EFPF: European Connected Factory Platform for Agile Manufacturing

European Factory Platform

WP 4: Development of EFPF Building Blocks
WP 5: EFPF Add-ons

D5.4: EFPF Matchmaking and Intelligence Gathering Final Report

Vs: 1.0

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Short Abstract

This deliverable presents an update of the developments under Matchmaking and Intelligence gathering tasks in EFPF project since D5.1 - EFPF Matchmaking and Intelligence Gathering. The report consists of two chapters dedicated to each task respectively and ends with a common conclusion section which explains the close connection they share.

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See Annex A.

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

Further Information

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Project Partners:

Executive Summary

This deliverable summarises the development relating to Matchmaking and Intelligence gathering tasks in WP4 “Development of EFPF Building Blocks” and WP5 “EFPF Add-ons”. The work covered in this report has been developed from month 18 to month 48 of the project. The aim of the task is to present audiences the overall architecture and the detail solutions EFPF provided in ‘Matchmaking’ and ‘Business and Network Intelligence’.

Matchmaking chapter introduces the reader to the matchmaking approach being taken in the EFPF project. It continues to bring out the various features allowing agile team creation and matchmaking being implemented in this task. Federated search is one of the most important functionalities in this project as it allows the user to search and get result from all connected platforms making this a powerful feature for matchmaking.

An account of federated search is presented along with the major changes since initial implementation. Subsequent sections explain individual indexing workflows of connected platforms. The second part of matchmaking task focuses on implementation of agile team formation allowing users to collaboratively form a team with companies found from different connected platforms. The team evaluated the feasibility of implementing a recommendation system which will predict and present the users with relevant recommendations based on their searches but due to limited time and resource, the focus was dedicated to agile team creation, creating a team directly from federated search result, and automatically recommending teams based on the business opportunities specification.

The matchmaking chapter ends with two pilot cases: a description of pilot use case which addresses the automated matchmaking during online bidding in the Circular Economy scenario by partner KLEEMAN; a pilot case for automatic team recommendation utilising Team Creator by partner LAGRAMA.

Business and Network Intelligence chapter introduces the reader to the wider understanding of intelligence in the industry and explains the context of this service inside EFPF ecosystem. The report also explains the different services made available and their relation to other EFPF components.

The business and network intelligence module is divided into three sections by application. All tools and services that enable organisations to generate intelligence from their internal operations are grouped under the category ‘Intracompany Level Intelligence Service’. The tools and services that help manufacturers explore and exploit intelligence from their existing networks (industry associations, supply chain networks, digital platforms) are grouped under the category ‘Platform/Network Level Intelligence Services’. The third category is to do with gaining intelligence beyond your known existing network such as the wider industry or the region manufacturer is based in.

The business and network intelligence chapter continues to detail two pilots, Hanse Aerospace and AIDIMME, being carried out with project partners to test these services as well as share these as case studies for other adopters.

The SDK and BI Applications chapter further showcase EFPF SDK capabilities and the Business Intelligence Applications developed to help business gain ‘Intracompany Level Intelligence’.

The report ends with concluding note that surfaces the close connection in above tasks and provides a summary on benefits these solutions bring to the users.

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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 circa 16M€. Further information: EFPF-project.eu

In order 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 the four base platforms from FoF-11-2016 cluster funded by the European Commission, early on. This will set the foundation for the development of EFPF Data Spine and the associated toolsets to fully connect the existing platforms, toolsets, and user communities of the 4 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), user access management functionalities to hide the complexity of dealing with different platform and solution providers.

0.2 Deliverable Purpose and Scope

This is a final report presented at M48 milestone of the EFPF project. The purpose of this document "D5.4 Matchmaking and Intelligence Gathering – Final Report", is to present an overview of matchmaking services as well as business and network intelligence gathering services in the EFPF project. This deliverable articulates the vision behind introduction and continuous development of these services as well as their benefits to prospective users. The report presents an account of the development made since project start, with more focus on elaborating new developments after M18.

0.3 Target Audience

The target audience for this document are all parties that are interested in understanding matchmaking and intelligence components of EFPF ecosystem. This includes project partners who would like to collaborate or contribute to the development of these solutions or simply get a better understanding of them. This also includes external readers who are interested in following the developments taking place in EFPF project with respect to these two components (including open call participants who might be interested in using these services as part of their open call project).

In addition, this deliverable provides the European Commission (including appointed independent experts) with an overview of the matchmaking and intelligence components of the EFPF platform.

0.4 Deliverable Context

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

- **D3.12: EFPF Data Spine Realisation - II:** Provides an overview of the data spine architecture necessary to understand dependencies and component relationships.
- **D4.4 Smart Factory Solutions in the EFPF Ecosystem** – Final Report: Describes the Tools and Services that are brought together by the project partners to satisfy the needs for Smart Factory solutions in the EFPF ecosystem
- **D5.13: EFPF Interfacing, Evolution and Extension:** Provides an overview of the ecosystem creation and the evolving nature of this unified platform.
- **D5.15: EFPF Security and Governance - Final Report:** Provides an overview of the portal which acts as an access point for using these services as well as data protection policies being developed/adopted in the project.
- **D5.16: EFPF Interfacing, Evolution and Extension - Final Report:** Provides an overview of the EFPF project and platform

0.5 Document Structure

This deliverable is broken down into the following chapters:

- **Chapter 1: Federated Search, Team Formation and Matchmaking** – Provides an overview of the Matchmaking services available to federated ecosystem.
  - **Section 1:** Introduction
  - **Section 2:** Design of Federated Search
  - **Section 3:** Agile Team Formation in EFPF
  - **Section 4:** Matchmaking Services for Automated Online Bidding
  - **Section 5:** Matchmaking with Team Creator
- **Chapter 2: Business and Network Intelligence Gathering and Propagation** – Provides an overview of the business and networking intelligence solutions made available to the federated ecosystem.
  - **Section 1:** Introduction – Data, analytics and Intelligence
  - **Section 2:** Scope and Relationship with other EFPF components
  - **Section 3:** Requirements
  - **Section 4:** Tools and Services
  - **Section 5:** Execution and Pilot Case Studies
  - **Section 6:** Limitations
- **Chapter 3: SDK and BI Applications** – Provides an overview of BI applications developed via EFPF SDK, and the corresponding technologies used.
  - **Section 1:** Introduction – SDK and BI Applications
  - **Section 2:** Technologies
  - **Section 3:** BI Applications
- **Chapter 4: Conclusion** – Provides conclusion to the progress and achievements discussed in previous chapters and explains the closeness between them.

Annexes:

- **Annex A**: Document History

- **Annex B**: References

0.6 Document Status

This document is listed in the Description of Action (DoA) as “public” post recent amendments. It presents the description of tools and solutions provided by the EFPF platform under matchmaking and intelligence services. The document can be used especially by external entities to understand their function and further utilise them through the portal.

0.7 Document Dependencies

This document is the final part of two deliverables that describe ‘matchmaking’ and ‘business and network intelligence’ components of the EFPF platform. This first version is submitted as an interim report in Month 18 of the project. The second and final iteration is presented in Month 48 here as the final report.

0.8 Glossary and Abbreviations

A definition of common terms related to EFPF, as well as a list of abbreviations, is available in the supplementary and separate document “EFPF Glossary and Abbreviations”.

Further information can be found at https://www.EFPF-project.eu/glossary

0.9 External Annexes and Supporting Documents

Annexes and Supporting Documents:

- None

0.10 Reading Notes

- None

1 Federated Search, Team Formation and Matchmaking

1.1 Introduction

In the modern manufacturing era, supply chains are increasingly becoming multi-enterprise and global in nature. Agility, shared data and business collaboration are key factors for multi-enterprise supply chain success. To build agile multi-enterprise supply chains, companies first need to have access to a large supply base and secondly need an efficient mechanism for cost-effective and rapid identification, evaluation, and selection of suppliers and products & services provisioned by them. Matchmaking mechanisms for connecting buyers and sellers of manufacturing services based on different criteria are a powerful tool towards building global multi-enterprise supply chains. These mechanisms can be automated to make the overall process efficient and robust. A prerequisite for automated matchmaking is a formal representation of supply and demand data. Based on a common interoperable data model across integrated platforms of manufacturing and logistics suppliers and service providers, effective matchmaking mechanisms can be developed connecting buyers and sellers across heterogeneous manufacturing platforms.

In EFPF, several key manufacturing and smart factory tool platforms interlinked as a federation of digital manufacturing platforms. Namely, they are NIMBLE, COMPOSITION, DIGICOR (represented by SMECluster), vf-OS, B2B Market and Valuechain Network Portal. In EFPF, these platforms offer different types of manufacturing and smart factory solutions. With an effective matchmaking strategy these platforms can offer their products and services to a wider client audience through a unified EFPF portal with value added features.

The goal of matchmaking in EFPF is to facilitate EFPF users to find the best suited suppliers and enable them to transact with them efficiently and effectively. This is achieved through 4 layers of matchmaking in EFPF platform;

1. Federated search of participants (suppliers/service providers) & their value-units (products/services)
2. All users to form a network with selected suppliers to continue further collaboration.
3. Navigate users to perform negotiations and transactions with selected suppliers and service providers from different base platforms
4. Enable users to find the best supplier to fulfil a request for a service or product in a fully automated way (via automated agents)

In the following sections, these different layers of matchmaking will be discussed in detail.

1.1.1 Federated Search

This is the first level of matchmaking that is implemented in EFPF platform. A prerequisite to achieve a federated search is a common interoperable ontology for cross-platform search. The platforms need to be able to exchange data and facilitate effective information retrieval across the base platforms conforming to such an interoperable data model. Once a common interoperable ontology is defined, a dataflow mechanism should be implemented to ingest base platform data from heterogeneous sources to a common index which will be used as a federated search index across the EFPF platform.

In the previous report, the problem domain federated search resolves and state of the art have been fully explored, hence this report will focus on the major changes happened after the initial implementation.

Federated search is a technique used to simultaneously search multiple data sources using just one query and one search interface. The two fundamental components of each federated search product include an index and a search algorithm. An index is a reference to the data to be searched (parsed) by a search algorithm. These two components interact in different ways to achieve a federated search, e.g., using search-time merging, index-time merging and/or through a federated search interface (Algolia, 2019). Analysis of the pros and cons of each of these technologies have been presented in previous report, and decision has been made to use index-time merging in EFPF. The detail design and recent changes are presented in section 1.2Design of Federated Search. The major changes of Federated Search include:

- UI enhancement for federated search, such as tooltip including “basePlatfom” in the label, and showing logo image for companies and products.
- Integration with more external platforms, such as B2bmarket, ZDMP, etc.
- Ontology extension for support Business Opportunities and Integration with Team Creator
- New feature of federating business opportunities from SMEcluster (details of business opportunities in EFPF can be found in section 2.4.2.3.2.
- Enhancement of the indexing process to cache indexed company data in order to provide high availability.

1.1.2 Federated Search and Agile Team Formation

The matchmaking process in EFPF includes both federated search and agile team formation, which are executed through the EFPF Portal and its user interfaces (UIs) for entering search criteria and select companies of interest. These services enable EFPF users to find and select most suitable service providers and their products & services via information retrieval techniques, then move forward to further collaboration via Team Formation features implemented.

The search user interaction data are stored using the User Activity Log Service, which listens to all user interaction events generated from the EFPF Portal, e.g. item views, purchased items, etc. In addition to maintaining the data about partners, products and services, the matchmaking process in EFPF also stores all the user interactions data through Solr Index. These data could be further utilised for machine learning model creation, based on an ML library (Apache Mahout) that is used to create item-similarity and user-similarity-based search recommendations to the user. The envisioned recommendation service is illustrated in section 1.1.3.

The outcomes of the federated search and agile team formation are presented to the users through an intuitive UI that is integrated in the EFPF Portal:

- Detail features in Federated search are presented in as illustrated in Figure 1 and the subsequent screenshots.
- Agile Team Formation UI is presented in section 1.3.

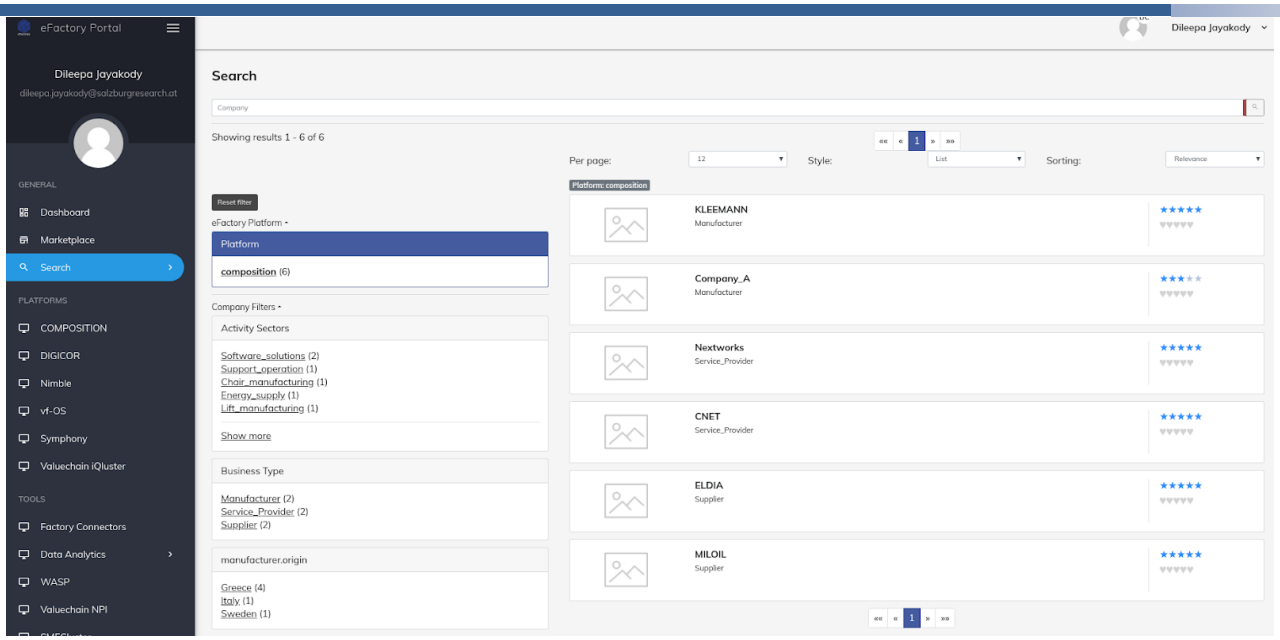


Figure 1 EFPF Federated Search UI

The user is given search term suggestions when entering a search term. This makes user's search queries efficient and effective. These suggestions can be ranked according to many criteria such as similarity-based ranking, most searched terms based ranking and personalized search terms-based ranking, etc. Currently this is configured to similarity score-based ranking.

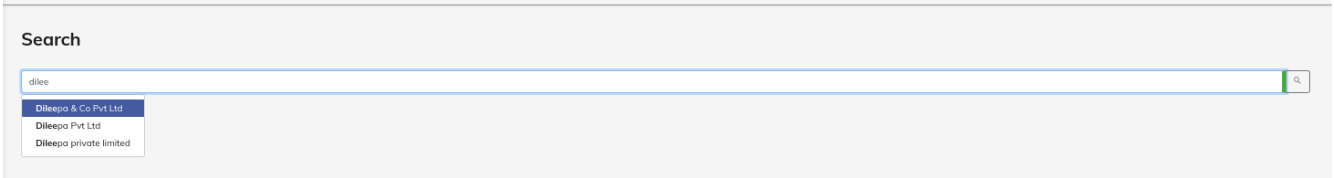


Figure 2 Search Term Suggestions

Once the user gets a set of search results, he/she can use the granular level filters given to drill down the results based on a range of facets based on the EFONT ontology (details in section 1.2.2). For example, user can further drill down the search results based on facets such as platform, activity sector, business type, origin location and trust scores of the service provider as depicted in Figure 3.

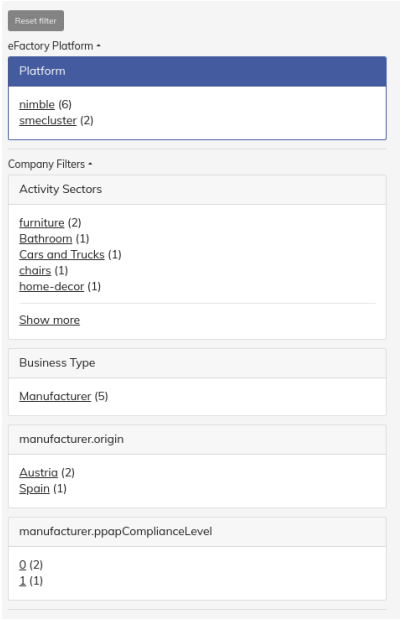


Figure 3 Filter Options

Furthermore, the user can click on the interested product or service provider in the results list and view further details and options to execute a business transaction or business negotiation with the service provider. The user is redirected to the base platforms company and product pages via EFPF user federation to continue his/her transactions seamlessly within the connected platform ecosystem in EFPF. Figure 4 and Figure 5 are examples of a service provider and product details pages in base platforms integrated into the federated search in EFPF.

Figure 4 Service Provider Details Page

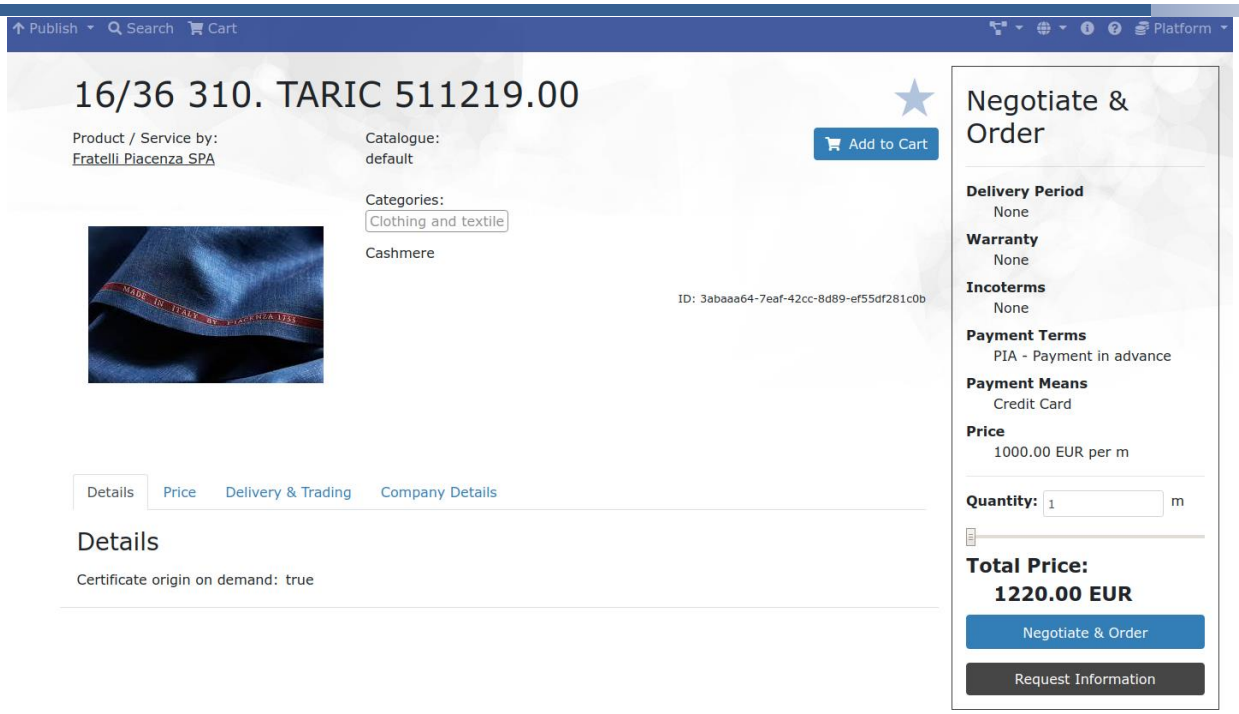


Figure 5 Product Details Page

1.1.3 Recommendation Service and Automatic Matchmaking

The previous proposed Solr based recommendation engine architecture was only in the research stage around M18. As it is not part of the original DoA, and the estimation indicates there is not enough time within EFPF timeframe to finish this, it was de-prioritised, and the effort was moved to the team formation feature.

The envisioned recommendation system will utilise the user activity data concerning federated search events logged in the ELK stack. Following are few metadata captured in a search event in EFPF portal.

- Search type: product or company search
- Search query: the main query and associated faceted queries
- Search response: the associated search response for the executed query and the facets
- Date & time of the query
- The search results the user clicked on and proceeded with purchasing

These captured data could be fed into a Machine Learning model to predict the relevance of different products/services and service providers to each user. This model will be iteratively trained in a training pipeline and connected to the ranking model of the search framework to give automatic search recommendations to the EFPF users.

Though the current matchmaking features provided in EFPF is not built on the recommend engine proposed above, EFPF is able to provide automatic matchmaking capabilities in two contexts: automated online biding as detailed in section 1.4; automatic team

suggestion via Team Creator detailed in section 1.3.2 and a detail pilot case presented in section 1.5.

1.2 Design of Federated Search

The EFPF platform is a digital platform ecosystem that encompasses four digital manufacturing platforms: NIMBLE, COMPOSITION, DIGICOR and vf-OS, including some of their tools and services. In addition to these four platforms, EFPF is designed to be extended towards external platforms in the future. Such a design approach requires that interoperation and federation challenges need to be resolved with a high priority, enabling tools and services from various platforms to be used and their results merged in a beneficial manner. For example, enabling matchmaking and agile network creation mechanisms in EFPF requires federated search to be put in place, in the first instance.

Federated search mechanisms in EFPF are about searching for partners and/ or for products and services. The EFPF user is able to 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. The search criteria and the results are collected to support the recommendation process for both partners, and for products/ services based on different techniques of information pattern matching. These techniques include information retrieval and similarity matching techniques, which are both based on Machine Learning (ML) and data analysis. After the most suitable partners and products/services are identified by recommendation algorithms, the users evaluate the results based on several selected indicators, e.g., cost, reliability, quality, etc. Finally, in the third step that is about matchmaking, the user decides how to proceed with it and initiates a suitable business transaction.

1.2.1 Federated Search

A federated search in EFPF enables a search functionality over multiple sources using one query. The architecture for federated search is derived considering the existing base platforms' architectures and features, available data sources and other technical requirements related to the design of a recommendation engine. In EFPF, we follow the index-time merge architecture to implement a federated search approach. The main reason to select index-time merge architecture over search-time merge and hybrid architectures is due to non-availability of search indices in most of the base platforms. Only NIMBLE currently has a search index to provide text-based search functionality.

The index-time merge search requires content from base platforms to be acquired into a central index at the EFPF platform to enable platform level search for products/services and partners/companies across the four base platforms. The index-time merge search is also used to implement traditional enterprise search systems, in which information can be retrieved across heterogeneous data sources in an enterprise. Figure 6 depicts the index-time merge architecture for federated search in EFPF.

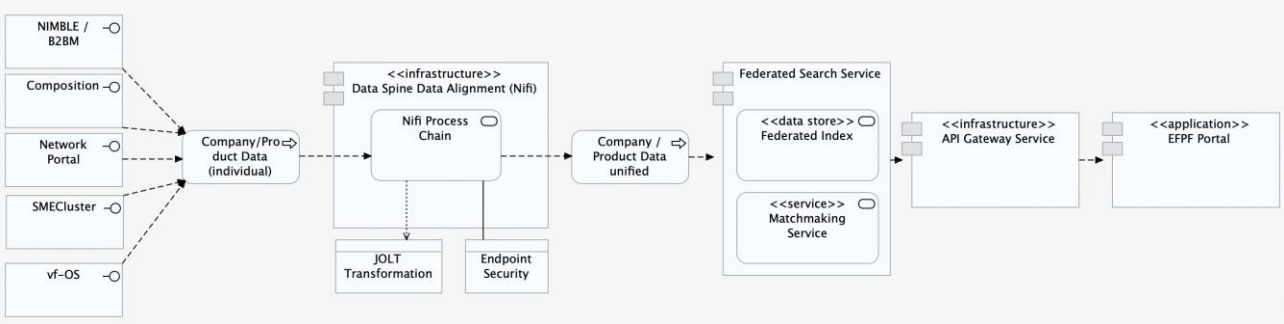


Figure 6 The Index-Time Merge Federated Search Architecture

The major advantages of the index-time merge architecture are as follows:

- Through acquiring all data into a central index, sophisticated query enhancement and relevancy algorithms can be applied, providing the user with excellent search results.
- The selected search architectural approach allows for flexibility in the implementation of the recommendation and matchmaking engine.
- The indexed data and ML algorithms can be used to provide products, services, partners, and business opportunities recommendation.

The following disadvantages of the index-time merge architecture are summarised below:

- Acquiring the content from the various repositories and data sources of the base platforms requires considerable efforts; for example, it needs to be done using scheduled read-only processes that would need to be designed and implemented at the data integration layer. This also requires a decision about the frequency of the data ingestion into a central index. Data ingestion frequency needs to be configured hourly, daily or weekly, depending on the data velocity of the base platforms.
- For different types of data sources, additional data connectors need to be implemented to enable the data integration.

One of the major changes made since the initial implementation in previous report is enhancing the indexing process (the first bullet point of disadvantages above) to provide high availability.

The process for indexing in Apache NiFi has the following:

- indexing service: A dedicated service "in front" of Apache Solr. This helps dealing with dynamic fields, cross references to other collections, to name a few. The indexing service has a similar API as the standard query API from Solr, provides add-ons for simplifying queries over multiple collections (e.g., search Items whose Manufacturer's name starts with 'A')
- Apache Solr: The search engine behind the scenes.

However, with the previous Apache NiFi process groups implemented before M18, the indexing service is bypassed because the collected data is stored directly with Apache Solr. Moreover, the defined processes include the deletion of all entries in the index, mainly designed for eliminating companies which are no longer provided by the base platforms.

In order to resolve the issue, we want to: a.) avoid the deletion of each distinct basePlatform entries and b.) let the indexing service consume the provided data. Each entry is then updated and there is no longer a time slot where a basePlatform is not available.

As a disadvantage, the process covers only new and updated entries, not the deletions. This is addressed in the indexing-service when consuming the list of new/changed parties by:

- caching all parties of a base platform
- processing new/updated party entries and remove the handled entities from the cache
- removing unhandled entries from the index.

1.2.2 EFPF Manufacturing Ontology

The type of data collected from the base platforms include data of companies, service providers and products & services offered by them, and business opportunities. The base platforms have different data schemas to define these entities. In order to capture different attributes of the entities (companies & products/services) these base platform data schemas need to be consolidated into a common schema/ontology.

To enable an effective federated search in EFPF, we designed a common ontology called EFPF Manufacturing Ontology (EFONT) that includes the following concepts (see Figure 7):

- A Class/ Category of a product/ service/ partner's capability has 0 or more properties.
- A Property describes the product/service class in detail, e.g., length, height, certificates.
- An Item is an instance of a Class/ Category. Each Class/ Category has 1 or more item instances representing the actual product/service or partner's capability that will be manufactured/ provided by a party/ company.
- A Party has attributes such as a legal-name, keywords and activity sector that extend a variety of attributes for matchmaking processes.

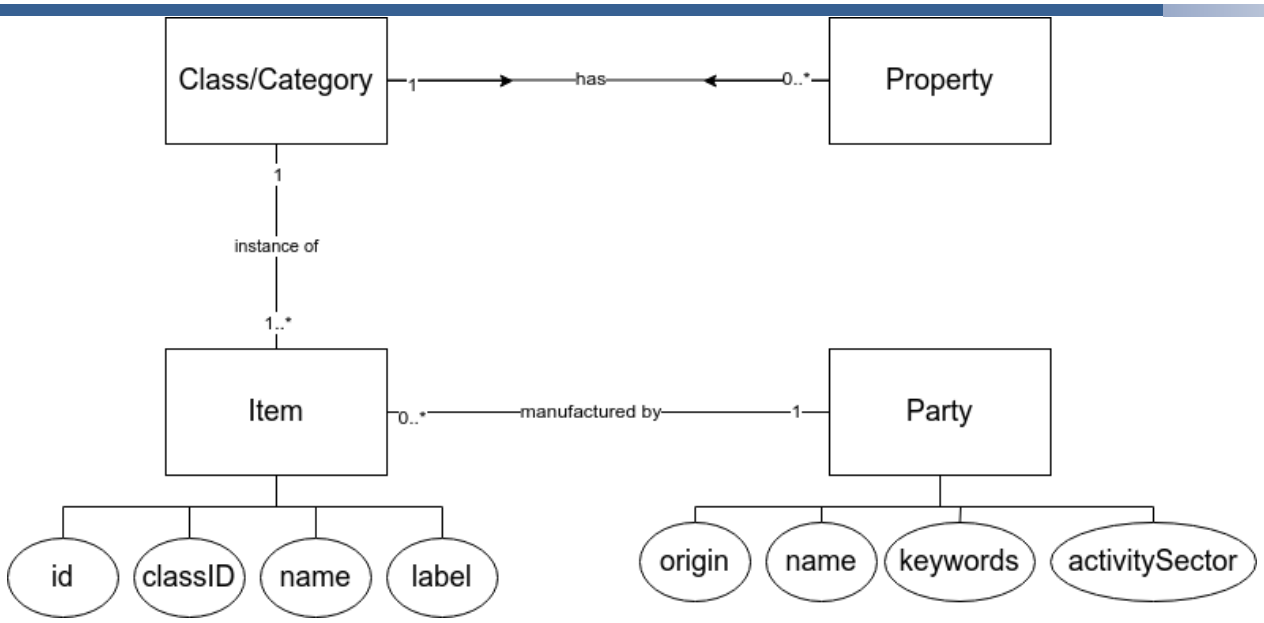


Figure 7 A High-Level View of the EFPF Manufacturing Ontology

The concepts and their attributes defined above are inspired by the Universal Business Language (UBL) specifications on Supplier PartyType (SupplierPartyType, 2013) and CatalogueType (CatalogueType, 2013). We extended the above ontology with more attributes which will be useful for matchmaking transactions and the extended version of the EFONT is depicted below in Figure 6. The additional relations/attributes were added mainly to the Item and Party concepts by analysing the different schemas used across the base platforms. Some of the main attributes of the concepts are as below.

- Party: Legal name, brand name, business type, origin, address, website, projects, trust score
- Item: Label, manufacturerID, price, packageUnit, packageAmount, totalCapacity, deliveryTime, certificateType

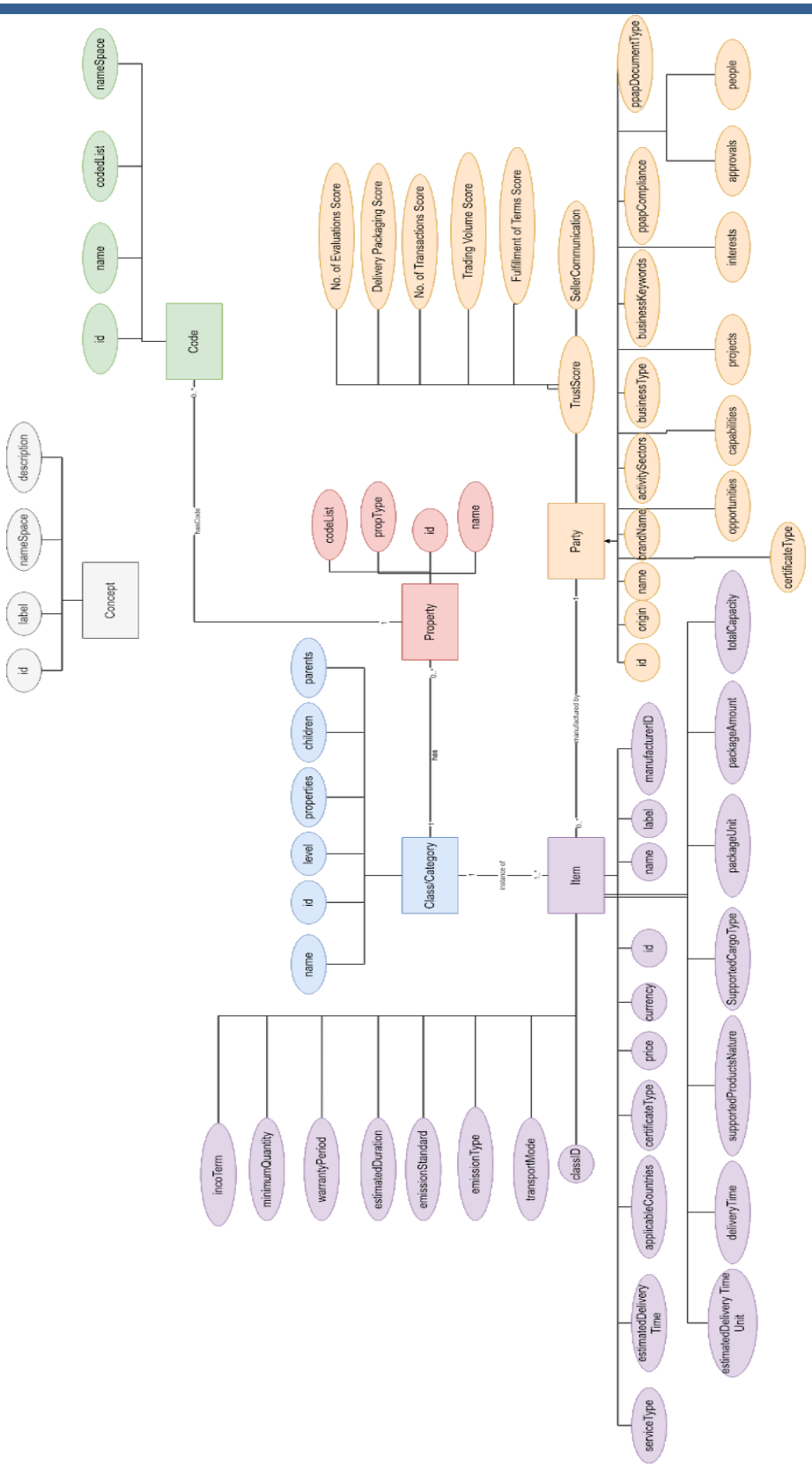


Figure 8 Extended EFPF Manufacturing Ontology

The data from different base platforms are retrieved and indexed into above common EFONT ontology using a data flow process implemented in EFPF Integration Flow Engine/ Data Spine.

The Matchmaking Service is the central component collecting the data from the distinct platforms as depicted in Figure 6**Error! Reference source not found.**. It consumes the data from the EFPF Integration Flow Engine/Data spine and maintains a full-text index, based on Apache SOLR. The Matchmaking Service also provides the federated search functionality to the EFPF Portal.

The EFONT ontology is designed to cover the main aspects of the data hosted by the distinct platforms. These main aspects are reflected by the internal model classes used by the Matchmaking Service when indexing data with Apache SOLR and when answering queries from the Federated search. To support not predefined, custom properties at runtime, the Matchmaking Service allows for custom properties to be indexed.

The next section describes the details about the matchmaking data flows and the implementation details of the indexing workflows of base platform data.

1.2.3 EFPF Matchmaking Data Flows

The main data flows in matchmaking components can be depicted as below. Noted the envisioned recommendation service is not implemented during EFPF project period (hence greyed out) though it was investigated around M18 time. Focus was shifted to agile team creation/formation feature which was elaborated in section 1.3**Error! Reference source not found.**

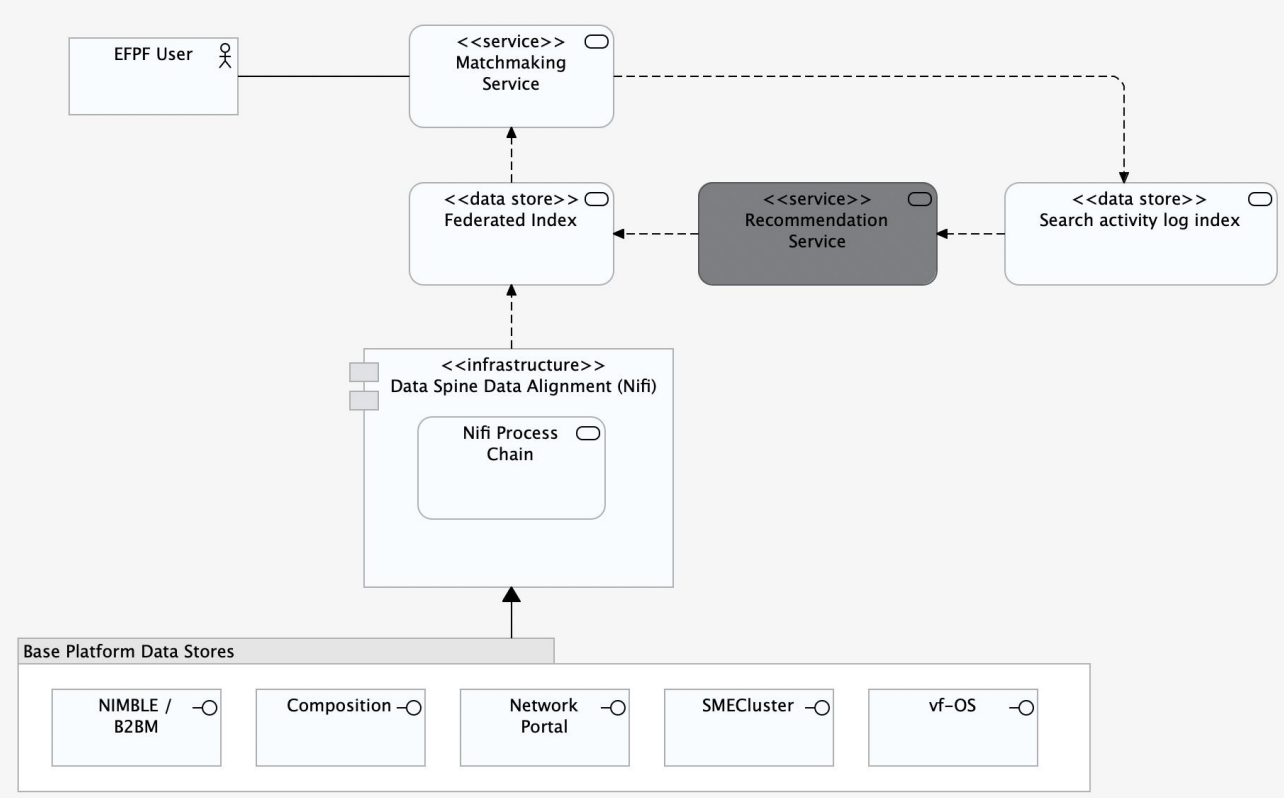


Figure 9 Data flow in EFPF Matchmaking Components

The main data flow is the one from base platform data stores (most base platforms expose their data stores via an API) to the federated index in matchmaking via the indexing

processes running on the integration flow engine (data spine). The data ingestion process is implemented as a set of Apache NiFi workflows. This data flow is triggered periodically to retrieve the latest data from the base platform. The schedule is configured in NiFi configurations in the processes.

For the implementation of the federated search-index as a data store, we use Apache Solr which is a scalable and fault tolerant search platform that provides distributed indexing, replication and load-balanced querying, automated failover and recovery, centralized configuration and more. The EFONT ontology content needs to be indexed by the Apache Solr to ensure that all required information about participants and value-units (domain knowledge) can be captured during the search process.

In the indexing workflow a data transformation occurs between the incoming data model to the federated data model. The federated data model is discussed in detail under EFPF Manufacturing Ontology in the next section. The data transformation is implemented using NiFi Jolt transformation processor. Jolt (JSON Language for Transform) is an open-source JSON to JSON transformation library. It allows the developer to define rules of transformations as a JSON specification file. The Jolt transformation processor in Apache NiFi processes the incoming data flow file and executes the transformation rules and converts the data flow file to the target schema in the NiFi workflow. Then a Solr output processor is configured as the final processor in each indexing workflow to index the data into the EFPF federated index.

Another dataflow happens at service level, from the federated index to the EFPF client via the search & recommendation service (matchmaking services). This dataflow is connected to the EFPF portal application as a REST API.

The search events (user's search queries and filtering queries) are received from the EFPF portal and logged in the EFPF data analytics framework. This analytics framework is implemented using ElasticSearch, LogStash, Kibana (ELK) stack. This data is utilized effectively in the network intelligence components in EFPF.

Following section describes the details about the different indexing workflows of EFPF connected base platforms.

1.2.4 Indexing Workflows

The integration flow engine encompasses the ETL (data extraction, transformation and loading) workflows to ingest data to the federated index from the base platform data sources. Following sections describe the individual base platform data indexing workflows implemented thus far.

All the platforms provide their data as REST endpoints. This data is extracted in a platform specific, proprietary format. The transformation step is covered with distinct transformation specifications for each of the platforms. The result of the transformation is then loaded to the Matchmaking Service.

1.2.5 SMECluster Data Indexing Workflow

SMECluster (representing DIGICOR) platform also exposes data about companies and products/services as RESTful APIs. They have exposed multiple APIs with different levels of data granularity. Currently following APIs are connected in the matchmaking indexing workflows.

- SMECluster companies data API endpoint : https://www.smecluster.com/api/DirectoryWebService/GetAllCompanies
- SMECluster services data API endpoint : https://www.smecluster.com/api/CatalogueUtilsWebService/GetAllProducts
- SMECluster business opportunities data API Endpoint: https://www.smecluster.com/api/OpportunityWebService/GetAllOpportunitiesFull

1.2.6 NIMBLE Data Indexing Workflow

The NIMBLE base platform already has a data indexing workflow to its base search index (Apache Solr). NIMBLE can be configured to index the data to multiple indexes. Instead of defining a periodic data indexing workflow in EFPF integration flow engine, the NIMBLE base platform instance is configured to index its company and products data upon creation, to the federated index in real time.

- NIMBLE companies data endpoint: http://nimble-staging-neu.salzburgresearch.at/identity/parties/all?size=100&includeRoles=false&deleted=false

1.2.7 B2BMarket Data Indexing Workflow

The B2BM Market data platform uses NIMBLE as its base platform, thus represents another instance of NIMBLE. Therefore, B2BM Market data platform supports data propagation to the Matchmaking Service the exact same way as the NIMBLE Platform.

- B2BM Market Data endpoint: https://b2bmarket.aidimme.es/api/identity/parties/all?size=10000&includeRoles=false

1.2.8 COMPOSITION Data Indexing Workflow

The COMPOSITION platform has exposed data about companies and products/services as RESTful APIs.

- COMPOSITION companies data API endpoint: https://EFPF.composition-ecosystem.eu/matchmaker/COMPOSITION_RBMM_Restful_WS/RBMM/getMarketplaceCompanies
- COMPOSITION services data API endpoint: https://EFPF.composition-ecosystem.eu/matchmaker/COMPOSITION_RBMM_Restful_WS/RBMM/getMarketplaceServices

These APIs are secured with basic authentication (username, password). The indexing workflow is configured with the basic authentication credentials to retrieve data.

1.2.9 Valuechain Network Portal Data Indexing Workflow

Valuechain's Network Portal, previously known as iQluster, exposes data about companies as RESTful APIs. They provided multiple APIs with different levels of data granularity. A few examples are given in the table below. Currently the API to get full details of all accessible companies is connected in the matchmaking indexing workflows.

- Get all companies: https://api.valuechain.com/api/company/AllCompanies

- Get company basic info: https://api.valuechain.com/api/company/generalinfo
- Get full detail of all companies: https://api.valuechain.com/api/company/AllCompaniesFull

1.2.10 Vf-OS Data Indexing Workflow

Vf-OS API provides a list of applications from Vf-OS platform. The API detail is as below:

https://vfos-datahub.ascora.de/v1/products?access_token=xxxx&per_page=<per_page>&page=<page>

From the API output, following fields are identified and indexed in Federated search (Products/Services).

- productLink
- productNames & productDescription
- categoryNames

vf-OS Products API route documentation: Request information about all assets – vf-OS Documentation (ascora.eu)

1.2.11 ZDMP Data Indexing Workflow

The ZDMP API is secured via Keycloak and behind the API Gateway. To access the product endpoint, a token should be obtained from ZDNP Keycloak first, using the link below:

https://keycloak-zdmp.platform.zdmp.eu/auth/realms/testcompany/protocol/openid-connect/token

To obtain the products from ZDMP, this endpoint should be used:

https://apigw-zdmp.platform.zdmp.eu/gateway/il-zdmp-plm/1.0/api/v1/products

Relevant fields from the JSON output can be utilised to federate the product info to EFPF and display the product name, description, image (if have), and link to the corresponding product page.

1.3 Agile Team Formation in EFPF

1.3.1 Agile Team Formation with Network Portal

Agile Team Formation provides user options to create a team based on their search and preference. Federated search made it feasible for users to see consolidated search result, can then directly select interested companies from their search result to form a team on a

connected platform, such as building a network on Valuechain's Network Portal. Figure 10, Figure 11 and Figure 12 demonstrate the initial steps to form a team.

User uses EFPF federated search to get companies of interest (based on commodity or capability for example). The user is then able to select companies of interest (ticking the checkboxes next to the company names/icons). The selected companies are listed at the top of the page allowing users to confirm the selection before continuing the team creation process. An example is shown below that user can view companies from all federated platforms, filter by platform, select companies which come from different platforms or same platform based on their preferences. Once more than one companies are selected (checkbox next to the company is ticked), the button for 'Invite to collaborate on Network Portal' will be enabled (if no selection is made, the button will remain grey).

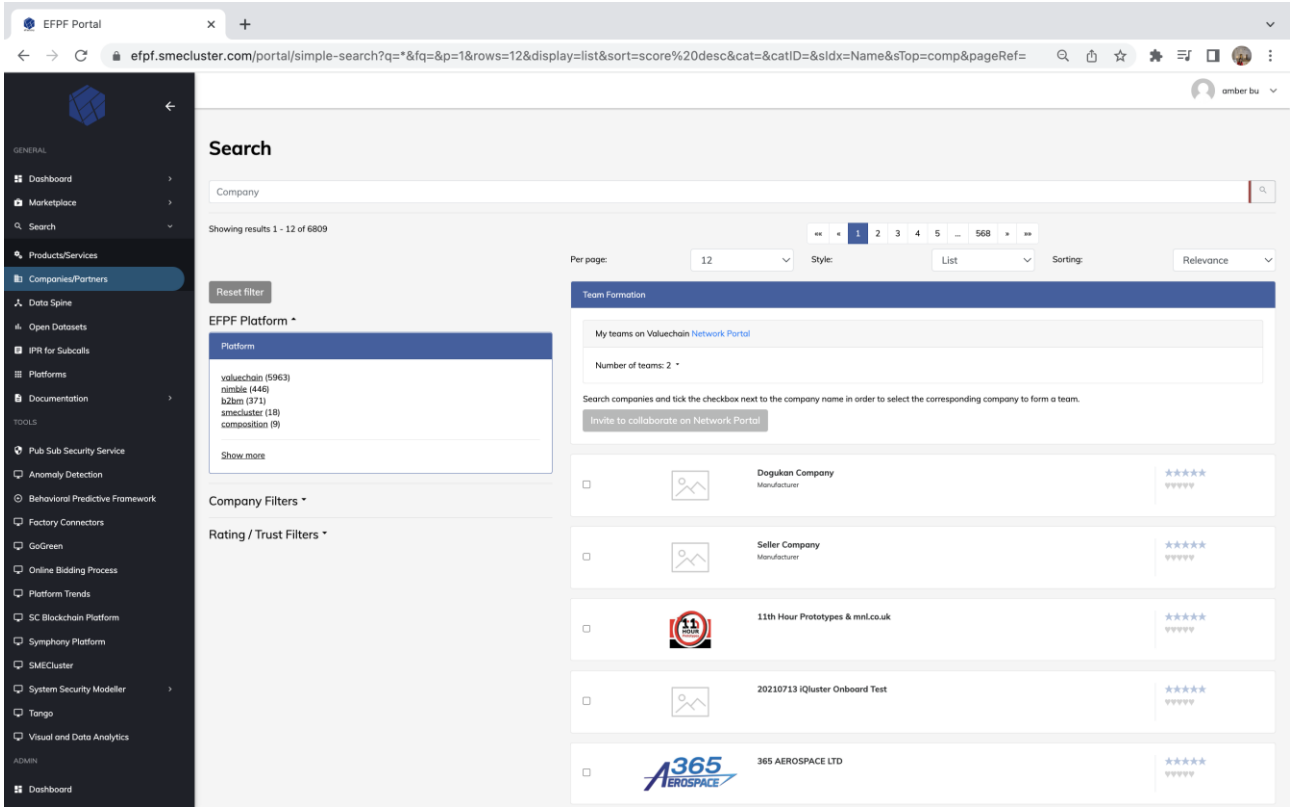


Figure 10 Federated Search - Companies/partners

Once user confirmed to continue onto Network Portal, EFPF posts selected companies list and related info in JSON format to Network Portal with specified parameter (to indicate event for creating a network). User will be logged in to Network Portal via Single Sign On. Once SSO check is ok, user will see the first page where they can either choose to create a new network or add the selected companies to existing networks (if they have already had some networks in Network Portal).

The following screenshots show an example with the starting point in EFPF federated search and transition point from Federated Search (Matchmaking) to Team Formation on Network Portal.

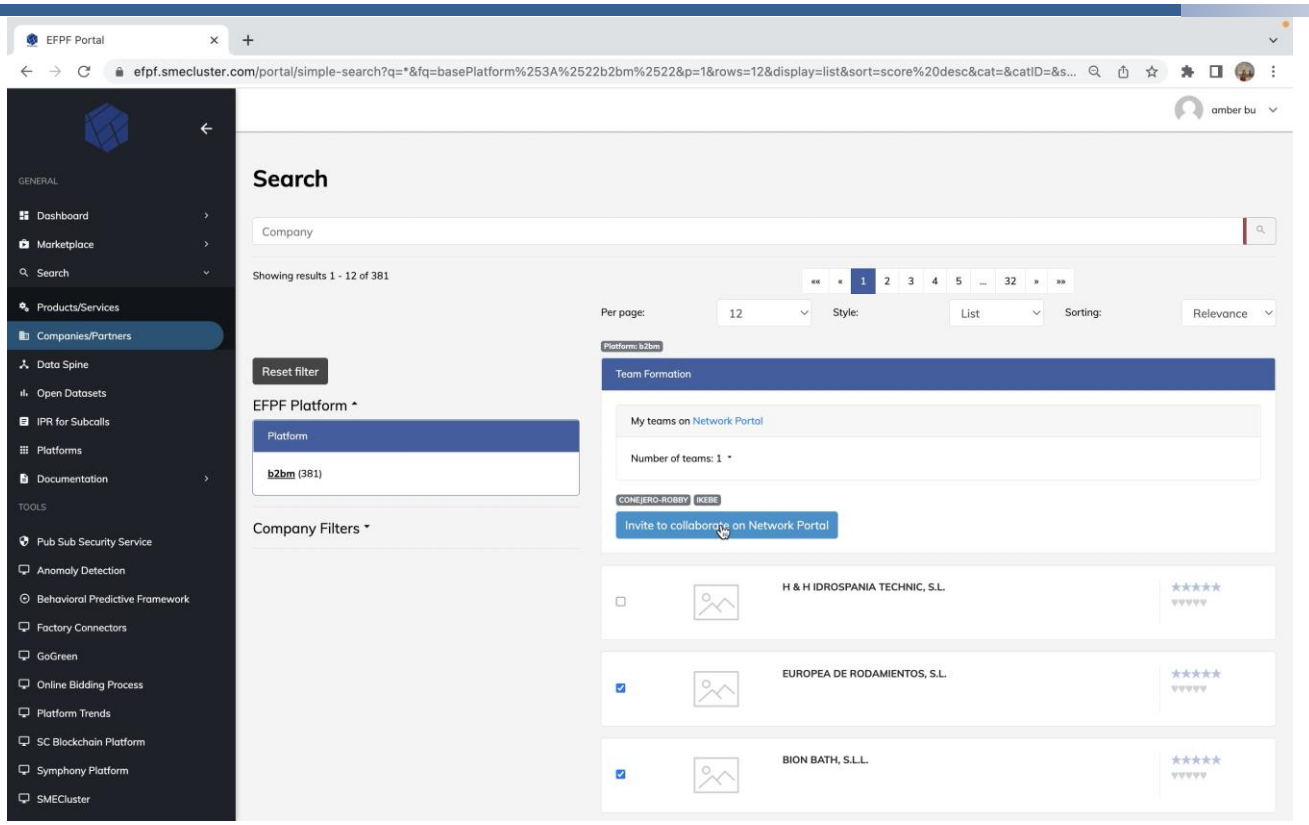


Figure 11 Filter and Select Companies of Interest

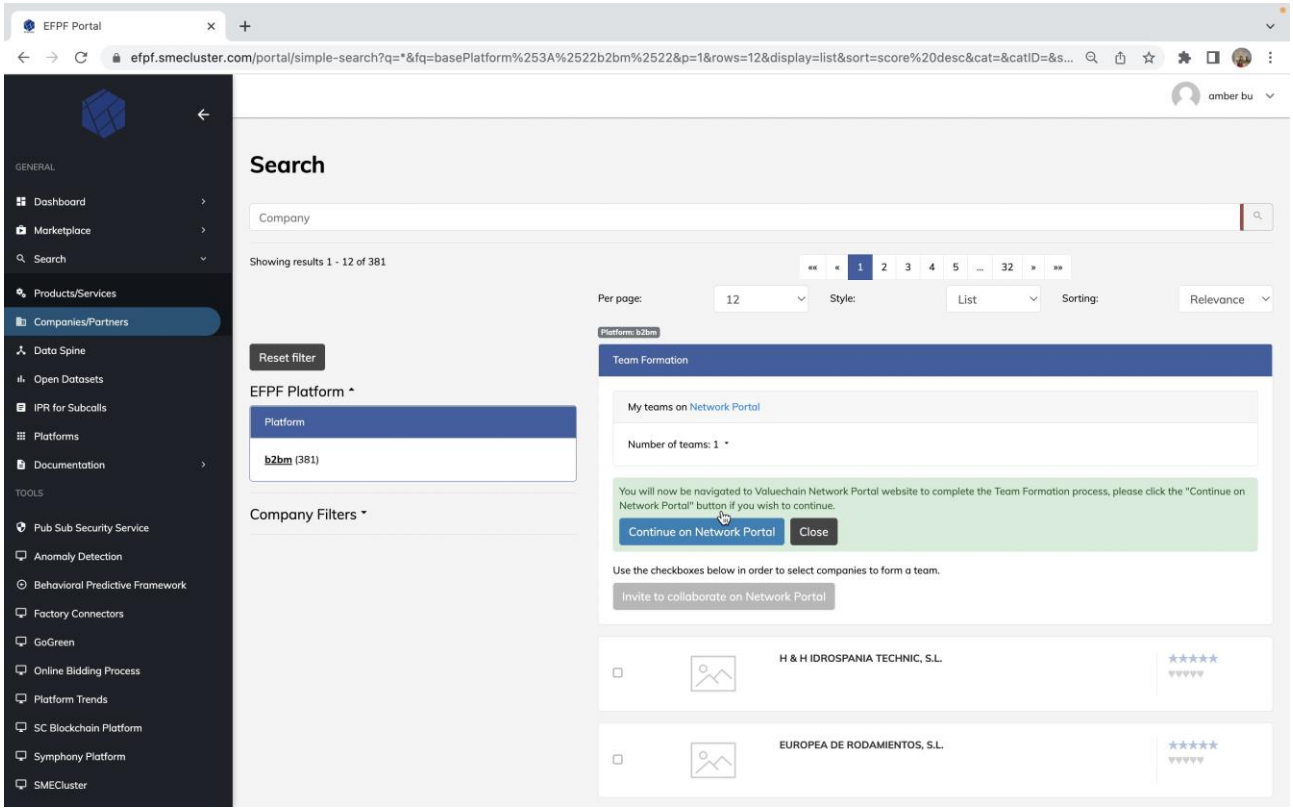


Figure 12 Confirmation to Continue onto Network Portal

The following screenshots demonstrate the steps of team formation (creating a network) on Network Portal.

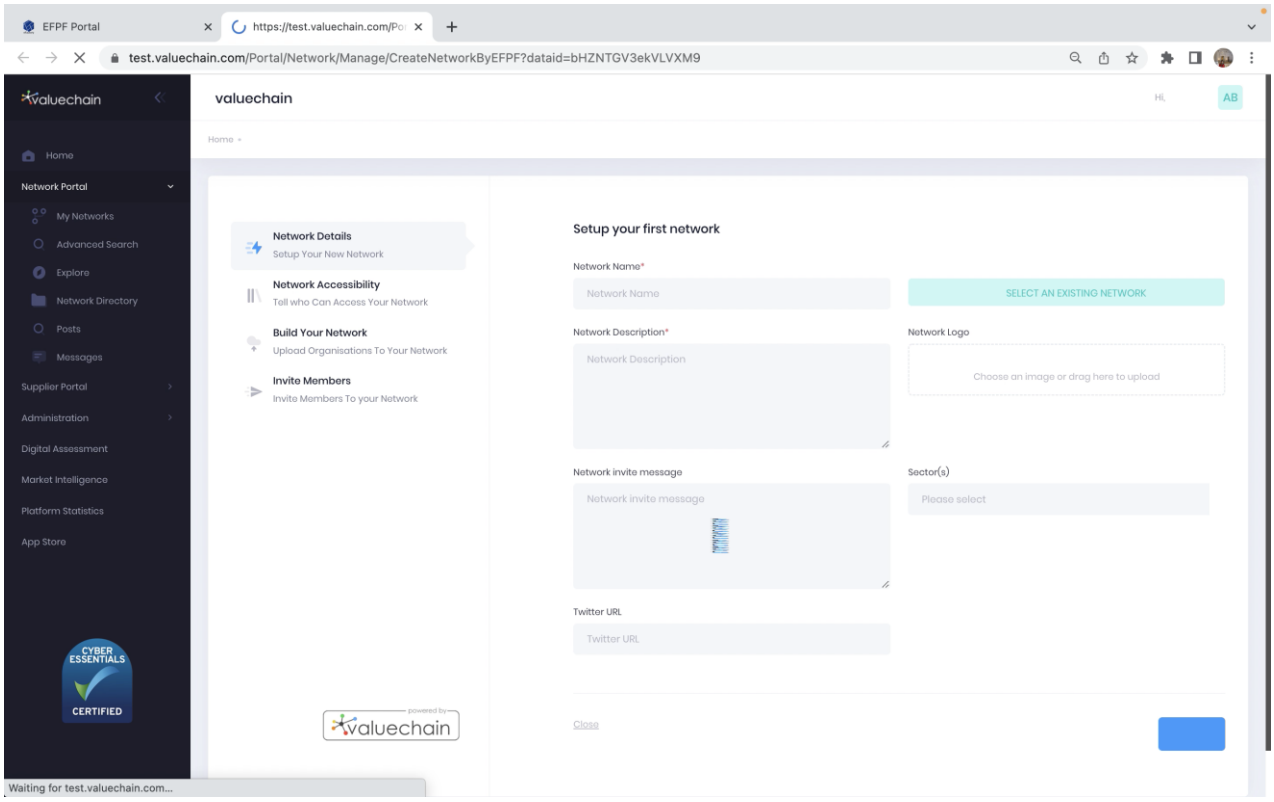


Figure 13 Creating a Network/Team on Network Portal - Network Details

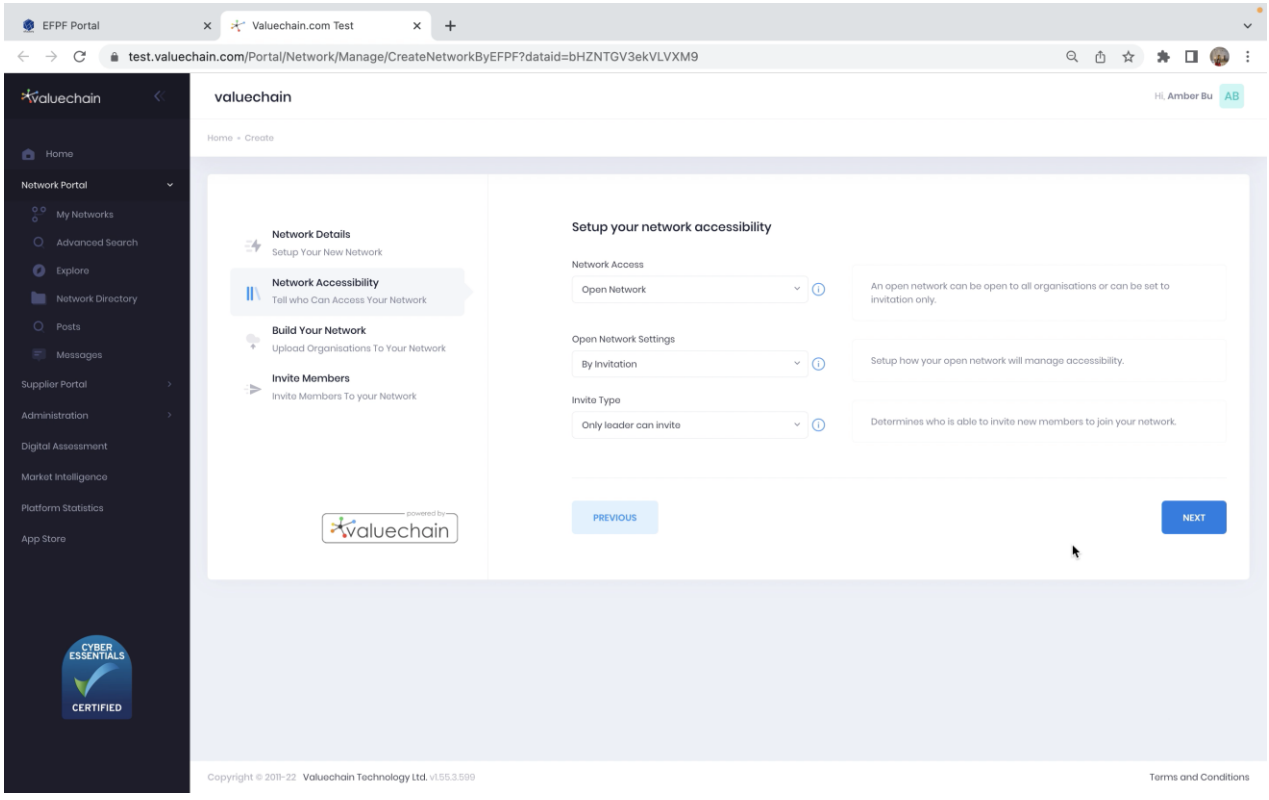


Figure 14 Creating a Network/Team on Network Portal - Network Accessibility

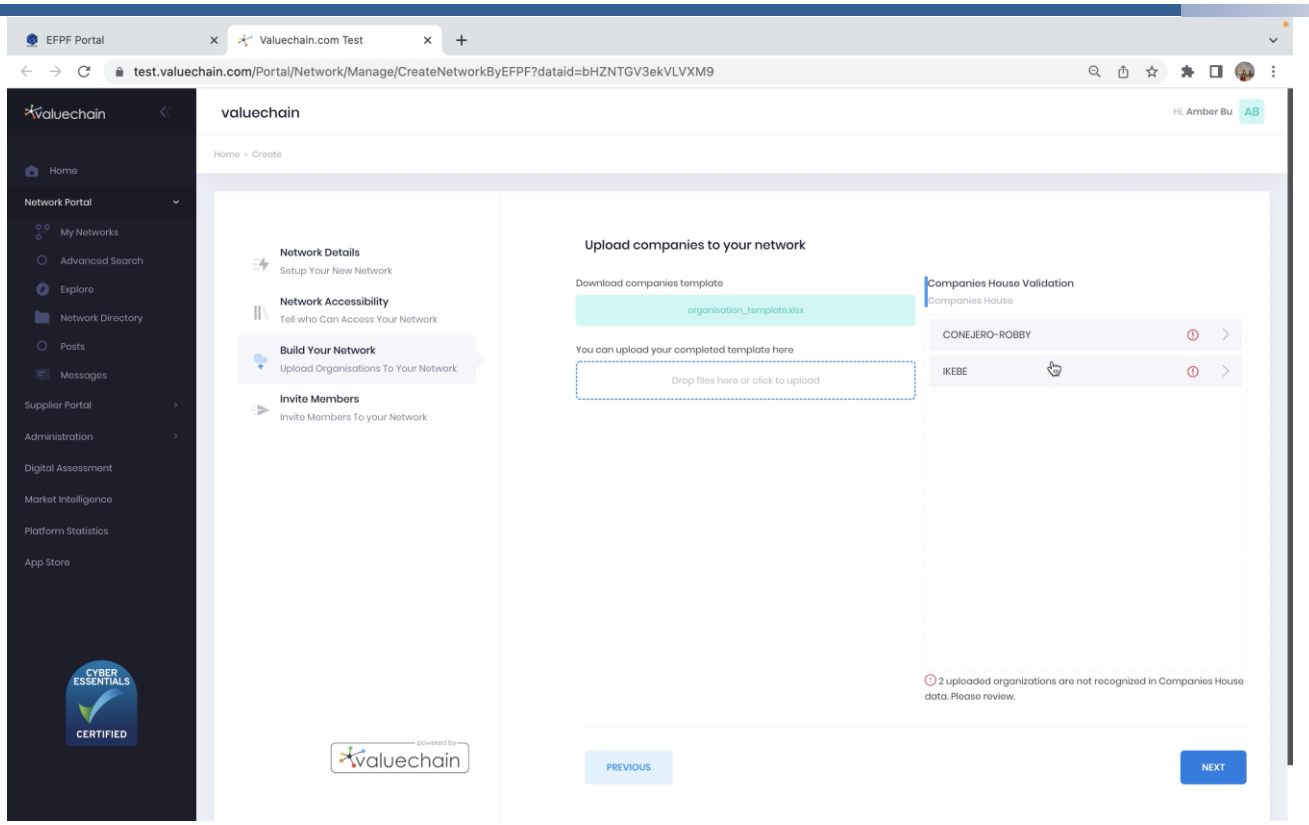


Figure 15 Creating a Network/Team on Network Portal - Build Your Network

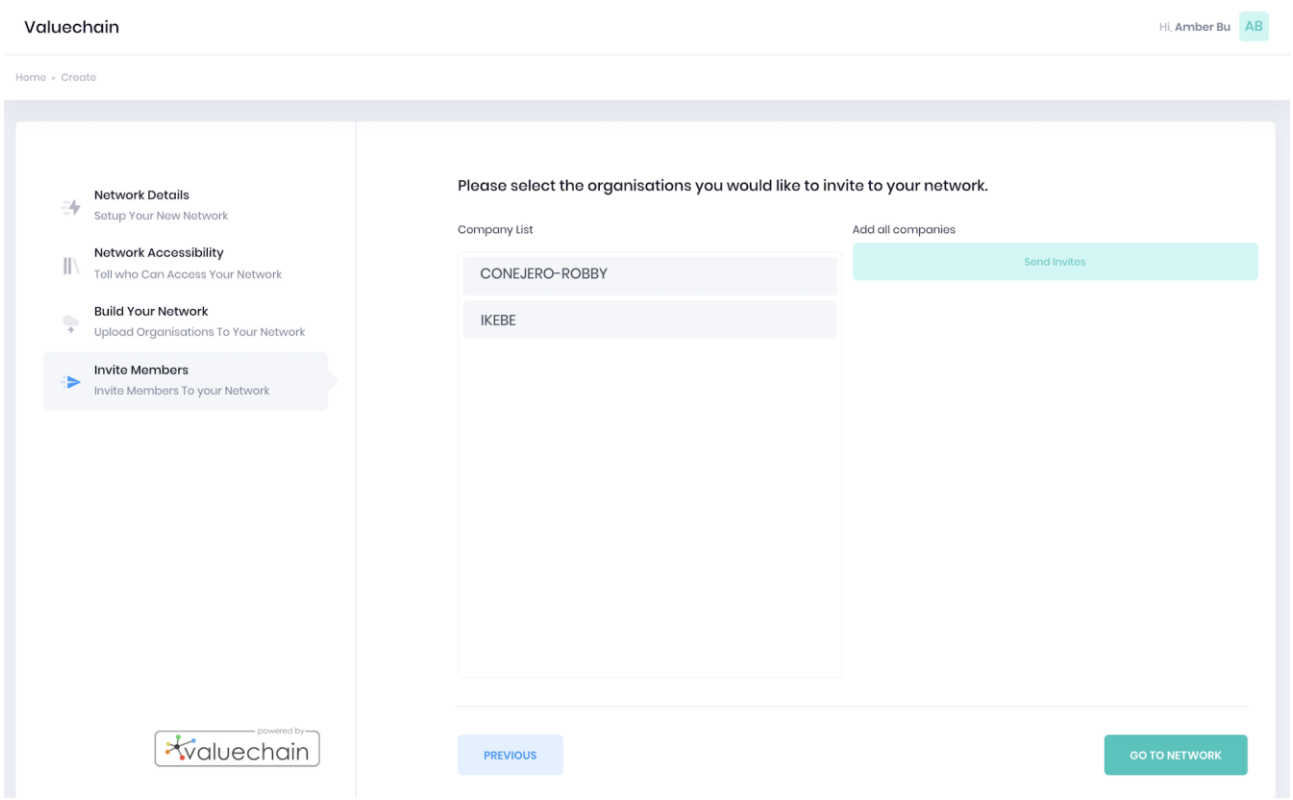


Figure 16 Creating a Network/Team on Network Portal - Invite Members

The user now has built a ‘team’ with selected companies in the form of a ‘network’ on Network Portal. Noted in the last step user can decide to send invitation now, or later. What more can they do from here? They can go to their network and start further collaboration. The following features are a few highlights offered by Network Portal. For details on what Network Portal brings to the platform, see section 2.4.2.2.

a. The user/network leader can expand this team by inviting other companies when the need is felt.

b. The user/network leader can design surveys or questionnaire to collect information for selected team and can build report/analytics on collected data.

c. Pull all or further down selected companies from within that network into a Tender application.

d. Other value-added features: Network Explorer, Advanced Search, b2b Matchmaking, Company posts, member to member chat and national database integration for validation of company information. Access to other manufacturing collaboration application in the wider Valuechain ecosystem.

Data about all companies entering Network Portal through SSO and the networks (teams) created are available to be retrieved by EFPF. The following screenshot shows the full list of networks/teams the current user's company had created on Network Portal. And users can easily click the Network Portal link to view details and interact with their networks.

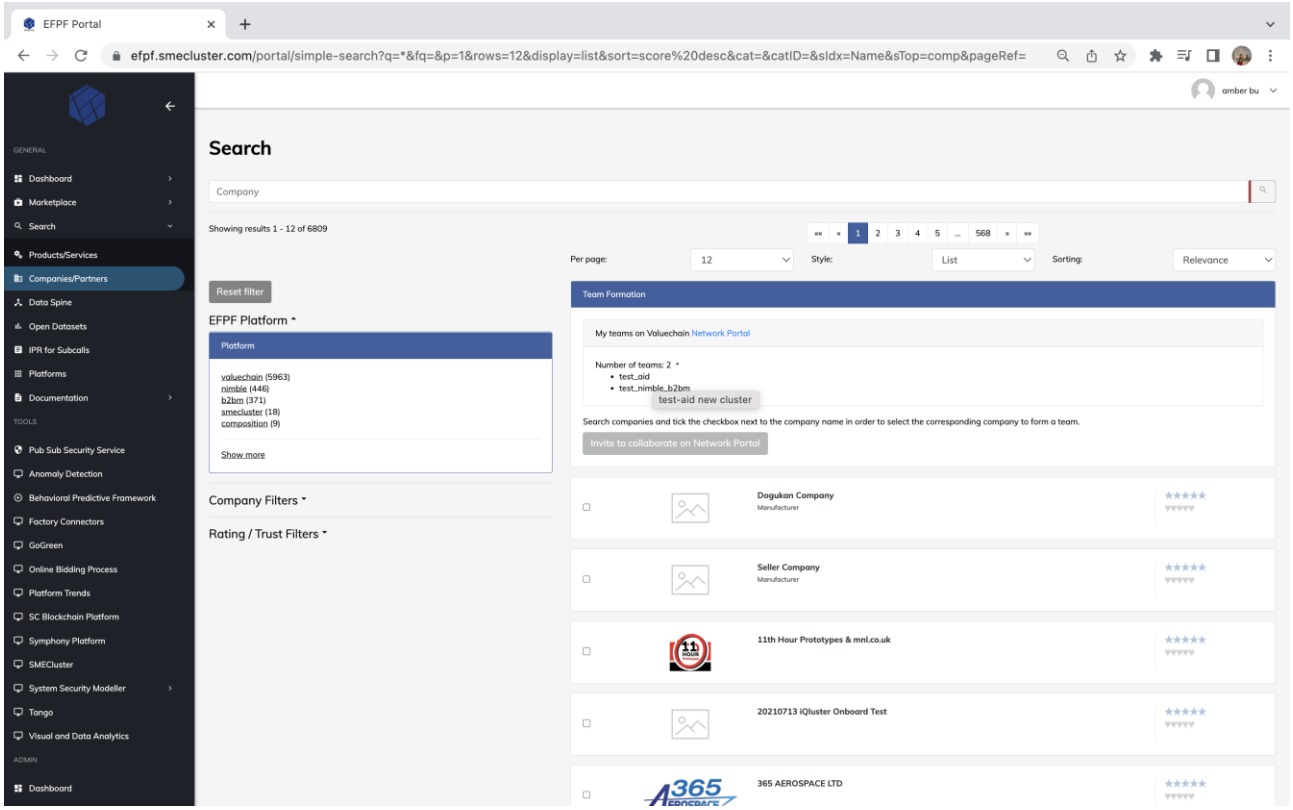


Figure 17 List of My Networks (Network Description in the Tooltip)

1.3.2 Team Creator Integration

Team Creator[1] provides a platform allowing companies to find suitable partners, putting together skills and resources to respond to business opportunities and invitations to tender. Team creator development and integration was done as part of Open call project. Team creator was integrated with EFPF via Single Sign On. EFPF Federated search ontology was extended, and API was adjusted to support functionality integration with Team Creator.

Team creator uses EFPF federated search to retrieve companies and business opportunities (aka, tenders). It utilises semantic matchmaking module to automatically match requirements from the business opportunities to the company's capabilities. Users will be presented with the recommended teams, consisting of companies with corresponding capabilities. The following two figures respectively demonstrate the Team Creator UI recommending teams for a Tender, and how team creator service is integrated with EFPF, utilising EFPF matchmaking service.

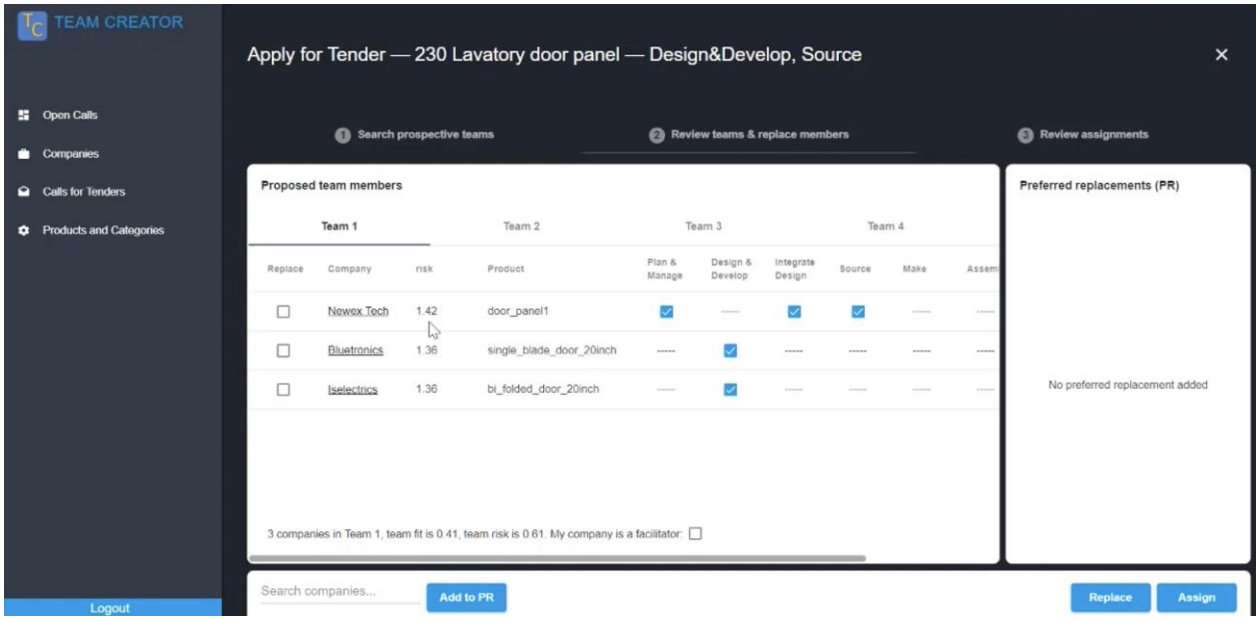


Figure 18 Team Creator UI

[1] https://digisys4.eu/projects/teamcreator/

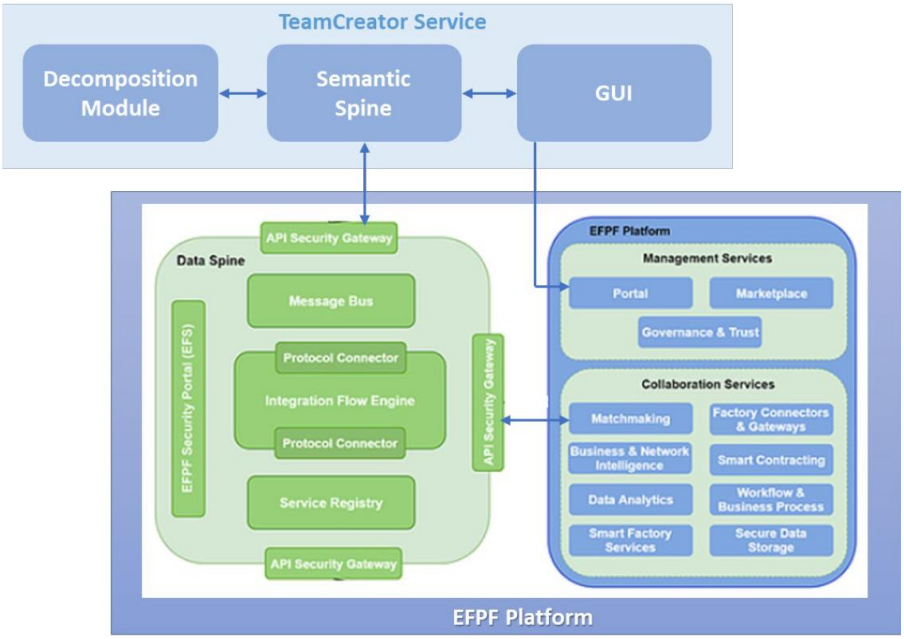


Figure 19 Team Creator Integration Flow

Team creator can also support customisation allowing adding categories, products, and companies in its independent UI. The integration with EFPF is piloted with the pilot partner LAGRAMA in furniture domain. Details of this user case can be found in section 1.5.

1.4 Matchmaking Services for Automated Online Bidding

This service is an extension of EFPF matchmaking capabilities. Federated search and recommendation service architecture provides the EFPF user with flexibility to find and select the best suppliers and products/services via information retrieval techniques. This service provides an automated matchmaking mechanism for information requests from buyers to suppliers, to execute negotiations and business transactions automatically via configured agents. Furthermore, this Matchmaking component consists of a full semantic framework that provides services to federated search enabling indexing of companies and services coming from COMPOSITION project and Circular Economy (CE) pilot of EFPF.

1.4.1 Application and Demonstration Scenario of the Service

The Automated Online Bidding differs from the aforementioned search and recommendation systems. It is a matchmaking application that achieves automated negotiations and business transactions between interested stakeholders. The matchmaker's goal is to find the best possible supplier to fulfil a request for a service or product in a fully automated way. The matchmaker considers different decision criteria for supplier selection, according to several qualitative and quantitative factors. It also evaluates the available offers from the providers in order to suggest the best one to the supplier.

For the project purposes, this matchmaking solution aims to address the challenges and realize the Circular Economy Scenario of EFPF regarding automated negotiations for wastes. KLEEMANN (KLE), ELDIA and MILOIL are the three participants of the scenario,

focusing on Closed-Loop Supply Chains. The scenario starts with KLE granting the potential to a stakeholder business to collect and manage waste material on a marketplace, like wood waste or scrap metal. Then, ELDIA and other interested companies attend the process of online bidding to acquire the business contract. The winning bidder can use the marketplace again to sell the waste to bio-energy companies such as MILOIL. The recycled material is offered back to KLE and other manufacturers through the marketplace for reuse, completing the business circle. Figure 20 is a comprehensive illustration of the circular economy scenario.

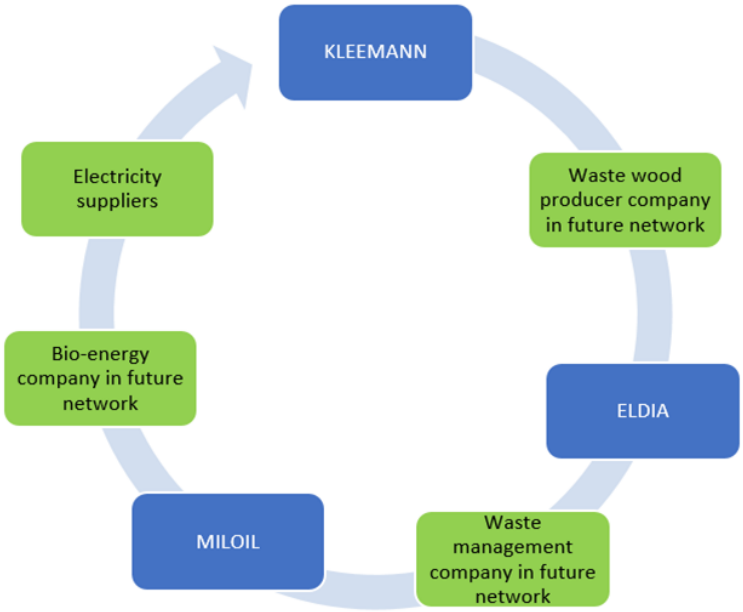


Figure 20 Circular Economy Scenario of EFPF

The Matchmaker's functionalities that will be described in detail below are fully exploited by the circular economy scenario. The Agent Level Matchmaking is extensively used for discovering services, products and capabilities as well as available agents and stakeholders, whereas the Offer Level Matchmaking module is operating for the bidding process and the automatic negotiations among the scenario participants. Finally, yet importantly, the Ontology Querying Module is responsible to provide information regarding the companies of CE scenario in order to be visible in EFPF federated search results.

1.4.2 State-of-the-art

There are several techniques regarding semantic representation and matchmaking and some of them are presented hereby. An agent-based system which performs different level information management activities is InfoSleuth (Nodine, 2000). InfoSleuth offers a set of Broker agents which provide syntactic and semantic matchmaking between services' providers and requesters by using a specific "InfoSleuth ontology". IMPACT (Interactive Maryland Platform for Agents Collaborating Together) (Arisha, 1998) is an international research project, related to software implementation that facilitates the creation, deployment, interaction, and collaborative aspects of software agents in a heterogeneous, distributed environment. Furthermore, Digital Manufacturing Market (Ameri (AMeri), 2012) is a multi-agent web-based framework that contains a manufacturing services ontology and a matchmaking mechanism which matches a consumer's requirements with suppliers' manufacturing capabilities. Lastly, FITMAN-SeMa (Metadata and Ontologies Semantic

Matching SE) (FITMAN-SeMa, 2018) is a component of FIWARE (FIWARE, 2018) for 'smart industry' and provides storing and retrieving functionalities for ontologies and triplets. By using various algorithms FITMAN-SeMa performs effective semantic matching.

The matchmaking over bidding definitely includes the evaluation of given offers and the best offer selection. An interesting approach related to offer evaluation in an automatic way is the decision support tool presented in (Idrees, 2015). This study mentions the evaluation steps taken in order to make a decision towards the best offer. Nevertheless, weighted criteria assessment can also be implemented as a part of matchmaking and enhance even the previous method, so a small literature review is presented at this point. Multiple decision-making problems enclose the determination of the optimal alternative from several potential candidates in a decision, depending on several criteria or attributes that may be concrete or vague. The most widely used method is the Weighted Sum Model (WSM) (Fishburn, 1967). This method requires a dataset expressed in the same unit for each alternative, thus it is an utmost convenient method for single-dimensional problems. The analytic hierarchy process (AHP) is another popular method (Saaty, 1994). AHP is similar to WSM, thus it can be applied in both single and multi-dimensional problems, since it uses relative values for each alternative and not the actual ones which add up to one. A revised AHP method was introduced later on (Belton and Gear, 1981) with some effective modifications. The extension of the method is that instead of calculating relative values of the alternatives sum up to one, each relative value is divided by the maximum value of the relative values.

1.4.3 Design of the Semantic Matchmaker

The matchmaker component provides an explicit match of requesters and suppliers which participate in an ecosystem and enables automated negotiations. It is a rule-based matchmaking engine enhanced with multi-criteria algorithms for offers' evaluation. It supports semantic matching in terms of services, products and business entities' capabilities at the EFPF platform and is used in cross domain scenarios in order to enable a real time bidding process.

The actual actors of the matchmaking component are the Agents. They instantiate the supply-chain formation strategy of industry stakeholders and are in charge of triggering the start of the automated negotiations. The Requester and the Supplier are the two types of stakeholders/agents which request the matchmaker services in order to:

- Request the list of the suitable agents for a certain negotiation, e.g., the agents offering a certain service on the marketplace
- Evaluate the offers that have been received during a negotiation

The matchmaking application contains a comprehensive representation of the marketplace ecosystem encompassed by the system's core Ontology coming from the COMPOSITION project's Collaborative Manufacturing Services Ontology and its thoroughly defined data models. For the EFPF purposes, this ontology was continuously updated to meet EFPF requirements for both Online Bidding Process and Federated Search services. Semantic rules and queries are designed and executed to achieve optimal suggestions and matching between Requesters and Suppliers. Stakeholders and Agents are external participants of the matchmaking application, but as it is crucial, they have to reflect the classes, functions and attributes defined in the common ontology, so as to enable interoperable behaviour and matching. Matchmaker is a RESTful application, using open-source components combined with custom-made components towards an automated matchmaking procedure. Its integrated and modular architecture is described in detail below. The technical details of the

design and implementation of the Semantic Matchmaker will be analysed in this report. The corresponding interfaces are presented in the dedicated report of D5.3 - EFPF Interfacing, Evolution and Extension.

The Semantic Matchmaker is built upon Apache Jena framework (Apache Jena, 2018), a free open-source Java framework suited for Semantic Web and Linked Data applications. Jena provides a programmatic environment for RDF, RDFS and OWL, SPARQL, GRDDL, and includes a rule-based inference engine (Jena Rules). The exported application was deployed in an Apache Tomcat Server and a Docker image was created to enable the containerization of the matchmaking service. The matchmaking service communicates with other components using REST protocol. EFPF Data Spine API Security Gateway was used to secure these endpoints. Also a corresponding NiFi processor were created to enable faster integration with components like Agents and Federated Search.

The Semantic Matchmaker application has adopted the architecture depicted in Figure 21, including:

- The Ontology Store (RDF triple store), initialized by the System's Service Ontology.
- The Ontology Query Engine inside the corresponding Ontology API which enables the manipulation of the Ontology Store by the Marketplace Agents and Stakeholders.
- The Matchmaker API, which exchanges information through the Ontology Model with the Ontology Store. Two matchmaking levels are developed, the Agent and Offer Level matchmaking. Both use the Semantic Rules Module for the matching, while the latter matchmaking level implements the Weight Assessment module.
- The REST API, on the top of all APIs, which enables the requests of Agents and Stakeholders in the Semantic Framework's different components.

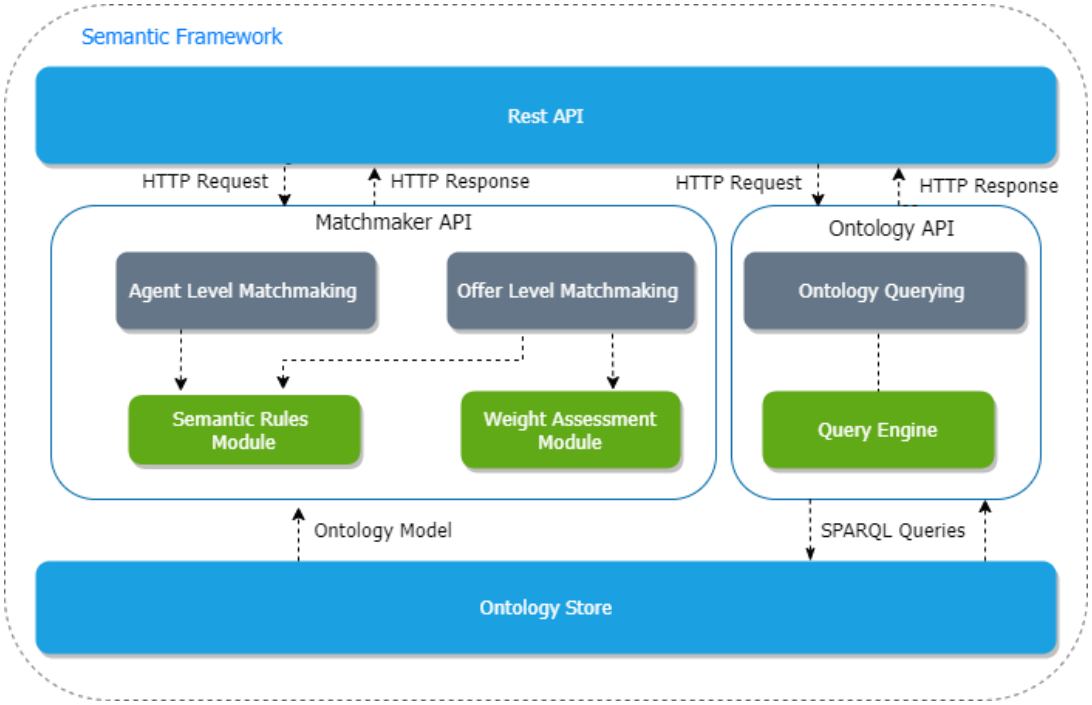


Figure 21 Semantic Framework's Architecture

The Semantic Matchmaker's core functionality is to receive Agents and Stakeholders' requests via the Semantic Matchmaker API and carry them out through the Semantic Rules

and Weight Assessment Modules. In order to start the matchmaking process and execute an external request the Matchmaker follows some specific steps.

The Semantic Matchmaker receives the requests from the Agent or Stakeholder (requests are based on REST and HTTP). At once, the Matchmaker accesses the available services from the Ontology Store. An Ontology Model is then created in the memory. The Semantic Matchmaker transforms the request from its initial format (JSON format) to the Ontology compatible format and creates the necessary instances. Then, the Semantic Matchmaker collects the proper Jena rules list, depending on the type of the incoming request. A reasoner is created by calling an instance of a reasoner class or by retrieving from the reasoner registry which contains instances indexed by URI assigned to the reasoner. The rules' list is set after the reasoner instance is created. This way, the reasoner obtains the set of rules that should be executed. An inference model is created after applying the reasoner to data. The Semantic Matchmaker, then, accesses the information stored in the inference model.

After the execution of the request either by implementing the Agent Level or the Offer Level Matching, the output is constructed by the following way. The module transforms the inferred information to agents' request format. Finally, the output is returned as a response via Semantic Matchmaker API (REST and HTTP) to the Agent in a format compatible to the agents' request format. At this level of matching the semantic rules are focused on service level. For an agent who requests a service in the Agent Ecosystem, the Matchmaker will provide the agents which offer this service.

Agent Level Matchmaking

The Agent Level Matchmaking focuses on matching agents and stakeholders which are possible customers and suppliers. The Matchmaker applies the semantic rules constructed with ontology classes of Business Entity, Service, Operations, Goods and the properties between them. The execution of the rules achieves to infer knowledge and trigger negotiations among the Marketplace stakeholders. A list of possible suppliers or customers is returned to the requester agent.

Figure 22 is a diagram illustrating the Agent Level Matchmaking procedure. The Agent Request is a JSON request including the requester's personal information and the services or products that the requester is seeking. The Semantic Rule engine retrieves the information from the ecosystem's Ontology and the Semantic Matchmaker responds with a set of agents which provide the requested product, service or capability.

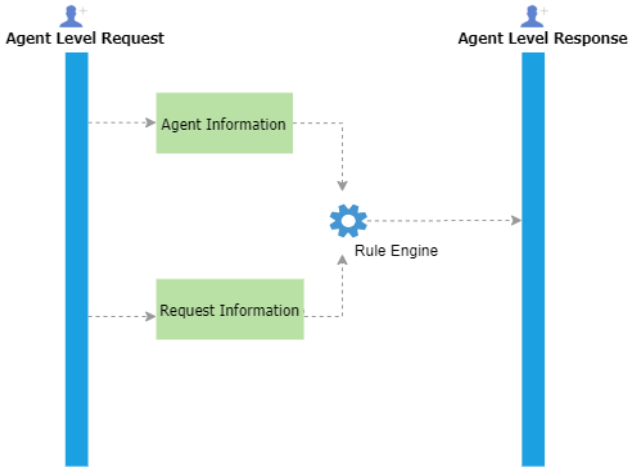


Figure 22 Agent Level Matchmaking process

The semantic matchmaker can match these requests based on the services and products but mostly on common operations and goods that exist in the ecosystem's Ontology. Every business entity uses its own terms to describe one of its offered services and products. However, every one of these vendor specific terms will be mapped with a common operation. This way, on the one hand every business entity participates in the Marketplace and advertises its services and products with its own terms, whereas the Matchmaker matches similar concepts in order to set the Marketplace capable to relate offers and requests among stakeholders or to find possible solutions for some Marketplace participants.

Moreover, further rules can be added to give a matchmaking result based also on some criteria by the requesters as a kind of filtering. Additional criteria by the requester agent can improve the Matchmaker's result. After the initial matching based on the provided services the Matchmaker can apply more rules in order to exclude some suppliers from its final output. The rules that will be applied are related to quantitative criteria of the services.

Offer Level Matchmaking

The Offer Level Matching regards the process of offers' evaluation achieving online bidding for fully automated negotiations. Starting with an agent or stakeholder which provides a set of offers that this agent or stakeholder had received from supplier agents, the Matchmaker is responsible for the bidding procedure to return the most convenient offer. The Offer Level Matchmaking follows a multi-criteria decision-making method combining the semantic rules inference with the enhancement of a weighted criteria assessment algorithm.

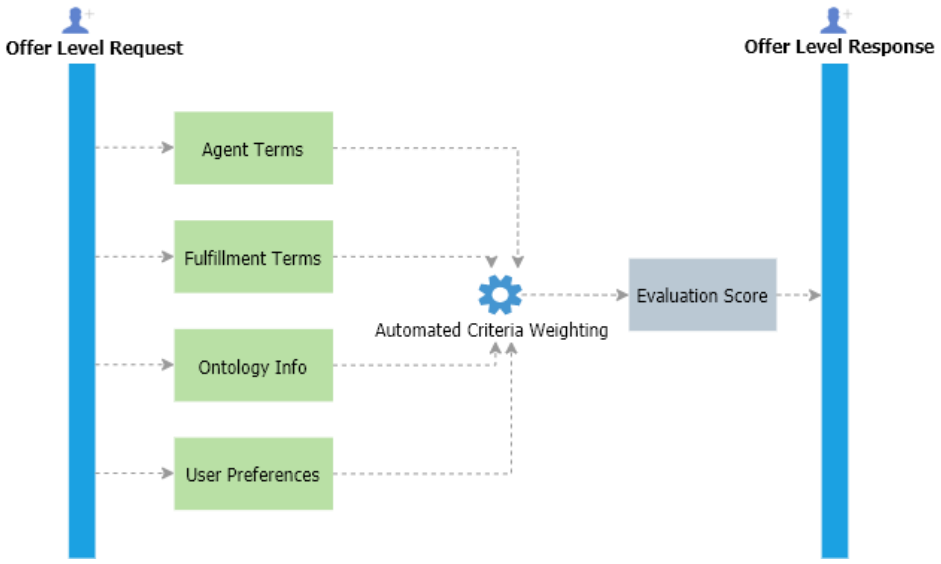


Figure 23 Offer Level Matchmaking Process

Figure 23 is a high-level illustration of the offer evaluation process, highlighting the involvement of several criteria extracted from the agent's input. The properties of the Offer Level Request (JSON format) are annotated to form the weighted criteria. The criteria are evaluated and extract the best evaluation score and return the best suggested offer.

The criteria are formed by extracting the following information from the Offer Level Request body:

- **Agent Terms**: The Service, Transportation and Insurance Price given by the offers request, sum up to an overall price. Also, the Delivery time and Payment terms (credit).
- **Fulfilment Terms**: Payment and Delivery Methods, two optional properties defined by the initial request, are checked by a fulfilment rule and if they match with the offers' available methods, their value is set to 1, otherwise to 0.
- **Ontology Info***:* The Certification possession and the corresponding value (0 or 1) and the Rating of a Business Entity (1 to 5) according to the marketplace.
- **User Preferences***:* The relative importance of the criteria defined by the user.

Each criterion owns a weighting factor, defined by the end-user, and a multi-criteria decision-making method is being implemented, the Analytic Hierarchy Process (Saaty, 1994). The key advantage of this method is the automated evaluation of the criteria based on the preferences provided by the user. Once the criteria weights are calculated, each alternative offer gains a weighted score, with the best one indicating the best offer. The user selects the order of preferences among all the available criteria with the first being the most important and the last being the least important. Weighted scores for each offer are then calculated and the best score indicates the best offer.

Ontology Query Engine/Module

This module enables the manipulation of the Ontology Store by the Online Bidding Process Agents/Stakeholders and provides services for the indexing of the stored knowledge to the EFPF Federated Search mechanism. CRUD operations are enabled by this component, and they are available as REST web services to both Agents and Federated Search components. The requests are translated to SPARQL queries that enable the updating of the ontological resources stored in the Ontology RDF Triple Store.

In total, the Semantic Framework (Matchmaking Services and Ontology Querying) provides the following list of endpoints:

REST Endpoint	HTTP Method	Description
/getInfoFromOntology	GET	Retrieves all Marketplace Companies, Services and Products with the corresponding information
/getMarketplaceCompanies	GET	Retrieves Marketplace Companies with the corresponding information
/getMarketplaceServices	GET	Retrieves Marketplace Services and Products with the corresponding information
/getServicesFromCompany	GET	Retrieves Marketplace Services and Products of a specific Company with the corresponding information
/getCompanyDetails	GET	Retrieves specific Company's information
/getGoodsByCategory	GET	Retrieves the Marketplace Goods for each Service Category
/deleteCompany	GET	Deletes a specific Company from Marketplace
/performMatchmaking	POST	Performs agent level matchmaking
/offersEvaluation	POST	Performs offer level matchmaking
/setMarketplaceCompany	POST	Inserts new Company in Marketplace
/setMarketplaceService	POST	Inserts new Service in Marketplace

Figure 24 List of Available API Services

1.4.4 Matchmaking Service Availability in Platform Level

Beyond the abovementioned application/demonstration scenario, a generic design approach has been followed to enable the execution of various scenarios regarding automated negotiations. The matchmaking component is not directly available to end users, but it is accessible through virtual agents as it was stated before. This matchmaking service consists of the core part of the EFPF Online Bidding Process that it is available through

EFPF Portal. The general actions scheme that is followed for request a service/good is available in the next figure:

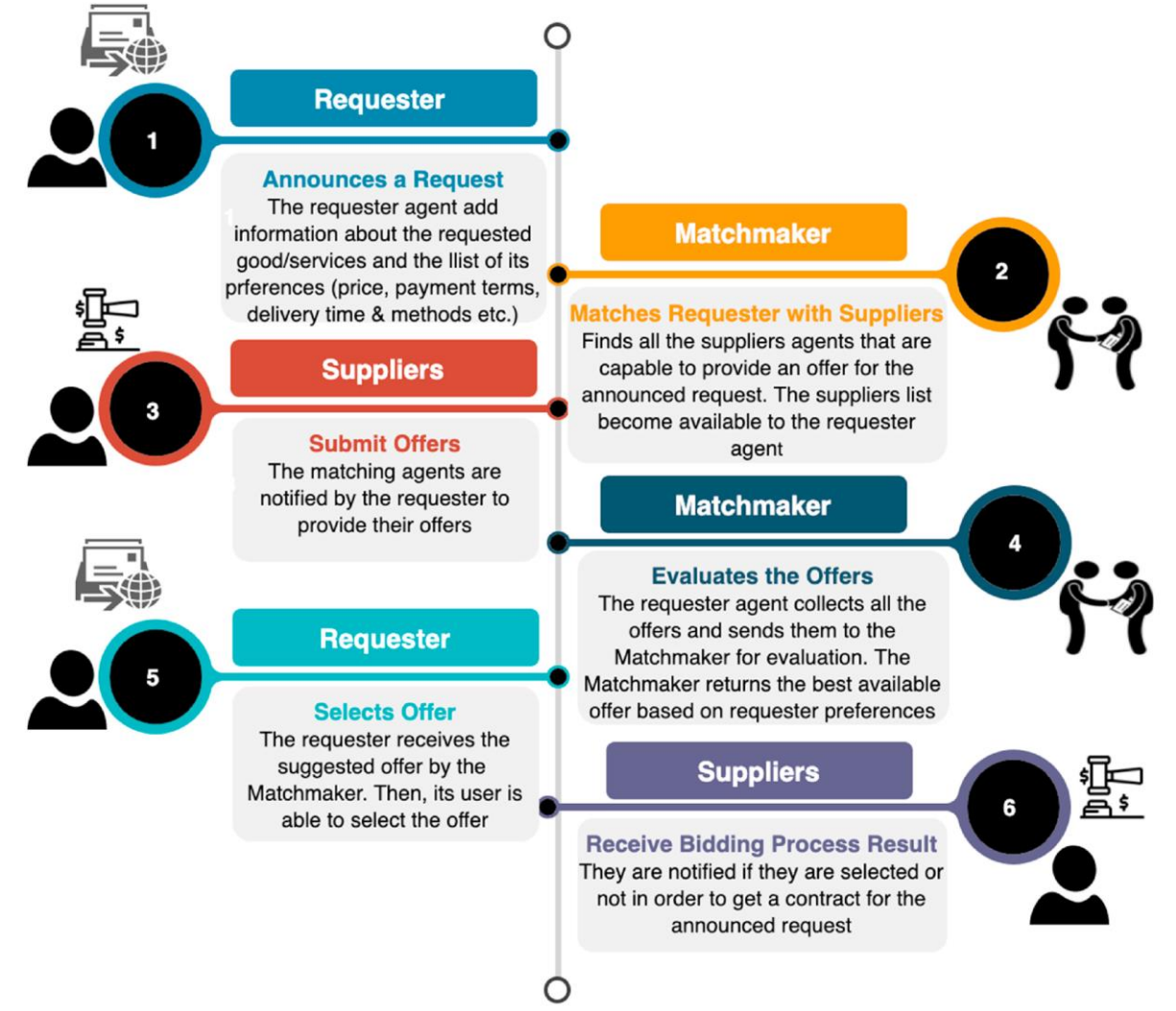


Figure 25 Process Flow of Matching Requster/Suppliers and the Request with Best Available Offer

The end-user can set the matchmaking criteria by using the corresponding user interfaces by Online Bidding Process. During the creation of a new bid, the end-user as a first step provides the criteria that the matchmaker will use for finding companies/agents able to fulfil user's request. The end-user interaction with UIs to setup the criteria is depicted in the next figure:

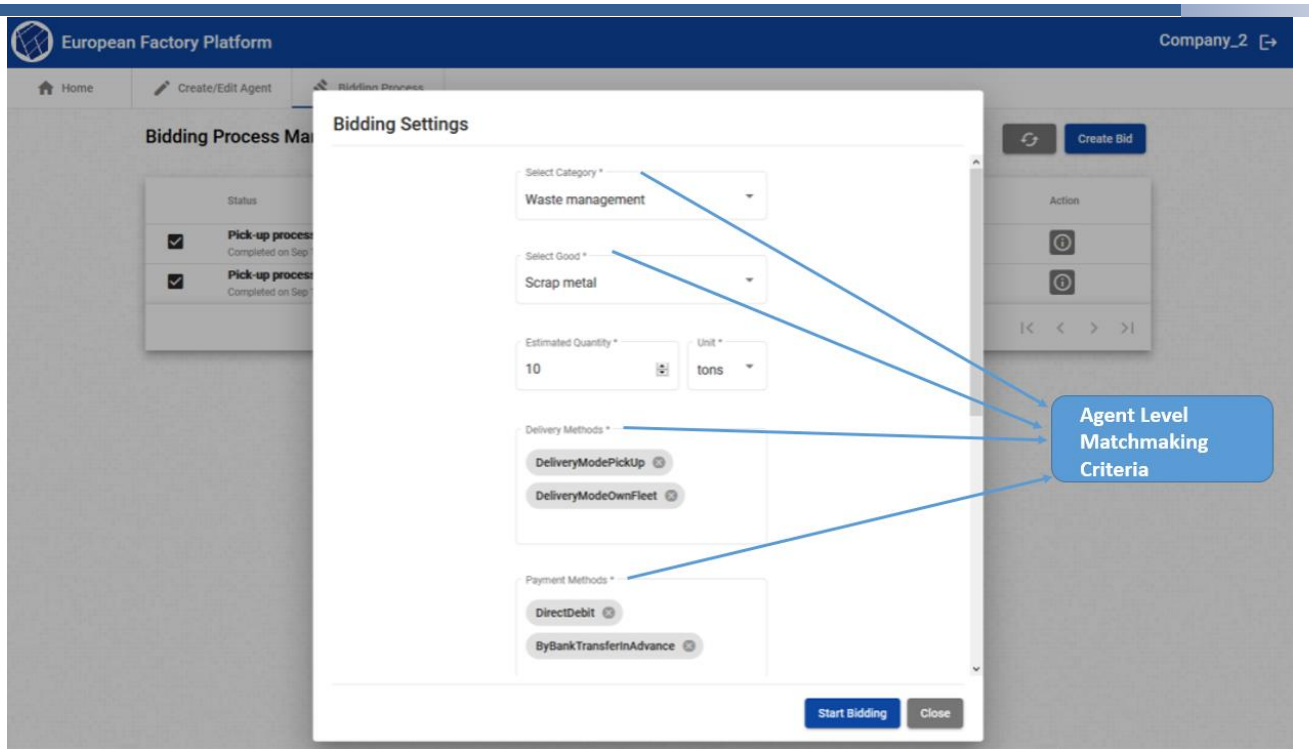


Figure 26 UIs to setup criteria for Agent Level Matchmaking Criteria

As a second step of creating a bid is considered the injection of user's needs/priorities regarding the offer's evaluation by the matchmaking services. The corresponding UI is available in the next figure:

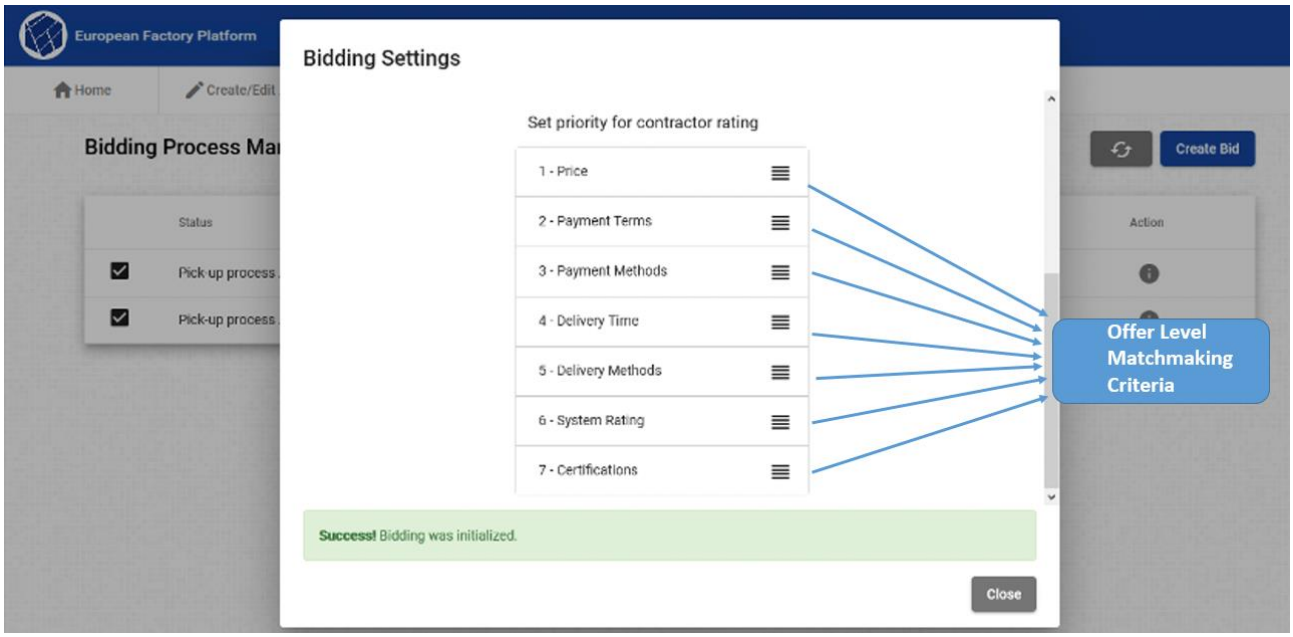


Figure 27 UIs to setup criteria for Offer Level Matchmaking Criteria/Priorities

Regarding the scalability testing some 'dummy' scenarios were implemented to test the solution's matchmaking functionalities. Over 15.000 dummy entities (companies) were

created in the semantic backend (ontology) and some agent level matchmaking tests were executed. The matchmaker was able to response in a time just over 5 seconds in every case and indicated the matching suppliers. Furthermore, as the solution is deployed using a Tomcat virtual server, it is able to receive about 8000 simultaneous requests. Finally is the usage of a native triple store to save the ontological components as it scales better than typical SQL databases as it enables the direct execution of SPARQL queries and semantic rules for inference.

1.5 Matchmaking with Team Creator

1.5.1 Background

The scenario considered for the Team Creator tool demonstrator is based on the creation of a consolidation centre managed by LAGRAMA as industrial company producing home furniture. The company is specialized in the manufacturing of custom furniture items and “lot size 1” orders. Therefore, the supply network for customer orders is defined from scratch when some products (e.g., textiles, lighting) are not produced by the company, raising the need to establish a dynamic network of collaborators. At this point, LAGRAMA plays the role of main producer, and it is responsible for the reception and execution of the orders by coordinating the contribution of the involved suppliers. The present scenario arises from the need of LAGRAMA to furnish and decorate a set of rooms in a small hotel boutique, which also is becoming a growing demand in the furniture sector.

Figure 28 Pictures of the Hotel Boutique to be furnished by suppliers on Team Creator tool

LAGRAMA produces most items for the rooms’ furnishing (beds, desks, tables, wardrobes, and nightstands) while other items need to be provided by external parties (lamps, armchairs, flooring, and carpets). The company then needs to manage the overall supply of goods and its installation in the hotel. Main capabilities to be addressed in this scenario are:

- Management of various proposals to solve the furnishing and decoration of the hotel rooms

- Integral service of furnishing and decoration
- Search and selection of suppliers
- Coordination of deliveries
- Internal and external planning
- Overall monitoring of the supply

To that end, the Team Creator tool has been used to define the project that enables the management of the overall supply of goods, allowing the selection of the best supply option for the different items involved in the project.

Figure 29 Product typology covered by the Hotel Boutique scenario and potential partners selected for the supply of each product category

1.5.2 Team Creator Highlights

Team Creator is a service which is a part of EFPF wider ecosystem. It is driven by Artificial Intelligence algorithm working with semantic descriptions of companies, products and their decomposition into components and materials. Given an invitation to tender, Team Creator searches through the database of available companies, the products they supply or the materials they work with, their compliance to set standards, their geographical locations and track record on related projects. It then creates combinations of these companies (teams) which can together fulfil the requirements of the invitation to tender in terms of product to be delivered. Every team is ranked according to the degree of fit and the risk calculated from their track record.

Team Creator can be used for different manufacturing domains, despite it being originally developed within aerospace manufacturing. When Team Creator is customised for the furniture domain as here, the different product categories required for the hotel decoration project can be imported to the Team Creator tool by consuming specific domain ontologies. In this case, the Furniture Sector Ontology has been adopted. This is based on the international standard for the information exchange FunStep (ISO 10303-236), which is focused on the furniture and wood cluster and captures the most used concepts inside the furniture and furniture-related industry (e.g., furniture items, processes, machines, facilities, etc.), including properties and relationships between concepts.

1.5.3 Pilot Case Study

When the user logs in, the following screen appears displaying open calls for tender. At present we only have one call for tender active – the furnishing of “modern hotel room” for our boutique hotel.

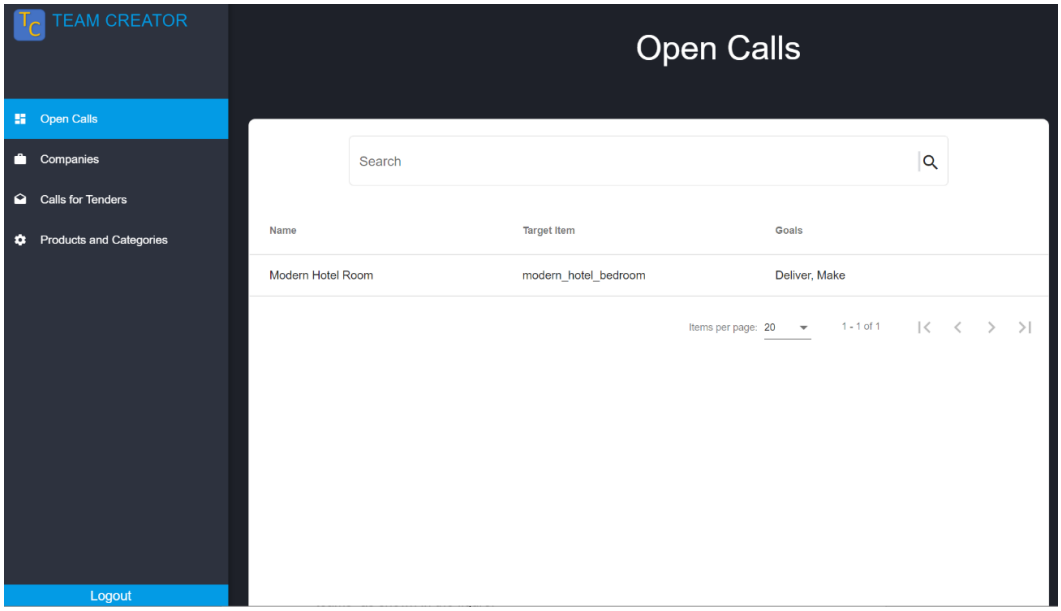


Figure 30 Team Creator UI - Open Calls

If the user clicks on the specific call for tender, they will see the product decomposition of the product which is the target for this call.

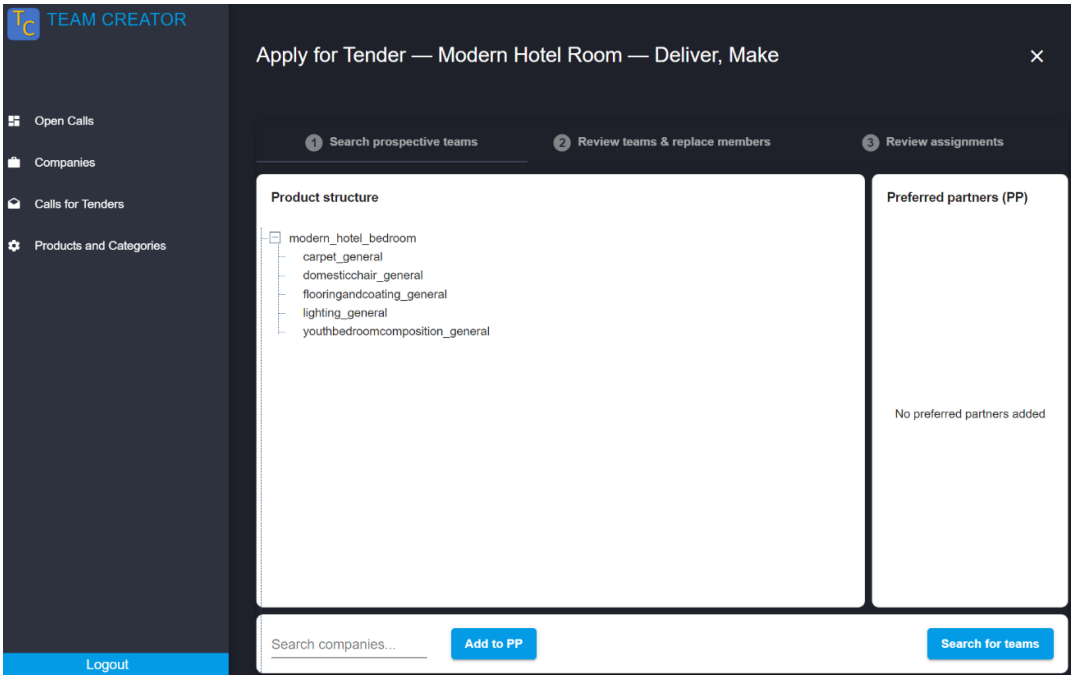


Figure 31 Team Creator UI - Tender Decomposition

If the user already has a specific company in mind to involve when forming the team which can respond to the specific call for tender, they can use the tab at the bottom of this screen

to search companies – say LAGRAMA, and then add it to the list of preferred partners by pressing the blue button – as shown in the next screen.

We are now ready to search for teams suitable to meet the requirements of the tender. This is done by clicking on the "Search for teams" button at the bottom right. The system then actives the AI combinatorial algorithm to find suitable teams.

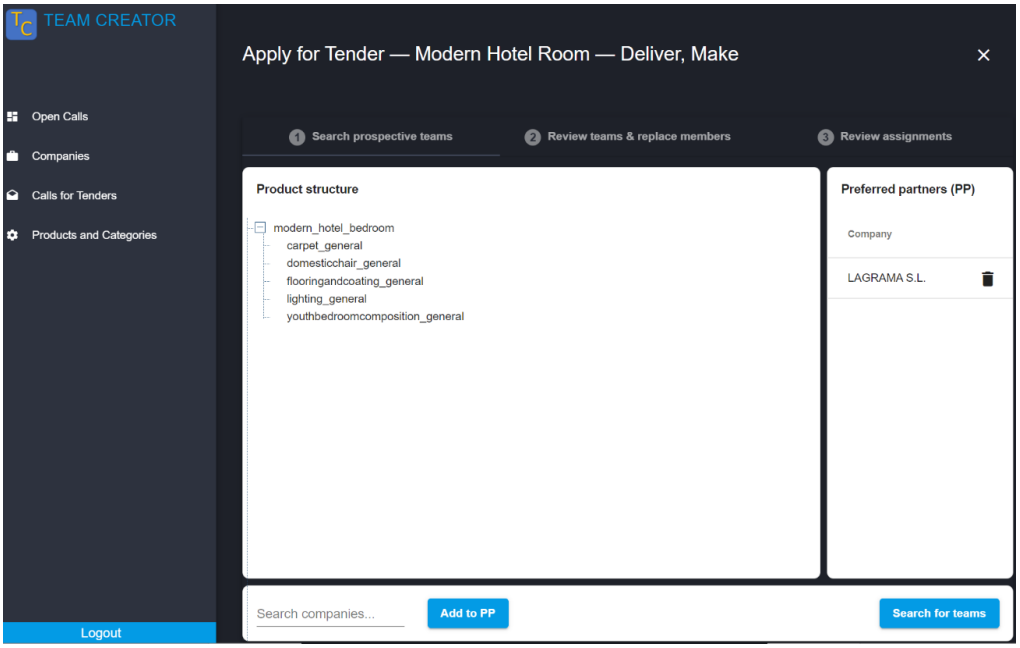


Figure 32 Team Creator UI - Preferred Partners/Search for Teams

The proposed team alternatives are displayed when the user clicks on "Search for teams" as shown in the figure below. As you can see, every team now has LAGRAMA since this company was specified as a preferred partner.

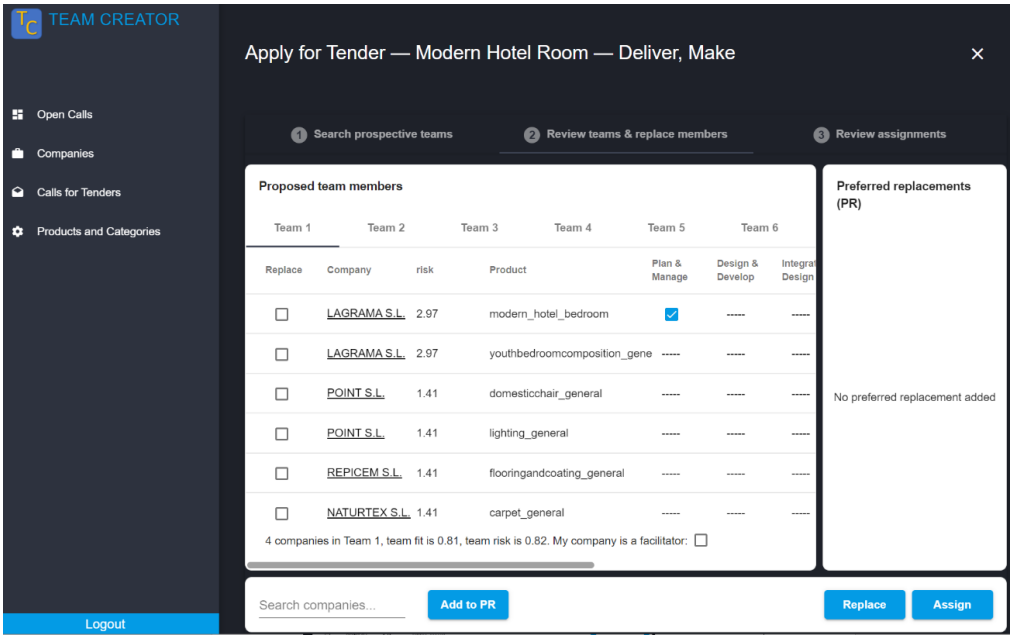


Figure 33 Team Creator UI - Search for Teams/Preferred Replacements

Team Creator also calculates team fit and team risk e.g. team 1 shown has a team fit of 0.81 and team risk of 0.82. Team fit measures how close the companies selected match the requirements of the call, whilst team risk measures if they can work together as a team based on track record and geographical location.

The user can add/remove companies by selecting a company for replacement and searching for another company in the "search companies" search box. Once the replacement is selected, the user can click on button Replace at the bottom right-hand side of the screen and click on button Assign to go to the next page.

Team assignments can be viewed in the "Review assignments" tab where the companies responsible for each product are shown. The user can click on the button Check (to check the team for completeness) or the button Proceed at the bottom right-hand corner of the screen (if satisfied with the assignment).

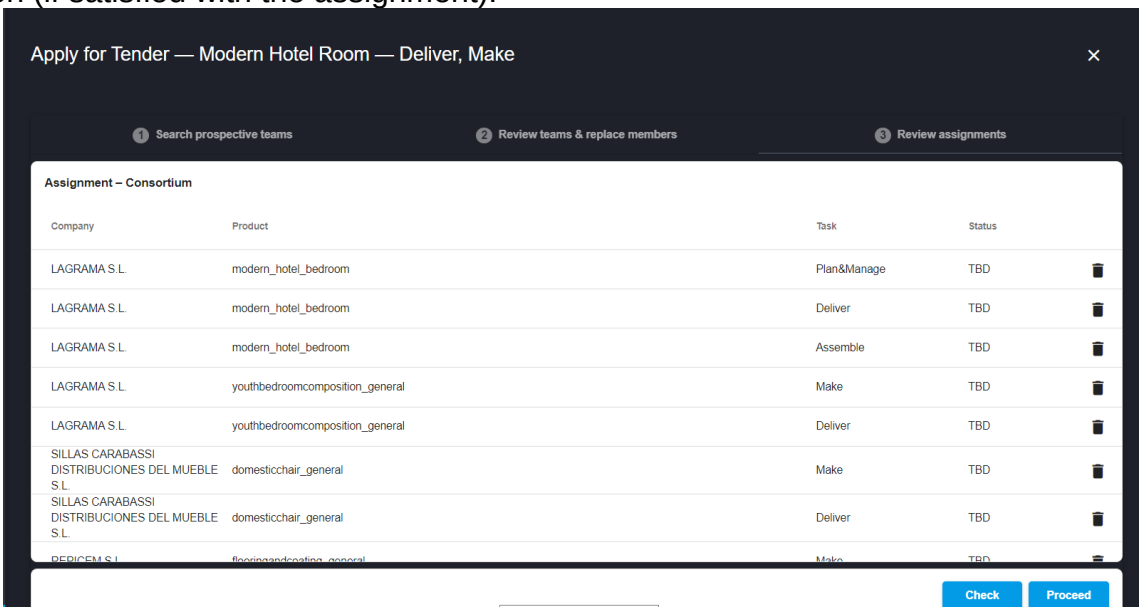


Figure 34 Team Creator UI - Team Assignment

Companies

Team Creator also has facilities for specifying details of Companies who can act as providers, specifying Calls for Tenders and also adapting the product decomposition and product categories knowledge.

When a user clicks on Companies, a list of registered companies appears as shown in Figure 35. The user can also add a company to Team Creator by clicking on the "+" icon on the top right side of the screen.

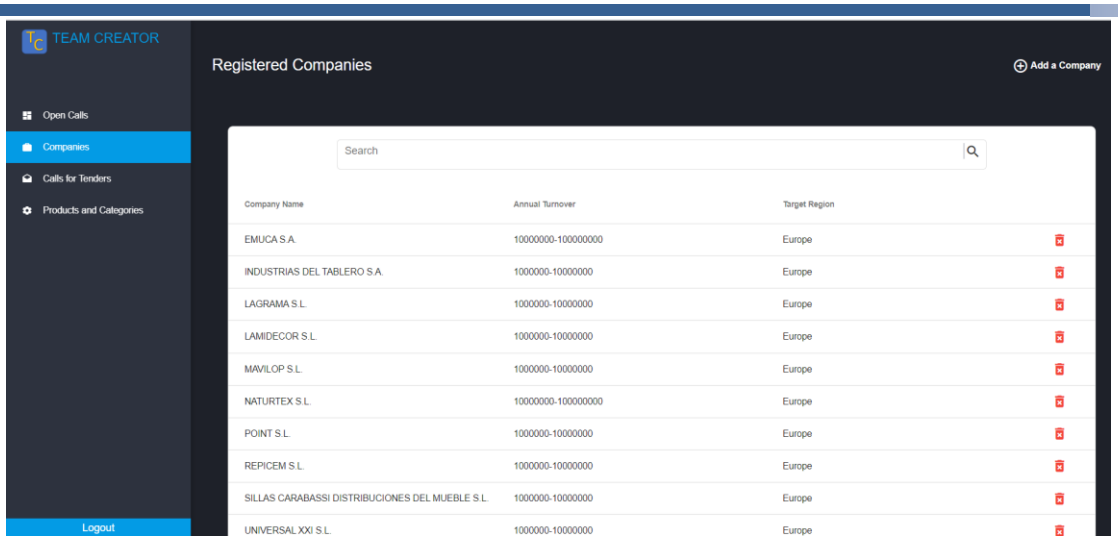


Figure 35 Team Creator UI - Add Company

When the user clicks on a company, the company details, departments, and capabilities are displayed as shown in the following three figures.

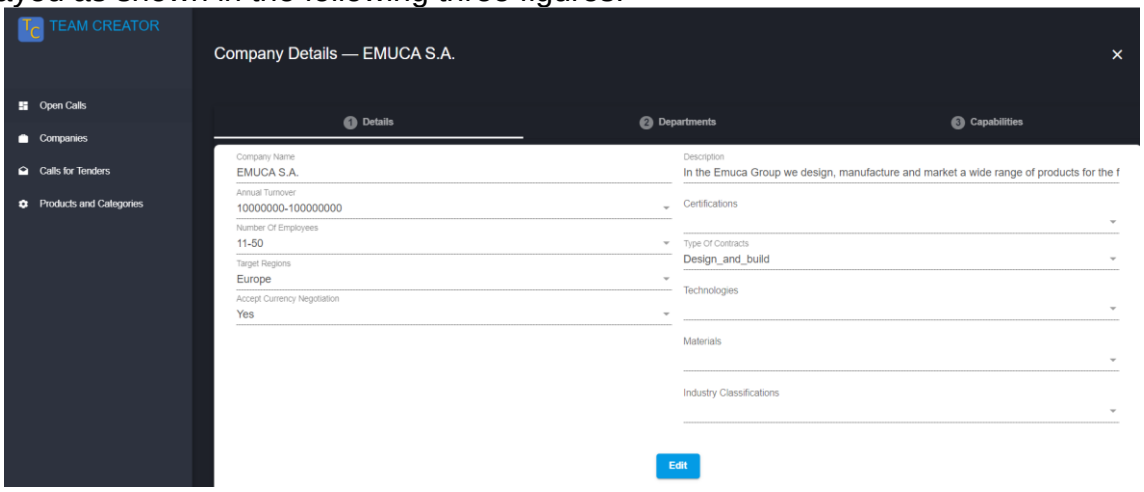


Figure 36 Team Creator UI - Company Details (1)

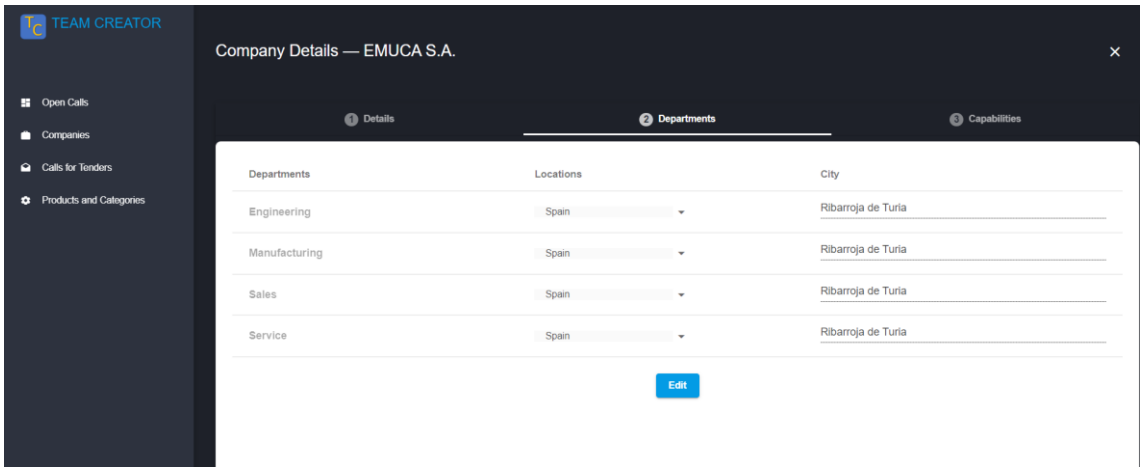


Figure 37 Team Creator UI - Company Details (2)

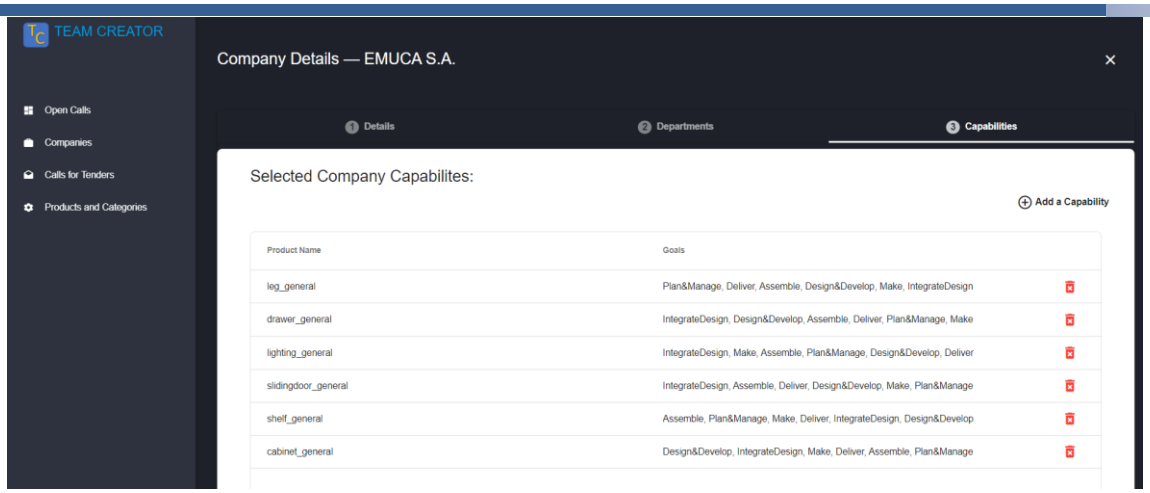


Figure 38 Team Creator UI - Company Details (3)

When the user clicks on a capability in the Capabilities tab, the following screen appears.

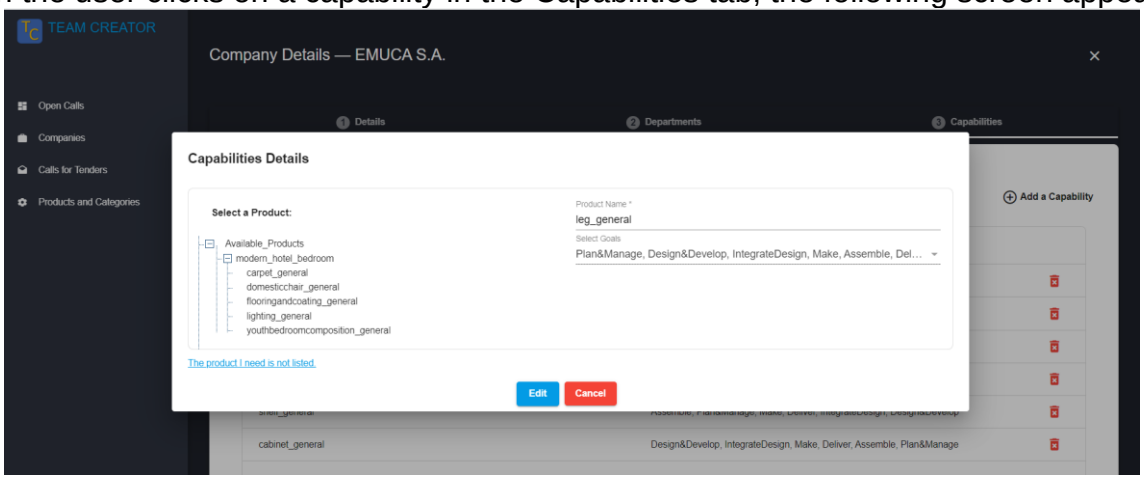


Figure 39 Team Creator UI - Capabilities Details

If the required product is not listed in the product tree, the user can click on “The product I need is not listed” and the user will get a notification (Please send the details of the product to be added to your IT specialist). They will have access to the “Products and Categories” menu option of Team Creator, and they can add the details there) as shown in Figure 40.

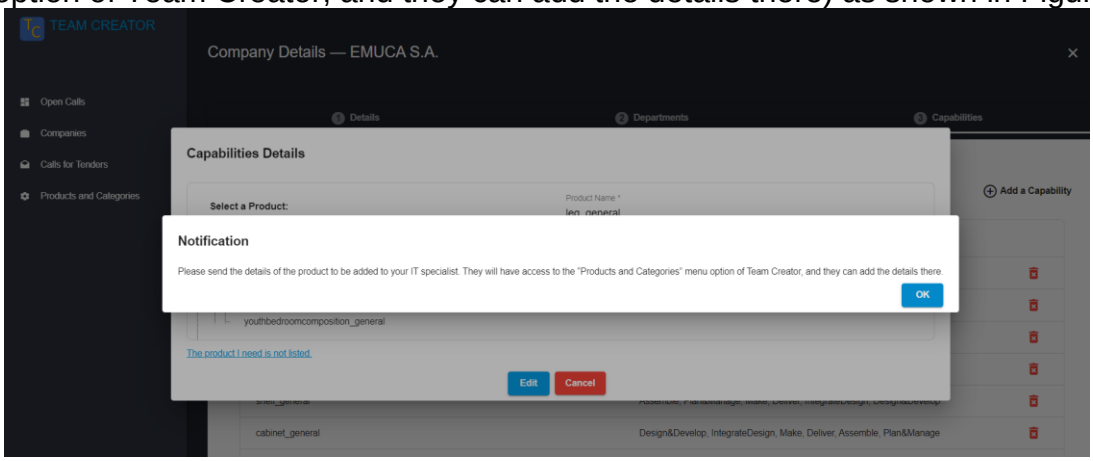


Figure 40 Team Creator UI - Request to Add Product

When a user clicks on “Calls for Tenders”, all the business opportunities stored in the system are displayed, even if they are not currently open or the details of a product are not completed e.g., target items and goals information is missing. While in the “Open Calls” only the business opportunities having all the details and being current (open) are shown to the user.

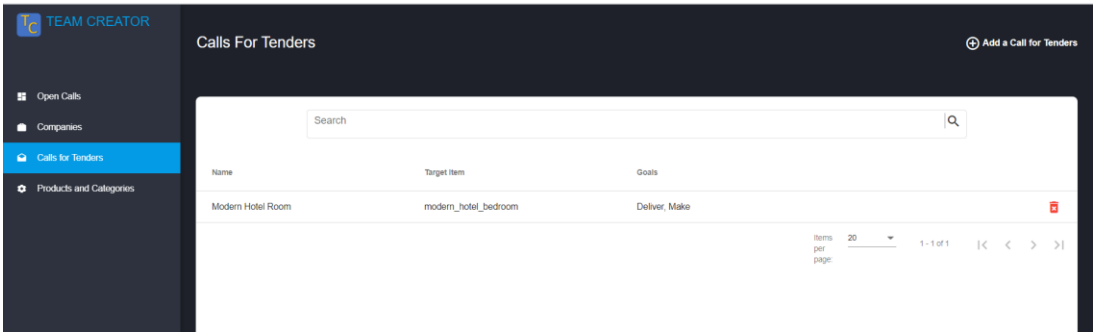


Figure 41 Team Creator UI - Calls for Tenders

Products and categories:

When the user is an IT specialist, he/she will have access to the 4th tab “Products and Categories” option from the menu. The first sub-screen displays the available products view only as shown in the figure.

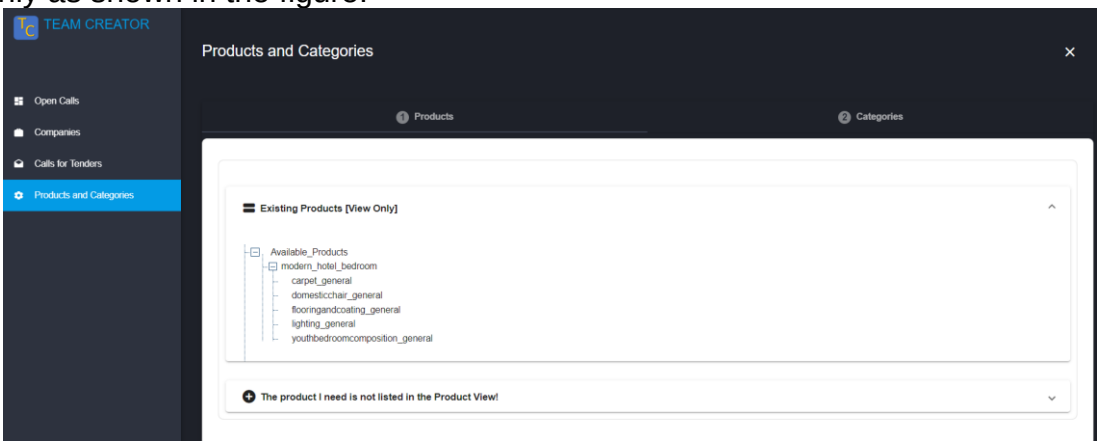


Figure 42 Team Creator UI - Products and Categories

In the second sub-screen, the user can add a product in three steps.

1. Selecting a parent node: When the user clicks on a product, the name of the parent node is displayed, and the category of the parent node is automatically filled.

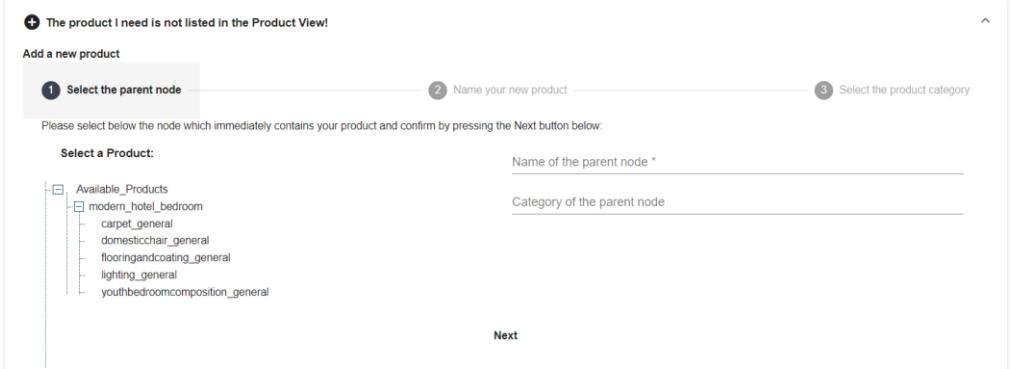


Figure 43 Team Creator UI - Add Product (step 1)

Upon clicking on the “Next” button, the second tab appears as shown in the figure below where the user can add name of the product.

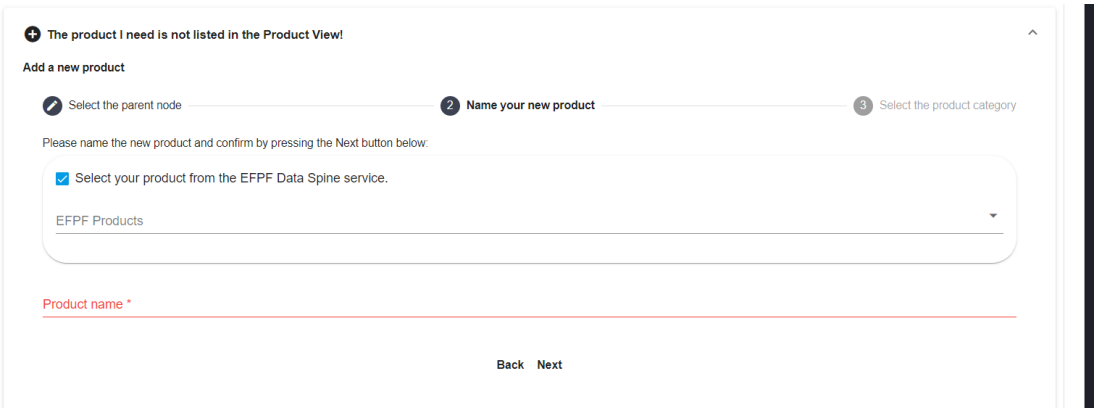


Figure 44 Team Creator UI - Add Product (step 2)

When the user clicks on the next button at the bottom of the screen, a third tab opens where the user can select the product category and click on the save button to save the selection.

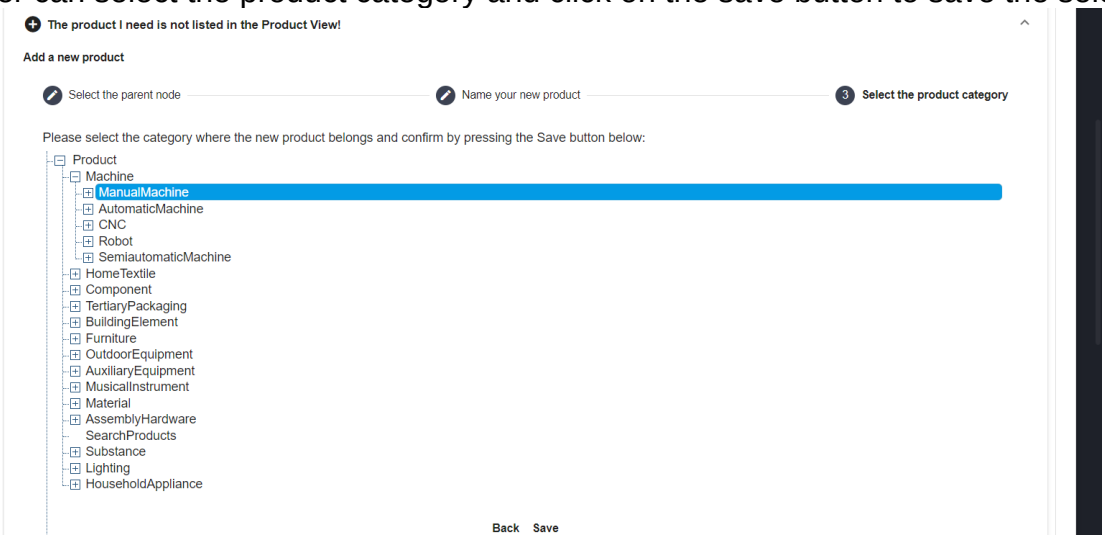


Figure 45 Team Creator UI - Add Product (step 3)

Categories:

When the new product category is not listed in the product tab, then the user is asked to add a new category in the categories tab. The available product categories are displayed as shown in the figure below.

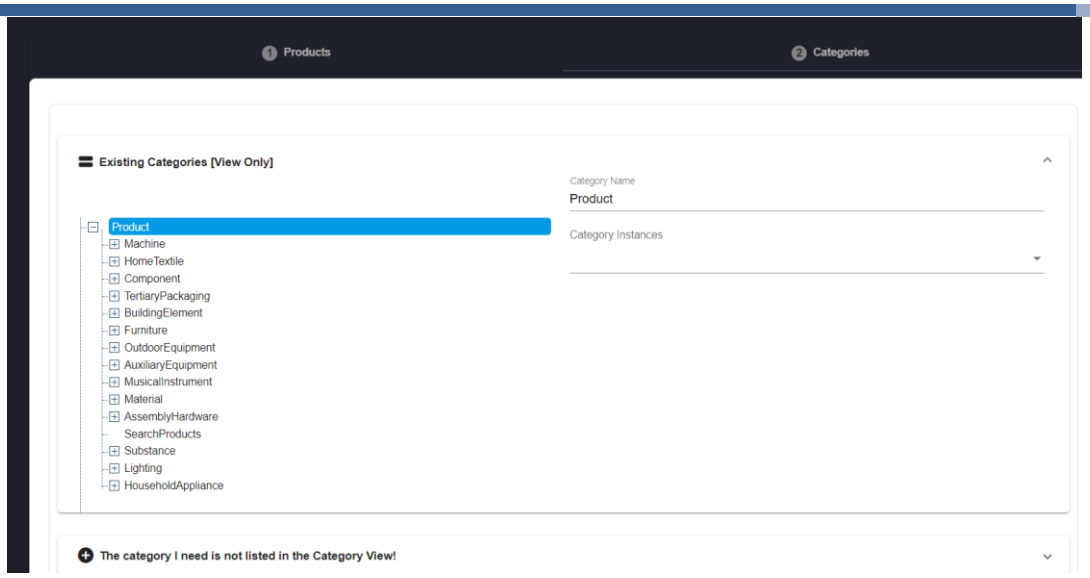


Figure 46 Team Creator UI - Existing Categories

When a category is not displayed, the user can add a new category.

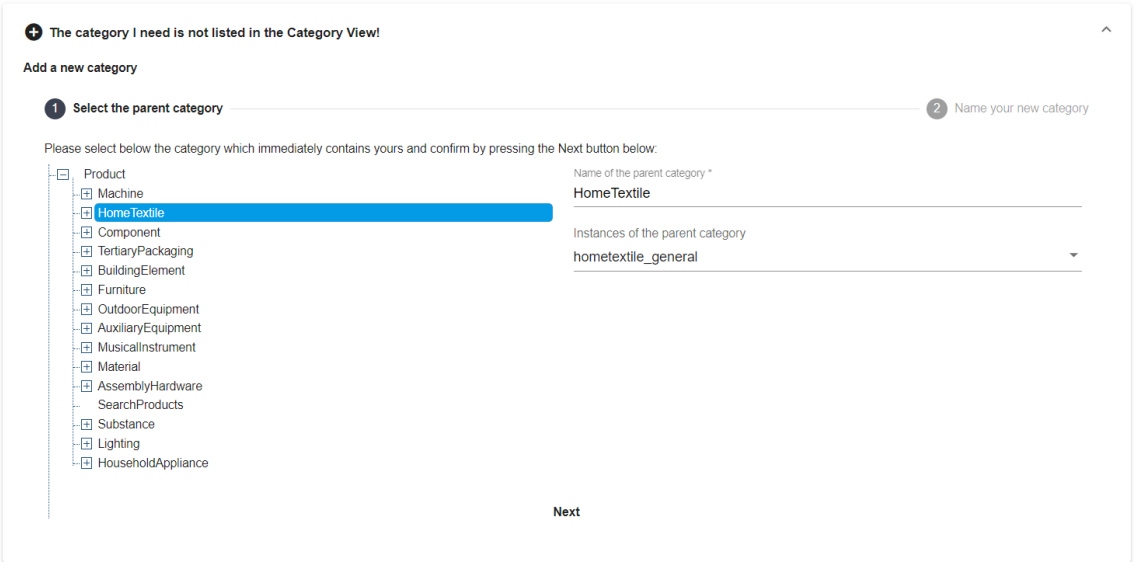


Figure 47 Team Creator UI - Add Category

When the parent category is selected, the name and instances of the parent category are automatically filled. The user is taken to the next screen when the “next” button at the bottom of the page is clicked. The category name can be filled by the user on the screen as shown in the figure and changes are saved when the “Save” button is clicked.

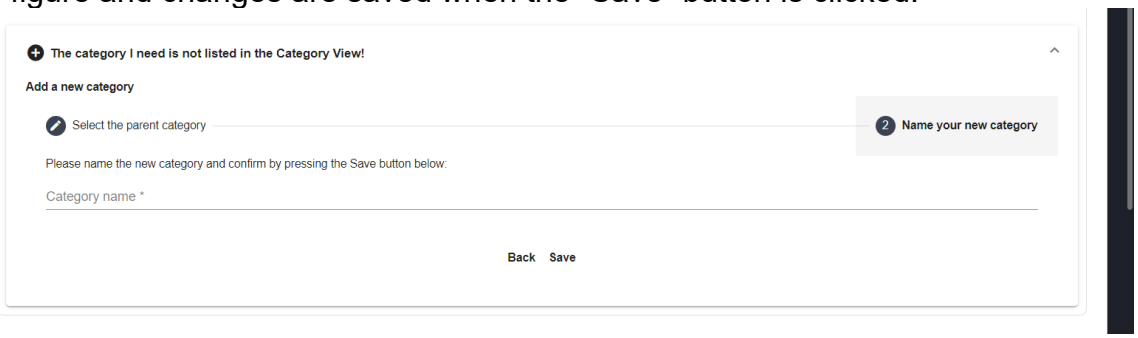


Figure 48 Team Creator UI - Add Category (cont.)

2 Business and Network Intelligence Gathering and Propagation

2.1 Introduction – Data, Analytics, and Intelligence

This chapter presents the key concepts related to the business and network intelligence services of the EFPF ecosystem. The subchapters describe the methodology used to develop these tools and service as well as their benefit to the end user.

Standards and best practices are followed where appropriate as described in the following subchapters. In addition, the project partners have met and contributed to discussions that helped produce and refine the intelligence components.

Data is core to all modern manufacturing processes and increasingly becoming even more important in driving productivity for manufacturers. Every stage of traditional value chain is demanding more data and increased digital connectivity from their peers and partners.

DATA

It is important to understand what we mean by ‘data’ here for manufacturers and other related businesses. The following sections will explain the breadth of this ‘data’ using a few examples.

Manufacturers use a range of data to inform their decision making. This includes shop floor data from the machines, production control systems, IoT devices likes sensors etc. Collection and analysis of such data is largely useful in improving efficiency and reducing wastage / losses due to oversight or bad management. For example, by measuring the down time on machines between jobs, the owner can calculate the overall equipment efficiency. And that can further lead to some actions such as trying to bring the OEE to get a better return on the investment in this machine.

Similarly, ‘data’ can also include information stream coming from process management software like CRM (customer relationship management), SRM (supplier relationship management), PLM etc. Analysis of this information will provide an understanding of resource commitment and planning. Based on this analysis a company can try to mitigate potential operational risks such as being ‘undermanned on project’ and ‘not being able to deliver customer request on time’ to name a few.

And finally, there are other forms of ‘data’ that help manufacturers make business decisions such as ‘whom should I contract this work to?’, ‘what are my competitors doing?’, ‘How can I find more work with companies near me?’ Such data can include information about the organisational make up, supply chain connections, market and industry information. For example, by mapping and understanding the sub-tier suppliers, the manufacturer can keep a closer relationship and ensure compliance as well as coordinate deliveries. This can realise a massive benefit for the customer as it allows them to implement supply chain concepts such as ‘just in time’ which helps reduced the need for big inventories and frees up capital for growth.

ANALYTICS

When this 'data' is systematically computed to discover, interpret, and communicate meaningful patterns in information it is usually knows as analytics. Analytics is a power tool and has been used by manufacturers for a long time. Traditionally done on graph sheets and physical paper, there are now several advanced digital tools that enable analytics for these companies.

After discovering meaningful patters using analytics, the next step is to make informed decisions and generate (enabling or mitigating) actions. Therefore, analytics can be understood as an essential bridge between data and informed decision making.

INTELLIGENCE

Business & Network Intelligence typically refers to two distinct areas, the first of which being Business Intelligence (BI). Traditionally, BI refers to the processes that take place with the use of software systems to gain increased insight, knowledge, and actionable intelligence into a particular area. The actionable intelligence is provided through data analysis, reports, and data visualisations to better inform the strategical, tactical, and operational decisions a business may encounter (Lans, 2012). The second area covered by the term is Network Intelligence (NI), conventionally, NI can be seen to refer to the variety of techniques and software systems that can be used to perform the monitoring and analysis of IP packets and other network information to gain an increased insight and intelligence into the flow of traffic that takes place within a network (Thorpe, 2019). However, in the context of EFPF, NI can also be seen as the analysis of connections that form within a network of organisations, such as within a supply chain. The Business and Network Intelligence Service within the EFPF platform offers a range of solutions for different needs with one such solution being Platform and Network Intelligence. This solution provides insight into the usage of the EFPF platform, its traffic flow and the networks of companies formed within the platform.

Intelligence in this context is the act of generating 'actionable insights' from the data. It helps organisations to take optimum actions that can bring maximum benefit subject to modelled constraints. For example, if a supplier is partly dependent on the aerospace industry and their advanced software picks up several news articles that are suggesting the decline in aerospace demand due to onset of a large-scale pandemic. The intelligence software will gather analytics from multiple sources and combine it to arrive at a suggestion / action. In this case, the intelligence module might check the WIP (work in progress) levels for all aerospace orders, order book to identify the aerospace orders booked and the financial analytics to calculate the amount and its percentage of total value and highlight this as a risk citing that the dependence on aerospace production is over 50%. You need to reduce it to 30% to avoid cash flow problems in the next 3 months.

This allows the manufacturer to follow the actionable insight surfaced by their intelligence software/module while having the ability to audit the input analytics and modelled dependencies. Since the real world is a lot more dynamic than a software module can anticipate, the manufacturer can choose to modify or abandon the action suggestion all together. However, it does provide an ability to delegate tasks that require cognitive skills, traditionally reserved for humans.

Such modules are extremely popular in the supply chain industry where these systems are known as 'supply chain event monitoring and alert management' systems.

2.2 Scope and Relationship with other EFPF components

The aim of this task in the EFPF ecosystem is to promote interoperability between disparate digital tools, services, and platforms by providing a component for intelligence services

related to their business activities. EFPF is poised to become a massive ecosystem with all its core platforms and tools and their users coming together. This is a great opportunity to access, analyse and generate insights from this congregation.

The scope of tools and services introduced as a part of this module is limited to using openly available information scraped from the internet, metadata collected from the users and their activities on the platform and some other forms of data (factory machine data, ERP data, CRM data etc.) uploaded by the users to be combined with other streams and add more value, if any.

This task follows EFPF standard terms and conditions, user licence agreement and GDPR policy and guidelines. As a result, no personally identified information is acquired or used without prior consent of that party.

The EFPF consortium has decided to offer multiple tools under this component (explained in detail under subchapter 2.4 Tools and Services) to address a range of needs for European manufacturers. Each of these tools works to their own scope of data input, analysis and outcomes which is discussed in greater details in subchapter 2.4 and further subsections.

Relationship with other EFPF components

With Matchmaking

Business & Network Intelligence and Matchmaking share a close relationship. It is important to analyse the purchasing and search demographics within the EFPF ecosystem to understand the market trends and promote matching products and services to the suitable clients. Furthermore, the data gathered in matchmaking and associated network intelligence can be reused in matchmaking to offer personalized recommendations and suggestions to the portal users.

The user's event data captured from the marketplace, federated search and related matchmaking functionalities are utilized effectively to generate Business and Network Intelligence. Many KPIs in the B&NI dashboard are derived from search event data -Top 10 searched companies and products, highest searched base platform, to name a few.

The data from all connected platforms, tools and services flows into the federated search index as a result of the indexing workflows set up in matchmaking task. When a search is made on the portal, it is logged as an event in the 'search activity log index (ELK)'. This log index or ELK stack serves as a source of information for the Business & Network Intelligence component. The ELK stack serves as the main storage for this component as well.

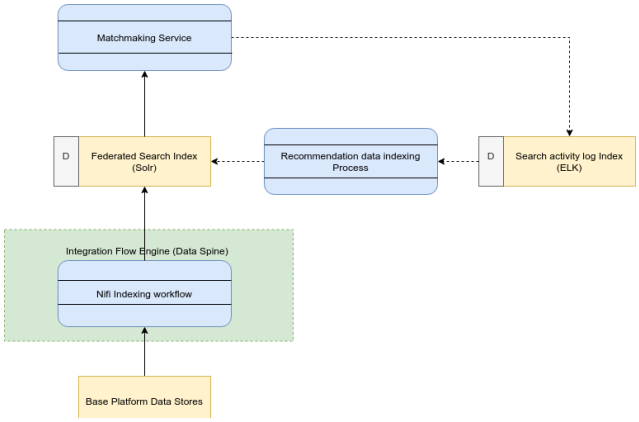


Figure 49 Data flow in EFPF Matchmaking Component

With EFPF Portal

All Business & Network Intelligence solutions discussed in this chapter are made available to the user through the EFPF Portal. Business and Network Intelligence have a dedicated 'Value Proposition' page, under which individual solution pages is made available.

With other EFPF Components

The architecture diagram shown in Figure 50 also illustrates the relationship to other components in which it interacts. The input to the solution can be seen on the left of the diagram with platform usage data coming from the EFPF Accountancy Service through the EFPF Data Spine. The visualisations produced and present within Kibana are then displayed as a dashboard within the EFPF Portal.

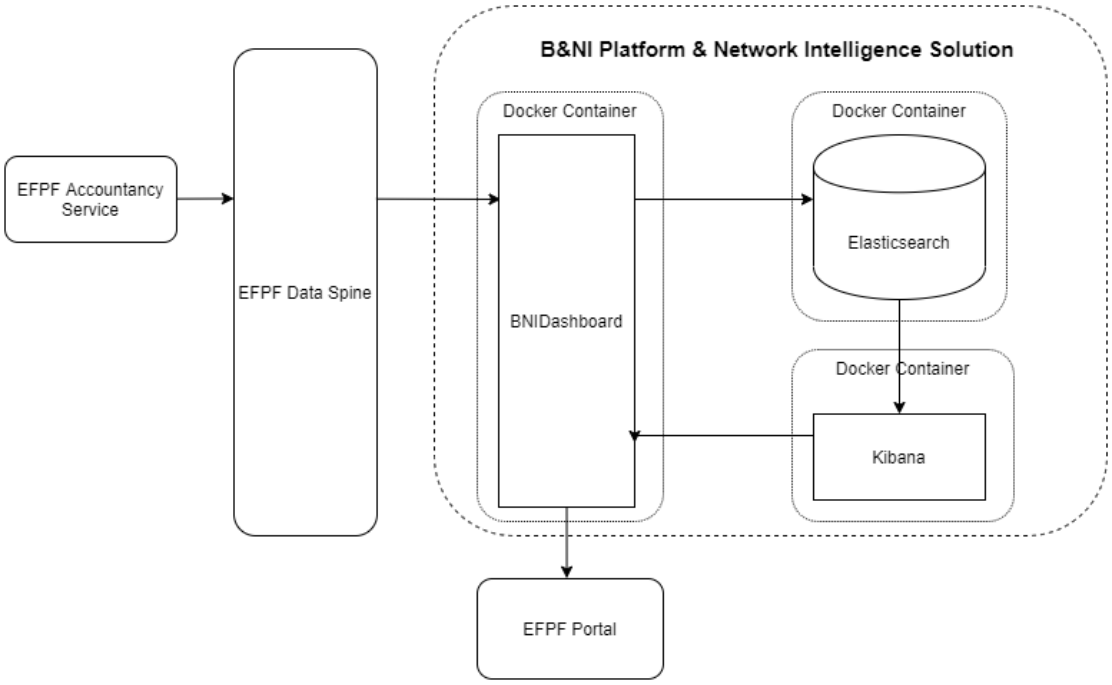


Figure 50 Platform and Network Intelligence Solution architecture diagram

2.3 Requirements

Before we dwell on the details of this task, it is important to understand the context behind the introduction of this module to EFPF ecosystem. A number of requirements gathered from our pilot partners as well as experience and best practices from previous projects have contributed towards the requirements for this task.

Within the initial stages of the EFPF project, requirements elicitation took place in collaboration with the project's user partners. This process identified specific requirements of the platforms intended user base in the form of User Stories, with several highlighting the need for a business and network intelligence solution. The user stories identified were then analysed and grouped as tasks within higher level scenarios in the form of epics. Both user stories and epics that have been identified in relation to business and network intelligence can be seen in Table 1 below. From the user requirement scenarios shown, user stories EF-296, EF-297 and EF-298 are tasks within epic EF-A8 and user stories EF-299, EF-300 and EF-301 are tasks within EF-A5. The user requirements collected were then analysed to determine the technical requirements (see Table 2) of the business and network intelligence solution needed.

Table 1 - Business and Network Intelligence User Requirements

Type	Jira Details	Description
User Story	EF-296	I want to view the most searched keywords in the EFPF Platform
User Story	EF-297	I want to view the most searched products in the EFPF Platform
User Story	EF298	I want to view the most searched companies in the EFPF Platform
User Story	EF299	I want to view company specific data
User Story	EF-300	I want to view the most searched products in a company's catalogue
User Story	EF-301	I want to view the status of all products and services within a company's catalogue
EPIC	EF-A5	As a Sales Manager I need a "cockpit" that offers me KPIs and other important information and notification about my catalogue to be informed about my performance and the correctness of information.
EPIC	EF-A8	As Marketing Manager, I aim to receive information about upcoming trends at the earliest possible, so that I can develop and design products, and bring them as quick as possible on the market. For SMEs this is extremely important, because they usually do not have separate market analysis departments

Table 2 - Business and Network Intelligence Technical Requirements

Type	Description
Technical	Capture platform data from the Data Spine
Technical	Use AI inspired analytic techniques to analyse the captured data and extract intelligence
Technical	Provide a dashboard to the platforms users to propagate intelligence gathered

In addition to the above requirements, the following generic scenarios were discussed by project partners which also contributed to the overall requirements followed in this task. These scenarios are inspired by some of the ancillary decision points that manufacturers have to follow ahead of collaborating in supply chains. A brief description on some of these has been provided below to for context and relevance.

1. How can I generate more intelligence from my internal data (shop floor/ERP…) without committing to single expensive solutions built for large scale deployment?

   European SMEs are faced with an incredible challenge when adopting digital technology. Advanced business intelligence software modules are expensive to subscribe, complex to operate and have a big cost associated to their implementation. The vision of creating a ubiquitous platform meant that it should provide simple modules that can be used by all companies over the internet (easily accessible), eliminating the need for expensive implementation and allowing interoperability between different software tools on EFPF portal.

2. Visibility – Europe is big!

Europe is the second largest manufacturing economy in the world. There are roughly two million manufacturing SME's (small and medium enterprise) in the European Union (Vladimirov, 2017). EFPF is a digital platform enabling connectivity between these European manufacturers. It is impossible to know and understand all the capabilities of all manufacturing companies in the EU. Companies need this information to acknowledge, partner, buy/supply or compete with each other. Therefore, in order to facilitate matchmaking (see chapter on matchmaking - Matchmaking) and other business decisions the platform should enable channels through which more intelligence can be gathered and used for decision making.

3. What information can I generate from the activity of others on EFPF platform?

   There is great potential to harness the metadata associated with the activities and engagement of EFPF users on this platform into actionable insights or intelligence. This can better inform the decision making, strategy and future engagements. For example, a manufacturing SME could use such a service to understand the demand for products that are similar or complimentary/supplementary to their offering. The SME can use this information to narrow down to the companies actively searching for these products/services on the platform and connect with them directly with aim of doing more business with them. In this example, the manufacturer/user of the platform is able to access metadata from the platform activity, analyse and filter it to give them actionable insights into the trends by region, industry, or sector.

4. Can I generate intelligence directly from other users?

   Often, the best source of insightful data comes from other companies directly. This is a common practice in the industry and is usually done through audits, surveys and/or questionnaires which are widely known. Pushing the agenda of bringing European manufacturers closer over a digital platform, a need was felt to introduce a service that could enable you to build consortiums/networks based on the capability information available for those businesses. Within this consortium, the user can build and publish surveys (mining intelligence) and audits (ensuring compliance) and get meaningful information directly from other EFPF users. This information can be visualised in the form of reports and charts that can easily be shared or distributed across supply chains. Subchapter – Execution and Pilot Case Studies presents a detailed account of this use case.

While the requirements initially identified by pilot partners at the beginning of the EFPF project were met within the last deliverable, the platform and network intelligence service further investigated the potential for new and improved insights for EFPF users. Through collaboration and discussion with both EFPF partners, and members of the EFF, additional requirements were collected for the enhancement of the tool. Through this process, the potential to capture additional event data from the accountancy service alongside the search and login event data previously captured and analysed, was identified. Alongside this, two other sources were identified for analysis in order to provided EFPF users with additional platform intelligence. This included the marketplace backend to provide insights around the products offered and sold within the platform, and also the EFS in which a user's company data can be queried to provide company-based insights to the platforms usage.

Regarding the company-based insights identified for future development, while the EFS has been identified as the current sources of company associations for each user, it should also be noted that ongoing work within the Portal component will lead to the movement of company related data from the EFS to a dedicated service. Once ongoing work has completed, work will begin within the platform and network intelligence component to obtain

this data from the new dedicated service, in which the schema and company attributes will be more tightly defined. This contrasts with the current configuration where company-based attributes are stored as user attributes in a more ad-hoc manner.

2.4 Tools and Services

The business and network intelligence task focused on identifying and catering to the applications of this service for different levels of engagement of a company. To simplify it further, the partners have decided to compartmentalise the tools and services under this task into three distinct levels:

- Intracompany level – Aims to generate actionable intelligence from activities and processes within a company. This category is to do with generating and sharing intelligence for work done within the organisation.
- Platform/Network level – Aims to generate intelligence from the existing networks that a company is already involved in as part of their supply chains and other business activities. This category is to do with analysing all work that goes on in the existing networks of a company.
- Market/Industry Level – Aims to provide intelligence about the general market the organisation works in. This category includes all entities that might not directly be known to / linked to your organisation but their activities in the industry/geographical area/sector of interest provides useful insights and trends. In other words, this goes beyond a company's internal operations and existing networks (both digital and physical).

2.4.1 Intracompany Level Intelligence Services

Modern day manufacturer is collecting huge amounts of data from their internal systems (production control systems, project management systems, CRM systems etc.). There is a pressing need to digest this information and produce meaningful insights that will help the manufacturer in better decision making for their company's progress.

The tools/services introduced under this category are focused on helping manufacturers use digital tools that can be accessed through EFPF platform, are simple to use and provide key insights towards a certain goal. An example could be analysis of machine usage data, along with sales pipeline data and inventory levels et al to optimise the cashflow for a manufacturer.

EFPF Software Development Kit (SDK) supports the development of business intelligence applications, such as resource monitoring and factory monitoring. In previous report in M18, we have delivered the shopfloor application via SDK. From M18 to M48, apart from developing more BI apps to help business and showcase the SDK capabilities, we have also enriched the SDK offerings to allow manufactures easily create their own developed new applications, such as the development engagement hub, and additional documentations. Further details on BI applications development via SDK is in Chapter 3.

2.4.1.1 Production KPIs

In order to implement process improvement strategies within manufacturing environments its vital to have an agreed set of metrics or key performance indicators (KPI). This can then

be used as a benchmark to gauge the degree of improvement as a result of changes to the process. Common examples of this types of Manufacturing Business Intelligence are listed below:

- Manufacturing Cycle Time
- Overall Equipment Effectiveness (OEE)
- Overall Throughput Effectiveness (OTE)
- Production Yield Rates by Product, Process and Plant Location
- Perfect Order Performance
- Return Material Authorizations (RMA)

OEE is commonplace in the manufacturing domain and is concerned with measuring the overall performance of a given machine, product line or work centre. OEE is calculated using the formula of Availability * Performance * Quality and is considered an accessible metric for tracking production performance to the machine and plant floor level since it is easy to calculate and easy to evaluate resultant improvements.

The potential to share KPI metrics, such as those described above, within an organisation and potentially between manufacturing sites would be a valuable indicator to support management and strategic planning. The goal in EFPF is to offer one or more KPI based on the manufacturing data made available within the project pilots.

2.4.1.2 Resource Monitoring Intelligence

The potential to gain Business Intelligence from the resource usage within a production process is critical to understand the efficiency of production, and the waste that it generates. Resources within the process can be materials, consumables, energy, staff and even time. The environmental perspective of such resource usage is becoming increasingly important, as the drive towards net zero becomes a key business objective. From the financial view point the amount of waste of resource during production is a key indicator for inefficiency within the processes, or potentially a generator of revenue as potentially waste material can be purchased by cycling suppliers.

Three aspects of business intelligence of resource management are considered within EFPF:

- Data from monitoring of waste levels to automatically track bin fill levels and compare local suppliers to find the best price. This will offer benefits for both customer and supplier. Suppliers will be able to track businesses within a perimeter that all require the same waste disposal. Whereas customers will have the opportunity to monitor waste identify patterns in waste generation that can be fed back into their production process. Further details about this application are provided in D4.13 and D4.14.
- Detection of operatives wearing approved breathing apparatus for a spray paint application process to support business intelligence to enforce health and safety regulations. The events associated with the detections are streamed to the EFPF platform to enable it to be visualised on a BI application providing valuable knowledge of the use spray process. This also supports auditing of health and safety systems within the business. In parallel, the monitoring of energy consumption and run-time KPIs are carried out with the aim of reducing energy consumption by being able to visualise the corelation between energy consumption, and the production schedule. Further details about this application are provided in D4.13 and D4.14.

- Data from the production stores of a manufacturing site to allow for dynamic monitoring of the stock levels of consumables used within the various production stages. The amount of stock being carried is derived from load cell sensors within the stores shelving, which is streamed in at 20 second intervals to EFPF platform to enable logic to determine pre-warnings of low stock levels to suppliers. This allows for a more dynamic procurement process, and minimises stock carried by a company in line with Kanban principles. Further details about this application are provided in D4.13 and D4.14.

2.4.1.3 Factory Monitoring

Manufacturing effectiveness can be dependent on numerous factors including those internal to the machine / process such as machine condition, and external factors such as environmental variables. This is particularly in sectors where high tolerances are adhered to can be subject to variations which affect quality and therefore waste when environmental variations occur within the factory.

Machine / process condition affects all domains of manufacturing, where wear within the machine over time can lead to reduction in quality, increase in waste, increase in energy consumption, and unpredicted machine breakdowns. In the furniture manufacturing domain the monitoring of current draw of motors, their housing temperature and the pressure used in pneumatic circuits are key indicators for the state of the machine. By streaming data to the EFPF platform, BI analytics applications can be used to provide both visualisation of time series data, but also the use of AI algorithms support predictive alerts to be raised of anomalies in the data that could relate to a potential future breakdown or quality issue.

An example of environmental impact on production quality would be within aerospace industry where temperature affects the metal materials used to fabricate the parts by causing thermal expansion. Since tolerances are extremely high (in the microns range) this can have a significant impact and needs to be factored in when producing. To reduce any issue with incorrect parts, live data could be married with predictive weather and forecasted temperature data to provide Business Intelligence that could later be automatically fed back into the parameters of the process. Initially this can be carried out by manual adjustment of parameters, but the goal would be to adjust parameters automatically.

2.4.2 Platform/Network Level Intelligence Services

Another application of intelligence is in outwards facing business decisions that manufacturers have to make in their networks. An example of this network could be the existing supply chain relationships. The manufacturer will have a great relationship with immediate suppliers and/or customers. The manufacturer can leverage this personal relationship to collect information (for example, about forecasted demand, changed lead times, new product introduction etc.) that will help them plan ahead and plan better. However, since there is no direct relationship with the other actors in this supply chain (manufacturing supply chain can span across multiple tiers comprising of thousands of suppliers) it is difficult for the manufacturer to collect information, analyse it and get any indication of a possible knock-on effect from their actions. To solve this, a couple of tools have been introduced in this category that address these challenges in different ways. A description of the scope, maturity level and application of these tools has been provided below:

2.4.2.1 Platform & Network Intelligence Solution

The Platform & Network Intelligence solution collects data around the usage of and traffic flow within the EFPF platform. Through the collection and analysis of events that take place within the platform, the insights gained from the analysis are visualised and presented within a set of dashboards in the EFPF portal. This enables users to gain intelligence not only about the trends within the EFPF platform, but also within its ecosystem of connected platforms through the Federated Search feature.

Technologies

The Platform & Network Intelligence Solution is composed of several technologies and components which have been identified in Table 3. As shown below, the solution consists of Elasticsearch and Kibana to store and visualise the data respectively, and also the BNI Dashboard application which has been developed with the use of Java, Maven and docker to provide the solution with a back end to source all required data.

Table 3 - Platform and Network Intelligence Solution Technologies

Component / Technology	Type	Version	Description
Elasticsearch	Search Engine / Data Store	7.6.0	Elasticsearch is a distributed, RESTful search and analytics engine which is used to both analyse the data ingested into the solution and acts as a Data Store for the solution. This is deployed in the form of a docker container.
Kibana	Data Visualisation Tool	7.6.0	Kibana is a Visualisation tool that is used within the solution to visualise the data that is ingested into Elasticsearch. This is deployed in the form a docker container.
BNIDashboard	Web Application	1	The BNIDashboard is a web application that has been developed to first provide a backend to the solution, retrieving the platforms search and login events, then passing the data to Elasticsearch. The application also provides the solutions front end in the form of a Kibana dashboard which is displayed within the EFPF Portal. This is deployed in the form of a docker container.
Java	Language	1.8.0_191	Java is the programming language used within the development of the BNIDashboard application.
Maven	Dependency Management	3.6.0	The Dependency Management System used within the BNIDashboard application
Docker	Docker Engine Docker Compose	19.03.5 1.17.1	Docker and docker-compose are used to deploy and host Elasticsearch & Kibana and the BNIDashboard application.

Architecture

To Illustrate the architecture of the Platform & Network Intelligence Solution, the solutions architecture Diagram has been included below. The diagram shows that the solution consists of three core components; Elasticsearch and Kibana which are existing technology solutions and the BNI Dashboard which has been developed for the Platform and Intelligence Solution. As illustrated in the diagram, all components of the Platform and Network Intelligence Solution are deployed as docker containers.

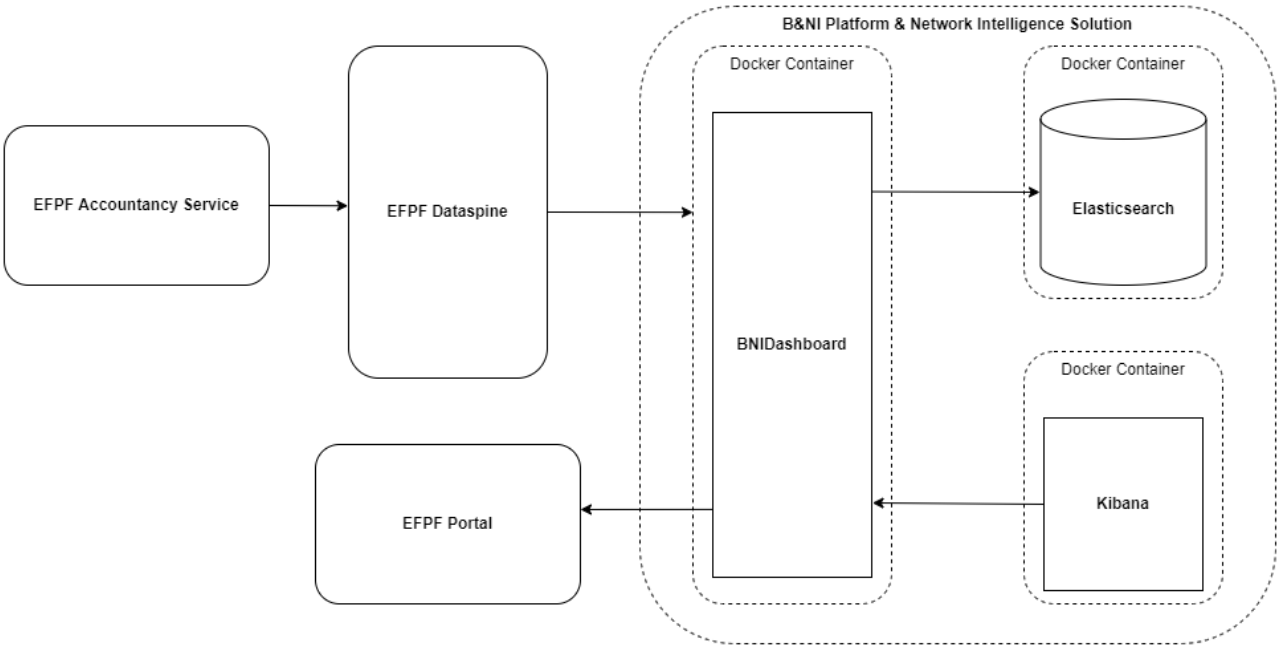
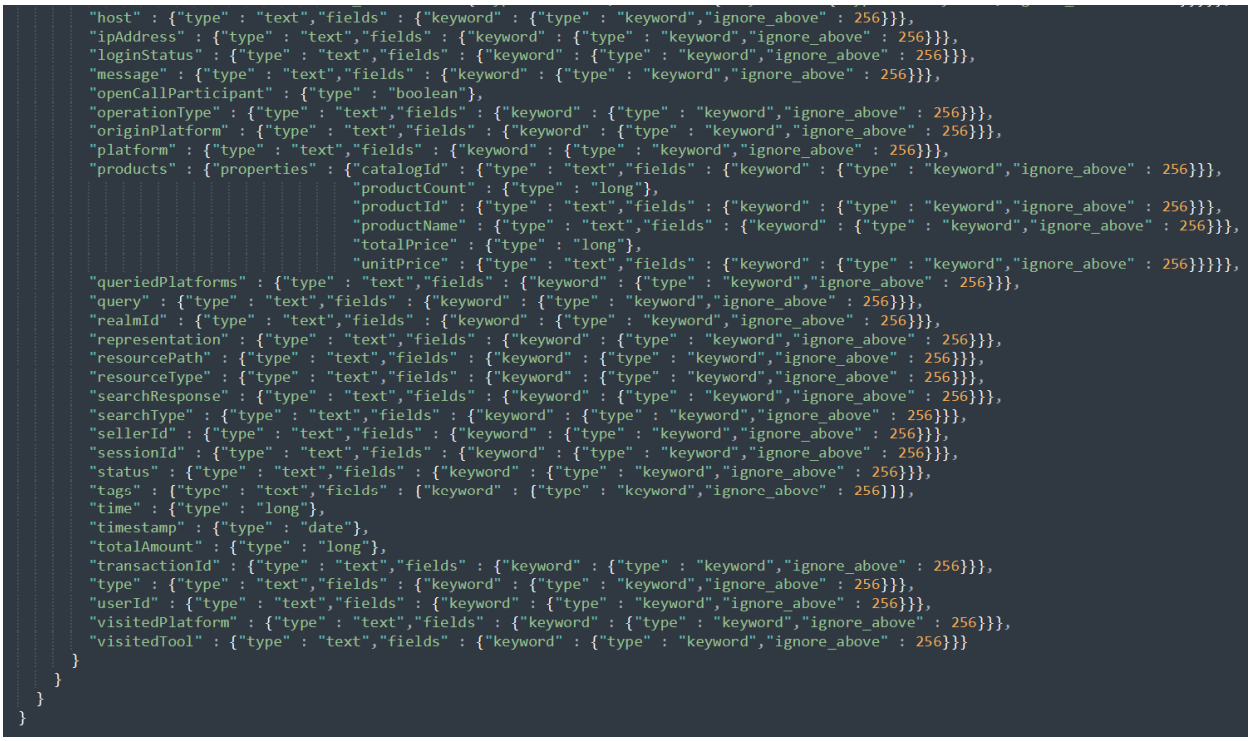


Figure 51 Platform and Network Intelligence Solution - Architecture Diagram

Within the Platform and Network Intelligence solution, Elasticsearch is used as the data store for all platform events. To further illustrate the construction of this data store, the schema or mapping used has been included. Each event, in the form of a document, has been indexed into Elasticsearch with a nested structure. The documents indexed consist of search, login, payment, tool_visit, platform_visit, user_registration, and company_registration events. The schemas defined have been included and can be seen below in Figure 52, and Figure 53.

```
{
  "efpf_platform" : {
    "mappings" : {
      "properties" : {
        "@timestamp" : {"type" : "date"},
        "@version" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "action" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "authDetails" : {"properties" : {"clientId" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                         "ipAddress" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                         "realmId" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                         "userId" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}}}},
        "buyerId" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "clientId" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "details" : {"properties" : {"client_auth_method" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "grant_type" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "refresh_token_id" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "refresh_token_type" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "scope" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "token_id" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "updated_refresh_token_id" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}}}},
        "facetQuery" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "headers" : {"properties" : {"accept_encoding" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "accept_language" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "cache_control" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "connection" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "content_length" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "content_type" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "contenttype" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "cookie" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "from" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "http_accept" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "http_host" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "http_user_agent" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "http_version" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "kbn_xsrf" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "postman_token" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "pragma" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "referer" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "request_id" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "request_method" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "request_path" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "sec_ch_ua" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "sec_ch_ua_mobile" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "sec_ch_ua_platform" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "sec_fetch_dest" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "sec_fetch_mode" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "sec_fetch_site" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "sec_fetch_user" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "upgrade_insecure_requests" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "x_forwarded_for" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "x_forwarded_host" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "x_forwarded_port" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "x_forwarded_proto" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "x_real_ip" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                     "x_userinfo" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}}}},
```


Figure 52 Platform and Network Intelligence Solution - Data Schema – Part 1



```
        "host" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "ipAddress" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "loginStatus" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "message" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "openCallParticipant" : {"type" : "boolean"},
        "operationType" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "originPlatform" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "platform" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "products" : {"properties" : {"catalogId" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                      "productCount" : {"type" : "long"},
                                      "productId" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                      "productName" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
                                      "totalPrice" : {"type" : "long"},
                                      "unitPrice" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}}}},
        "queriedPlatforms" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "query" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "realmId" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "representation" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "resourcePath" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "resourceType" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "searchResponse" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "searchType" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "sellerId" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "sessionId" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "status" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "tags" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "time" : {"type" : "long"},
        "timestamp" : {"type" : "date"},
        "totalAmount" : {"type" : "long"},
        "transactionId" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "type" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "userId" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "visitedPlatform" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}},
        "visitedTool" : {"type" : "text","fields" : {"keyword" : {"type" : "keyword","ignore_above" : 256}}}
      }
    }
  }
}
```


Figure 53 Platform and Network Intelligence Solution - Data Schema – Part 2

Functionality

The platform and network intelligence solution has been enhanced since previous reporting with the previous dashboard provided now moved to its own distinct tab within a wider set of dashboards. This array of platform intelligence tabs includes, the original platform trends dashboard, and three new tabs, for personalised, company and marketplace insights and can be seen below in Figure 54.

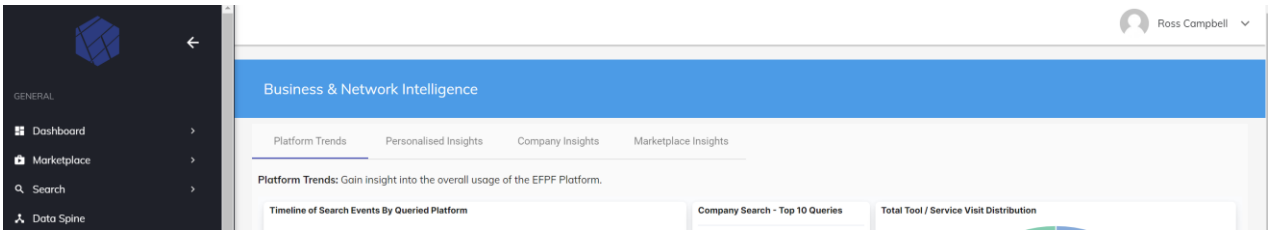


Figure 54 Platform and Network Intelligence Solution Tabs

Platform Trends Tab

The platform trends tab is the first of 4 tabs provided by the platform and network intelligence solution, which is focused on providing general insights into the overall usage of the EFPF Platform (Figure 55). This has included the provision of the visualisations focused on the search events that take place within the EFPF platform, and also the visited tools and platforms by EFPF users. Further information around the individual visualisations will also be provided below.

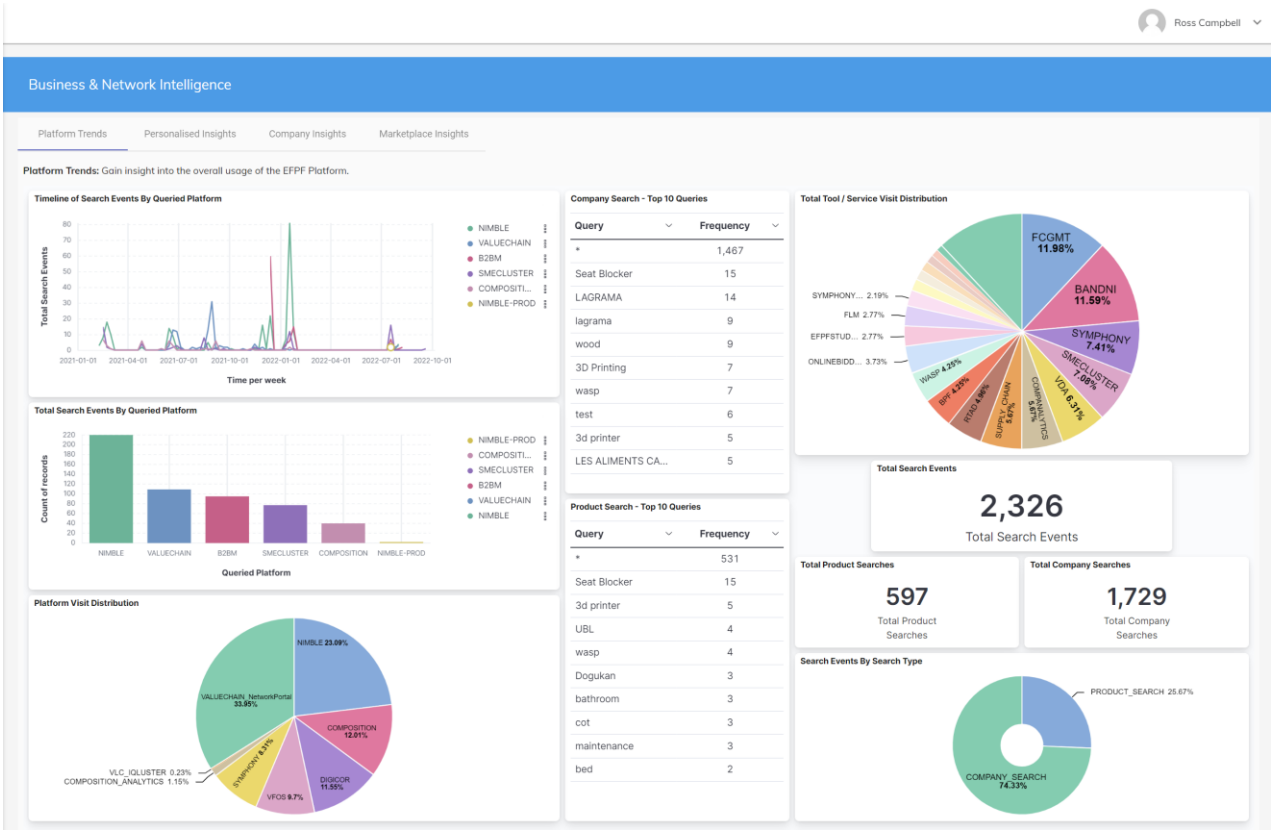


Figure 55 Platform and Network Intelligence Solution – Platform Trends Tab

Within the Platform Trends tab, there are two visualisations, as can be seen in Figure 56 below, which reflect the search events by its respective queried platform. The first of which is a date histogram to displays the total search events that have taken place within the connected platforms, over the course of the EFPF Platforms lifetime. The second visualisation displays the same data set, this time as a bar chart to show the comparative total searches that have taken place against each connected platform. These visualisations allow the platforms users to view the level of interaction in the platform at a given point in time.

Figure 56 Platform and Network Intelligence Solution – Search Events by Queried Platform Visualisations.

In the platform trends tab, there are also three metric-based visualisations which are included to illustrate the number of search events that have taken place within the platform (Figure 57). The first metric displays the total number all search events that have taken place, while the next two visualisations display the total number of product searches and company searches respectively. Through the application of filters on the data source the user can then refine the data. For example, by selecting the Nimble platform in another visualisation, the metrics will then display the total amount of searches in this base platform.

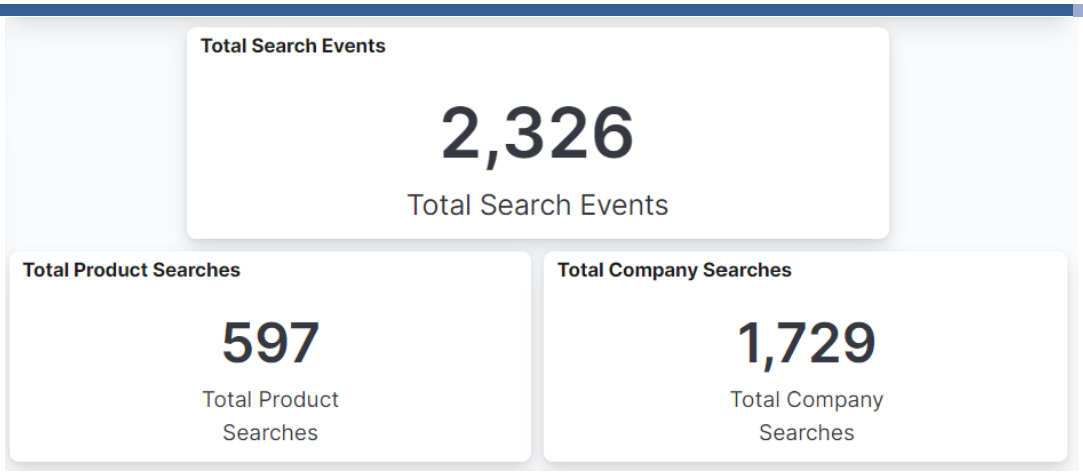


Figure 57 Platform and Network Intelligence Solution – Total Search Event Metric Visualisations

The pie chart present in the dashboard has been included in Figure 58 and displays the division of search events in the EFPF platform. It displays the proportion of search events that have taken place within both the product and company search features of the platform. This allows user of the platform to understand what other users are searching for within the platform.

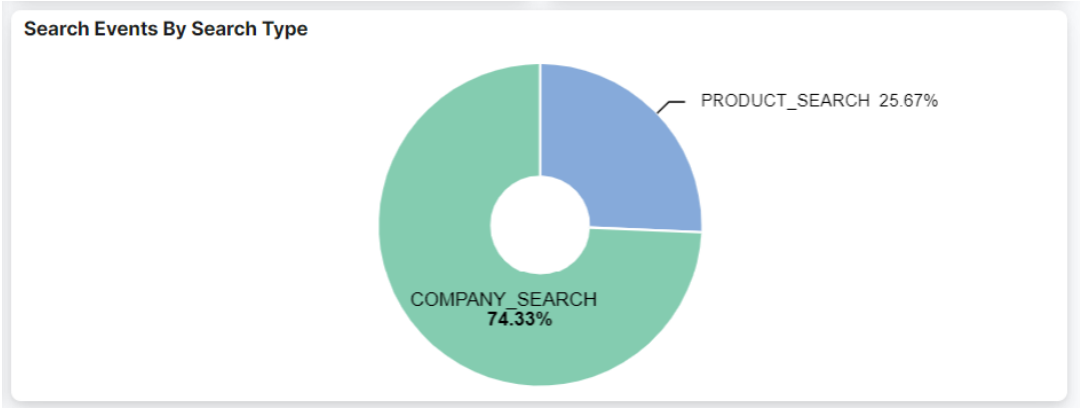


Figure 58 Platform and Network Intelligence Solution – Search Event Distribution by Search Type Visualisation

Included in the platform trends dashboard are two top ten query visualisation which can also been seen below in Figure 59 and Figure 60. These visualisations illustrate the top ten most search queries for both the product and company search features in the platform. This allows the platforms users to view the ongoing trends within the EFPF platform to understand what it is the platforms users are searching for. Through the application of additional filters on the data source, the users can then refine this data. For example, a filter may be applied so that the visualisation displays the top ten searches that have taken place within the Nimble base platform.

Company Search - Top 10 Queries

Query	Frequency
*	1,467
Seat Blocker	15
LAGRAMA	14
lagrama	9
wood	9
3D Printing	7
wasp	7
test	6
3d printer	5
LES ALIMENTS CA...	5

Figure 59 Platform and Network Intelligence Solution – Top Ten Company Search Queries Visualisation

Product Search - Top 10 Queries

Query	Frequency
*	531
Seat Blocker	15
3d printer	5
UBL	4
wasp	4
Dogukan	3
bathroom	3
cot	3
maintenance	3
bed	2

Figure 60 Platform and Network Intelligence Solution – Top Ten Product Search Queries Visualisation

The final two visualisation present in the platform trends dashboard are the platform visit distribution, and tool visit distribution pie charts that have also been included in the Figure 61 and Figure 62 respectively. The platform visit distribution pie chart reflect the connected platforms that are most visited by users of the EFPF platform. The tool visit distribution pie chart then displays the most visited tools by users of the EFPF platform, as a proportion of overall tool visit events that have taken place in the platforms lifetime.

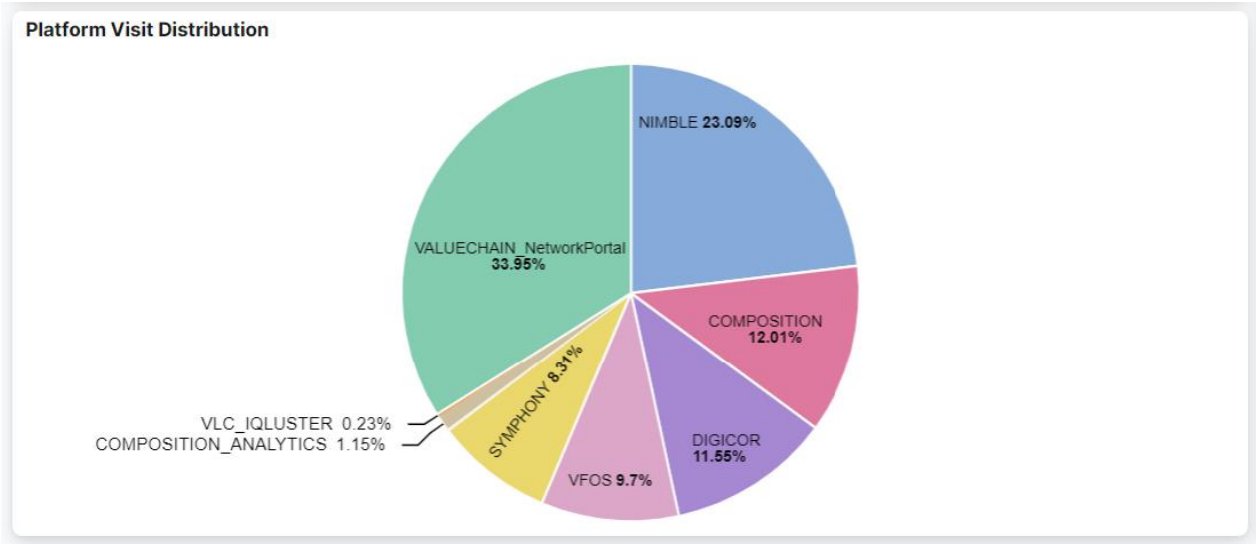


Figure 61 Platform and Network Intelligence Solution – Platform Visit Distribution Visualisation

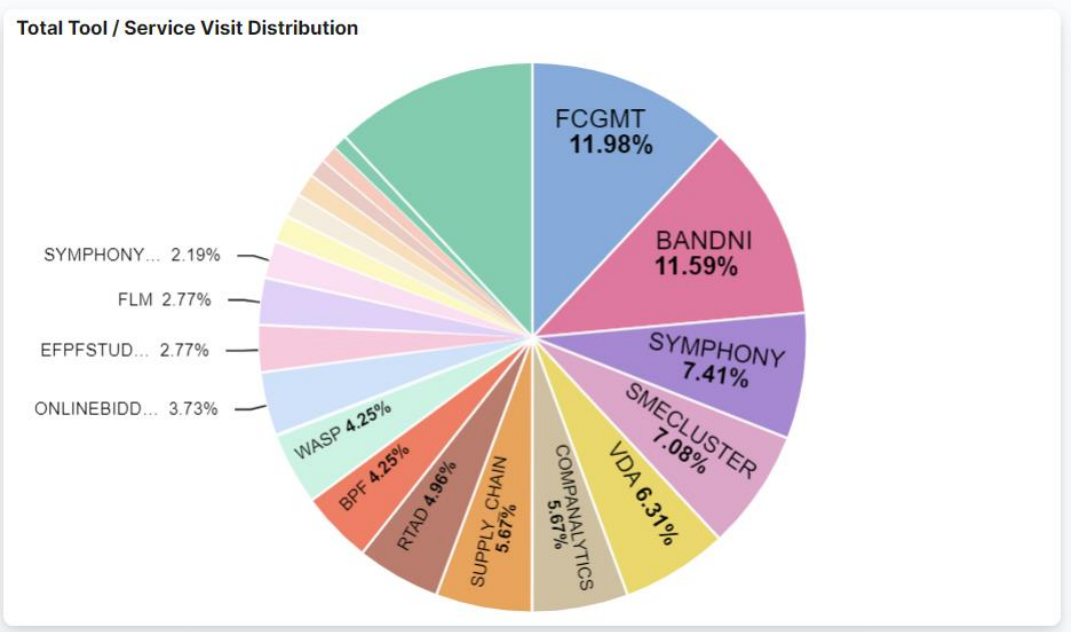


Figure 62 Platform and Network Intelligence Solution – Tool/Service Visit Distribution Visualisation

Personalised Insights Tab

The Personalised Insights tab, as an addition to previous developments is designed to provide each EFPF user with insights into how they have been interacting with the EFPF platform. The dashboard provided focuses on aspects of platform engagement such as searches, logins, platform, tool and service visits, and payment events. The dashboard provided by the Personalised Insights tab has been included in Figure 63, while the individual visualisations provided by the dashboard are discussed in more details below.

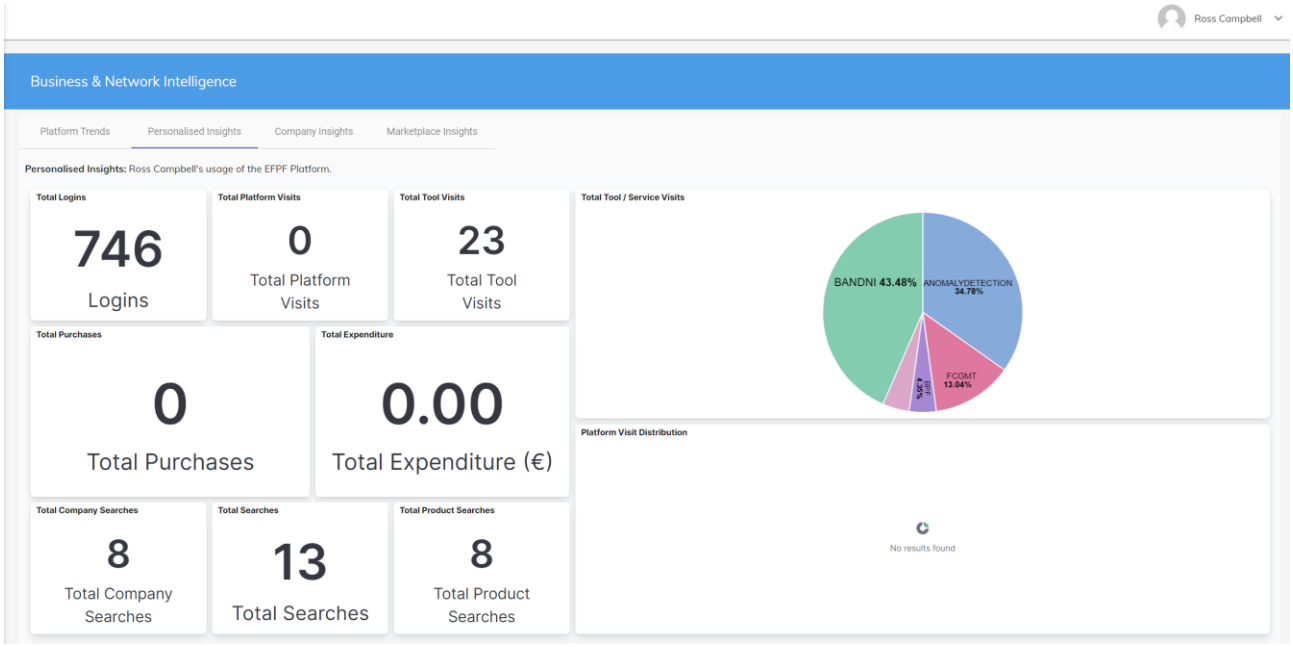


Figure 63 Platform and Network Intelligence Solution – Personalised Insights Tab

The first set of visualisations provided by the personalised insights tab is focused on direct engagement with the platform and is displayed as metrics. This has been included in, and as shown provides the user with their total number of Logins, Connected platform visits, and tool or service visits within the platform.

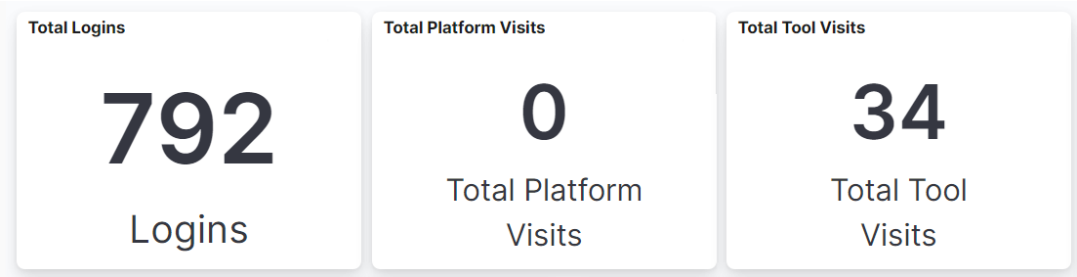


Figure 64 Platform and Network Intelligence Solution – Login, Platform Visit, and Tool Visit Visualisations

The next set of metric-based visualisations has been included below in Figure 65, and are focused on payment related events of the EFPF user. This will allow users to quickly obtain information related to both their total number purchases and the total expenditure for purchased items within the platform.

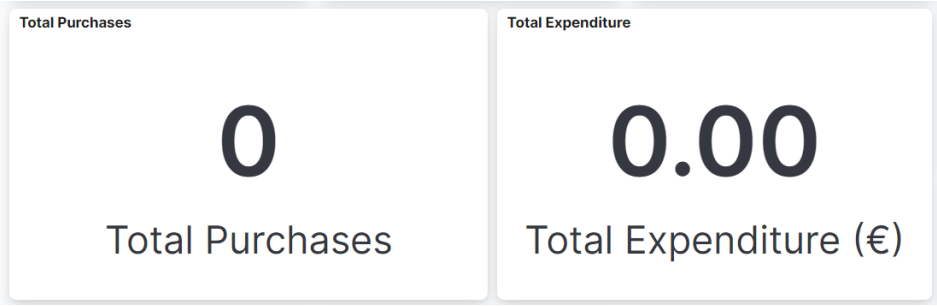


Figure 65 Platform and Network Intelligence Solution – Total Purchases, and Total Expenditure Visualisations

The final set of metric-based visualisation is focused on the users search activity within the platform, and is provided in Figure 66. The set of metrics includes individual visualisation for the total searches, total company searches, and total products searches they have made within the EFPF Platform.

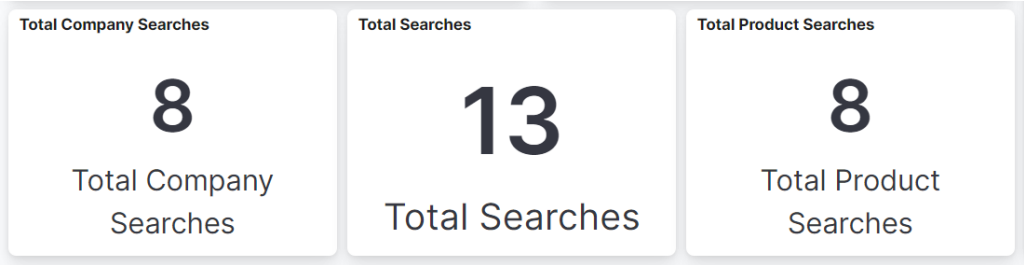


Figure 66 Platform and Network Intelligence Solution – Total Searches, Company Searches, and Product Searches Visualisations

The final visualisations provided by the Personalised Insights tab are pie-charts based and can be seen in Figure 67 and Figure 68. The first of which displaying the tools and service visit distribution of the users, while the second illustrates the visit distribution of the user to the connected platforms.

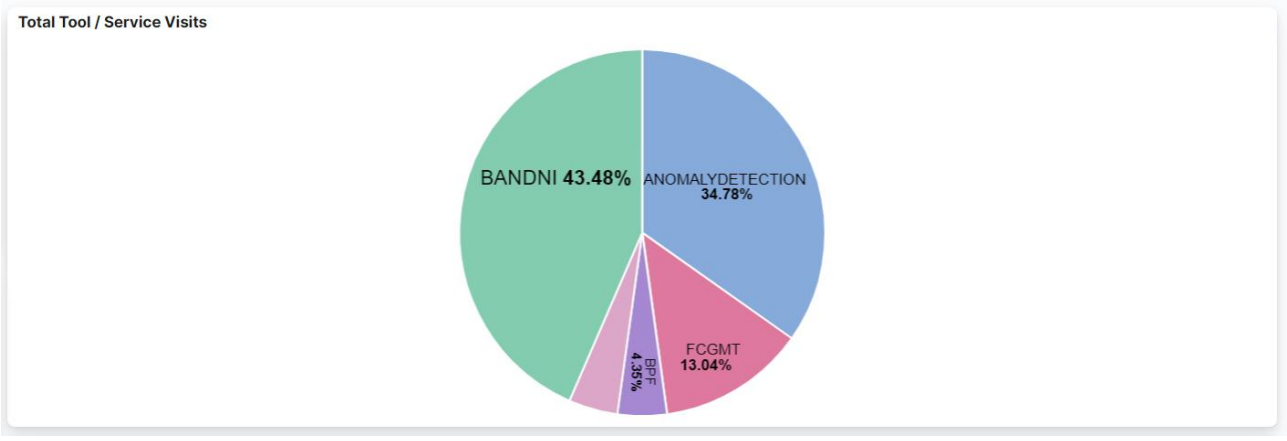


Figure 67 Platform and Network Intelligence Solution – Tool/Service Visit Distribution Visualisation

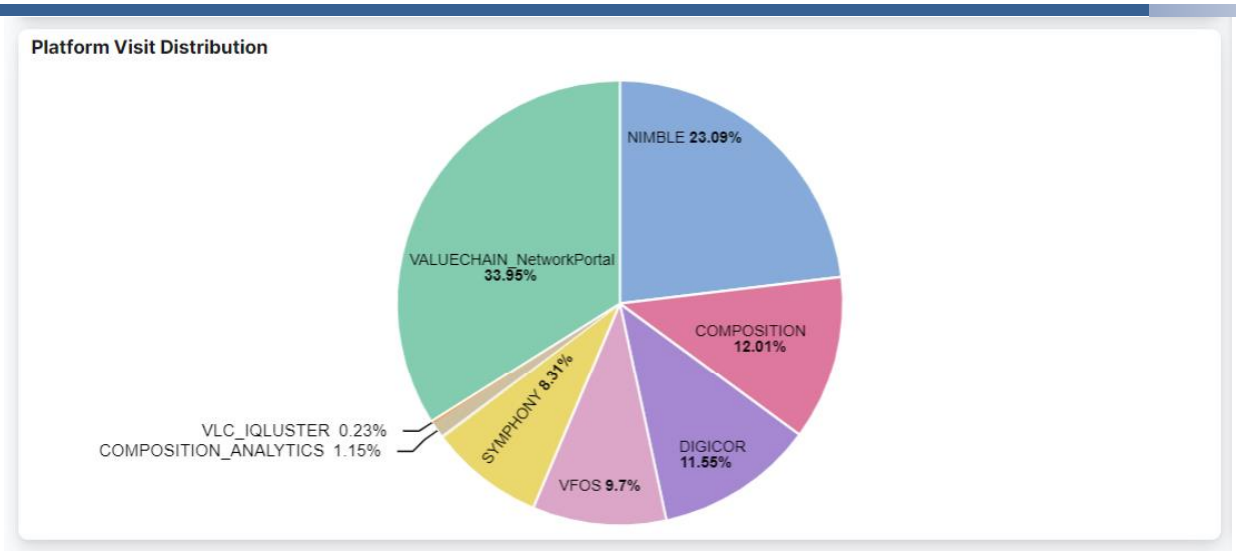


Figure 68 Platform and Network Intelligence Solution – Tool/Service Visit Distribution Visualisation

Company Insights

The Company Insights tab has been provided as an enhancement to previous work reported for the Platform and Network Intelligence Solution, and is designed to provide insights to each user surrounding their companies overall engagement within the Platform. The provided dashboard can be seen in Figure 69, and as shown is an identical set of visualisations to the Personalised Insights tab. However, while the latter is filtered based on the user id of the logged in user, the Company Insights tab first queries the EFS for a list of user ids, from the logged in user's company, and then filters the dashboard accordingly. While the dashboard has been included, individual visualisations in the Company Insights tab will not be discussed in more detail, with this information describes in the previous section on the Personalised Insights tab

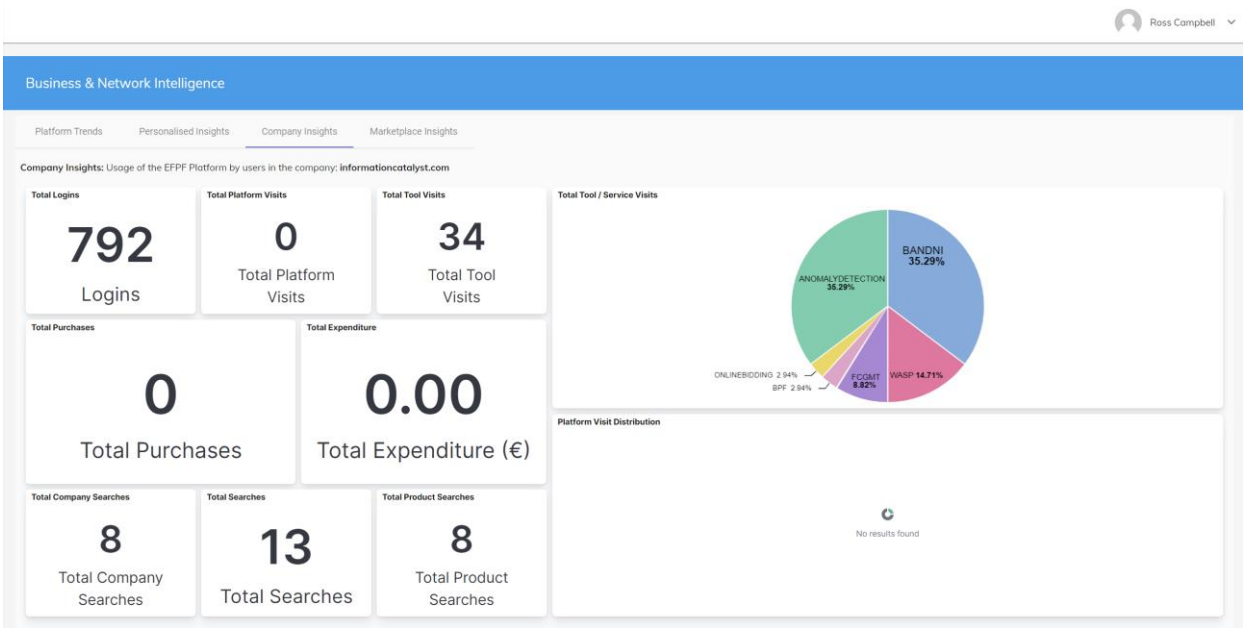


Figure 69 Platform and Network Intelligence Solution – Company Insights Tab

Marketplace Insights

The Marketplace Insights tab (Figure 70) had been added to the Platform and Network Intelligence Solution to provide EFPF users within intelligence surrounding usage of the marketplace and platform by both users and registered companies. The page is divided into two sections with the first focusing on Insights related to products and catalogues offered on the EFPF Marketplace. Included in this section are metric based visualisations that reflect the total; products, catalogues, catalogue items, products offered but not sold, unique products sold, and products sold. Alongside this, a second section is offered focusing on company engagement within the platform and EFPF marketplace. Within this second company/user insights section, metric-based visualisations have been provided to reflect the total; companies in the platform, companies in contracts, companies not in contracts, users registers, users in companies, and private users.

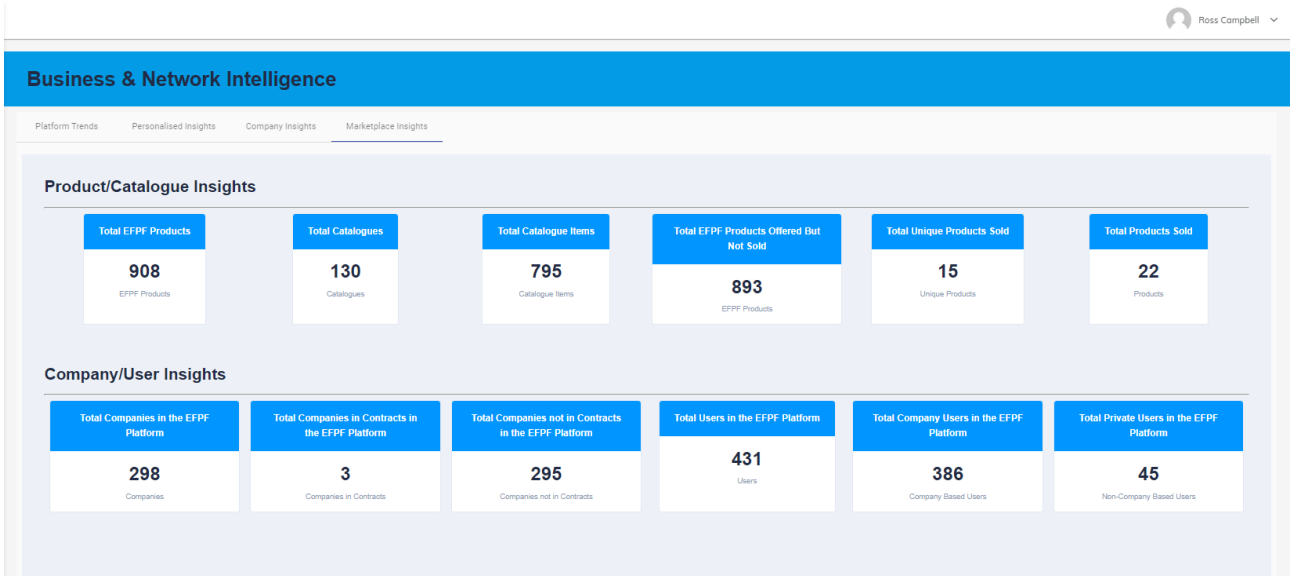


Figure 70 Platform and Network Intelligence Solution – Marketplace Insights Tab

2.4.2.2 Network Portal Platform

Valuechain's Network Portal (previous name 'iQluster') is a supply chain intelligence platform that is designed to facilitate supply chain visibility, easily share data, and engage the lower tier supplier by creating a digital community. Unlike most platforms which are 'one to many' in design, Network Portal leverages its 'many to many' platform model to engage every stakeholder, big and small. The idea is to return some benefit to every company that joins and share data/information with the network. This creates a direct benefit to for each user and the benefit compounds as we move up the tiers of supply chain as this data aggregates and reflects unparalleled intelligence that is otherwise fragmented or unavailable.

Network Portal combines the conventional 'top down' supply chain mapping with an innovative 'bottom up' approach to address the gaps. Network Portal's data science expertise creates a great take off platform by big data scrapping to identify key intelligence about companies in supply chain. Then, the suppliers are invited to join the platform and a unique incentivisation model is used to boost adoption rates. Network Portal offers freemium digital productivity tools (limited functionality CRM, digital auditing tools etc.) to drive engagement. Network Portal enables modelling and adoption of established diagnostic tools

such as DRL – Digital Readiness Level, BUSex, MANex, Digital productivity tools (Valuechain IP), anti-slavery, conflict minerals etc. that can be used in the same network. This gives individual companies a benefit of measuring their readiness level, while it gives intelligence to their customers about their level and improvement over time. The benefit for the sub tier suppliers is the benchmarking or anonymous intelligence they receive back after sharing information in the network (filling out diagnostics, supplier benchmarking metrics etc.) which is a direct value for their business and perhaps a conduit into the bigger picture of the industry which they are usually very distant from.

Network Portal has been integrated as a 3rd party add-on to EFPF platform. Network Portal is currently available through the EFPF Portal under Business Intelligence section. EFPF users can seamlessly enter Network Portal platform through 'single sign on' (SSO). Prominent features of the platform are explained in sub sections below:

Creating a Network – Consortium Building

Users can create a new network and invite members (suppliers, partners, association members etc.) The user goes through a 3-step setup wizard, which guides them though the set-up process. Figure 71 shows a screenshot of the network setup wizard form Network Portal platform.

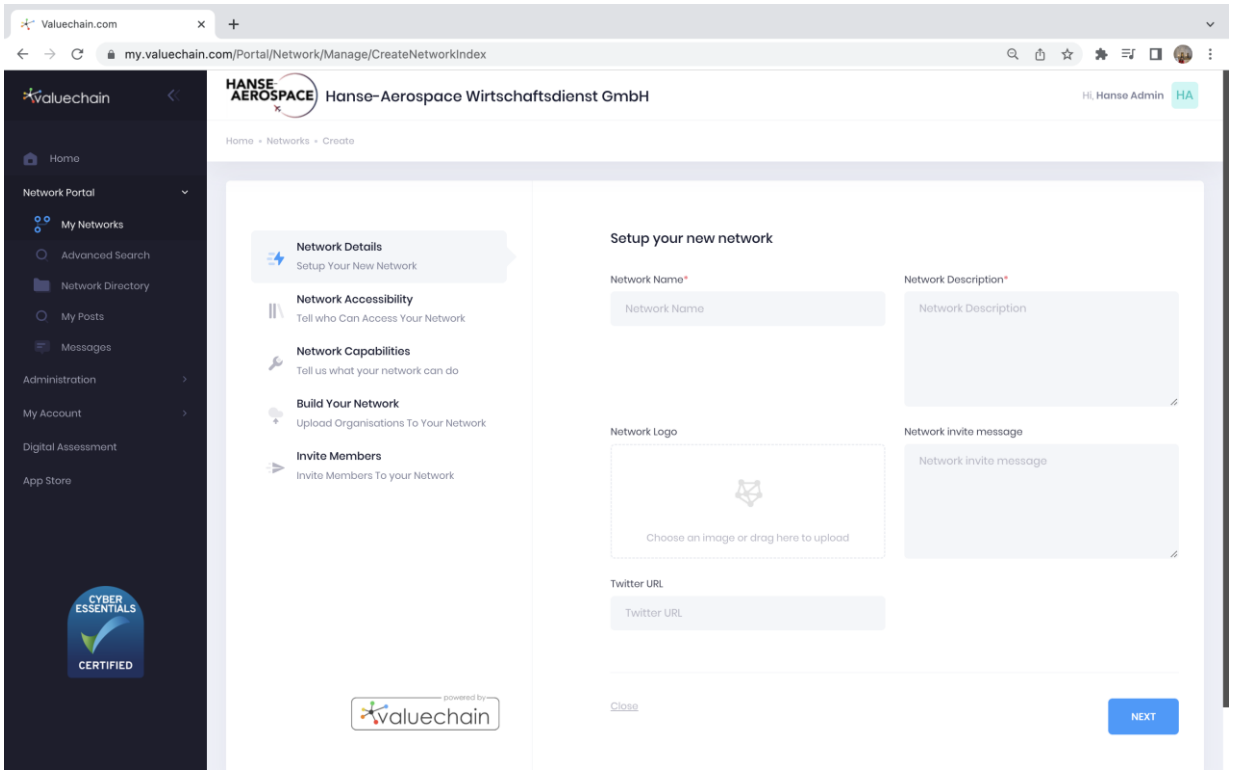


Figure 71 Network creation wizard in Network Portal

New members can always be added to the network after it is created by sending them an invite link under 'Companies Tab' as shown in Figure 72.

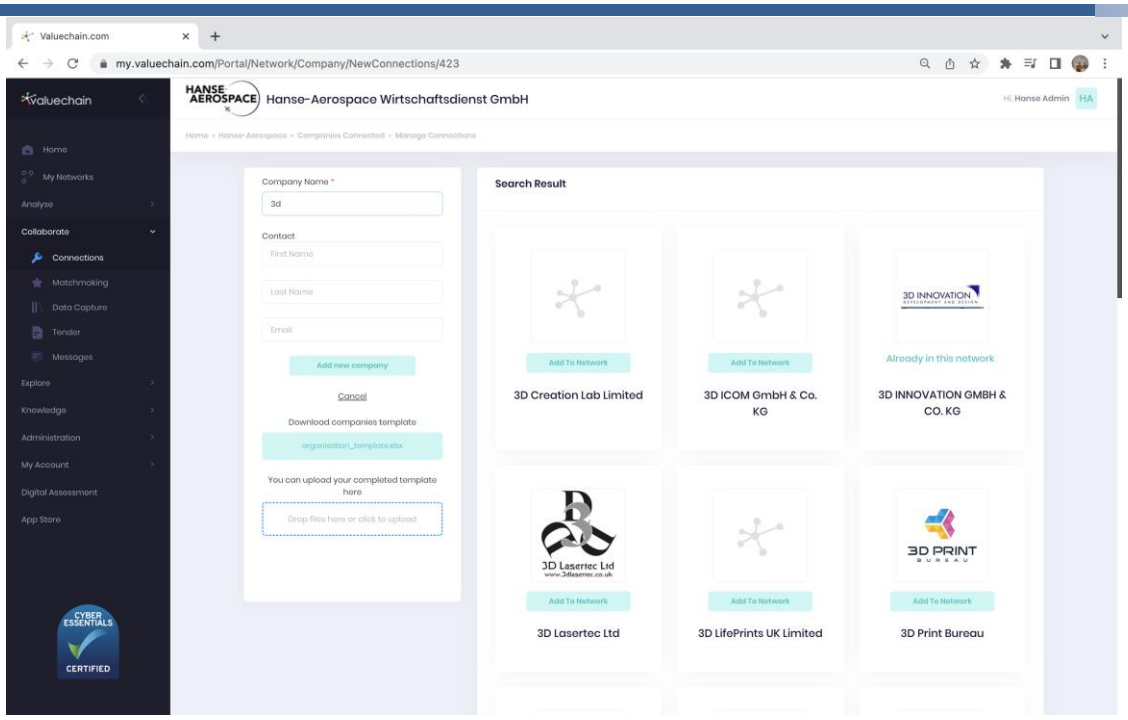


Figure 72 Inviting new companies to join Network Portal network

Alternatively, user can browse through the 'Network Directory' which allows them to explore the wider platform and discover other existing networks. If the user finds a particular network of interest, they can view activity dashboard of that network to get a high-level understanding as well as data reflecting its engagement shown in Figure 73. The user can then request to join that network, which is routed through to the network leader for approval before they are granted access.

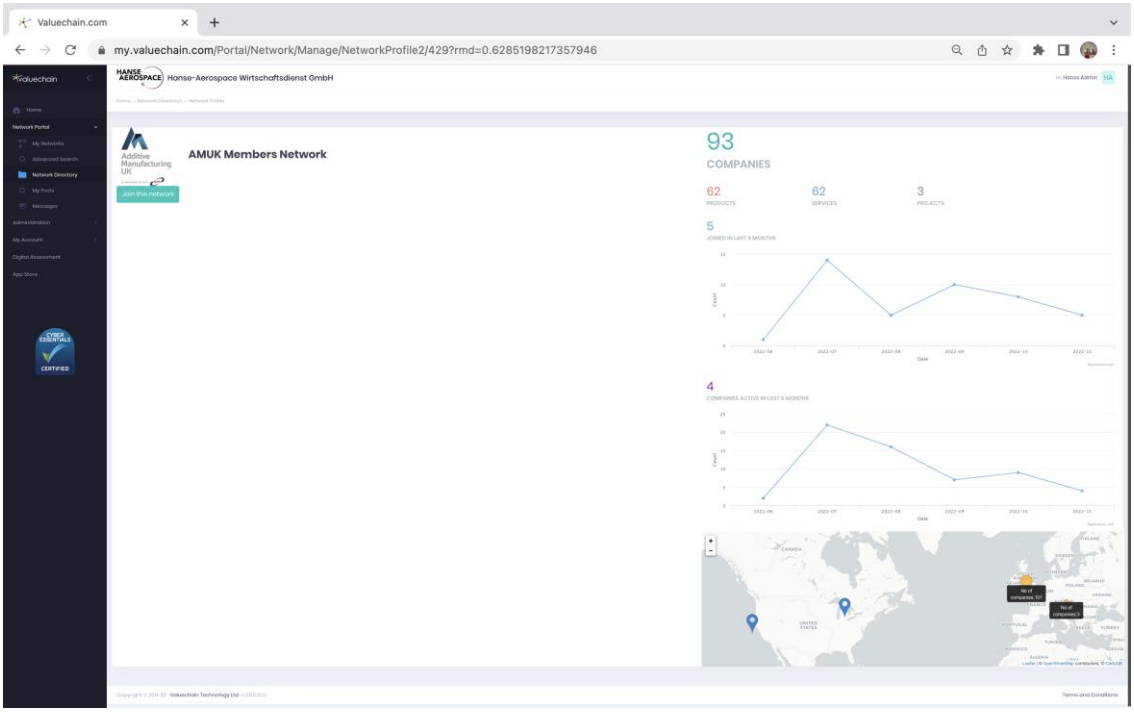


Figure 73 Network analytics and request to join – Network Directory

Automated Data Collection

Network Portal uses advanced web scraping that work to collect openly available information on companies. The algorithms are constantly looking for information that is deemed useful for manufacturing supply chains. Some of those categories are mentioned below:

- Alternate Company Addresses
- Certifications such as 'ISO9001' or 'AS9100'
- Manufacturing Capabilities such as 'Milling' or 'Machining'
- Technologies such as 'Additive Manufacturing'
- Sectors such as 'Aerospace' or 'Nuclear'
- Financial information

This information comes from a variety of open sources including websites, new feeds, social media as well as national company registers and other credit rating industries. It provides the user a great deal of intelligence on these companies. Therefore, Network Portal acts as an intelligence engine which aims to capture as much useful information as is possible to continuously provide the user with updated information. A great example of this is presented in Hanse Aerospace's network case study - Hanse Aerospace.

Audit/Survey

Network Portal provides a data capture feature embedded in the platform. The data capture module is simple yet powerful tool to generate intelligence from the network (consortium). Data Capture allows the network leader to curate Audits and surveys to capture information directly from the active network members. This further enhances the information available on companies through web scraping providing a more complete understanding of the network.

The platform provides a range of preconfigured templates for standard audits such as 'ISO9001', 'AS9100', 'OHSAS18001', 'Business Excellence (BUSex)' etc. Users can also quickly build their own custom audits or questionnaires. These questionnaires can be configured as scored assessment such that each question get marked automatically based on the answer, resulting in a final score. This makes it useful to analyse the scores achieved by different companies in the network while also enabling a trend analysis (for a scheduled recurring questionnaire) for that individual company. The questionnaires can be scheduled into the future and can be made recurring too.

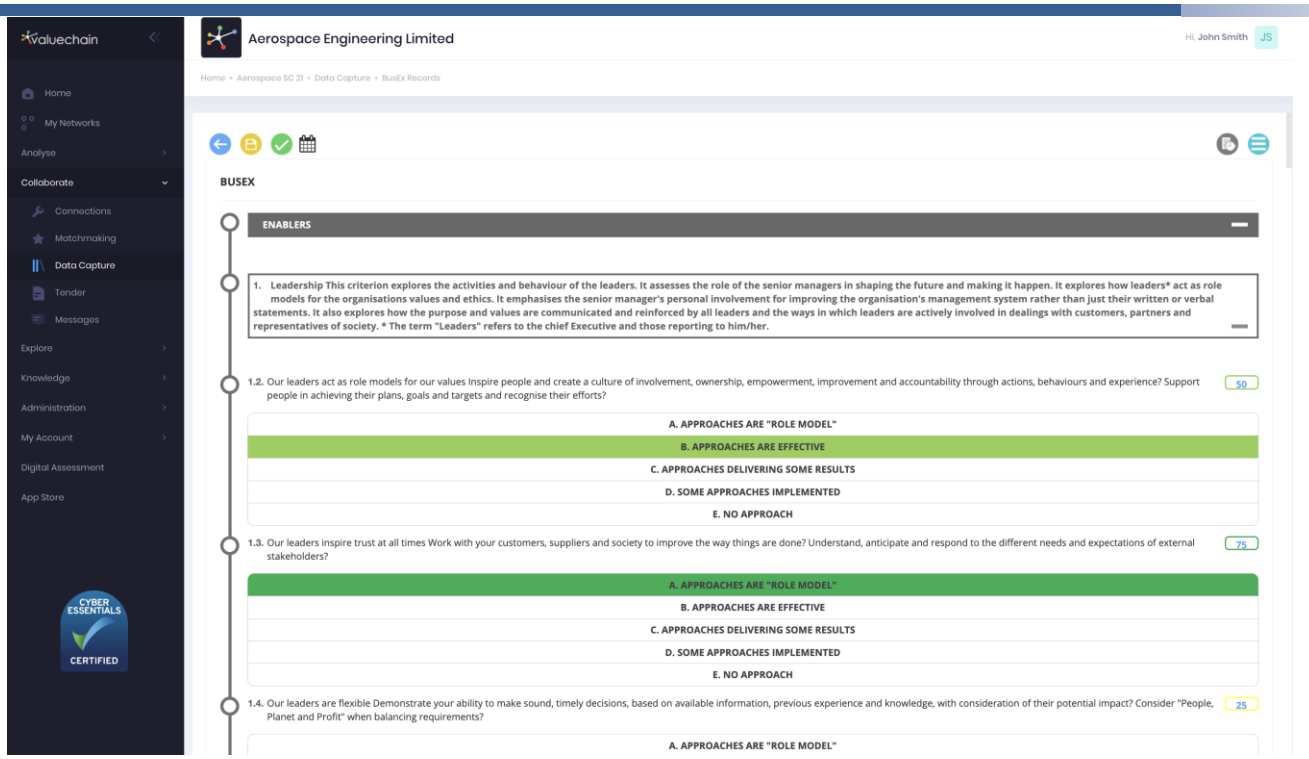


Figure 74 Example of preconfigured Business Excellence audit on Network Portal platform

Analysis and Visualisation

Network Portal provides advance visualisation tools to bring out meaningful insights from the data collected in previous steps above. The advanced search provides ability to search for companies with any related information that the platform holds about them. For example, instead of typing company names, the user can type ‘steel brackets’ and all companies that say they do that will appear. The user can further filter the results by other attributes like ‘region’ or ‘certifications’ etc. Similarly, the user could not only search through the companies but also the products, services, and projects in the network too. An example of this is provided in Figure 75.

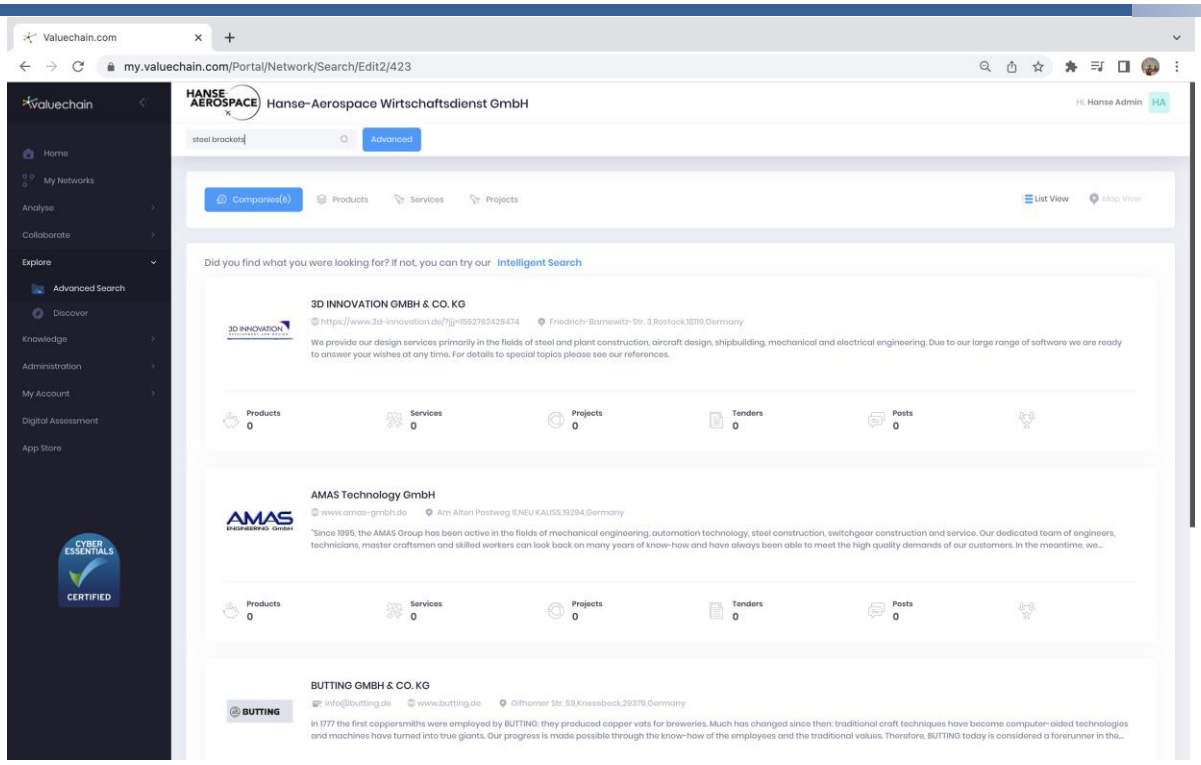


Figure 75 Advanced Search example in Network Portal

Another visual module is the Explore Map. This is designed to use the intelligence generated in steps above and drill down into the network. This provides a structured method of exploring the companies as well as modelling and visualising supply chain connections. An example is provided in Figure 76.

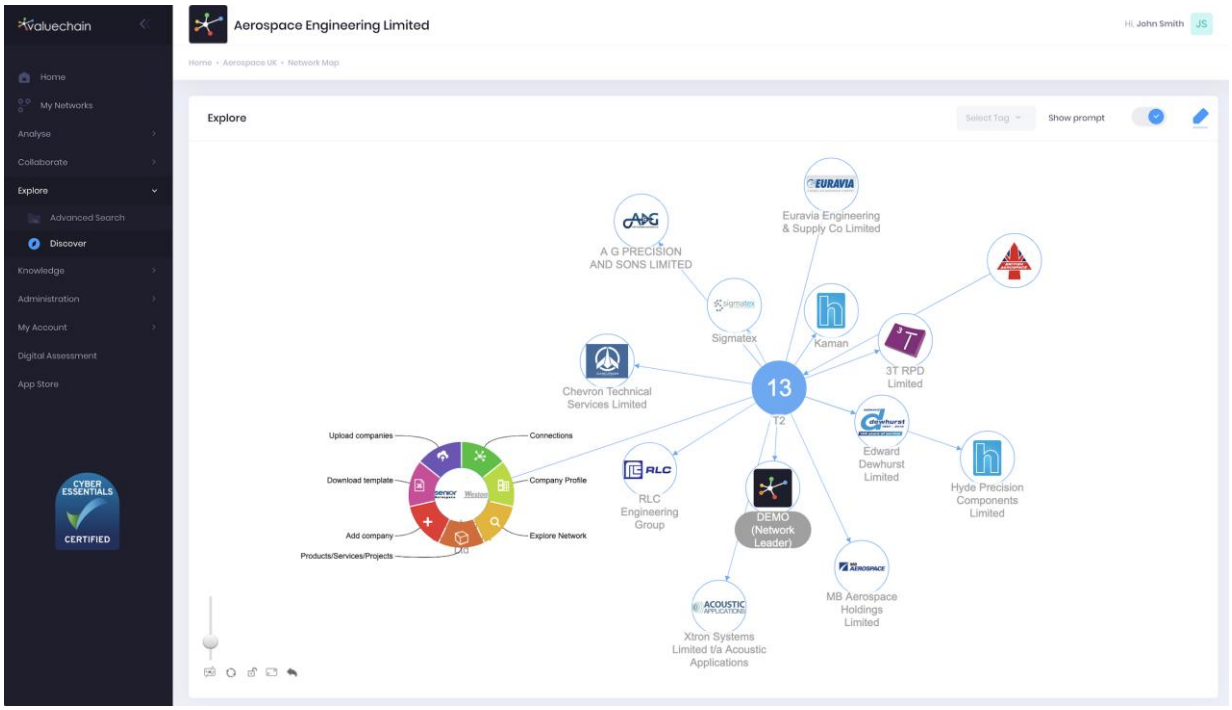


Figure 76 Supply Chain connection modelling in Explore Map

This module can also be integrated to websites and blogs to provide a window into the network and related intelligence. An example of this is demonstrated in Hanse Aerospace's case study under section 'Website integration' - Hanse Aerospace.

Network Portal provides configurable Dashboard that can be populated with analytics and reports generated using data collected in above steps. The reports are interactive and allow users to click through them to see underlying information. An example is shown in Figure 77 and Figure 78 (noticing Network Portal provide options for user to switch between light and dark theme).

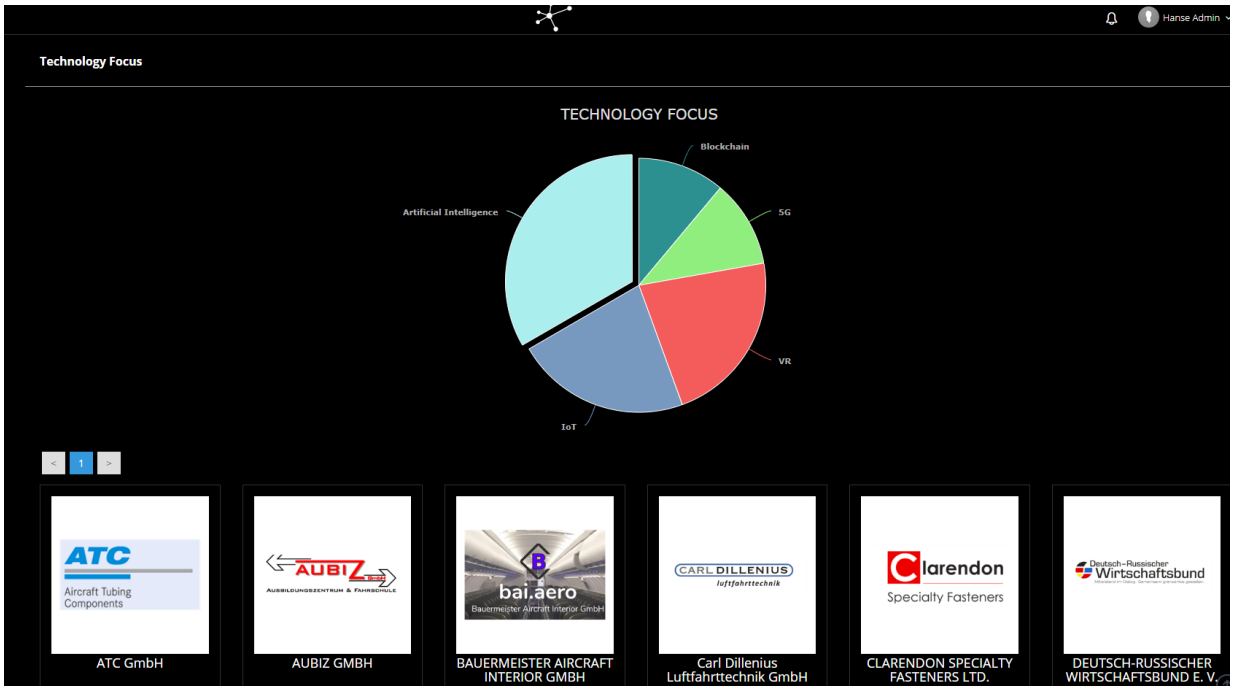


Figure 77 Interactive Reports in Network Portal Dashboard

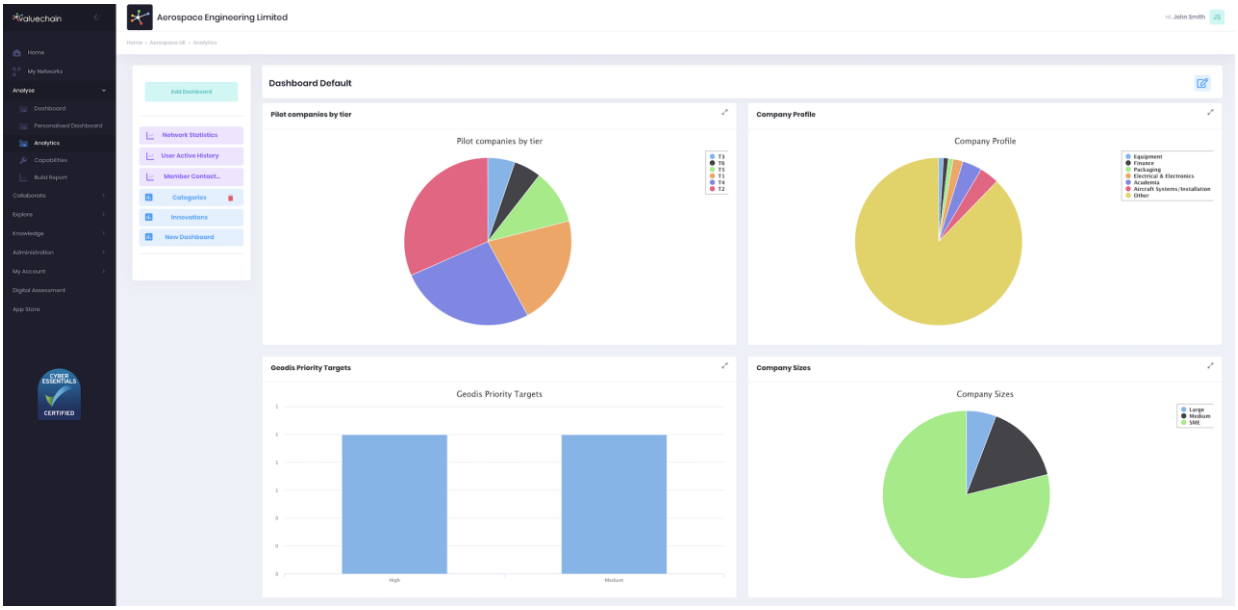


Figure 78 Interactive Reports in Network Portal Dashboard (2)

Data Sharing

Network Portal does a great job of continuously mining intelligence from these networks and visualising them. As part of the wider EFPF ecosystem, Network Portal is sharing all this data back with EFPF ecosystem, through carefully designed APIs. This allows sharing of

information continuously between the platforms. The API is called to write the data from Network Portal platform to the federated search index – Solr. This also provides greater flexibility to EFPF users who can access this intelligence directly from the ELK stack and combine it with other data sources to perform enhanced analysis.

2.4.2.3 Tendering and Bid Management

The Business Opportunity tool is a Tendering and Bid Management service within EFPF, delivered by the SMECluster base platform. It provides platform users a chance to offer their services for income generating opportunities, and to procure for their business by posting tenders in the format of a Business Opportunity. Business Opportunities can be things your business wishes to procure (both formal Tenders, simple call for supply of parts or materials), or things you wish to offer and receive applications for (notification of available capacity). In the Business Opportunities portal is made up of two profile types, Procurer and Supplier.

Procurer companies are those wishing to post Business Opportunities. These can relate to the following types of opportunity:

- Procure Products
- Procure Service
- Offer Products
- Offer Service
- Raw Material / Consumable
- Group Purchase

The procurer dashboard includes links to applications coming in, live opportunities, drafts etc - sitemap is shown in Figure 79.

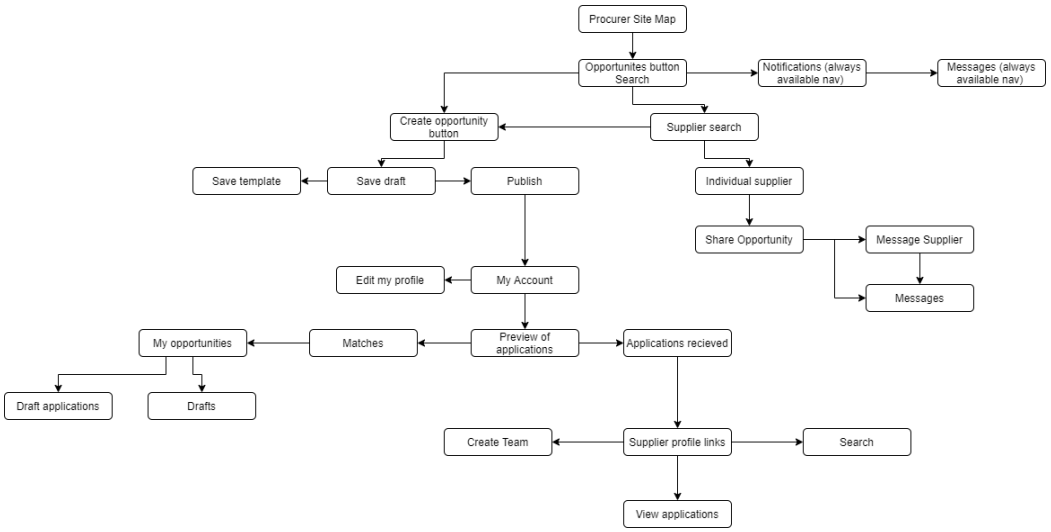


Figure 79 Procurer site map

Suppliers companies are those able to offer services or materials, they will access the portal to search for opportunities, submit applications and reach out to ‘procurers’. Suppliers also want to use the portal as an opportunity to advertise themselves through our company directory. The Supplier dashboard works almost as an opposite to the procurer portal. Here you can manage submissions previously sent, new opportunities, awarded opportunities etc.

The sitemap for the Suppliers area of the Business Opportunity tool, is show in Figure 80.

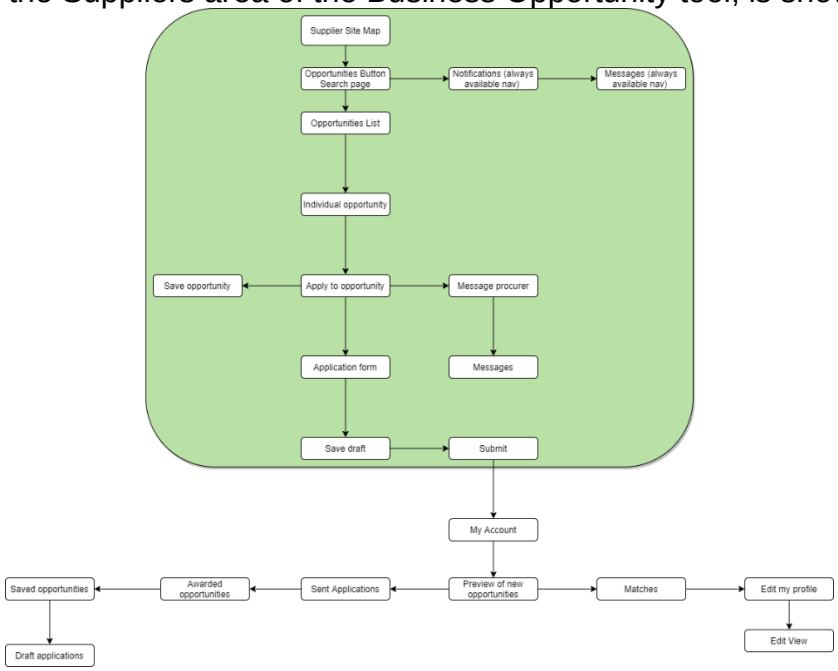


Figure 80 Supplier site map

The functionality underlying the Business Opportunity tool is achieved through the following service frameworks:

2.4.2.3.1 Company Capability Directory

The Company Capability Directory framework provides a directory of company profiles that describes their capabilities, services and accreditations. Members can register the details of their company, their capabilities, and accreditations for free, allowing their profile to be searched as part of the Directory search interface.

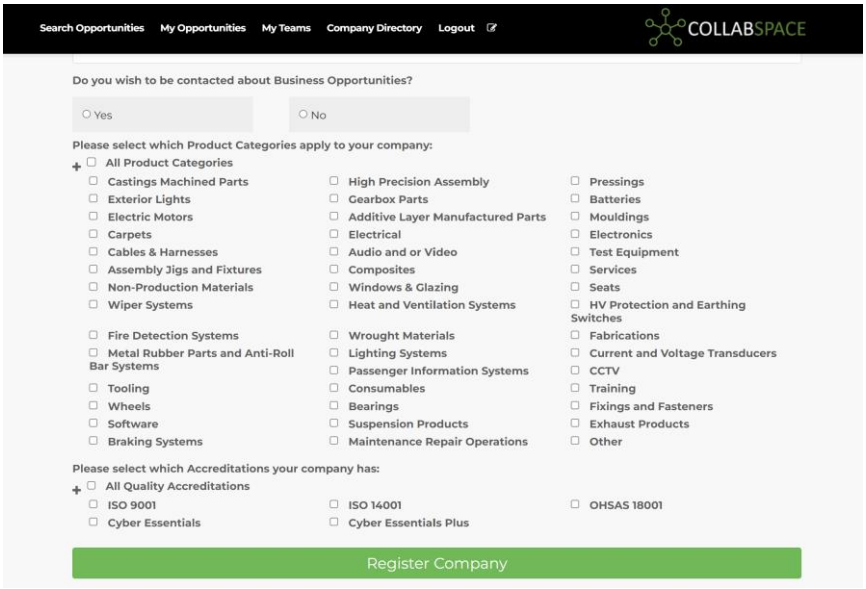


Figure 81 Company Registration - Product categories

The directory search supports keyword search, and filter by category and accreditations. This framework can be queried by the Matchmaking Service within EFPF in order to be able to provide a broader scope of companies considered.

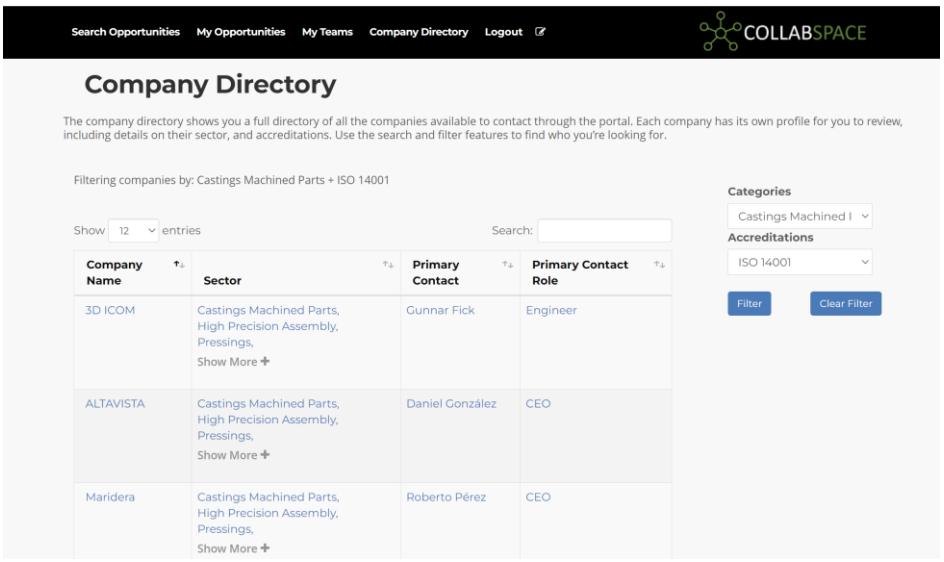


Figure 82 Company Directory search interface

2.4.2.3.2 Business Opportunity

This framework will allow users to post Business Opportunities that can be viewed by other users of the system. The requirements for the opportunity can be defined including any mandatory skills or accreditations, other metrics such as quantity or capacity, whilst allowing the user to restrict access to certain fields until they grant access to them. In the Aerospace domain this is particularly important as privacy of data and procurement is particularly stringent.

For example, if procurers are regularly looking for suppliers that hold specific accreditations (i.e. QS 9000) suppliers will be able to make an informed decision on what is necessary for their business development.

Procurers can add Opportunities through a simple wizard (shown in Figure 83), which capture details of opportunity requirements, when it should be delivered by and for how long, along with supporting documents for suppliers to download, including application forms and other Terms and Conditions. The “Show?” checkboxes are there to help protect company information. These boxes will toggle whether this is visible from the first instance or should this be hidden.

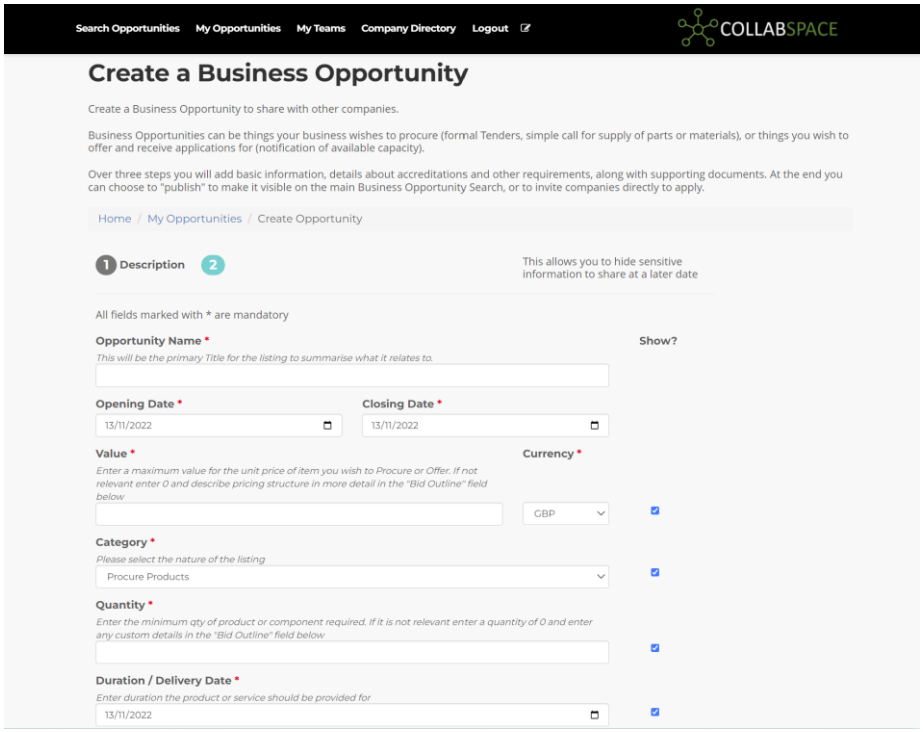


Figure 83 Opportunity Creation wizard

Users of the system can search opportunities based on keyword, geographical location, category and mandatory accreditations. The search interface is shown in Figure 84.

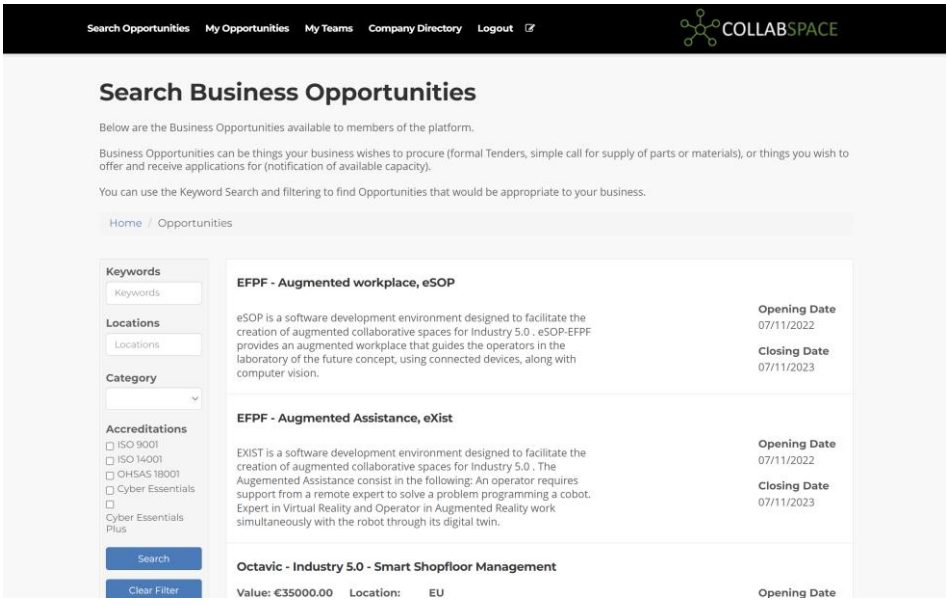


Figure 84 Business Opportunity Search interface

Once the user has found Business Opportunity that they would like to apply for they can view the details, and additional documents uploaded by the procurer, along with a more detailed specification.

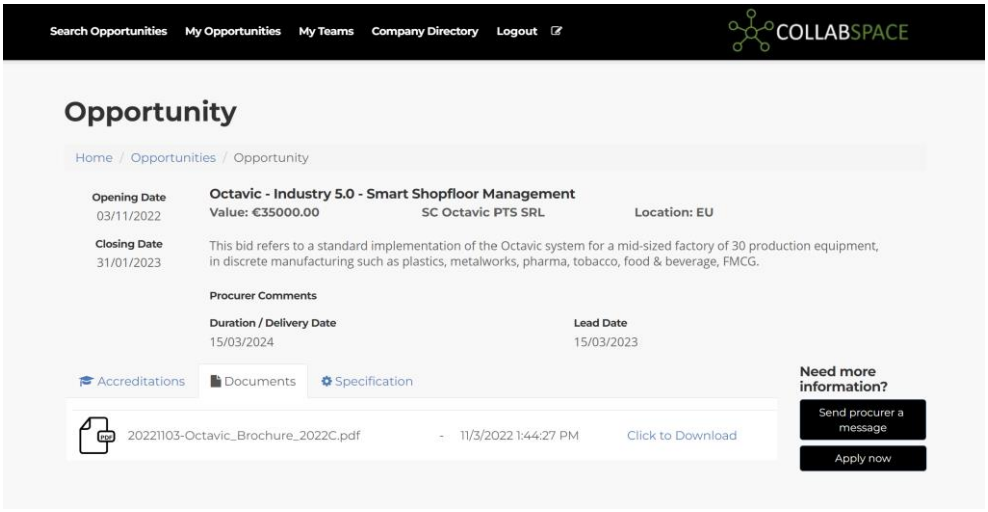


Figure 85 Opportunity Details page

This framework can be queried by the Matchmaking Service within EFPF in order to allow opportunities to be searched by all EFPF members by keyword, category or accreditations. This is achieved through a foundation of REST APIs which are updated automatically when new opportunities are added, and when opportunities removed after their closing date. An example of the GetAllOpportunities API is shown in Figure 86.


```
▼<Opportunity>
   <CategoryShow>true</CategoryShow>
   <ClosingDate>2021-04-08T09:13:00</ClosingDate>
   <CompanyID>0</CompanyID>
   <CompanyName i:nil="true"/>
   <CreatedBy>OpportunityWebServiceController</CreatedBy>
   <CreatedOn>2021-04-08T10:21:18.1541224</CreatedOn>
   <Currency>EUR</Currency>
   <Description>We would like to find a partner for the raw material as described above. If we
   together get to 10 ea plates for the group purchase, we could reduce lead time, avoid setup
   costs and thus would get generally better prices.</Description>
   <DurationDate>2021-04-29T09:13:00</DurationDate>
   <DurationShow>true</DurationShow>
   <LeadDate>2021-04-22T09:13:00</LeadDate>
   <LeadShow>true</LeadShow>
   <Location>Germany</Location>
   <LocationShow>true</LocationShow>
   <ModifiedBy/>
   <ModifiedOn i:nil="true"/>
   <Name>Looking for a partner for phenolic Honeycomb Panels 3mm (e.g. EC-PA233B-3)</Name>
   <OpeningDate>2021-04-08T09:13:00</OpeningDate>
   <OpportunityAccreditations i:nil="true"/>
  ▼<OpportunityCategory>
     <CategoryGuid>b44389fd-c607-4c99-bc3b-944c41463c4f</CategoryGuid>
     <CreatedBy>OpportunityService</CreatedBy>
     <CreatedOn>2021-03-22T00:00:00</CreatedOn>
     <Description/>
     <ModifiedBy i:nil="true"/>
     <ModifiedOn i:nil="true"/>
     <Name>Group Purchase</Name>
     <OpportunityCategoryID>11</OpportunityCategoryID>
     <SortOrder>5</SortOrder>
   </OpportunityCategory>
   <OpportunityComments/>
   <OpportunityDocuments/>
   <OpportunityFields/>
   <OpportunityGroups>Composites,Wrought Materials</OpportunityGroups>
   <OpportunityGuid>be258f8b-aba9-4241-9282-c6385073d8cc</OpportunityGuid>
   <OpportunityID>61</OpportunityID>
   <ProductionDetails>Phenolic Honeycomb Panels with two layers each side, overall thickness 3mm.
   Plate dimensions 2440x1220mm per each plate.</ProductionDetails>
   <ProductionDetailsShow>true</ProductionDetailsShow>
   <Quantity>10 ea</Quantity>
   <QuantityShow>true</QuantityShow>
   <Value>10000.00</Value>
   <ValueShow>1</ValueShow>
 </Opportunity>
▼<Opportunity>
   <CategoryShow>true</CategoryShow>
   <ClosingDate>2021-04-30T00:00:00</ClosingDate>
```


Figure 86 Get All Opportunities API

2.4.2.3.3 Team Formation

Team Formation service framework from SMECluster base platform allows procurers to form Teams with one or more suppliers who have applied for a business opportunity. This will allow a procurer ask further details of the suppliers' capabilities, or if the Opportunity has been awarded then the system can be used to help co-ordinate the project documentation.

Within a Team two functions are available, messaging and document sharing. Messages essentially offers bulletin board type functionality allowing all parties to submit, read and reply to messages within the team. Document sharing on the other hand allows all parties in a team to upload documents so that the team has access to them, therefore acting as a repository for important bid documents.

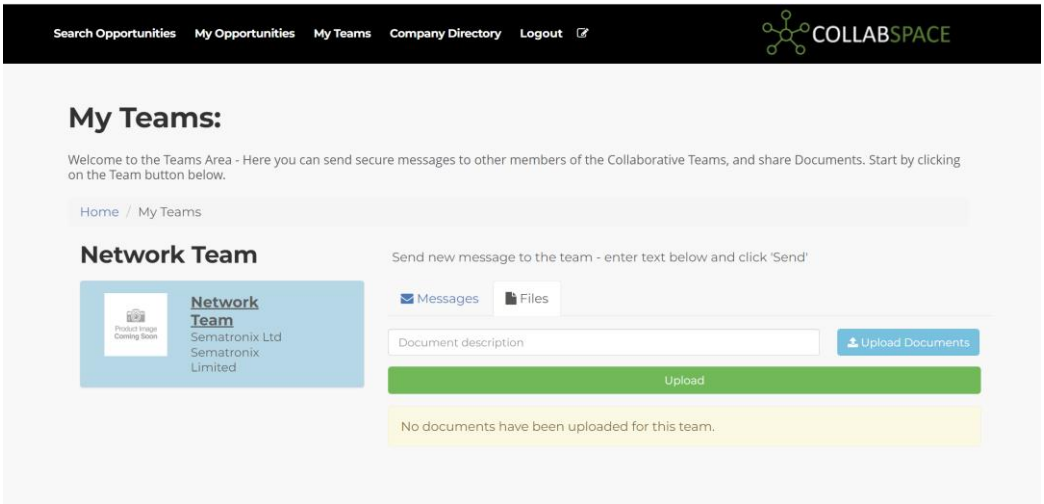


Figure 87 Team Management UI

2.4.3 Market and Industry Intelligence

Finally, for the residual factors that are not covered in internal workings and that of other connected companies through their network, market and industry level intelligence is required. Market and industry specific intelligence features aim to utilise advance data engineering and ML (machine learning) over both curated data and openly available public data streams to provide an insight into the status, condition, and trend of corresponding industry.

The task partner VLC brought such capabilities to the EFPF users via its Network Portal platform. At earlier stage of the project, the team proposed to introduce a standalone application but after evaluation of scope, resource and time, the team has decided to utilise the framework and data Network Portal has, to offer a wide range of features to discover industry specific intelligence, particularly leveraging the insights obtained from the clusters and industry associations that have already been onboard on Network Portal.

Motivation: To leverage both existing platform data and the openly available information on the web about other manufacturing companies and use it to profile them (prospects, competitors, potential customers etc.).

Potential Application: The intended application for the platform users could be to use the relevant services to find potential customers/suppliers that they did not know of and to explore working with them to expand their business. For instance, a user could benefit from getting a demographic summary of the companies in a region via the Advanced Search 'location' filter, network directory explorer, industry specific report, just to name a few.

The features provided in Market and Industry Intelligence is being designed to be completely GDPR (General Data Protection Regulation) compliant and does not collect, store, or use any personal information in any way.

Two SIPOC Diagrams shown below are from initial research stage before M18.

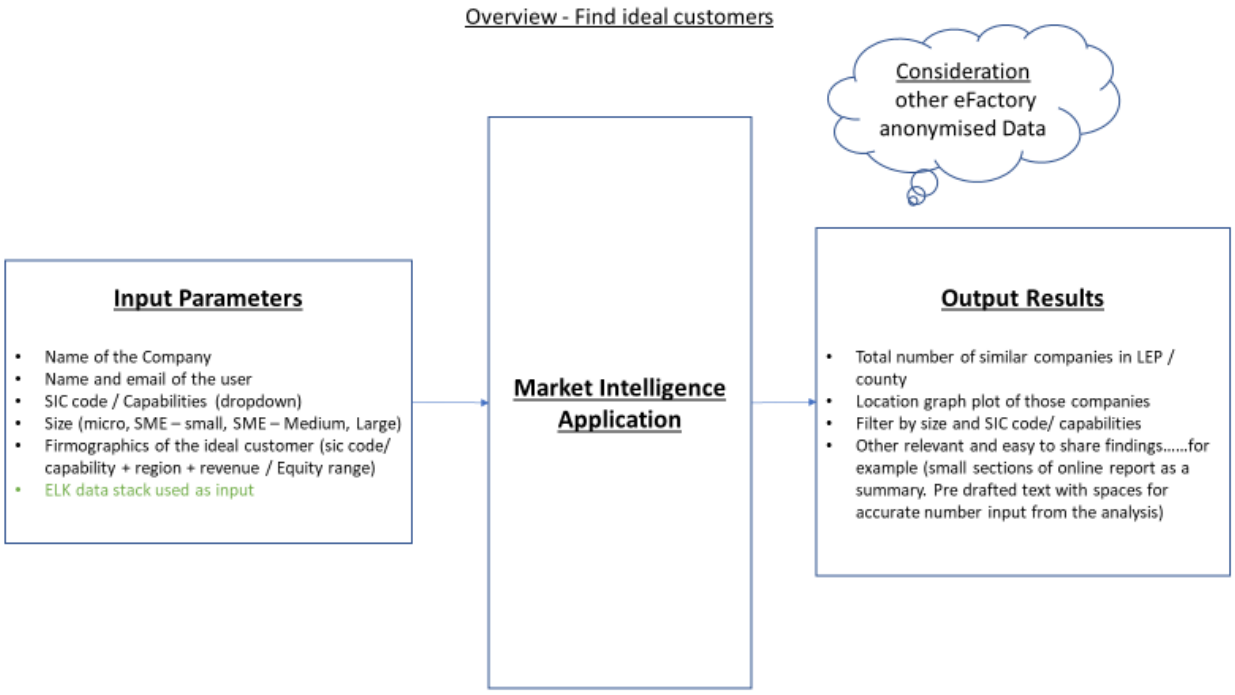


Figure 88 Previous SIPOC diagram – Market/Industry Intelligence (1)

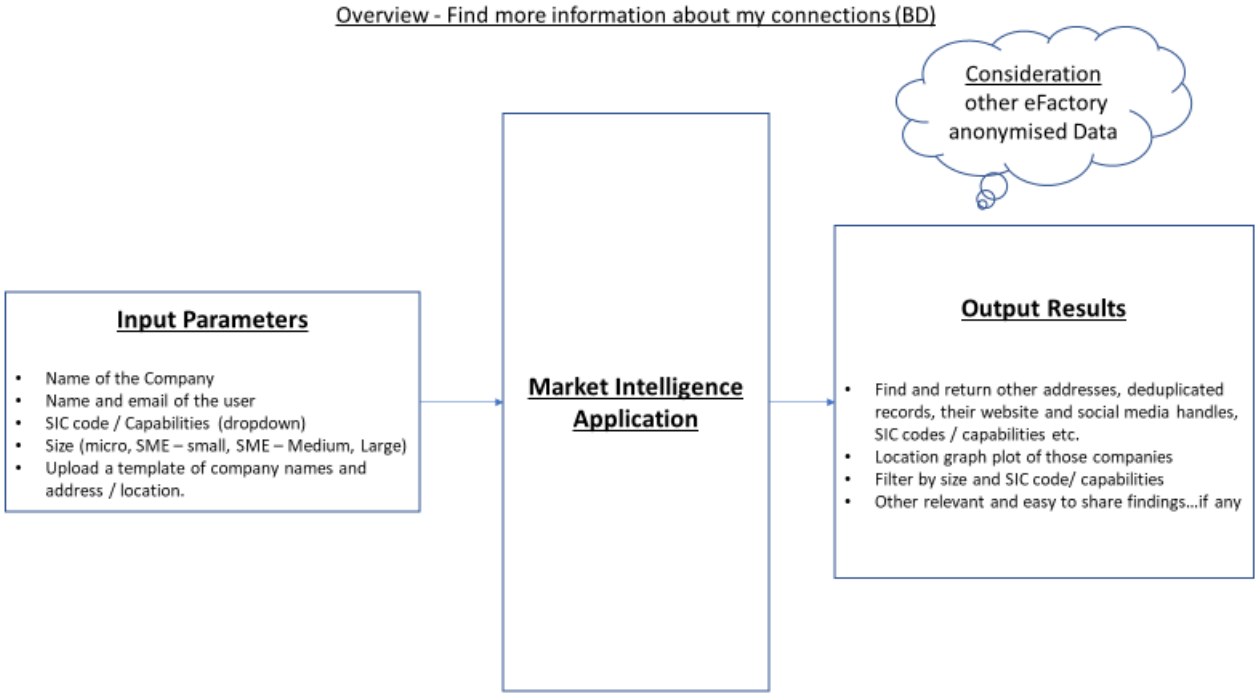


Figure 89 Previous SIPOC diagram – Market/Industry Intelligence (2)

The main idea from these two initial diagrams is to find or present an aggregated data, view or report to the users based on their input – which can be further divided as explicit search inputs or saved/indicated interests. Hence it is better the features embedded in Network Portal to provide such intelligence to users are treated separately. Users can reach Market Intelligence page via a direct link from Business Intelligence value proposition page. Alternatively, users can navigate to Network from Platform area on EFPF portal via SSO, then explore the features allowing them to gather market intelligence based on their search criteria or saved interests.

The main features include:

Industry specific reports – This feature aims to provide samples of comprehensive industry specific analysis and report produced by Valuechain's data science team. This helps users/companies in the corresponding industries to understand the overall status of their market, where the similar companies are distributed, their size, financial status, export status etc. Two examples of these reports are shown below:

Figure 90 shows two free reports a user can view; clicking on the corresponding report tile or thumbnail image will lead user to the detail report, shown in Figure 91 and Figure 92.

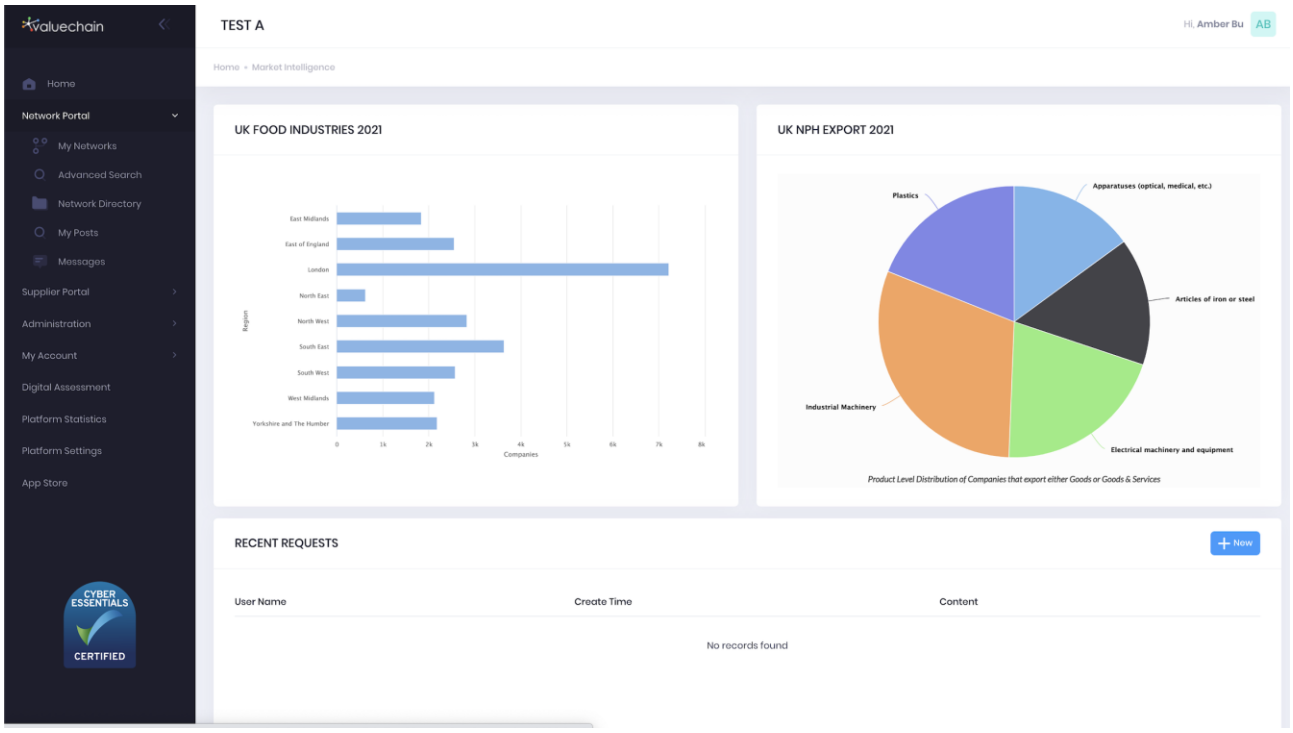
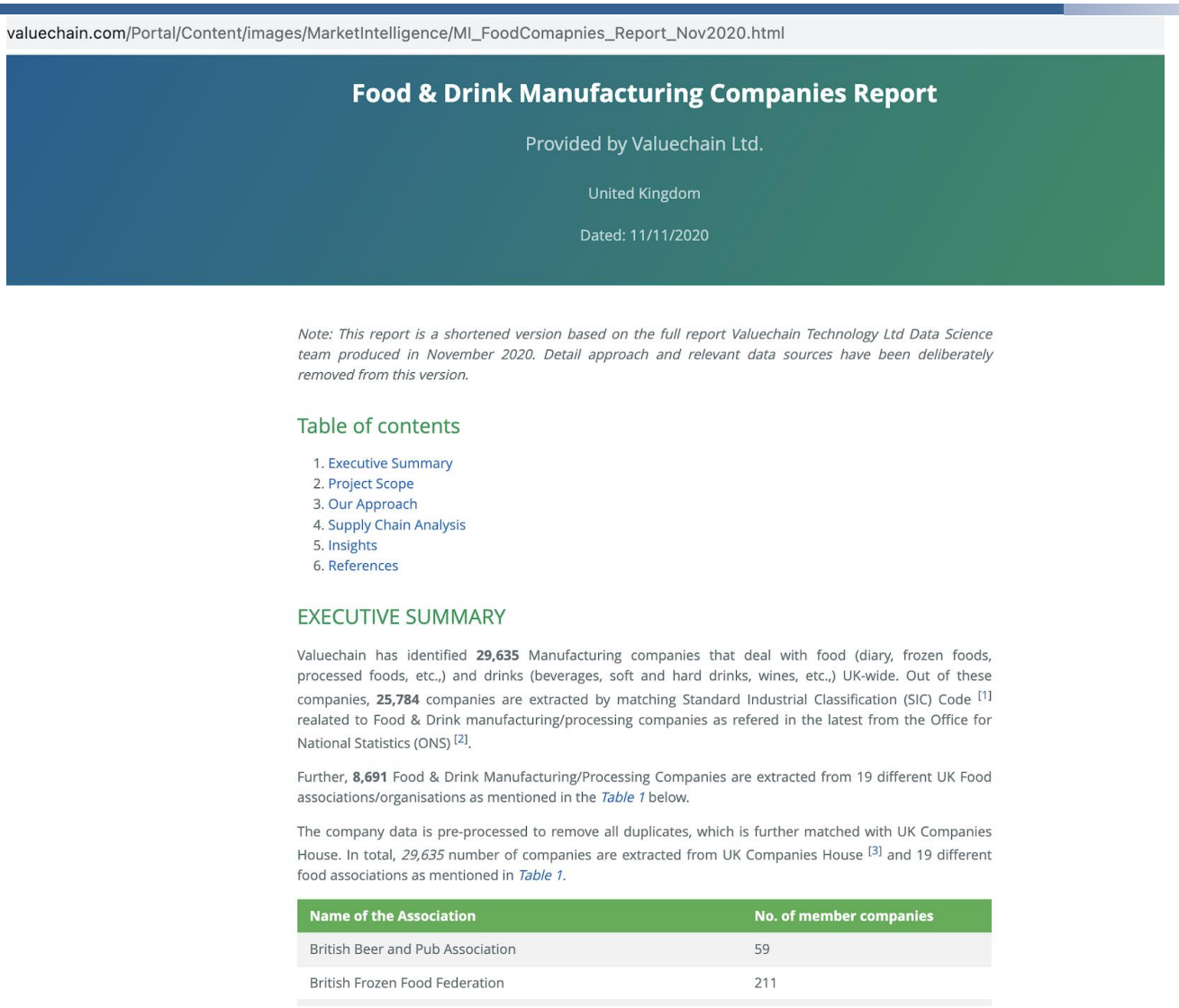


Figure 90 Industry Specific Reports (samples)



valuechain.com/Portal/Content/images/MarketIntelligence/MI_FoodComapnies_Report_Nov2020.html

Food & Drink Manufacturing Companies Report

Provided by Valuechain Ltd.

United Kingdom

Dated: 11/11/2020

Note: This report is a shortened version based on the full report Valuechain Technology Ltd Data Science team produced in November 2020. Detail approach and relevant data sources have been deliberately removed from this version.

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1. Executive Summary
2. Project Scope
3. Our Approach
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EXECUTIVE SUMMARY

Valuechain has identified **29,635** Manufacturing companies that deal with food (diary, frozen foods, processed foods, etc.,) and drinks (beverages, soft and hard drinks, wines, etc.,) UK-wide. Out of these companies, **25,784** companies are extracted by matching Standard Industrial Classification (SIC) Code [1] realated to Food & Drink manufacturing/processing companies as refered in the latest from the Office for National Statistics (ONS) [2].

Further, **8,691** Food & Drink Manufacturing/Processing Companies are extracted from 19 different UK Food associations/organisations as mentioned in the *Table 1* below.

The company data is pre-processed to remove all duplicates, which is further matched with UK Companies House. In total, *29,635* number of companies are extracted from UK Companies House [3] and 19 different food associations as mentioned in *Table 1*.

Name of the Association	No. of member companies
British Beer and Pub Association	59
British Frozen Food Federation	211

Figure 91 Industry Specific Report - example 1

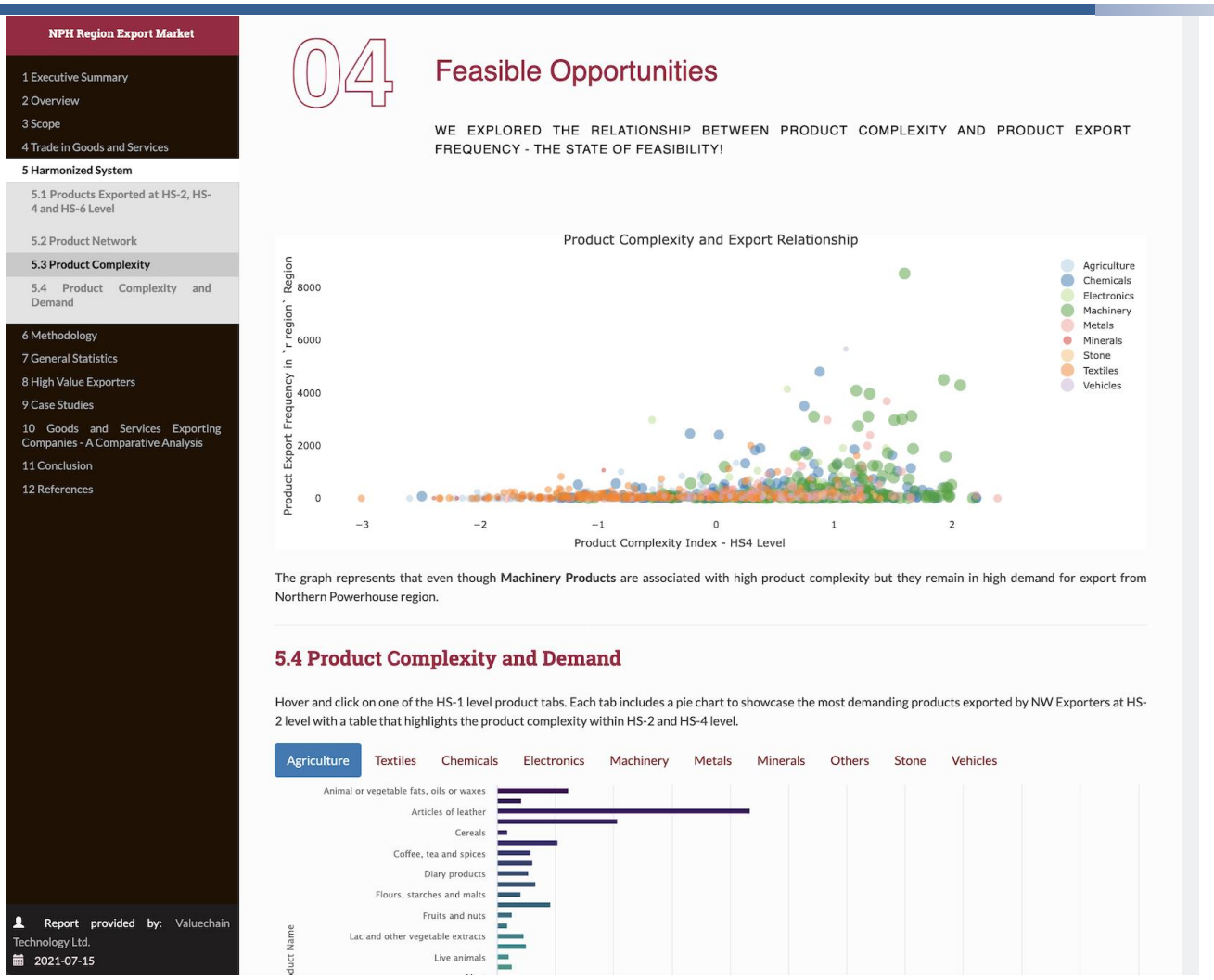

Figure 92 Industry Specific Report - example 2

Request for customised report – Users are given the option to submit a request form to enquire on analysis on specific industry. This complements the needs beyond free reports accessible to all Network Portal users, allowing users to get their industry, sector or region-specific analysis. Figure 93 shows an example the user is enquiring on an additive manufacturing industry specific analysis.

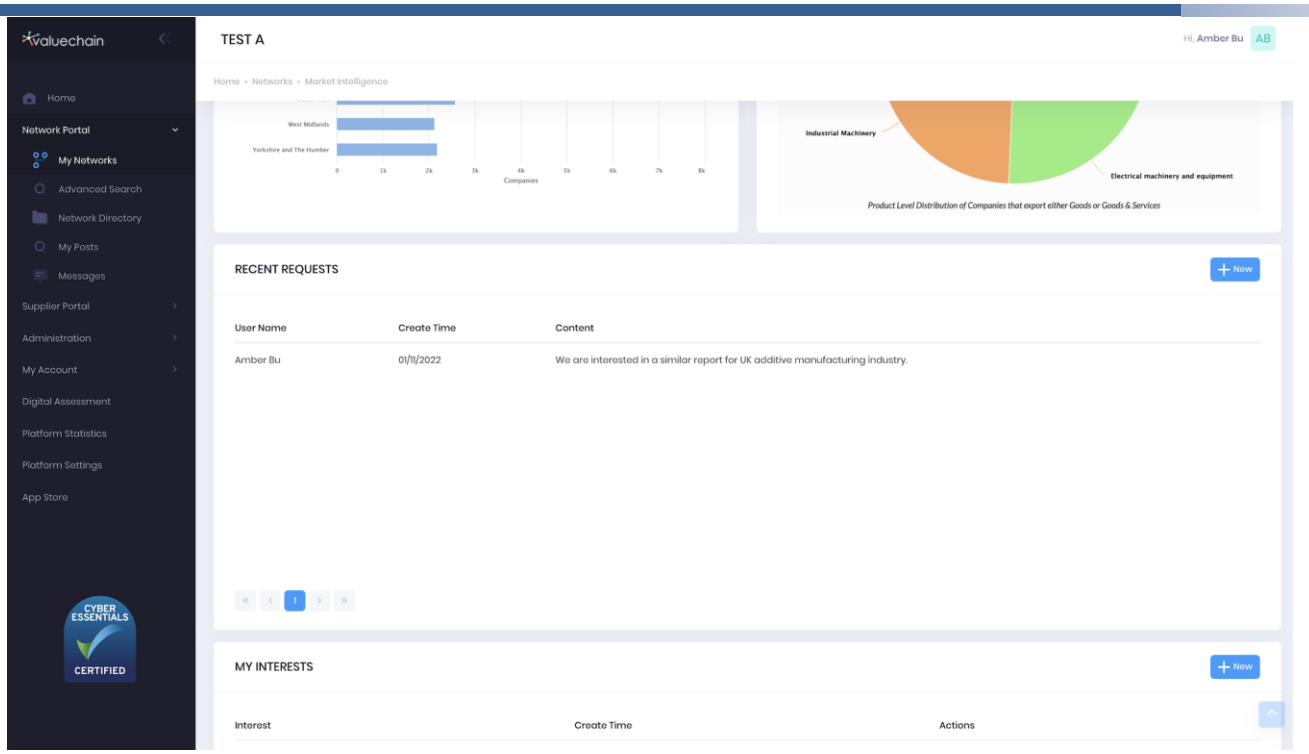

Figure 93 Submit Request for Analysis and Report for Specific Industry

Create or Update Interest(s) – Users are recommended to save their interest(s) so that the system knows explicitly what the user wants and can recommend suitable partners, tenders, and news feeds/articles/posts accordingly. As it is also discussed in matchmaking chapter, recommendation based on user behaviour logs could be another method, but there are challenges which leads to the complexity of implementation and uncertain performance due to missing or insufficient data. The approach Network Portal takes at the moment is to utilise users' explicitly saved interests to provide further intelligence to them. The user's interest can be used for recommending companies with that specified properties in the matchmaking process.

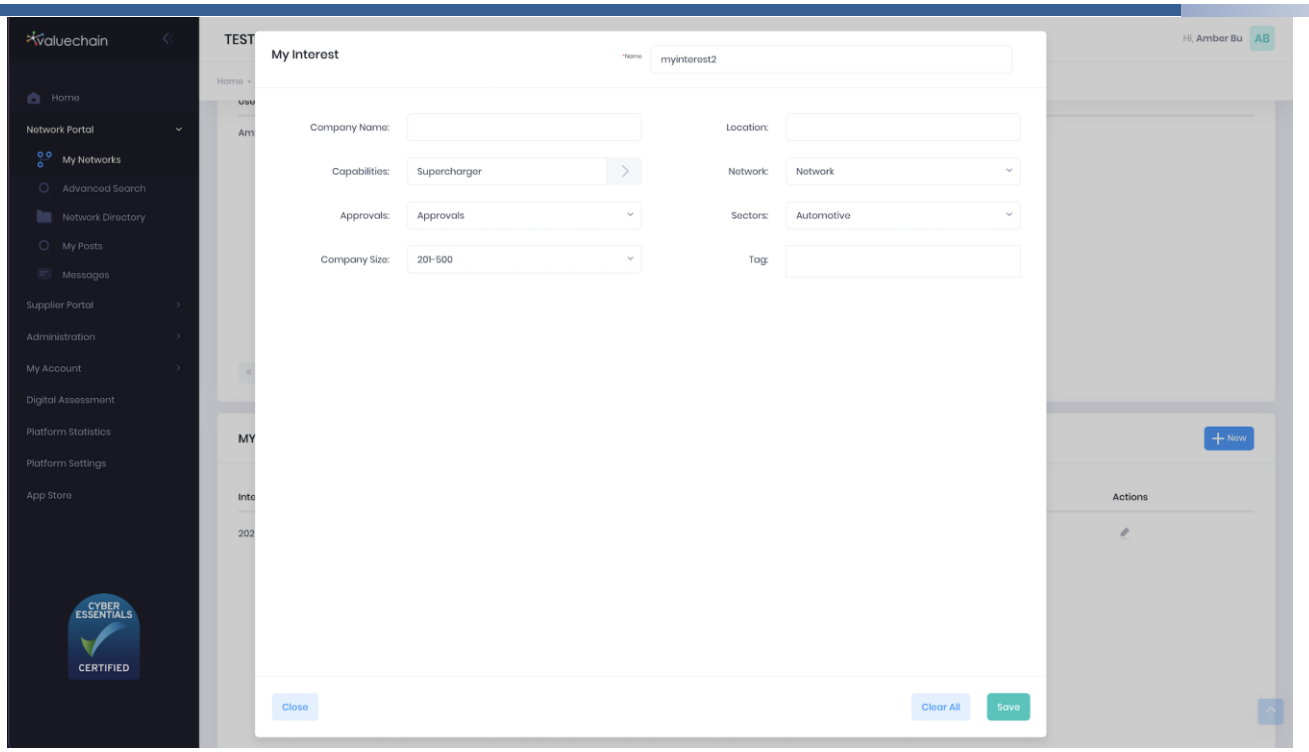

Figure 94 Create or Update an Interest

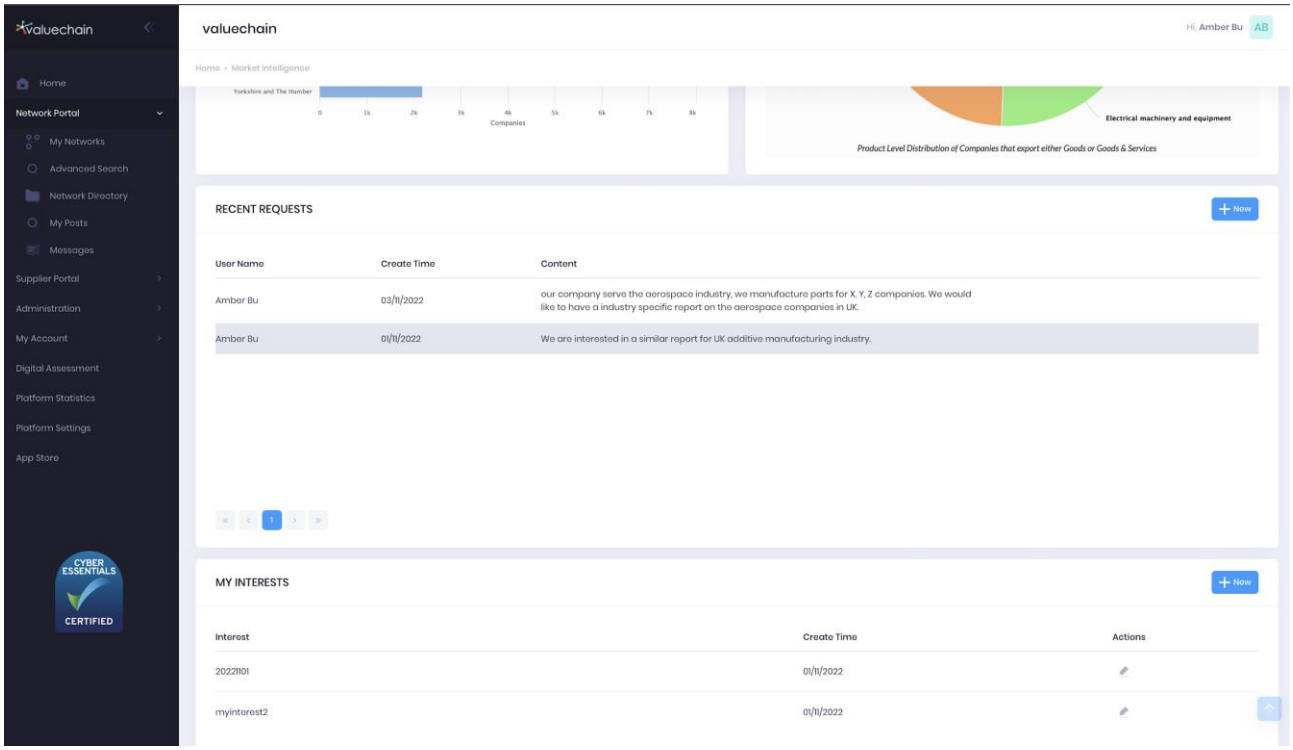

Figure 95 List of User Company's Interests

Matchmaking to get recommended companies – This is added as an explicit feature for users who need it. It is based on user's specified (saved) interests regarding desired capabilities and locations, combined with financial profile and accreditation status to score the potential matching companies. If users did not have any capability preferences (saved

interests) or there are no companies matching their interest(s). The matchmaking page will return 'no matching record found' as shown in Figure 96. If company's interest (companies explicitly indicate what they want, then matching companies/suppliers will be shown, see Figure 97) This matching mechanism will be further extended to support other premium features on network portal, such as tender invitation, opportunity discovery, etc.

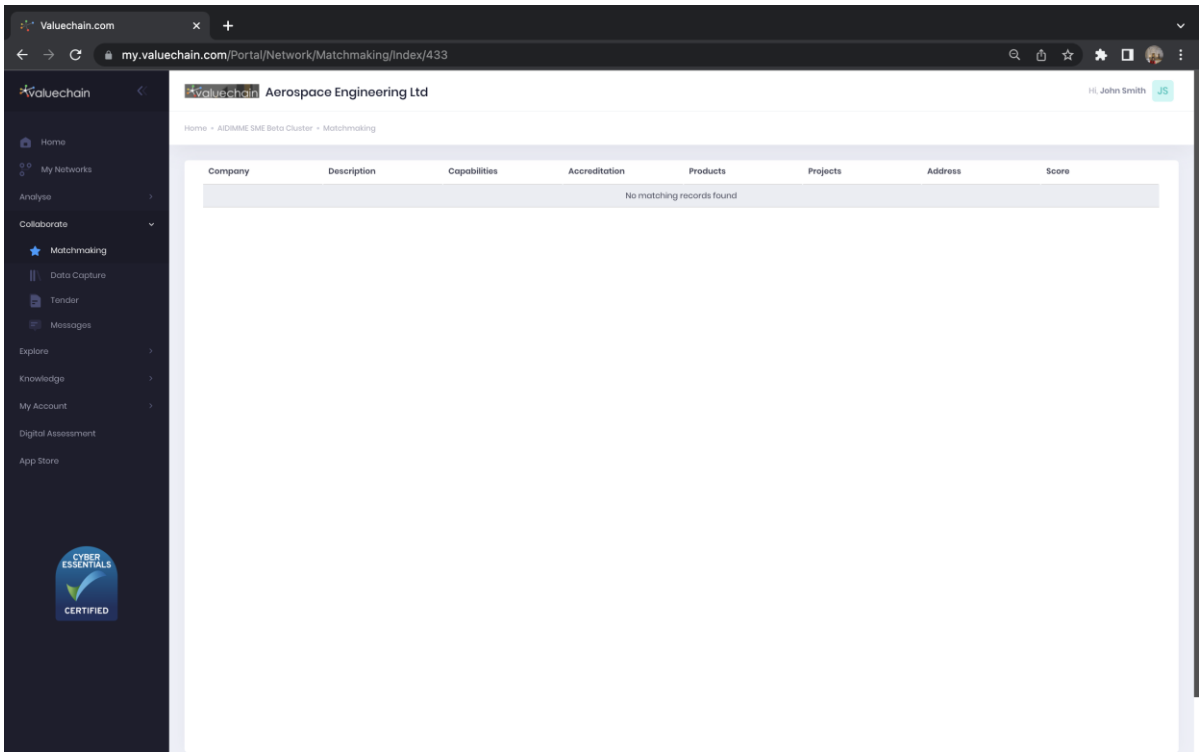

Figure 96 Network Portal Matchmaking (1)

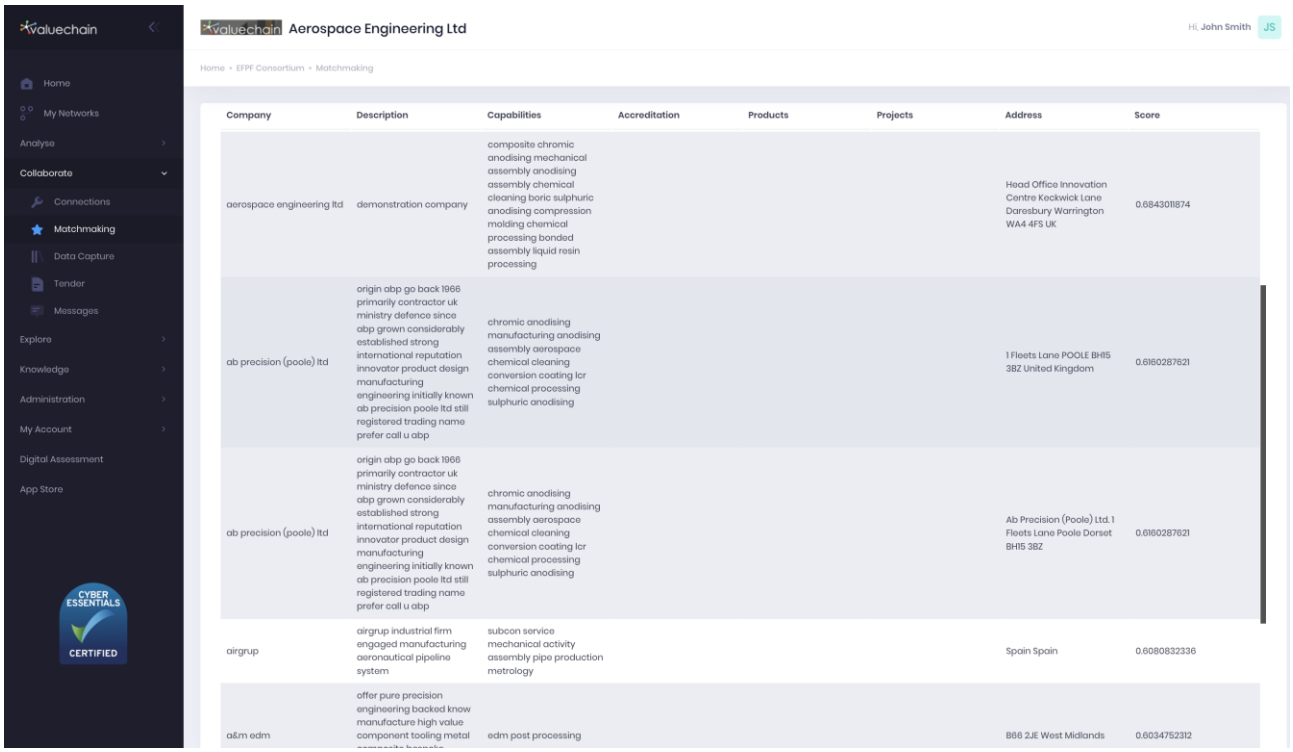

Figure 97 Network Portal Matchmaking (2)

Discover intelligence by advanced search and explore – Network Portal's search and explore haven been further enhanced to allow user to discover companies of their interest, either competitors or potential collaborators. Different search and explore features are provided:

- basic searches allowing user to find network or company, as well as search for products, services, and projects.
- advanced search allowing user to define refined criteria including location, capability, company size, accreditation, etc.
- Search result in map view allowing users to see locations of companies of their interests, understanding competitors/collaborators in their region.
- Explore network from different perspectives – connections, capabilities, company size, tiers, etc.

A few examples showing the range of search functionalities facilitating users discover the information (company/network) are listed below. These features are also explored by pilot partners as detailed in section 2.5.

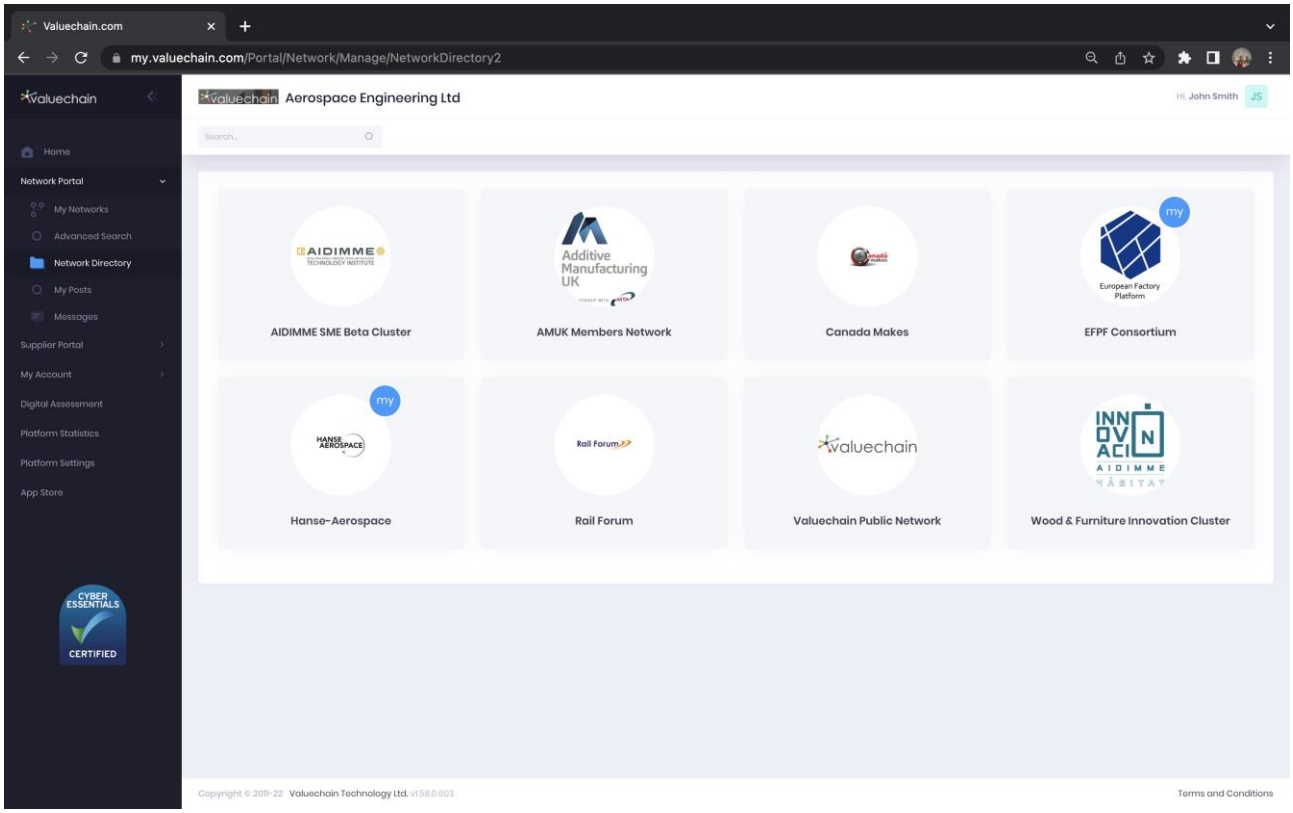

Figure 98 Network Directory View

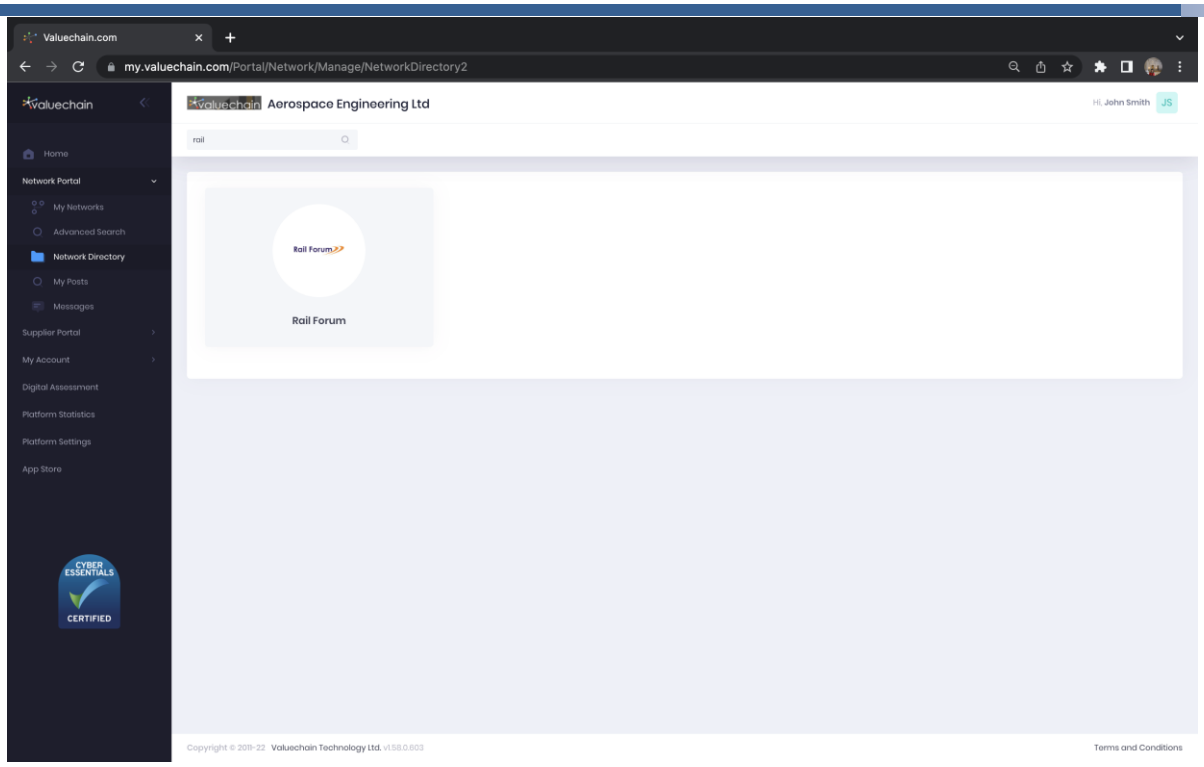

Figure 99 Network Directory - Search for a Specific Network

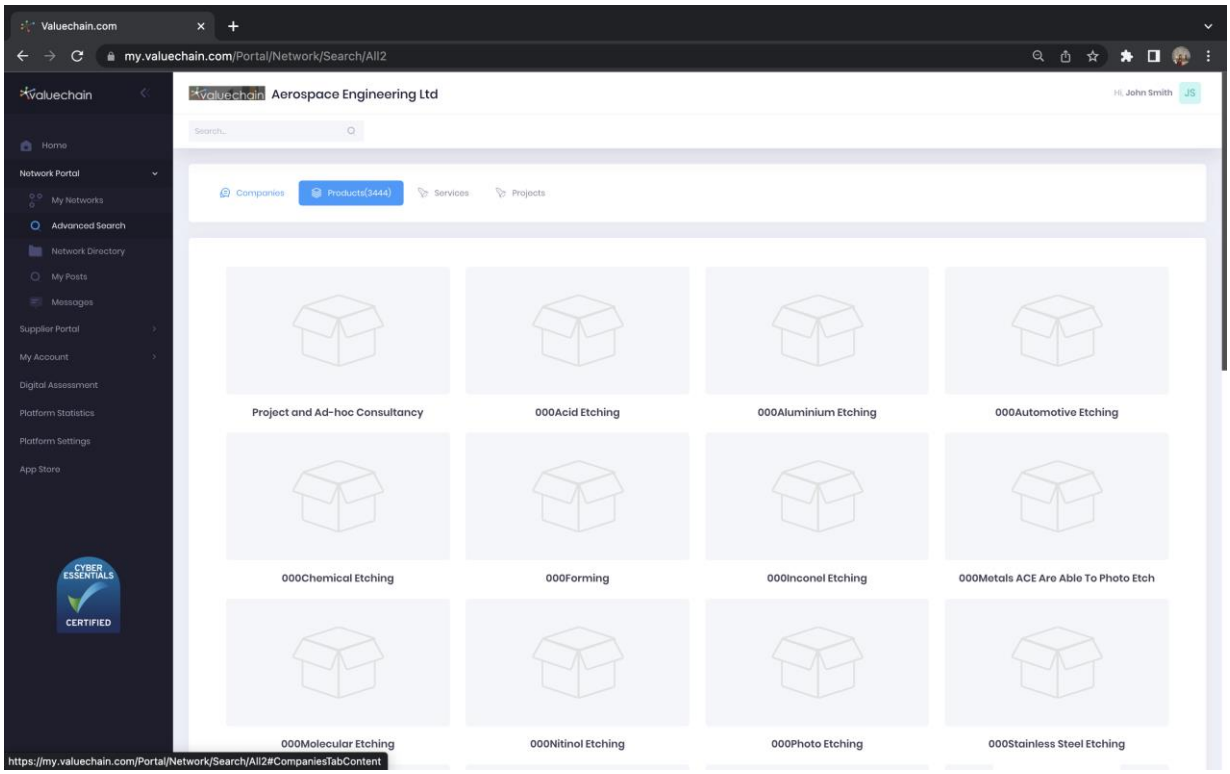

Figure 100 Search for Companies, Products, Services and Projects

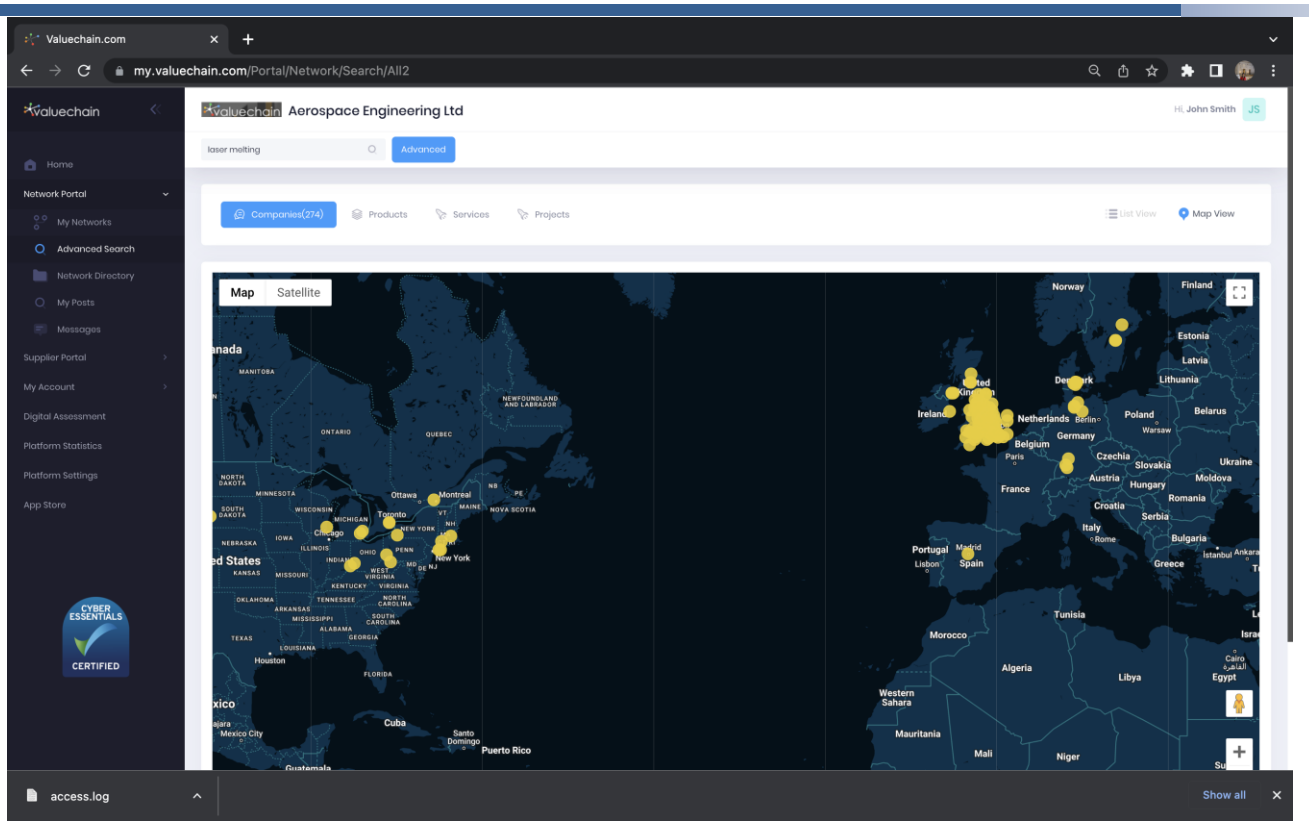

Figure 101 Map View of Companies of Interest

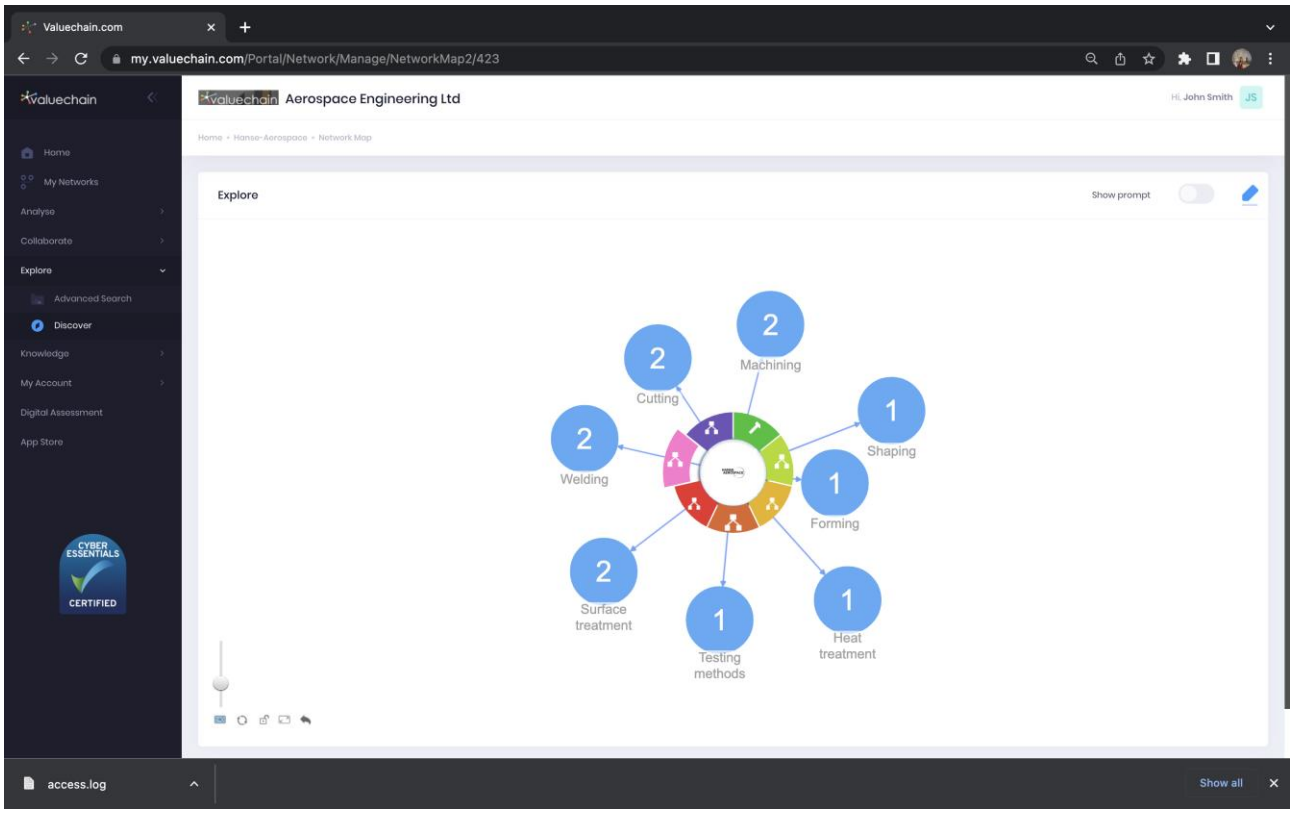

Figure 102 Discover Companies and Connections by Exploring Networks

2.5 Execution and Pilot Case Studies

The task partners have decided that the best way to bring out the benefits of all solutions being offered under business and network intelligence, is to carry out pilots with our pilot partners. This is done with an aim to increase adoption of these tools amongst the consortium. Furthermore, it is believed that this will provide relatable case studies for users joining the platform through open calls and beyond. Therefore, we have engaged two pilots with our partners AIDIMME and HANSE AEROSPACE respectively.

2.5.1 Hanse Aerospace

As the largest independent association of suppliers and service providers in the aerospace industry, Hanse Aerospace connects small and medium-sized companies in Germany and around the world.

Hanse Aerospace currently has over 150 member companies with varied capabilities. It is a complex job to succinctly represent all the capabilities and ensure that each member gets relevant exposure to prospective clients.

Therefore, Hanse Aerospace have adopted Network Portal platform offered through the EFPF and has continued using Network Portal provided feature to address its needs. Screenshots were recently captured from Hanse Aerospace's user case on Network Portal.

Platform to achieve following results:

1. **All Legacy information compiled together**

   Hanse Aerospace have collected information from their membership for a number of years. This information relates to understanding their capabilities, previous projects, current and future customers, etc.

   Traditionally, for any industry association, this information sits in a combination of spreadsheets, emails and other survey tools.

   By adopting Network Portal, Hanse Aerospace are able to onboard as much of that information as they would like. Network Portal then serves as a central repository which is much more powerful as it allows them to not only store all this data together, but also report on it. This is great for both the leader (Hanse Aerospace) as well as the member companies who now have access to curated reports and charts that are useful.

   This also shifts the information flow form a traditional 'one-to-many' approach where the members submit their information but get nothing back in response, to a 'many-to-many' approach where the members can access these reports and chart analysis from the data that they have contributed to over the years. A snapshot of Hanse Aerospace's network dashboard is presented in Figure 103 and Figure 104. Noted in the Network Posts section it is blank at the moment because there are no recent posts from member companies in this network.

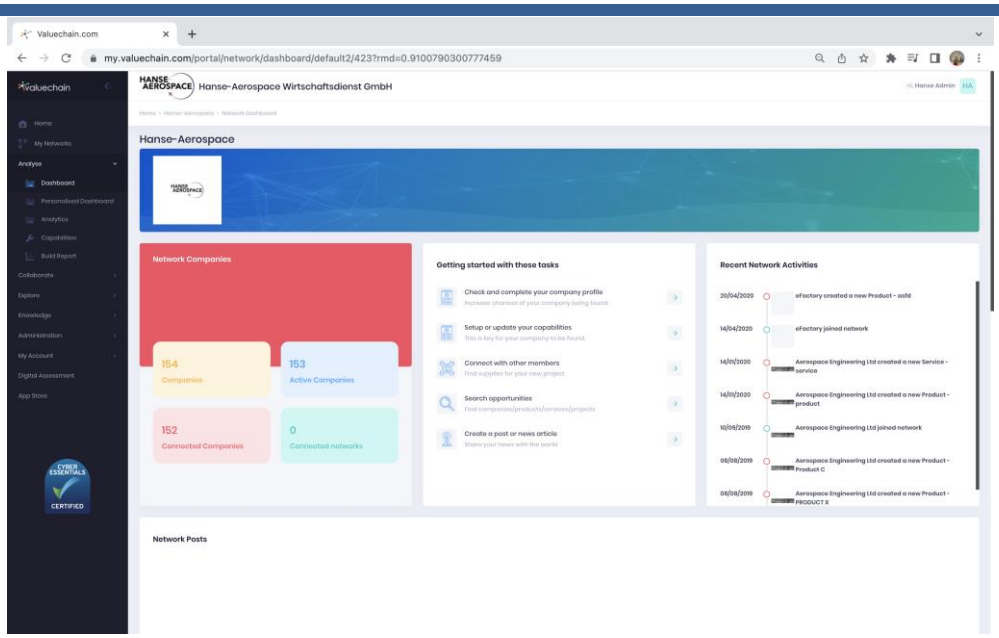

Figure 103 Hanse Aerospace network dashboard

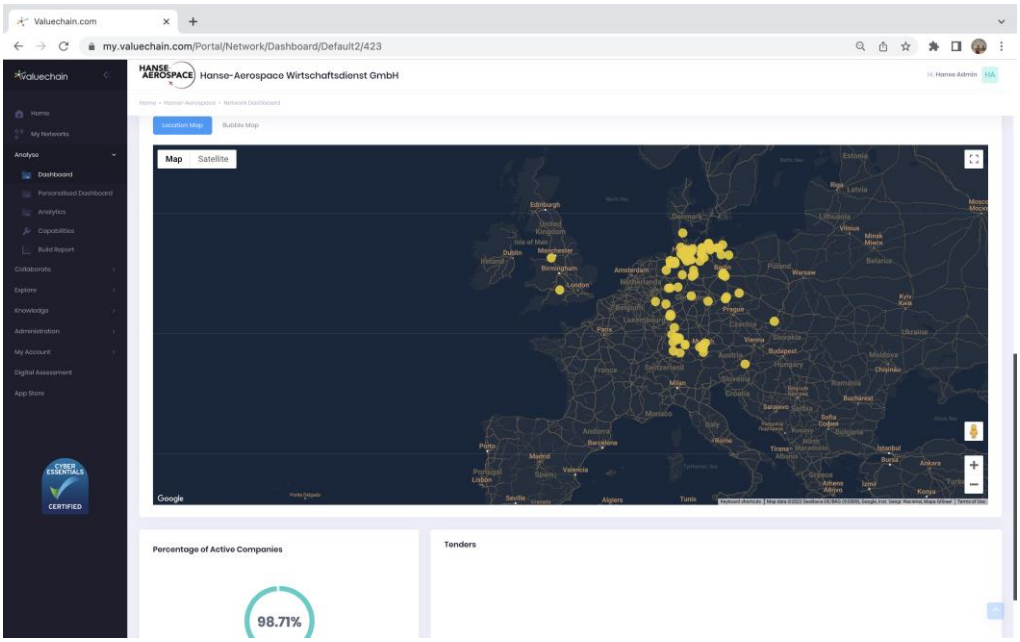

Figure 104 Hanse Aerospace network dashboard (2)

2. Gathering open-source information

Getting information from the companies through lengthy forms and email chains is cumbersome. Hanse Aerospace are using Network Portal platform's intelligence gathering services to scrape openly available information about their member on web. This gets fed back into Hanse Aerospace's network and enhances the decision-making data available at their disposal.

Sometimes, it also brings out a more complete picture of their members as some companies only supply 'Aerospace related' information to them as they are an aerospace association. However, it is useful to understand the breadth of capabilities

of a member company so that they can be linked to relevant opportunities beyond the Aerospace sector. ‘Advanced Search’ along with refined search allowing users to save their interests in Network Portal are shown in Figure 105 and Figure 106.

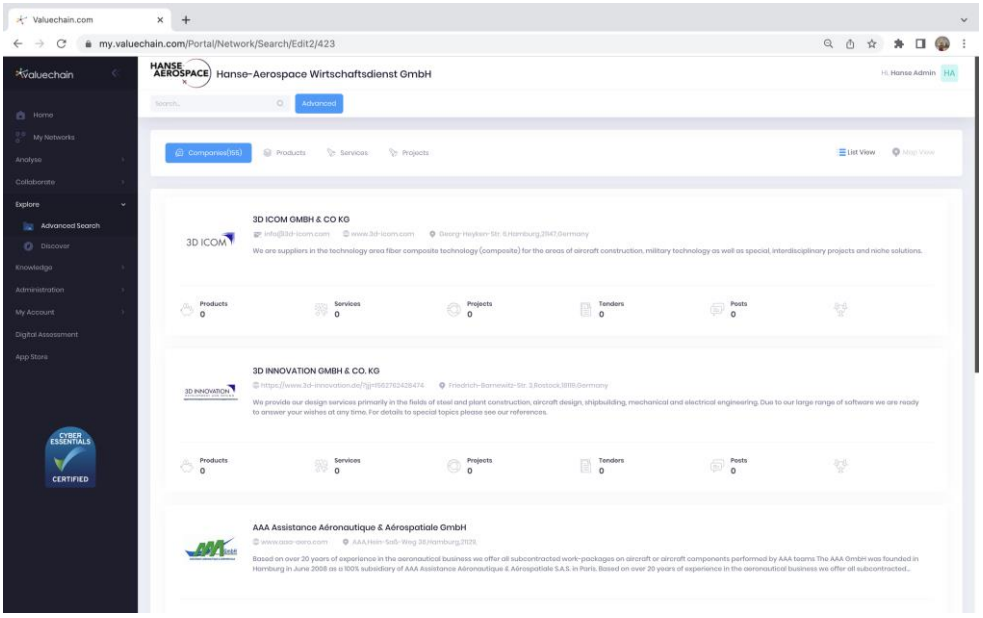

Figure 105 Advanced Search screen in Hanse Aerospace pilot network

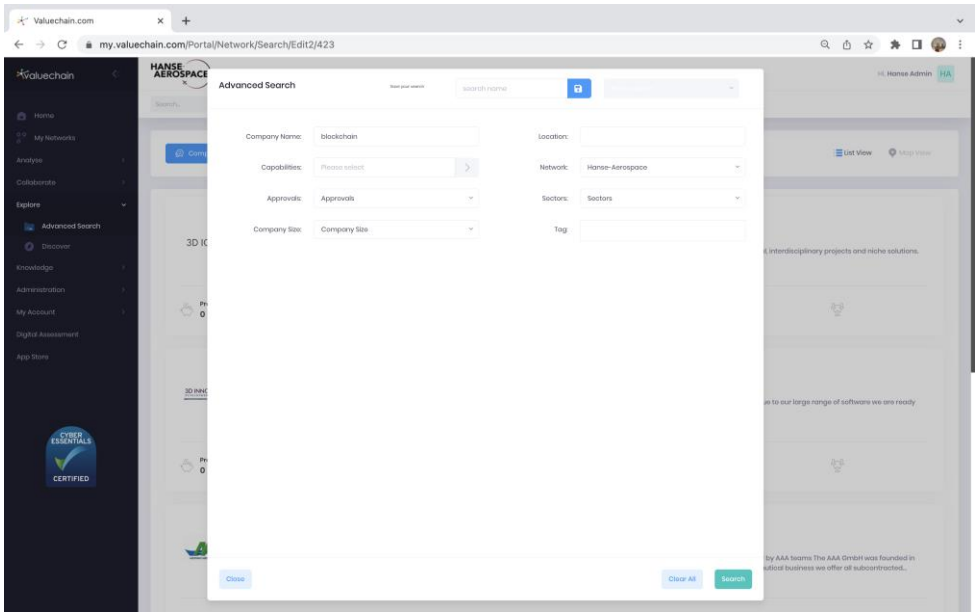

Figure 106 Advanced Search and Save Interest

3. Website Integration

While this is a great way to build up intelligence about your network, it is important to understand that this is available only to active members who log in using their license credentials. For Hanse Aerospace, a lot of the prospective customers and collaborators will be new (so there is no way to know of them in advance and cannot be given access to portal ahead of time); they will be visiting the website (in search of contact details and member listings); they will have a few starting questions/preferences (for example, ‘the company should have capabilities in

manufacturing Titanium parts' or they must have been 'certified by an OEM such as Boeing' already). A lot of this information is already collected, curated and analysed by Hanse Aerospace already on Network Portal platform.

Therefore, they decided to use 2 step integration process of their network's 'Explore Map' on to their website. This allowed their traffic to not only view member companies but also gave them the freedom to drill down into the network by capabilities, accreditations, technologies etc. (essentially all the prerequisites that their prospective clients or collaborators will be looking for) and find member companies of interest.

Individual members have and maintain their own profiles, so they have the freedom to upload and update as much relevant information as they would like to share. Hanse Aerospace believe that this has helped them extract important information out of this tool and make it available to outside the platform to key stakeholders through their website iframe integration. A screenshot of Hanse Aerospace's website with embedded Network Portal map is shown in Figure 107. The same page can be accessed through this link - https://www.hanse-aerospace.net/de/ueber-uns/mitglieder.

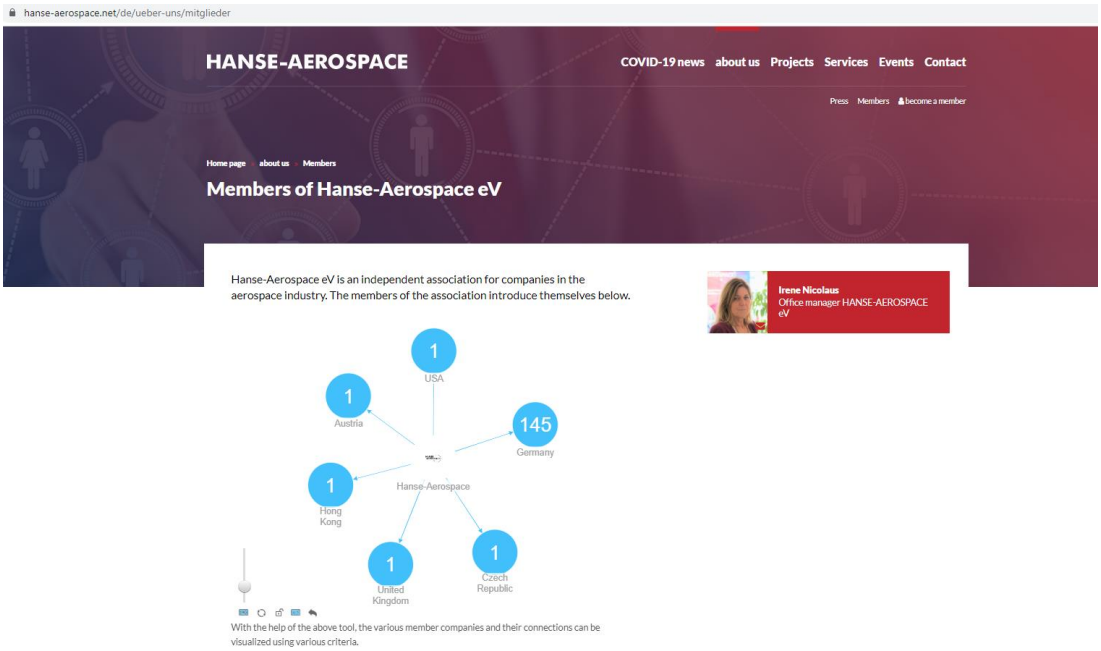

Figure 107 Network Portal Explore Map integrated into Hanse Aerospace's public website

4. Ongoing Activities and Next Steps

While this has already delivered great benefits for Hanse Aerospace with respect to collection, modelling and dissemination of intelligence, there are concrete next steps that have been planned to enhance the current status.

This includes using the already generated momentum to encourage all of the members to use this service and maintain their up-to-date profile. This will enable them to appear higher up when searched and also allow them to have a strict quality control over information about their work.

Once most members are online and connected through the platform, Hanse Aerospace will be able to conduct technology audits, surveys, and questionnaires all through the Network Portal platform. This will save up the added cost of using a third-party tool, extracting the results, and analysing them separately before embedding them into a static PowerPoint. Instead, this will allow Hanse Aerospace to build scored surveys that will populate the dynamic charts as the companies fill in their answers in real time.

A couple of steps further into the future are using:

- Tender functionality to release RFQs (Request for quotation) to the member population and receive their responses through this platform.
- Enabling cluster to cluster connectivity which will link Hanse Aerospace membership directly to other associations across Europe who adopt the EFPF platform.

2.5.2 AIDIMME

AIDIMME has continued working in their pilot case addressing a specific Innovation cluster called **AEI** (*Agrupación Empresarial Innovadora* – Innovative Business Association) aiming to improve the competitiveness of small and medium-sized enterprises in the Wood & Furniture domain with the Network Portal platform.

Industrial cluster scope: Wood & Furniture Innovation Cluster in the Valencian region (Spain).

Description of the cluster [2]: Around **260 private firms** in the Valencia region operating in the manufacturing of wood-derived products (wood-boards, flooring, facing, etc.), home and contract furniture (living room, bedroom, bathroom, kitchen, office, retail, etc.), services (installations, refurbishment, etc.) and related ancillary industries (components, fittings, coatings, etc.)

[2] https://clusters.ipyme.org/es-es/PoliticaClusters/Informacion/Paginas/QueEsCluster.aspx

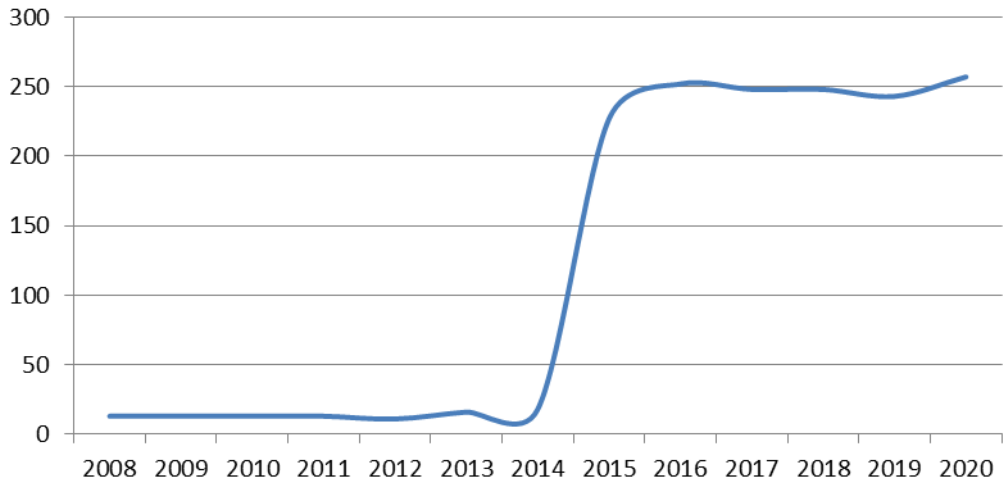

Figure 108 Evolution of Wood & Furniture Innovation Cluster

The manufacturing of furniture goods, wood, cork, metal, and wholesaling are the main activities of the Wood & Furniture innovation cluster.

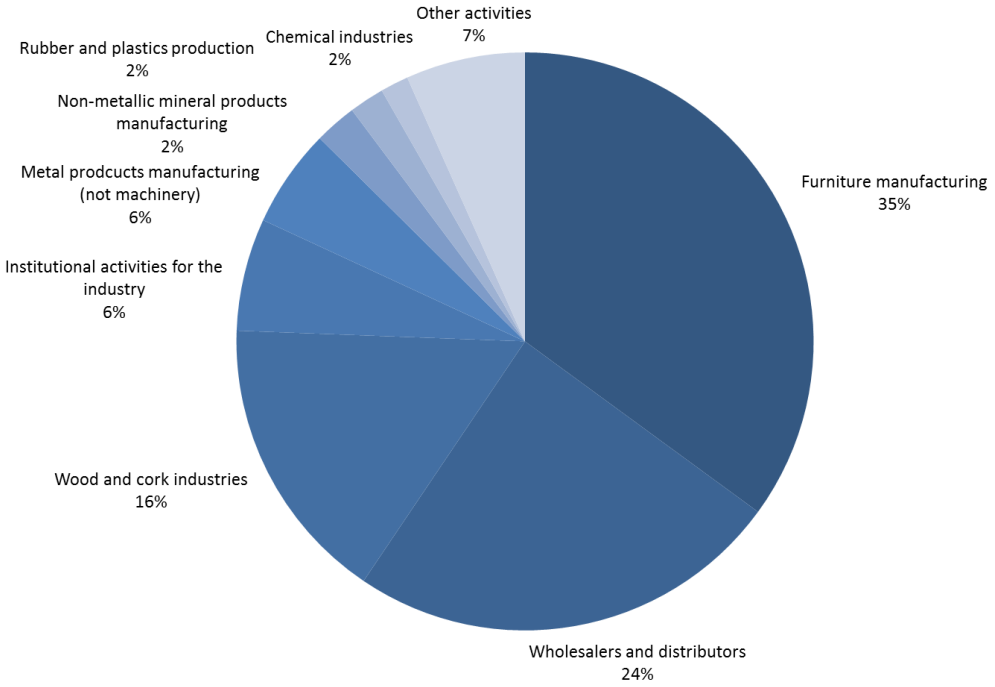

Figure 109 Main Industrial activities in the cluster

The bulk of the companies within the innovation cluster are SMEs, what has a direct effect on the distribution of income in the cluster: a few large companies represent an important part of the market, with a Gini index of around 0,6.

Objective: Create an analytic tool for specific data collection and treatment on innovation issues related to the wood & furniture industrial cluster in the Valencian Community.

Value proposal for firms (potential users) in EFPF:

1. Monitor the activity of the wood & furniture innovation network in Valencian region (number of companies, main projects, localisation, etc.).
2. Access to exclusive cluster firms' data on R+D and innovation issues.
3. Identify and contact potential partners in the wood & furniture industry cluster for B2B exchanges (purchase, sell, collaborate, etc.).
4. Identify focal players in the industry for key innovation variables (e.g., which is the company leading or taking part in most of innovation projects in the industry?).
5. Compare the firm's position in relation to the rest of the industry (e.g., how important is my company in the industry in terms of number of innovation projects?).
6. All these points through a friendly intuitive front-end with visual information (no complex log in process or interaction within the platform) would be great for the industrial companies.

Among the variables that impact the productivity in the wood and furniture sector, the decrease in the offering of industrial processes from the auxiliary industry is one of the most important ones. Indeed, the availability of these processes allows companies to develop its production activities and to potentiate the added values of its products, increasing competitiveness over traditional processes that need innovation. The enterprise and industrial environment is actually moving towards a service paradigm, where the industrial processes increase its value as far as they are integrated in an exchange framework between companies (Akaka, 2021).

The technological transformation offers digital opportunities to develop a competitiveness strategy based on the reconstruction of the auxiliary industry in the wood and furniture industry that retrieves traditional processes and updates them through an innovative approach. This transformation gains higher strategic potential as far as the industrial sectors operate in valuable collaborative ecosystems B2C (Vargo, 2017) and B2B (Pathak, 2022).

Functionalities

1. **Cluster management**: basic company data as turnover, employees, location, participation in b2bmarketplace, and description of activity and CNAE (National Classification of Economic Activities) code.
2. **Data collection (three domains):**
   I. **Innovation activity with AIDIMME** (e.g., number of R&D and innovation projects, euros spent, variety per department, funding programmes, associates to AIDIMME, participants in other industrial groups – Market Observatory, for example) → This data is introduced in Network Portal by AIDIMME and could be translated into standard indicators so confidential firm's data is not published (for example, a scale for measuring level of innovation from 0 to 10).
   II. **Innovation management in firms** (e.g., co-creation practices, 5 top innovative suppliers, 5 top innovative clients, number of employees dedicated to R&D+i, annual budget, external collaborators, etc.) → This data is gathered from companies.
   III. **Emerging innovation issues** (e.g., measuring interest in Circular Economy, industrial symbiosis, Industry 4.0, Big Data, Artificial Intelligence, Machine

Learning, Internet of Things, Business Intelligence, etc.). → This data is gathered from companies.

3. **Analytics & Reporting:** create accessible charts information for companies.
4. **Cluster mapping:** Network Portal should represent the following conceptual cluster maps:
   I. **Innovation supply chain** in the cluster (B2B flows within the cluster: represent upstream (providers) and downstream (clients) connections between firms at a cluster level.
   II. **Focal companies** that are in contact with most of suppliers or clients, so they act as focal innovators in the industry.
   III. **Value networks** created around main companies that pull the **ancillary industry** for wood & furniture in Valencian region.

The digitalisation and the collaborative platforms are key factors to maximise the efficiency when building the value chain (Sales-Vivó, 2021). It takes much time to locate specific suppliers meeting the required norms, apart from the regular ones that meet specific properties. Besides this, not only search and find but collaborate becomes crucial, as well as the reliability of the information available. Considering that the wood and furniture sector is covered mainly by SMEs, and it is a fragmented sector, the collaboration to facilitate the industrial symbiosis even reaching companies from different sectors becomes crucial. This leads to the necessity of a platform with a large range to build a network (Kohtamäki, 2016) of B2B exchanges of auxiliary industries of proximity in the sector, with all the functionalities needed for the enterprises, and providing proper communication channels between parties to optimise the processes. Moreover, the industrial symbiosis during the entire value chain needs to be promoted, so also resources (e.g., facilities, technology, etc., including wastes and generated subproducts) from some companies could be used by others in its corresponding supply chain. In this regard, the Network Portal provides capabilities to face the actual difficulty to find materials and to optimize the supplies by finding close resources instead of distant ones, increasing the reliability.

Testing and feedback provided to technical development team

It was detected that some company names appeared duplicated in search results from the EFPF portal. This occurred because some companies were registered on more than one platform in EFPF. So users could not distinguish between these companies, labels indicating the name of platform to which the company is registered were added in the EFPF Companies/Partners tab. Despite this, some companies showed the label “undefined”. This minor bug was quickly solved.

EFPF Nimble instance:

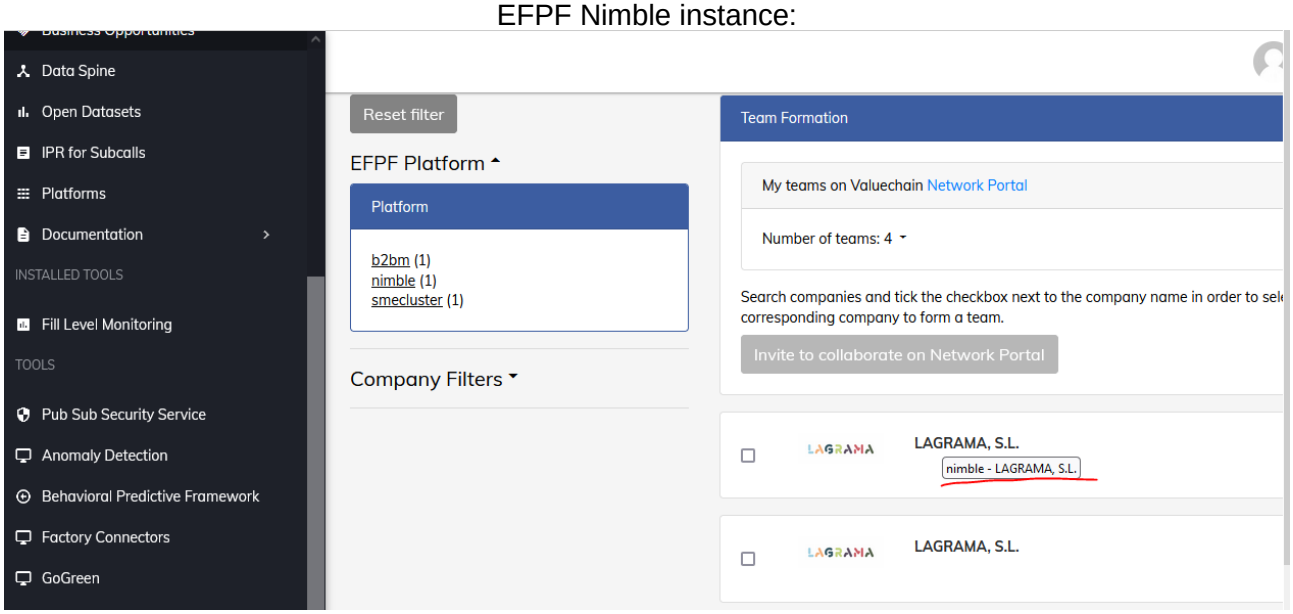

Figure 110 Federated Search - Company from Nimble

B2BMarket Nimble instance:

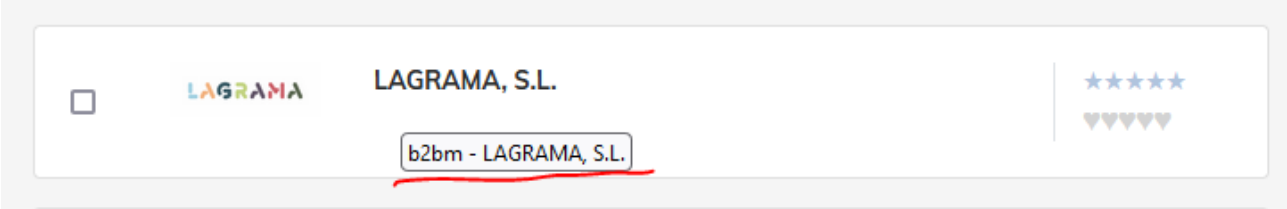

Figure 111 Federated Search - Company from B2BMarket

AIDIMME has progressively tested the improvements implemented in the EFPF platform, while creating the network for the collaborative Network Portal through invitations. In this regard, the email notifications generated when the companies are registered in the cluster was personalised. The information displayed in the invitation can be modified by the company owner of the cluster.

A web page was generated to show the list of registered users. In the next figures, two clusters can be inspected.

The AIDIMME SME Beta Cluster

The users can choose and inspect the profile of a company selecting between different attributes such as Activity Type, Company Type, Relationship, Cluster, etc.

Figure 112 AIDIMME SME Beta Cluster on Valuechain's Network Portal

The Wood & Furniture Innovation Cluster
The users can select: Companies, Activity, Nace Code, Firm Size, B2BMarketplace, Indicators, Province, Capabilities.

Figure 113 Wood & Furniture Innovation Cluster on Valuechain's Network Portal

After selecting a category, the different sub-categories as well as options are prompted as a diagram.

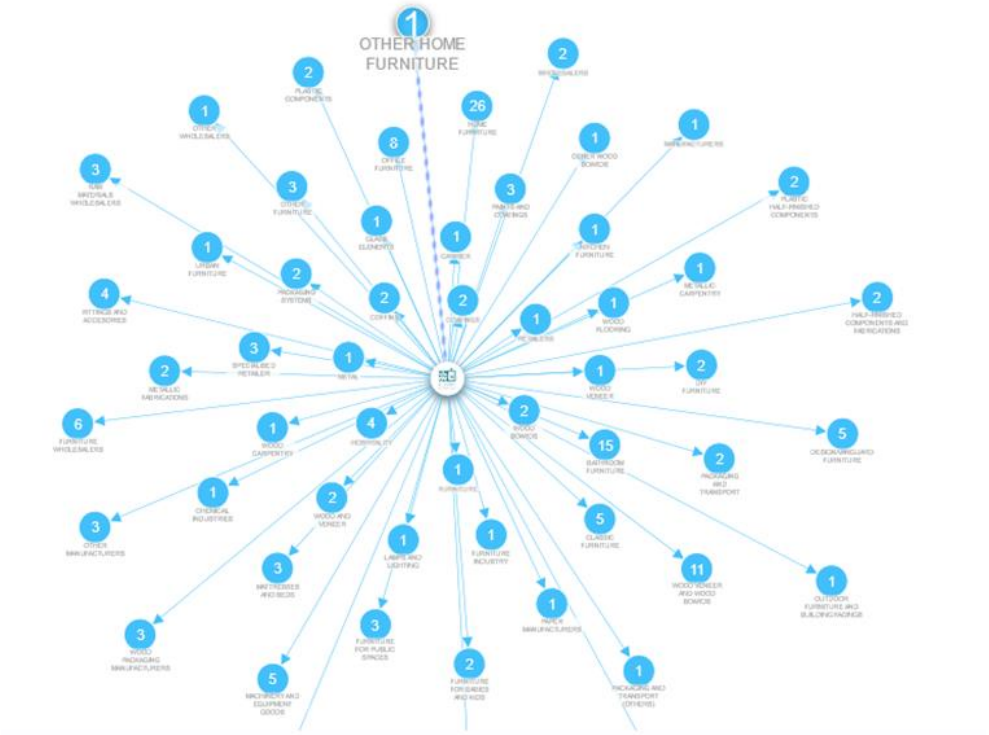

Figure 114 Custer Exploration on Valuechain's Network Portal

The following are some examples:

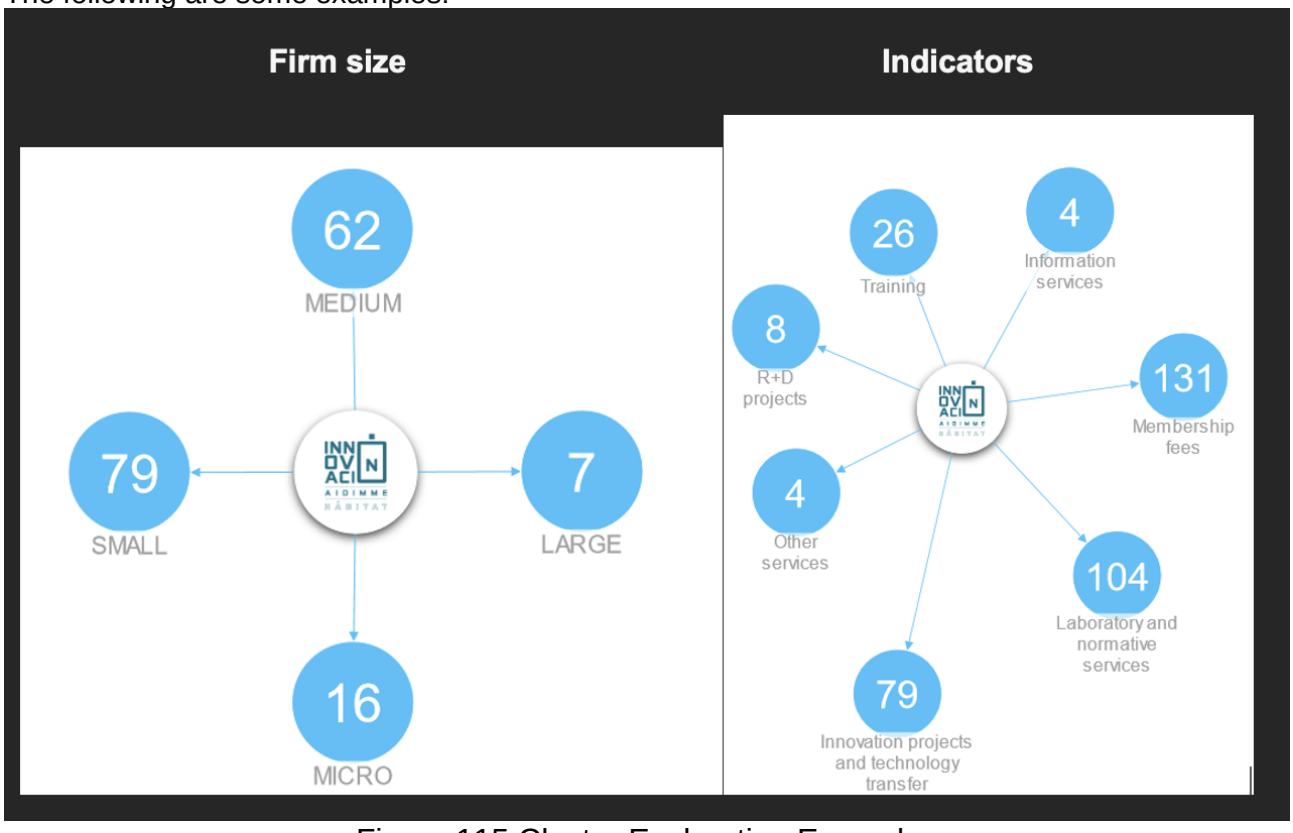

Figure 115 Cluster Exploration Examples

- Minor bugs were fixed.
- After exploring the guides for creating questionnaires and following the instructions step by step several bugs were spotted.

- Some image file uploads and display of images.
- The data capture uploading file was fixed by the dev team.
- Some backend problems.
- Frontend bugs like redirecting to an empty page. We did some comments on the usability and logic of the frontend that can be improved.

Data Capture Usage.

A new data capture is added to the cluster to communicate and get feedback from the companies that are using the platform. These companies can be interested in topics that other companies are looking for, so new collaborations can arise. The tool makes the creation of a team faster and more agile. In this case, AIDIMME is interested in knowing which innovation areas the wood and furniture companies are interested in. The name of this questionnaire is "Knowledge Areas".

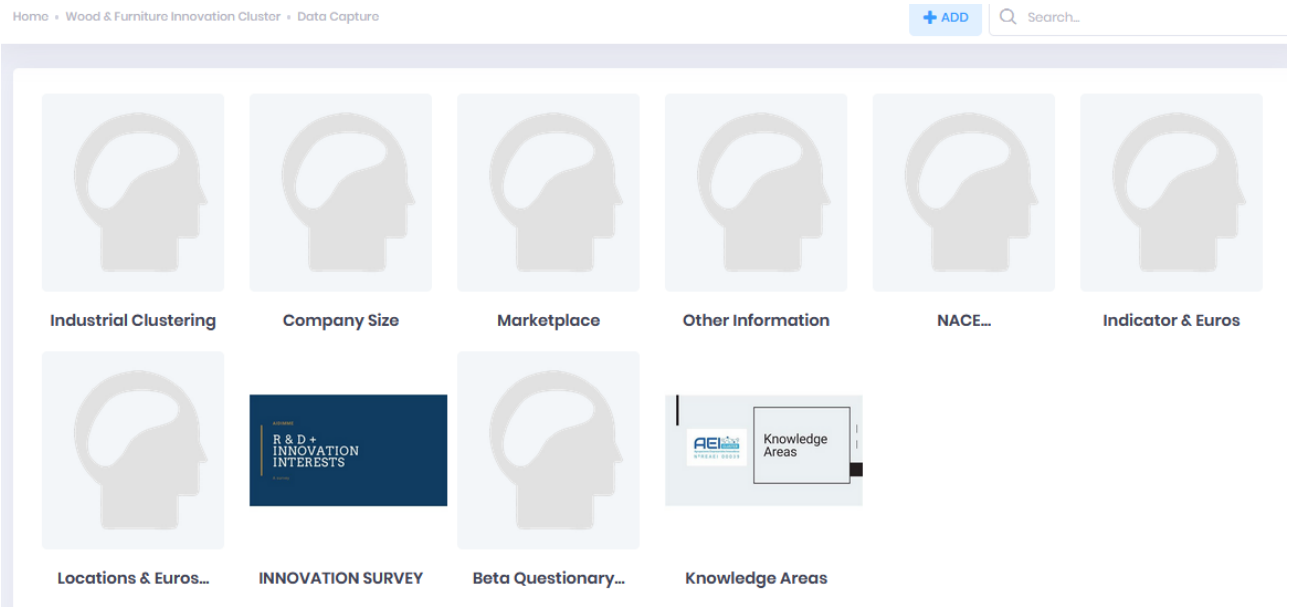

Figure 116 AIDIMME's Data Capture on Valuechain's Network Portal

Link to the questionnaire
https://my.valuechain.com/Portal/Network/Field/Settings2/11037?dstype=1&dssubtype=0&cutmkey=450&folder=0&source=iqluster_edit_dataset&rdm=0.0690086040477027

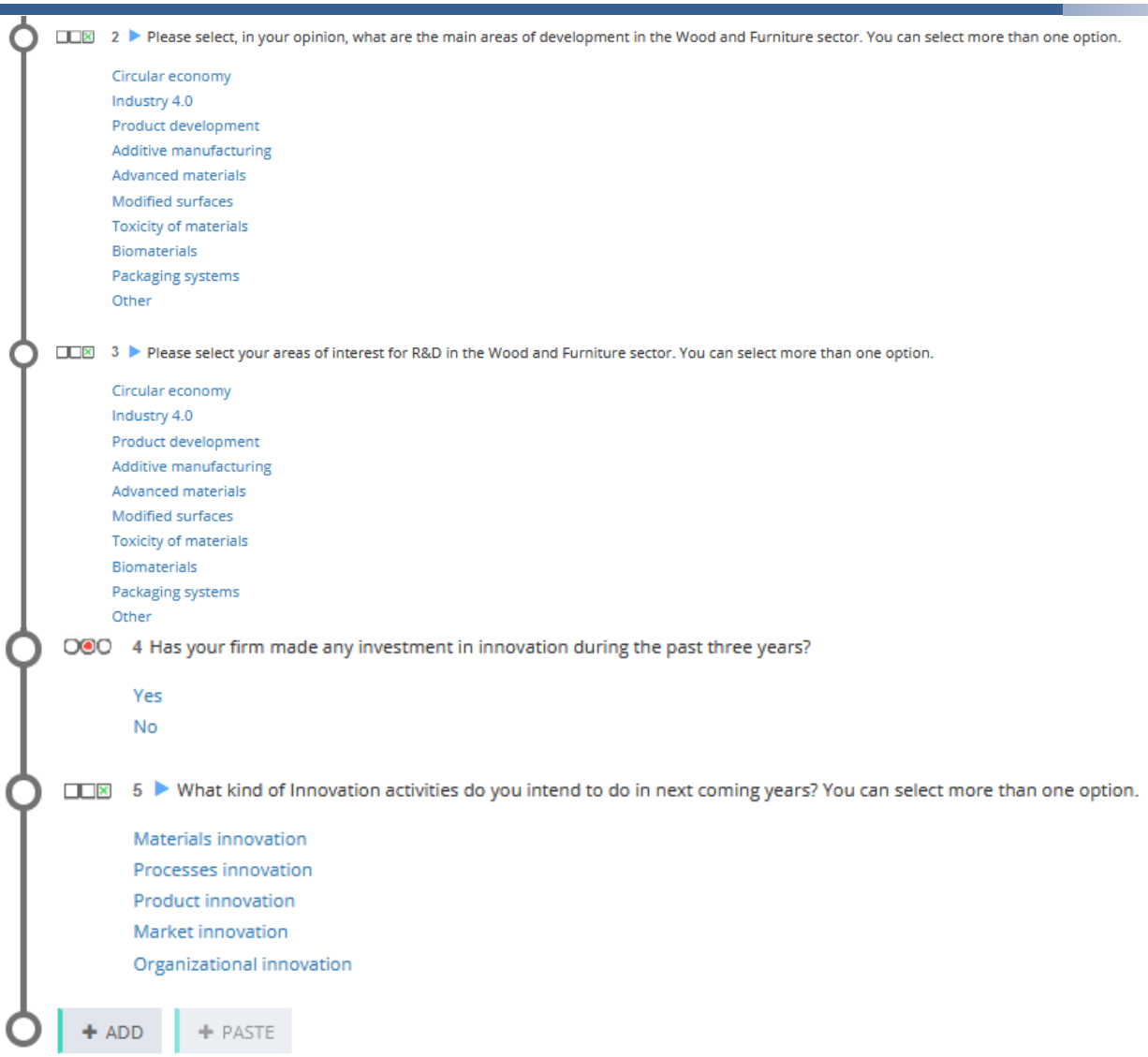

Figure 117 AIDIMME's Data Capture Example

2.6 Limitations

Biggest limitation of business intelligence and its widespread adoption is the lack of awareness and understanding of these systems amongst small and medium sized companies. This is new to smaller companies who aren't digitally aligned and do not have the necessary infrastructure in place to leverage its benefits. Prerequisite to generating intelligence is the availability of raw data in digital format. Most SMEs do not have the systems to capture and store this data in appropriate format necessary. For those that do have this infrastructure, data security and sensitivity concerns prevent them from adopting these (mostly cloud based) solutions.

There is certainly a cultural barrier too. Especially with older workers, which is a challenge for today's organisations due to workforce shrinking and ageing (Ewa Soja, Piotr Soja, 2020). Digital technology has made rapid advancements in recent years. While the younger generations have embraced it, the older generations, a big majority of whom work in manufacturing sector) resist this change in traditional ways. This makes it difficult for business owners to introduce even basic data capture which are only prerequisite to more advanced intelligence generating modules.

Therefore, a considerable effort for digital advocates goes into educating the manufacturing businesses about benefits of generating intelligence form their internal systems and their network.

With a unified access to central data spine as well as connected tools, services, and platform, EFPF aims to lower these barriers and promote adoption of intelligent digital systems in European manufacturing ecosystem.

3 SDK and BI Applications

3.1 Introduction – SDK and BI Applications

EFPF aims to provide manufacturing businesses an essential artifact, which is mechanisms to enable them to create their own applications, that can be best suited to the specific needs of the business, so that they do not require specialized companies (tied to EFPF) to make these applications. The objective is to enable the development of applications that can be done by small third-parties or even developers from the manufacturing customer. This in one hand allows the customers to be less dependent on specialised companies for performing any development that involves EFPF, fostering an environment where the services of EFPF are made available in a centralised way so that they can be configured and applied to small high-value applications. On the other hand, this development environment also allows external third-party software development companies to use it for developing their own applications using the EFPF framework, where these developed applications can then be built and published in the EFPF marketplace, thus fostering a parallel business model that can bring them interesting revenue.

EFPF provides a range of tools included in the Software Development Kit (SDK) to help achieve the above goals. Several Business Intelligence Applications (BI Apps) were also developed to demonstrate its benefits to business, as well as to showcase the SDK capabilities, which utilise different technologies provided by the EFPF SDK. Examples of these BI Apps are the Shopfloor Intelligence BI App, the LAGRAMA Predictive Maintenance App, and the Spray Booth BI App, which represent specific use-cases that show users what they can achieve by using the SDK. Details of the SDK and corresponding technologies are explained in section 3.2. Representative BI Apps are summarised in section 3.3.

3.2 Technologies

The development environment is very rich, featuring best-of-breed solutions such as an SDK that centralises the EFPF features and APIs so they can be accessed, a full web-based IDE (based on Eclipse CHE, a project of the Eclipse foundation) to develop the applications, which is integrated with the SDK and with other EFPF-developed tools such as a Frontend editor, which provides a simple way to produce the application's look & feel, the integration with WASP's Process Designer, which allows the users to define BPMN flows of the application behaviour, and integrating the generating code back in the IDE. Other tools are also integrated such as the EFPF Engagement Hub, a portal that is aimed to promote the connection and interactivity between the developers, fostering open source and collaboration between them, as can be seen in Figure 118.

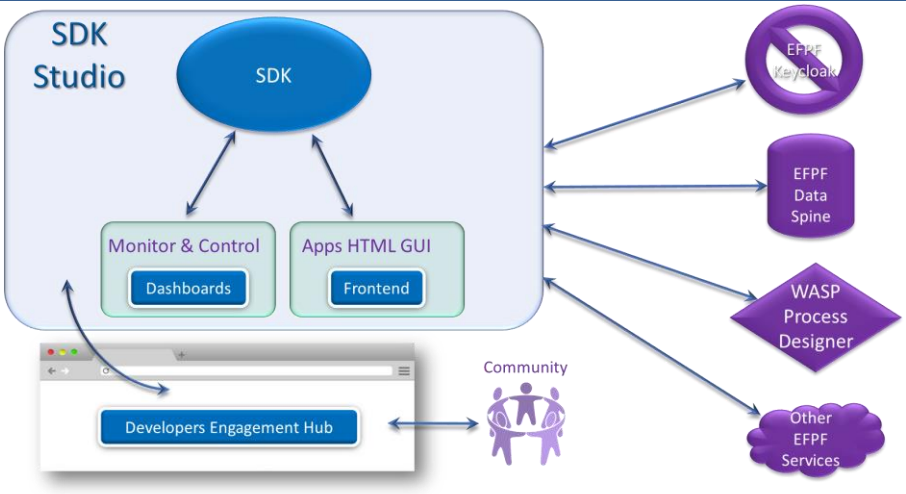

Figure 118: EFPF SDK Architecture

3.2.1 EFPF Software Development Kit (SDK)

The EFPF SDK is a JavaScript wrapper that comprises calls to the EFPF APIs, which then can be integrated in the IDE to make successful calls to the EFPF services as long as they are conformant with the corresponding protocols. All the SDK code is available (open source) in the Developers Engagement Hub[3]. The internal scripts have a flow that can be seen in Figure 119.

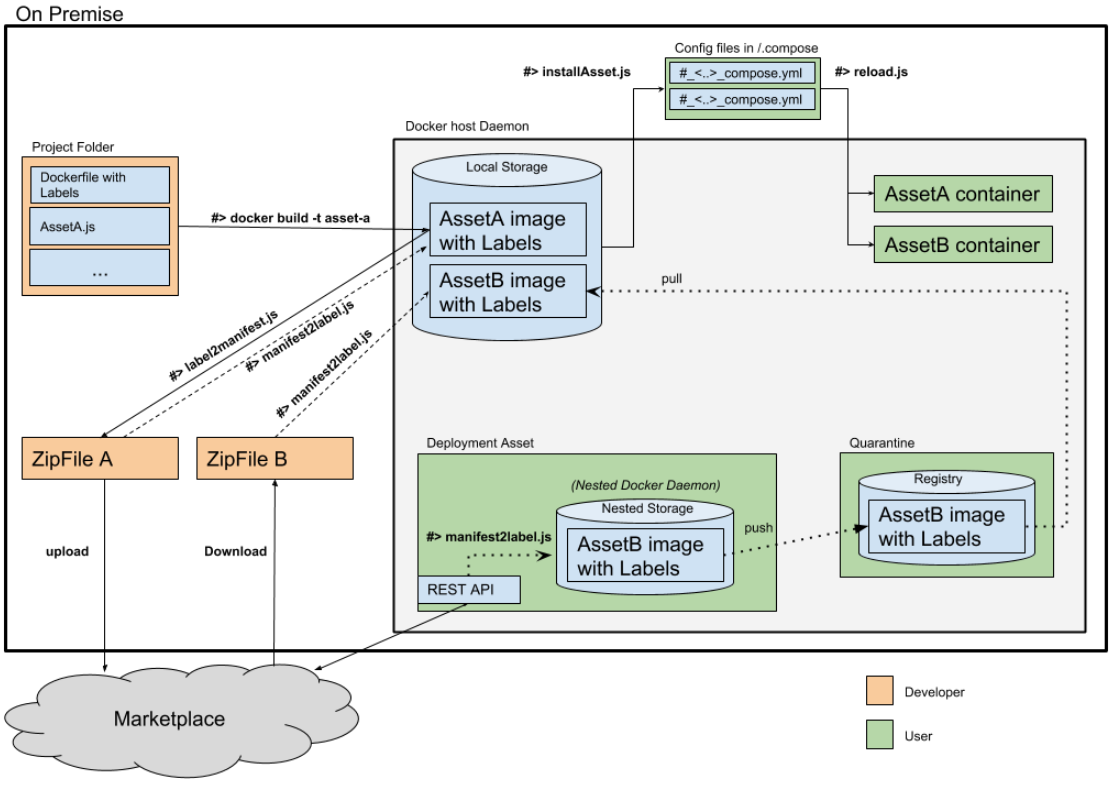

Figure 119: EFPF SDK Flow

[3] https://engagementhub.caixamagica.pt/efpf/sdk and https://engagementhub.caixamagica.pt/efpf/internal-sdk-libraries

3.2.2 EFPF SDK Studio

The SDK Studio is a full-fledged IDE (Integrated Development Environment), based in one of the most popular development platforms, Eclipse. The Eclipse project in stake is Eclipse CHE, a novel environment that allows to have all the development environment in a Web-based platform, as can be seen in Figure 120.

The SDK Studio is able to develop applications in multiple languages, integrate with different technological stacks, and of course, includes all the best features of the Eclipse IDE, such as the Project development management, extensions, a complete editor with syntax highlighting and many others. Despite the fact that the project uses Eclipse CHE, numerous customisations needed to be performed to integrate it with the EFPF environment, namely the SDK, the SDK Frontend, EFPF Keycloak, the WASP Process Designer etc. All the code that was developed to implement those customisations and integrations is fully available as open source in the Developers Engagement Hub[4].

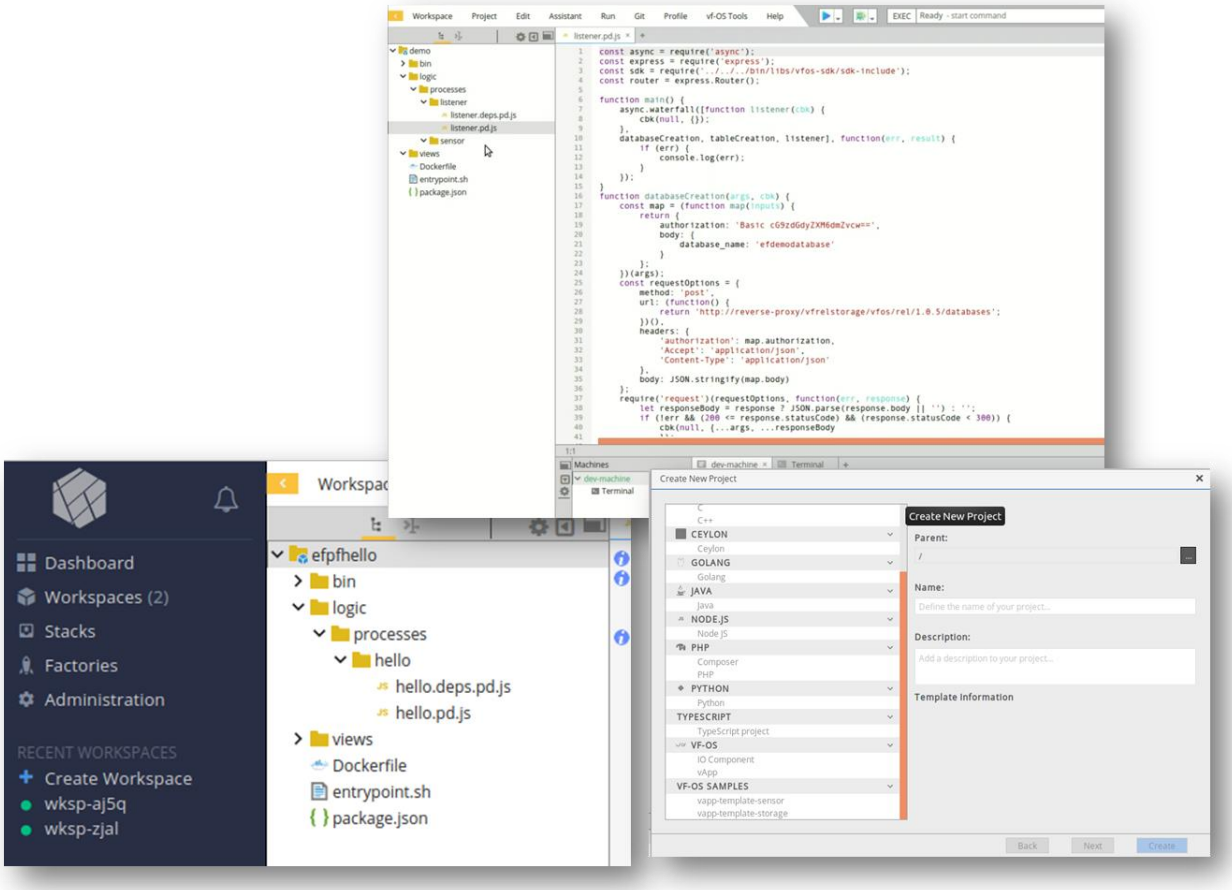

Figure 120: EFPF SDK Studio

3.2.3 EFPF SDK Frontend

The EFPF SDK Frontend Editor is designed to support the development of custom applications initiated with the EFPF Software Development Kit (SDK) based on the services provided by the EFPF platform. The Frontend main functionality is to provide developers

[4] https://engagementhub.caixamagica.pt/efpf/sdk-studio

with a graphical user interface (GUI) editor for prototyping, to integrate and customize applications built with the SDK. Developers can combine all microservices based on implementations of the SDK integrated functionalities.

The Frontend can be accessed by the SDK Studio interface using a plain browser. The solution is based on predefined templates that stand for themselves (e.g.. customized GUI elements) and can bind data sources from EFPF that are orchestrated by Application Development Studio. Application developers have a high degree of flexibility and power by combining the predefined templates and visual elements that can be used inline or nested. This approach results in a multitude of possible applications designs.

The Frontend UI offers additional guidance and allows developers to speed up the process of rapid prototyping. Any design strategy is supported, and a broad range of applications can result from mixing single-page, multi-page, and progressive web application designs. The workflows are highly configurable translating business process models of the use-case scenarios into functional maintainable applications.

The following diagram shows an overview for the Front-end module along with its integration with the EFPF SDK: https://sdk.efpf.caixamagica.pt/dashboard/

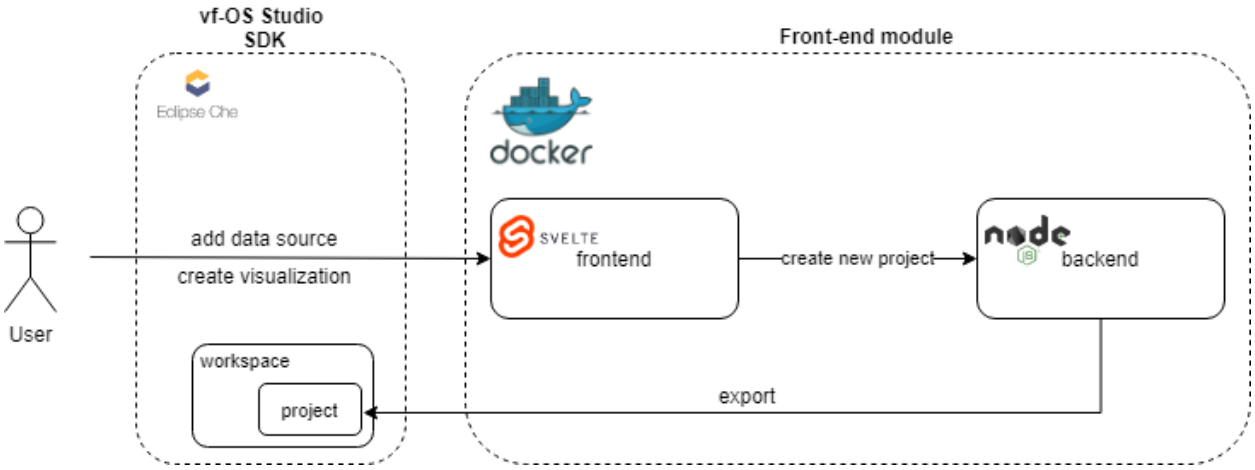

Figure 121: Frontend Editor Architecture

The main purpose of this web-frontend is to get information from data-sources (e.g., database) and display it in different components (e.g., tables, charts) in order to provide a better understanding of data, by using various visualizations elements. Each component presents specific data for each requested scenario.

In terms of functionalities offered, the Frontend Editor comprises ten categories of components, as exemplified below:

- *Add Data Source*, which allows users to add a data source API in order to populate different tables or graphs.
- *Layout* category includes the main page layout components such as header, horizontal and vertical tabs, horizontal line, and footer. With these components, users can create customized visualizations.
- *Display* category includes the main elements that provides users ways to trigger an event on the page (e.g., searching for a query on the page). This category comprises three components: Background, Image, and URL host.

- *Text category, which contains two text boxes: a paragraph, and a text area. These elements provide users the ability to type and insert text anywhere in the page.*
- *Tables category, which includes a table element and a Gantt chart. In order to add these elements on the page and populate them with values, the user shall provide a data source and/or select a data source from the list.*
- *Bar charts category, which includes vertical and horizontal bar charts. To add these elements on the page and populate them with values, the user shall provide a data source.*
- *Line charts category which includes simple charts. To add this element on the page and populate them with values, the user shall provide a data source.*
- *Radial charts category which includes the most common-used radial charts: donut, pie, radar and polar. To add these elements on the page and populate them with values, the user shall provide a data source.*
- *Point charts category includes bubble and scatter charts. To add these elements on the page and populate them with values, the user shall provide a data source*

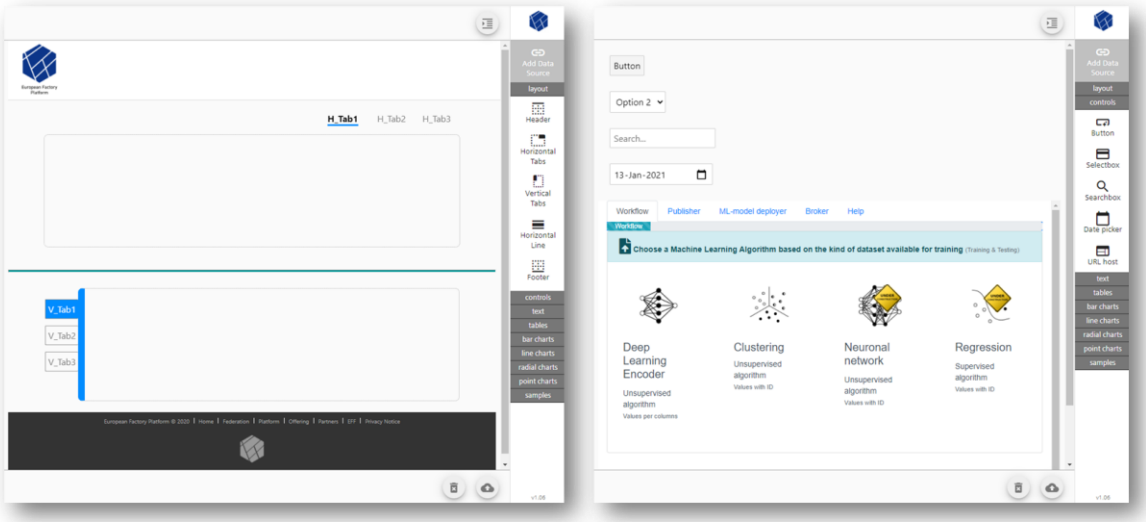

Figure 122: SDK Frontend's basic GUI element

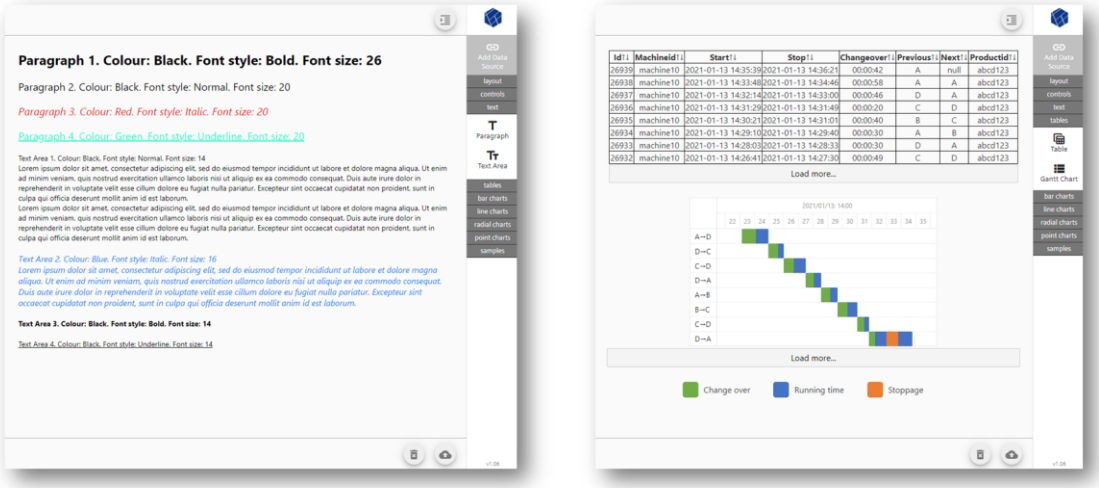

Figure 123: SDK Frontend Elements

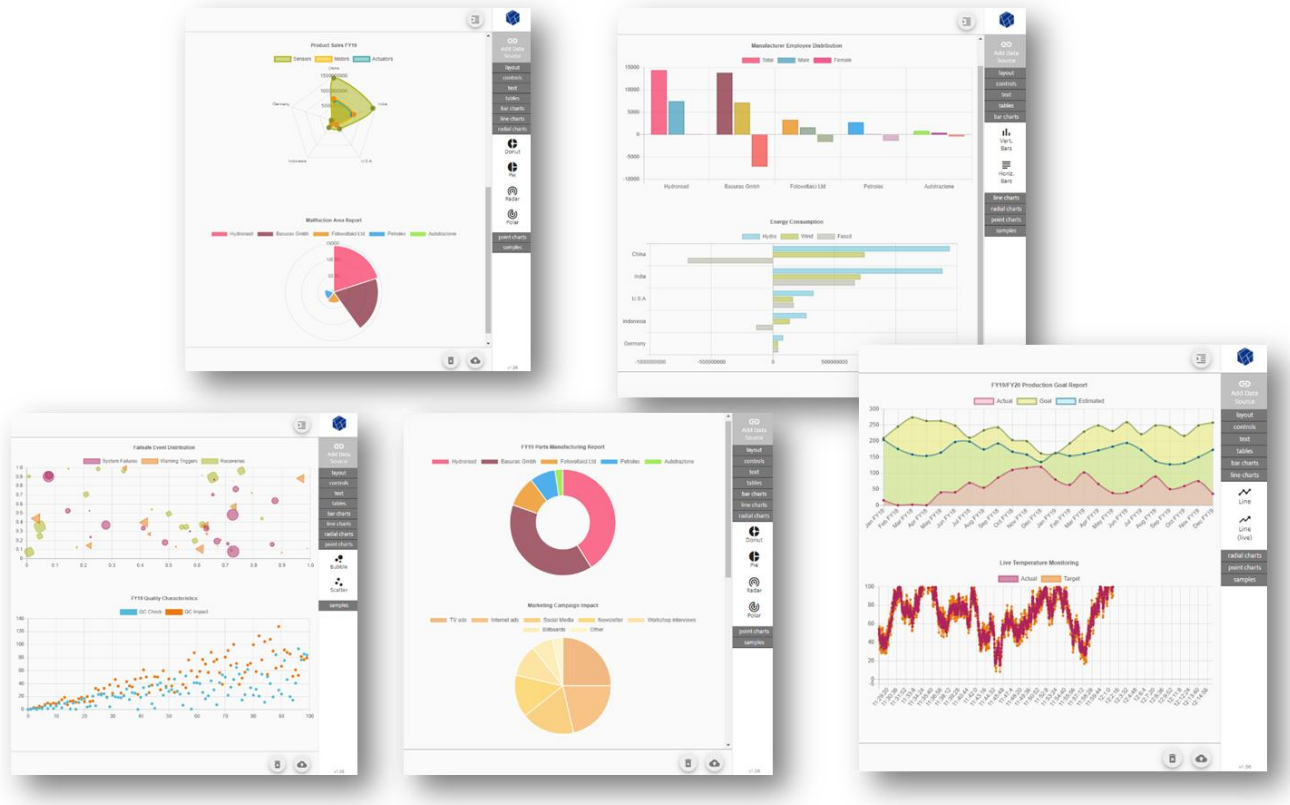

Figure 124: SDK Frontend Charts

3.2.4 EFPF SDK Developers Engagement Hub

The EFPF Developer Engagement Hub has the purpose to define and develop a suite of tools that fit together and consist of a platform to support developer collaboration between developers, customers, and communities. It is a framework available from one single platform location (web-based), which not only supports the development of tools, but it also involves the development community, fosters their active contributions in the shape of tests, comments, suggestions, and new requests in the form of change requests in existing applications, e.g., to support other platforms, trends, needs, or extensions. It allows the community to download/reuse/fork the existing code from the Studio (if published) and actually use/test it on new conditions or scenarios. The outcomes of these tests will always come in the form of issues, reports, comments, or suggestions. It also promotes the usage and creation of standards, methodologies, and best practices. This framework includes mechanisms such as wikis, issue trackers, forums, and blogs. Other tools such as configuration management, business continuity, and business process design and management are initially conceived out of scope of this component and relevant to other components such as the SDK/Studio. This component will be implemented by a web server hosting information that fosters the creation and support of communities related to the manufacturing business. Figure 125 shows some of the screens of the Developer Engagement Hub Tool.

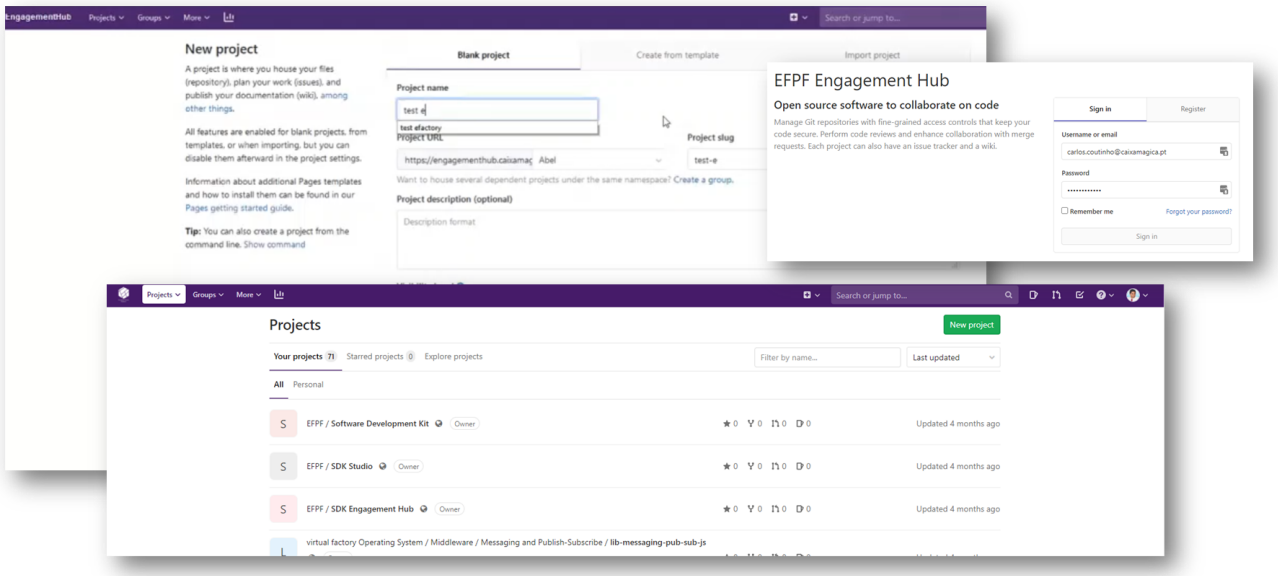

Figure 125: The EFPF SDK Engagement Hub

This tool was developed on top of best-of-breed portal GitLab Community Edition (CE). Besides having all the standard features of GitLab, numerous developments were added to the base platform, such as allowing multiple level projects (useful for maintaining large projects) with multiple-level issue trackers as well, and the inclusion of a chatting tool for better collaboration between the developers, integration with the SDK Studio and many other features. All the code that was developed to implement those customisations and integrations is fully available as open source in the Developers Engagement Hub[5] .

3.2.5 SDK OGC SensorThings API Compliant data integrator

To prove the concept, a set of data integrators conforming to OGC SensorThings API were created by the EFPF team, by using available open-source tools and standards. These data integrators are integrated with EFPF Data Spine as well. First of all, a scenario is implemented by simulator synthetic data to show the concept. In this scenario, the sensor types by the end users are selected. After that a real application by Almende is implemented and integrated to Data Spine.

3.2.5.1 Technologies Used

Node-Red - Node-Red is a flow-based programming tool built on Node.js. Node-Red provides a visual editor on web browsers, which is used to make flows using the wide range of customizable nodes. It is also possible to create Javascript functions as nodes.

Frost-Server - FROST offers different packages that can be used in various scenarios. The one used is here is the All-In-One Package, which contains both the HTTP and MQTT. It also has HTTP-only and MQTT-only packages and it is possible to combine arbitrary number of instances of these packages together. Furthermore, FROST has configurable settings,

[5] https://engagementhub.caixamagica.pt/efpf/sdk-engagement-hub

offers authentication and authorization options, and has plugin support. Frost-Server currently supports several HTTP methods and queries. It also supports creation of observations via MQTT publish and subscription to entity inserts and changes.

3.2.5.2 Sensor Types

There are different sensors in different scenarios. But in general, they make measurements and then these measurements are processed and sent to the Frost-Servers as 'Observation' objects via MQTT.

Bin Fill Level Monitoring

Distance Sensor - Distance sensors take raw distance measurements from their position to the surface of the waste over a fixed time period. This data is then processed and translated to fill percentage - according to bin type and sensor placement.

Factory Connectivity

Temperature Sensor - Temperature sensor is placed into the equipment that requires temperature measurement. The temperature data coming from the sensor is then processed if necessary.

Sound Sensor - Sound sensor is placed to the area that requires sound level measurement. Data is then processed if necessary.

Accelerometer - Accelerometer is placed to the area that require the vibration measurement. Data is then processed if necessary.

Working Environment Monitoring

Temperature Sensor
This sensor is placed to the working area of the machine that requires the measurement. Data is then processed if necessary.

Humidity Sensor
This sensor is placed to the working area, same as the temperature sensor. Data is then processed if necessary.

3.3 BI Applications

3.3.1 Shopfloor Intelligence

This BI application allows users to view various Tools that can support the analysis of machine condition data. The aim is to predict and alert when a machine will need

maintenance before it becomes a more serious breakdown. This is currently available on EFPF Marketplace.

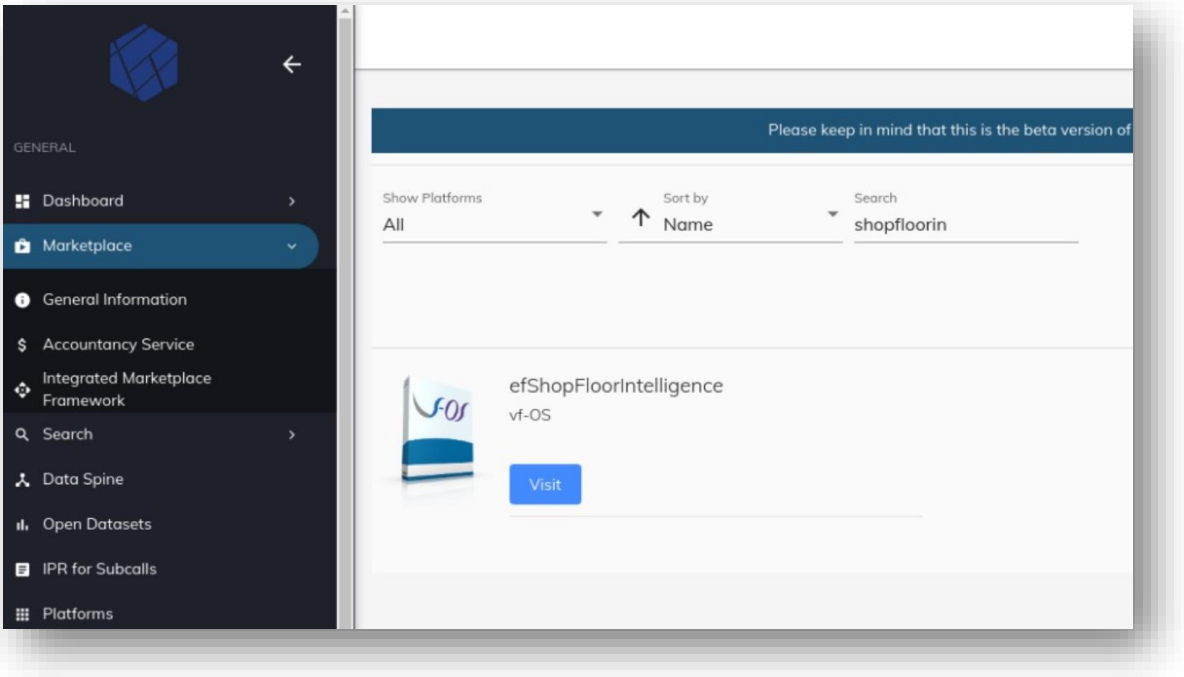

Figure 126 Shopfloor BI App

3.3.2 LAGRAMA Predictive Maintenance

The application consists in a set of visualization tools provided by Almende: a Live data tab containing real-time data coming from the sensors (Current, Pressure and Temperature) and three additional tabs with embedded wireframes to risk and analytics tools (opportunity, analysis and monitoring - ROAM, Anomaly Data Solution - ADS and Deep Learning Toolkit - DLT).

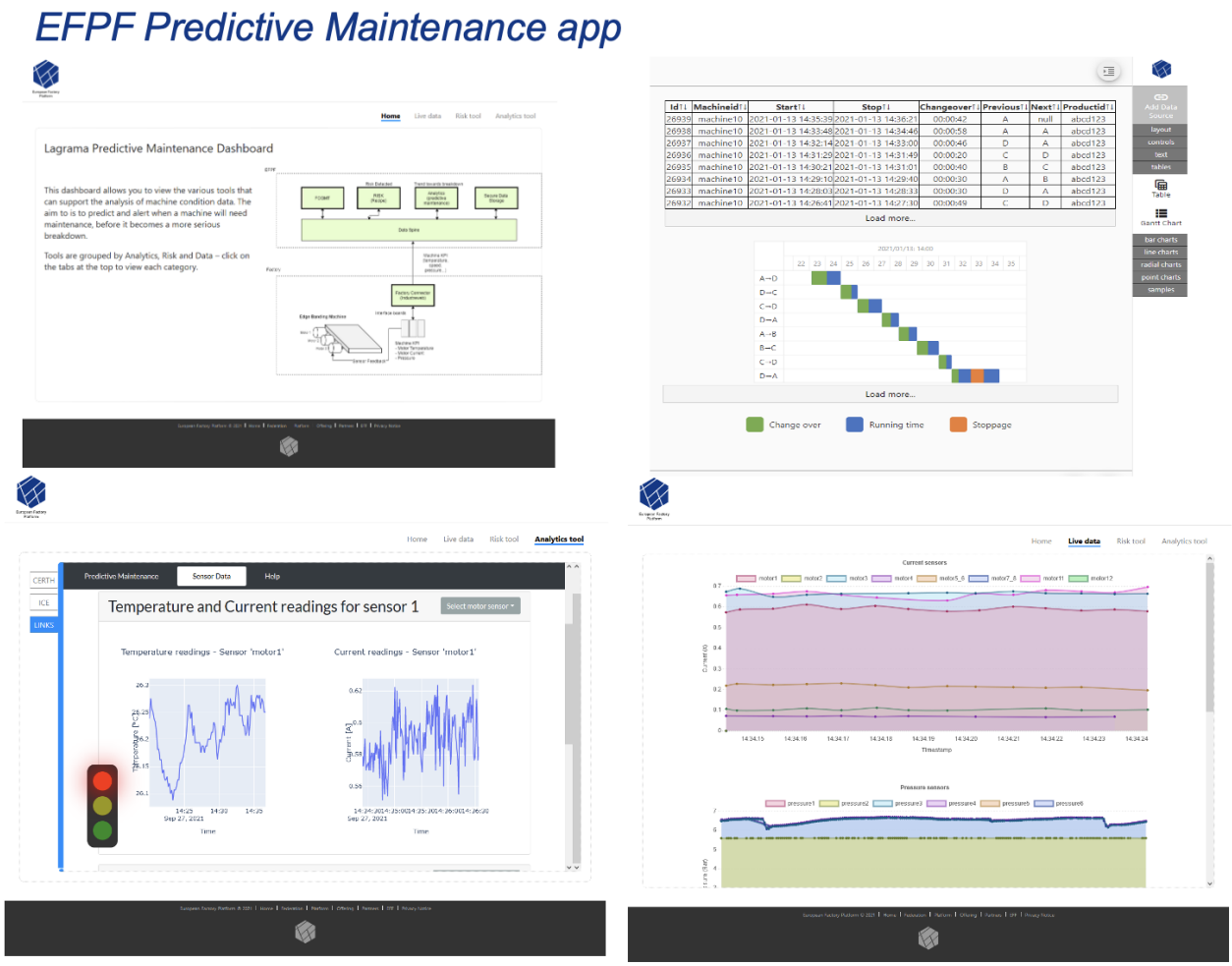

Figure 127 Predictive Maintenance BI App

3.3.3 BI Factory Connectivity and Monitoring Application

This application aims to provide a monitoring application by using EFPF Factory Connectivity Tools for IoT data coming from crownstones published by Almende. This BI app showcases a comprehensive case of utilizing most of the technologies presented in earlier section and present an intuitive monitoring UI via Grafana to the end user.

The deployment diagram is shown in the following figure. All the open-source tools shown in below diagram are deployed to EFPF Portal SDK.

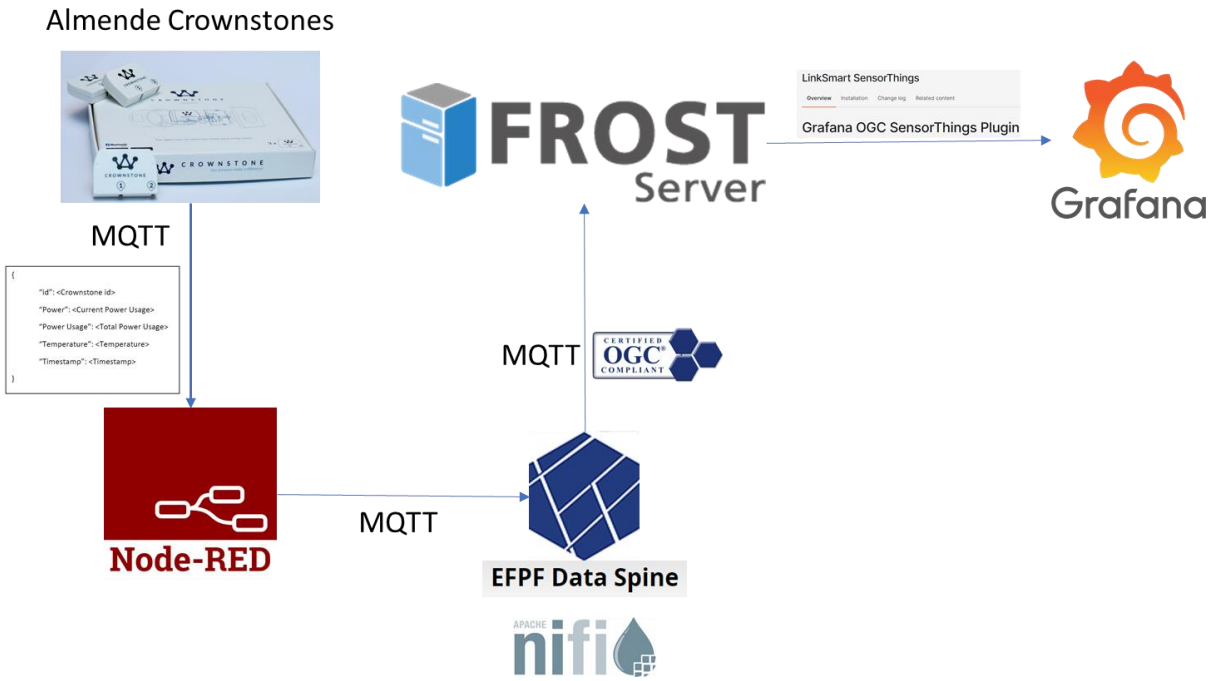

Figure 128 Overall Architecture

In this application, the Grafana installation at http://efpf.caixamagica.pt/grafana/ is used. To login, please use username/password: admin/admin. Then skip the password change page. Click to Configuration -> Data Sources from navigation bar then click to Add data source -> LinkSmart SensorThings. Configuration of the Data Source is presented below. Click the “Save & Test” button.

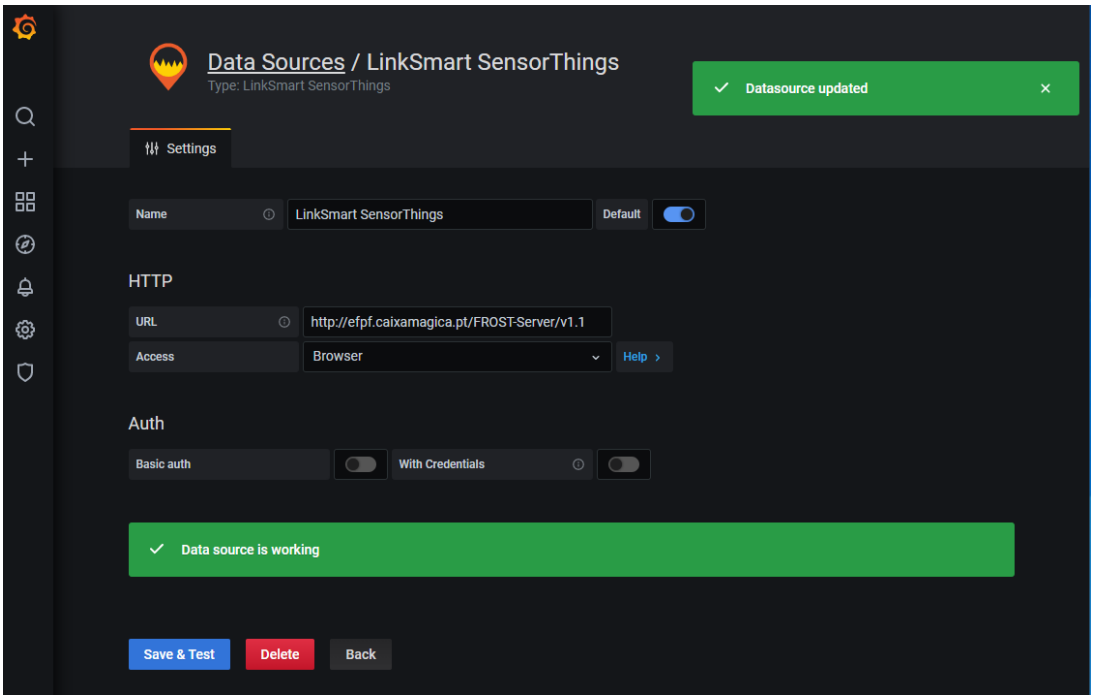

Figure 129 Grafana - Data Source Configuration

Click to Create -> Import from navigation bar then select panel.JSON file. After that, you will see dashboard as shown below.

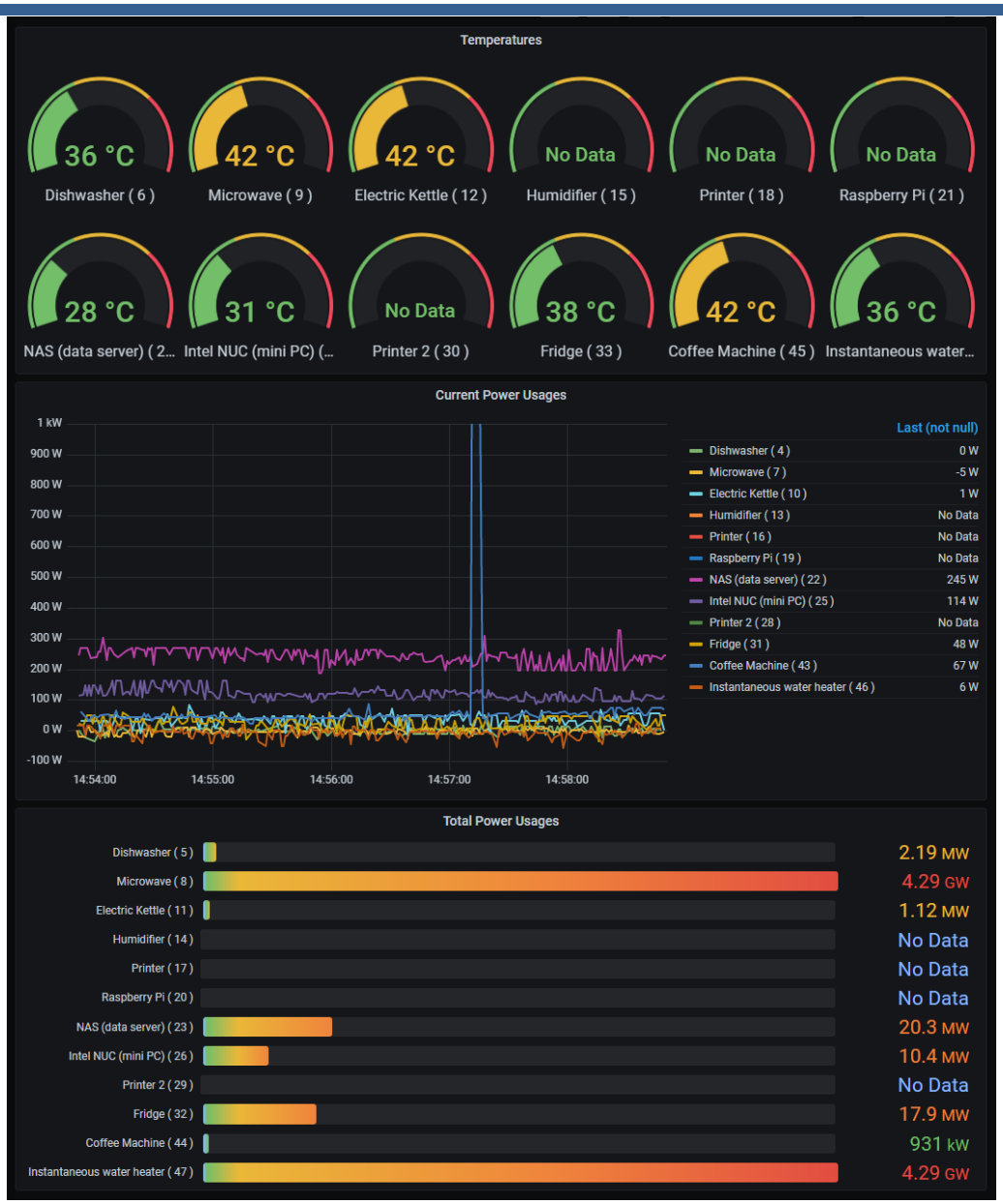

Figure 130 Grafana - Dashboard

3.3.4 Spray Booth BI App

This application provides users with the ability to see data regarding paint job number and number of particles in the air captured by a particle sensor installed in the paint booth. The dashboard provides information regarding the occupation of spray booth, staff exposure time, duration of real paint job, and data regarding predictive maintenance for the filter of the abstraction system.

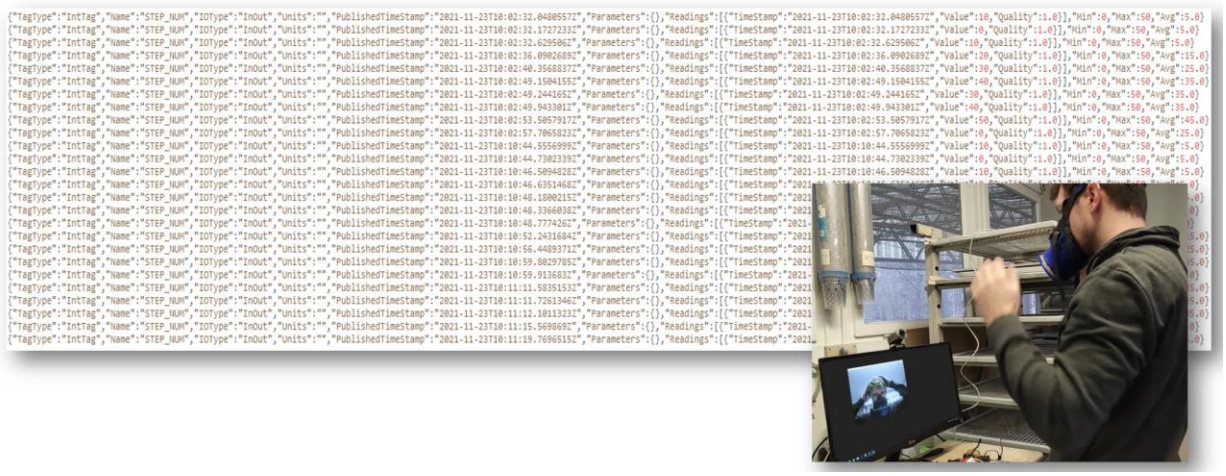

Figure 131 SprayBooth BI App

4 Conclusion

This report shows an innovative approach to combining federated search, agile team formation, and agent based automated matchmaking systems to improve user experience, increase user engagement through incentives and rewards mechanisms, boost conversion rates and operationalisation of businesses to the connected platform companies and their products and services through EFPF ecosystem. It discusses the design and implementation of matchmaking functionality in EFPF and its relationship with Business & Network Intelligence components. The data captured in the EFPF portal's federated search and matchmaking components are effectively utilised in B&NI to generate valuable platform and market intelligence in EFPF ecosystem. The two components complement each other as matchmaking generates logs of user journey which is utilised by Business and Network Intelligence components (as well as other BNI tools capture and share intelligence back with the ecosystem) which in turn helps in better matchmaking and the cycle continually improves over time. This reports also discusses the relationship between SDK & BI Applications with the EFPF Business Intelligence offerings and include details from SDK offerings to showcase how it can be used by users to create customised BI apps for further Business Intelligence.

Some of the key benefits of implementing federated search, team formation and matchmaking can be summarized as follows (Algolia, 2019) (Melton and Buxton, 2006):

- It is an efficient way for searching through multiple sources and a larger volume of information, which results in getting more accurate results and improving overall user experience within EFPF in finding the most suitable service providers/partners and products & services;
- It increases the relevance of search results by using different parameters to rank different types of content;
- It requires to maintain only one search engine for several platforms and a variety of their data sources, which improves reliability and security;
- It ensures that the content of new platforms that join a platform ecosystem, is early integrated into existing federated search and recommendation services.

Some key benefits of Business and Network Intelligence solutions in the context of EFPF are summarised below:

- Business can use a range of web-based applications that help them collect, analyse, and derive intelligence from their internal operations through a single portal without having to spend on complex implementations and vendor lock in.
- Manufacturers can utilise tools available to help them connect, visualise, and mine intelligence from their supply chains digitally, while promoting digital uptake throughout the value chain.
- Platform users can utilise network intelligence to understand demand and trends across Europe thorough the EFPF ecosystem and position their business accordingly.
- Provides an opportunity to generate meaningful intelligence from the user behaviour of the connected manufacturing community across Europe.

Some key benefits of SDK and developed BI applications in the context of EFPF are summarised below:

- Create a development environment allowing manufacturing business and developers to build customised applications
- Build BI applications easily by making use of the EFPF features and components
- Integrate with other EFPF componentises such as DataSpine, SDSS, Process Designer, etc.
- Enhance EFPF Development capabilities by offering SDK, SDK Frontend, SDK Interface Studio, and Developers Engagement Hub.

However, there are still many questions to be explored in the intersection of these fields:

- What is the minimum amount of data to run an effective recommendation system?
- Which recommendation algorithms are more suitable for federated digital environments?
- How to reduce the negative impact of the performances of recommendation systems due to incomplete and/ or missing data?
- How symbolic AI methods can compensate for the missing data and support recommendation systems?
- How can ML (machine learning) models help in aggregated procurement opportunities for companies on the platform?
- How to provide better insight on supply chain mapping, supplier risks, and mitigating carbon footprint of supply chain by combining data from different system and open data?

Annex A: History

Document History	
Versions	V1.0 Final version to be submitted to the EU V0.9: Revised version for final round internal review V0.8: Issues corrected, revised for second round internal review. V0.7: First version for review by all partners V0.2 – V0.6: Collection of contributions from partners V0.1: Document set-up and draft Table of Contents
Contributions	AID: María José Núñez Ariño Daniel Ivaylov Gerchev Fernando Gigante Valencia CERTH: Alexandros Nizamis CMS: Carlos Coutinho C2K: Simon Osborne ICE: Ross Campbell SIE: Raluca-Maria, Repanovici SRDC: Yildiary Kabak SRFG: Dietmar Glachs Violeta Damjanovic-Behrendt VLC: Amber Bu Hannah Williams Tony Guo

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