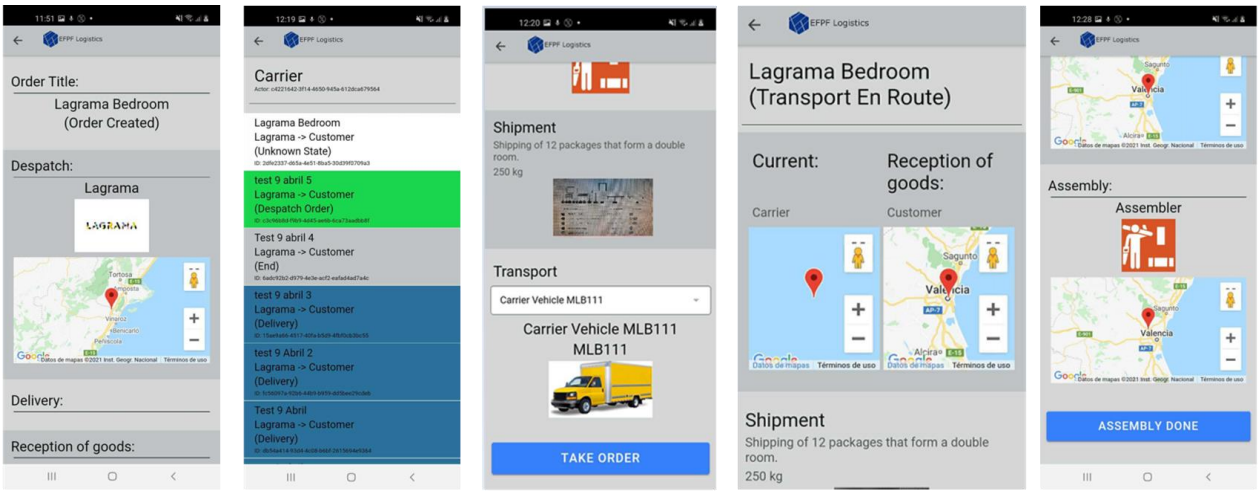


Figure 86: Summary of delivery workflow using the DApp tool, from request to delivery

The user feedback has motivated the correction of bugs and the implementation of some missing functionalities, such as the visualization of the whole delivery process once finished and the prevention of the disappearance of the workflow when the user performs each task. Also, additional fixes were made, such as allow users to inspect the stage where the process is going on and the actor in charge of performing each task.

2.2.4.1.3 Lessons Learned and Outlook

The lack of active notifications means that actors need to manually check the status of the process periodically, what does not reduce the reaction time when upsets are faced as

expected. This required a new DAML version. The creation of new actors to be involved in the process and the definition of the process workflow must be done through the backend of the solution, which is not accessible and oriented to the end-users. This requires a specific effort by the technical partners while end-users do not have the accessibility to make such adaptations. However, if the solution has not been fully covered the initial requirements, the user feedback is positive in general also considering that many of the reported problems and suggestions have been fixed during the experimentation.

2.2.4.2 US-FUP4.2: Local Reception of Goods

2.2.4.2.1 Short Description

The purchasing manager wants to monitor the reception of goods in the facilities to be aware of any immediate and unexpected problem during the reception.

2.2.4.2.2 Testing and Evaluation

This user story could not be evaluated so there was not resource to cover the expected functionality.

2.2.4.2.3 Lessons Learned and Outlook

Not applicable

2.2.4.3 US-FUP4.3: Delivery Schedule

2.2.4.3.1 Short Description

The managing director wants to have a schedule of deliveries available to be able to get a broader and quicker overview of the general status of the delivery.

2.2.4.3.2 Testing and Evaluation

It should be remarked that the WASP tool is used to define and execute processes that may also include delivery tasks, while the DApp tool is used to perform a live monitoring of all the delivery-related activities. However, none of them provides some calendar visualization to follow the ongoing delivery activities and any possible deviation concerning the expected timings.

2.2.4.3.3 Lessons Learned and Outlook

Not applicable

2.2.4.4 US-FUP4.4: Replace Logistics Provider to Meet Just-in-Time Delivery

2.2.4.4.1 Short Description

The purchasing manager wants to manufacture and deliver just-in-time to reduce storage costs.

2.2.4.4.2 Testing and Evaluation

This user story is based on the need of LAGRAMA to replace the logistics providers in its supply chain under certain conditions. This functionality is provided by the NIMBLE platform, which covers the characterization of logistics companies and processes that enhances the search capabilities. The logistics services are annotated with properties which are retrieved from the data model provided by the furniture sector ontology to that end, which include transport (road, maritime, air and rail), warehousing, order picking, reverse logistics, in-house services, customs management and logistics consultancy. The conditions of the delivery can be negotiated through the platform, in the same way that the order of products and services reported in *US-FUP1.1: Send and Receive Orders*.

A detailed workflow experimentation of this functionality can be found in the previous experimentation reported in D9.2.

2.2.4.4.3 Lessons Learned and Outlook

The indexing service of the NIMBLE platform covers the functionality demanded by this user story. In addition, the furniture sector ontology adopted in the platform provides a comprehensive and reliable characterization of the logistics services, improving the quality of the search results by providing specific filters for these ad-hoc properties defined in the data model. LAGRAMA often operates with its own transport means, the replacement of logistics providers is not a common but a punctual process, but the availability of this functionality provides a great value to the company when special deliveries are required.

2.2.4.5 US-FUP4.5: Set up Logistics Supply in a Different Country

2.2.4.5.1 Short Description

The purchasing manager wants to find logistics providers when delivering to a country for the first time to provide an adequate delivery time at an adjusted cost.

2.2.4.5.2 Testing and Evaluation

As reported in the first experimentation of this user story, the focus was on the contracting of the negotiated service, which is performed by the 'Accept & Order' option in the NIMBLE platform and documented in detail in D9.2. Also, the negotiation of LAGRAMA with a logistics provider has been covered in the previous user story *US-FUP4.4: Replace logistics provider to meet just-in-time delivery*.

2.2.4.5.3 Lessons Learned and Outlook

The functionality associated to this user story is also provided by the indexing service of the NIMBLE platform as well as the furniture sector ontology adopted by the platform.

In this user story, LAGRAMA can inspect all the agreed details of the service to be contracted (e.g., information about the shipment, pickup and drop off date, origin, destination) and the customer can add notes and attach files if considered. From the provider perspective, this can accept or reject the terms of the execution plan, so LAGRAMA receives its response to finish the collaboration. All users involved in the process can visualize the transport execution plan at any moment once the negotiation has ended up. This is a collaboration processes in the catalogue service, so the customer can rate the collaboration when finished, introducing new options related to the delivery service.

This covers the needs of LAGRAMA regarding the searching and finding of delivery suppliers although this is not a common situation for the company so, as stated in the previous user story, the availability of mechanisms to solve this upset has been greatly received by the company.

3 Circular Economy Pilot (CEP)

3.1 Short Pilot Description

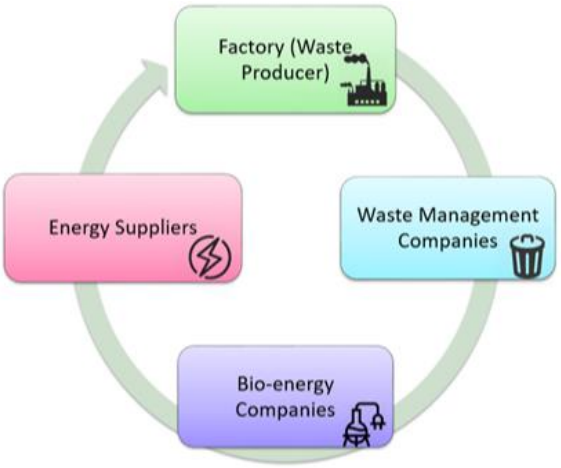


Figure 87: CLSC scenario in EFPF pilot

Life-Cycle assessment (LCA) is a widely used technique to assess environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacturing, distribution, use, repair and maintenance, and disposal or recycling. Compliance with LCA requires manufacturing companies to establish collaborations with different stakeholders in the waste management domain. Similarly, highly customised solutions and special projects in the waste management domain require agile supply chain networks to respond to the dynamic customer demands. In the case of EFPF partner KLEEMANN (KLE), a global manufacturer of Lift Systems, Escalators, Moving Walks and a specialist in lot-size-one projects such as anti-vandal lifts, oil rigs, marine solutions, requires agile relationships with different partners and suppliers in the waste management domain to be compliant with LCA regulations. KLE works with waste management companies, e.g. ELDIA (ELD), the largest waste management and recycling company in Greece to dispose solid waste. KLEEMANN's waste is screened to recover materials (paper, wood, plastics, metal, pallets, and glass) and then recycled for use in several industries from different sectors.

In this circular economy model, the value of products and materials is maintained for as long as possible, which can bring major economic benefits contributing to innovation, growth and job creation. This pilot in the EFPF project specifically focuses on realising closed-loop supply chains (CLSC) in the KLE ecosystem, where the return processes and the manufacturers in the network have the intent of capturing additional value and further integrating all supply-chain activities.

The pilot scenarios address the agile supply network through circular economy activities involving KLE, ELD and other European companies from the business ecosystem of KLE. At present, the supply chain and business relationships in the KLE ecosystem lack the visibility and tracking of waste. The companies also face lag in material transition phases and the ecosystem pose entry barriers for new innovative European companies to join the market. Therefore, the pilot realisation focuses on establishing Closed-Loop Supply Chains (CLSC) at the European level, where the KLE has the intent of capturing additional value and further integrating supply-chain activities through return processes. Moreover, the pilot also focuses on providing new business opportunities to European companies through their inclusion in the different levels of the waste management supply chain. The tools and services provided by EFPF will support the overall process to ensure risk management, regulatory and environmental compliance and for optimising the production and waste management processes. The EFPF tools and services will play a crucial role in the design, execution, monitoring and optimisation of ad-hoc collaborative processes to deliver time, cost and service improvement benefits.

3.2 Experiences from Circular Economy Pilot Experimentation

In the Circular Economy Pilot in total 4 epics and 9 user stories were defined. User stories (US) in the Circular Economy pilot are implemented in three different companies, and they are combined in four epics. Detailed description for the Epics and User Stories is available in *D9.3 Implementation and Validation through Pilot-3 (M28).*

3.2.1 CEP-Epic 1: Enable the Integration of IT systems and Blockchain technology in the Supply Chain to Bring More Visibility and Real-time Support Across Distributed Activities While Keeping Regulatory and Compliance Procedures

3.2.1.1 US-CEP1.1: Bins' Fill Level Monitoring

3.2.1.1.1 Short Description

At KLEEMANN and ELDIA, the bin's fill level monitoring remains a key business activity that before the EFPF solution, involved several employees that were responsible for the detection of fill levels of scrap metal and recyclable waste bins. The developed bin's fill level monitoring procedure is partially optimized, and now both companies can automatically monitor the specific bins' fill-level so that the involved stakeholders know immediately which bins need to be emptied. The responsible personnel, know when the bins and containers are almost full and collect the waste before the bins overflow.

A technical solution was applied (it is described in detail in *D9.3 Implementation and Validation through Pilot-3*) including fill level sensors, LoRa Gateway, scripts for turning raw measurement to valuable information, a web-based user interface and notification mechanisms. The integration of the components was enabled by EFPF Data Spine and it is accessible by end-users through EFPF Portal.

3.2.1.1.2 Testing, Evaluation and Experimentation

Initial Testing and Validation Phase

The first stage of testing and evaluation of fill level monitoring has been described in D9.3 on M28 including an experimentation period of more than six months. Validation of the fill level monitoring is done from KLEEMANN and ELDIA companies. Scrap metal and recyclable waste data are continuously being generated and described as a percentage indicating the fill level of the scrap metal and recycling bins. Implementing the EFPF fill level monitoring solution provides early and automated detection of scrap metal and recyclable waste fill levels to empty the bins before they get full. The pilot partners comparing the fill level percentage in the solution's dashboard with the actual fill level that was measured by workers for the evaluation of the solution. The measurements considered as high accurate. The difference of actual fill level and the measured one by sensors were about 5%. This deviation is considered more than accepted by the end-users. Moreover, the pilots have measured the time spent and costs before and after deploying the solution.

Continuous Experimentation and Validation Phase

From M29 to M46 a second phase of solution's validation was followed. The testing is done again in scrap metal and recyclable wastes of KLEEMANN and recyclable wastes in ELDIA. The key point of this experimentation and validation period was to confirm the solution's functionality in every day operation. The requirements were related to the access fill level

live data, the monitoring of fill level, the customization of the fill level notification and the collection notification. It seems that they are totally fulfilled.

An example of the fill level dashboard is available in the following figure:

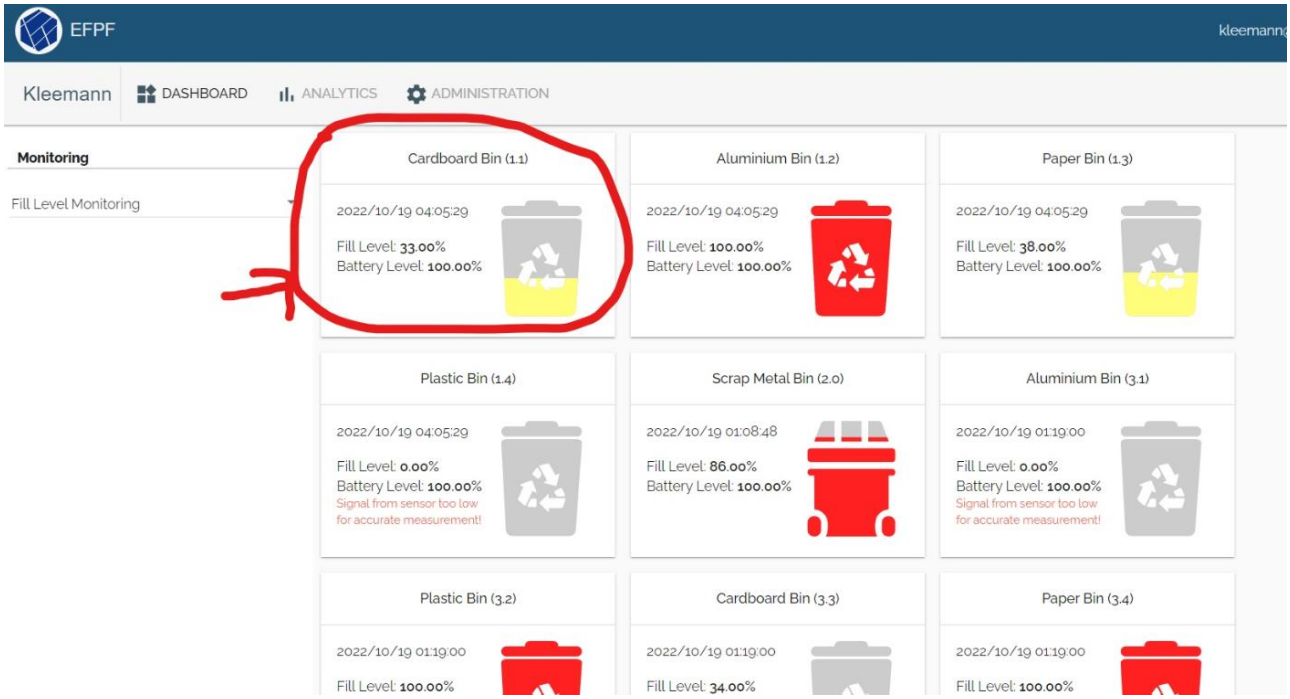


Figure 88: Fill Level Monitoring Solution

During this period, there was more time to evaluate the fill level solution's accuracy. The outcomes were the same with the error to be at maximum 5% for indoor bins. For the large outdoor containers, a bit larger error percentage was reported especially in the case of the scrap metal wastes of KLEEMANN (15-20%). For ELDIA outdoor container it was about 10%. This kind of errors were detected for the cases that the open top containers were almost empty or the fill level was less than 40%. The issue here is the large size of the containers that causes issues to sound signal from ultra-sonic sensor. However, this is something that has been considered also during the design phase and has been defined that is not an actual issue as the end-users requires notifications in fill level percentages over the 70% to empty the bin. Therefore, the larger testing phase just confirms the behaviour that was expected by the design stages.

The batteries were changed only one time for over 2 years of continuous operation. Also, it should be noted that for initial testing the measurement was get every 5 minutes. For normal operation a measurement is captured every 20 minutes. So, the expected battery lifetime is about 4 years. The process to change the batteries were considered as a very easy and straightforward process.

Besides the fill level accuracy testing, a better experimentation and evaluation of notification mechanisms were done in comparison with the previous period:

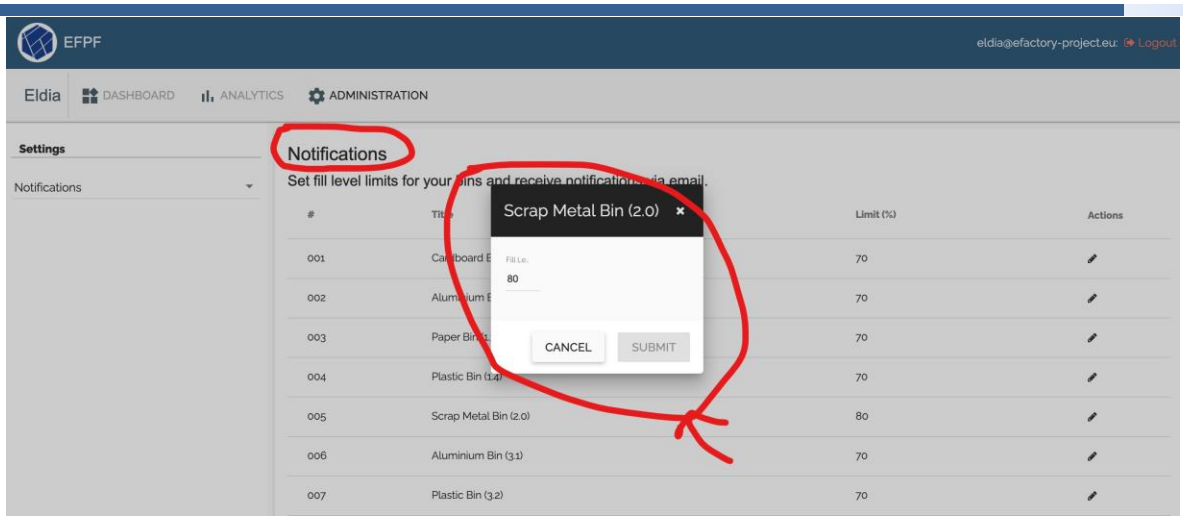


Figure 89: Experimentation with Fill Level Notification Threshold

The end-users tested to change the notification threshold and the notifications correctly arrived to the corresponding user for all the cases were tested.

During this largest period of experimentation, the Fill Level Monitoring Solution was detected to be unavailable but it was not a solution's problem. The EFPF portal was down for maintenance etc.

3.2.1.1.3 Lessons Learned and Outlook

The bins' fill level monitoring solution is evaluated by end users KLE and ELDIA in their industrial real-world operations (for a period over than 2 years) and based on the experimentation and evaluations of the functional and non-functional aspects of the developed solution the following lessons are learned.

In general, the pilots feel confident with all measurements, since the solution is tested for more than a year.

- The solutions accuracy and functionally meets the end-user requirements of both companies
- The solution is used in every day operation by the companies for the last couple of years
- KLEEMANN has demonstrated the solution to its Serbian and Chinese factories and received positive feedback. Possible installation of the solution in Serbia's factory is under discussion.
- ELDIA has demonstrated the solution to their customers and received positive feedback
- The fill level sensors of the open top containers do not always provide accurate measurements. This is still a problem caused by the external environmental conditions and the type of the material (scrap metal) which can act as a signal absorber, hence not providing accurate fill level measures.
- Real time fill level monitoring enables optimisation of services and transport routes
- Cost minimisation due to the reduction of unnecessary collections is achieved
- Carbon footprint reduction due to the reduction of pickups is also achieved, yet not measured

In general, measuring the time spent and the costs before and after deploying the solution it is estimated time savings of 15% in waste collection procedures and 5% reduction of operational costs.

3.2.1.2 US-CEP1.2: Blockchain Verification to Improve Transportation Security and Reliability

3.2.1.2.1 Short Description

The EFPF solution related to the blockchain verification provides full supply chain visibility and improves transportation security and reliability through updated, secure and reliable data that enables efficient decision making.

Transportation security and reliability play a critical role in all transport operations, especially in the waste management sector. Companies face significant challenges such as the lack of transparent and accurate data which increase overall transportation costs. Reliance on paper transactions also increases processing and administration costs. Furthermore, matching shippers (the demand) with carriers (the supply) is another issue that companies need to face when doing business. The challenges, result in partial or empty truckloads.

The solution is enabled by a mobile app available to the users (driver of the transportation) and a web application that enables to add permissions to drivers and vehicles by waste management company (ELDIA) relevant administration. Both applications' back end was based on blockchain/smart contracts. Integration and security mechanisms were provided by EFPF Data Spine. The web application was available to the users though EFPF Portal.

3.2.1.2.2 Testing, Evaluation and Experimentation

Initial Testing and Validation Phase

The first stage of testing and evaluation of solution has been described in D9.3 on M28 including an experimentation period of more than six months. The end-users aimed to check the applications functionality against the requirements that were:

- Secure handover with customers,
- Secure and trusted notification (real driver/company insert my place to provide an order/pickup service),
- Record every stage of pickup process in a verifiable and trusted way,
- Explore details about pickup process

The three circular economy pilots (KLE, ELD and MIL) have been testing and evaluating the proposed solution for more than six months. The provided solution has satisfied the three pilots by offering clear transportation security and reliability functionalities. The information about the sender and receiver of every supply chain level, the involved drivers and trucks as well as the type and details (pick up site, destination, driver, truck, times/dates etc.) about of the exchanged asset are logged as immutable transaction thus providing full visibility. Overall, the solution provides accurate transportation information for every supply chain stage.

The Blockchain as a Service (BaaS) solution is accessed through the EFPF platform. After the registration the users interact with the system through their DApps which are web and mobile applications. The requirements for verification of the data for improving transparency, transportation security and reliability are fully met by the different SCs that have been implemented and the recording of the transactions on the ledger along with the user's digital

signatures. The underlying cryptography and the IDM permission system guarantees security, non-repudiation, verifiability and transparency. The following figures, illustrate how each of the requirements has been addressed by the BaaS solution.

All the above-mentioned requirements were met and corresponding screenshots of the applications are available on D9.3

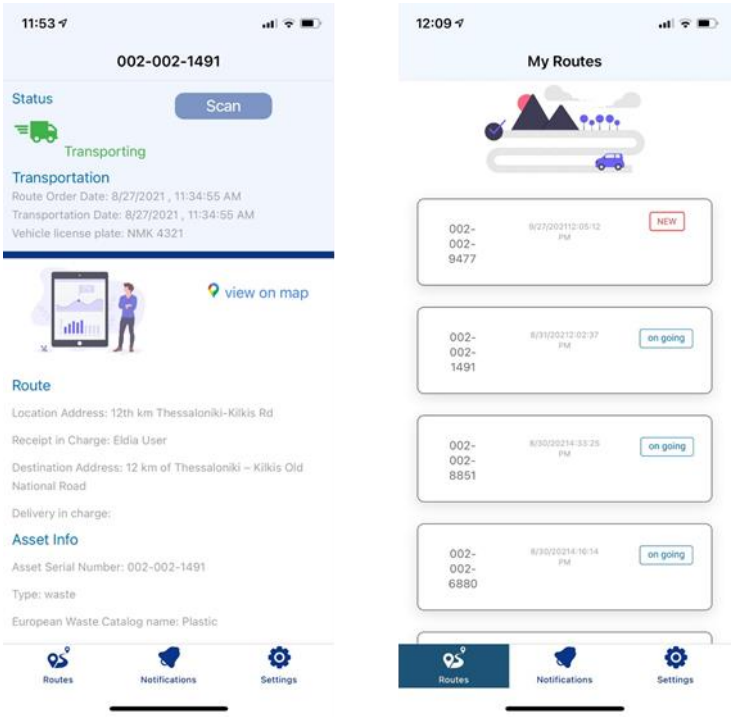


Figure 90: Examples of Driver App

Continuous Experimentation and Validation Phase

From M29 to M46 a second phase of solution's validation was followed. This experimentation period included further usage of the mobile and web-based application in some real-world transportations of wastes between KLE and ELDIA and of processed wastes between ELDIA and MIL.

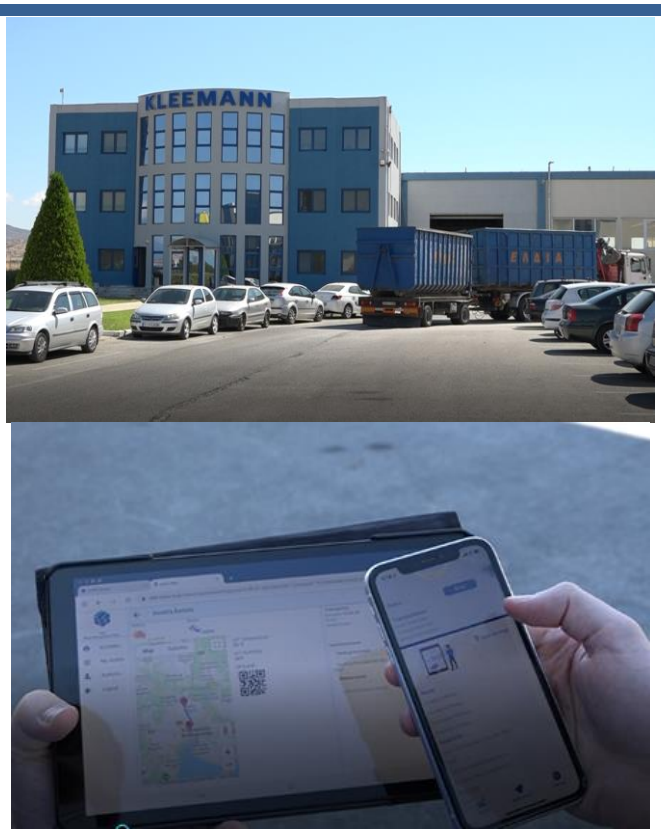


Figure 91: Handshake Example between KLE and ELDIA during Wastes Pick-up

The correct functionality of the applications was confirmed in this further experimentation phase and the 3 pilots validates the results. The only issue that was detected by the pilot partners was that the mobile solution was available only for iOS devices. This was not an issue during the initial testing phase but in continuous experimentation phase it was considered as a blocker issue. Most of the drivers were using Android phones. To solve this issue, CERTH delivered an Android application as well:

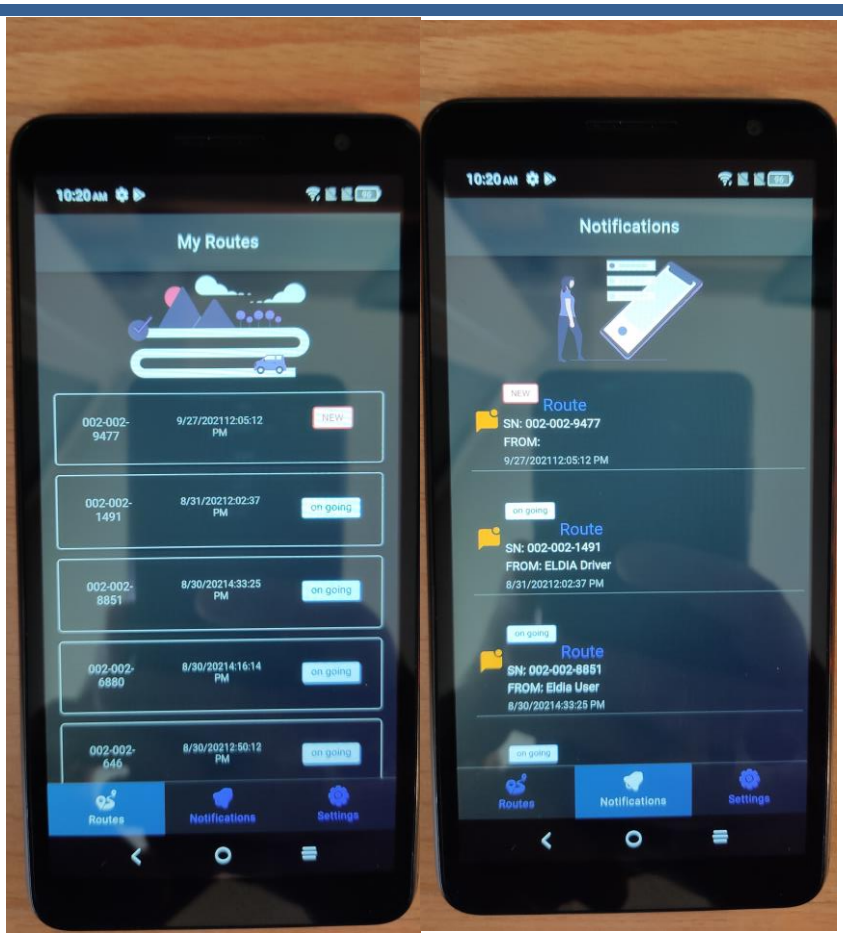


Figure 92: Driver App available in Android Devices

3.2.1.2.3 Lessons Learned and Outlook

The proposed solution offers the following user value outcomes:

- Supports and increases transparency in transport operations
- Ensures risk management, regulatory and environmental compliance
- Enables track and trace negotiation and delivery processes
- Reduces manual procedures related to transportation procedures
- Reduces transportations costs and use of resources
- Increases transport security and reliability in all customer services due to the complete information reports
- Enables the automatization and control all routes executed by trucks
- The solution is available to all devices as it supports both web-based interfaces and mobile apps for Android and iOS devices
- The solution is tested for a large period and its operation has been validated in a very good level

It should be noted that EFPF Open Call Experimentation from sub-projects Digitanimal and Pressious evaluate further the Blockchain that back-ends this solution. An overview of this outcomes is available in the corresponding section of this document.

3.2.1.3 US-CEP1.3: Blockchain Traceability to Improve Closed Loop Supply Chain Management

3.2.1.3.1 Short Description

The lack of capability to track and trace assets and transactions throughout the entire supply chain, is one of the key challenges that the three companies are facing towards circular economy. This lack of traceability is hindering companies to quickly adapt, plan, and manage their assets in an effective and optimised way.

A solution is needed to help companies track and trace their assets at every supply chain stage and increase supply chain visibility, without significantly increasing operational costs.

Partners involved in this user story were from the user side KLEEMANN, ELDIA and MILOIL and from the technical side CERTH. The solution is supplementary with the previous one as it is available through the web interfaces that were mentioned in the previous section. However, it is focused on traceability matters and not to permissions and secure handshake. As it is still related to wastes transportation it is included in the same tool/platform available to end users to provide a complete solution. The solution's back end was based on blockchain/smart contracts. Integration and security mechanisms were provided by EFPF Data Spine. The web application was available to the users though EFPF Portal.

3.2.1.3.2 Testing, Evaluation and Experimentation

Initial Testing and Validation Phase

The first stage of testing and evaluation of solution has been described in D9.3 on M28 including an experimentation period of more than six months. The end-users aimed to check the applications functionality against the requirements that were:

- Record supply chain transactions in a verifiable and trusted way (Type & Quantity of waste Information about the transportation, requesters and suppliers' details during bidding processes, uploaded guarantees or certification of origin etc.)
- Track waste/material/service at every supply chain stage
- Explore details about documents etc. from different supply chain stages
- Explore details that relate to pick up process

The three companies have tested and positively evaluated the blockchain solution. The solution is displaying different information per user role and per organization/company role. For example, a manager of KLEEMANN who enters the system can update his/her profile, access a dashboard and manage all the company's assets that have been added and the contracts signed with other companies such as ELDIA, track the current position of each asset, retrieve specific information about the assets regarding their current state and if they have been processed or delivered. The above-mentioned actions have been iteratively tested and evaluated by the three companies during a period of more than 6 months.

All the above-mentioned requirements were met and corresponding screenshots of the applications are available on D9.3:

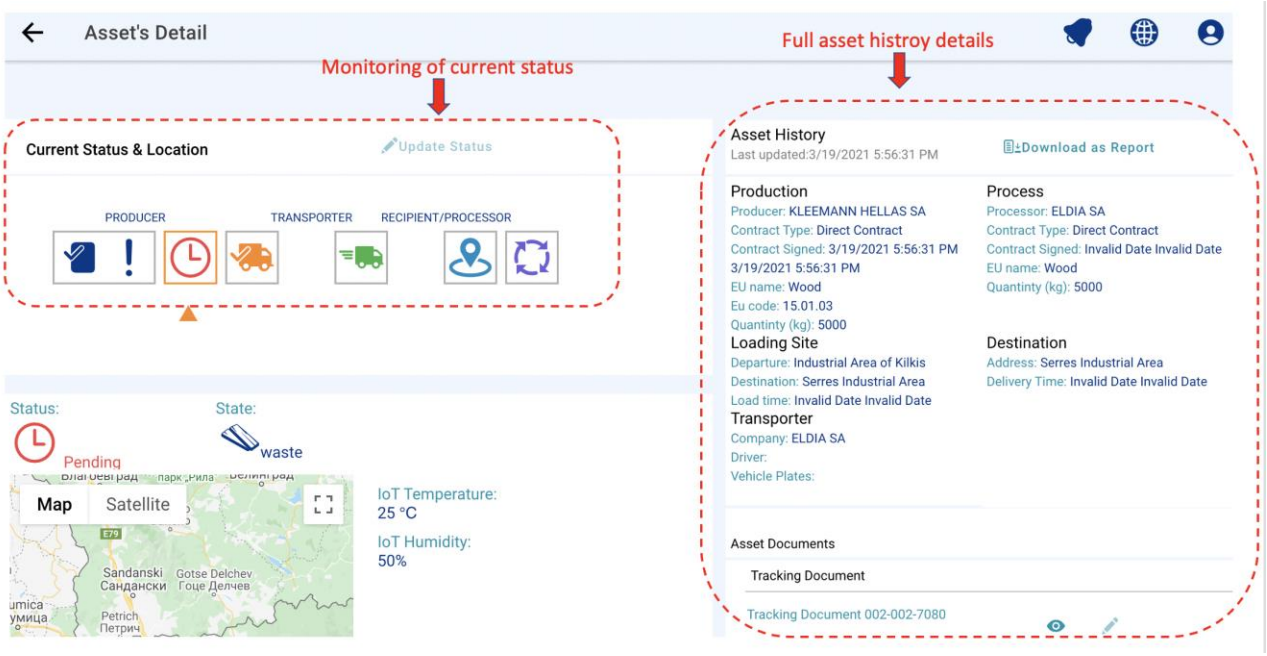


Figure 93: Example of Track & Trace Web Interface

Continuous Experimentation and Validation Phase

From M29 to M46 a second phase of solution's validation was followed. This experimentation period included further usage of the solution in some real-world transportations of wastes between KLE and ELDIA and of processed wastes between ELDIA and MIL (same as in the previous use case scenario)

All the three companies confirmed their initial validation results regarding the positive feedback and functionality of the solution. An issue regarding the user experience and interfaces functionality was detected by MIL partners during this extended experimentation and validation period with the solution. Some of the MIL and KLE users were using a dark them in their web interfaces and they realised that some of the application's graphics were not visible there. Some examples are available below:

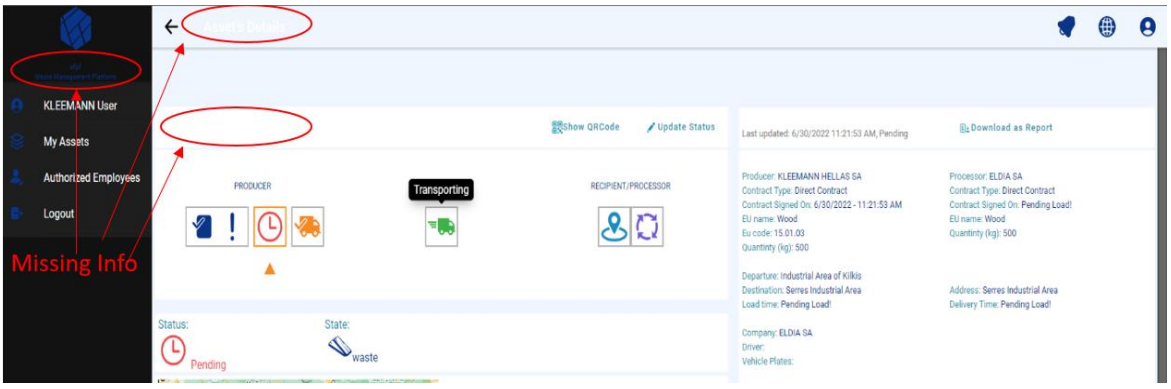


Figure 94: Example of Issues using Dark Theme in Browser

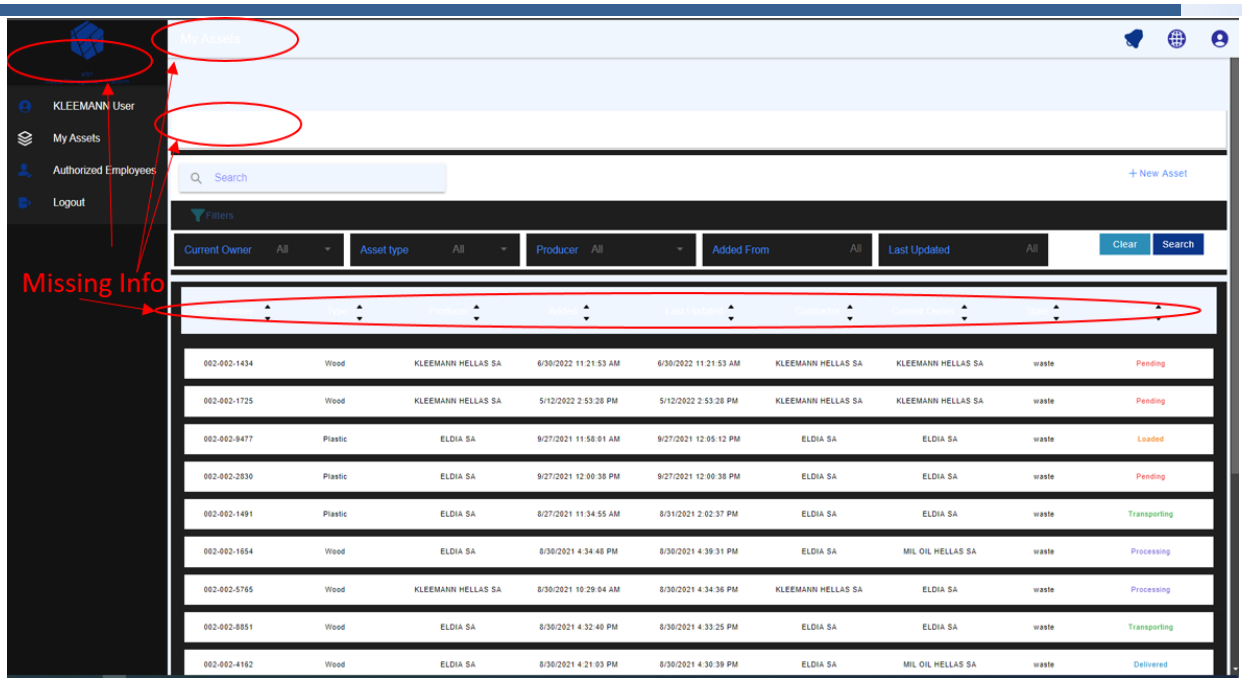


Figure 95: Another Example of Issues using Dark Theme in Browse

To solve these issues an updated version of the web application was provided to the end-users. Previously, dark mode could not be rendered correctly in browsers and the pages of the platform were rendered partially in light mode. After the implemented updates the rendering problem has been addressed and several other UX (user experience) and UI (user interface) changes have been introduced to modernize and improve user interaction with the application. Notable changes, include the normalization of the colour palette across the entire application as well as the change of certain UI elements (such as buttons) to be generally uniform. There are other updates to several visual elements to improve user experience and/or visual clarity. Below, are presented some indicative changes that took place. Please note that the changes introduced affected the whole platform and not just the pages shown below.

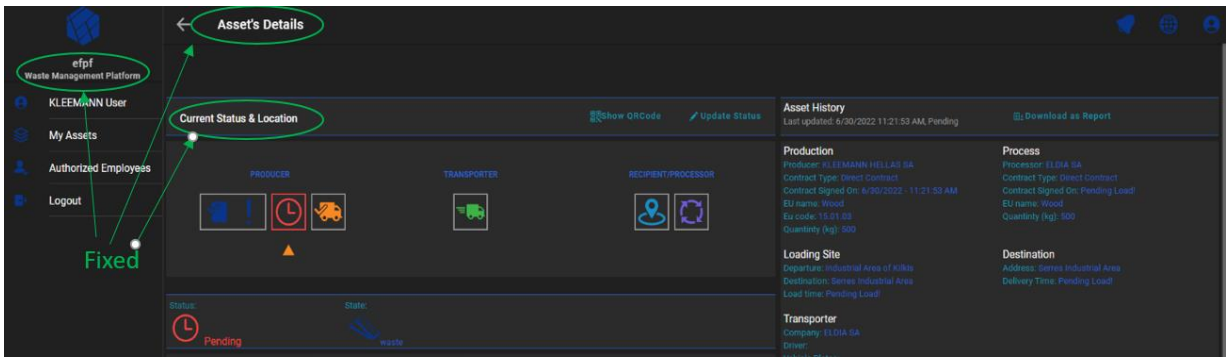


Figure 96: Screenshot Example of Issue was solved

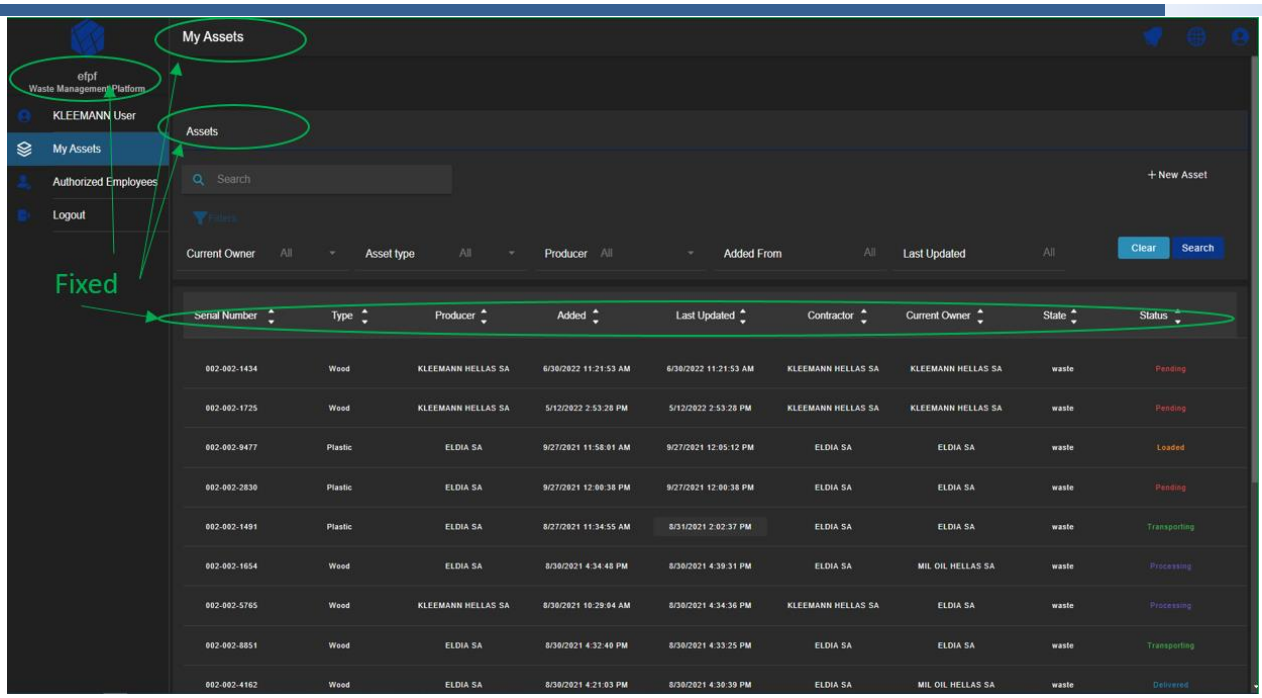


Figure 97: Screenshot of another Issue that was solved

3.2.1.3.3 Lessons Learned and Outlook

The proposed solution offers the following user value outcomes:

- Increases customer loyalty and Improves brand name
- Supports the overall CE processes and ensure risk management, regulatory and environmental compliance
- Enables track and trace negotiation and delivery processes
- Enables the optimisation of collaborative processes
- Reduces manual procedures
- Reduces costs and use of resources
- Provides trustworthiness of transactions and minimises risks
- All the exchanged documents including asset tracking information among the stakeholders are immutably logged on the blockchain
- The solution seems stable after a long period of experimentation and testing
- After the update the web application supports various web browsers settings

It should be noted that EFPF Open Call Experimentation from sub-projects Digitanimal and Pressious evaluate further the Blockchain that back-ends this solution. An overview of this outcomes is available in the corresponding section of this document.

3.2.1.4 US-CEP1.4: Trusted and Secured Information Flow Across the CE Partners

3.2.1.4.1 Short Description

The large quantities of data flows among manufacturers and other organisations including SMEs that participate in global supply chains, create an environment in which security and risk assessment are critical in all cyber-transactions. The deployment of cybersecurity solutions is proved to be an expensive process especially for SMEs, that may have limited knowledge and expertise in cybersecurity or risk assessment tools. This may cause a competitive disadvantage over larger organisations that have dedicated resources to invest in developing and applying such solutions. This challenge is also identified by the circular economy pilots.

Hence, a solution is needed to help companies to communicate in a more secure way, identify existing and potential threats across the entire supply chain and mitigate their impact, without increasing costs.

Partners involved in this user story were from the user side KLEEMANN and ELDIA and from the technical side University of Southampton and CERTH. Components were used the SSM (Software Security Modeller) tool, EFPF Data Spine and Portal.

3.2.1.4.2 Testing, Evaluation and Experimentation

Initial Testing and Validation Phase

The first stage of testing and evaluation of solution has been described in D9.3 on M28. The tool validation had started by using the tool to build this scenario that required:

- The modelling of the communication between the participating companies within the distance fill level monitoring scenario
- The definition of risks and threats to mitigate their impact

The modelling of communication between ELDIA and KLEEMANN for remote monitoring of bins' fill level (in KLEEMANN premises) by ELDIA and the risks definition were enabled by using System Security Modeller tool developed by UoS-ITI. KLEEMANN and CERTH (which has supported the real system setup for both KLEEMANN and ELDIA) designed the model that simulates the real-world communication scenario, by using the interfaces and functionalities of SSM tool.

The first part of the evaluation is containing the usability of the tool and the level of modelling that it enables. The tool interface was evaluated as user friendly, and it enables with an easy way the creation of various systems' model. Furthermore, the level of modelling that can provide was defined as well accepted by both KLEEMANN's IT staff and CERTH that have been working on the real-world system setup. All the necessary means and components were used for setting up the system could be modelled by using the available assets providing by the SSM tool. A large variety of network assets (network types, routers, controllers, devices, sensors etc.), hosted assets (data, DBs, web clients etc.), spaces (public, private) and stakeholders (adults, organizations etc.) are available by the solution and enables a detailed modelling of the actual system.

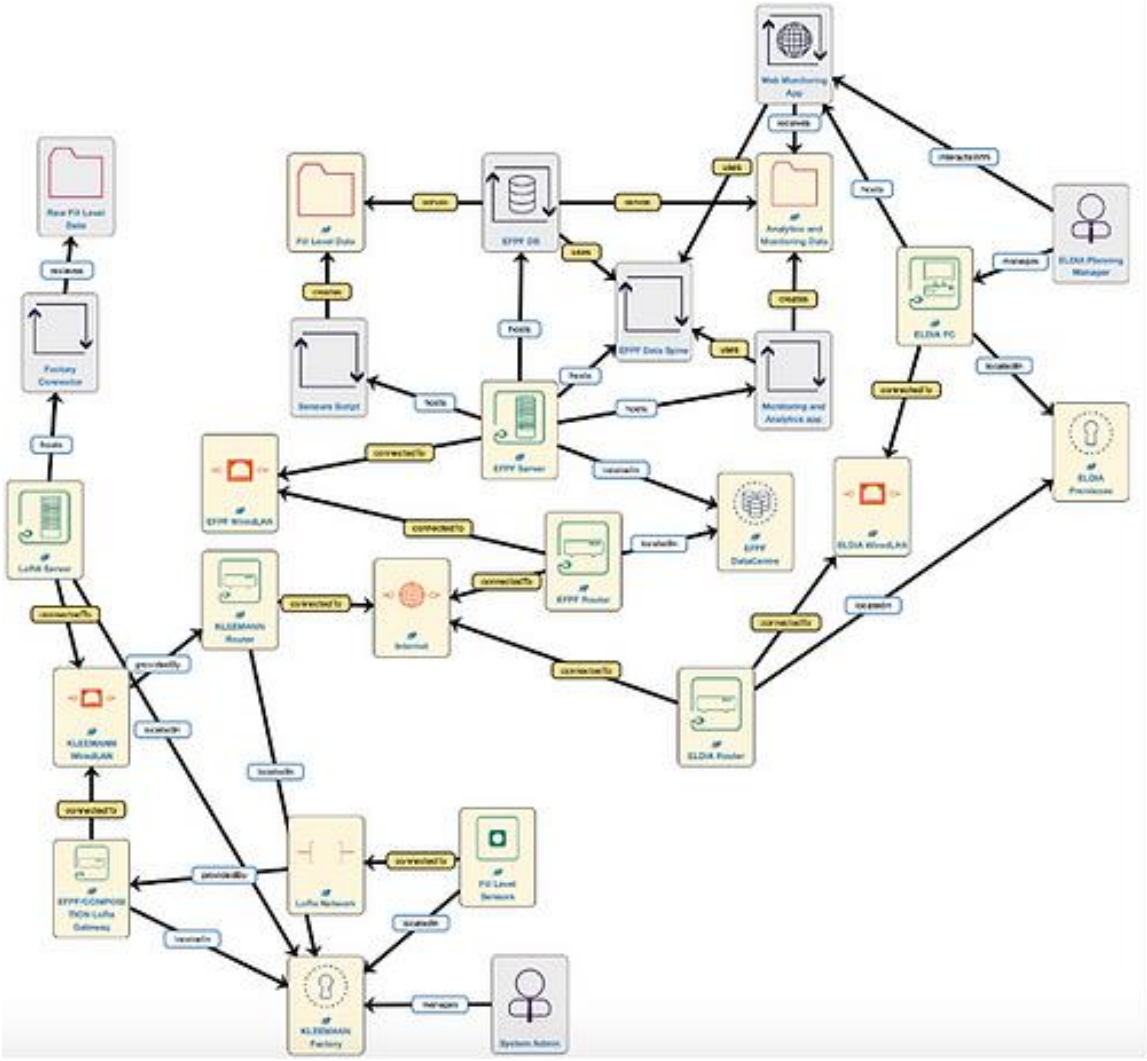


Figure 98: Model of Fill Level Monitoring Scenario between ELDIA and KLEEMANN

The second part of the evaluation is related to the risk definition and the threats that are detected by the tool. As soon as the modelling part was completed then the risk analysis was exported by the tool and the results were available to stakeholders. This analysis was evaluated as very useful, detailed and concrete. The tool defines threats and risks, their root cause, their likelihood, their risk level (very high, high, medium, low, very low) and effects of the threat. Furthermore, it was considered as very valuable feature the control strategies that are available by the tool and support the users to mitigate risks and threats. Overall, the solution was considered to cover the needs of this user story and demonstrate a lot of potential to further be used in other systems to provide system modelling and risk analysis.

Continuous Experimentation and Validation Phase

The next phase of experimentation (from M29 to M46) it didn't include any further actions regarding this tool as the use case scenario was focused to the model creation and risk analysis were done in the previous period.

Then the threats checked one by one to define if they have been removed by security procedures followed from CERTH, KLEEMANN and ELDIA related to shop-floor installations and in general of EFPF project for the parts of the solutions that are using cloud services and components of EFPF platform such as data spine, storage services, analytics services etc. Most of the threats were already solved by technical partners involved in the solutions,

some other threats were ignored as considered of 'false positive'. However, some others must be taken into consideration by various KLEEMANN departments as they were related to some physical security issues. The tools' outcome regarding them was collected by KLEEMANN partners participating in EFPF project and were communicated to their Safety Department as a kind of feedback for possible improvements etc.

3.2.1.4.3 Lessons Learned and Outlook

The proposed solution offers the following user value outcomes:

- Improves cybersecurity processes in closed loop supply chains
- Gives the opportunity to conduct advanced risk assessments in a user-friendly way
- Enables the identification of risks throughout the circular supply chain data flows
- Protects the functioning of supply chains by demonstrating the existing complexities and assisting in developing a fast response.
- Secures various components that are vital for the effective supply chain communication such as sensors, routers, gateways, servers, scripts and applications.

The end-users are confident that SSM enabled trusted and secure data and information flows across the entire supply chain

3.2.2 CEP-Epic 2: Online Bidding Process for Circular Economy Enabled by Automated Matchmaking

3.2.2.1 US-CEP1.5: Online Bidding for Processed Wastes

3.2.2.1.1 Short Description

The negotiation of offers and services regarding processed wastes is a very challenging procedure since it involves several organisations from different sectors (such as recycling companies) and needs fast decision making. All these procedures are conducted manually using phones and emails to select the offers and choose the best one based on specific criteria such as price, health and safety issues (regarding the way of collection) etc. This procedure is inefficient and expensive and the three companies participating in the circular economy scenario need a solution that will provide automated bids and negotiations through an online system to obtain high-quality services and products at reasonable prices.

Partners involved in this user story were from the user side KLEEMANN, ELDIA and MILOIL and from the technical side CERTH and LINKS. The Online Bidding Process is available to the user through the EFPF Portal where an authenticated user can configure and set up a new virtual agent and to control the bidding processes by the means of UI. A semantic framework provides matchmaking capabilities. It matches the requester agent with possible suppliers based on various criteria and matches the request with the best submitting bid/offer to support and automate at the higher possible level the selection process. Therefore, the EFPF components in this solution are Matchmaking Services, Virtual Agents, web-based UIs, EFPF Data Spine and Portal.

3.2.2.1.2 Testing, Evaluation and Experimentation

Initial Testing and Validation Phase

Initially, the Online Bidding Process solution has been tested and evaluated from the three CE companies for a period of more than 6 months as it was reported on D9.3. The initial validation aiming to the acceptance of the following requirements:

- Initialize an online bidding process
- Choose the priority of the offer evaluation criteria
- Receive notification for a new bidding process.
- Submit an offer (predefined or new).
- Receive a ranked list of offers
- Explore details of the offers
- Select an offer
- Receive a selection /rejection notification
- Receive information for the pickup arrangement

During this testing period the online bidding process was successfully tested between KLEEMANN and ELDIA for negotiations regarding wood wastes and scrap metals. MILOIL has also tested the online bidding process as a bio-energy company requesting processed wood-waste, in scenario tests between MILOIL and ELDIA. ELDIA used the marketplace to sell the waste to bio-energy companies. In the testing scenarios, MILOIL won the bidding

process and arranged a transportation with all the steps logged on the blockchain (US2/US3). To sum up the tests were performed (a) between KLEEMANN and ELDIA with KLEEMANN having the role of requester for waste management services and ELDIA the role of the corresponding supplier and (b) between ELDIA that requests to sell the processed wastes and MILOIL that bids to buy them for producing bio-energy. For the testing scenario each company was represented by a virtual agent. To provide some more realistic test scenarios with more companies some dummy companies/agents were created and were part of the experiments as well.

The user requirements were met through the multiple functionalities provided to the Online Bidding Process UI (accessible through the EFPF Portal). The most important functionalities were described in D9.3 with corresponding screenshots examples:

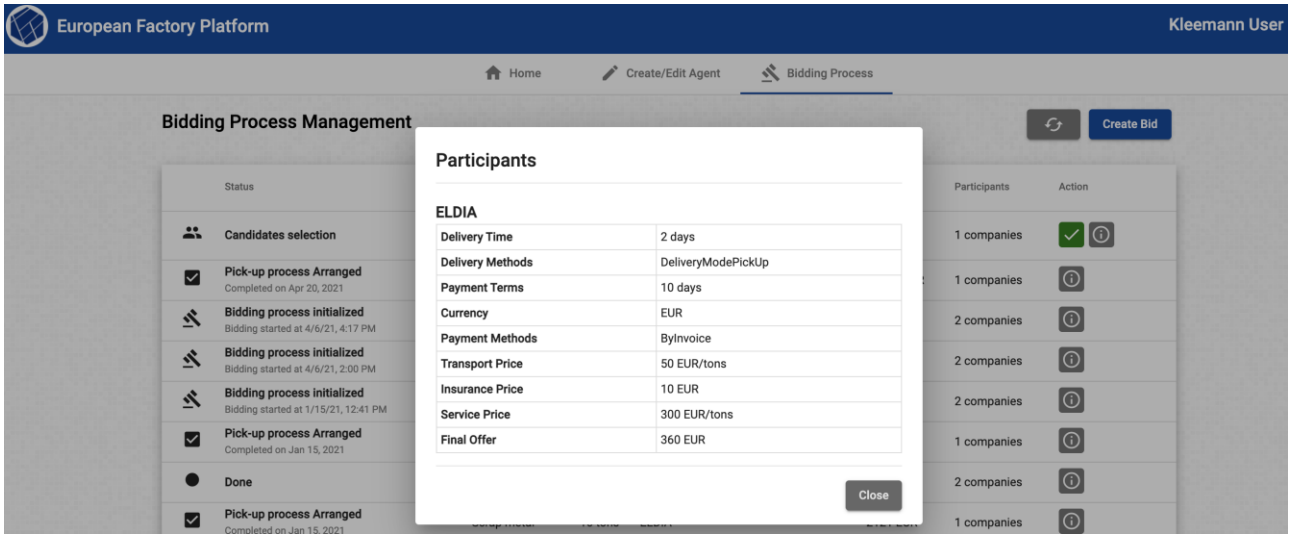


Figure 99: Screenshot of Online Bidding Process User Interfaces

Continuous Experimentation and Validation Phase

The next phase of experimentation (from M29 to M46) included the execution of similar test scenarios by the three companies participating in CE pilot. Again, some pre-defined agents/companies were used as well. More people of the companies tested the tool this time to provide further feedback. The new users that were experimented with the tool confirmed the validation results of the previous period regarding the tool's operation and overall user experiment.

Only an issue reported by MIL partner when they were trying to setup a new agent as it is depicted in the next figure:

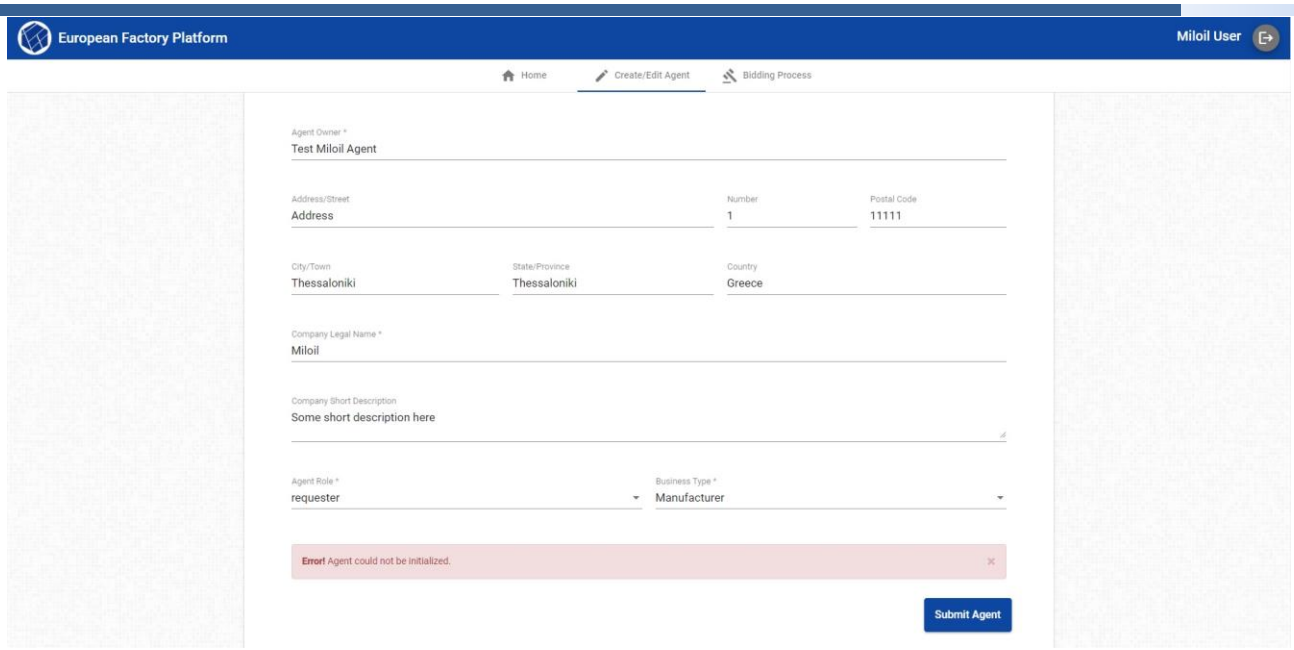


Figure 100: Error during Agent Creation/Deployment

The error investigation by technical partners indicated an error to the agents' deployment functionality. LINKS did a major agents' update to be solve this issue and to enable the realisation of most extended scenarios.

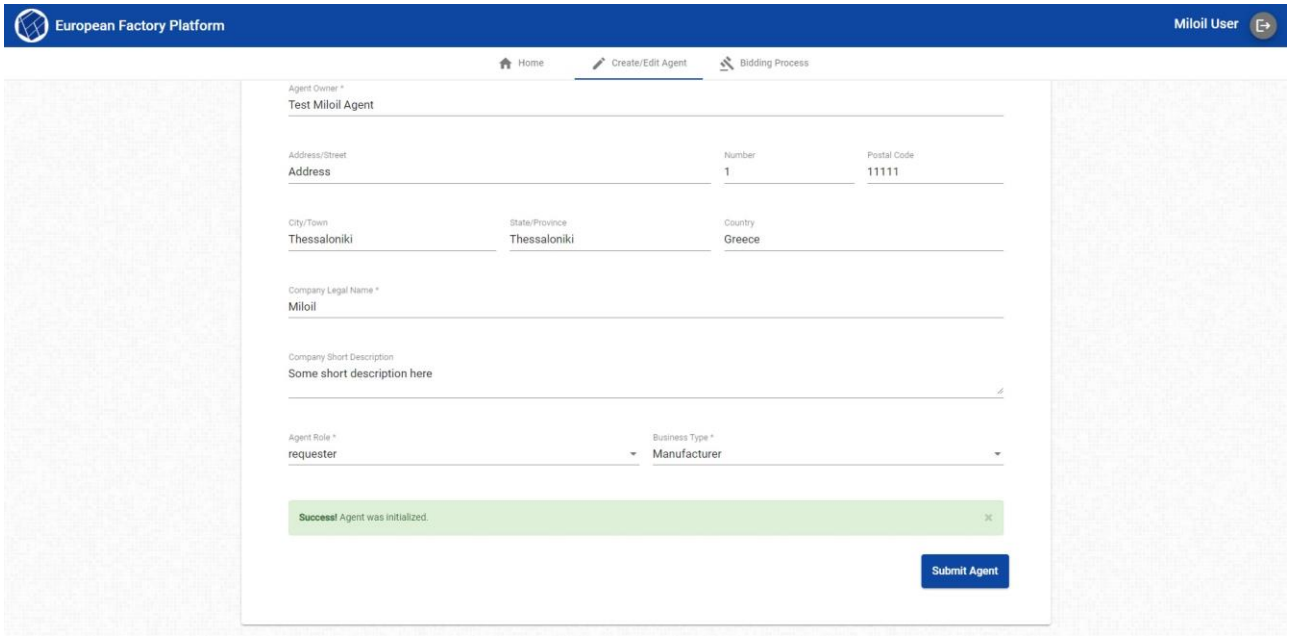


Figure 101: New Agent Deployment became Functional again

A further validation could now be planned with the invitation of 3rd parties' companies to participate in this agent-based ecosystem and EFPF Online Bidding Process.

3.2.2.1.3 Lessons Learned and Outlook

The Online Bidding Process solution was evaluated by target users KLE, ELDIA and MILOIL. The experiments in the online bidding process demonstrate the interconnections of the EFPF solutions and the capability of EFPF platform to manage supply chain complexities and support decision-making. More specifically, the results demonstrate that the automated matchmaking between supply chain members and the real time offers submission and

evaluation strengthen the development of circular economy supply chains. The solution is well received from the three CE pilot partners as it is considered as a very promising solution that addresses several key supply chain complexities such as, numerous phone calls and emails for negotiations offers. The following user value outcomes were extracted:

- Enables optimal matchmaking (right supplier and right material)
- Improves the design, execution, monitoring and optimisation of collaborative processes
- Enables automation and control of collection processes
- Provides automation in negotiations monitoring
- Minimises costs through efficient matchmaking

Furthermore, a large-scale scenario comprised by more participants and services in the EFPF marketplace, would give better insights and feedback to strengthen the developed solution. This scenario was not possible to be tested in a large-scale environment due to the limited number of end users that participated in the EFPF project.

It should be noted that a solution named RescrapIt coming from EFPF Open Call Experimentation sub-project from Future Intelligence was tested and validated by KLEEMANN as a kind of alternative solution regarding wastes management. It is not clearly an alternative but a bit different approach. The user there do not use a platform to negotiate for the wastes and he/she is able to evaluate alternative options to handle this waste (recycling, refurbishment etc.). Details regarding this application are available in the corresponding section of this report.

3.2.3 CEP-Epic 3: Search for specialised products/services

3.2.3.1 US-CEP1.6: Search for New Customers / Market Research for Specialized Product Customers

3.2.3.1.1 Short Description

Searching for specific suppliers that have the capacity to manufacture highly customised products or provide tailor made services that meet very strict deadlines is a challenging task both for large manufacturers and SMEs. While SMEs have the flexibility and speed to respond to customer requests, larger companies may lack this ability. On the other hand, SMEs do not have the same business opportunities to expand their customers' network as larger companies do. These challenges are also identified by the three circular economy pilot partners.

Hence, a solution is needed to provide advanced search functionalities that will help companies to find customers and suppliers that could offer highly customised products and services, without spending too much effort in research.

Partners involved in this user story were from the user side KLEEMANN, ELDIA and MILOIL. As technical partners SRFG, CERTH and C2K were responsible for the technical development. EFPF Matchmaking and Federated Services were used alongside with EFPF Data Spine and Portal for the delivery of this use case.

3.2.3.1.2 Testing, Evaluation and Experimentation

Initial Testing and Validation Phase

Initially, the Search for New Customers service has been tested and evaluated from the three CE companies for a period of 6 months as it was reported on D9.3

The testing and validation aiming to the acceptance of following criteria/functionalities:

- Search for customers
- Customize search criteria
- View customer details and previous transactions ratings
- Select a possible customer
- Contact a possible customer
- Check an invitation
- Send acceptance/rejection
- Receive acceptance/rejection notification
- Negotiate online for collaboration

The first validation results have shown that companies are able to enter the marketplace and offer or request specific goods and services such as waste management services. During this period ELDIA and MILOIL, which are SMEs that provide waste management and bio-energy solutions, have advertised their services to the EFPF platform and KLEEMANN as a potential customer has searched for these specific solutions based on geographical and rating criteria, to strengthen its circular economy strategy. The testing and evaluation of this user story is performed in the first level of matching services and more tests will continue.

Another solution focusing on stakeholder collaboration is available in the EFPF digital manufacturing platform. The solution is covered by multiple tools and core functions of EFPF platform. The CE pilot partners, have tested the solution separately, as collaboration in test scenarios in this case is not needed. The Federated Search functionalities and the Bidding Process tool (described in the previous user story and tested there) were available to users tested for a period longer than six months. The TBMS tool was later available and it is tested for a short period before this report

The tests were especially focused on the search capabilities of the EFPF ecosystem to define how easy it is to find companies, products and future collaborators. Furthermore, for the CE pilots it was also important to test and evaluate if their companies are available in search results and the way they are appear in them. So, the tests were about how they can find companies but also how other companies can find them.

The user story as explained before is fulfilled primarily by using the Federated Search tool User Interface, which is available in the EFPF Portal. The EFPF user can search for partners across the base platforms, based on different criteria, e.g. capabilities of partners, their geographic locations and acquired feedback and online rankings. The EFPF user is also able to search for products and services based on product/ service-related criteria. Detailed examples of the solution's usage and validation are available on D9.3. Some indicative screenshots are added to this report as well:

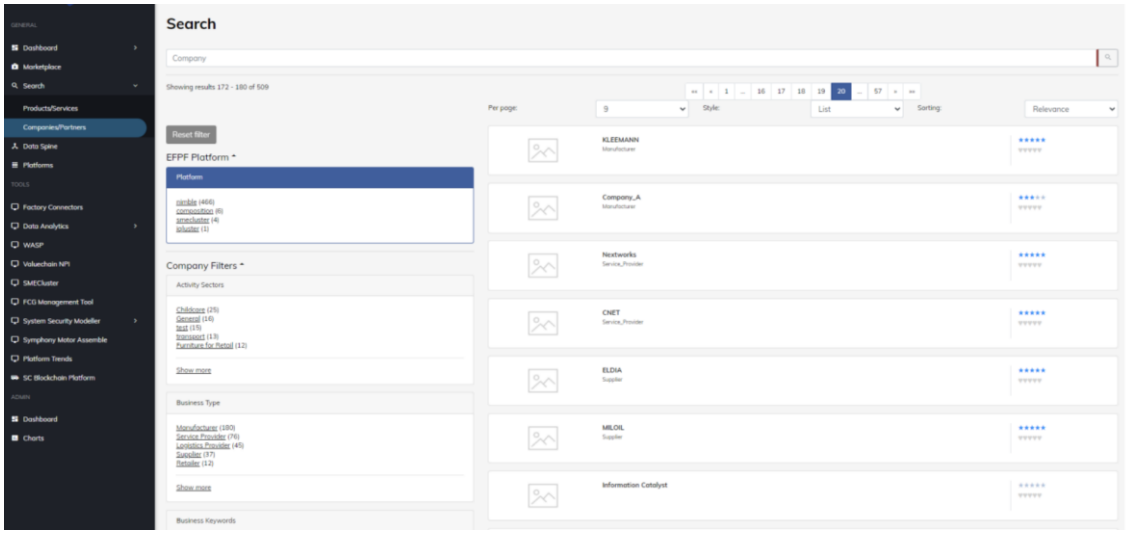


Figure 102: EFPF Federated Search Results

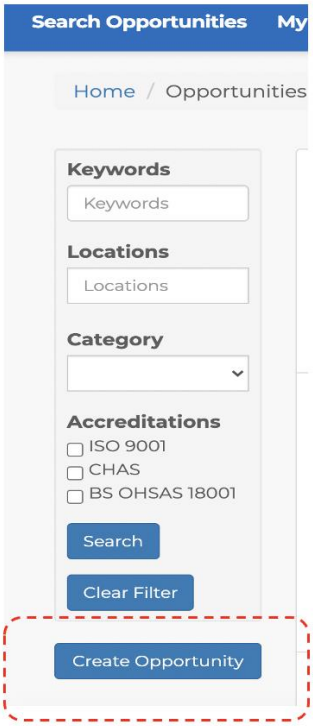


Figure 103: TDMS Tool - Create Opportunities UI

Continuous Experimentation and Validation Phase

The next phase of experimentation (from M29 to M46) included the execution of similar scenarios by the three companies participating in CE pilot especially for the case of the TDMS tool that was not available for a long period during the first validation period. During this period further experimentation was done with the tool. CE pilot partners identified the lack of some standards to be supported as accreditations by the tool and communicated to technical providers (C2K) that responded with corresponding updates/additions.

3.2.3.1.3 Lessons Learned and Outlook

The Federated Search and TDMS solutions were evaluated by target users KLE, ELDIA and MILOIL in their scenarios and based on the actual user-based evaluations of the functional and non-functional aspects of the developed solution the following lessons are learned:

- The Federated Search solution offers the opportunity to search for specialised circular economy partners and solutions, based on different criteria, e.g. capabilities of partners, their geographic locations and acquired feedback and online rankings and service related criteria.
- The negotiation needs of the companies are covered by Online Bidding and TBMS tool of EFPF in a very satisfied level.
- The UIs were well accepted and the tools were almost continuously available from EFPF Portal. Only some cases were reported that the whole EFPF Portal infrastructure were unavailable for maintenance and update issues.

A new solution for team creation is available through EFPF Open Call Experimentation procedures. The TeamCreator tool by Digital Systems 4.0 is planned to be evaluated by CE pilots as it is considered as a kind of alternative or supporting tool for this user story.

3.2.4 CEP-Epic 4: Data Analytics for the Optimization of Procedures Related to Circular Economy Activities

3.2.4.1 US-CEP1.7: Optimization of Planning Activities for Effective Waste Management through EFPF Platform

3.2.4.1.1 Short Description

The lack of automated notification of ELDIA's customers' bin's fill levels is the factor that triggered the development of a solution that will provide functionalities that will monitor the customers' bins' fill level, so that the company can be notified when waste is ready for collection and optimise its planning activities for effective waste management. The developed solution will facilitate the logistics service and improve the reaction time of replacing full containers. A further analysis of the waste management data will be conducted to enable possible estimations of the fill level of various containers as well as price and tonnage forecasting.

Partners involved in this user story were from the user side ELDIA and from the technical side LINKS and CERTH. EFPF tools were used Visual and Data Analytics Tool and Deep Learning Toolkit. Fill level sensors were used as well alongside with EFPF Data Spine for security and integration. The solution is available through EFPF Portal.

3.2.4.1.2 Testing, Evaluation and Experimentation

Initial Testing and Validation Phase

Initially the solution was tested and validated for a 1-year period. The results were documented in D9.3.

(a) Fill Level Monitoring and Trend Estimation

ELDIA has tested the solution by continuously checking the fill-level monitoring of her customers' bins through the EFPF platform. The solution uses fill level sensors were installed during COMPOSITION project, however the solution is currently active and updated only though EFPF Portal and it is completely functional only by using EFPF infrastructure (Data Spine). The benefits of using EFPF platform infrastructure include, added security, scalability and extensibility of the solution e.g. new types of data can be easily integrated using the secure and interoperable Data Spine.

The measurements are reported to be very accurate (about 95%) and the data analytics tool is helping ELDIA's staff to monitor containers fill level, to analyse fill level trends, to forecast the tonnage of wastes that will be transported and to perform price forecasting analysis for various types of wastes. The solution is in a mature stage and ELDIA is using it in its day to day business. This evaluation was to the first requirement of this case that is the ability of ELDIA to monitor bins fill level of their customers.

(b)Tonnage Forecasting

The next requirement was the ability to *explore tonnage predictions per material* for EDLIA end user.

The Tonnage Forecasting component of the Visual and Data Analytics tool is related to the estimation of the future tonnage of raw material that a company is going to buy based on historical data. It aims to enhance suppliers' planning activities by giving estimations of the

future wastes/materials they must pick up in upcoming months. For EFPF purposes, the methodologies are available to ELDIA through EFPF portal (as did for KLEEMANN case as well) and an analytics dashboard with similar solutions has been setup during EFPF for MILOIL.

The specific user requirements about data analytics solution and the corresponding Acceptance criteria are:

- Deploy historical data related to previous purchases for raw material
- Explore tonnage predictions per raw material

The requirement of exploring tonnage predictions per raw material is covered within this component. The users could be able to view tonnage predictions from all the available methods implemented for this tool. Furthermore, the requirement of deploying historical data was covered by the functionality of Tonnage Forecasting module which gives the user the capability of loading new data either from the Mongo DB connected to the tool or by uploading a csv file with the historical data.

(c) Price Forecasting

The third requirement of this case was *a price forecasting service* for waste materials.
Price Forecasting component based on Deep Learning Toolkit provides prediction for different type of materials to further support and optimize the planning activities for end user (e.g. purchasing managers). This module tries to predict the next values of a dataset containing information about purchases of a given good. A single instance of this module can be used to predict the prices outlook of different goods since there is the possibility of choosing different models when invoking the APIs. This feature can also be used to have different models for the same good in case the price behaviour changes in different scenarios. It is initially tested by monitoring price forecasts that were based on previous pilots; historical data. The monthly base forecast was considered as a valuable information for the end users.

Continuous Experimentation and Validation Phase

The next phase of experimentation (from M29 to M46) included the execution of similar scenarios for the cases of Tonnage and Price Forecasting and for further monitoring of fill level solution.

(a) Fill Level Monitoring and Trend Estimation

During further experimentation and testing ELDIA confirmed the first period's result regarding the high accuracy of the sensors. More details regarding this are available in the first epic of CE pilot.

Beyond the monitoring further usage of Fill Level Trend analysis in this case demonstrates that the algorithm operates well and provides consistent and valuable information regarding trend's aggressiveness regarding fill level of specific bins. ELDIA considers that can use this outcome and prioritize the collection of the customers' bins with the most aggressive trend.

(b)Tonnage Forecasting

ELDIA was further testing the tool functionalities. As ELDIA now had more historical data to load to the tool was able to be continuously evaluated. ELDIA could compare for example the previous month prediction with actual tonnage data of the current month as soon they are available. It was detected that the algorithms operate well providing forecasts near to actual data to the most of the cases.

A first outcome of the process was that from the three available analytic options, Markov Chain models, Auto-regression and Moving Average, the latter had a better accuracy and was the one that was more often used by end-users.

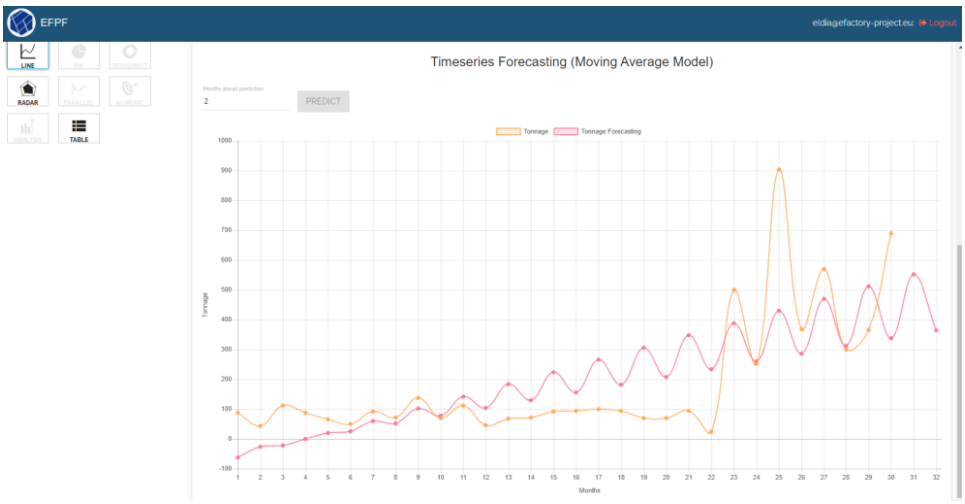


Figure 104: Tonnage Forecasting based on Moving Average

(c) Price Forecasting

In this case the Price Forecasting interface were further evaluated. The outcomes are a bit the same with the initial period. The forecast's accuracy is continuously improved as more historical data are available for deep learning model's training.

3.2.4.1.3 Lessons Learned and Outlook

The proposed solution offers the following user value outcomes:

- Planning optimization over a waste management supply chain
- Improved reaction time of replacing full containers
- Price and tonnage forecasting

The Data Analytics solution was evaluated by target user ELDIA in its industrial real-world scenario and based on the actual user-based evaluations of the functional and non-functional aspects of the developed solution the following lessons are learned. The solution is considered as very useful as it is of great assistance to the Management team in tits decision making based on past data. The tools good operation was confirmed in this extended validation and experimentation period. Moreover, ELDIA has estimated that the analytics/forecasting implementation by the company's management team is offering savings of at least ½ of an employee's salary (€ 12000,00).

The Fill Level Trend Analysis and Tonnage Forecasting solutions were evaluated, validated and used in Pressious Open Call Sub-project as well for cases related to ink fill levels. Outcomes of this experimentation are available in the corresponding section of this document. Moreover, the Deep Learning tool was used and validated in EFPF Open Call experiments like Octavic (more info is available in the relevant section).

3.2.4.2 US-CEP1.8: Optimization of Planning Activities for Purchasing New Materials

3.2.4.2.1 Short Description

The rapid growth of MILOIL's contractual farming network has resulted in large activities in the production and supply of animal feed which is the by-product of the processing of oilseeds of contractual farming. These activities require optimised procedures that will improve upstream and downstream supply chain planning. A key component to achieve optimised planning activities is accurate forecasting methods that will assist decision making especially when purchasing new materials.

Hence, as solution is needed to provide forecasting information for raw materials.

Partners involved in this user story were from the user side MILOIL and from the technical side CERTH and LINKS. Similar tools as above were used.

3.2.4.2.2 Testing, Evaluation and Experimentation

Initial Testing and Validation Phase

Until M28 and based on D9.3 descriptions, MILOIL has tested the solution for a period over 10 months with its real data (from June 2020 to March 2021). The end-users explored cases regarding the following requirements:

- Deploy historical data related to previous purchases for raw material
- Explore price forecast per raw material
- Explore tonnage predictions per raw material

(a) Tonnage Forecasting

The end-user evaluated the tool for its usability and user friendliness of the UIs. Besides that, the evaluation was focused on the quality of the predictions for both price and tonnage forecasting. For tonnage forecasting were defined a lack of accuracy for real data related to material, frying oils, so another method was added to moving average and Markov chain-based approaches that were initially available. For this reason, a method based to auto-regression was added as well.

(b) Price Forecasting

Regarding Price Forecasting to get better prediction as the data from MILOIL were not enough to train the artificial neural networks of the solution, the model was trained with global historical data about the specific materials.

Both solutions interfaces were considered as user friendly and easy to use. The tool's accuracy was not possible to be clearly evaluated to this short period.

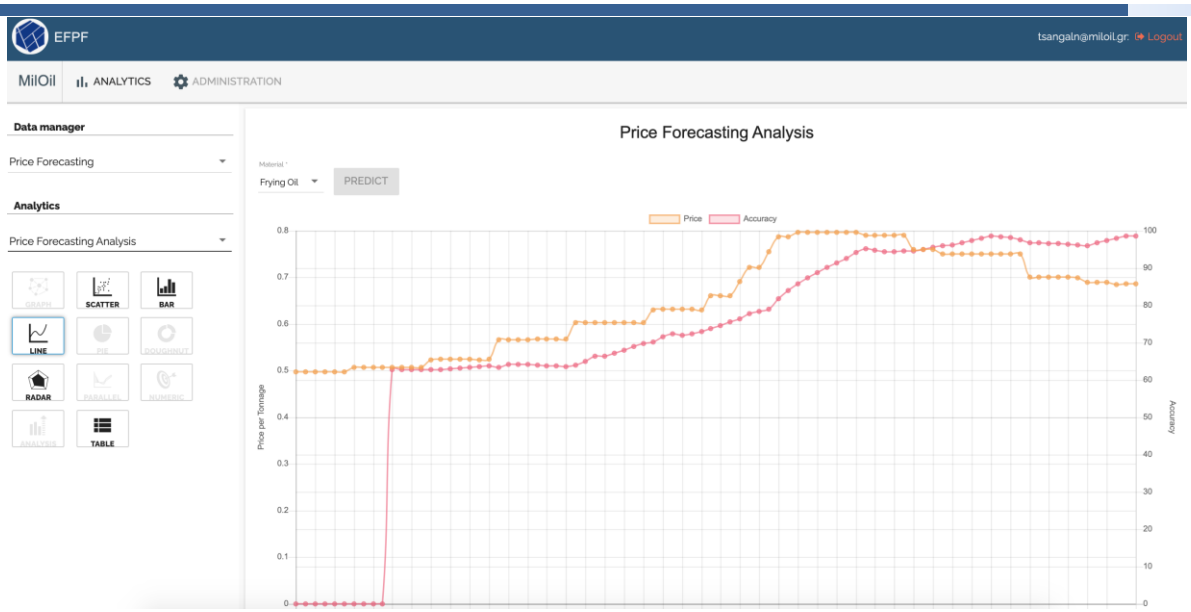


Figure 105: Price Forecasting Solution UI

Continuous Experimentation and Validation Phase

The next phase of experimentation (from M29 to M46) included the execution of similar scenarios for the cases of Tonnage and Price Forecasting.

(a) Tonnage Forecasting

This time more data were used. Now data until spring of 2022 were available by MILOIL to load them in the tool for getting predictions. The predictions sometimes were considered as accurate however in some others not. The data and market related to some bioenergy raw materials such are the frying oil is not stable, without any common pattern or seasonality. Furthermore, as all the collected data was coming from Covid-19 period they cannot be considered as the best possible of data sample to enable accurate predictions. From all the available methods the auto-regression one was more often used by end-users and it was considered as the most accurate.

(b) Price Forecasting

The solution was considered as accurate enough by the end users and the further experimentation in this period confirmed this. An accuracy level over 90% was detected for the most cases. The accuracy was detected to be continuously improved over the time as more data was used for LSTM training of this deep learning approach.

3.2.4.2.3 Lessons Learned and Outlook

Based on MILOIL further experimentation and continuous validation the proposed solutions offer the following user value outcomes the following lessons have been learnt from the data analytics solution:

- Solutions regarding Tonnage and Price Forecasting can be provided by digital platforms and be available to the company's related stakeholders
- The optimisation of planning activities is expected to enable the extension of contractual farming network
- The price and tonnage forecasting for specific raw materials will improve purchasing decision making

- The price and tonnage forecasting are expected to enhance the company's position in the field of trading of biodiesel.
- The tonnage forecasting operates better for some materials than some others
- The price forecasting demonstrates high accuracy

Tonnage Forecasting solution was evaluated, validated and used in Pressious Open Call Sub-project. Outcomes of this experimentation are available in the corresponding section of this document. Moreover, the Deep Learning tool was used and validated in EFPF Open Call experiments like Octavic (more info is available in the relevant section).

3.2.4.3 US-CEP1.9: New Predictive Maintenance Solution for KLEEMANN Polishing Machine

3.2.4.3.1 Short Description

This user story focuses on the early detection of machine failures in the polishing machine at KLEEMANN's shop floor. The sensors installed are used to capture vibration data. To achieve this, a solution is needed to predict potential machine defects, so that the Maintenance Manager can improve maintenance operations and procedures.

The machine's vibration monitoring for Anomaly Detection is a dynamic solution based on real-time data coming from deployed vibration sensors. The real-time vibrations monitoring and analysis result in an anomaly detection pipeline towards early fault detection predictive maintenance. The method uses the historical data to calculate the MAHALANOBIS distance of each point and modelling normal behaviour. A threshold is defined at this point, too, to detect outliers when new incoming sensor data overcome this threshold. The maintenance manager is visually informed via the Visual Analytics when the machine's activity surpasses the abnormal vibration threshold and can check for potential faults in the machine operation. The overall requirements to have met are:

- The ability to visualise vibration data coming from polishing machine
- The functionality to detect outliers in real time

Partners involved in this user story were from the user side KLEEMANN and from the technical side CERTH. Visual and Data Analytics tool and vibration sensors were used alongside EFPF Data Spine for data integration. The solution is available to end users through EFPF Portal.

3.2.4.3.2 Testing, Evaluation and Experimentation

Initial Testing and Validation Phase

In the first validation phase until M28 the solution implemented in this user story is tested and evaluated for a period of 3 months at KLEEMANN's premises. The solution offered a new predictive maintenance method and considered to need more time to be evaluated since no deficiencies have occurred in the testing period. The measurements in normal machine operation demonstrated that the solution implemented has been working without any issues and it was able to deliver the expected performance. This solution comes as an addition to an already existing functionality based on Vibration Behaviour Analysis.

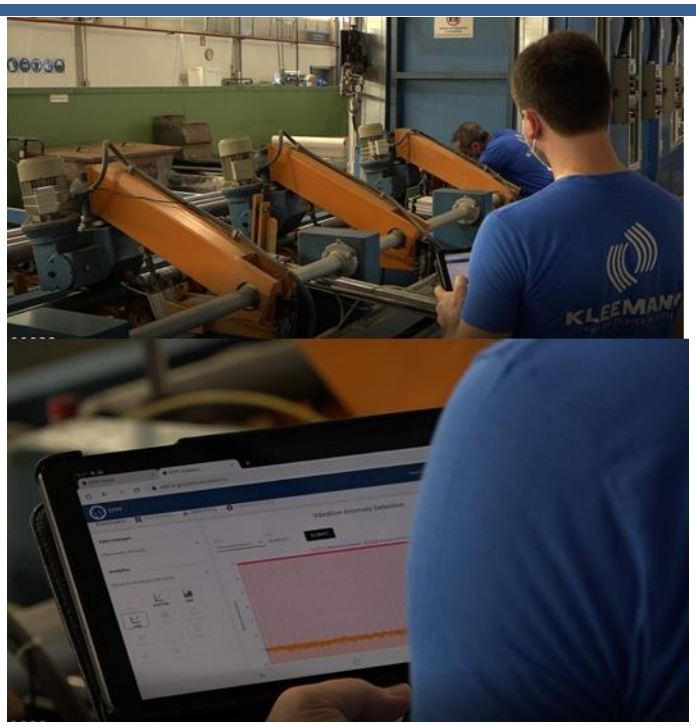


Figure 106: Solution is used in KLEEMANN Polishing Machine

Based on this first evaluation period the new solution, Vibration Anomaly Detection seems to be more sensitive and capture more outliers than the previously available solution based on behaviour analysis through Eigen values[4].

Continuous Experimentation and Validation Phase

Further validation was done from M29 to M46. After some months of every day operation and monitoring of the solution it was detected that the algorithm behaviour was not operated as expected. As the algorithm hasn't trained in a large amount of data couldn't provide by the beginning a stable and correct behaviour. However, the machine was evaluated and it was fine. Furthermore, the other available approach based on Eigen values didn't detect any abnormal operation by the polishing machine.

The issue was fixed by retraining the ML model with more data that were available at that stage. Furthermore, more on-site feedback has been given by KLEEMANN regarding the sensitivity calibration of the sensor, to avoid capturing vibration noise from other sources than the polishing machine. The sensors now capture only the polishing machine's activity.

[4] https://en.wikipedia.org/wiki/Eigenvalues_and_eigenvectors

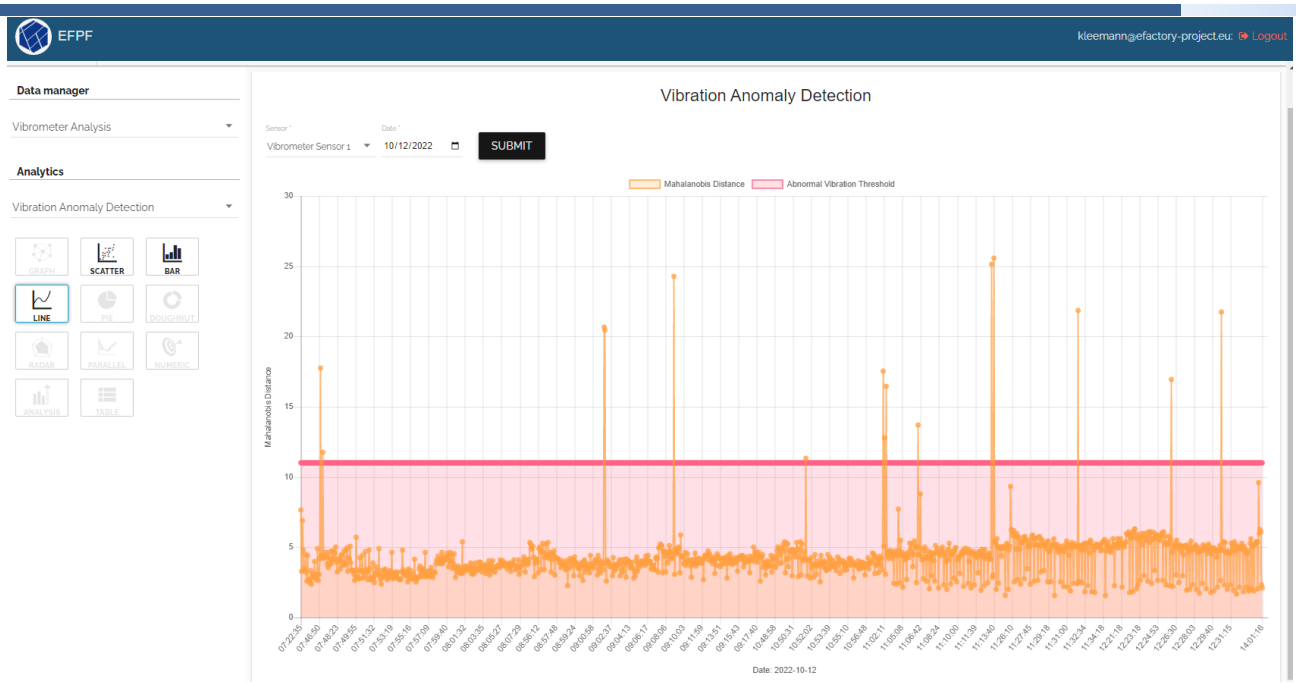


Figure 107: Screenshot of Real-time Machine Anomaly Detection at KLEEMANN

After that, the end-user confirms the correct operation of the solution that was further validated until M46. It was confirmed that the solution can detect any issues regarding to machine and polishing process operation. Anomaly points were detected and the Maintenance Manager was confirmed that they were faults that happened during the polishing process. The operators used different sizes of the pistons that were expected or place them faster in the machine than expected. Of course, the validation of the solution is continuous process as the solution has been adopted by company's maintenance department and relevant stakeholders.

3.2.4.3.3 Lessons Learned and Outlook

The proposed solution offers the following user value outcomes:

- Real time condition monitoring
- Failure predictions are available
- KPIs tracking in real-time

The Data Analytics solution (with a focus on predictive maintenance) was evaluated by target user KLEEMANN in its industrial real-world scenario and based on the actual user-based evaluations of the functional and non-functional aspects of the developed solution the following lessons are learned:

- The solution is a promising tool that is expected to improve maintenance management on the shop floor and allow for predictive actions to be implemented.
- The data is visualised and analysed in real time and this can be used by the maintenance manager to provide predictive maintenance actions rather than corrective.
- A key feature of the solution is that the threshold of abnormal vibrations can dynamically change and this strengthens the accuracy of the vibration data in relation to possible defects.

- The tool already detects some operational issues that occurs during polishing processes
- Of course, further testing is needed to analyse the vibration data and connect them to specific machine conditions

In addition to this solution, another approach based on Fusion and XAI is available to KLEEMANN users for the anomaly detection in the polishing machine based on vibration data. It comes from EFPF Open Call Experiment named XAI-FS by Atlantis Engineering. Of course, it is an early evaluation stage as it is available about a month so far. More details are available in the corresponding section of this report.

4 Open Call Experiments (OCE)

4.1 Short Open Call Description

4.2 Experiences from Open Call Experimentation

4.2.1 OCE 1: XAI-FS - Explainable AI Fusion Service for Predictive Maintenance (Atlantis Engineering)

4.2.1.1 Short Description

The XAI-FS project aimed at designing and implementing a solution that combines detection and prediction maintenance models within an intelligent fusion engine so to provide more accurate prediction/detection outputs and improved understandability on AI-based predictive maintenance solutions. The solutions inherited capacity to provide explainable AI capabilities (during the whole process) offering the user understanding and controlling of the process and enhanced trust to the solution and the result.

Project objectives

- To develop the XAI-FS solution and integrate it on the EFPF platform.
- To demonstrate seamless integration of the solution with the EFPF predictive maintenance services.
- To technically evaluate and assess the performance of the XAI-FS solution following a methodology which is aligned with the validation framework of the EFPF project.
- To build a business plan with focus on sustainability.

Technical Achievements

- In the XAI-FS solution the following components have been developed:
- Input Integration Service (Raw data collection, EFPF analytics data collection) has been developed by connected to EFPF Data Spine Message Bus
- Baseline models (Anomaly detection/prediction models, e.g. kNN, SVM, XGBoost, etc.) has been implemented/used
- Fusion Engine (Feed Forward NN, responsible for fusing the outputs of the baseline models) has been developed to fuse inputs by Baseline models
- XAI [5]module based on SHAP XAI techniques has been developed and it able to provide insights about feature importance and effects on the final output
- Output Integration Service (Responsible to post the results from Fusion Engine to EFPF DataSpine)

[5] XAI = Explainable Artificial Intelligence

- User Interface about the raw data measurements, visualization of the anomaly detection/prediction tool and plots for the XAI-FS module is available by adding the XAI-FS to EFPF Visual and Data Analytics tool

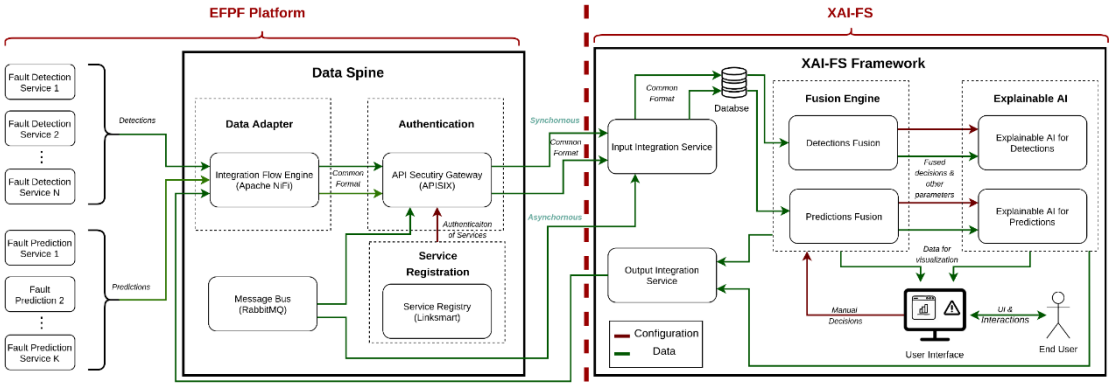


Figure 108: XAI-FS Architecture

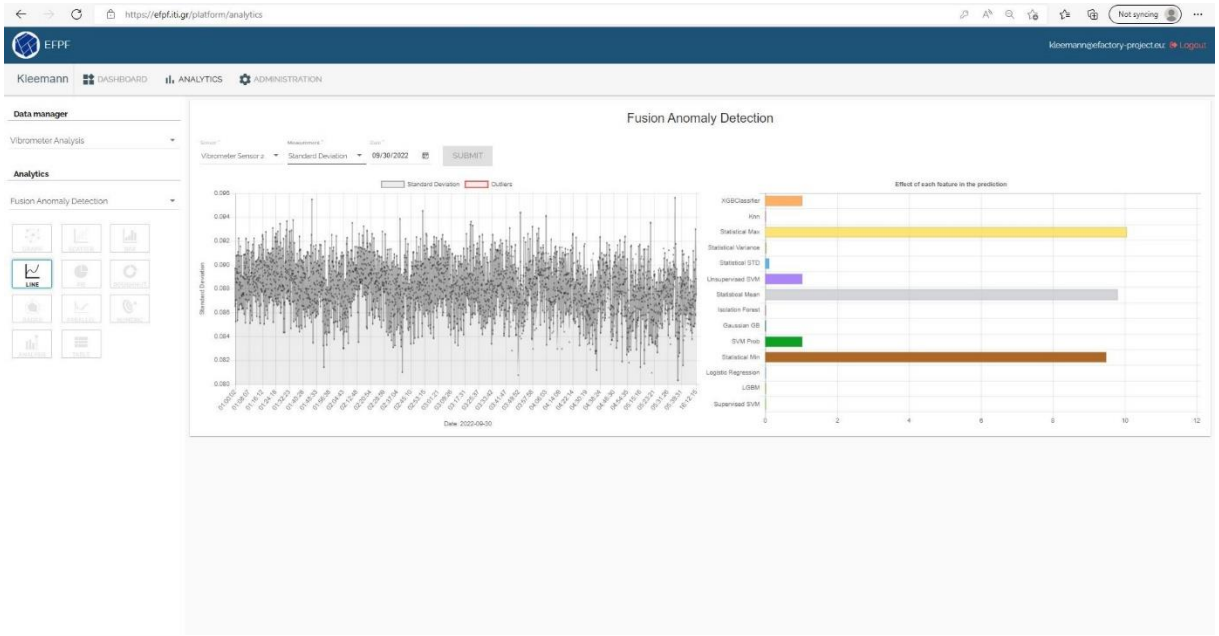


Figure 109: XAI-FS Application in EFPF KLEEMANN Pilot

4.2.1.2 Results, Lessons Learned and Outlook

Results

- A complete solution regarding XAI and ML models' Fusion has been developed and is available to EFPF Portal
- The solutions interfaces extend the EFPF Visual and Data Analytics tool and they are available to EFPF pilot partner, KLEEMANN
  - The solution was developed using both historical and real-time vibration data from KLEEMANN
  - The solution is available with other EFPF analytics service in the same dashboard and they are used and validated by the pilot partner in every day company's operation

- A detailed report including various KPIs and metrics (Accuracy, Precision, Recall, F1-score metrics etc.) of the fusion engine is available
- Demonstration video and plans for further exploitation are available

Lessons Learned

As it was mentioned above, EFPF real time vibration data was used and the tool is currently used by EFPF partner KLEEMANN. The access to EFPF Data Spine Message Bus was consider as an easy, well-documented and straight forward process. Some issues regarding the non-continuous data transmission were detected but, in the end, it was considered as a 'false alarm' because the polishing machine that produce the vibration data operates specific hours per day. The tool integration to Visual and Data Analytics tool was effortlessly done but it couldn't be done completely automatically without the effort of EFPF partners.

Regarding the validation of the tool by KLEEMANN it is an in-progress activity as the tool was available in the end of August 2022 and the validation of real time anomaly detection services requires more time. By now, the interfaces of the tool are considered to provide the right level of details regarding the real-time anomaly detections. Regarding XAI interfaces, some more diagrams could be added. Also, this interface seems to be more for KLEEMANN's data analysts and not for machine's operators.

Outlook

- Very positive thoughts towards EFPF ecosystem and intentions to exploit the EFPF Platform and eyeing future collaboration with both technical and pilot partners
- Interaction with EFPF analytic tools and Data Spine strengthened company's technical know-how.
- Actions like the exploration of XAI for manufacturing industry, the development of anomaly detection models and the delivery of an end-to-end solution for real scenarios contribute to strengthen further the company's presence in Industry 4.0 domain
- High quality of mentoring and supporting services by EFPF

4.2.2 OCE 2: Ceramics 4.0 (Sabanci University)

4.2.2.1 Short Description

Building upon the current framework of EFPF, the project generates an automated route for the green machining of yttria-stabilized zirconia (YSZ) since the translation of ceramics manufacturing to Industry 4.0 significantly lags other materials. Therefore, the project aims to bring the green machining of ceramics as a forefront showcase for the integration of high-performance ceramics to EFPF. For this purpose, a mobile app, process and material databases, physics-based simulations for the selection of process parameters have been developed for smart manufacturing of ceramics on EFPF.

Project objectives

- Create model-based datasets for process parameter selection
- Monitor the process for continuous improvement and consider a holistic approach for the planning of rapid manufacturing by accounting interaction among different manufacturing processes
- Work towards 100% recyclability of materials
- Initiate an open process and material database for green machining

Technical Achievements

- Laser cutting parameters for magnesium oxide in addition to yttria-stabilized zirconia and
- Volumetric simulations and process monitoring based on given shrinkage information
- Mobile app for visualizing the toolpath and analysis of cutting forces after FFT (Fast Fourier Transform)

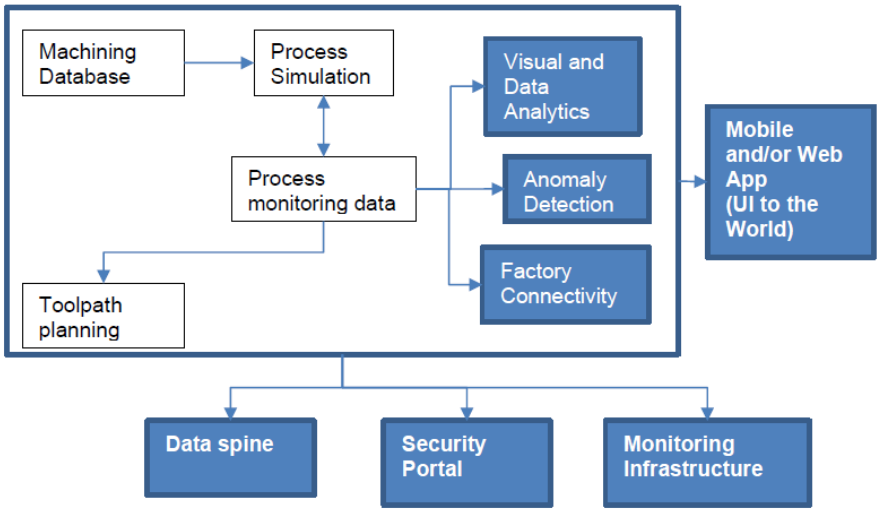


Figure 110: Ceramics 4.0 Architecture

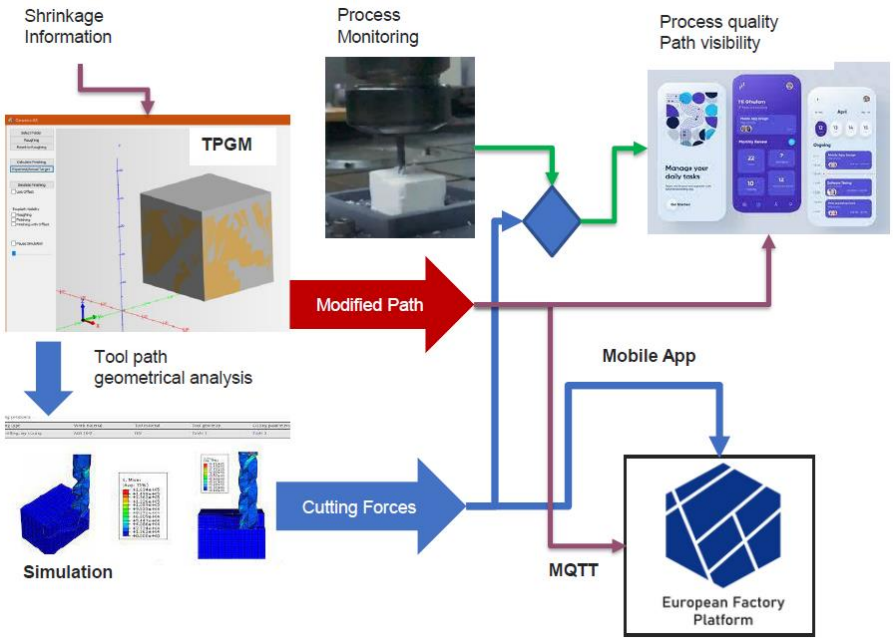


Figure 111: Application Flow

4.2.2.2 Results, Lessons Learned and Outlook

Results

- Parameterization of laser machining at the green state for different ceramics
  - The tool path computation time is competitive with the existing CAD/CAM packages. In general, the tool path computation is finished less than 30 seconds
  - The developed module can handle tool path accuracy up to 1 micron, which is suitable for the geometries aimed in the project
- Achieved high performance for circularity:
  - Use of scrap ceramics is more than 90%.
  - It has been concluded that 50% of the powder can be used without any deterioration in the part quality
- Analysis method for cutting forces to assess process quality

Lessons Learned

Due to the parametrization of laser machining at the green state for different ceramics, new collaboration opportunities with industry were obtained to transform their current ceramics processes on a fee-basis. Demonstration of easy machining of ceramics to the industry led to low force machining, the tool life is improved and hence tooling cost can be decreased. Moreover, they also learnt that part distortions can be minimized, helping in achieving accurate part manufacturing.

Outlook

- They will continue to use EFPF tool and services beyond the scope of their project
- Highly passionate and active in demonstrating EFPF project and Ceramics 4.0 outcomes
- Willing to be a part of EFPF network

4.2.3 OCE 3: Sentient (Digiotouch)

4.2.3.1 Short Description

The project SENTIENT enabled the creation and management of smart contracts exploiting several components offered by EFPF.

Project objectives

The specific objectives of the project were:

- Enable creating ad-hoc supply network with blockchain powered smart contracts.
- Providing real-time holistic view of the production state using an Android app.
- Develop a SaaS business model tailored to manufacturing companies.

Technical Achievements

- Platform integration of an ANDROID front-ed and a back-end exploiting smart contracts and blockchains.

4.2.3.2 Results, Lessons Learned and Outlook

Results

An integrated architecture supporting SMART contracts.

The prototype is composed of both the Android app and the service backend components developed in the project. These are shown in the SENTIENT architecture (Figure 112) below (already reported in D1.1).

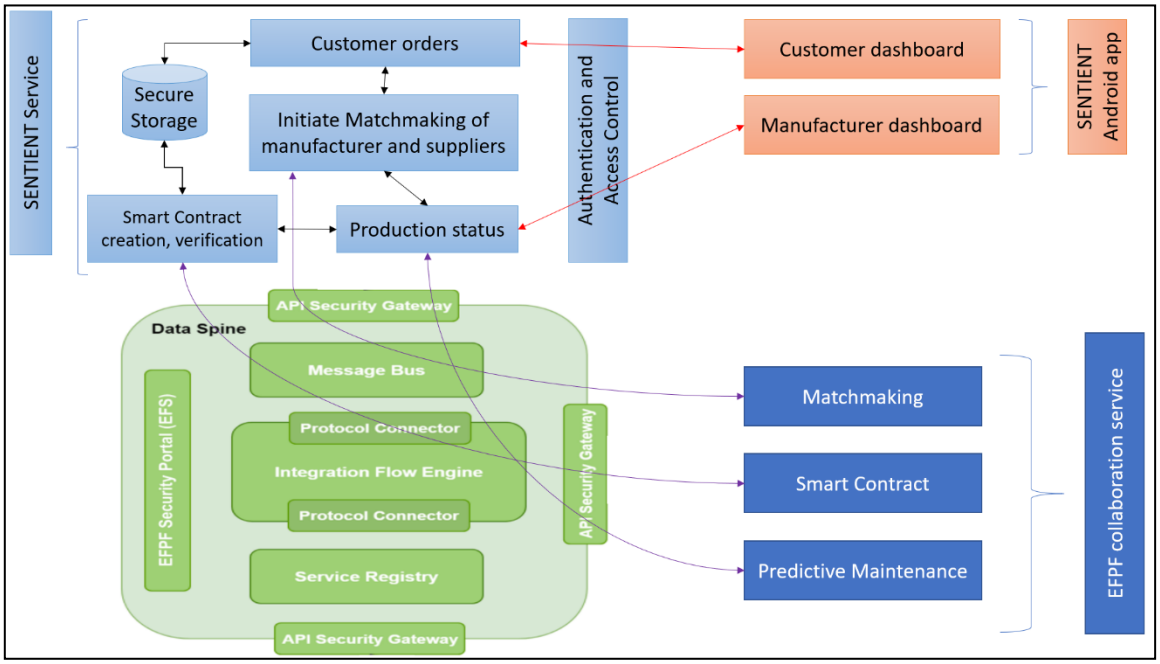


Figure 112: SENTIENT service backend and Android app shown in the overall architecture

Digiotouch has utilised two well-known methodologies – agile and secure software development lifecycle (SDLC) - for the technical work reported in this deliverable. A summary of SDLC is provided below.

Lessons Learned

All the intended goals and KPIs were achieved. There were no significant workplan deviations.

Outlook

The customer interface is dedicated to the end users of the SENTIENT solution intending to buy lot-size-one (LSO) product. The supported functionalities are –

- Authentication (sign up and log in as well as resetting password)
- Viewing products for which personalisation can be obtained (This is basically all manufacturers who are offering LSO products)
- Placing an LSO product order, receiving a price quotation from the manufacturer
- Secure payment of the order that is accepted by the manufacturer and setting a preferential data of delivery
- View current state of order previously placed (i.e., order place, order confirmed, payment successful, pending payment, or production status etc.)
- Coordination of delivery of the LSO product

During the prototype implementation and testing (performed in the last three months of the project), more emphasis has been provided on the customer interface of the mobile app. This is done so because of developed business model for commercialisation which will focus more on functionalities described above on the customer interface.

The above features are shown with screenshots from the Android app below –

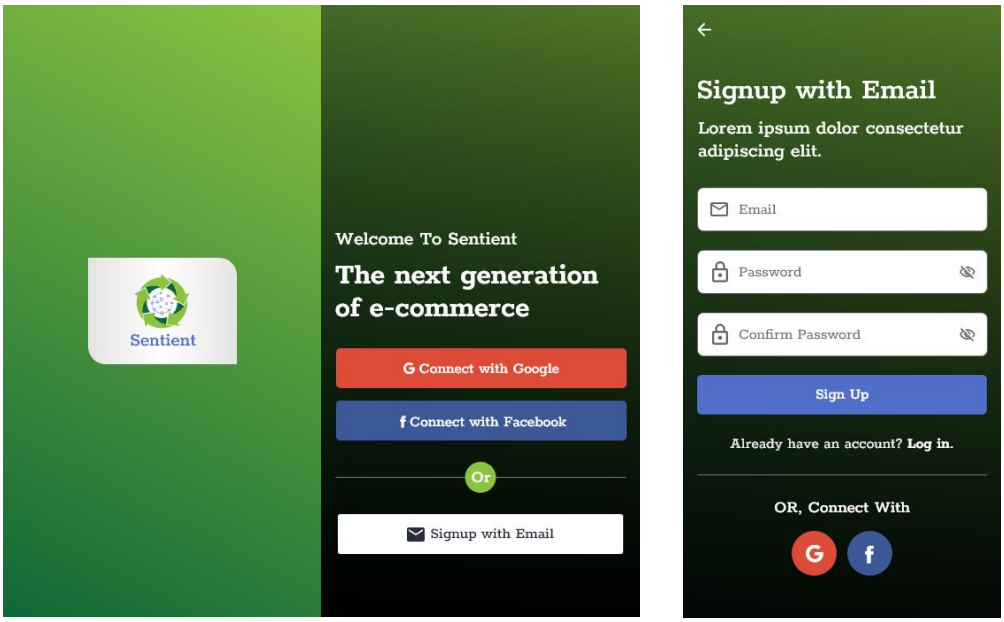


Figure 113: Sign up screens

For the sign-up step, single sign-on with Facebook and Google accounts are offered along with sign up with an email address and password. For the final prototype demonstration, the second method has been followed.

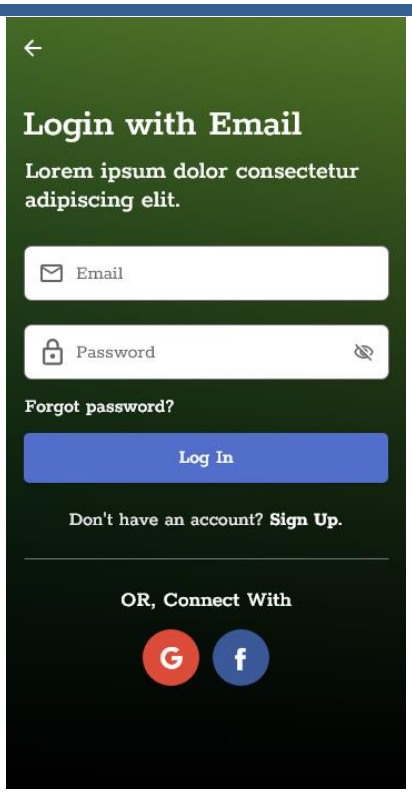


Figure 114: Log in screen

Like the sign-up process, the log in screen supports logging in with Facebook or Google account along with an email-based log in. For the demonstration of the final prototype, a combination of email address and password is used for log in.

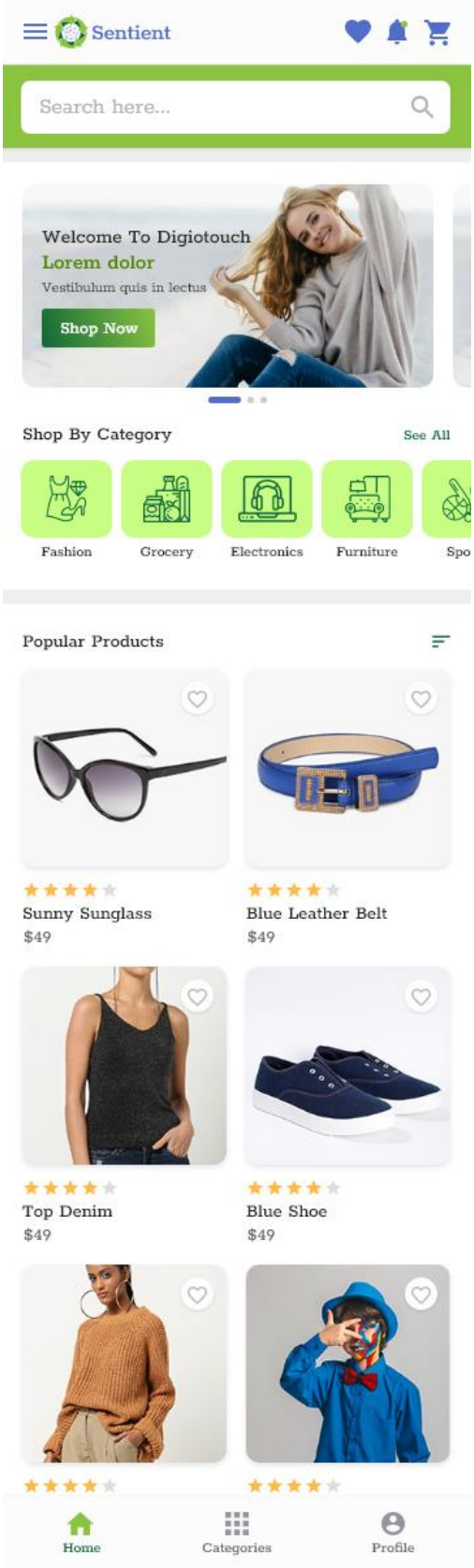


Figure 115: Home screen of the SENTIENT mobile app

Following a successful log in, the home screen of the mobile app shows the products that can be purchased through the SENTIENT platform (which acts as a digital marketplace in this case).

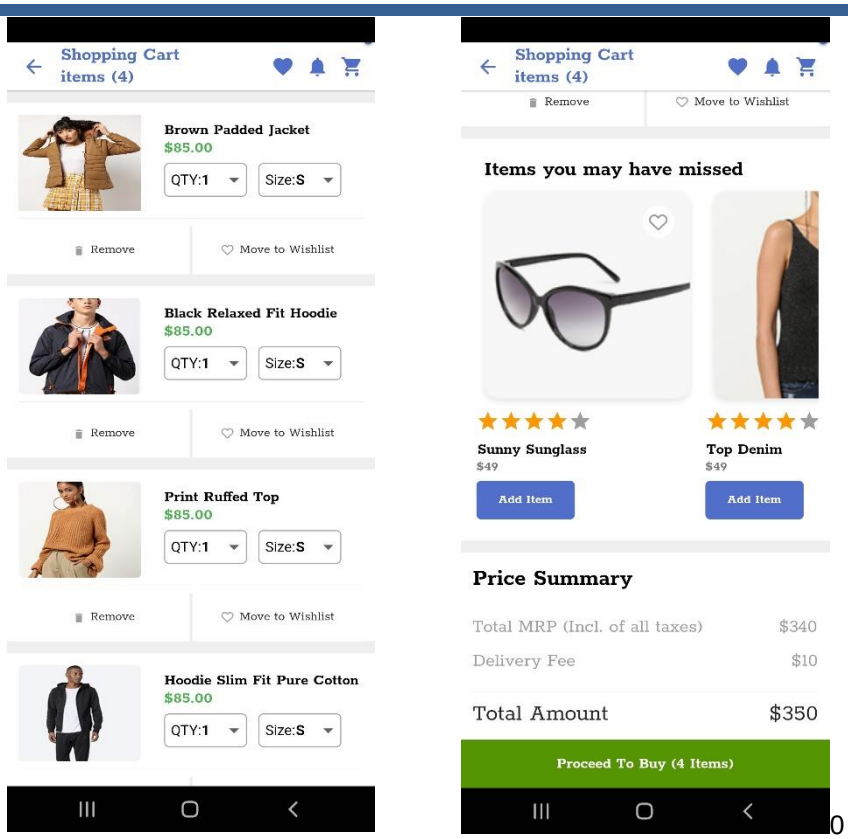


Figure 116: Shopping cart

Once the user has selected items to buy, they are added to the cart. The customer can review the card, add more quantity, remove any item, and make payment[6].

[6] Note that integrating a payment gateway for commercial transactions through the SENTIENT app is out of the scope of this project.

4.2.4 OCE 4: TeamCreator (Digital Systems 4.0)

4.2.4.1 Short Description

This project develops and integrates a TeamCreator module in the EFPF Platform. The module is based on the Team Composer (TDMS) output from the DIGICOR project, one of the four base EU projects in EFPF. TeamCreator provides a semantic search service that uses "Semantic Spine", enriching the EFPF Data Spine with ontology-encoded knowledge. TeamCreator supports (a) searching for a team of suppliers who can jointly provide a product when a single supplier cannot be found, and (b) creating a team capable of responding to a tender.

Project objectives

- Add a semantic matchmaking module to EFPF
- Use Federated Search to retrieve companies and tenders
- Create teams of companies which can bid for a tender

Technical Achievements

- All modules delivered and integrated within EFPF with SSO
- Lack of detailed semantic information in EFPF circumvented
- Includes secure API for EFPF to retrieve information from TC

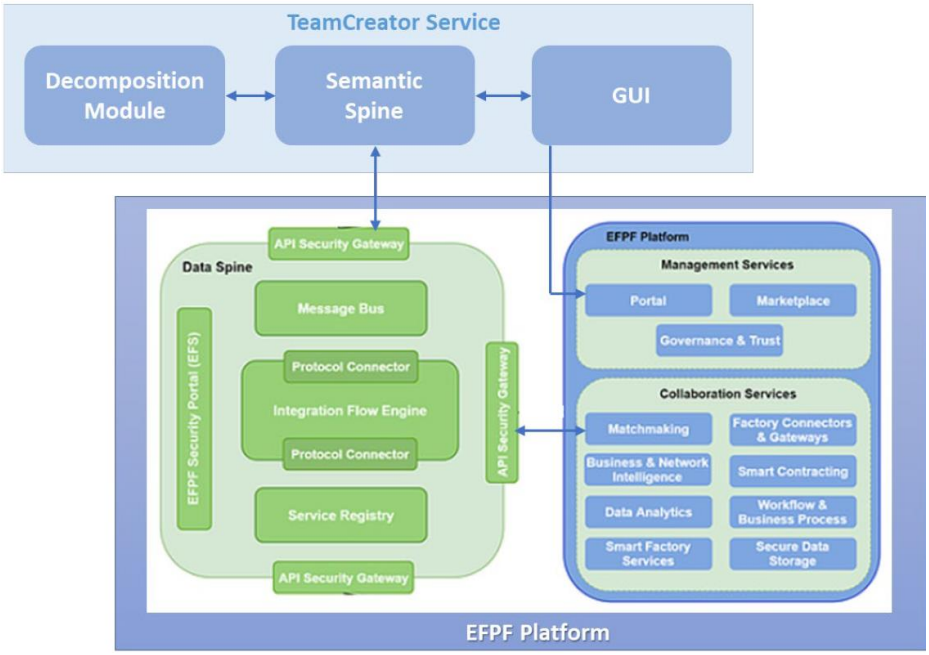


Figure 117: Architecture of the solution “TeamCreator”

4.2.4.2 Results, Lessons Learned and Outlook

Results

- Pass rate for integration tests with EFPF: 100%
- Proportion of teams validated by business domain experts as viable: 90%, but further tests will take place

- Integration tests of Semantic Spine and Data Spine: 100%
- User satisfaction with the Team Creator user interface: Currently 85%, but further tests will take place when real data sets are available

Lessons Learned

All the intended goals were achieved. There were minor deviations in the original schedule. These were since extensive coordination at the technical level with the EFPF development team was necessary to ensure the Single Sign On function and the use of Federated Search. In addition, the ontology of the necessary data was discussed, as well as the behaviour of the EFPF platform towards potentially interested companies if they were not previously active on the platform but wanted to use the TeamCreator tool. All issues could be solved with practicable solutions. The development work was quite successful and the support by the EFPF team has been brilliant.

Outlook

- Considering status of service vis-à-vis EFF
- Potential synergies with EFPF
- Increased market penetration (6%) in automotive and aerospace segments
- Seeking pilot (reference) install

4.2.5 OCE 5: BBi4.0 (EURECAT)

4.2.5.1 Short Description

BBI4.0 project developed signal processing modules bounded with data-driven Virtual Sensors and novelty/anomaly detection Machine Learning solutions for the manufacturing industry. The project has developed user-friendly tools to work with numerical algorithms that usually require a background knowledge not available in most manufacturing SME companies. BBI40 is designed and executed by the Applied Artificial Intelligence (AAI) Unit of Eurecat Technology Centre. AAI develops innovative solutions based on a combination of artificial intelligence and knowledge management technologies, especially for the industrial, energy and sustainability sectors.

Project objectives

- Design and develop a signal processing module and solutions customized to manufacturing sensor data.
- Design and develop anomaly detection Machine Learning (ML) and Deep Learning (DL) based solutions for Predictive Maintenance (PM) applications.
- Development of Virtual Sensors (VS) for vibration data to better understand the stability of the system and its change with time.
- Demonstrate and validate the BBI4.0 solutions developments through bespoke solutions for specific pilot datasets (both EFPF and EUT data).

Technical Achievements

- The Analytics Platform is responsible for executing and coordinating the different jobs.
- It includes one Analytics Component for each presented solution.
- The system exposes a User Interface as frontend component.
- SSO token verification from EFPF implemented in the Platform to assure secure login.
- Possibility to connect to pub/sub EPFP topics to receive data and publish the outcomes in the dedicated topic.
- The tool is directly integrated in the EFPF portal and can be deployed at EFPF user own servers.

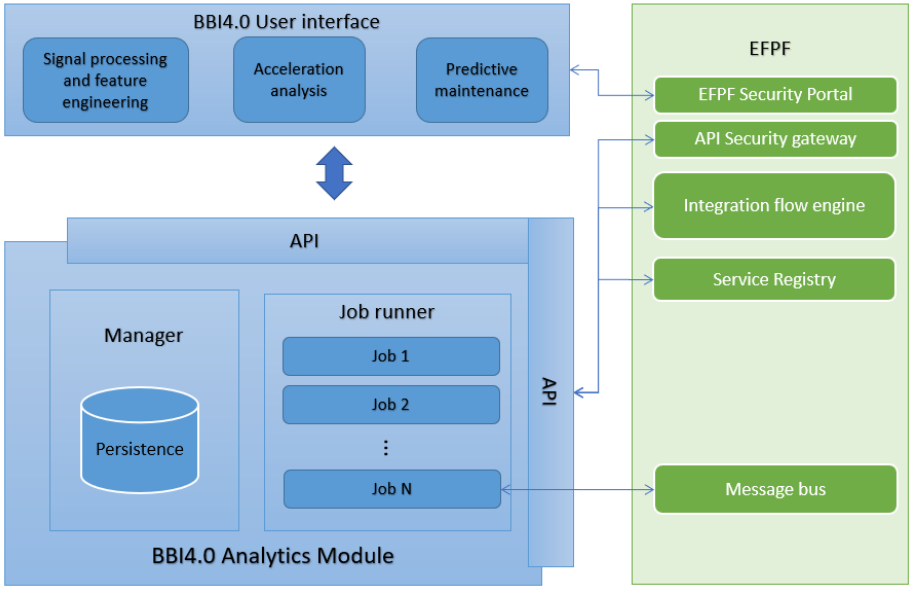


Figure 118: Architecture of the solution “BBi4.0”

Figure 119: Example of the result page for the signal processing component.

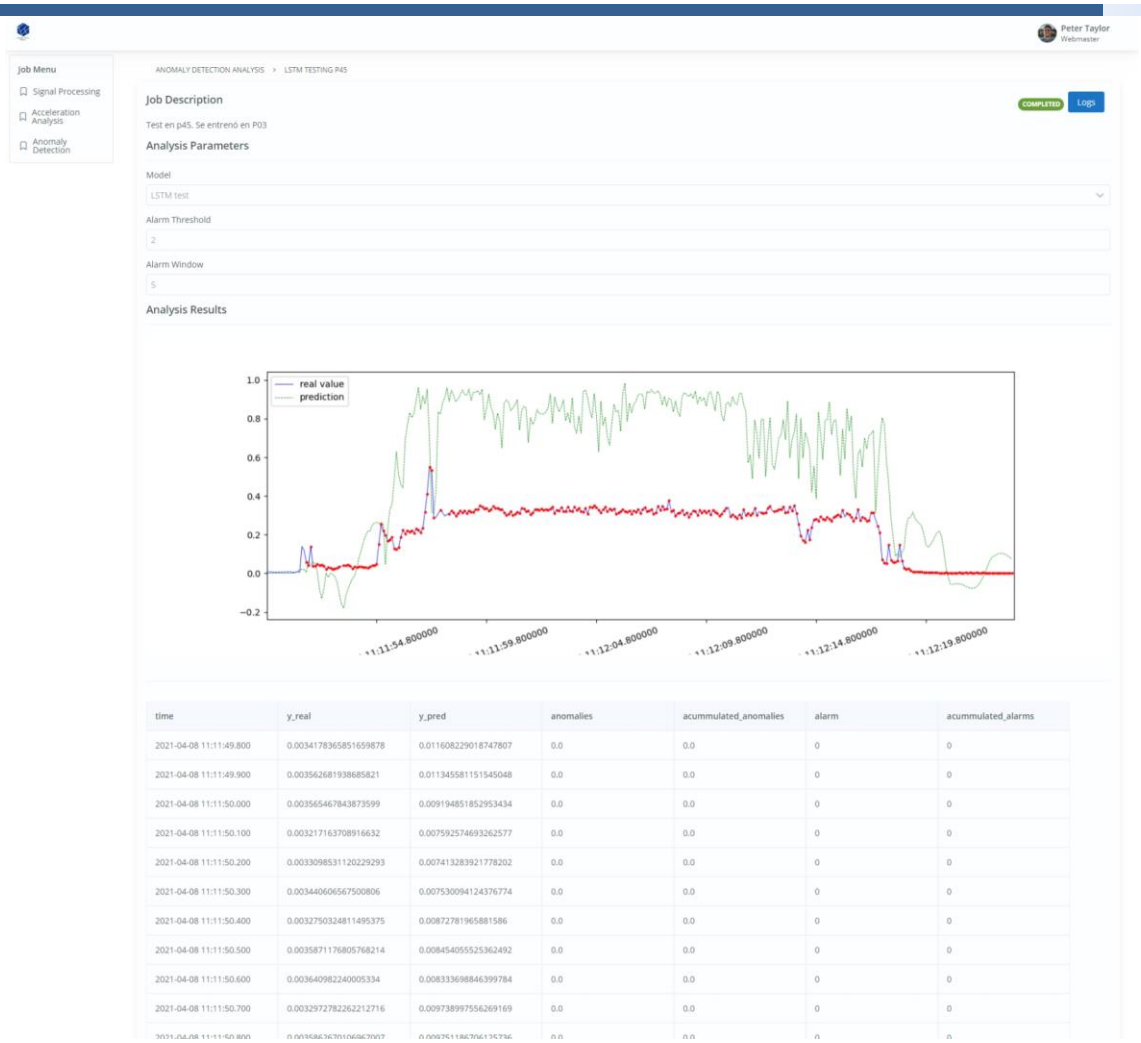


Figure 120: Result of the prediction of anomalies identified with the anomaly detection component.

4.2.5.2 Results, Lessons Learned and Outlook

Results

- Integration with the EFPF platform using the Data Spine via MQTT messages and integrating the SSO via token verification.
- Achieving the development of the proposed components.
- Possibility to identify anomalous behaviours in measured time-series data for business processes.

Lessons Learned

The main intended goals were achieved thanks to the interaction with the EFPF platform and community. The development of a cloud application to synthesize some of our work gave us a new experience useful beyond the EFPF scope. Some parts of the platform could not be finalized in the project length, but the early interaction allowed the project team to monitor the evolution of the platform, which has been very positive. The figure of the supervisor was very helpful to facilitate the interaction with the different EFPF project partners and became key for the success of the project.

Outlook

- Some issues about the commercialization plan were still open so they depend on different exploitation aspects to be refined.
- Some bugs could be found by early adopters, requiring a quick response from the project side to solve any incidence in the service.
- The project development has raised potential collaboration points with EFPF.

4.2.6 OCE 6: ReScrapIt (Future Intelligence)

4.2.6.1 Short Description

ReScrapIt project was focused on the development of a new Digital Scrap Item (SI) Catalogue Service for the optimum destination of industrial Scrap Items. The Main idea/concept was that the Industrial SIs/waste are managed in a time-consuming and inefficient way. Therefore, ReScrapIt provides a tool for efficiently managing the SIs, by offering the optimum destinations possible, with respect to the SI features and criteria. The solution uses EFPF Data Spine parts and it is available through EFPF portal.

Project objectives

- Contribution to next generation manufacturing systems and Industry 4.0 with respect to recycle, reuse and safe disposal of old/defective equipment or products, raw materials and waste
  - Supporting Circular economy
  - Offering environmental benefits
- New service for the EFPF platform
  - Attractive to new & existing customers

Technical Achievements

- ReScrapIt: new offering in the EFPF
- New Digital SI Catalogue Service
- Web-based User-friendly Interfaces
- Classification Algorithm that is applying a set of functions that encapsulate the logic of rules. These rules decide on the eligibility of an SI for a specific destination that is suggested to end user
- Backend solution & API descriptions available

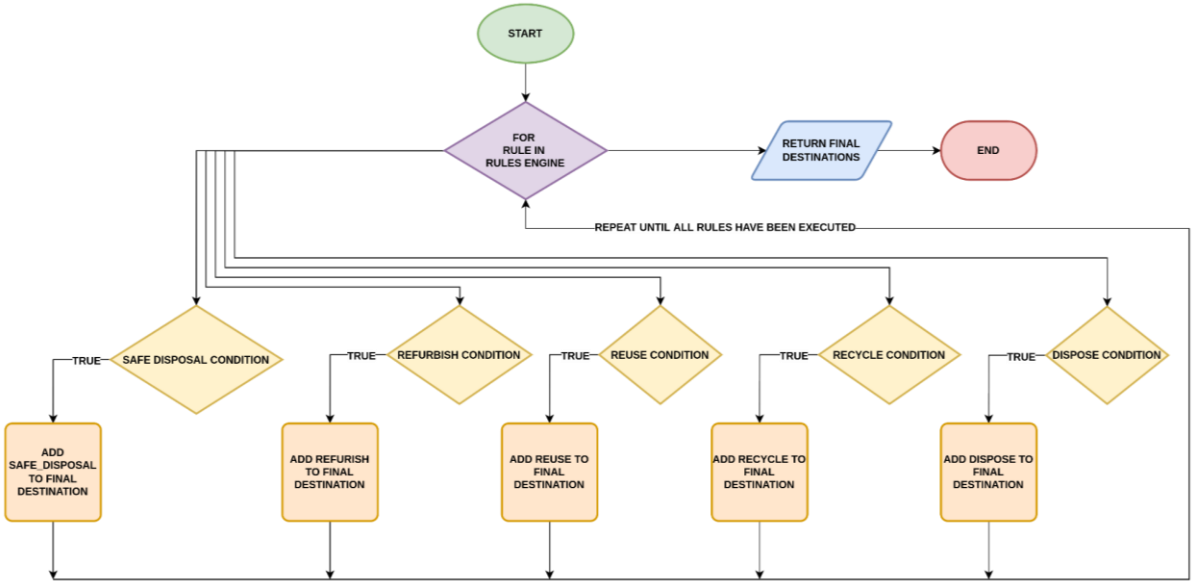


Figure 121: Algorithm rules engine logic flowchart

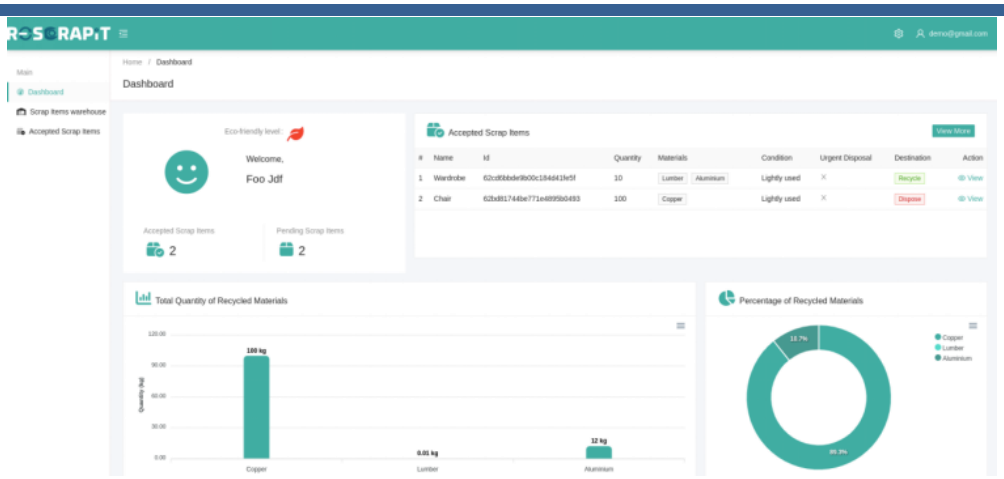


Figure 122: ReScrapIt Main Dashboard

4.2.6.2 Results, Lessons Learned and Outlook

Results

- A complete solution/marketplace for scraps available to EFPF with the ability to provide the best handling strategy regarding the scrap items
- Automated solution for safe disposal of scrap items offering time & cost savings
- Optimised destination choices based on environmental friendliness, cost, safety, etc. so to better motivates manufacturer's environmental awareness
- Over 70% success factor of the algorithm's decision regarding the correct destination of the SI, when the algorithm has been trained using various data sets.
- Validation of the application by EFPF CE pilot partners by real use of the application and provision of feedback
- Demonstration video and plans for further exploitation

Lessons Learned

As it was mentioned above, EFPF CE pilot partner evaluate the ReScrapIt tool. The tool was Easy to use tool as the functions and capabilities of the tool are well visible and usable. The users were feeling confident and comfortable while using this tool. The Scrap Item eco-friendly level is a very useful information as it can be used by end-users as an environmental criterion for business development, supplier selection etc. Besides this, EFPF user suggested the addition of functionalities like (a) the group info in time periods (1 month, 3months or 1 year) in the main dashboard, (b) the "View scrap item" should be exported as a PDF report and (c) the addition of a tab: "material images" to evaluate (at a photo level) the declared condition (lightly used, mediumly used, new etc.).

Outlook

- Very positive thoughts towards EFPF ecosystem and intentions to exploit the EFPF Platform and eyeing future collaboration
- Strengthening company's presence in Industry 4.0 and Supporting company's position in the EFPF/EFF ecosystem by the opportunity to promote our ReScrapIt solution
- Strengthening company's technical know-how (algorithmic, integration with Data Spine, etc.)

4.2.7 OCE 7: DAWN: Data-driven service for quality monitoring and Assessment in robotic arc WeldiNg for steel joints of industrial components (Lortek Coop)

4.2.7.1 Short Description

The main objective of DAWN is to develop an intelligent weld quality monitoring and evaluation data-driven system for fusion-welded steel parts to overcome current limitations of the industry and boost zero-defect manufacturing.

Project objectives

- Develop a real-time process data acquisition system using IoT.
- Develop an advanced platform for process data visualization.
- Add Data analytics and process modelling functionalities in the system to correlate main welding process parameters (i.e. current, voltage, wire feed speed) with the external quality of the weld, i.e. geometric characteristics of the weld bead (e.g. height, width, contact angle).

Technical Achievements

- Data acquisition, based on a Beckhoff acquisition card with PROFIBUS to get data (external sensors, energy source, robot) with a queue system and publish to EFPF data spine.
- AI module, to provide the correlation between welding geometry and process data.
- User interface based on Django and plotly[7], to provide real-time and history process data visualization, and to emit alarms (via the EFPF anomaly detection module).

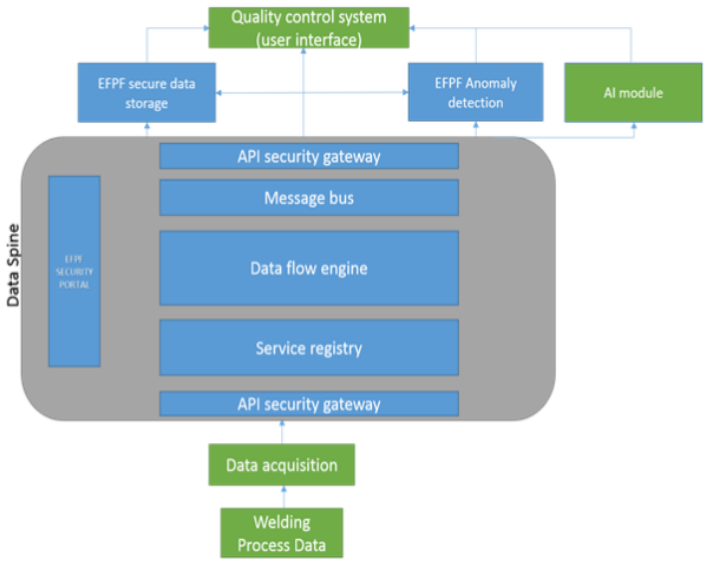


Figure 123: DAWN System Architecture.

[7] https://readthedocs.org/projects/django-plotly-dash

4.2.7.2 Results, Lessons Learned and Outlook

Results

- Quality control predictive algorithm reached an accuracy of 90%.
- Achieved efficient data collection with a data frequency of 1/ms data.
- Reduction of manual quality inspection processing time at least of 50%.

Lessons Learned

The overall EFPF components were easy to configure and allowed an easy plugin of the proposed solutions. The anomaly detection module is highly relevant and has a very intuitive interface. The NIFI data flow engine had some limitations during the open call, but the response time to failures has been reasonable and allowed to deal with issues detected.

Outlook

- Components developed by Lortek will be registered for IPR protection.
- The developed components, supported by EFPF components, are already being applied in other research projects.

4.2.8 OCE 8: ExtraCash (MASTA)

4.2.8.1 Short Description

The project develops a solution supporting lot-size-one manufacturers in getting near real time insights into their production schedule and helping them to expose the order status, production capacity and machines capabilities to their existing and future customers. The solution is a cloud-based with web-app deeply embedded in the EFPF framework and offered via the EFPF marketplace.

Project objectives

- Develop software components for exposing the production status, capacities and capabilities of a manufacturing company developed and tested in near-industrial settings
- Validate the technological and business assumptions both in terms of the usability of the developed features and the market response to the proposed solution
- Access to the well-established innovation ecosystem of EFPF

Technical Achievements

- Single sign-on with the EFPF identity
- Scheduling component with the Earliest Dates algorithm maximizing efficiency of the equipment with respect to constraints like available capacity of all required resources considering available technological dependencies, alternatives, and shop floor situation
- Execution tracking by receiving Work Journals from the shop floor both human and robotic agents
- Visualisation of the capacities of the machines park on Gantt chart updated in near-real time
- Alerting mechanism informing about changed expected delivery dates by any defined communication channel

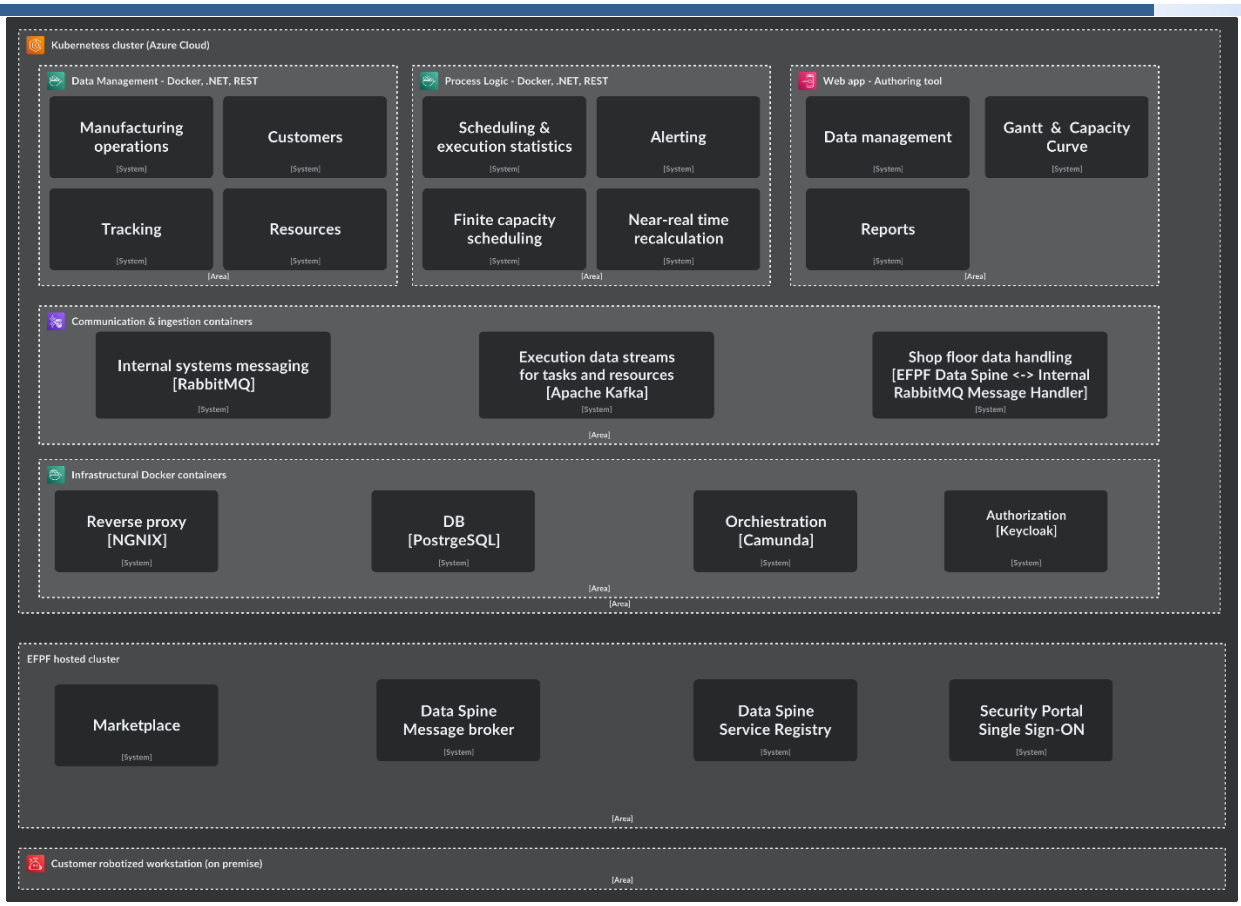


Figure 124: Component landscape and architecture

4.2.8.2 Results, Lessons Learned and Outlook

Results

- Integrated with two different machines (a bender and a saw) directly reporting work order progress
- Ability to react to the shop floor situation and update the lead time estimate in near real time
- Monitor and expose the status of an existing order to the client
- Promotional video highlighting the results of the project

Lessons Learned

To control the computing resources for every processing step implemented in the component, MASTA realized that it is critical to migrate component from initially implemented monolith to fully modularized event driven microservice architecture. Moreover, to ensure code stability, they introduced unit tests, integration tests and end-2end tests. For a fault tolerant and consistent message delivery, the optimal QoS (Quality of Service) setting was identified as 1 while using the EFPF Message Bus. Additionally, by analysing the interactions with their customer, they have realized that selling this class of software only through digital channel is valid only for the customers who are aware of their needs and have previous experiences with Manufacturing Operation Management software. Customers who are still struggling with digitization of manufacturing process needs to be

acquired by the traditional channel and physical sales process. Additionally, the communication for both groups needs to be differentiated.

Outlook

- Very positive thoughts towards EFPF ecosystem and intentions to exploit the EFPF Platform
- Increase in prospects coverage after the project implementation
- SaaS (Software-as-a-service) business model built on EFPF Integrated Marketplace

4.2.9 OCE 9: d2ProcessHealth (Nissatec)

4.2.9.1 Short Description

Project objectives

- Main objective is to provide an EFPF-enabled solution, d2ProcessHealth, for process health self-assessment based on existing EFPF services and data, enabling manufacturing companies, esp. SMEs, a deep dive in process behaviour analysis.
- Tangible outcome is a service for performing process behaviour analysis based on past process data which can be used as a self-assessment test by manufacturing SMEs
- Close the gap between data analytics and process analysis, which is one of the most important challenges for realizing data-driven economy

Technical Achievements

There are two types of process health analysis:

- Off-line analysis, focused on past data
- On-line analysis, focused on real-time data

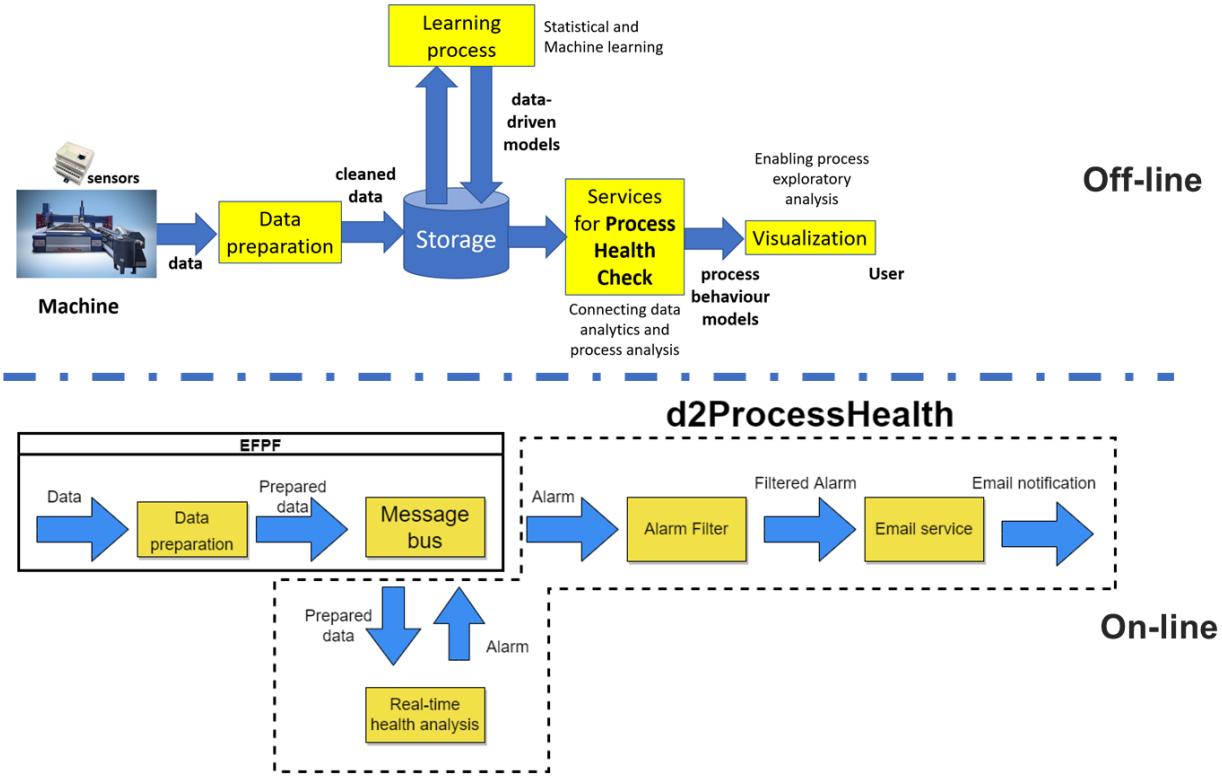


Figure 125: Types of Process Analysis

4.2.9.2 Results, Lessons Learned and Outlook

Results

- KPI1. Process-understanding: it is a user-driven validation, where a user will validate the soundness and completeness (KPIs) of information provided in health assessment.

- KPI2. User experience: since the users should interacts with the system intensively, it is very important to measure user satisfaction.
- KPI3. Business value: it is related to the added value for a business user (process owner). This KPI is related to the improvements which are enabled by our service.

Lessons Learned

- Very well-organized mentoring process
- Very efficient reporting process
- Enough freedom for own development
- Very suitable for boosting innovations
- NEW healthy check approach
    - Beyond the quality check
    - Sustainability monitoring and control

4.2.10 OCE 10: TANGO (Xgility)

4.2.10.1 Short Description

This project develops and integrates a distributed and operational planning system, called TANGO, in the EFPF Platform. TANGO allows users to create plans that involve multiple entities and systems. All plans can be designed and monitored through an intuitive GUI. TANGO supports (a) design and monitoring of plans involving multiple activities (b) allocation of activities or tasks to different collaborators and systems, (c) gathering updates from human collaborators through secure interfaces concerning assigned tasks, (d) gathering automated system updates concerning assigned tasks through EFPF Data Spine-based connectivity and interoperability

Project objectives

- To deliver an operational planning system (TANGO) that is validated (both in terms of functional and non-functional aspects) in real-world supply chain scenarios
- To enable companies to design collaborative plans and share real-time status of planned activities within security and privacy constraints
- To integrate the developed system in the EFPF federation and offer through EFPF Portal for wider reach and recognition
- To develop innovative business models that support the exploitation of TANGO towards different types of users/customers
- To introduce TANGO in the target market (manufacturing SMEs) by taking advantage of the EFPF dissemination and communication activities

Technical Achievements

- Fully functional TANGO solution delivered and integrated within EFPF with SSO
- Achievement of all relevant KPIs through testing and validation activities

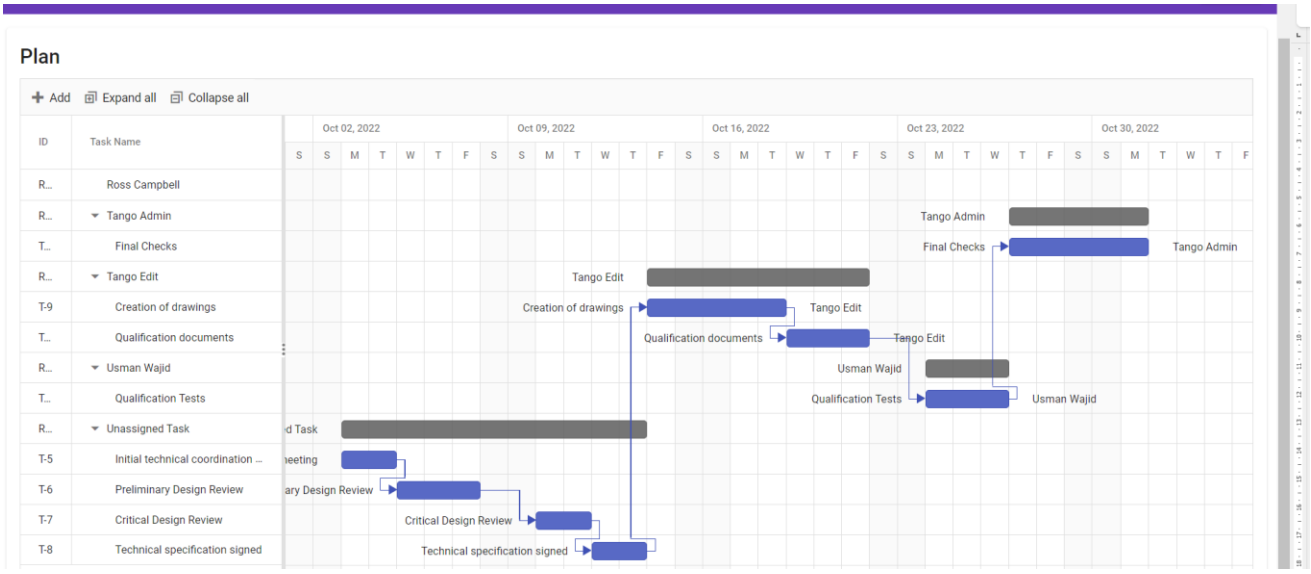


Figure 126: Sample Interface of the TANGO solution

4.2.10.2 Results, Lessons Learned and Outlook

Results

- Design, storage, execution and monitoring of plans with multiple collaborative companies/partners
- Parallel execution of multiple plans while preserving the integrity and privacy of users e.g. plans can only be shared and updated by specific users
- Scheduling and real-time tracking of multiple tasks assigned to different partners through intuitive interfaces
- Testing and validation of TANGO functionality involving users >=4
- Integration with >=4 EFPF components/services (e.g. Data Spine, Portal, Security Portal, and Marketplace)
- Success rate of integration tests = 100%

Lessons Learned

TANGO is developed as an operational planning system that can assist manufacturing supply chain companies in managing their operations in a more transparent and reliable approach. Both Xgility and EFPF teams gained experience and know-how through this project. On one hand, the solution is developed in assistance with the EFPF teams as it uses core EFPF components (such as Data Spine and Portal) to enable interconnectivity, interoperability and unified access to different types of users. On the other hand, the EFPF team learned about the different type of Data Spine usage scenarios as well as the distributed planning functionalities that can enhance the existing offerings in the EFPF platform.

Outlook

- Continued provisioning of TANGO in the EFPF platform
- Potential synergies with EFPF on new functionalities and extensions
- Increased market penetration of TANGO in EFPF pilot sectors
- Knowledge exchange and collaborations on future research and innovation initiatives

4.2.11 OCE 11: PREMAR (CTAG/CABOMAR)

4.2.11.1 Short Description

The PREMAR "Monitoring, Analytics and Predictive Maintenance of Machinery in CABOMAR" aims to prevent machinery failures in the fish processing industry. Fish and seafood refrigeration and manufacturing is a harsh environment: humidity and aggressive water are everywhere, and machinery suffers from high rates of unexpected failures, disrupting production and causing large losses. As a solution, CABOMAR and CTAG aimed to integrate EFPF into the line, validating the tools and sharing lessons learned with the community. The goal was to improve machine reliability in a harsh manufacturing environment by validating the EFPF core and the monitoring and data analysis tools.

Project objectives

- Integration of the EFPF tools for the prevention of existing failures in selected machinery of CABOMAR to improve its reliability the manufacturing environment.
- Validation and testing of EFPF tools for integration and interoperability, especially considering the EFPF data spine and the interface with one machine.
- Validation and testing of factory connectivity (monitoring), real time anomaly detection (data analysis) and predictive maintenance in one machine.
- Performing of valuable dissemination activities, at least through four relevant events.

Technical Achievements

- To meet the predictive maintenance objectives, the EFPF Data Spine as EFPF core component has been adopted.
- For data analytics, the Real Time anomaly detection tool has been experimented.
- Furthermore, the predictive maintenance has been performed using the ROAM, Visual Data Analytics and Deep Learning Toolkit.
- A local server at CABOMAR collects data from the machine.
- The functionalities are directly provided by the EFPF cloud where all components are served.

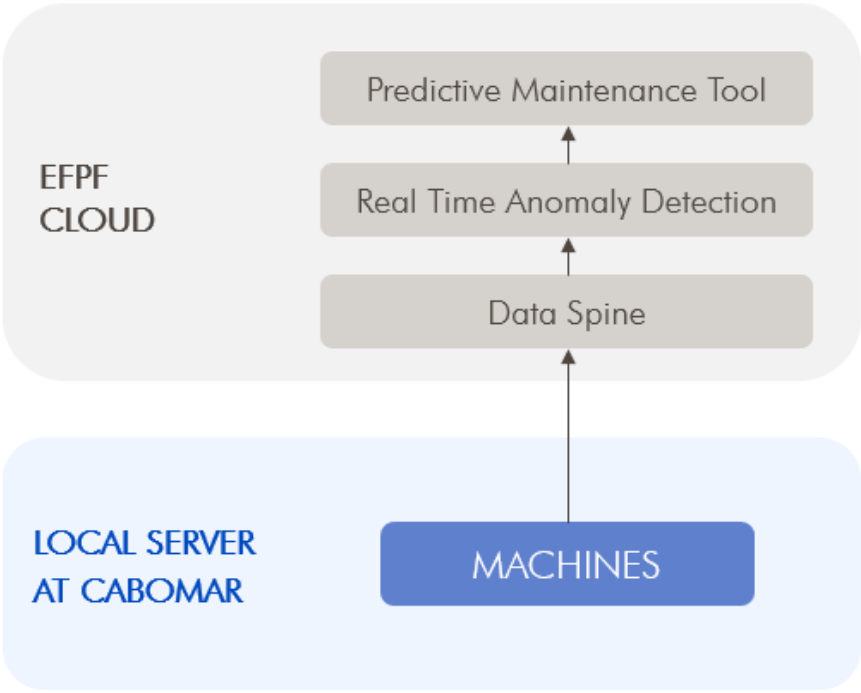


Figure 127: Overall of the main architecture for the project experimentation

4.2.11.2 Results, Lessons Learned and Outlook

Results

- Three EFPF tools were experimented: ROAM, Deep Learning Toolkit, Visual Data Analytics
- The validation process was performed on two iterations, documented in two different deliverables.
- Two machines have been monitored and analysed with the real-time and predictive maintenance tools.
- More than 20 variables have been collected involving the thermoformer machine, in which 52 process variables have been selected to be part of the experimentation.

Lessons Learned

PREMAR was conceived as a validation project to perform a constructive and objective testing of the platform from an industrial manufacturing perspective, with the focus put on analytics tools on machine data. The performed validation raised that EFPF means a powerful platform with very interesting features useful to address problems in manufacturing companies like CABOMAR. However, the project lifetime did not allow to properly squeeze the potential of the provided components, also considering the skills and training required to make a proper use of these tools and specific adaptations. Besides this, the value of these components in the European landscape will increase more and more also gaining maturity towards the end of the project. PREMAR has meant a new experience for both CABOMAR and CTAG. Indeed, CABOMAR has approached its digitalization challenges using a different perspective which will be useful in the future. PREMAR also thanks the EFPF team and the coaching support for their very valuable help, support and contribution to the development of the project.

Outlook

- Future usage of the analytics tools at later stages may lead to the reduction of the annual incidents (an objective that could not be finally met so the project period did not finally allow to get the required rules or correlations from the machine data collected).
- Considering the use of the overall solution by CABOMAR, the potential revenues can be estimated in up to 94K per year
- Activities such as consulting and support for implementation Support may lead to potential revenues up to 35k after 3 years.

4.2.12 OCE 12: Sentient (Digiotouch)

4.2.12.1 Short Description

The project delivered a system to sensor failures directly on the edge for a machine in Sappi's Lanaken mill in Belgium. Edge deployment (i.e. in-situ as opposed to the cloud) reduces latency and energy consumption. In the context of a Sappi's mill that would mean quicker detection of sensor failures and therefore avoiding costs due to machines' downtime and pre-emptive maintenance when and where necessary.

Project objectives

The specific objectives of the project were:

- validate anomaly detection models by using these in a demanding industrial context, and
- (further) validate the EFPF services "on the Edge" and Scailable's platform for deployment of trained AI models in the context of industrial paper making.

Technical Achievements

Deployment of the EDGE of the EFPF anomaly detection component based on a system model developed training the system in the EFPF cloud with a digital twin of the machine data.

4.2.12.2 Results, Lessons Learned and Outlook

Results

The approach has been validated and a white paper has been produced describing the experience of deploying predictive maintenance component directly on the edge.

Lessons Learned

The implementation was successful. Some issues with the availability of the EFPF platform had postponed the development a bit.

4.2.13 OCE 13: Digitanimal (Digitanimal)

4.2.13.1 Short Description

Digitanimal aims to bring EFPF technology to digitalize direct sales of livestock products, aligned with the "Farm to Fork" strategy, through the development of a platform between all agents. Digitanimal has validated its own developed technologies with the technologies developed by EFPF by creating a digital solution that connects all the agents of the meat production chain, including the final consumer. In this way the EFPF technology has been applied to a use case following the "from Farm to Fork" strategy. Producers can monitor in real-time their stock and consumer purchases, allowing a more efficient meat production chain (energy consumption and food waste). This project pilots' direct sales, providing consumers with real information and offering a new service to farmers and processing meat industries.

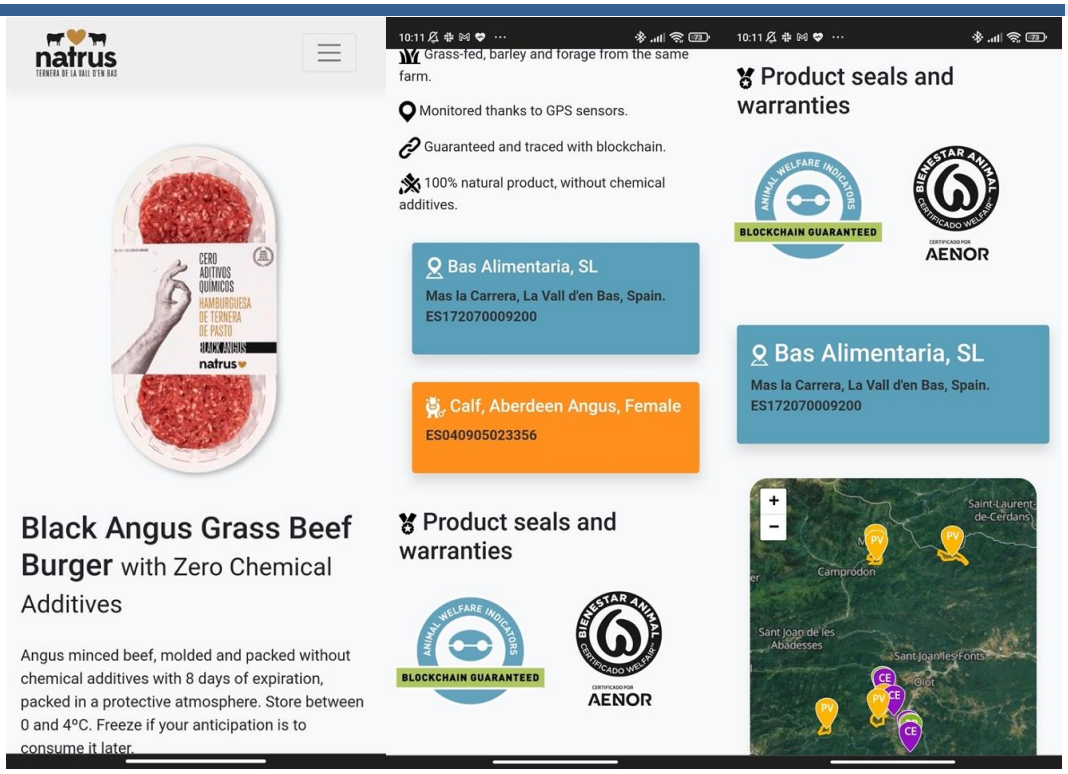


Figure 128: Landing page of the Digitanimal solution

Project objectives

- Development of a SW solution that, using EFPF platform modules, allows the digitalisation of the production process of meat products from the moment the animal leaves the farm.
- Thanks to this solution, food waste will be reduced, farmers will improve their profits, processors will reduce inefficiencies and waste of time, and consumers will have more accurate information about the product purchased.
- To carry out a demonstrator within the EFPF project involving all the agents in the "From farm to Fork" production chain, including consumers.
- Develop a business model that will allow commercialisation once the EFPF project is completed.

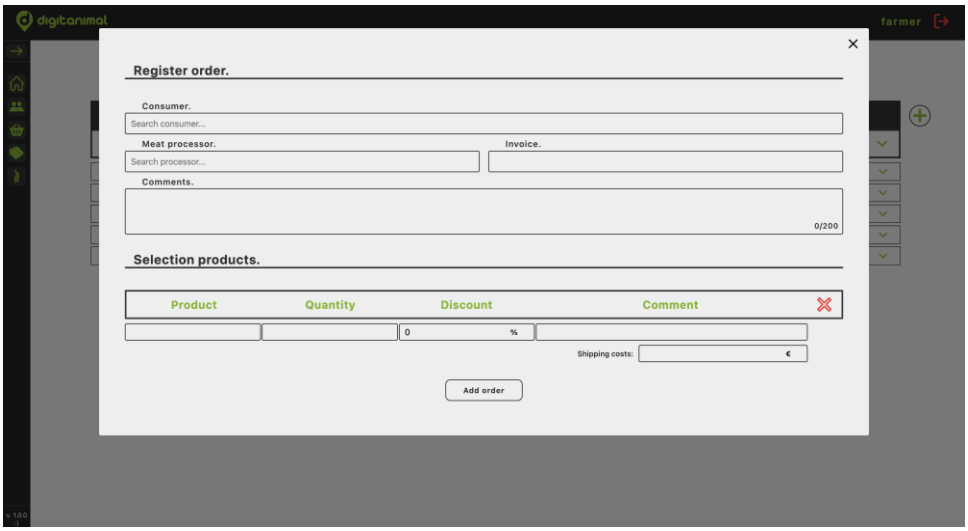


Figure 129: Register page of the Digitanimal solution

Technical Achievements

- Integrated with EFPF SSO
- Integration of production chain data through Data Spine
- Integration with EFPF Blockchain API
- An integrated software solution composed of backend modules, EFPF platform utilities and blockchain services and multi-device user applications enable the digitisation of meat processing industries was developed.

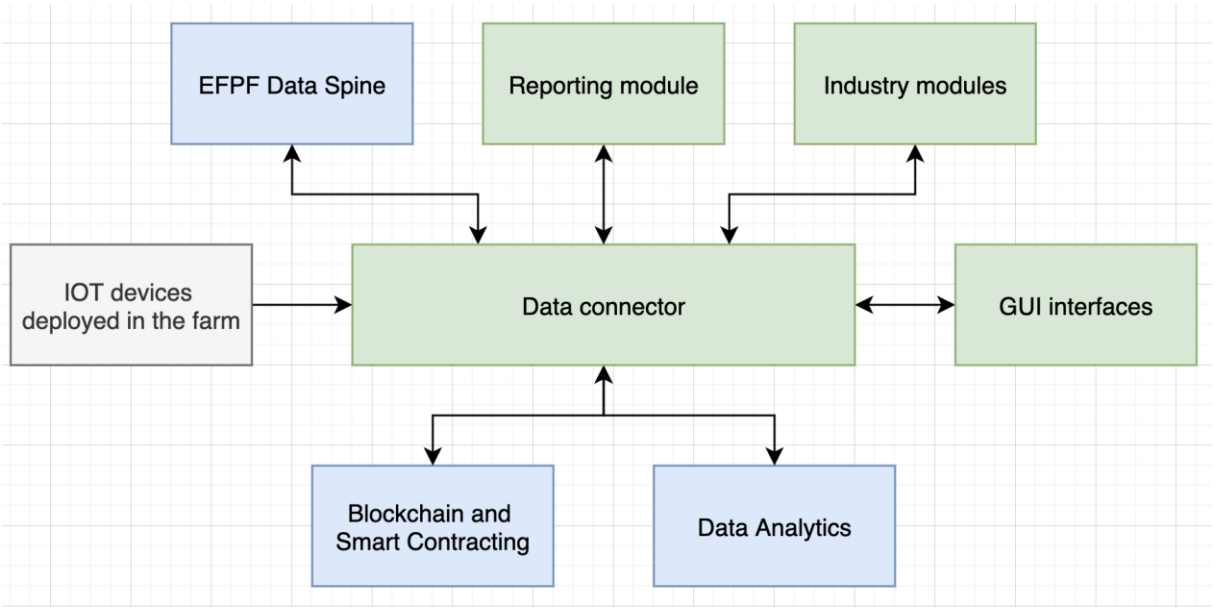


Figure 130: Components used in the Digitanimal solution

4.2.13.2 Results, Lessons Learned and Outlook

Results

- All KPIs achieved.
- The software solution has been used to validate selected components of the EFPF platform, with the results presented in a validation report.
- The service has been validated in a real environment with real farmers, consumers and industries.
- During the project, results have been communicated and disseminated publicly using Digitanimal's digital channels and the service itself has been promoted to its target audience.

Lessons Learned

In conclusion, the validation of EFPF technologies (DataSpine, Blockchain and EFS) has been carried out correctly within an existing Digitanimal service, which in turn has been improved thanks to the development of the project. Except for an instance of downtime when the Blockchain API was not accessible, the technology provided by the EFPF platform has worked correctly and can therefore be used in a commercial system.

Digitanimal are satisfied with the experience of validating the EFPF technology. The documentation was correct and allowed to adapt the service for validation quickly and easily.

Outlook

- The service continues to run on the EFPF – and further on EFF – platform.
- Marketing activities of the improved product using the EFPF technology towards customers will be boosted.
- The solution developed within the project will be commercialised by Digitanimal.
- From the economic point of view, it is desirable to know the price of the EFPF technology as soon as possible to check if it fits in the business model of the Digitanimal service.

4.2.14 OCE 14: Pressious (Pressious Arvanitidis and National & Kapodistrian University of Athens)

4.2.14.1 Short Description

The present validation project aimed, on the one hand, to interconnect 6 EFPF tools (Blockchain DApp, Deep learning for anomaly detection, Visual Data analytics, WASP and including 2 from Data Spine, namely the Keycloak Identity Provider and the Integration Flow Engine) within the PRESSIOUS production line and, on the other hand, to provide a full functional, scenario and technical testing and validation, leading to potential enhancements in the tools.

Project objectives

- Use and Validate EFPF tools to use them within PRESSIOUS company processes
- Development of an application based on EFPF validated tools
- Reduction of production failures
- Reduction of raw materials usage (paper, aluminium and water)
- New service for the EFPF platform
    - Attractive to new & existing customers

Technical Achievements

- EFPF WASP tool was used and validated towards standardizing and digitalizing the physical process of the prepress production phase, since this production stage shows inter-dependences among its individual processes
- EFPF Visual Data Analytics tool was used and validated using ink level datasets for fill level and tonnage forecasting in PRESSIOUS printing machines were employed
- EFPF Deep Learning for Anomaly Detection tool was applied to PRESSIOUS labelled datasets to validate them and enable proactive management inside the production chain
- EFPF Blockchain DApp from CE scenario was used as an API that enables the intra-factory waste management tracking and materials recycling, aiming at reducing the environmental footprint of PRESSIOUS. The wastes produced (namely paper and mud) through the whole printing process were tracked
- Implementation of a WPF Application that can directly connect to the EFPF platform and leverage its tools. This software application aims at interconnecting the EFPF platform in PRESSIOUS everyday operations by leveraging a user-friendly User Interface (UI), and following function modes of existing applications. The application is built over EFPF Blockchain DApp as mentioned in the previous bullet.

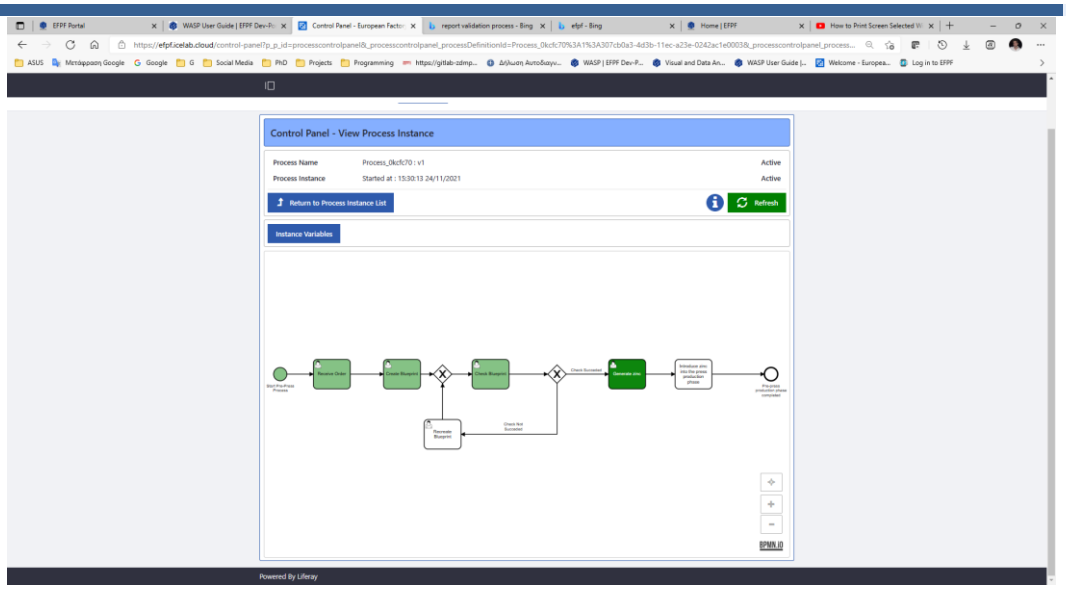


Figure 131: Example of WASP Validation

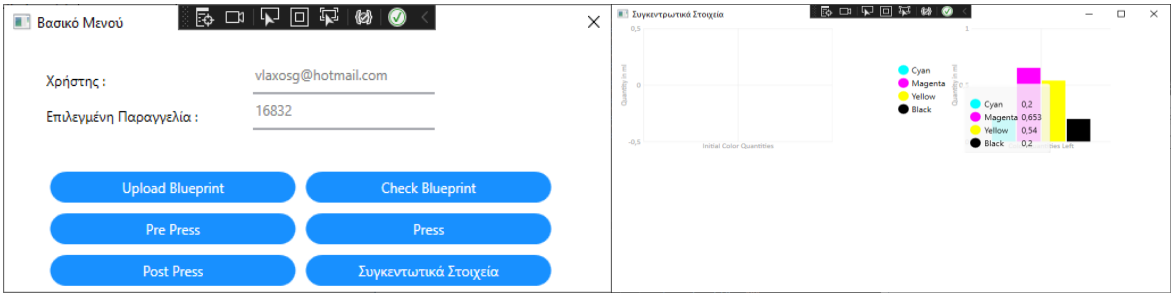


Figure 132: WPF Application User Interfaces

4.2.14.2 Results, Lessons Learned and Outlook

Results

- A solution for waste management activities tracking is available to PRESSIOUS company and adopted in everyday use
- A detailed validation report including feedback for various EFPF tools is available
- According to current measurements approximately 3% reduction of defected products and 2% reduction in paper consumption so far
- Demonstration video and plans for further exploitation
- Scientific Publication accepted in AIAI 2022 Conference: “Allocating Orders to Printing Machines for Defect Minimization: A Comparative Machine Learning Approach”

Lessons Learned

EFPF Blockchain DApp and WASP work correctly and as expected. Noteworthy, the application of these tools allowed PRESSIOUS to successfully track and trace intra-factory waste management and materials to be recycled, in an automatic fashion. The EFPF Anomaly Detection tool works correctly and as expected. More importantly, the tool was able to correctly identify the anomalies when presented with a historical dataset. Nevertheless, the neuronal network and regression algorithms are “under construction”, so a

straightforward extension of the tool is to include these ML algorithm families. The Visual Data Analytics tools was able to deliver the expected functionality but it could be improved by ensuring that potential inexperienced users receive appropriate error messages caused by various reasons, such as wrong file formats. Furthermore, the application could be enhanced by applying checks regarding the selections required for the analysis (Dataset and Configuration).

Outlook

- Significant expertise gained and ability to experiment, test and validate valuable components and state-of-the-art Industry 4.0 tools
- Significant marginal cost per unit reduction accomplished by reducing the number of defected products, by employing the Deep Learning for Anomaly Detection and WASP tools
- Production enhancement, which may be accomplished by minimizing the machinery idle time and environmental footprint minimization, by reducing the raw materials needed, by employing Blockchain DApp, Visual Data Analytics and WASP tools
- Excellent collaboration with the advisor and EFPF consortium
- Slight enhancements and improvements needed n some of validated tools and slight problems with the support

4.2.15 OCE15: Predictive and Connected Continuous Galvanization Line with EFPF Services (Simtera & Borcelik)

4.2.15.1 Short Description

The project aims to implement a predictive failure detection approach to Borcelik's maintenance activities on Continuous Galvanization Line by using EFPF solutions. Since, the most critical assets of Continuous Galvanization Line (CGL) are equipped with vibration sensors and analysers, project seeks to create a central data warehouse, and run predictive outputs with this data, to optimize maintenance activities, and increase uptime. The project also aims to find a cost-effective connectivity approach for medium critical level assets.

Project objectives

- Increase the uptime of Borcelik's CGL (Continuous Galvanization Line) and optimizing the maintenance activities by using related EFPF services.
- Better visibility by Anomaly Detection services
- Better planning with remaining lifetime calculator models

Technical Achievements

- Established a pilot architecture at Borcelik facilities
- Tested and validated various EFPF tools and services and provided findings
- Benchmarking between EFPF Anomaly Detection Service vs. Amazon Lookout for Equipment

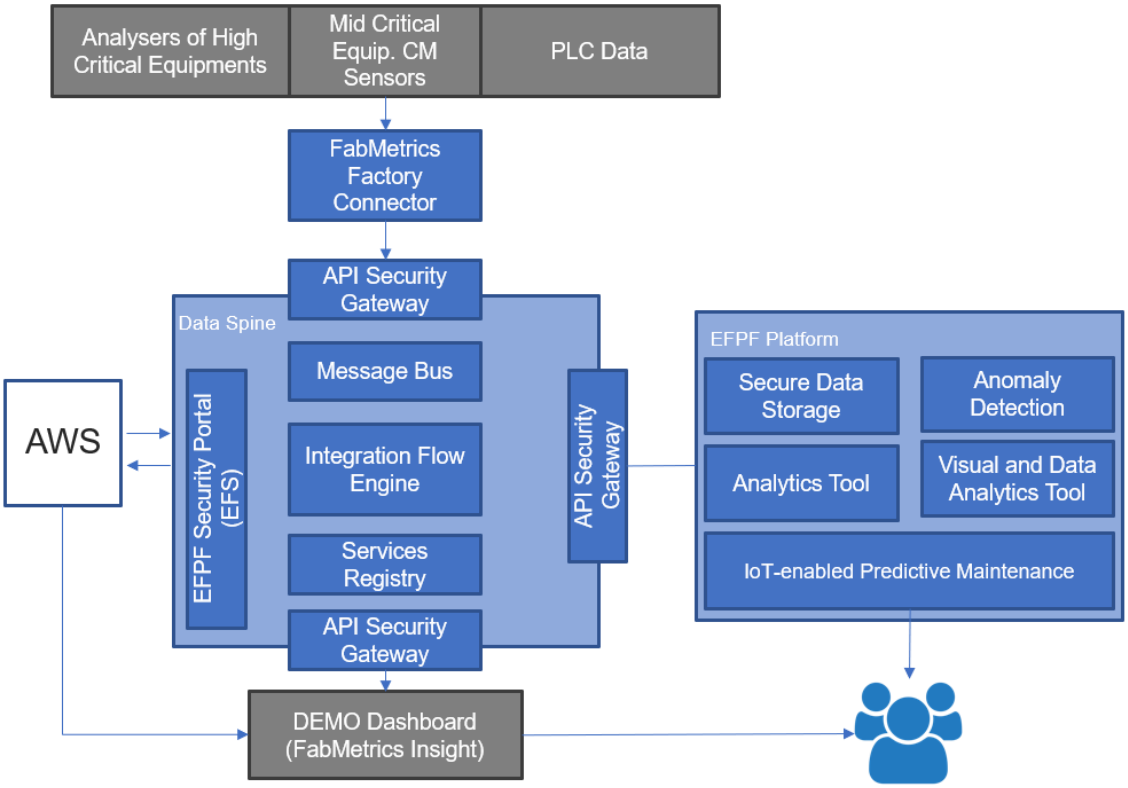


Figure 133: Solution architecture

4.2.15.2 Results, Lessons Learned and Outlook

Results

- Achieved connectivity at least 6 different equipment types (e.g. fan, pumps, process related motors, motion control motors)
- Achieved connectivity with 2 types of sensors.
- Tested EFPF Anomaly Detection Services with 6 training models.
- Held a webinar to present Pros & Cons of benchmarking results between EFPF Anomaly Detection Service and Amazon Lookout for Equipment.

Lessons Learned

By testing and validating various EFPF tools and services, the project consortium realized that the learning period for detecting anomalies in Borcelik's Continuous Galvanization line is around 6 months, corresponding to a dataset of around 2-3 million data rows per asset. Similarly, testing period for detecting anomalies is determined as 4 months, corresponding to a dataset containing 1 – 1.2 million data rows per asset. For detecting anomalies, EFPF Anomaly Detection Service has certain advantages over Amazon Lookout for Equipment; therefore, Borcelik found the tool useful for their infrastructure when the ongoing development stabilizes.

Outlook

- No major or critical issues detected after testing and validation
- Neutral interest towards EFPF tools and services due to minor shortcomings of EFPF Anomaly Detection Service
- Simtera & Borcelik might adopt EFPF Anomaly Detection Service when ongoing developments are completed

4.2.16 OCE 16: AITALENTUM

4.2.16.1 Short Description

Companies are aware about the need to reduce emissions and water footprint and need tools to help them achieve a zero-emission objective, or at least reduce it as much as possible. GoGreen platform calculates, simulates and predicts emissions of industrial processes to reduce carbon and water footprint enabling corrective actions to improve the environmental impact indicators.

Project objectives

- Give factories a reliable tool to calculate and manage their carbon and water footprint.
- To integrate the tool with EFPF so it meets standard characteristics of European directives.
- To expand our products' portfolio focused on climate change.
- To enter the European market through the EFPF marketplace.

Technical Achievements

- Cover the 3 different scopes in impact assessment: #1 direct emissions from onsite generation and fleet fuel consumption, #2 indirect emissions from purchased energy and #3 all other emissions associated with activities of the company (i.e.: travel, supply chain management)
- To provide an integrated, centralized web-based to get the calculation of environmental footprints (GoGreen tool).
- Use of standards: DEFRA/DECC, GHG Protocol, BEIS, EPA, Carbon Trust, Global Water Footprint Assessment Standard.

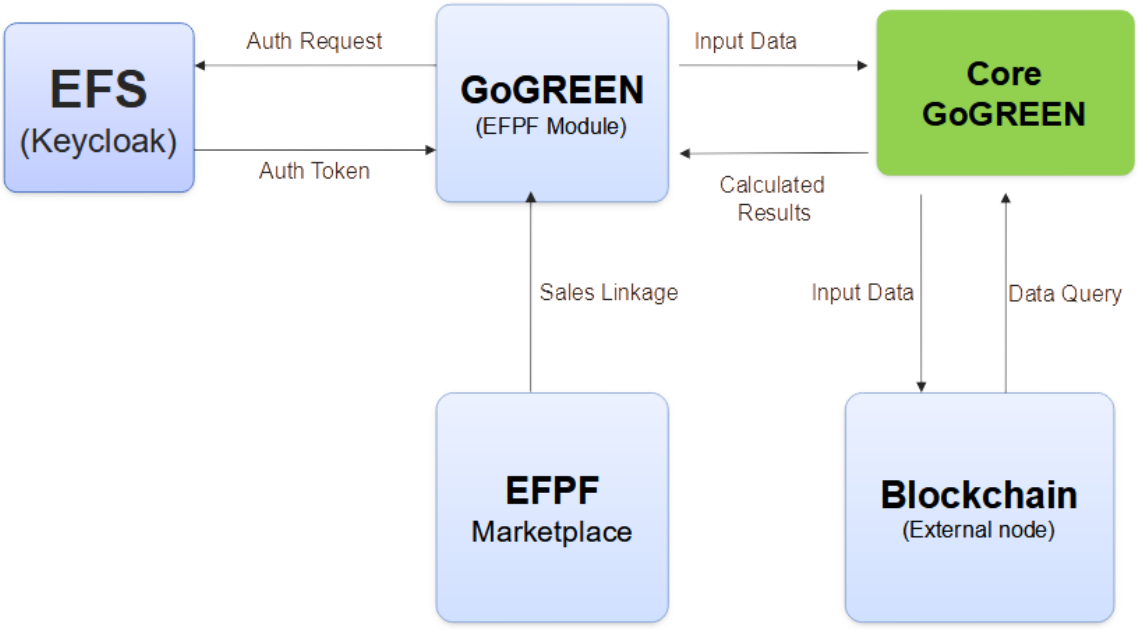


Figure 134: Overall architecture of the GoGreen solution including EFPF components

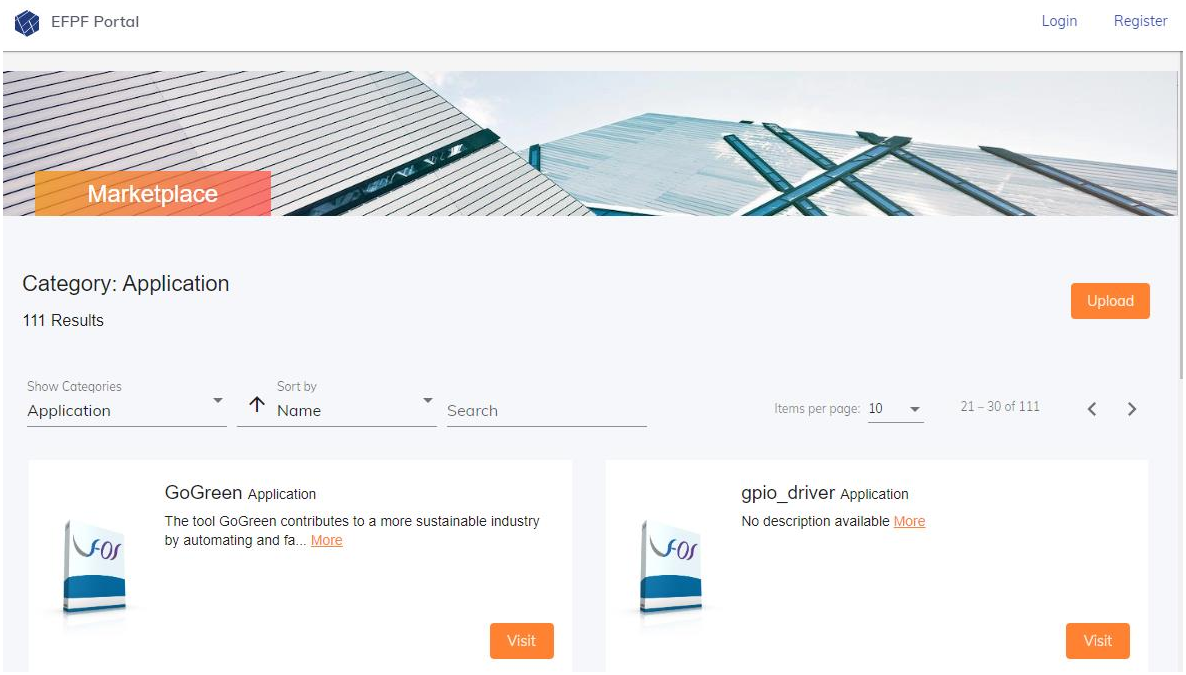


Figure 135: GoGreen published in the EFPF marketplace

4.2.16.2 Results, Lessons Learned and Outlook

Results

- Solution integrated in the EFPF marketplace to reach new markets
- EFPF user management through Keycloak
- TSMatch Gateway (IoT connectivity devices) evaluated
- Focus group of 4 people
- 3 live demonstrations of the solution arranged
- Valuable dissemination activities involving a specific talk in workshop, monthly posts on social media and one journal article published

Lessons Learned

To be part of a European ecosystem of solutions particularly targeted to industry has been a very positive remark, as well as accessing the implemented EFPF components and modules with powerful usage applications. The close collaboration with assigned advisors has been also a good experience. Besides this, the technical deployment of some components was not mature enough at the beginning of the project or the documentation was not complete or clear enough, issues that have been significantly improved during the project timeframe, as well as the mechanism to reporting the technical issues to partners. The EFPF DAML component for Blockchain finally could not be adopted, so a specific module directly conceived by the company was placed to cover this functionality. Also, a “Welcome program to the new partners involved in projects”, such as technical workshops or video tutorials for every component, would help to shorten the apprenticeship period.

Outlook

- Subscription or Software as a Service model have been considered for the exploitation of the solution

- For end users, an initial set-up fee round 2.500,00€ and a recurring fee round 450,00€ have been estimated
- EFPF developers and integrators may have a waived fee during this process, and an annual fixed fee round 1.500€ afterwards
- Exploring additional features integration with EFPF components.

4.2.17 eXist-EFPF (CapGemini)

4.2.17.1 Short Description

The main objective of the eXist-EFPF activities has been to carry an integration between eXist and EFPF platform, providing new EFPF federated services. The expected outcomes of the project were the functional integration of Exist with EFPF and the demonstration of this integration with the deployment of 2 Use Cases. The main achievements have been the integration of the Augmented Assistance Application with the EFPF Services, demonstrating how a remote expert can give support to an operator thanks to the EFPF ecosystem (Use Case 1), and the connection of the unity application with the message queues declared in the EFPF RabbitMQ, which allows to obtain the corresponding information and verify the steps during the operation (Use Case 2).

Project objectives

The main objective of the project is to carry out an integration between eXist

and EFPF platform, providing new EFPF federated services. Once integrated, the

new platform will be able to:

1. Have access, through the EFPF Data Spine, to advanced analytics services and secure data storage, functionalities currently not available in its infrastructure.
2. Complement the services offered by EFPF, focusing on providing digital assistance and guidance to shop floor workers by means of advanced HMI and extended Reality.
3. Join an ecosystem of ICT developers and industrial companies, creating synergies with both tech partners and industrial validators.

Technical Achievements

Use Case 1:

Integration of services between eXist and EFPF are defined in different scopes:

1) Security: Using Keycloak

2) DataSpine: Using pub/sub service Augmented Assistance

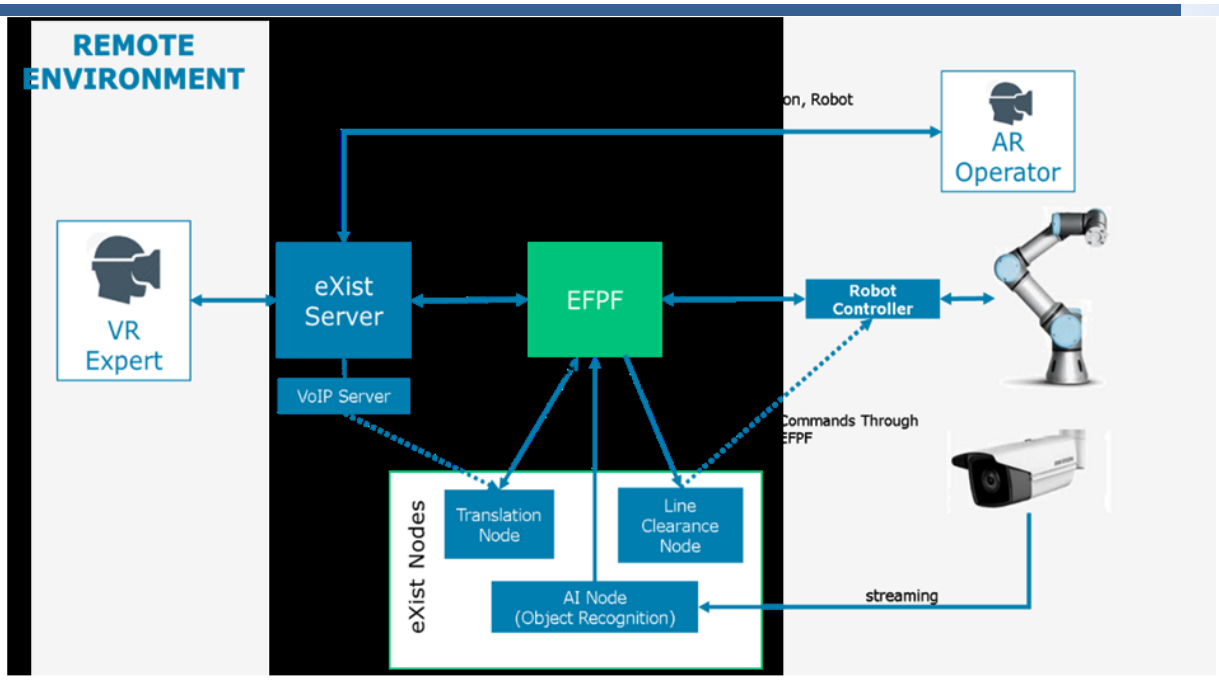


Figure 136: Architecture of the solution Augmented Assistance Application

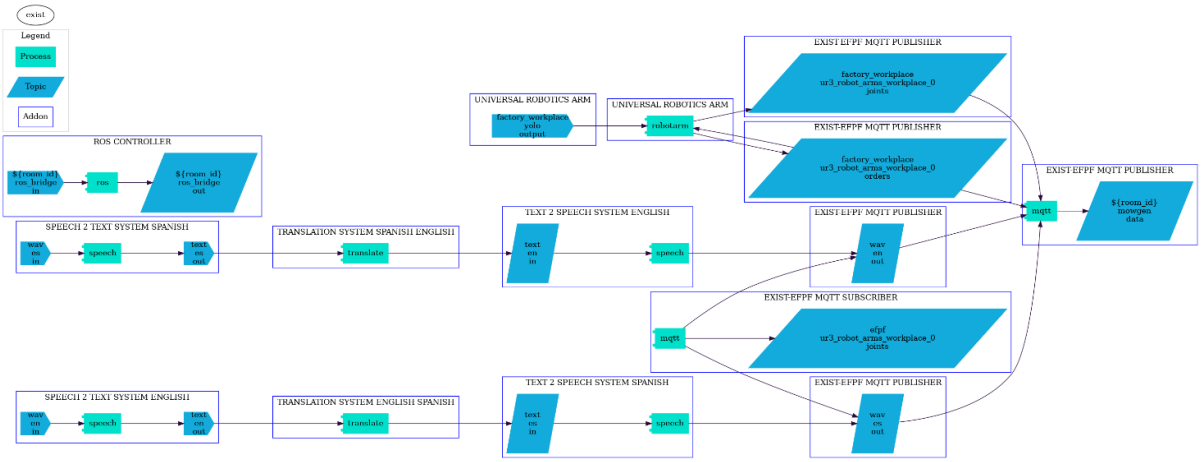


Figure 137: Interaction Flows between eXist and EFPF

Use Case 2:

The main achievement of this activity is the connection of the unity application with the message queues declared in the EFPF RabbitMQ. This has allowed to perform the complete demonstration of the workshop, polishing the errors during the workshop process to adapt to any type of connection and the limitations offered by them.

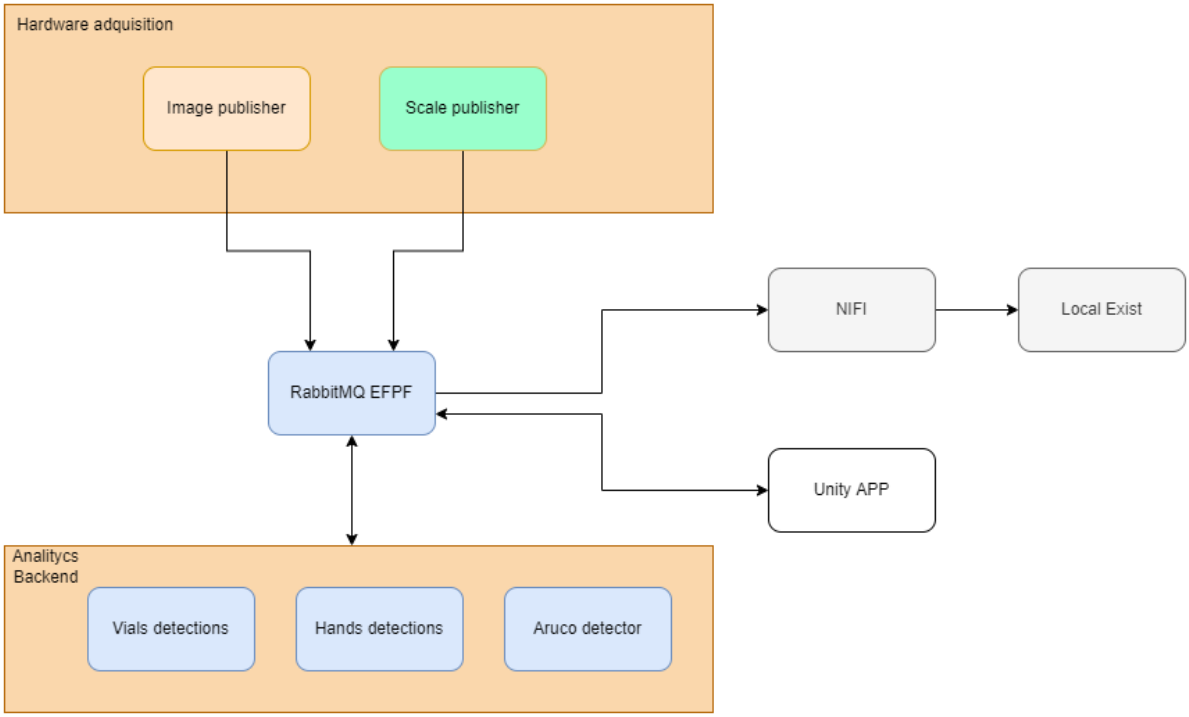


Figure 138: eSOP architecture with EFPF

4.2.17.2 Results, Lessons Learned and Outlook

Results

Use Case 1:

Fully functioning demo showing how a remote expert can give support to an operator in relation to a robotic arm, including real-time language translation, thanks to the EFPF ecosystem. The demonstration has included the augmented operator application and the remote expert application.

Use Case 2:

The results obtained verify the robustness of the hand detection model and a high efficiency when it comes to fulfilling the objective for which it was developed. In the experiments carried out with the model, an accuracy of 96.79% is achieved.

The results obtained show that the final proposed vial detection model performs better than the initial YOLO-based architecture. In addition, the high precision obtained makes it a robust model that effectively meets the objective for which it was developed.

Lessons Learned

All the intended goals and KPIs were achieved. There were no workplan deviations.

Outlook

The future steps to be developed will be focused on scaling the application for a more industrialized use, focused on trying to provide training or collaboration in real environments. This will be achieved by adding new use cases that focus more on business purposes.

With the use of the EFPF platform it has been possible to generalize the type of connection, not depending on on-premises architectures to develop the solution, so in future steps the

architecture will be maintained, in addition to trying to deploy modules in the cloud to have the lowest possible workload in the final execution environment of the application.

The goal would be to Increase the level of maturity of the solution to reach market ready developments TRL 8-9. The results from EFPF project will be translated to a Smart Factory Tech Lab, the company is building in Cádiz, Andalucía, Spain, which will be a co-innovation space and technological laboratory to scale the digital solutions from Capgemini with our customers.

The exploitation plan takes into consideration the inclusion of EFPF services, such as Data Spine, and Smart Connectors to enhance the technological maturity of the solutions and shorten the time and efforts to reach TRL 9. This engineering efforts need to be covered by both external and internal funding and new R&D proposals and funding focused on achieving high TRL will be launched. In addition, other EFPF services are considered to increase revenues streams and wider adoption, such as the web portal and marketplace.

4.2.18 SmartMetal (DNET Labs)

1.1.1.1 Short Description

The aim of the project is to extend the EFPF platform federation with product passport services[8]. The goal is to provide new service for monitoring of the workflow and the business processes in the Factory using sensors and digital identity of the machines. DNET proposed also to validate the integration in the manufacturing scenario with the EFPF workflows. The solution therefore relies on a product from DNET Labs (Passport Services) and augments it with the Deep Learning Toolkit (Predictive maintenance) and Blockchain functionalities to give insight into business processes, and to ensure their immutability for transparency purposes.

The proposed solution has been co-designed with the Digital Innovation team of Metalac and has been validated in their kitchenware factory.

Project objectives

- O1: To analyse EFPF, draft requirements for the adaptation and integration of the existing product passport service and analyse the data pipelines with the existing EFPF tools and services to be able to improve them and ensure data exchange.
- O2: To adapt and integrate the DNET existing predictive maintenance product passport service with EFPF interfaces and domain services. This objective will enable 1) integration of vibration sensors from Metalac and log activities/ products data with EFPF Data Spine, EFPF Blockchain Network, 2) integration with existing EFPF predictive maintenance component (EFPF Data Spine, Deep Learning Toolkit for Predictive Maintenance), and 3) make the product passport service available in the Marketplace.
- O3: To evaluate and test the product passport component with predictive monitoring capabilities for the metal domain using use case deployment with EFPF federated platform.
- O4: To prepare business plans and drive exploitation with project partners as well as to disseminate outcomes of the project and ensure end-user engagement.

Technical Achievements

- All proposed interconnections to EFPF achieved.
- Periodic measurements are published to the EFPF Data Spine Message Bus.
- The SmartMetal mobile application is used for visualization of measurements.
- A Blockchain module is used to ensure data traceability by writing the results of the assessment of the working conditions and regimes into the Ledger.

8https://www.mdpi.com/1424-8220/19/3/586

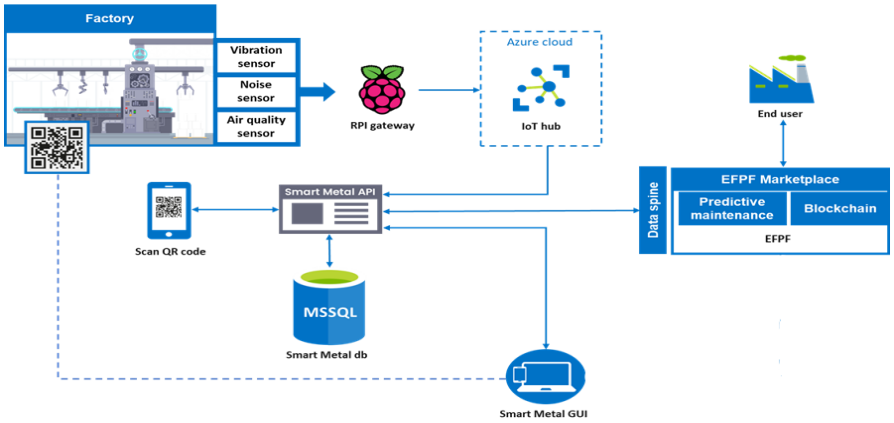


Figure 139: Architecture of the solution “TeamCreator”

1.1.1.2 Results, Lessons Learned and Outlook

Results

- Pass rate for integration tests with EFPF: 100%
- Integration tests with the Data Spine: 100%

Lessons Learned

The project achieved all the proposed goals. There were some minor deviations that relate with the creation of topics on EFPF (development team) and integration of blockchain aspects. DNET proposed and suggested approaches to circumvent the detected issues.

DNET states that the participation in EFPF gave the possibility to expand Europe-wide, and to leverage opportunities and partnerships.

Outlook

- Potential synergies with EFPF
- Expects to use the EFPF Predictive maintenance to further enhance the DNET Machine monitoring solution, increasing its competitive edge.

4.2.19 OCE 19: ebWASP (eBusiness eXpert)

4.2.19.1 Short Description

Electronic Data Interchange (EDI) is widely used in collaborative networks to exchange structured data (business documents) in a standardised way. eBin is an established cloud-based platform that, enables companies to manage (exchange, track, store, audit) invoices. The proposed project will integrate eBin with EFPF (WASP) to support B2B processes, where invoicing is an integral part, to reduce costs, increase processing speed, eliminate errors and improve relationships among business partners.

Project objectives

This project will integrate eBin workflows (on AWS) with the EFPF workflow platform (WASP) to support the automation and orchestration of different activities in collaborative processes. This will enable users to:

- Design and execute B2B processes, involving multiple activities, using WASP.
- Use integrated eBin functionality to send/receive, validate, convert, archive invoices.
- To make the eBin Services available to the European market through the EFPF marketplace.

Technical Achievements

- The creation of 2 WASP processes (buyer / seller workflows) that will be used to drive the implementation of a prototype based on a realistic e-invoicing scenario.
- The extension of the WASP Process Designer to integrate secure services in a way that is transparent to the user. This uses OAuth2 security protocol and leverages Open API latest specifications.
- The extension of the ebWASP API to provide secure endpoints that are OpenAPI compliant.
- The addition of the secure ebWASP API in the WASP marketplace, allowing for the implementation of several secure ebWASP API endpoints in the buyer / seller workflows.
- Execution of the 2 workflows in the WASP Runtime, 2 WASP users emulating the buyer & seller roles.

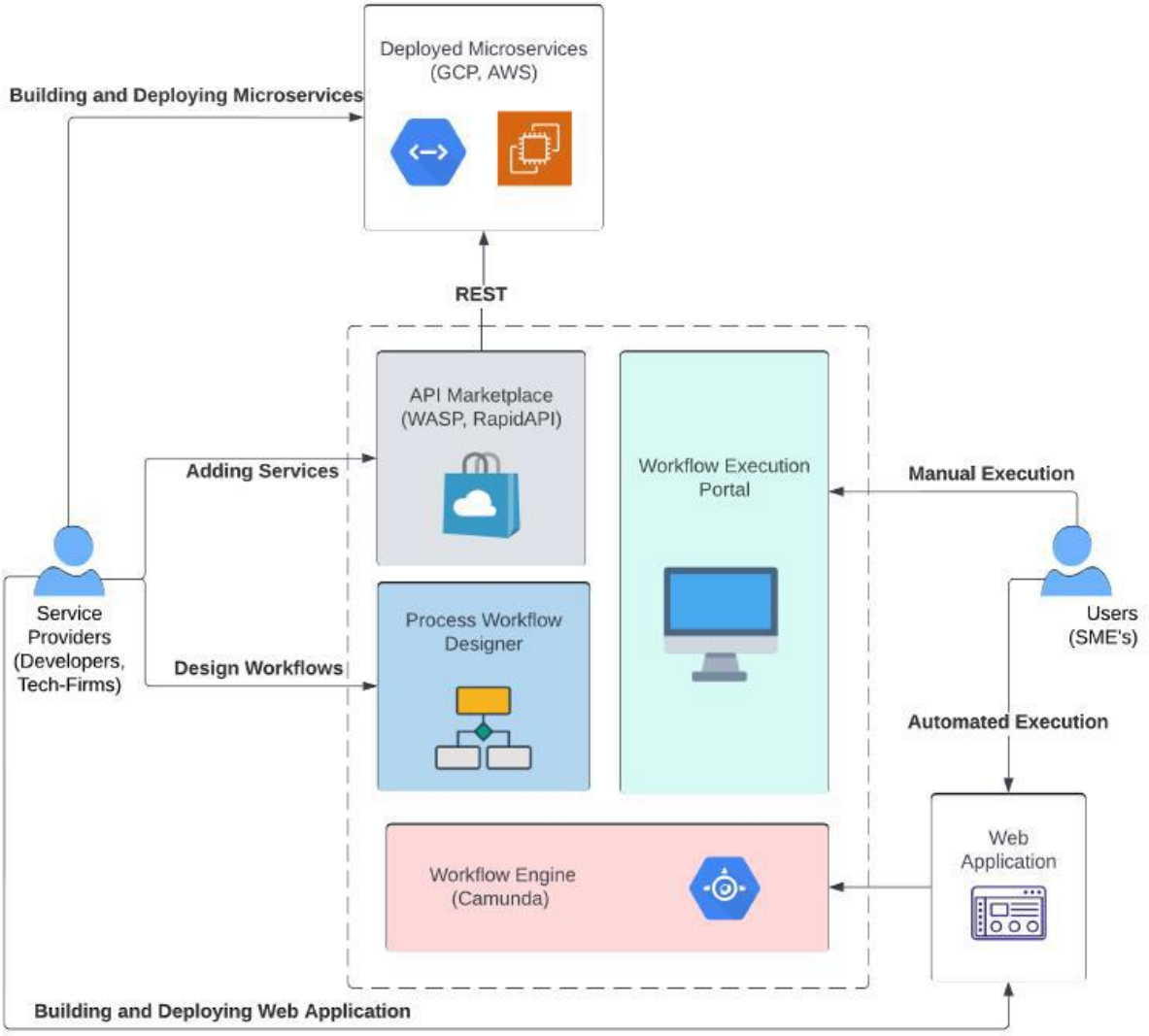


Figure 140: ebWASP architecture

4.2.19.2 Results, Lessons Learned and Outlook

Results

- The proof-of-concept prototype deployed & demonstrated on the WASP (Test) Server.
- The project & the POC prototype were included in a presentation in the 11th International Workshop on Enterprise Applications, Markets and Services in the Finance Industry, at the University of Twente, Netherlands was done on 23 August 2022. The paper was titled “Towards an API marketplace for an e-invoicing ecosystem “
- Adding information about the project deliverables on the eBusiness eXpert website
- Delivering regular presentations to prospective customers and standard bodies like GALIA.
- Plans to post again on both LinkedIn and Twitter concerning the EFPF ebWASP project advancements and our EFPF Open Call pitch and presentation taking place in Vienna on September 27 and 28.

- Newly created social media channels on Twitter, YouTube & LinkedIn

Lessons Learned

There are still many limitations in the proposed approach.

- Firstly, the creation of workflows still requires technical skills and existing workflow portals need to enable business users more control over the creation and execution of their workflows without IT support
- Secondly, the business processes selected in the case study are very simplified versions of those used. There are many more variations such as invoicing of deliveries of goods and services against purchase orders, based on a contract, invoicing the delivery of an incidental purchase order, pre-payment, spot payment, payment in advance of delivery, invoices with references to dispatch advice etc.

There are many more business processes that require the use of additional services and hence there is a need to define and test new workflows in this space. As the number of available e-invoicing APIs is still very low, there is a need to have a higher number of services from different providers. This will lead to the creation of an e-invoicing API marketplace with additional functionalities complementing those provided in the existing proof of concept prototype.

Outlook

- The intention of the project going forward is to deliver an integrated (eBin + WASP) workflow automation platform with embedded support for standardised EDI communication (i.e. exchange and management of e-invoices).
- The integrated platform will allow companies to develop end-to-end (B2B) collaborative processes in WASP and call eBin to handle the vital EDI related tasks/activities in such processes.
- It is intended that the integrated platform will make use of EFPF Data Spine to support the information exchange (interoperability, data model alignment, data harmonisation etc) in collaborative B2B processes.
- Access to integrated platform will be provisioned through WASP - in the EFPF Portal. Moreover, the native eBin system will be listed in the EFPF Marketplace from where existing functionality can be used by EFPF pilot partners among other companies

4.2.20 OCE 20: PdM-RASP (Octavic)

4.2.20.1 Short Description

Octavic (OCT) integrated with EFPF services for Predictive Maintenance (PdM) Analytics. Human-contextualized and anonymized datasets, as collected by the Manufacturing Operations Management (MOM) system developed by OCT, were passed via an integration layer to EFPF PdM Analytics services, and the result (probability of machine failure) was re-integrated into the Octavic system smart production scheduler (SPS) module, as a risk-based planning tool. The integration enabled real-time adaptation of factory operations and robustness in industrial manufacturing.

Project objectives

- To develop a new module (option) as part of its existing MOM system. This will allow its SPS module to operate more accurately
- To integrate with EFPF PdM Analytics services
- To meet or exceed in-field tests accuracy of 60% correct predictions for PdM events

Technical Achievements

- Platform integration between OCT MOM system, including the scheduler and the UI (i.e. front and backend integration), and EFPF PdM analytics (the Deep Learning Toolkit by Links Foundation)
- Provision of 3 human-contextualized anonymized, validated and processed datasets from industrial manufacturing environments, from different industrial equipment, from 1 industrial partner
- Test reports for validating the PdM Analytics against old data, in which the maintenance context is exactly known, providing a 75% accuracy rate
- Field-test reports by deploying the new module from O1 at existing customer and assessing the accuracy of the PdM Analytics risk prediction, providing >90% accuracy (although during the testing period there were no actual failures, so this result must be treated cautiously)

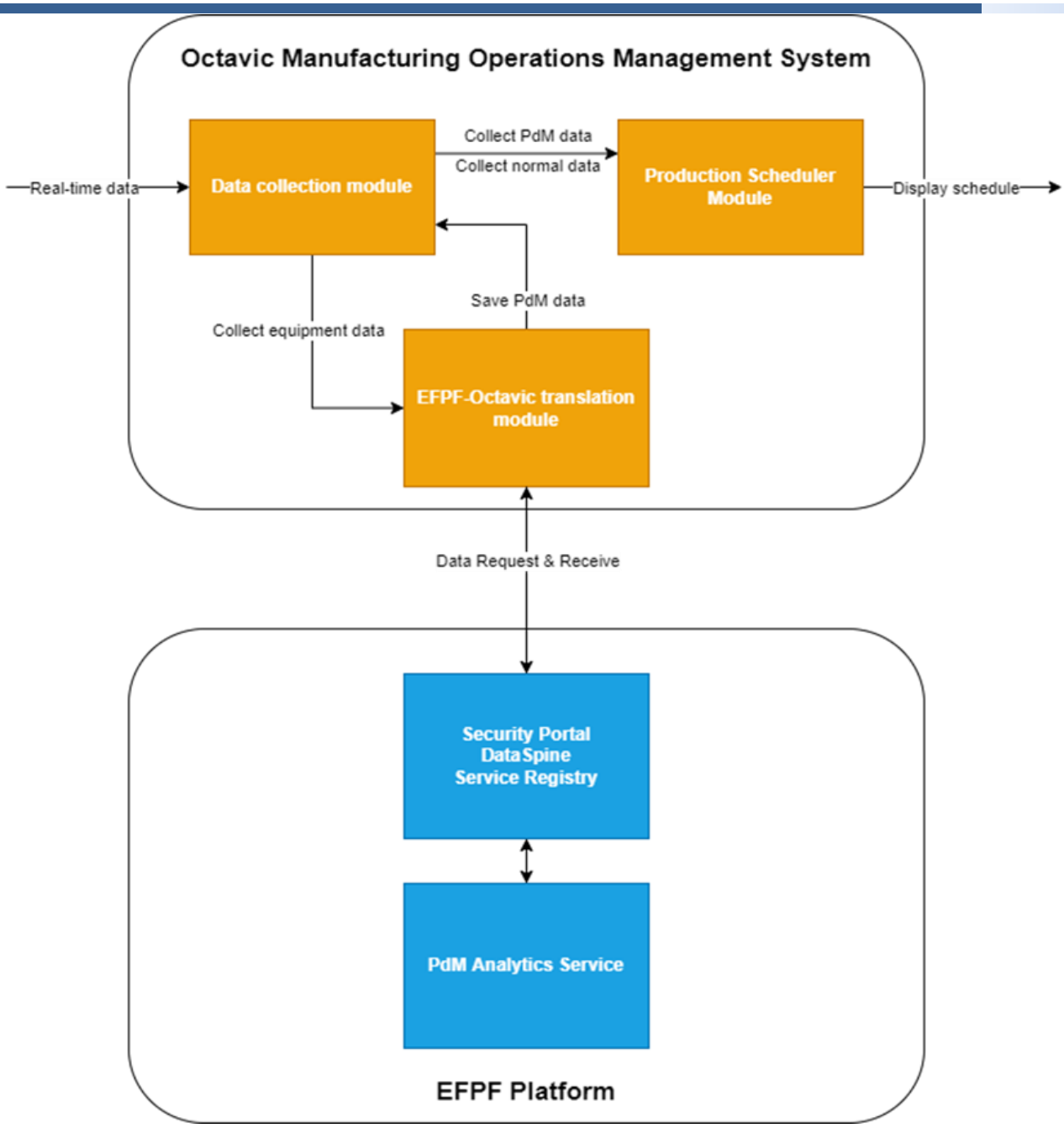


Figure 141: Architecture of the PdM-RASP solution

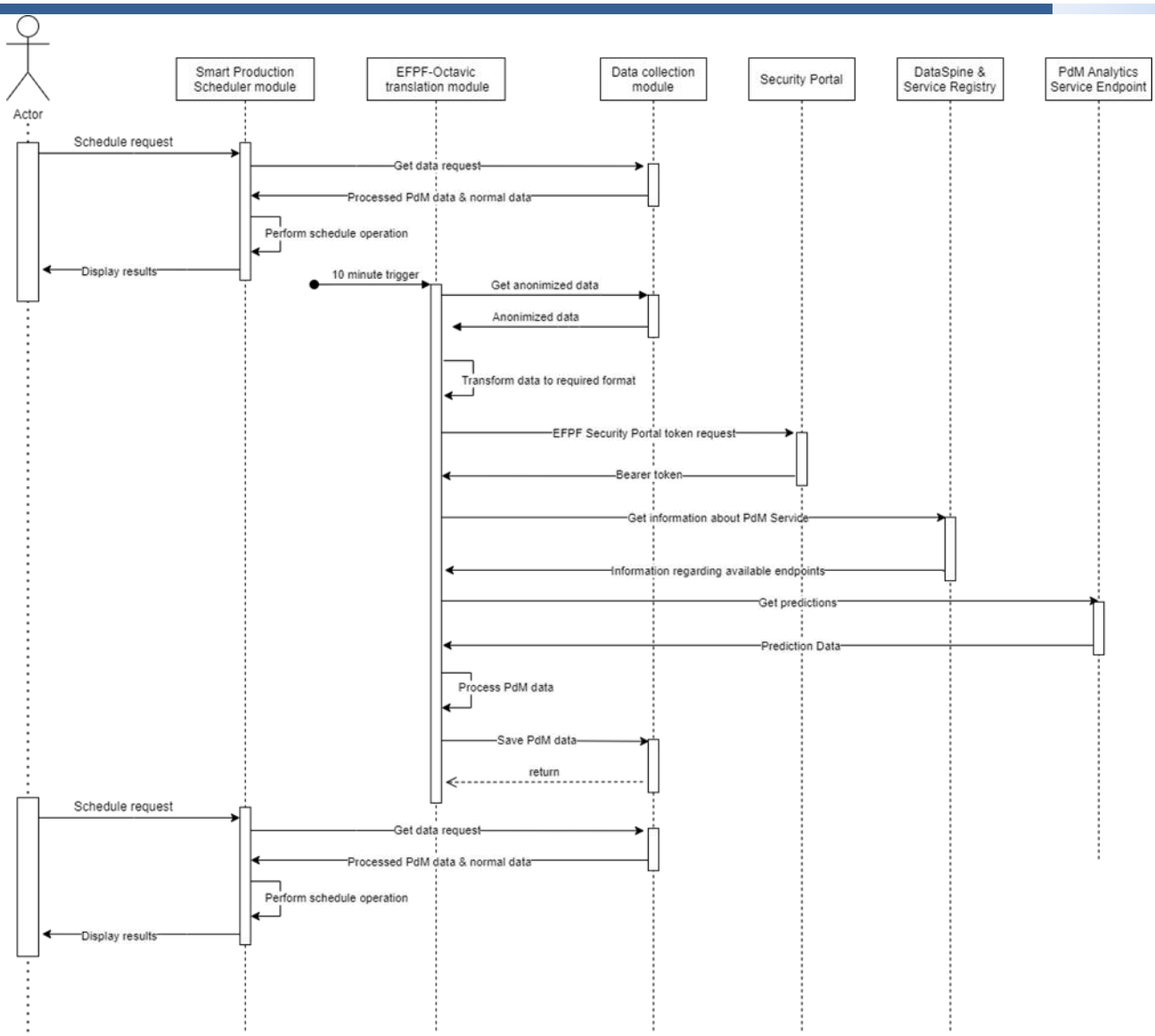


Figure 142: PdM-RASP and Scheduler Communication Flow

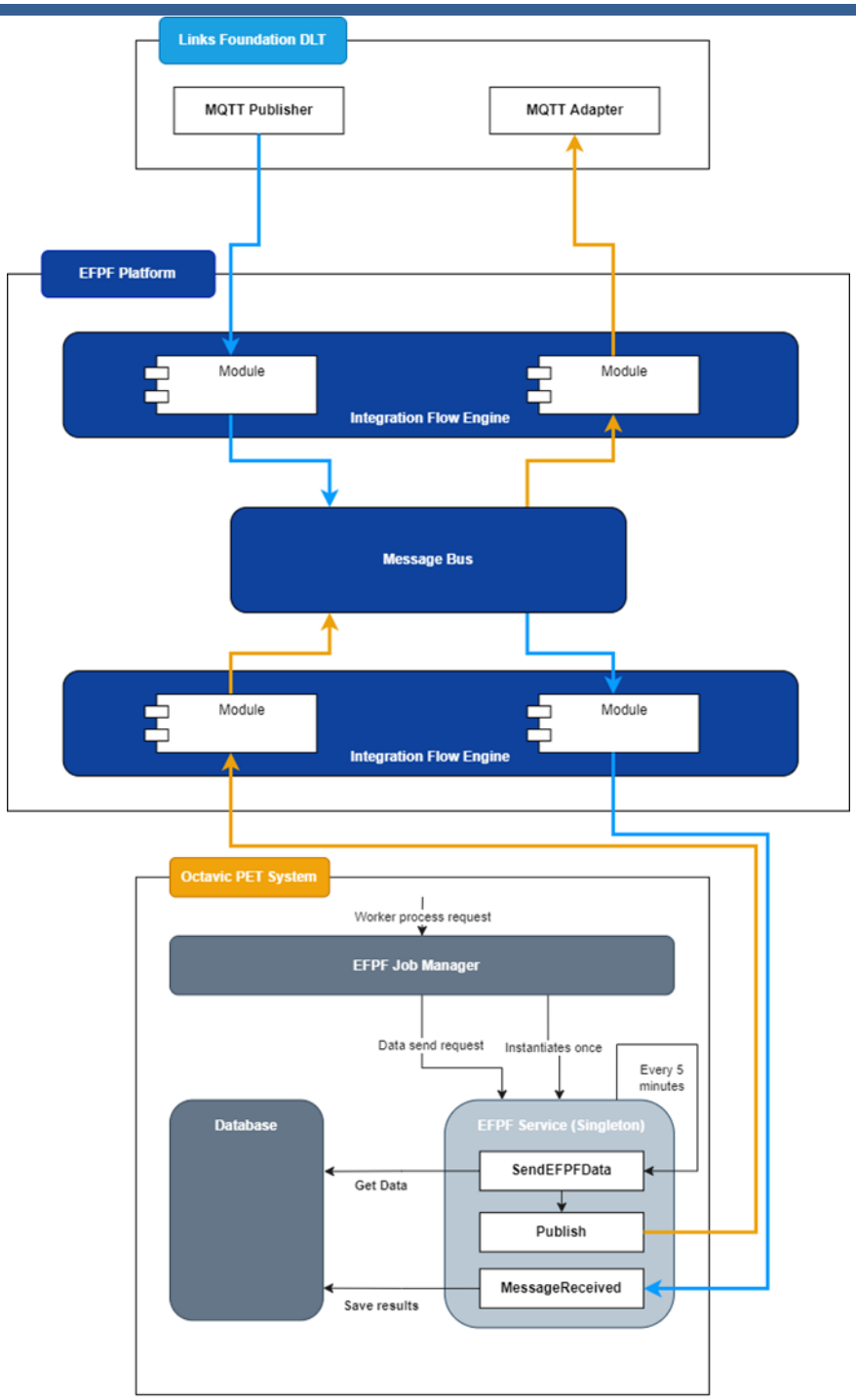


Figure 143: Octavic-EFPF Deep Learning Toolkit Communication Architecture

4.2.20.2 Results, Lessons Learned and Outlook

Results

An integrated new module into the Octavic MOM System for predictive maintenance, fully integrated into the MOM UI and the MOM Scheduler.

The project outcome is offered now as a standard module option in Octavic commercial offers format, as a monthly subscription per production equipment.

Lessons Learned

All the intended goals and KPIs were achieved. There were no significant workplan deviations.

Outlook

Currently there are 5 ongoing discussions regarding implementing a solution that integrates the PdM module with new customers.

For Octavic, the continuation of this project is already being pursued, by incorporating the PdM risk into a wider class of risks (such as missing operators, lack of raw material, breakdowns, quality problems) for production scheduling – a research project financed by Innovation Norway that started in May 2022.

Octavic will also look to extend the PdM-RASP module and MOM system with additional functionality (such as vision-based data sources and or human behaviours mapping). Funding for this will be sought through EC Horizon Europe consortium membership, (including with partners from the EFPF consortium).

The extended MOM system, using the EFPF services, has also attracted Venture Capital to Octavic, who are in the process of receiving significant investment.

5 Conclusions

During the further development of the tools in the 3 pilots, it has become clear that a highly available EFPF platform is essential for the validation of the developed tools. This led to delays at times, but these could be absorbed in the end. All the goals set in the pilots were achieved. The practice partners were able to prove the functionality and added value of the developed solutions. Where it seemed appropriate, concrete requirements for further development were worked out together with the developers. These could be tackled after the end of the project. As it is becoming apparent that the European Factory Foundation (EFF) will take over the EFPF platform and ensure its long-term operation, a sustainable further use of the developed solutions in the companies is seen for the future. Depending on the implemented business models at the EFF, a quick reaction of the software developers in case of malfunctions must be guaranteed. Updates must also be accessible to the companies. Especially regarding cyber security, it must be ensured that the ongoing operation of the tools on the shop floor does not lead to critical situations with data theft or loss. If this is ensured, the companies will appreciate the added value of the implemented solutions in the future.

During the work on the pilots, new ideas and project approaches have also emerged that could no longer be realised within the framework of this EFPF project. However, it makes sense to continue to use the excellent network of project partners for further development and implementation activities even after the end of the project. For example, a statement by the project partner 3D-ICOM is quoted here that underlines this fact.

"3D ICOM has been pleased to work with various companies across Europe to improve contacts and communication across countries and to open up new, creative ways of collaboration in the aerospace supply chain. We were also excited about the opportunity to promote the possibilities of lightweight manufacturing at events across national borders and to be part of the advancing digitalisation. We hope the project will lead to further collaborations, such as joint purchasing, via the digital platform. One of our pilot projects could serve as an example for the future development of a sensor-controlled warehouse for lightweight assembly vehicles. We therefore expect that the tools developed will help us strengthen our local and transnational business relationships and increase customer satisfaction by simplifying purchasing and sales processes and new ways of ordering raw materials."

Like the work on the pilot solutions, the findings from the Open Calls are also to be evaluated. The general feedback from the Open Call partners was very positive. The results of all 20 sub-projects were impressively presented at the Open Call pitching event in September 2022. Here, too, the unstable availability of the EFPF platform at the beginning of the Open Call activities was noted. In the end, however, the problems were overcome through a joint effort.

6 Annex A: History

Document History	
Versions	V0.1: • Document setup and draft Table of Contents V0.2: • First draft version V0.3: • Final draft V0.4 • First internal review V0.5 • Second internal review V1.0 • Final deliverable
Contributions	all WP9 partners and some WP4 partners for technical assistance