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Abstract:

This deliverable will document the activities that have been performed in the implementation of the pilots and the use cases, and the description of the final results.

Keywords:

Use cases, pilots, activities, plan, progress, final version, status, analysis, design, development, deployment, integration

Revision History

Revision	Date	Description	Author (Organisation)
V0.1	24.11.2022	First version of the document.	Héctor Iturria (PRO)
V0.2	21.12.2022	Public draft.	Héctor Iturria (PRO)
V0.3	09.01.2023	Section 6 as example	Héctor Iturria (PRO)
V0.4	02.02.2023	New section 6 version	Héctor Iturria (PRO)
V0.5	20.03.2023	New contributions merged	Héctor Iturria (PRO)
V0.6	21.03.2023	IDS use case and improved scenarios	Héctor Iturria (PRO)
V0.7	23.03.2023	Scenarios corrections	Héctor Iturria (PRO)
V0.8	28.03.2023	Scenarios improvements	Héctor Iturria (PRO)
V0.9	30.03.2023	Minor fixes	Héctor Iturria (PRO)
V0.10	31.03.2023	Annex completed and final version	Héctor Iturria (PRO)

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More information available at https://DataPorts-project.eu

Copyright Statement

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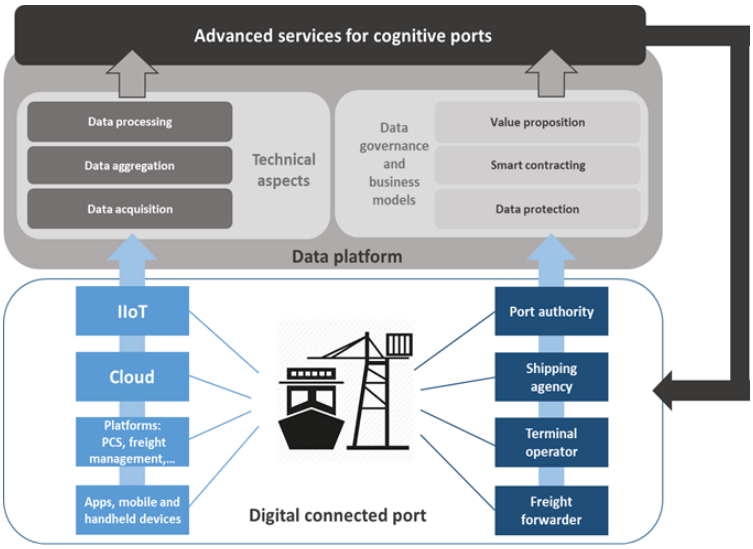
1 INTRODUCTION

1.1 DATAPORTS PROJECT OVERVIEW

DataPorts is a project funded by the European Commission as part of the H2020 Big Data Value PPP programme, and coordinated by the ITI - Technological Institute of Informatics. DataPorts rely on the participation of 13 partners from five different nationalities. The project involves the design and implementation of a data platform, its deployment in two relevant European seaports connecting to their existing digital infrastructures and addressing specific local constraints. Furthermore, a global use case involving these two ports and other actors and targeting inter-port objectives, and all the actions to foster the adoption of the platform at European level.

Hundreds of different European seaports collaborate with each other, exchanging different digital data from several data sources. However, to achieve efficient collaboration and benefit from AI-based technology, a new integrating environment is needed. To this end, DataPorts project is designing and implementing an Industrial Data Platform.



The DataPorts Platform aim is to connect to the different digital infrastructures currently existing in digital seaports, enabling the interconnection of a wide variety of systems into a tightly integrated ecosystem. In addition, to set the policies for a trusted and reliable data sharing and trading based on data owners' rules and offering a clear value proposition. Finally, to leverage on the data collected to provide advanced Data Analytic services based on which the different actors in the port value chain could develop novel AI and cognitive applications.

DataPorts will allow establish a future Data Space unique for all maritime ports of Europe and contribute to the EC global objective of creating a Common European Data Space.

1.2 DELIVERABLE PURPOSE AND SCOPE

Specifically, the DOA states the following regarding this Deliverable:

This deliverable consists on the final version of the software applications developed in the pilots, including change-set, final list of features and user documentation.

The purpose of this document is to describe the final state of the pilots on M39, with a description of what has been done, from the final use case descriptions to the step-by-step demonstration. With that view in mind, this document splits the content in two different kind of progress reports.

On one hand it contains descriptions of the activities that have been performed by many involved partners, how the functionalities of the platform are demonstrated in the scenarios, and how the components and other outcomes of the project (i.e., data models) are present in the use cases.

On the other hand, the final description of the use cases is presented, including the activities that have been carried out, from the allocation of physical resources to the implementation of new applications. Each scenario will include its own description of how the pilot has been implemented and the user documentation of the applications involved.

1.3 DELIVERABLE CONTEXT

Its relationship to other documents is as follows:

Primary Preceding documents:

- Description of Action (DOA): Provide the foundation for the actual research and technological content of DataPorts. Importantly, the Description of Action includes a description of the overall project work plan.
- D2.1 - Industrial Data Platforms and seaport community requirements and challenges: the content of the analysis of current infrastructures is the basis for the use case definitions.
- D2.4 – Platform architecture and specifications: it describes the functionalities and the components that are demonstrated in the pilots.
- D5.1 - Integration, software quality assurance and deployment plan: it describes the plan of activities for the pilots' implementation.
- D5.3 – Use case oriented pilot initial version: The status of the pilots and the applications at the beginning of the integration.

Primary Dependant documents:

- D5.5 - Use cases and applications evaluation report: Contains the results of the DataPorts requirements and use cases evaluation.

1.4 DOCUMENT STRUCTURE

This deliverable is broken down in the following sections:

- **Section 1 Intro**: It includes an introduction to the project, a short description of the purpose and scope of this document and the dependencies with other deliverables.
- **Section 2 General**: A project progress overview, functionalities and usage of the components in the pilots. Also, description of the status of the activities that can't be split by scenario.
- **Section 3 Port of Valencia:** It describes the activities performed for the implementation of the pilot, the required infrastructure, the deployment of the applications and services, and the use of the platform. They are included also the final version of the use cases and the references to the applications' user manuals.
- **Section 4 Port of Thessaloniki:** It describes the activities performed for the implementation of the pilot, the required infrastructure, the deployment of the applications and services, and the use of the platform. They are included also the final version of the use cases and the references to the applications' user manuals.
- **Section 5 Smart containers:** It describes the activities performed for the implementation of the pilot, the required infrastructure, the deployment of the applications and services, and the use of the platform. They are included also the final version of the use cases and the references to the applications' user manuals.
- **Section 6 Port management system integration:** It describes the activities performed for the implementation of the pilot, the required infrastructure, the deployment of the applications and services, and the use of the platform. They are included also the final version of the use cases and the references to the applications' user manuals.
- **Section 7 Conclusions**: It resumes the final status of the demonstrations, the obtained experience and the lessons learned.

Annexes:

- **Annex A:** User manuals
- **Annex B:** Change logs

2 GENERAL

2.1 PROJECT OVERVIEW

A project overview considering the pilot's point of view was already described in D5.3 Use Case Oriented Pilots Initial Version (M24). In this section we will explain in a general way the progress of the project and the integration of the platform in the different pilots that have been implemented in the last year of the project.

In this document we will find the final use case description and status, and a new scenario that has been added to the Valencia pilot to showcase the integration of services provided by other data federation with data from DataPorts through IDS connectors.

First thing to mention is that the project had an initial planning for 36 months, starting in January 2019 and finishing in December 2022. Because of the COVID pandemic some of the tasks were delayed and some partners had difficulties to find the expected resources, so the consortium decided to ask for a 3 months extension of the project, that was accepted by the EC.

The Figure 1 depicts the activities performed from the M24 to M39, containing the main activities related with the pilot's implementation, the platform integration and the whole evaluation.

	Year 2	Year 3												Year 4		
	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Use cases specifications																
Common vocabulary																
Description of scenarios																
Functionalities demonstration matrix																
Roles																
Data access																
Data models																
Required infrastructure																
Implementation																
Platform components																
Current applications																
New applications																
Integration																
Platform components																
Current applications																
New applications																
Security and quality assurance																
Testing and evaluation																
Deliverables	D5.3												D5.4			D5.4
													D5.5			D5.5

Figure 1 – Performed activities

As shown in the previous figure, the main deliverables of the WP5, including this one, have been moved to M39.

Along the last year of the project, in each of the pilots, the task leaders have provided all the required infrastructure, that is needed not only for the applications and the demonstrations but also for the deployment of DataPorts. Because the platform has a modular architecture, some of the components are present in every pilot to keep the data near the source following an edge computing approach and other are single instances shared among the scenarios. For this purpose, servers have been provided and access has been granted to stakeholders and involved parties, as the needed support to be able to work in the different environments.

Agents have been implemented for the acquisition of data and its transformation into the data models defined also in the scope of this project. The whole components of DataPorts have been integrated with the mechanisms defined for the security of the platform, building a secure environment for the exchange of information. All the agents have been also prepared to work with the different components required in each of the scenarios for the processing of the data, considering the conditions of the use cases. How to access the components of the platform and how they interact, the user rights to access these components and the permissions to the data, everything is ruled and protected through the Data Governance and other security components of the platform.

Furthermore, to meet the use case objectives, new applications have been implemented to demonstrate the benefits of using DataPorts. These applications are described along the document, as well as how users interact with them to validate the platform functionalities.

In addition, in the following sections of the document, all the activities performed by the consortium related with the implementation of the pilots to achieve the results are described.

2.2 COMPONENT DEFINITIONS

The Table 1 briefly describes the components of DataPorts architecture.

COMPONENT	DESCRIPTION
Data Access Component	Responsible for gathering, transforming and publishing data from different data sources to the platform.
Semantic Interoperability Component	Exposes a unified API to access the data from the different data sources connected to the DataPorts platform, providing both real-time and batch historical data to the data consumers.
Data Abstraction and Virtualization Component	Prepares the data inputs form various sources inside the generic DataPorts architecture, exporting the result datasets through exposed RESTful APIs.
Data Governance Component	Enables the handling of high-quality data, monitoring its complete lifecycle. It increases consistency and confidence of the data registered, improving data security, and minimizing the risk of not complying with relevant regulation.
Automatic Model Training Engine	Optimises business process using machine learning techniques.
Process-based Analytics Component	Uses the data available in the form of event logs (i.e., sequences of business process actions) to deliver predictive, prescriptive and explainable process monitoring capabilities.

Table 1 – DataPorts platform components

2.3 USE CASES AND PLATFORM FUNCTIONALITIES

The DataPorts platform has been designed to provide multiple functionalities in order to achieve the expected goals. The pilots and scenarios use them as part of the demonstrations of the project.

The Table 2 shows the scenarios of the use cases with their short names.

Use case short name	Use case complete name
TTO	Tracking of Transport Operations
DSS	Port Authority Data Sharing and Analytics Service
VGM	Sharing Verified Gross Mass
DCN	Digital Consignment Note

Use case short name	Use case complete name
CPU	Container Pick-up
AUC	Analytics Use Case for ThPA
SCO	Smart Containers
PNS	Posidonia Notifications

Table 2 – Scenarios of the pilots

Each scenario of the pilot implements or integrates the platform's components required to reach their objectives; functionalities are demonstrated depending on the use of these components. The Table 3 lists where the functionalities of the platform are showcased.

ID	Functionality	TTO	DSS	VGM	DCN	CPU	AUC	SCO	PNS
F-2.1	The DataPorts platform provides various platform governance capabilities and interoperability among different platforms	✓	✓	✓	✓	✓	✓	✓	✓
F-2.2	The DataPorts platform sets a data driven ecosystem ready for a comprehensive exploitation of data, and virtual data repositories	✓	✓	✓	✓	✓	✓	✓	✓
F-2.3	The DataPorts platform introduces a novel, decentralized architecture, data and events can be recorded on a blockchain for transparency and credibility	✓	✓	✓	✓	✓	✓	✓	✓
F-2.4	The DataPorts platform (through blockchain technology) implements all the authentication and authorization mechanisms to allow data sharing and trading in a secure and reliable way	✓	✓	✓	✓	✓	✓	✓	✓
F-2.5	The DataPorts platform will be aligned with International Data Spaces (IDS) reference model, offering data owners the option to describe connectors where type and conditions of data will be clearly stated and offered to data consumers	✓	✓	✓	✓	✓	✓	✓	✓
F-2.6	The DataPorts platform provides Orion Context Broker and Blockchain component, registering the description of the data	✓	✓	✓	✓	✓	✓	✓	✓
F-2.7	The DataPorts platform enables the data owners to exchange data	✓	✓	✓	✓	✓	✓	✓	✓
F-2.8	The DataPorts platform enables data sovereignty	✓	✓	✓	✓	✓	✓	✓	✓
F-3.1	The DataPorts platform enables connections with external sources of data supported by data agents manager	✓	✓				✓	✓	✓
F-3.2	The platform will enable a real connection among current IT systems in ports environment, allowing them to share data and knowledge	✓	✓	✓	✓	✓			✓
F-3.3	The DataPorts platform provides data sanitization algorithm to guarantee data integrity		✓				✓		
F-3.4	The DataPorts platform establishes machine learning models		✓				✓		

F-3.5	The DataPorts platform enables the federation of data varying in syntax and semantics	✓	✓				✓	✓	✓
F-3.6	The DataPorts platform provides efficient and effective techniques for data wrapping to represent the underlying mechanism to support a selective, release, storage, and analytics on data		✓				✓	✓	✓
F-3.7	The DataPorts platform provides semantic stream processing	✓	✓					✓	✓
F-3.8	The DataPorts platform provides semantic data compression	✓	✓						
F-3.9	The DataPorts platform provides declarative, distributed data aggregation	✓	✓				✓		
F-3.10	DataPorts platform provides an innovative user interface to guide the user in specifying privacy and data access policies	✓					✓	✓	✓
F-3.11	The DataPorts platform provides the data owners data driven analytic services		✓				✓		✓
F-3.12	The DataPorts platform provides the consumers and end users new AI and cognitive applications		✓				✓		
F-3.13	The DataPorts platform provides tools to help decision processes	✓	✓				✓		✓
F-3.14	The DataPorts platform provides smart API for cognitive services	✓	✓				✓		
F-3.15	The DataPorts platform processes streams of records and publish and subscribe to streams of data	✓	✓				✓	✓	✓
F-3.16	The DataPorts Platform provides a framework for semantic interoperability from several sources	✓	✓				✓	✓	✓
F-3.17	The DataPorts Platforms offers an ontology to guarantee semantic interoperability	✓	✓	✓	✓	✓	✓	✓	✓
F-3.18	The DataPorts Platform provides REST-style interaction with Linked Data	✓	✓				✓	✓	✓
F-3.19	The DataPorts Platform provides a data source metadata registry	✓	✓				✓	✓	✓
F-3.20	The DataPorts Platform provides data from a federated database on demand	✓	✓				✓	✓	

F-3.21	The DataPorts Platform provides data from a federated database through publish and subscribe model	✓						✓	✓
F-4.1	Provide a platform to ensure data sharing among the actors operating in diverse supply chains per the defined data governance rules that respect the competitive advantage of all (who access what)	✓					✓	✓	✓
F-4.2	The DataPorts platform provides services to ensure security and protection of shared data	✓	✓	✓	✓	✓	✓	✓	✓
F-4.3	The DataPorts platform ensures the needed anonymization or de-identification mechanisms while preserving the individual features required for effective big data analytics	✓	✓				✓		
F-4.4	The DataPorts platform provides clear rules on how data will be accessed	✓	✓				✓	✓	✓
F-4.5	The DataPorts platform provides flexibility of policies on data distribution	✓						✓	✓
F-4.6	The DataPorts platform provides end to end secure environment	✓	✓	✓	✓	✓	✓	✓	✓
F-4.7	The DataPorts platform ensures full compliance with General Data Protection Regulation (GDPR)	✓	✓	✓	✓	✓	✓	✓	✓
F-4.8	The DataPorts platform enables efficient processing over protected data while preventing (or limiting) access to actual data content by other parties	✓	✓	✓	✓	✓	✓	✓	✓

Table 3 – Functionalities of the platform

2.4 DATAPORTS COMPONENTS

From the previous Table 3 where the scenarios and functionalities have been matched, we can go one step further and showcase which components of the platform are going to be part of the scenarios.

Depending on the requirements of the scenarios because the functionalities of the platform are provided by components, the elements to include are not the same for all of them. The Table 4 lists the usage of the different components of the platform in the scenarios implemented in the project demonstration.

Component	TTO	DSS	VGM	DCN	CPU	AUC	SCO	PNS
Data Access Component	✓	✓				✓	✓	✓
Semantic Interoperability Component	✓	✓				✓	✓	✓
Data Abstraction and Virtualization Component		✓				✓		
Data Governance Component	✓	✓			✓	✓	✓	
Automatic Model Training Engine		✓						
Process-based Analytics Component (*)		✓						
Blockchain infrastructure			✓	✓	✓			

Table 4 – Components and scenarios

(*) Note concerning **process-based analytics component:** The functionalities of this component are fully implemented[1] and validated using extensive benchmark data sets from the research community[2]. This

[1] The implementation of the components is available from:

- **Prescriptive Analytics:** https://git.uni-due.de/abpm/isj
- **Explainable Predictive Analytics:** https://git.uni-due.de/adi645f/cf4bpm-artifacts
- **Explainable Prescriptive Analytics:** https://git.uni-due.de/rl4sas/xrl-dine

See the following research papers:

- **Prescriptive Analytics:** https://git.uni-due.de/abpm/isj
- **Explainable Predictive Analytics:** https://git.uni-due.de/adi645f/cf4bpm-artifacts
- **Explainable Prescriptive Analytics:** https://git.uni-due.de/rl4sas/xrl-dine

[2] See the following research papers:

- **Prescriptive Analytics:** A. Metzger, T. Kley, and A. Palm, “Triggering proactive business process adaptations via online reinforcement learning,” in 18th Int’l Conference on Business Process Management (BPM 2020), Sevilla, Spain (virtual), September 13-18, 2020, ser. LNCS, D. Fahland, C. Ghidini, J. Becker, and M. Dumas, Eds., vol. 12168. Springer, 2020;
- **Explainable Predictive Analytics:** T. Huang, A. Metzger, and K. Pohl, “Counterfactual Explanations for Predictive Business Process Monitoring,” in 18th European Mediterranean & Middle Eastern Conference on Information Systems (EMCIS 2021), December 8-9, 2021, Online, Springer LNBIP 437, pp. 399-413 – Best Theoretical Paper Award
- **Explainable Prescriptive Analytics:**F. Feit, A. Metzger, K. Pohl, „Explaining Online Reinforcement

demonstrates the innovation and progress from the state of the art brought about by the deep AI/ML techniques focused in this component.

The process-based analytics component addresses the following recommendation of PR1: "The focus of the development in data analytics services and cognitive applications is mainly on regression models of time-series data, but tools for other type of analytics tasks or data might also be considered to make the components more generally applicable to possible (future) use cases.". The process-based analytics component works on event logs. An important difference event log data and time series data is the kind of data used for the AI/ML components. While time series data represent values of single or multiple variables at different points in time (such as number of containers or trucks), event log data represent sequences of process events. In addition to a timestamp, a process event typically includes an event label (uniquely identifying the process step) and additional attributes of the event. As such, there is an important semantic difference between a data point in a time series and a process event[3].

By using benchmark data sets from research, the process-based analytics component addresses another recommendation of PR1: "Also, the components of data processing and data analytics services are currently restricted to and fine-tuned for the pilot use cases, the project might consider letting end-users build up their own data processing and analytics (including parameters) pipeline to provide more flexibility." We approached this recommendation from a research angle, meaning that by applying the process-based analytics component to benchmark data sets from research, we demonstrated the generalizability of results.

While the potential use of the component as part of the two indicated scenarios is described in the remainder of this deliverable, due to the limited volume and variety of the data that was collected via the DataPorts platform, it was not possible to assess and demonstrate the benefits of the component in the setting of the two concrete use scenarios.

2.5 SECURITY AND QUALITY ASSURANCE

The security and quality assurance process consisted in several tasks and activities performed along the project with the aim to secure the DataPorts platform.

The first task was a Risk Assessment, which is the process of identify, analyse, and evaluate the risks that may affect the DataPorts platform and impact the confidentiality, integrity or availability of DataPorts data or functions. By carrying out this task, the potential attacks, and risks in DataPorts were identified and measures to address them were proposed.

The following task was a Security Code Review, which is the process of reviewing the code through several tools and scans. By reviewing the code, vulnerabilities in the code were identified. These vulnerabilities constituted a risk of attack on the platform, so they were analysed and assessed. Also, proper countermeasures were proposed.

The following task was a Penetration Test, which is the process of carrying out a dynamic test to the platform. All vulnerabilities that the DataPorts platform present were identified, analysed, and evaluated. Each vulnerability presents a risk that was assessed. Also, countermeasures were proposed for addressing the vulnerabilities of the platform.

Learning Decisions of Self-Adaptive Systems“, in 3rd Int’l Conference on Autonomic Computing and Self-Organizing Systems (ACSOS 2022), Virtual, CA, USA, September 19-23, 2022, R. Casadei, E. Di Nitto, I. Gerostathopoulos, D. Pianini, I. Dusparic, T. Wood, P. R. Nelson, E. Pournaras, N. Bencomo, S. Götz, C. Krupitzer, and C. Raibulet (Eds.), IEEE, 2022, pp. 51-60 –Best Paper Nominee

[3] A. Metzger, A. Neubauer, P. Bohn, and K. Pohl, “Proactive process adaptation using deep learning ensembles,” in 31st Int’l Conference on Advanced Information Systems Engineering (CAiSE 2019), Rome, Italy, June 3-7, 2019, ser. LNCS, P. Giorgini and B. Weber, Eds., vol. 11483. Springer, 2019, pp. 547–562

The following task was a Security Revision, which is the process of testing the platform and to verify whether the security requirements defined for the platform and the components have been followed. Verifying the platform is compliance with the security requirements defined.

The following task was to deploy an Identity and access manager (IAM), which is responsible of the management of all the identities in the platform and provides an authentication system used internally by the components and in the front-end of the components to authenticate the users in a secure way.

Also, the definition, implementation and testing of governance rules for data sharing, as well as, the definition, implementation and testing of smart contracts in the blockchain are part of the security and quality assurance.

The table below presents the actions done regarding the security and quality assurance tasks.

Time	Actors	Actions
M01–M06	EVR	System identification during the risk assessment.
M06-M12	EVR	Risk identification, analysis and evaluation of risks. Selection of treatment options and countermeasures for facing identified risks.
M06-M12	IBM, EVR and CERTH	Definition of approach for Blockchain for governance rules. Selection of Fabric version and development language for chaincodes. Definition of a Minimum Viable Product (MVP) for VGM, CPU and data governance use cases
M06-M12	IBM, OTE, EVR, ICCS, CERTH	Definition of the environment and components necessary for traceability and secure sharing of data.
M12-M20	IBM, EVR and CERTH	Definition of APIs, authorization roles and data access, data model and smartcontracts for each use case Development of the MVP functionalities: frontend, api's and specific chaincodes for each use case Deployment of 3 blockchain networks
M12-M20	IBM, OTE, EVR, ICCS, CERTH	Definition of the necessary mechanisms for the traceability and security of data and users in the blockchain network.
M12-M20	EVR	Definition of security measures, scope and methodology of the pentest, security code review and security testing of the DataPorts platform. Definition of the data anonymization methodology.
M20-M30	CERTH, EVR and IBM	Development of the functionality not included in MVP 1 for each use case (VGM, CPU, Data governance) Integrate the Data Governance Services into the DataPorts platform Verification in smart contracts of the validity of the identity provided by the identity manager of the platform
M20-M30	CERTH, EVR and IBM	Monitoring and register of transactions in the logger chaincode (clearing house)
M20-M30	EVR	To carry out the pentest, the security code review and the testing of pilots. All the results are included in the deliverable.

Time	Actors	Actions
M20-M30	EVR	Deployed an IAM system that integrates with the platform components as an authentication and access mechanism.

Table 5 – Cybersecurity Plan Reporting Table

2.6 DATA MODELS

The data modelling is a process used to define and analyse data requirements needed to support the business processes within the scope of the corresponding information systems involved in the use cases. The data model organizes data elements and standardizes how the data elements relate to one another. Since data elements document real life entities, places and things and the events between them, the data model represents the reality. Therefore, the process of data modelling followed in the DataPorts project involved the partners focused on the design (WP2) and in the implementation (WP3) of the platform working closely with end user's / business stakeholders (WP5), as well as potential users of the platform. Mainly, from M12 to M29, periodic meetings were held with all these partners to work together on this common goal.

The DataPorts Data Model is a key element to enable the interoperability aims of the platform, since it defines the common representation of the information in the DataPorts platform. The common Data Model is currently hosted in the DataPorts Git repository[4], which contains the corresponding documents describing the syntax of the entities involved, as well as the documentation and examples. The DataPorts Data Model has been described in the software deliverable "D3.5 - Data processing services M27" [5]and has been adopted and validated in the use cases.

The Data Model has been defined considering the application domain, the needs of the pilots and the existing ontologies and data models related with the domains that must be covered by the DataPorts Data Model. The methodology followed to define the Data Model comprises the steps listed in the Table 6.

Time	Actors	Actions
M6 -15	UPV / TRX	Technology selection and methodology and steps definition.
M15-M22	WP2 / WP3 /WP5 partners	Periodical meetings and workshops to get feedback from the use case owners' expertise: • Identify the concepts involved in the DataPorts use cases. • Classify the concepts as entities, attributes, and relationships. • Represent these relationships in a technical view.
M15-M22	WP5 partners	Analyse the ontologies and data models (if this happens) currently used in each of the scenarios described in the pilots.
M18-M24	UPV	Draft version of the DataPorts Data Model that unifies the information identified by each use case. • High-level view of the Data Model. • Classify the entities of the common Data Model into a set of domains and subjects
M22-M24	UPV	Git repository structure creation and collaboration guidelines.

[4] https://github.com/DataPortsProject

[5] https://dataports-project.eu/deliverables/

Time	Actors	Actions
M22-M24	WP2 / WP3 /WP5 partners	Analyse the existing ontologies and data models from standardization committees that could be reused to define the DataPorts Data Model.
M22-M25	WP2 / WP3 /WP5 partners	Data Model Version 1.0: • Detailed specification of the Data Model.
M25-M32	WP5 partners	Taking as reference the first version of the Data Model: • Data Model improvement and integration in the use cases. Each Data Model folder defined in the Git Repository is going to follow this lifecycle: Incubated / Harmonized / Adopted. • Data Model Version 2.0. This version considers the improvements made during the initial integration in the pilots. This version of the Data Model also includes JSON-LD context documents and is compatible with NGSI-LD.
M30-M36	WP5 partners	Development and deployment in the pilots of the final versions of the agents.

Table 6 – Data Model Plan Reporting Table

The most relevant concepts from the common Data Model will be uploaded to GitHub[6] to make them available to everyone interested in the mechanisms of interoperability of DataPorts. In addition, some concepts from the common Data Model that can be used for a wide community of open-source developers will be uploaded to the Smart Data Models initiative repository as a contribution from DataPorts. Currently, these classes are incubated in that location, waiting to pass the corresponding reviews to be adopted.

2.6.1 Data Models Matrix

The Table 7 – Data models and scenarios shows which data models are used in each scenario. This means that an agent will get the data from the source and transform it according to the schema definition.

Data Model	TTO	DSS	VGM	DCN	CPU	AUC	SCO	PNS
Trackable Event	✓			✓		✓	✓	
Posidonia Event								✓
PortCall	✓	✓						
StoredItem		✓		✓				
Shipment	✓			✓				
PortGateEntry	✓							

[6] https://github.com/DataPortsProject/datamodel

Data Model	TTO	DSS	VGM	DCN	CPU	AUC	SCO	PNS
PortGateExit	✓							
Customs		✓						
MobilityData						✓		
CommercialShipCall						✓		
Booking					✓	✓		
Parking						✓		
ExpectedCruiseShipCall						✓		
GateEvent						✓		
TravelTime						✓		
TrafficDetection						✓		

Table 7 – Data models and scenarios

3 PORT OF VALENCIA

This section describes the five scenarios defined for the Valencia pilot including a description, flow of information, data sources, action plans, applications, etc.

For each of the scenarios is described which DataPorts components are used, and which are their interactions.

3.1 APPLICATIONS DEPLOYMENT

The port of Valencia pilot defined five different scenarios. Three of these scenarios are deployed in the same infrastructure, while two of them, the data sharing and analytics scenario and the IDS, are deployed in a different environment.

The three scenarios are in three virtual machines on cloud working in a cluster. In order to manage the cluster, there is an instance of Kubernetes called Rancher. Over Rancher there are all the needed components for the operation of the applications, including the blockchain infrastructure, the MongoDB database, and the front-end and back-end of the application. These components are replicated in the different pods, the replicas for the MongoDB database and two for the application code.

The blockchain network is based on Hyperledger Fabric 1.4.0. It includes the smart contracts necessary for the storage, access, modification, and deletion of the data in the ledger. In addition, blockchain client is included in the code. Finally, the blockchain credential are in several wallets stored in Mongo DB.

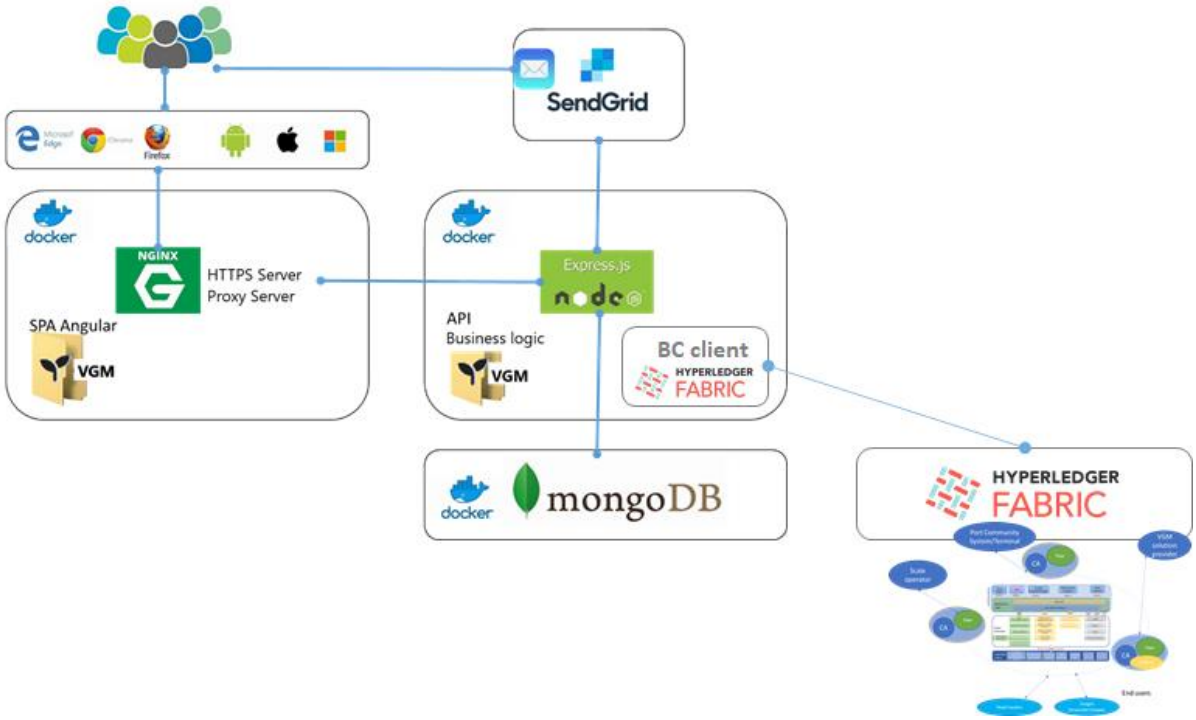


Figure 2 – Valencia port scenarios infrastructure 1

For the last scenario, one instance of the Automatic Model Training Engine has been deployed in a virtual infrastructure to enable the creation of an Artificial-Intelligence-based cognitive service to tackle a specific Ports' business KPI. To easy the deployment in any infrastructure, the component was dockerized. To carry out the services training phase, secure communications processes implemented in Dataports platform are performed, namely; communications with Data Governance to obtain permissions for a specific user of AMTE, information exchange with Data Abstraction and Virtualization to obtain metadata and pre-processed

datasets, and subscriptions with Semantic Interoperability. Finally, predictive results are provided through a secure API, so end user may make use of the predictions performed by the trained Cognitive Services.

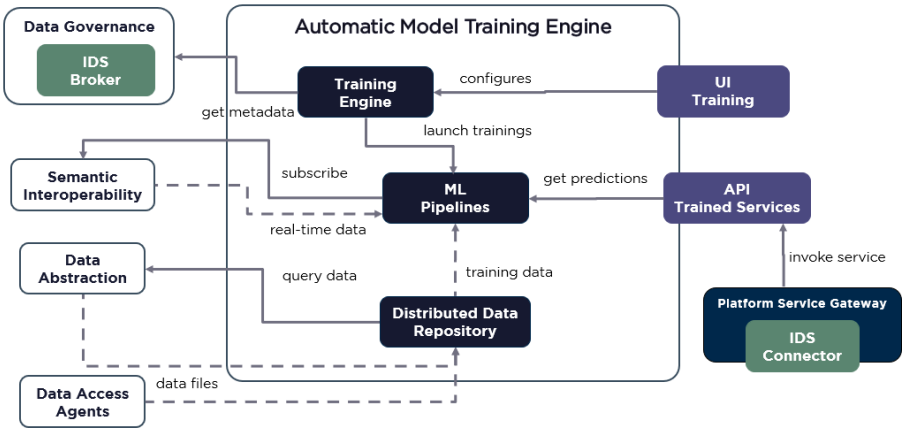


Figure 3 – Valencia port scenario infrastructure 2

3.2 TRACKING OF TRANSPORT OPERATIONS

3.2.1 Scenario Description

This scenario defines DataPorts as a hub for tracking events in the context of ValenciaPort to which port stakeholders could subscribe to. The data providers publish relevant information related to a unique identifier relevant in a maritime logistic chain: a container identification number, a ship identifier, or a goods identifier. Such published events are available to data consumers using the DataPorts data governance framework. For instance, a freight forwarder using DataPorts subscribes to every event related to a container identification number and/or the vessel transporting such container. If access is granted by the owners of the data, this freight forwarder receives in near real-time such events, which can then be used to improve its transport operations. The freight forwarder could, for example, be notified when the vessel with the container has arrived at the port, or when the container has left the port premises by truck, etc.

DataPorts provides a single access point for all the relevant events without the need of implementing specific integration or authentication mechanisms for each data provider. As every event data/message follows the data model already defined by DataPorts, also the process of understanding the received data is simplified: there is no need of understanding the underlying information system of the data provider.

The Figure 4 depicts the workflow and interactions of the scenario:

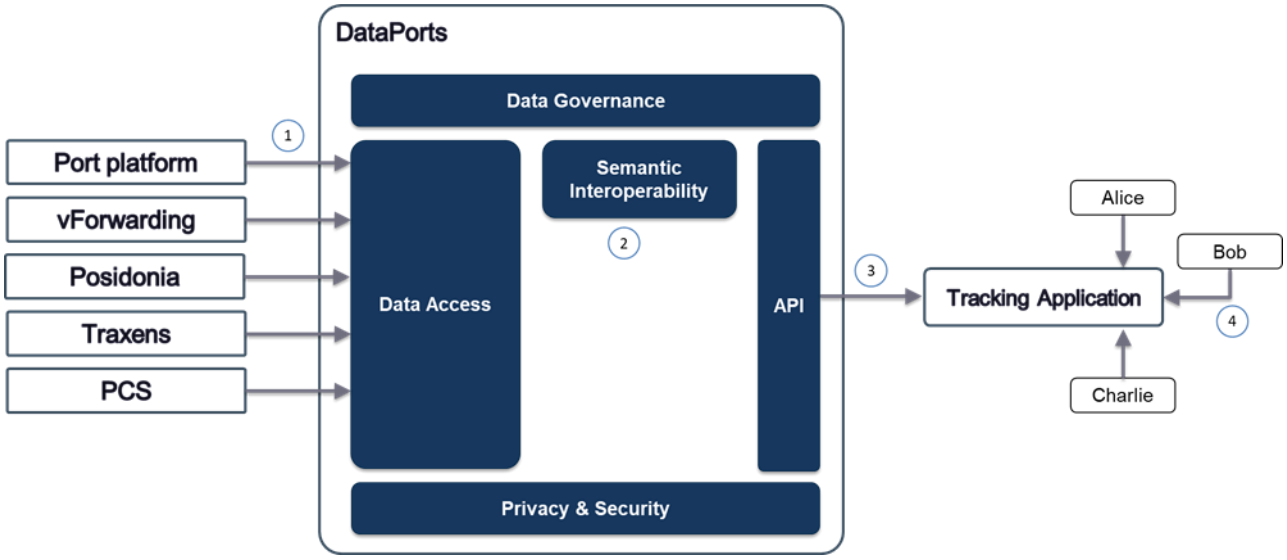


Figure 4 – Tracking of Transport Operations workflow

The Table 8 lists the interactions, events and processes of the scenario:

Step	Description
1	The Data Access component has an agent for each of the data sources to receive real-time data about container location or transport events
2	The Semantic Interoperability component checks with the Data Governance component if the user has permission to the requested data and transform it to the common model
3	The data is sent to the subscribed applications through the common API
4	Alice uses the Tracking application to get the location of all her containers Bob uses the Tracking application to get the location of all his goods Charlie uses the Tracking application to get the transport operation status

Table 8 – Tracking of Transport Operations Scenario Description

Initially, three applications were defined in the deliverable D5.3. However, these applications share the same data, roles, users, etc. so finally they are three different views of the same application.

The datasets shown on Table 9 are used in this scenario:

Datasource	Description of data
Valencia port authority platform	Gate access data including truck plates and containers number
vForwarding	Cargo and transport operations data from the freight forwarder
Posidonia Operations	Vessel events in the port of Valencia
Traxens	Container location for the containers monitored
~~**TradeLens**~~	~~Container transport events related to the port of Valencia~~
PCS	Road transport transactions in the Valencia port

Table 9 – Tracking of Transport Operations Scenario Datasets

TradeLens has been removed from the list of data sources because the owners decided to stop the platform at the beginning of 2023. During the pilot demonstration TradeLens will not be available.

3.2.2 DataPorts roles

The Table 10 – Tracking of Transport Operations Roles shows the organizations that take part in the scenario implementation and their roles:

Organisation	Role
VPF	Fundación Valenciaport is the scenario leader, provides the infrastructure and knowledge to successfully run the demo, and develops the application
PRO	Prodevelop develops the agents to acquire the data at port premises and deploys the Data Access component
UPV	UPV is in charge to transform data to a common data model with the Semantic Interoperability component
EVR	Everis deploys the data governance component and manage the permissions
TRX	Traxens integrates the container position from its platform

Table 10 – Tracking of Transport Operations Roles

3.2.3 Activities carried out

The Table 11 contains the tasks involved in the implementation of the scenario:

Time	Actors	Actions
M20-M24	VPF	Provide the scenario specification with the support of all involved partners
M24-M32	VPF, PRO, UPV, EVR	Deploy the necessary infrastructure for the scenarios and the DataPorts Components
M32-M36	PRO, VPF, TRX	Development of the Agents for all the data sources
M28-M36	VPF	Develop the three applications

Table 11 – Tracking of Transport Operations Action Plan Reporting Table

3.2.4 Data Integration

The aforementioned data sources have been connected with the platform with the development of the corresponding agents. The complete list of the agents developed for this scenario is shown in the Table 12 – Agents implemented in this scenario:

Agent	Type	Description
PCS Road	On demand	This agent imports historical data about interactions with deposits, indicating who is the depositary, and who is the cargo depositor, and also the date on which the action was carried out. Imported data is transformed into the StoredItem data model and split into two different objects (acceptance and release) which are stored in separate collections in Cygnus
Port Authority - Entry	Publish / Subscribe	This agent periodically imports (on a 5 minute basis) information regarding accesses through the entry gate by querying a REST endpoint at https://greenp.digiport.com.es Each entry event is transformed into two different data models, PortGateEntry and TrackableEvent, and stored in Cygnus

Agent	Type	Description
Port Authority - Exit	Publish / Subscribe	Similar to Entry agent but importing events happening at the Port's exit gate. Events are also transformed into two different data models, PortGateExit and TrackableEvent, and stored in Cygnus
vForwarding	Publish / Subscribe	This agent exposes and endpoint that can be used by an external system to push shipments related data. The information is mapped using the Shipment data model and stored in Cygnus.
Posidonia Operations	Publish / Subscribe	This agent subscribes a RabbitMQ broker for Posidonia Operations events. These events are translated using the TrackableEvent data model.
Smart Containers Geolocation	Publish / Subscribe	This agent queries periodically (defaults to 15 minutes) and external REST endpoint exposed at https://ws.traxens.com/traxwsext/cxf/external and imports events related to geolocation of a specific set of containers. Imported data is transformed using the TrackableEvent data model and stored in Orion
Smart Containers Geofencing	Publish / Subscribe	Similar to the Geolocation agent, but in this case the agent imports events related to containers entering or departing predefined georeferenced zones.
Smart Containers Door Opening	Publish / Subscribe	Similar to the two previous agents, but in this case the agent imports container door events (opening and close)

Table 12 – Agents implemented in this scenario

3.2.5 Applications

The Table 13 describes the applications that are part of the scenario that interact with the platform and should be modified or implemented:

Application	Action	Status
Tracking Application	New application	100%
A shipping line is interested in monitoring all its own containers. The application allows real-time location of the containers. An importer or exporter can access to the cargo tracking data that any data provider is sharing. A freight forwarder can monitor the status of all the transport operations that is managing. It includes location events, status, delays, etc.		
User documentation can be found in Annex A Section 9.1.1		

Table 13 – Tracking of Transport Operations Applications

This section shows the use of the application by the stakeholders participating in the transport process.

Shipments

The freight forwarder can see the list of all the shipments managed including all the all the messages received if we expand one of them.

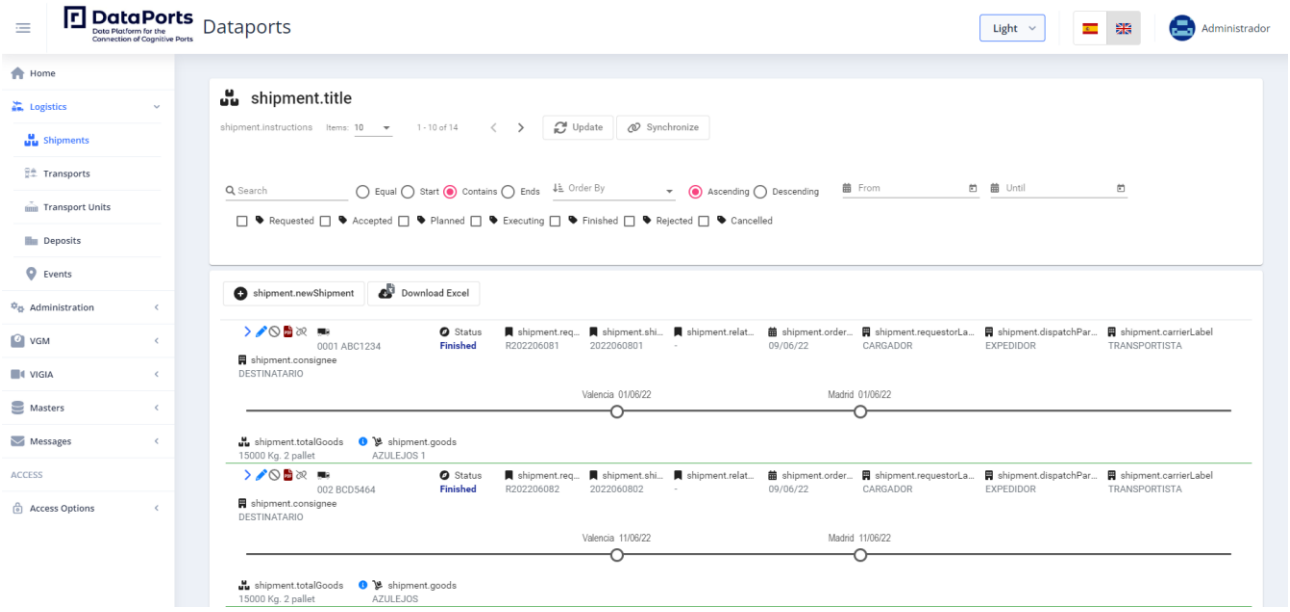


Figure 5 – List of shipments

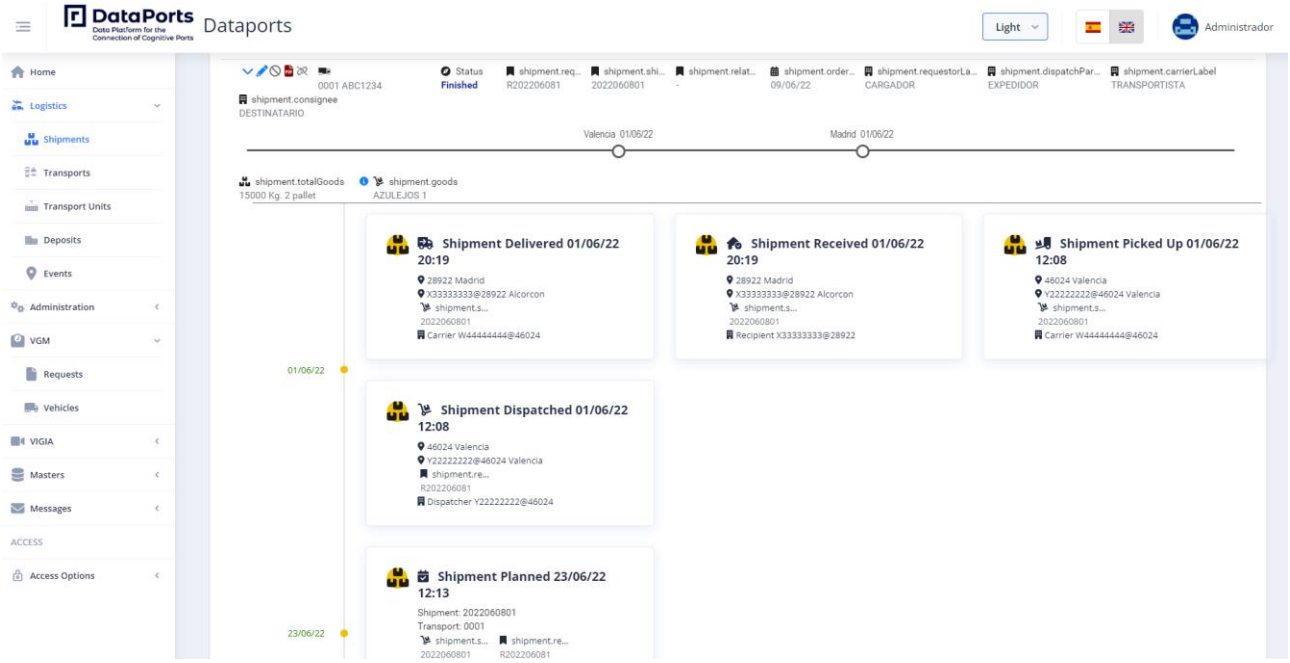


Figure 6 – Shipment individual messages

Transport

The freight forwarder can see the transports included in the previous shipments. If a shipment is divided in three different transport services (road, train, and maritime) these are showed separately.

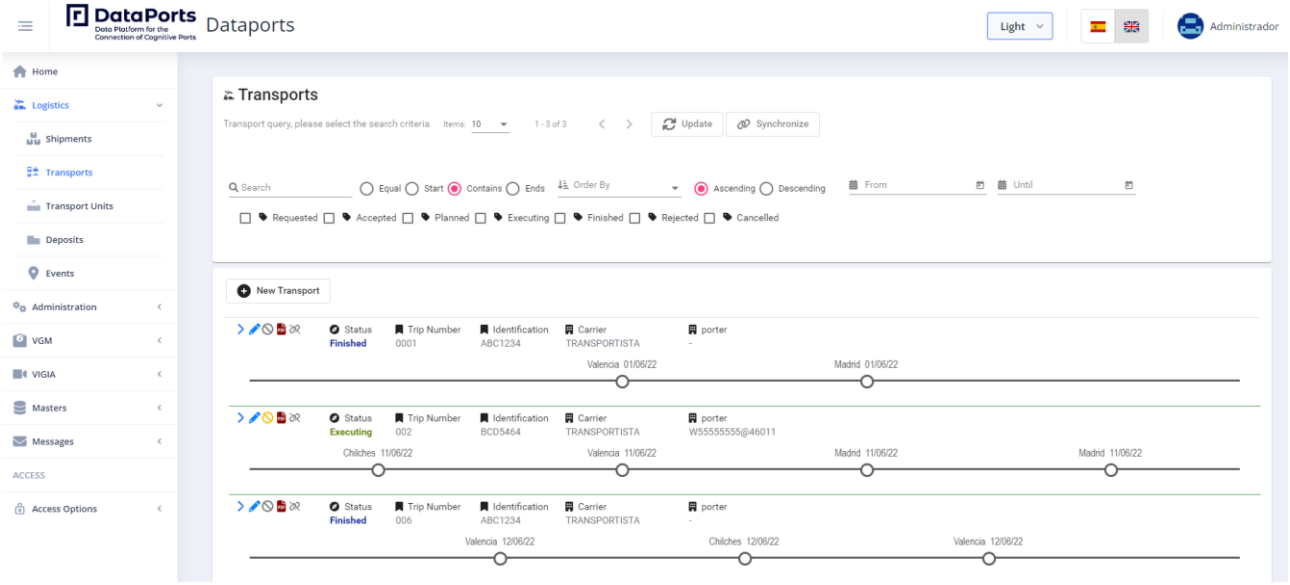


Figure 7 – Shipment divided by transports

Transport Units

The freight forwarder or the shipping line can see the list of containers from the registered shipments.

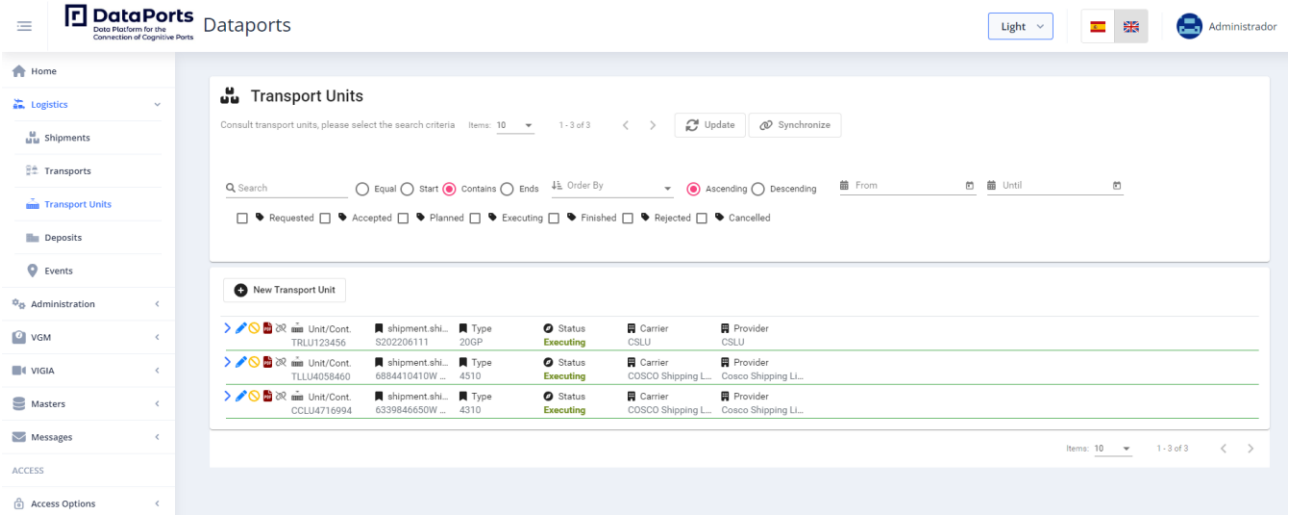


Figure 8 – List of containers used in the shipments

Deposit

The freight forwarder can see the gate in and gate out orders from the registered shipments.

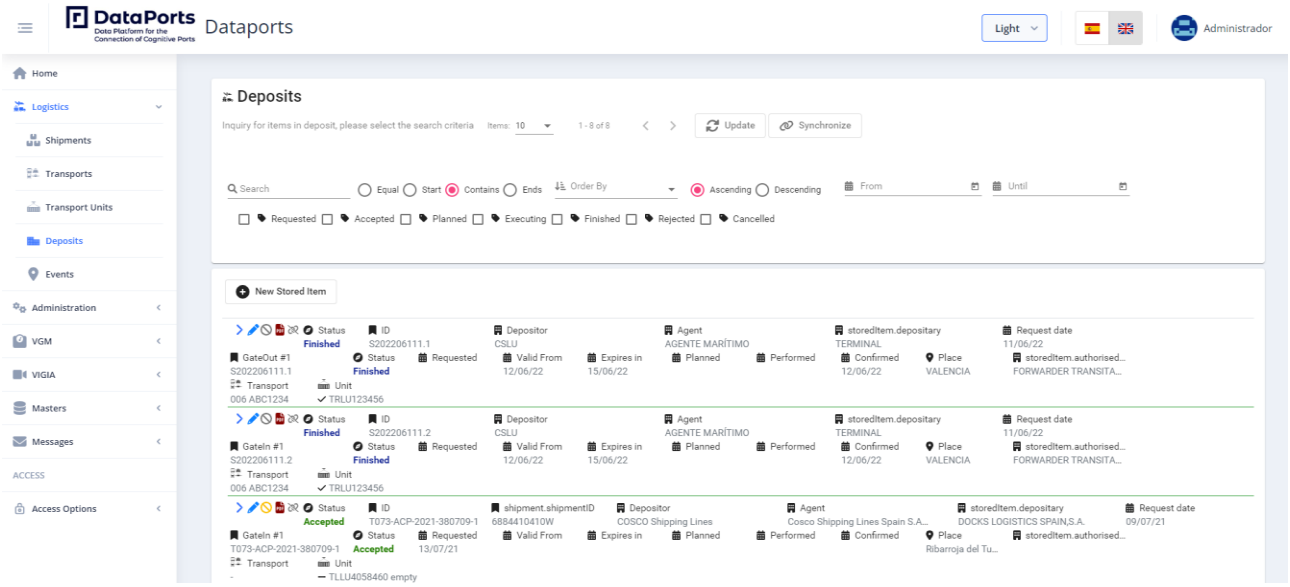


Figure 9 – Gate in and gate out orders in the shipments

Events

The "Events" section shows the individual operations of each shipment. In addition, it also includes events from other data sources such as vessel location from Posidonia, container location from Traxens, and truck entering and leaving the port.

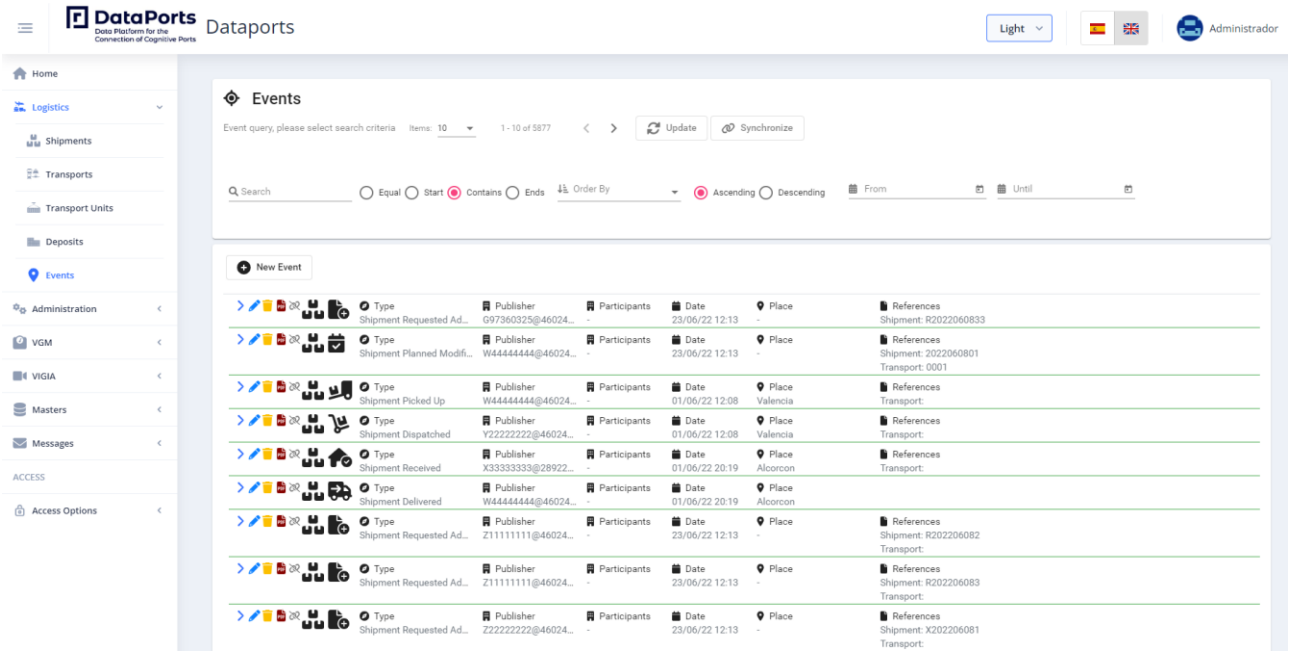


Figure 10 – List of events integrated with other sources

3.3 PORT AUTHORITY DATA SHARING AND ANALYTICS SERVICES

3.3.1 Scenario Description

The Valencia port authority requires to receive data from different companies in the port to monitor and control the activity. For that, it uses different systems and channels to gather historical data. Furthermore,

the port authority is interested in analysing what will happen in the following days and months to provide statistical reports to other companies operating.

Some of this data is received through the ValenciaPort PCS, but this system is only focused on transport transactions. At this moment, there is no standard way to share data with the Valencia Port Authority: this data is sent by different communication channels and using several data formats. Therefore, a specific process for each data source is required, and it is not straightforward to build such services.

The DataPorts platform improves the current data sharing approach. Using DataPorts historical data is processed and transformed into a common data format. This metadata is processed within the platform to perform predictions which can be useful for different purposes. This information is used to provide analytical services in top of such data to help the port stakeholders.

As an example, for this scenario, we gather data related with the vessel calls. Using such data, it is feasible to forecast the estimated time of arrival for a vessel. We also foresee the use of data from the road transport operations recorded in the ValenciaPort PCS. The resulting analytical service is made available to rest of the port stakeholders using the DataPorts platform's interoperability and governance mechanisms.

The Figure 11 depicts the workflow and interactions of the scenario:

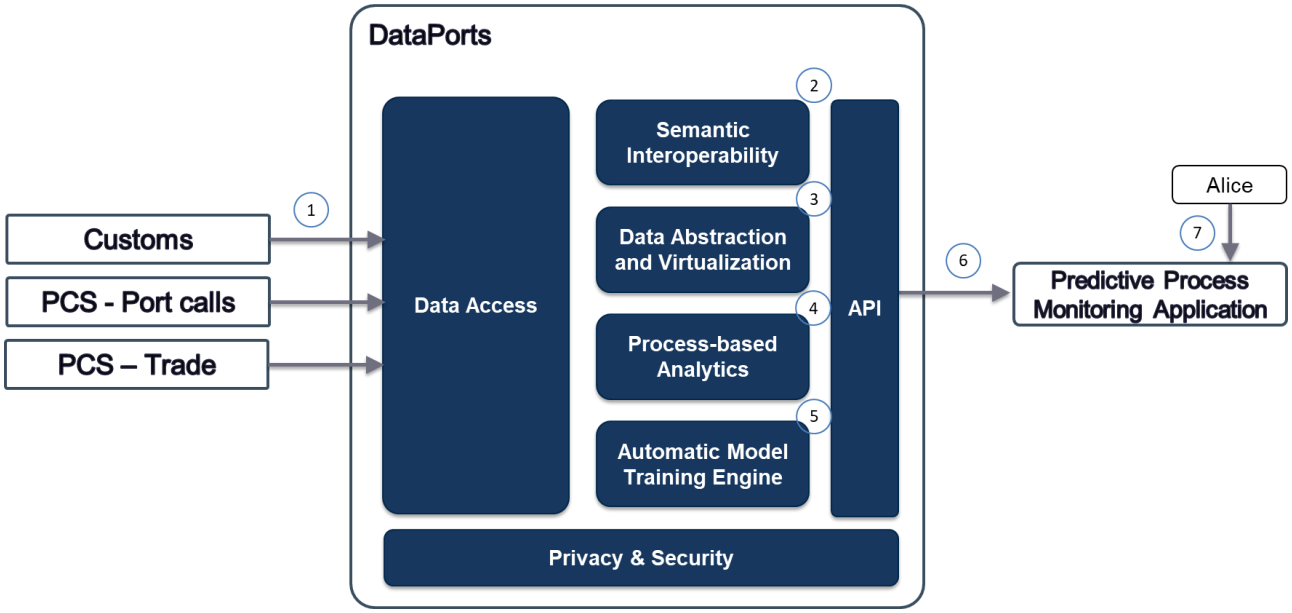


Figure 11 – Port Authority Data Sharing Workflow

The Table 14 lists the interactions, events and processes of the scenario:

Step	Description
1	The Data Access component asks for data about Vessels' port calls and container trade through an Agent
2	The Semantic Interoperability component checks with the Data Governance component if the user has permission to the requested data and transform it to the common model
3	The Data Abstraction and Virtualization component prepares the data inputs for the next components
4	The Process-based Analytics component optimizes the business process
5	The Automatic Models Training Engine searches the best ML predictive model to make a forecast based on the previous training data
6	The resulting data is sent to the subscribed application through the common API

7	Alice uses the Predictive Process Monitoring application to get the predictions

Table 14 – Port Authority Data Sharing Scenario Description

The datasets shown on Table 15 are used in this scenario:

Datasource	Description of data
Customs	Anonymised Container trade data in Spain
PCS	Vessel port calls
PCS	Container trade data in the port of Valencia

Table 15 – Port Authority Data Sharing Scenario Datasets

3.3.2 DataPorts roles

The Table 16 Table 10 – Tracking of Transport Operations Rolesshows the organizations that take part in the scenario implementation and their roles:

Organisation	Role
VPF	Fundación Valenciaport is the scenario leader, provides the infrastructure and knowledge to successfully run the demo
PRO	Prodevelop deploys the Data Access component and create the agents
UPV	UPV is in charge to transform data to a common data model with the Semantic Interoperability component
ITI	ITI deploys the Automatic Models Training Engine component to allow the creation and use of AI cognitive services based on the data available in DataPorts platform
ICCS	ICCS deploys and configure the Data Abstraction and Virtualization component
UDE	UDE deploys and configure the Process-based Analytics component

Table 16 – Port Authority Data Sharing Roles

3.3.3 Activities carried out

The Table 17 contains the tasks involved in the implementation of the scenario:

Time	Actors	Actions
M20-M24	VPF	Provide the scenario specification with the support of all involved partners
M24-M26	VPF, PRO, UPV, ITI, ICCS, UDE	Deploy the necessary infrastructure for the scenarios and the DataPorts Components
M25-M28	PRO	Development of the Agents for all the data sources
M20-M28	ITI	Implement the data pipelines to generate the cognitive services based on Port Authorities needs
M28-M34	ITI	Develop the application

Table 17 – Port Authority Data Sharing Acton Plan Reporting Table

3.3.4 Data Integration

The aforementioned data sources have been connected with the platform with the development of the corresponding agents. The complete list of the agents developed for this scenario is shown in the Table 18 – Agents implemented in this scenario:

Agent	Type	Description
PCS Port Calls	Publish / Subscribe	This agent imports port calls (a vessel's visit to the port for a period of time, in order to perform some kind of useful function, like the loading or unloading of goods) by querying periodically (by default, every minute) to a REST endpoint exposed at https://www.valenciaportpcs.net/portcalls/search/ExportBerths Imported data are transformed to PortCall data model and stored in Orion
PCS Port Calls	On demand	Similar to the "Publish/Subscribe" flavour, this agent imports historical port calls with a granularity of 1 month. Imported data is stored in Cygnus.
PCS Trade	On demand	This agent imports trade data generated by the Port systems and available as CSV files. The agent transforms source entities into the Customs data model and stores the data in Cygnus
Customs	Publish / Subscribe	Due to the large volumes of data from the source datasets at the AEAT's website, this agent has been decommissioned in favour of the "on demand" one.
Customs	On demand	This agent imports detailed information on aggregated statistics of the external commerce recorded in the Spanish customs provided by the Spanish Tax Agency (AEAT) and publicly available at the AEAT's website. The agent can be run with a granularity of one month and the imported data is stored in Cygnus using the Customs data model

Table 18 – Agents implemented in this scenario

3.3.5 Applications

The Table 19 describes the applications that are part of the scenario that interact with the platform and should be modified or implemented:

Application	Action	Status
Predictive Process Monitoring Application	New application	100%
The Valencia port authority needs to receive data from different entities in the port community for monitoring and statistics purposes. The application provides predictions about vessel calls and container trade.		
User documentation can be found in Annex A Section 9.1.2		

Table 19 – Port Authority Data Sharing Applications

The illustration of the Predictive Process Monitoring Application is described below.

Cognitive Services List:

The following figure shows the main screen of the web user interface, which presents a list of the created cognitive services along with their status, namely running, stopped, deployed… Additionally, a selectable menu is provided on the left-hand side (see Figure 12):

Figure 12 – Predictive Process Monitoring Application: Cognitive services list

Cognitive services creation wizard:

The creation wizard leads the user through the creation process of a new cognitive service in an easy manner. The wizard provides several cognitive services to achieve a specific type of prediction, such as the forecast of the ETD of a vessel or the calculation of the received tons of a specific good for the next months.

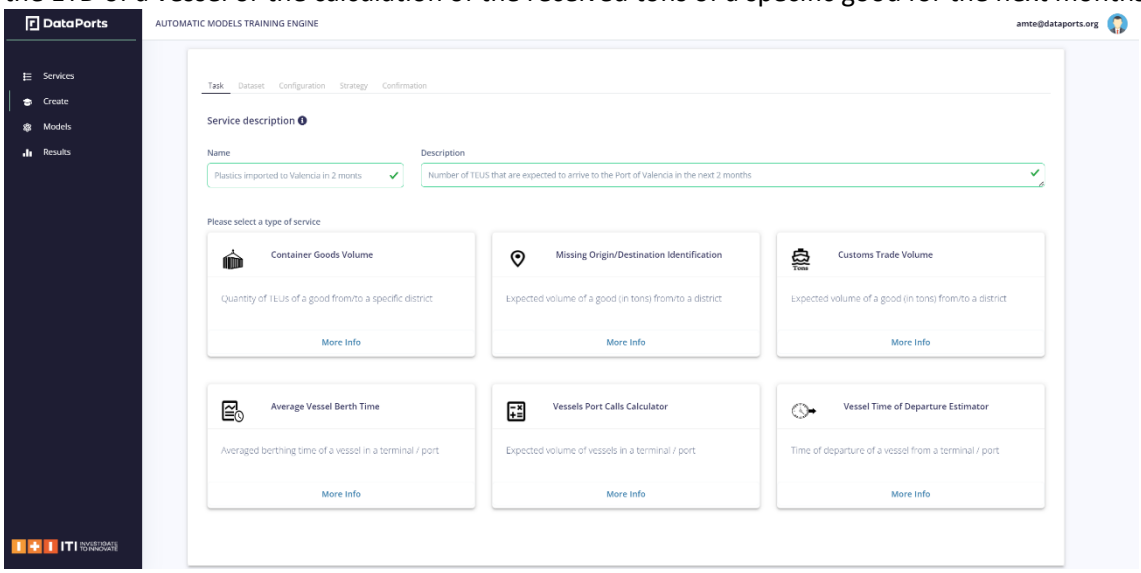


Figure 13 – Predictive Process Monitoring Application: Creation wizard

Machine Learning models tracking and analysis:

To investigate the collection of machine learning models trained for each cognitive service, the tab “Models” shows a list of the services along with some associated statistics. Additionally, to delve into each of the services, a deeper analysis option is provided by clicking the button “More Info”.

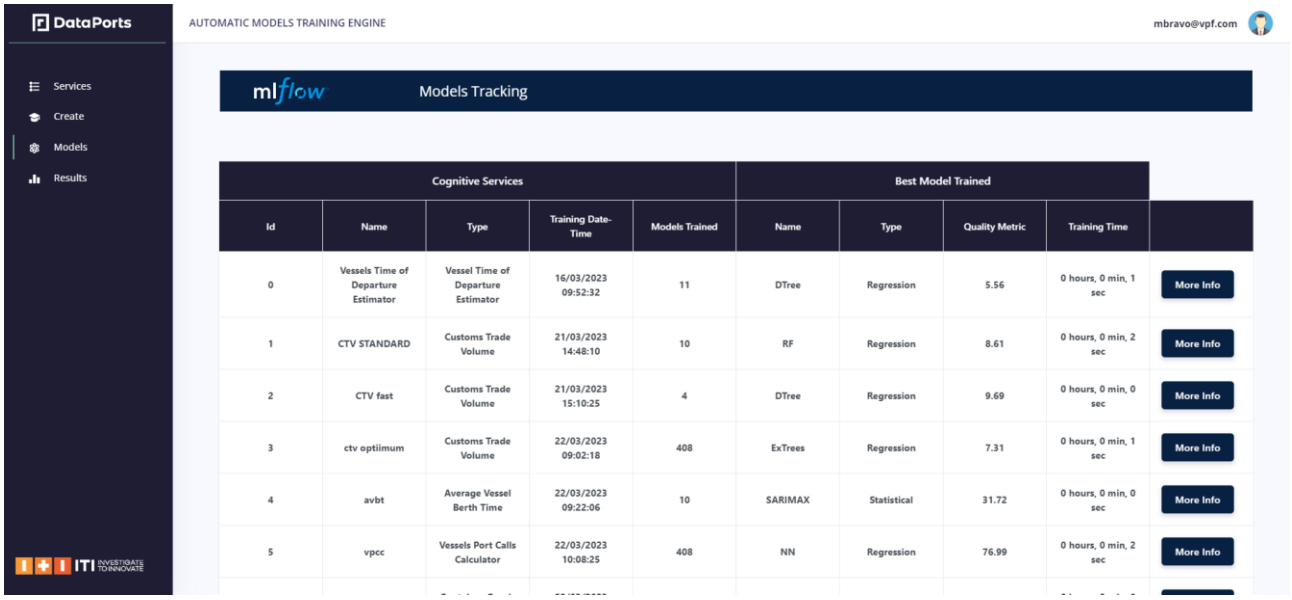


Figure 14 – Predictive Process Monitoring Application: Models tracking

Analysis of the results of a cognitive service:

Once the cognitive services have been trained, their outcomes can be visualized on the option 'Results' of the left panel. The results section is divided into 3 types of cognitive services:

(I) Results of "Port Services"

The data showed is a small extract of the real data extracted from the Port of Valencia in Real Time (to analyse the whole table of vessels, click the button **"View Full table"**), whereas the last column is calculated by the best predictive model trained in the cognitive service, and represents the expected time of departure of a vessel as illustrated in the next picture:

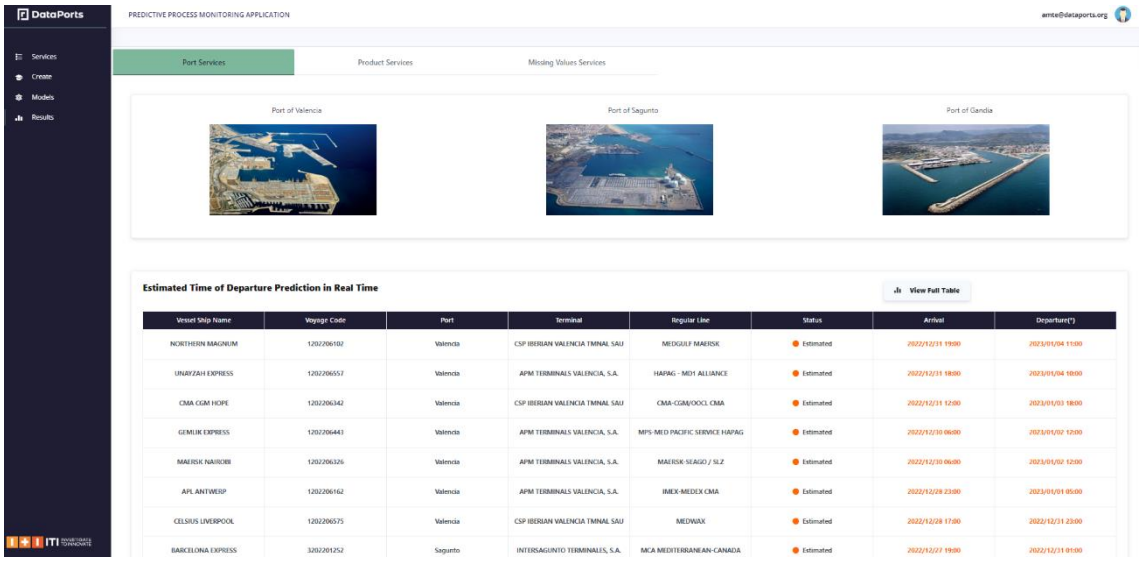


Figure 15 – Predictive Process Monitoring Application: Results – Port Services I

In Figure 17, the graph on the bottom-left represents the estimated occupation of ports/terminales based on the selected trained service of type Vessels Port Calls Calculator, whereas the graph on the bottom-right shows the expected average berthing time based on the selected trained service of type Average Vessel Berth Time, as illustrated in the next picture:

Figure 16 – Predictive Process Monitoring Application: Results – Port Services II

(II) Results of "Product Services"

In Figure 17, the graph on the top-left represents the expected values in Tons of the selected trained service of type Customs Trade Volume, whereas the graph on the top-right shows the forecasted values in TEUS of the selected trained service of type Container Goods Volume, as illustrated in the next picture:

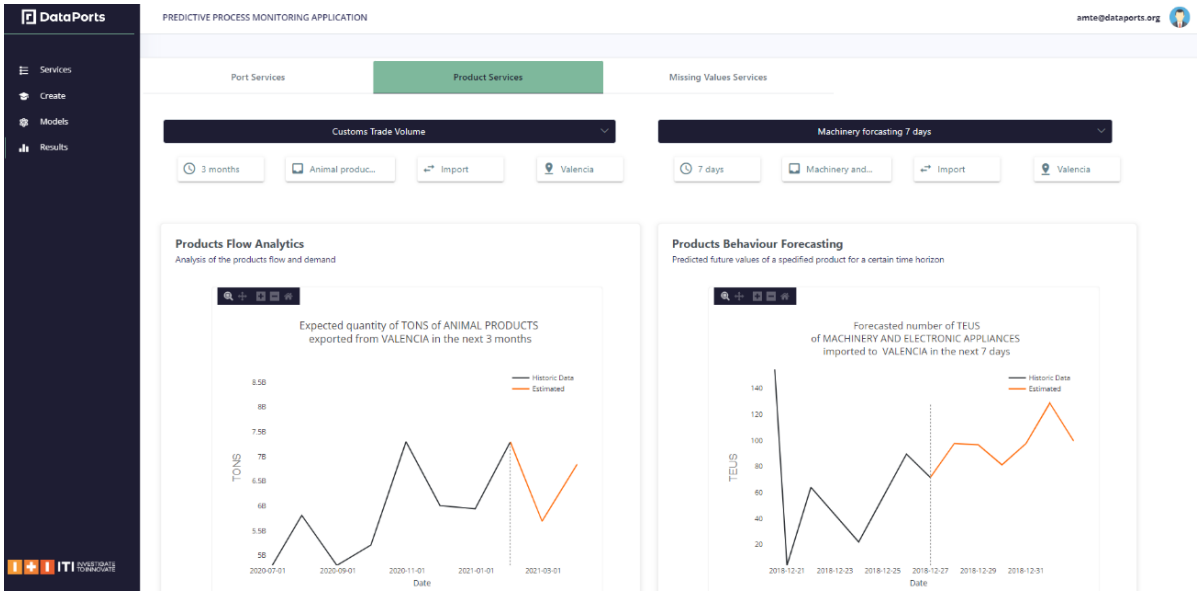


Figure 17 – Predictive Process Monitoring Application: Results – Product Services I

In Figure 18, the graph on the bottom-left represents the countries ranking based on the selected trained service of type Customs Trade Volume, whereas the graph on the bottom-right shows a ranking of all the products, based on the selected trained service of type Container Goods Volume, as displayed in the picture below:

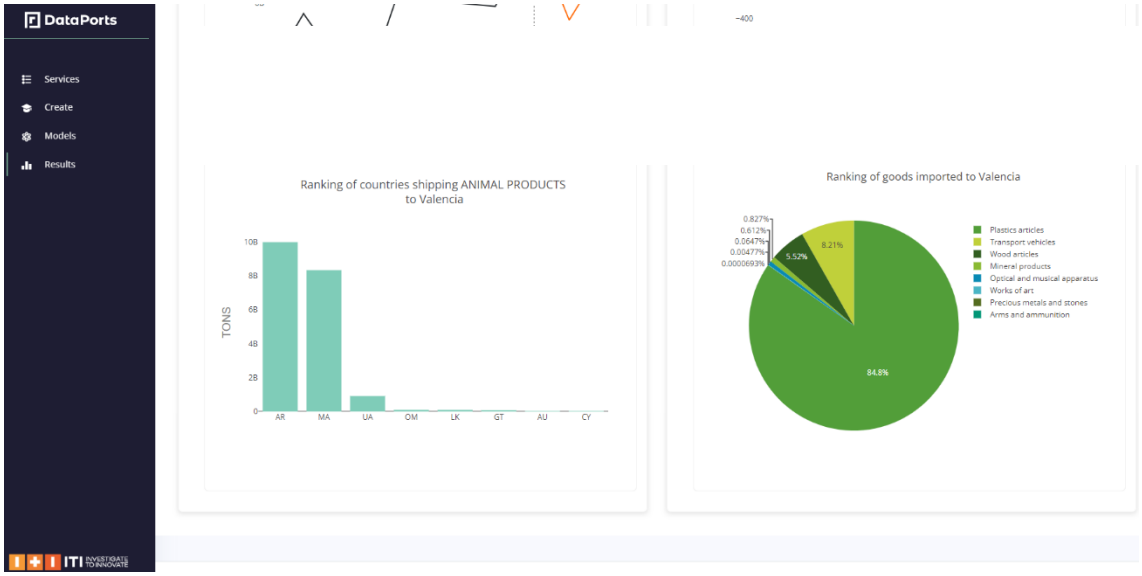


Figure 18 – Predictive Process Monitoring Application: Results – Product Services II

(III) Results of "Missing Values Services"

In Figure 19, the graph on the left represents the accuracy of the best predictive model trained for the service of type Missing Origin/Destination Identification. The graph on the right, displays the percentage of missing values filled up for each of the possible categories.

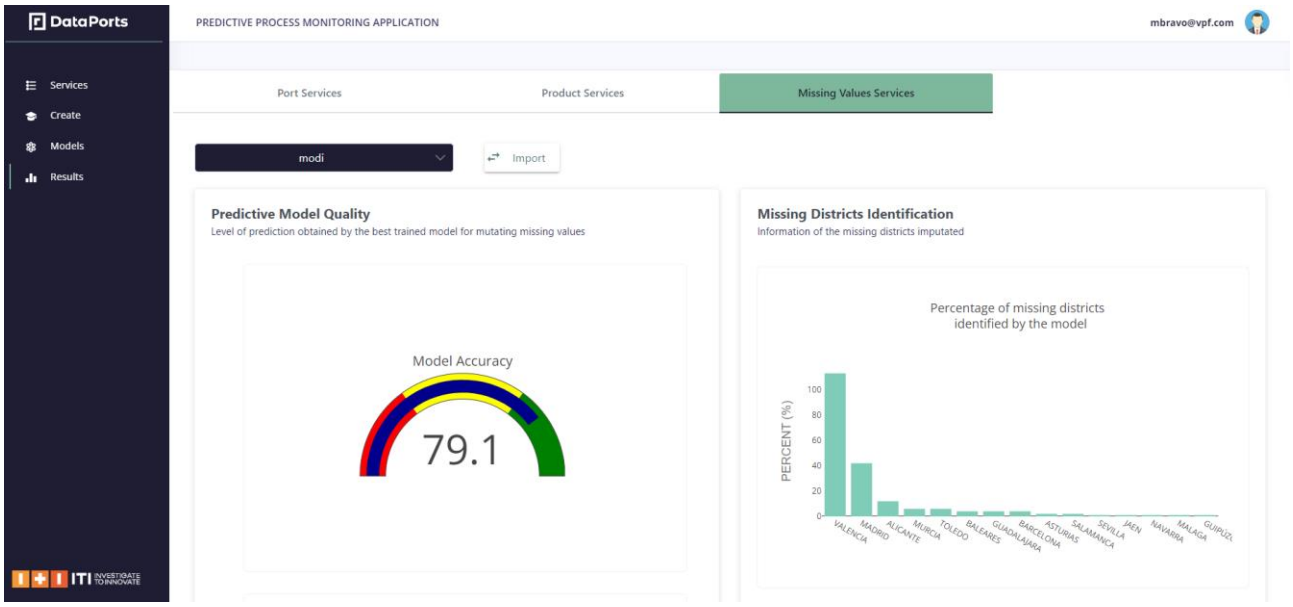


Figure 19 – Predictive Process Monitoring Application: Results – Missing Values Services

3.4 SHARING VERIFIED GROSS MASS

3.4.1 Scenario Description

In the container transport operations, it is needed a complete management of the lifecycle of container weight requests in order to comply with the Convention on the Safety of Life at Sea (SOLAS) from International Maritime Organization (IMO). It is a requirement before loading a full container on a vessel for

export. The shipper became the responsible for obtaining the Verified Gross Mass (VGM) of a full container and communicating it to the shipping company, with a VGM certificate.

DataPorts platform offer users an effective solution to allow containers to arrive at the port with the verified gross weight, reducing last minute incidents or delays at container terminals or the appearance of congestion situations. In addition, it offers a fast and automated method for the verified gross weight to reach the shipping company and the terminal; and allows the port to be more competitive.

The solution provides more added value than existing solutions by having a verifiable and immutable information on shared data through the entire chain to all concerned business participants serving as a source of truth and providing transparency and non-repudiation process. The VGM Blockchain implementation serves as a single source of truth and providing transparency and non-repudiation process, assuring that the weight cannot be altered at any point in the process.

The Figure 20 depicts the workflow and interactions of the scenario:

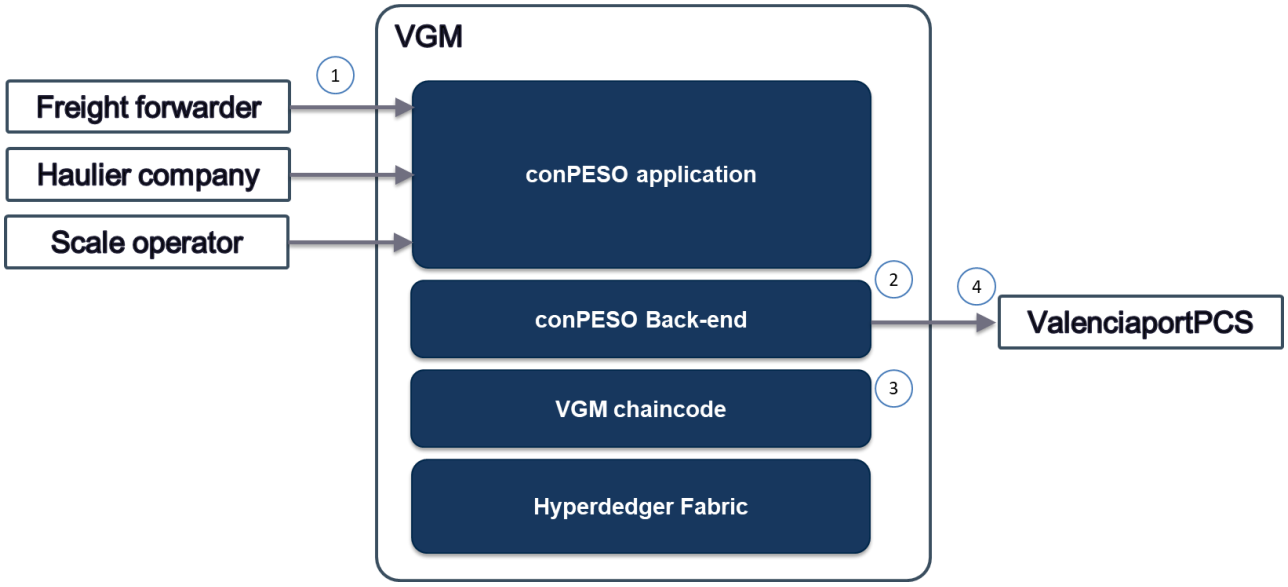


Figure 20 – Sharing Verified Gross Mass Workflow

The Table 20 lists the interactions, events and processes of the scenario:

Step	Description
1	One of the actors involved (freight forwarder, haulier company, or scale operator) provides data through the conPESO application
2	The data is processed and stored in the conPESO back-end
3	The proper data is stored in in Blockchain through the chaincodes
4	The VGM certificate is also sent to the ValenciaportPCS to be available to other companies which are not part of the process

Table 20 – Sharing Verified Gross Mass Scenario Description

The data providers of the scenario are included on Table 21:

Data Provider	Description of data
Shipper or the freight forwarder	Provide the information for the weight request
Haulier company or scale operator	Provide the truck data
Scale operator	Provides the weight data from each container after it is measured

Table 21 – Sharing Verified Gross Mass Scenario Datasets

3.4.2 DataPorts roles

The Table 22 Table 10 – Tracking of Transport Operations Rolesshows the organizations that take part in the scenario implementation and their roles:

Organisation	Role
VPF	Fundacion Valenciaport is the scenario leader, provides the infrastructure and knowledge to successfully run the demo, deploys the Blockchain infrastructure, and develops the back-end services and front-end application
IBM	IMB defines the deployment and configuration of the Blockchain infrastructure and develops the chaincodes

Table 22 – Sharing Verified Gross Mass Roles

3.4.3 Activities carried out

The Table 23 contains the tasks involved in the implementation of the scenario:

Time	Actors	Actions
M10-M12	VPF	Provide the scenario specification with the support of all involved partners
M12-M13	VPF, IBM	Deploy the local infrastructure
M12-M15	VPF	Develop first version of front-end and back-end
M14-M15	IBM	Develop the chaincode for interacting with Hyperledger
M16-M17	VPF, IBM	First MVP
M21-M24	VPF, IBM	Deploy the Blockchain infrastructure in virtual servers
M24-M30	VPF	Enhance development of front-end and back-end with extended functionalities

Table 23 – Sharing Verified Gross Mass Action Plan Reporting Table

3.4.4 Applications

The Table 24 describes the applications that are part of the scenario that interact with the platform and should be modified or implemented:

Application	Action	Status
conPESO Application	New version	100%
Actors involved in the VGM process use the application to submit the container weight request, register the certified gross mass of its trucks and semi-trailers, provide the VGM, ensure the payment, and obtain the VGM certificate		
User documentation can be found in Annex A Section 9.1.3		

Table 24 – Sharing Verified Gross Mass Applications

This section shows a typical flow of information with the participation of the different actors involved.

Vehicle registration

Before any weight request, the vehicles and the trailers should be registered by the haulier company in order to calculate the VGM.

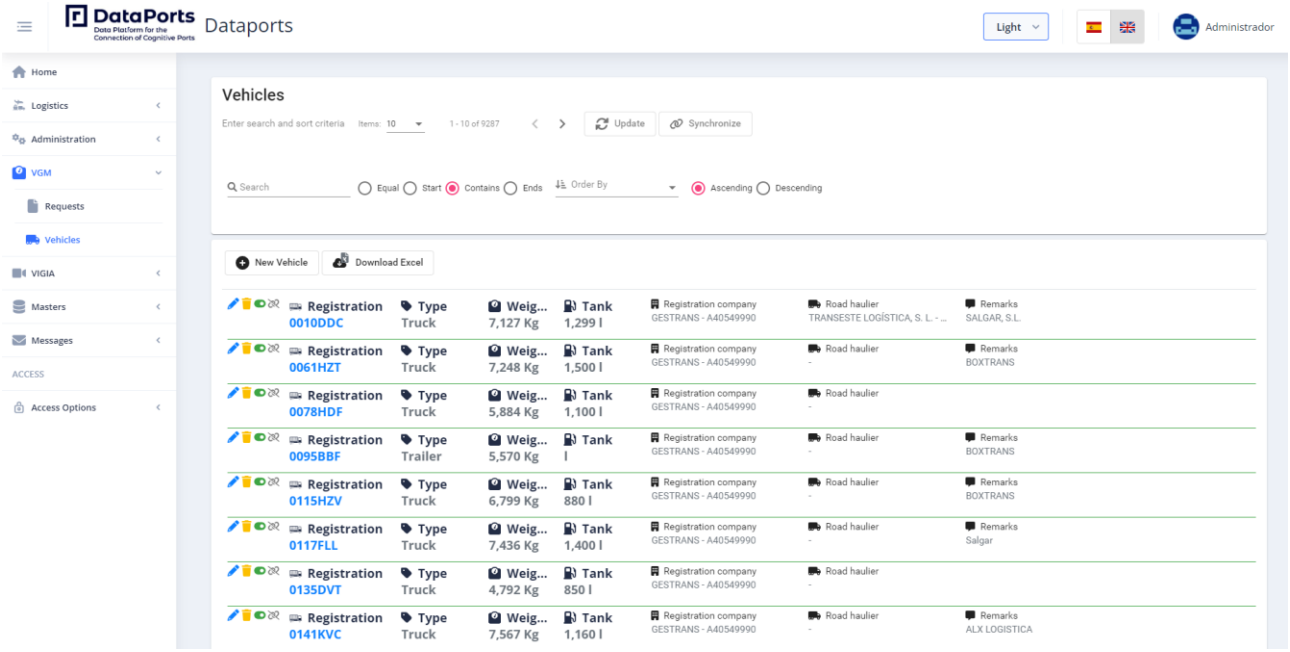


Figure 21 - List of registered vehicles and trailers

VGM request

The shipper or the freight forwarder can see the list of VGM request and the current status.

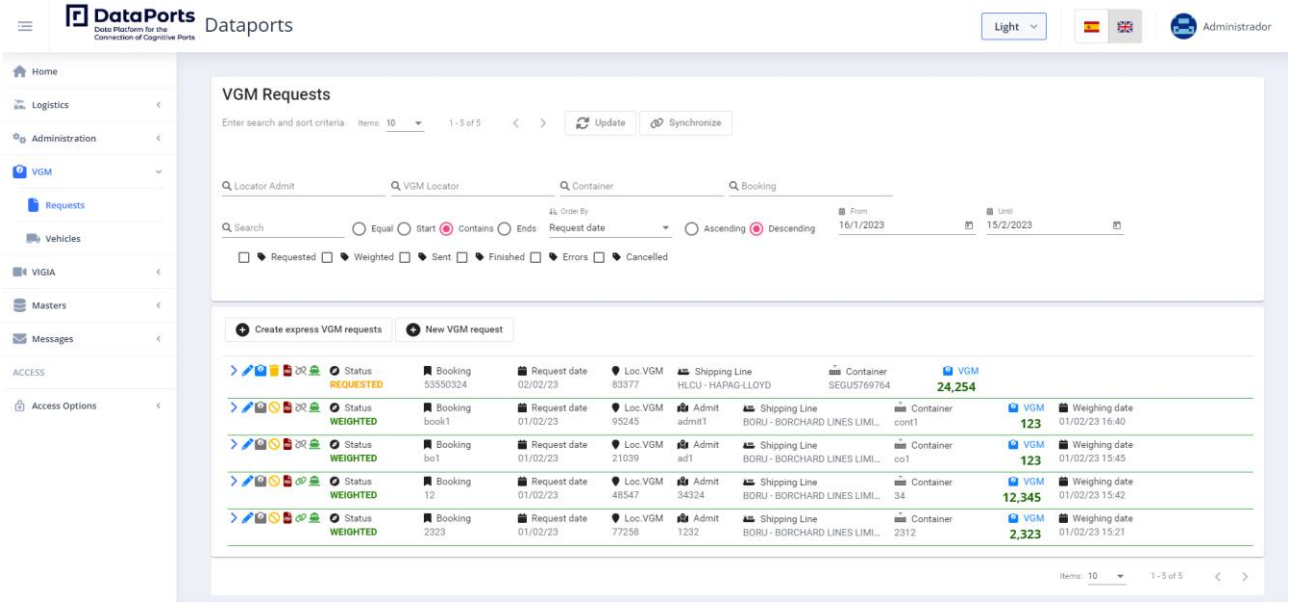


Figure 22 - List of VGM request

By clicking to “New VGM request” a new request can be created.

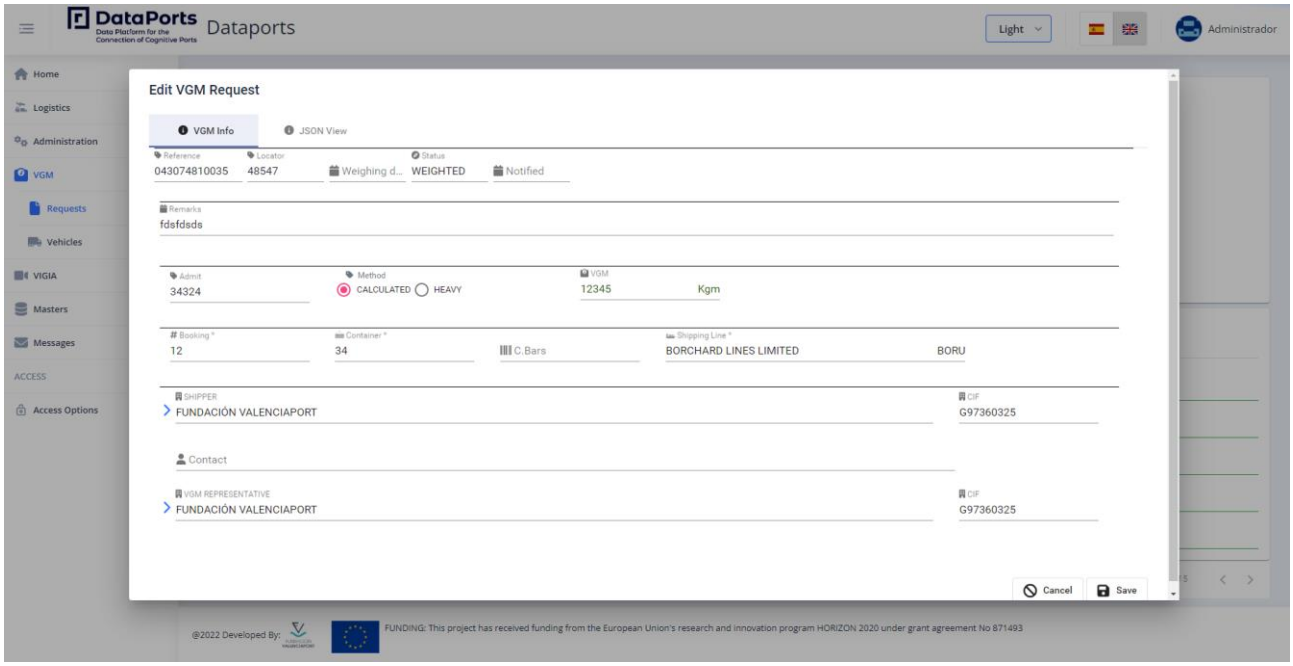


Figure 23 - Create a new VGM request

VGM certificate

Once the truck is weighted the scale operator can include the value by editing the VGM request. The VGM certificate is automatically generated and sent to the PCS.

3.5 DIGITAL CONSIGNMENT NOTE

3.5.1 Scenario Description

Management of road transport requires some documents which nowadays are not electronic. Exist some difficulties in using electronic transport documents identified by the European Commission. To tackle these difficulties, the EC is proposing a regulation on electronic Freight Transport Information (eFTI) that establishes the full obligation for Member State authorities to accept regulatory cargo transport information or documentation, with partially harmonised implementation. DataPorts capabilities should be able to tackle with the European Interoperability Framework and the functional requirements for eFTI platforms service providers.

In order to manage the operations, freight forwarders need to make available the electronic transport documents to all the involved organizations. The most interested parties are the haulier companies which need the consignment note during the transport operation if it is required by the authorities (e.g. police).

The Figure 24 depicts the workflow and interactions of the scenario:

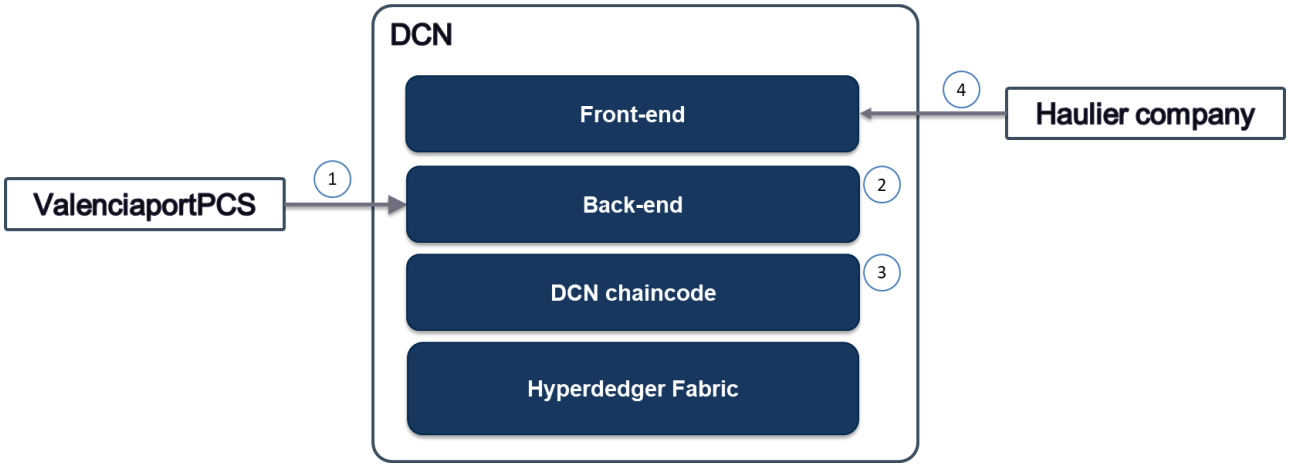


Figure 24 – Digital Consignment Note Workflow

The Table 25 lists the interactions, events and processes of the scenario:

Step	Description
1	Consignment note data is received from ValenciaportPCS to DataPorts platform
2	Consignment note is registered as PDF/A document in a document database in the back-end
3	The operation registered in Blockchain off-chain. A proof of registration is annotated in Blockchain
4	Stakeholders related to consignment note data (shipper, consignee, road haulier, container owner, empty container depot/terminal and authorities) can download the updated version of the consignment note PDF/A document and check the integrity and traceability through the DataPorts platform

Table 25 – Digital Consignment Note Scenario Description

The data providers of the scenario are included on Table 26:

Data provider	Description of data
ValenciaportPCS	Shares through to DataPorts the consignment note data with relevant stakeholders (shipper, consignee, road haulier, container owner and empty container depot/terminal)

Table 26 – Digital Consignment Note Scenario Datasets

3.5.2 DataPorts roles

The Table 27 Table 10 – Tracking of Transport Operations Rolesshows the organizations that take part in the scenario implementation and their roles:

Organisation	Role
VPF	Fundación Valenciaport is the scenario leader, provides the infrastructure and knowledge to successfully run the demo, deploys the Blockchain infrastructure, and develops the back-end services and front-end application

Table 27 – Digital Consignment Note Roles

3.5.3 Activities carried out

The Table 28 contains the tasks involved in the implementation of the scenario:

Time	Actors	Actions
M30-M31	VPF	Deploy the Blockchain infrastructure in virtual servers
M34-M37	VPF	Develop the front-end
M34-M36	VPF	Develop the back-end

Table 28 – Digital Consignment Note Action Plan Reporting Table

3.5.4 Applications

The Table 29 describes the applications that are part of the scenario that interact with the platform and should be modified or implemented:

Application	Action	Status
Digital Consignment Note Application	New application	100%
Freight forwarder and road haulier need to access the last version consignment note for their transport operations		
User documentation can be found in Annex A Section 9.1.4		

Table 29 – Digital Consignment Note Applications

The application is integrated into the tracking application because the data needed for creating the digital consignment note is managed in that application.

Shipment

The freight forwarder can see the list of shipments managed by them. There is a pdf icon which allows to generate the Digital Consignment Note with all the available data.

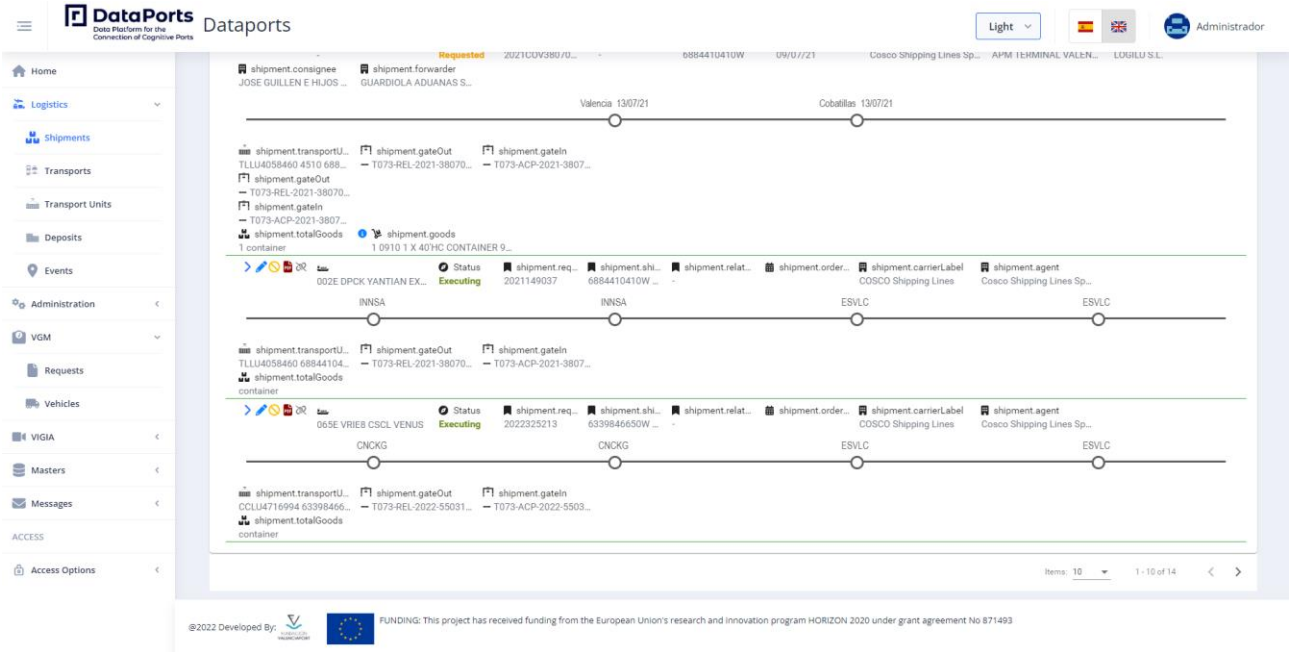


Figure 25 - List of shipments

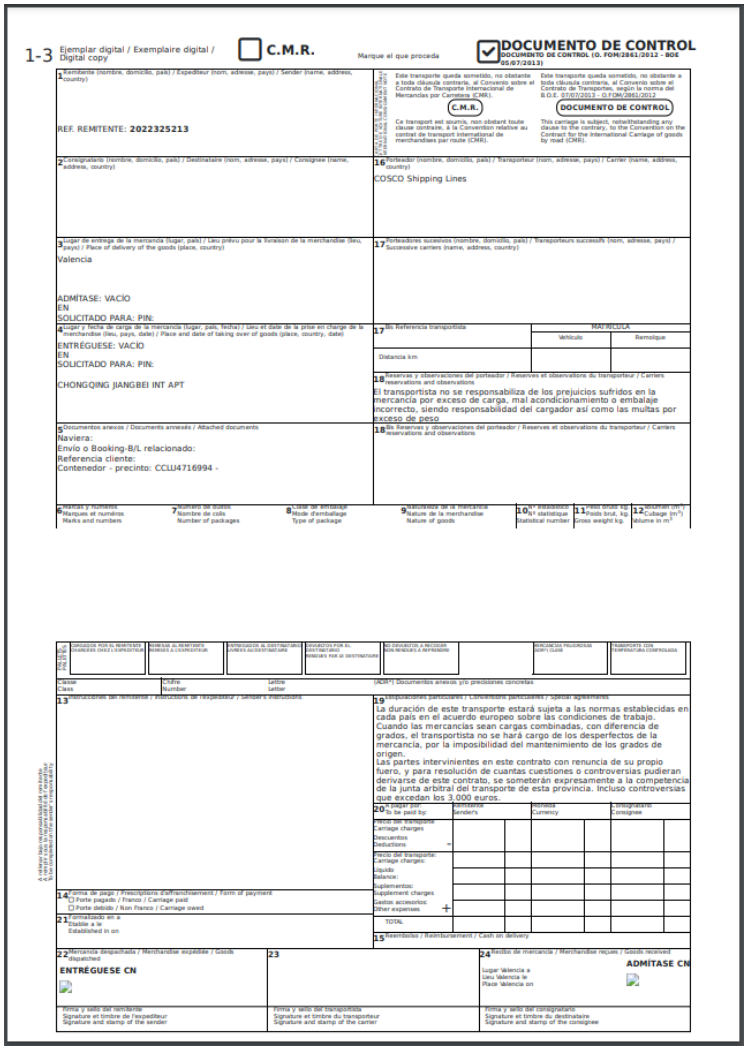


Figure 26 - Digital Consignment Note generated

3.6 DATA EXCHANGE THROUGH IDS CONNECTOR

3.6.1 Scenario Description

This scenario has been built as a proof of concept. The rest of the project scenarios assume communication and data exchange between entities inside the DataPorts data space. According to the DataPorts architecture, the IDS framework is the most suitable solution to data sharing among participants of external dataspaces. For that purpose, Dataports has used an IDS connector developed by Fraunhofer ISST and validated by IDSA, the Dataspace Connector, to become a participant of the EUHubs4Data (EUH4D) Federation (https://euhubs4data.eu/).

The scenario makes use of sovereign and trusted data sharing between two participants within the EUH4D Federation:

- Valencia Port wants to get some advanced analytics based on their data, but the services they want to use are inside the EUH4D federation **Fuente especificada no válida.** and are not reachable through the DataPorts data space.
- A technology provider inside EUH4D offers an AI model that will suit Valencia Ports' needs and provide valuable predictions.

This scenario assumes that some exchange of data has already taken place. So, the technology provider has built models capable of predicting vessel departures based on data from Valencia Port.

The data transactions pipeline carried out to perform the scenario is divided into three steps (see Figure 27):

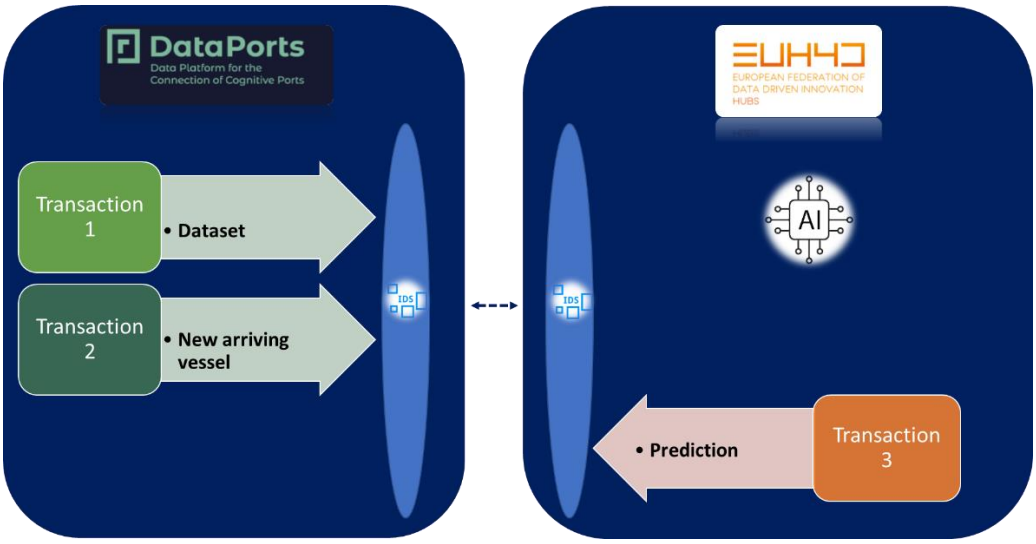


Figure 27 – Scenario description

Each of the data transaction steps are described in detail below:

Data Transaction 1: Dataports registers a dataset into IDS connector and EUH4D consumes it to create an AI cognitive service capable of making predictions.

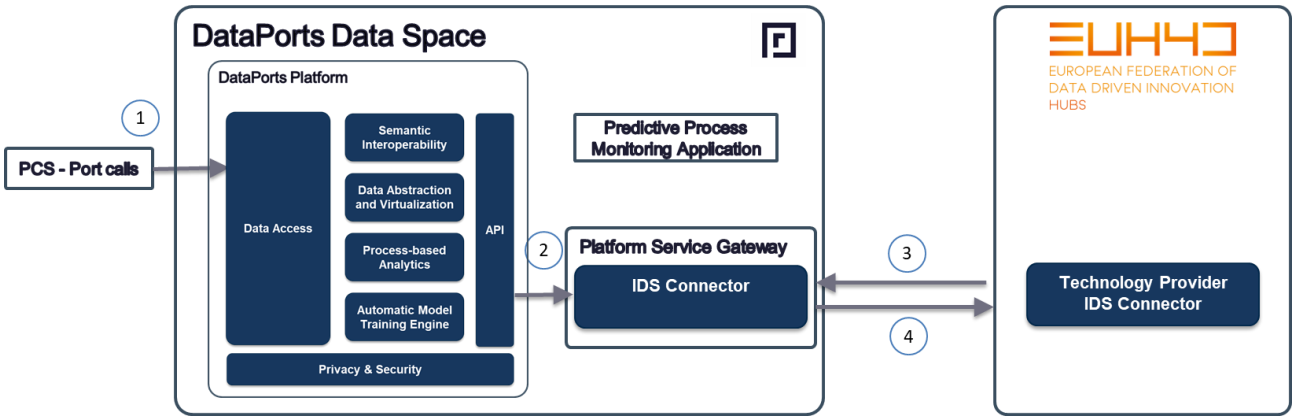


Figure 28 – Data transaction through IDS connector workflow. Data transaction 1

Step	Description
1	DATAPORTS registers a dataset (*) through Data Access component
2	DATAPORTS registers the dataset into IDS connector
3	EUH4D requires the available information in DATAPORTS' IDS connector
4	EUH4D downloads the dataset from the IDS connector

Table 30 – Data transaction through IDS connector Description

(*) In this concrete scenario, the dataset *PCS Calls* was used, which represents the series of historical vessel calls of the ports of Valencia.

Data transaction 2: Dataports registers a new incoming vessel into IDS connector and EUH4D consumes it to make a prediction.

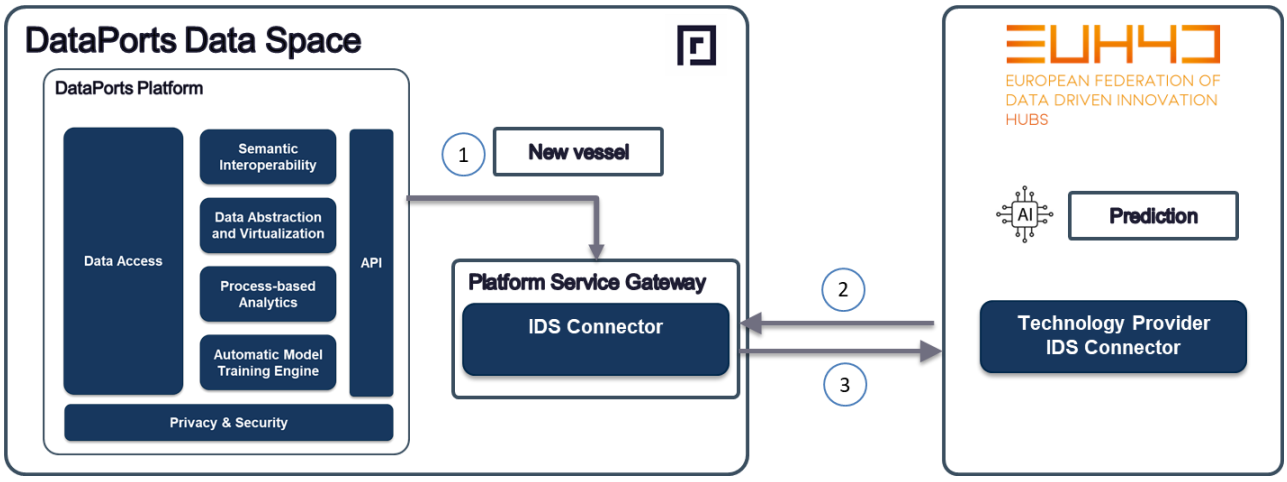


Figure 29 – Data transaction through IDS connector workflow. Data transaction 2

Step	Description
1	DATAPORTS registers a new arriving vessel into IDS connector
2	EUH4D requires the available information in DATAPORTS' IDS connector
3	EUH4D downloads the new arriving vessel information from the IDS connector

Table 31 – Data transaction through IDS connector Description

Data Transaction 3: EUH4D registers a prediction into IDS connector and DATAPORTS consumes it.

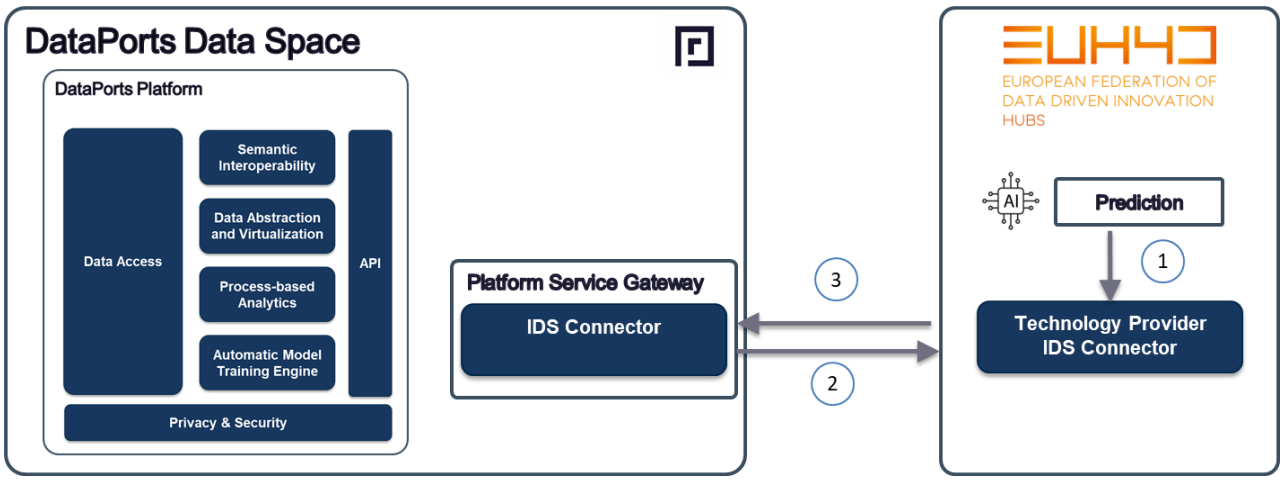


Figure 30 – Data transaction through IDS connector workflow. Data transaction 3

Step	Description
1	EUH4D registers a prediction into IDS connector
2	DATAPORTS requires the available information in EUH4D's IDS connector
3	DATAPORTS downloads the prediction information from the IDS connector

Table 32 – Data transaction through IDS connector Description

3.6.2 DataPorts roles

Table 10 Table 10 – Tracking of Transport Operations Roles shows the organizations that take part in the scenario implementation and their roles:

Role	Description of the role
DATAPORTS (VPF)	Data provider and consumer
EUH4D (ITI)	Technology provider

Table 33 – Data exchange through IDS connector Roles

3.6.3 Activities carried out

Table 11 contains the tasks involved in the implementation of the scenario:

Time	Actors	Actions
M24-M30	ITI	Assessment of different possibles solutions for the IDS connector. Implication for DataPorts platform.
M30-M36	ITI	Deployment of IDS connector backend
M30-M36	ITI	Integration between IDS connector and cognitive application
M34-M36	ITI	Deployment of IDS connector front end
M34-M36	ITI	Testing of the operation of IDS connector
M34-M36	ITI	Use case development and validation

Table 34 – Data exchange through IDS connector Action Plan Reporting Table

3.6.4 Data Integration

The aforementioned data sources have been connected with the platform with the development of the corresponding agents. The complete list of the agents developed for this scenario is shown in Table 35.

Agent	Type	Description
PCS Port Calls	Publish / Subscribe	This agent imports port calls (a vessel's visit to the port for a period of time, in order to perform some kind of useful function, like the loading or unloading of goods) by querying periodically (by default, every minute) to a REST endpoint exposed at https://www.valenciaportpcs.net/portcalls/search/ExportBerths Imported data are transformed to PortCall data model and stored in Orion
PCS Port Calls	On demand	Similar to the "Publish/Subscribe" flavour, this agent imports historical port calls with a granularity of 1 month. Imported data is stored in Cygnus.

Table 35 – Agents implemented in Data exchange through IDS connector scenario

3.6.5 Applications

The application used in this scenario is the same as in section 3.3.5.

Apart from this, the following figures show a series of screenshots of the IDS connector and how this was configured to work out together between DataPorts and EUH4D platforms.

Dataports IDS connector entry:

The following figure shows the Data Offering wizard to create new entries into the IDS connector of Dataports.

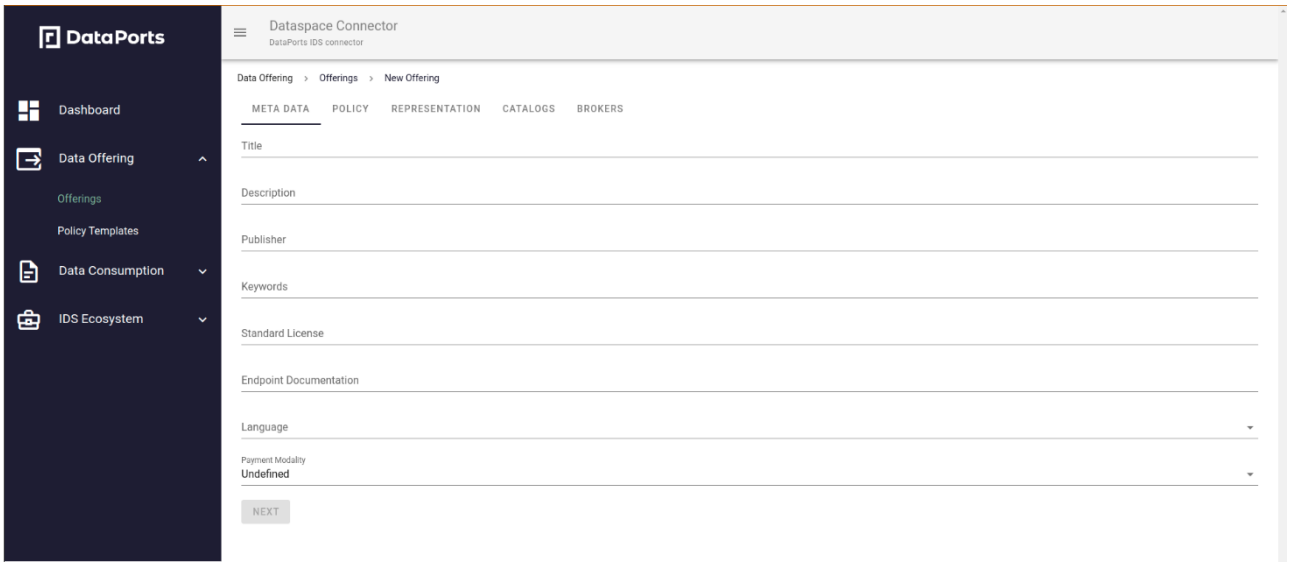


Figure 31 – Dataports IDS connector – Create new entry

Once the wizard has been completed successfully, the entries can be visualized in the offerings section, see Figure 32.

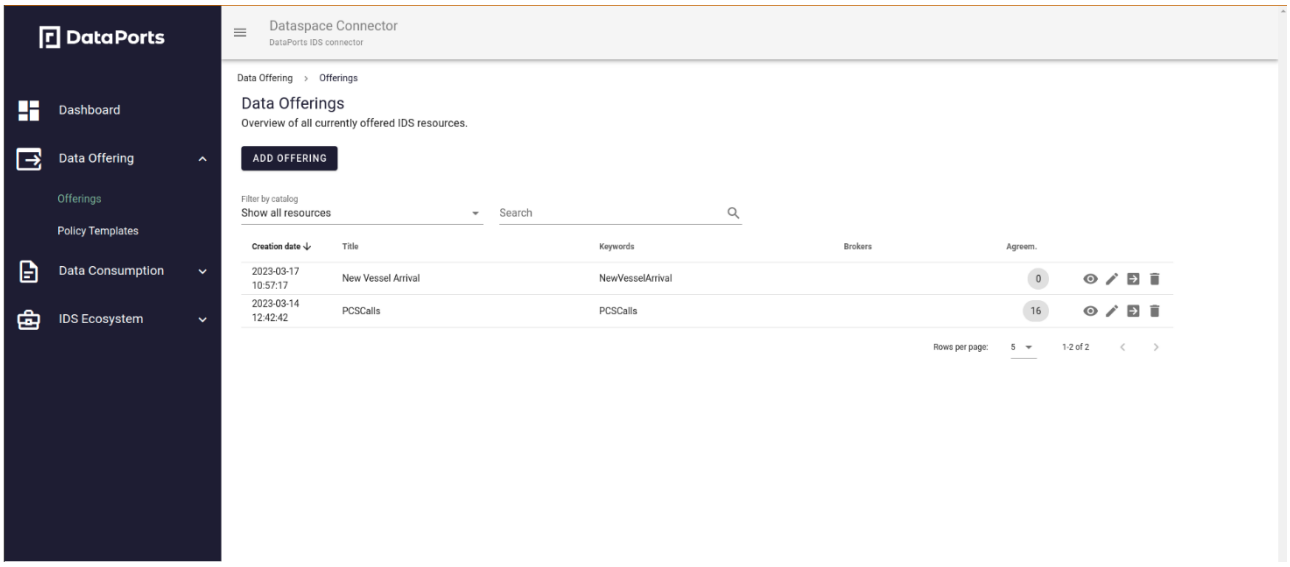


Figure 32 – Dataports IDS connector – Offerings list

EUH4D IDS connector entry:

Likewise, in EUH4D IDS connector, the entries can be analysed in the offerings section see Figure 33.

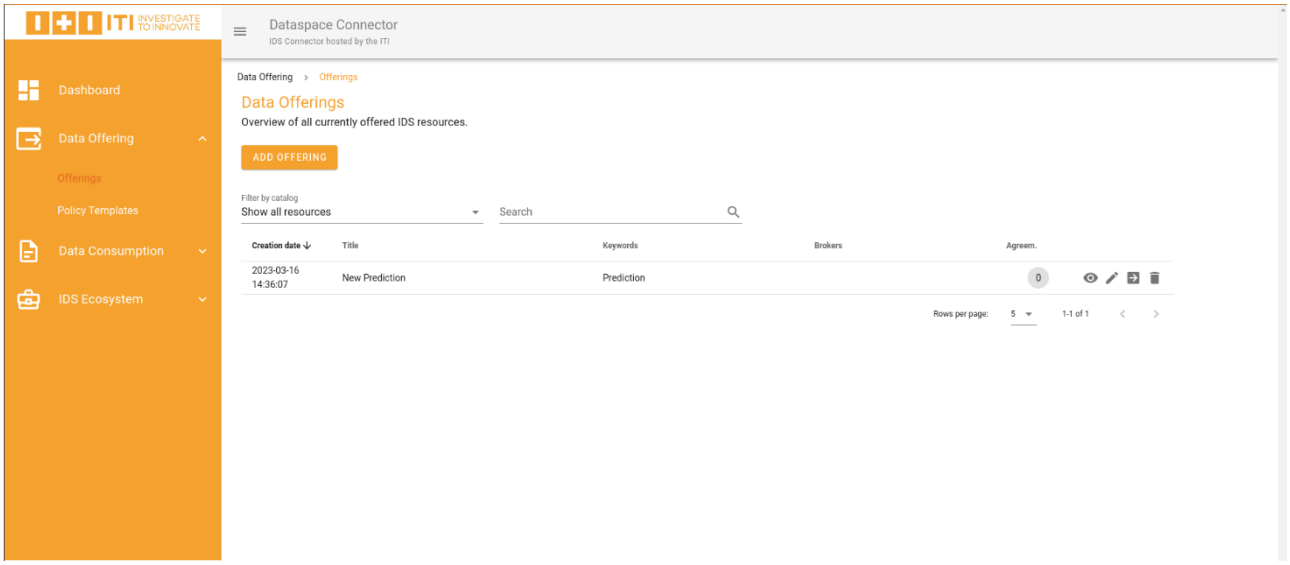


Figure 33 – EUH4D IDS connector – Offerings list

4 PORT OF THESSALONIKI

This section describes the two scenarios defined for the Thessaloniki pilot including a description, flow of information, data sources, action plans, applications, etc. The first scenario concerns the Container Pick-Up use case, while the second comprises of the four analytics use cases.

As already explained in the document D5.3 Use case oriented pilots initial version[7], the initial proposed scenarios have been merged and combined to build the current two of them.

For each of the scenarios, there is a description of the DataPorts components that are used, as well as their interactions. Two types of Blockchain solutions were developed for these scenarios; the first, is one of the main Dataports platform building blocks for trusted sharing of information concerning ports operations, i.e., the Data Governance component, while the second was implemented so as to build a custom solution for the Container Pick-up use case.

4.1 APPLICATIONS DEPLOYMENT

Two main scenarios for the Port of Thessaloniki have been implemented in the framework of DataPorts; the first regarding one of the port's core activities, the lifecycle management of containers and one regarding key analytics that will assist the port in bettering its operations. This last scenario includes four uses cases the **Analytics for the Port of Thessaloniki** and **Queues predictions**, while the remaining two case, utilize the available mobility data, for the **facilitation of all stakeholders visiting the** port or its surrounding area and **provide information for social distancing, due to Covid**.

The application for the container pick-up scenario is blockchain-based backend, reachable by the frontend, deployed and set up in ThPA network. It includes the smart contracts that control the Container Pick-Up process, invoking the transactions and queries of the designed solution.

In the analytics scenario a Visual analytics platform for analysis and metrics, customized for the Thessaloniki port authority was implemented. In this framework, AI driven algorithms, libraries and methodologies were set, to address the data and visual analytics at Thessaloniki pilot.

All applications developed as part of the ThPA pilot have been deployed on a VM within a ThPA VPN. This can be seen in Figure 34. The Container Pick-Up (CPU) concerns one of the port's core activities, the lifecycle management of containers. The rest of the applications are statistics and analytics based and employ a strong visual analytics component. ThPA statistics and Queues predictions applications are all accessible as part of a credentials-based web application. On the other hand, passenger facilitation and Covid-19 statistics are accessible through an open website available to the general public.

The Figure 34 depicts the components involved in both use cases.

[7] https://dataports-project.eu/deliverables/

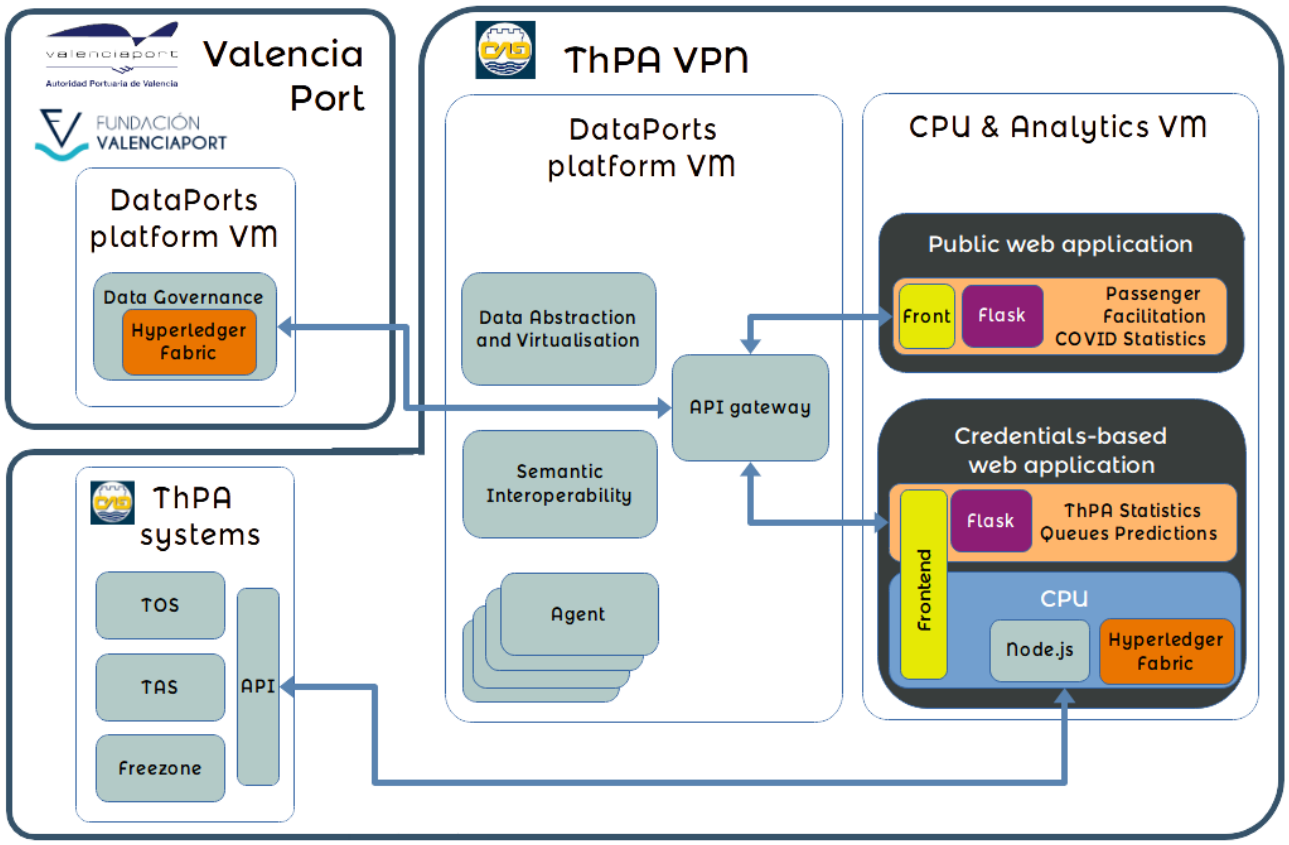


Figure 34 - CPU and analytics deployment in ThPA

In the diagram we see, in orange colour, two instances of a blockchain solution being used: the first is indirect usage and concerns the Data Governance component – a part of the Dataports platform – used to facilitate dataset sharing between DataPorts partners. The second is a direct use of a blockchain network, implemented so as to build a custom solution for the Container Pick-up use case, utilising blockchain technology to support a port operation involving the port itself and two other port ecosystem stakeholders.

4.1.1 Credentials-based web application

This web application combines both the CPU application and two of the analytics applications under one credentials-based web frontend. To deploy the CPU part of the web application, an instance of a Hyperledger Fabric network has been deployed on the VM. This includes the smart contracts that control the Container Pick-Up process, invoking the transactions and queries of the designed solution. Fabric acts both as an identity manager for the entire web application, on which the authentication mechanism is based, and as a common ledger for the stakeholders using the CPU application, i.e. shipping agents, trucking companies and the port authority. Furthermore, the application Node.js API middleware is installed on the same VM, through which the frontend communicates with the smart contracts. To deploy ThPA statistics and Queues Predictions, their python code is deployed on VM, together with their respective API, running with Flask. Finally, the frontend, hosting both CPU and analytics, is deployed in the same VM.

The CPU application interfaces with the ThPA computing systems through a purpose-built API, in order to pass on COREOR requests and receive permit IDs, COREOR acceptances and rejections, new bookings and their respective acceptances and rejections. The analytics applications ask the local deployment of the DataPorts platform – situated on a separate VM – for data. The local DataPorts platform consults with the single instance of the Data Governance component – situated at the VPF deployment of the platform – to verify the user's permissions for using the requested dataset.

4.1.2 Public web application

This publicly available web application, comprising both the Passenger Facilitation and the Covid Statistics applications, is deployed on the same ThPA VM. The deployment again comprises the python code, together with the respective API, running with Flask. Finally, the public frontend, hosting both Passenger Facilitation and Covid Statistics, is deployed in the same VM.

As with the previous analytics cases, the public analytics applications ask the local deployment of the DataPorts platform for data and the local DataPorts platform, in turn, consults with Data Governance at VPF to verify the user's permissions for using the requested dataset.

4.2 CONTAINER PICK-UP

The Container Pick-Up (CPU) use case has arisen from the merging of two initially (D5.1 Integration, software quality assurance and deployment plan) defined use cases: "Data-Driven Application for Strategic and Real-Time Decisions" and "Permit ID for Container Pick-up", which were finally deemed as inseparable since they are two procedures in line and, therefore, better understood as one use case.

4.2.1 Scenario Description

Ports are the nodes in the global network providing a key link between sea and land and the connection with the hinterland. The port community or the port ecosystem consists of a variety of stakeholders, like port authorities, terminal operators, shipping companies, trucking companies etc. As the transport industry becomes more demanding in terms of increased efficiency and lowered costs, sharing and timely provision of accurate information within the business network is more critical than ever.

Container loading and discharge is a core port activity for the port of Thessaloniki. The following description refers to the case of a container discharge from the port premises. The procedures involve a Shipping Agent, as the beneficial cargo owner at the time, who wishes to pick-up a container from the yard and a trucking company, which picks-up the container, on his behalf.

Currently, for ThPA to release a container from its premises, all relevant paperwork must be in place (customs clearance, invoicing, etc); however, it requires under some conditions the physical presence of the respective shipping agent in ThPA premises for the issuing or filling in of relevant documentation. After evaluation, ThPA then notifies only the related shipping agent, and he in turn contacts the trucking company to pick it up, without further THPA involvement.

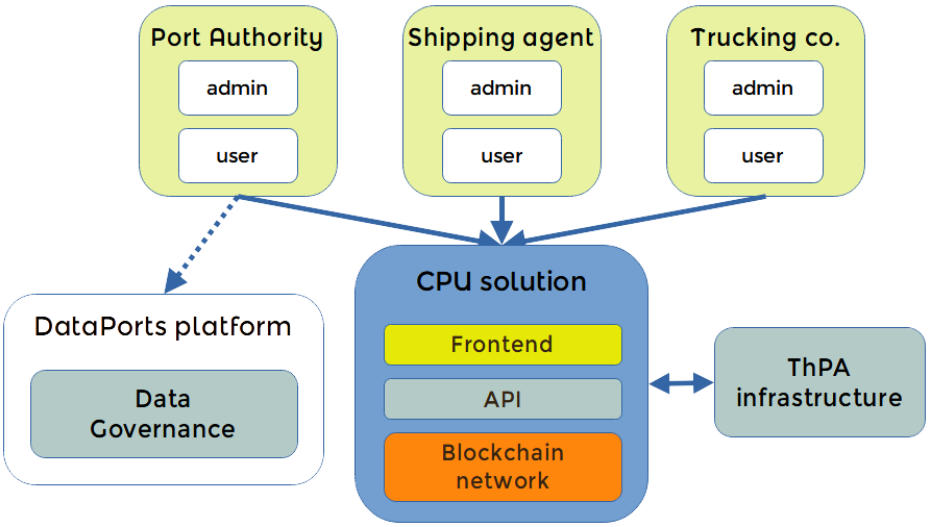


Figure 35 – Workflow Diagram of the CPU Use Case

Through the DataPorts solution for the CPU use case, a new environment is set up where the entire lifecycle of the container release/pick-up can be followed by all three involved parties. The interconnection of different systems in this environment is depicted in Figure 35. Table 36 lists the interactions, events and processes of the scenario.

Step	Description
1a	The Shipping Agent uses the DataPorts CPU solution frontend to register a COntainer RElease ORder (COREOR) request[8], specifying the Trucking Company to pick-up the container.
1b	A copy of this request is saved on the local blockchain infrastructure.
1c	The COREOR request is sent in XML format, to ThPA's TOS (Terminal Operating System).
2a	A ThPA Operator checks the request through the TOS and other relevant processes (invoicing, customs clearance); if everything is in order, the employee approves the request and a Permit ID is issued for that COREOR, otherwise it is rejected.
2b	The Permit ID is communicated to the DataPorts CPU solution blockchain backend through an API that exposes the CPU smart contracts. This updates the request in the blockchain, adding the Permit ID.
3a	The Shipping Agent can view the complete COREOR request information in their DataPorts CPU solution dashboard.
3b	The Trucking Company receives only a notification containing the Permit ID.
4a	Using the issued Permit ID, the Trucking Company can proceed to arrange the pick-up of the container, following the normal process of booking an available timeslot through the TAS and Freezone port systems.
4b	The ThPA systems notify the DataPorts CPU solution, through our API, of the new booking.
4c	Through a second API call, the blockchain backend is notified of whether the booking was accepted or rejected.
5	When the booking is accepted, the Trucking Company can view, in their DataPorts CPU solution dashboard, the QR code issued for it.
6	At a later stage, the ThPA operator can make the COREOR dataset available on Data Governance.

Table 36 – CPU Scenario Description

As can be understood from Table 36Table 30, at the end of the use case both COREOR and booking information is saved on-chain in the local ThPA Fabric network. Figure 36 is a sequence diagram showing the "success" scenario of the use case, i.e., both COREOR and corresponding booking are accepted.

The data sources used in the CPU scenario are shown in Table 37.

Data source	Description of data
Local DataPorts frontend	Produces the COREOR XML message, containing all the necessary details about the container to be picked-up.

8 The COREOR message is an order to release containers, which gives permission for them to be picked up by, or on behalf of, a specified party. It is used in Electronic Data Interchange (EDI) between trading partners and is specified by the United Nations Directories for Electronic Data Interchange for Administration, Commerce and Transport (UN/EDIFACT)

Data source	Description of data
Terminal Operating System (TOS)	Issues a unique Permit ID number that is attached to the COREOR. The Permit ID is essentially the approval of the COREOR request.
Truck Appointment System (TAS)	Application used by authorized users (mainly truckers and forwarders) to book timeslots for the delivery and/or pick up of containers. Produces part of the booking data.
THPA Freezone system	Application that provides the QR code.

Table 37 – CPU Scenario Data Sources

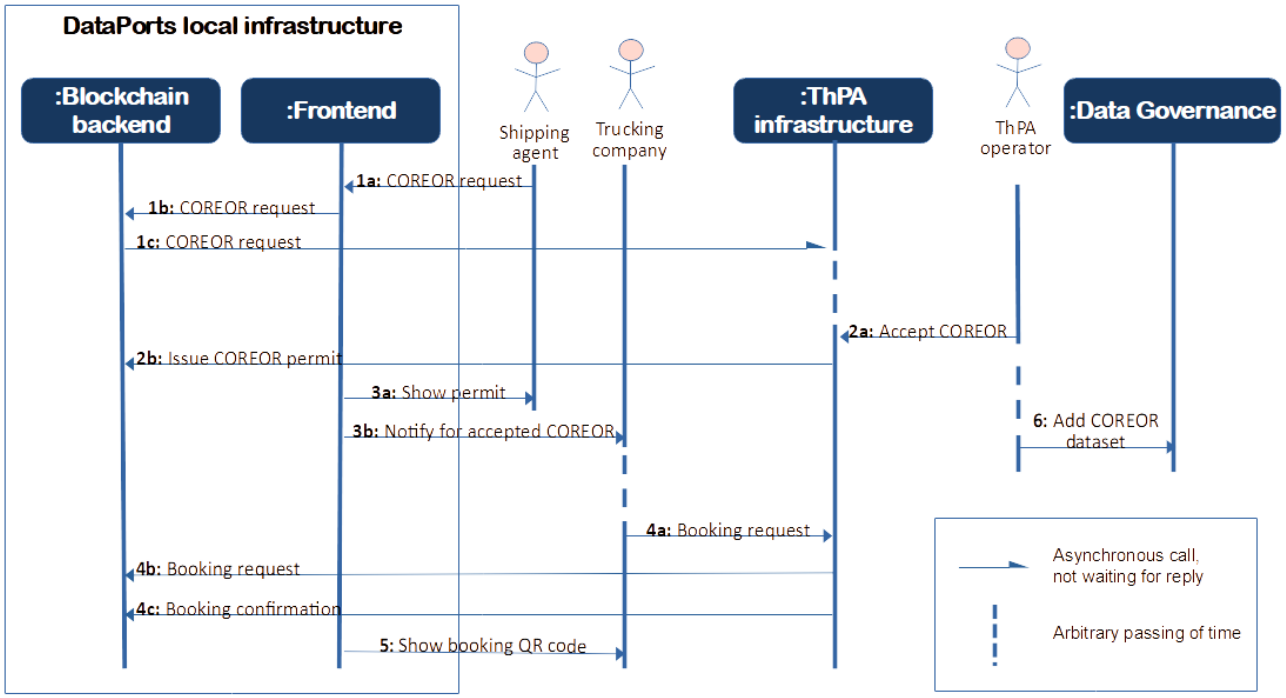


Figure 36 – Sequence diagram for the main scenario of the CPU use case

4.2.2 DataPorts roles

Table 38 shows the organizations that take part in the scenario implementation and their roles.

Organisation	Role
ThPA	THPA is the scenario leader, providing the infrastructure and knowledge to successfully implement the application.
CERTH	CERTH has defined the blockchain configuration and deployed the blockchain infrastructure. Moreover, it developed and deployed the chaincode, developed the backend API and the frontend for the application.

Table 38 – CPU Use Case Roles

4.2.3 Activities carried out

Table 39 contains the tasks involved in the implementation of the scenario.

Time	Actors	Actions
M10-M12	ThPA	Provide the scenario specification with the support of all involved partners
M11-M12	CERTH	Deploy test infrastructure
M11-M16	CERTH	Develop first version of front-end and back-end
M11-M15	CERTH	Develop the chaincode for interacting with Hyperledger
M16-M17	CERTH	First MVP
M18-M36	CERTH	Continuous development of frontend and backend with extended functionalities; continuous improvement/bug fixing of frontend/backend
M24-M36	CERTH, ThPA	CPU integration with ThPA infrastructure
M34-M37	CERTH, ThPA	CERTH deploys the blockchain infrastructure on ThPA premises

Table 39 – CPU Use Case Action Plan Reporting Table

4.2.4 Applications

Table 40 describes the applications that are part of the scenario that interact with the platform and have been updated or implemented, along with the links to the documentation.

TOS (FRETIS)	Modification	100%
Add the functionality to import the incoming COREOR message from the new THPA/DataPorts page and store it internally. Add the functionality to send the notification to the Platform, when the request is approved.		
User documentation can be found in Annex A: 9.2.1 Container pick-up		
Change log can be found in Annex B: 0 TOS		

Table 40 – CPU Use Case Applications

4.3 ANALYTICS USE CASES FOR THPA

The Thessaloniki Port Authority will be taking advantage of four analytics use cases developed specifically for its needs. These are briefly described in the following subsections.

4.3.1 General Workflow and Scenario Description

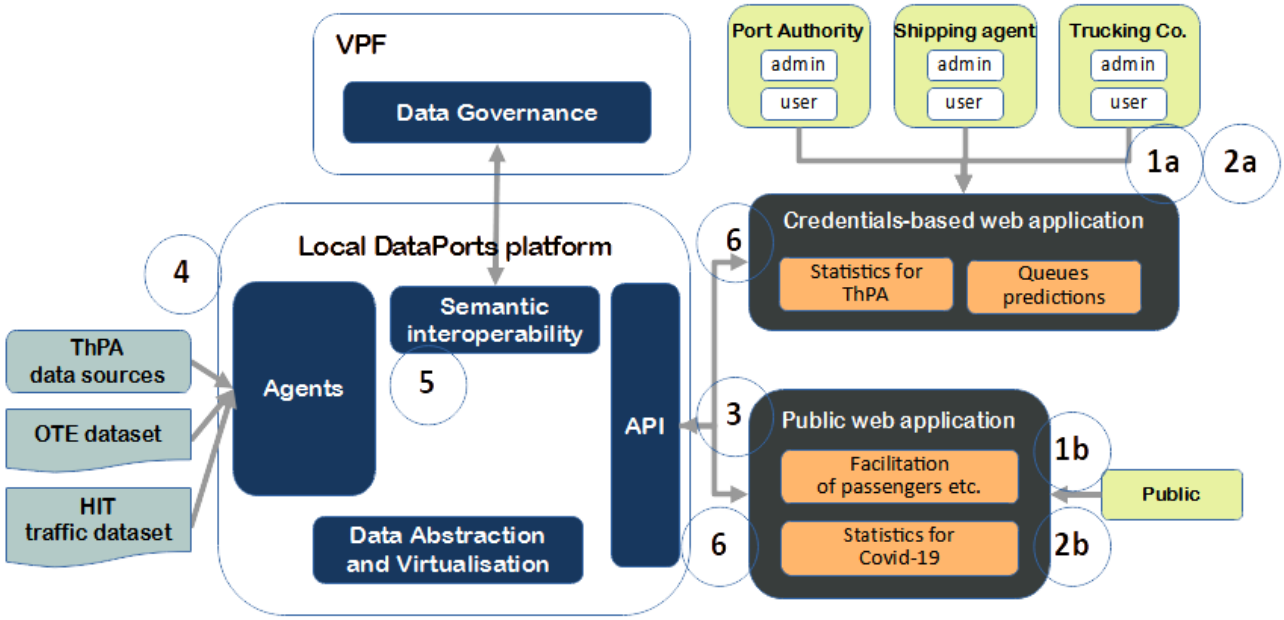


Figure 37 – Workflow Diagram of the Analytics Use Cases for ThPA

The interconnection of different systems in the analytics use cases is depicted in Figure 37. The analytics solutions are split between those that are used only by ThPA analytics users of the local infrastructure frontend (Statistics for ThPA, Queues predictions) and those that are used by the general public through a public web application (Facilitation of passengers, Statistics for Covid-19). Nonetheless, apart from the way each application is accessed by the end user, they all follow the same scenario of use. As soon as an analytics solution (Statistics for ThPA, Queues predictions etc.) needs an input dataset, it looks to see whether this dataset has already been retrieved in the past. If not, the relevant source dataset is requested through the DataPorts platform API gateway. Since all datasets used by the analytics use cases are on-demand datasets, the requested dataset is provided by the Data Abstraction and Virtualisation (DAV) component. However, for this to happen, Semantic Interoperability first checks with Data Governance whether there are sufficient access rights on this dataset. If access is legitimate, DAV informs analytics of the availability of the dataset. The analytics application then proceeds to download it from DAV.

Table 41 lists the interactions, events and processes of the analytics scenarios, with the only differentiation being the first step in the sequence. The “Statistics for ThPA” and “Queues Predictions” analytics applications are used from within the local DataPorts frontend, and therefore need the user to first log in (steps 1a, 2a). Conversely, “Facilitation of passengers” and “Statistics for Covid-19” do not require a login, but can be accessed through the DataPorts platform (steps 1b, 2b).

Step		Description
1	**a**	A ThPA analytics logs in to the local DataPorts frontend.
	b	A member of the general public accesses the public analytics web application
2	**a**	The user selects either the “Statistics for ThPA” or the “Queues Predictions” analytics application.
	b	The user selects either the “Facilitation of passengers” or the “Statistics for Covid-19” analytics application.
3		For each of the needed source datasets, the application checks whether it has already received said dataset.
4		For each of the missing source datasets, the application asks the DataPorts platform, through its API gateway, for that dataset.
5		The Semantic Interoperability component checks with Data Governance whether there are sufficient access rights on this dataset for the specified user.
6		If access rights are sufficient, DAV informs the application of the availability of the dataset.
7		The application proceeds to download the dataset from DAV.
8		The application proceeds to do the same for all source datasets it requires.
9		The application produces an analytics output, which is then visualised in the user’s dashboard.

Table 41 – Analytics for ThPA Scenario Description

The datasets shown in Table 42 will be used in the analytics scenarios.

Data source	Description of data
OTE mobility data	Data from OTE mobile phone network
Commercial vessel calls	Various operational data, including vessels arrivals, loading/unloading times, containers loaded/unloaded, etc, taken from the ThPA statistics application
Bookings	Details of truck bookings for container pick-up, taken from ThPA’s Truck Appointment System (TAS)
Gate Events	Information of vehicles passing through THPA gates, taken from ThPA’s Gate Access System (GAS)
Parking data	Data from two commercial parking lots situated at the port
HIT traffic data	Thessaloniki traffic data provided by the Hellenic Institute of Transport (HIT) (part of CERTH)

Table 42 – Analytics for ThPA Scenario Datasets

The following subsections present a short description of each analytics use case.

4.3.1.1 Statistics for THPA Prediction

ThPA collects operational data from several internal applications. Statistics for THPA Prediction (ThPA statistics, for short) uses the ThPA statistics application, the Truck Appointment System (TAS) and the Gate Access System (GAS). What this analytics application offers is a 'fusion' of all this data to get more meaningful

information. Through this application, these data can be combined to produce statistics, while the metrics and KPIs calculated can provide valuable insight of operations performance to a ThPA analytics user. The user can then decide on any corrective measures, if necessary.

Figure 38 – Vessel visualisation – part of the ThPA statistics visual analytics

Figure 38 shows the "Vessel visualisation" tab within the Analytics menu, which is part of the ThPA Statistics use case. Here, the "Commercial vessel calls" dataset from the ThPA statistics application is used. We have marked separate regions on this screenshot using coloured rectangles, which are not present in the actual frontend.

- The purple rectangle at the bottom contains a line plot showing the total number of vessels at the port at each day, during a large period of time (e.g. a year). By clicking on the line bar of the purple rectangle and dragging the mouse, we can select a sub-interval on the line graph. This selection affects the contents of the graph within the yellow rectangle.
- Within the yellow rectangle we can see each vessel that arrives at the port as a horizontal bar. The time span that this graph covers is the same as the time span selection in the line graph of the purple rectangle. The colour of the bar represents the type of cargo carried by the vessel while the thickness of the bar represents the cargo mass. Each coloured bar has two lines attached to it, one at the front and one at the end of the bar. The line at the front represents the time interval from the arrival of the ship until the start of the unloading of the cargo, whereas the line at the end represents the time interval from the end of unloading until the ship's departure from the port.
- Within the red rectangle, textual details for each vessel are shown, upon clicking on a vessel bar in the yellow rectangle.
- The bar charts in the light green rectangle show the distribution of the number of vessels operated at the port, with respect to the type of ship and the type of cargo. The bar charts are automatically updated when a new timespan is selected in the line plot of the purple rectangle.
- The bar charts in the dark green rectangle show the distribution of the average cargo weight of the vessels operated at the port, with respect to the type of ship and the type of cargo. The bar charts are automatically updated when a new timespan is selected in the line plot of the purple rectangle.

- For each vessel, we compute the work-time ratio, which is the ratio of the time the vessel was working at the port over the total time from arrival to departure (t_{work}/t_{total}). This takes values from 0 (idle ship) to 1 (efficient ship). We display the distribution of work-time ratios across the selected timespan in the blue rectangle graph. We can select a range to filter the vessels in the other plots.
- We can focus on outliers, i.e. relatively idle vessels, by clicking the "Select outliers" button in the blue rectangle, which automatically selects ships with work-time ratio lower than 0.2.

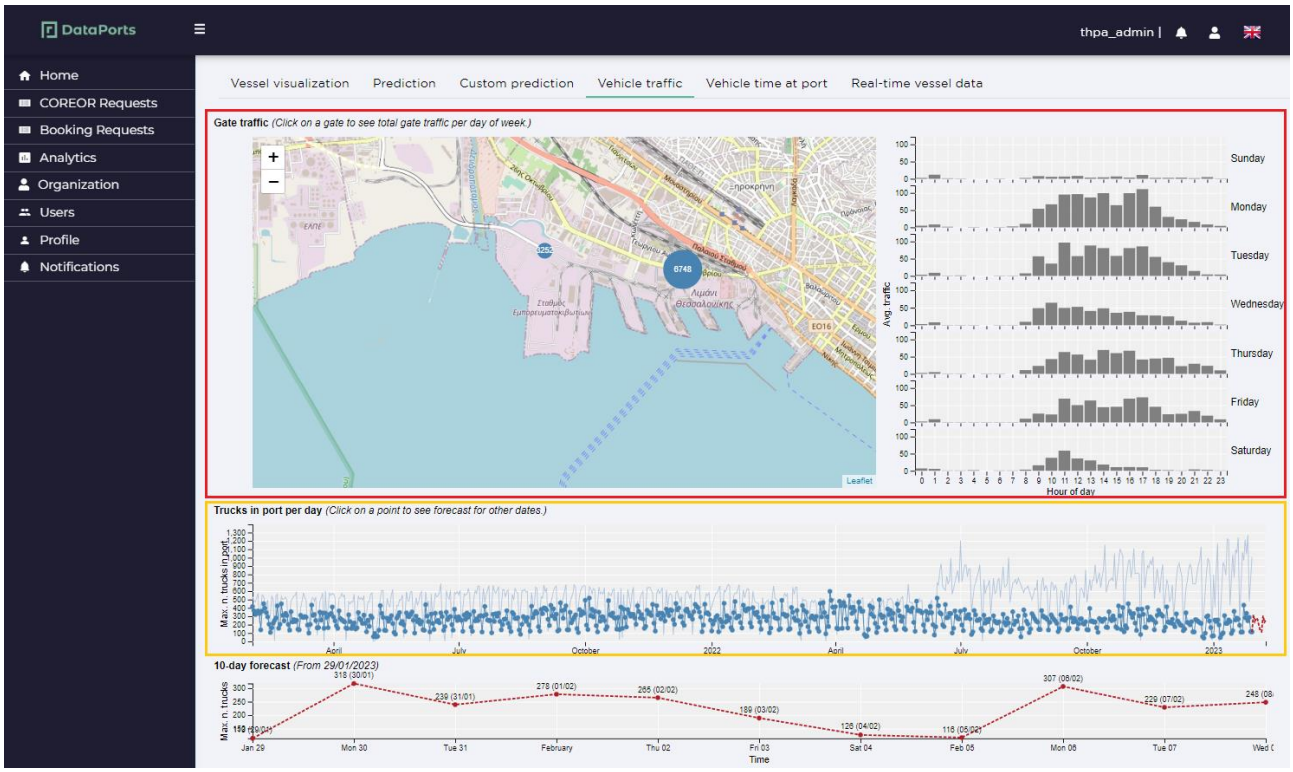


Figure 39 - Vehicle traffic – part of the ThPA statistics visual analytics

The second part of the ThPA statistics application can be found in the "Vehicle traffic" tab of the Analytics menu, as can be seen in Figure 39. Here, the "Commercial vessel calls", "Bookings" and "Gate Events" datasets from the ThPA statistics, TAS and GAS systems are used.

- In the red rectangle, we can see a map showing the positions of the port gates as blue circles, along with the total number of trucks that passed through them. Next to the map there is a set of 7 bar charts showing the average number of trucks passing through the gates per hour of the day, for each of the 7 days of the week.
- In the yellow rectangle we can see the maximum number of trucks inside the port per day, for a long period of time (several months), in a line plot (thick blue line). We also see the number of bookings per day, for the same period of time (light blue line).

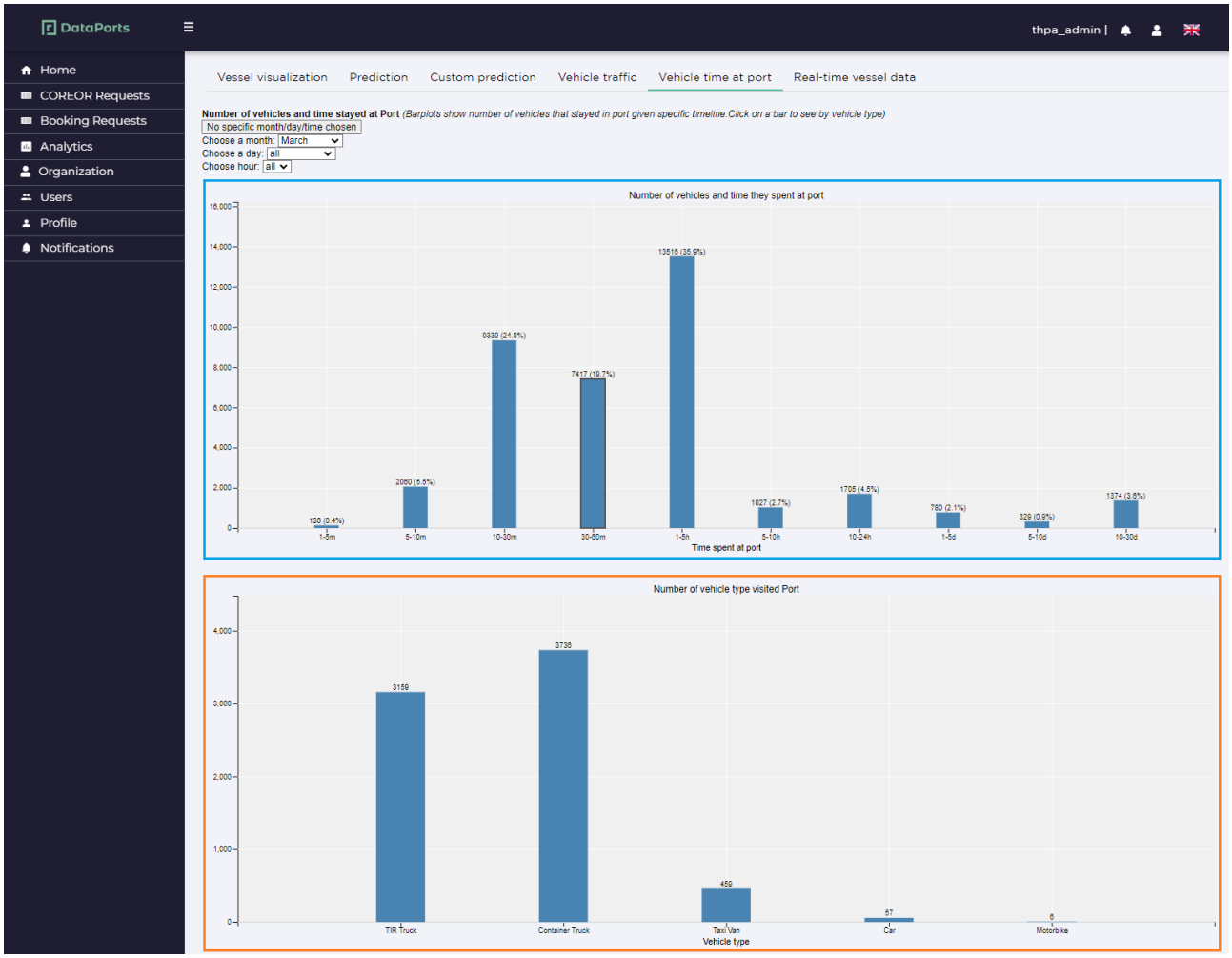


Figure 40 - Vehicle time at port – part of the ThPA statistics visual analytics

The final part of the ThPA statistics application can be found in the "Vehicle time at port" tab of the Analytics menu, as can be seen in Figure 40. Here, the "Gate Events" dataset from the GAS system is used.

- The bar chart of the blue rectangle shows the number of vehicles per duration of stay at the port premises. Each bar represents one stay duration category. There are 16 different duration categories: less than 1 minute, between 1-5m, between 5-10m, between 10-30m, between 30-60m, between 1-5 hours, between 5-10h, between 10-24h, between 1-5 days, between 5-10d, between 10-30d, between 1-3 months, between 3-6M, between 6-12M, more than 1 year and unknown time. Clicking on a specific bar opens up the bar chart in the yellow rectangle.

The bar chart in the yellow rectangle shows splits up the number of vehicles, corresponding to the selected bar from the blue rectangle chart, to number of vehicles per vehicle type. So, in the example shown in Figure 40, of the, on average, 7417 vehicles staying between 30-60 min in the port during the month of March, 3159 of them are TIR trucks, 3736 are container trucks, 459 are Taxi vans etc.

4.3.1.2 Queues Predictions

As with ThPA Statistics, the Queues Predictions use case utilises data from the ThPA statistics application, the Truck Appointment System (TAS) and the Gate Access System (GAS). These data are used to predict ship turnaround times, as well as estimate the traffic at the port premises. Again, such predictions can provide valuable insight into traffic load, as well as workload at the docks, to a ThPA analytics user.

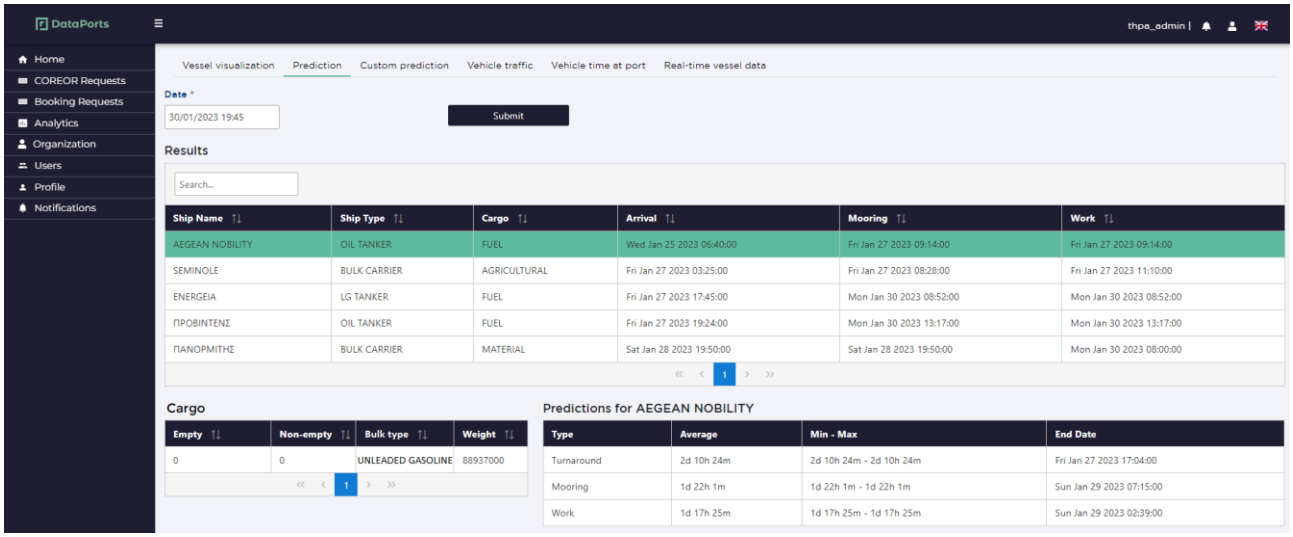


Figure 41 - Prediction – part of the Queues Predictions analytics

Figure 41 shows the “Prediction” tab within the Analytics menu, which is part of the Queues Predictions use case. Here, the “Commercial vessel calls” dataset from the ThPA statistics application is used. The view consists of a date picker field and three tables: Results, Cargo, Predictions for <ship_name>.

- When a datetime is selected in the date picker and the Submit button is pressed, the Results table is filled with ships that were in the port at that exact datetime, along with information like ship name, ship type, its cargo, and three dates regarding the arrival and the start date of mooring and work respectively.
- Clicking on a ship in the Results fills the Cargo table with the number of empty and non-empty containers, the type of bulk cargo and the weight of the cargo. If the ship is carrying bulk cargo, the number of containers will be zero and the weight will refer to the bulk cargo. If the ship is carrying containers, their numbers will be shown and weight will refer to container weight.
- The predictions table takes a few seconds to load. Once it does, it contains predictions for the three stages of the ship’s stay at the port (turnaround time, mooring time, work time), given both as a prediction on the average time and as a min-max range. There is also the ‘End date’ column that provides the prediction as an absolute datetime for the given stage of the ship’s stay at the port.

Figure 42 shows the “Custom prediction” tab within the Analytics menu, which is part of the Queues Predictions use case. Again, only the “Commercial vessel calls” dataset from the ThPA statistics application is used. The view consists of a series of fields describing a ship and its arrival, mooring and work times (if known), and a Predictions table.

The mandatory fields are the ship’s name, the arrival time, ship type, cargo, number of empty and non-empty containers, and weight. Once we input all the necessary information, we click on the Submit button and the Predictions table is filled with estimates for turnaround, work and mooring times. This table is identical to the Predictions table in the Prediction tab. Once we are done inspecting the given predictions, we can click the ‘Clear’ button so as to reset the fields and proceed with another custom prediction.

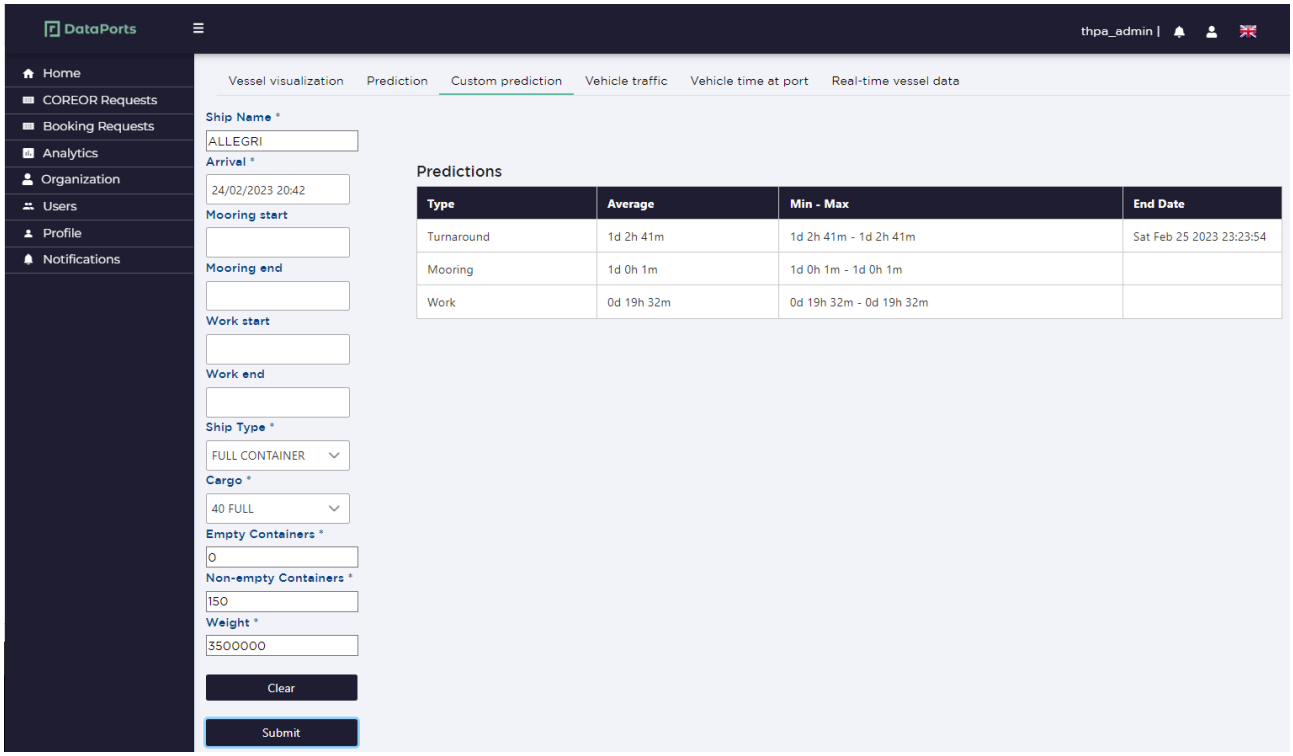


Figure 42 - Custom prediction – part of the Queues Predictions analytics

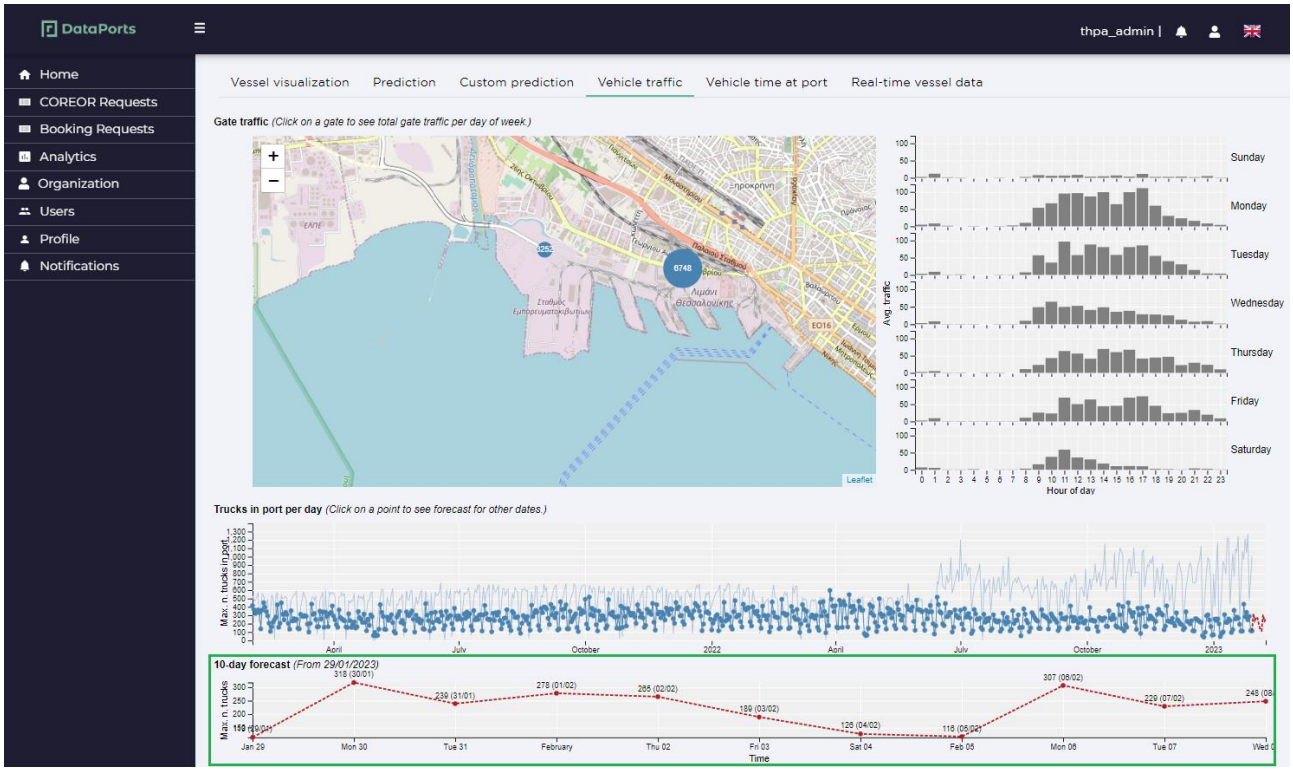


Figure 43 - Vehicle traffic – part of the Queues Predictions analytics

The final part of the Queues predictions application can be found in the “Vehicle traffic” tab of the Analytics menu, as can be seen in Figure 43. Here, the “Commercial vessel calls”, “Bookings” and “Gate Events” datasets from the ThPA statistics, TAS and GAS systems are used. The line chart in the green rectangle shows the forecasted number of trucks in port for the next 10 days.

4.3.1.3 Facilitation of Passengers, Professionals, and Visitors of the Port

The analytics developed for this and the Covid use cases are made available to the general public through a public web portal. Prior to visiting the port, professionals and general public alike can visit this portal to evaluate local traffic conditions, as well as the density of commuters, around the port. A visitor's needs vary according to the purpose of the visit. A professional having a business meeting in or around the port will want to assess the traffic conditions and parking spots in the area, to avoid hours of peak traffic and commuting. On the other hand, a street vendor that wants to set an outdoor stand, will want to "exploit" a high concentration of people around the port. The platform also "returns" information such as traffic and time required to reach the port premises per route. Through the application, the user has also the possibility to access the average number of visitors for both parking lots that ThPA S.A. handles. The use case solution is based on the OTE mobility data, parking data from the parking lots and traffic data provided by CERTH-HIT.

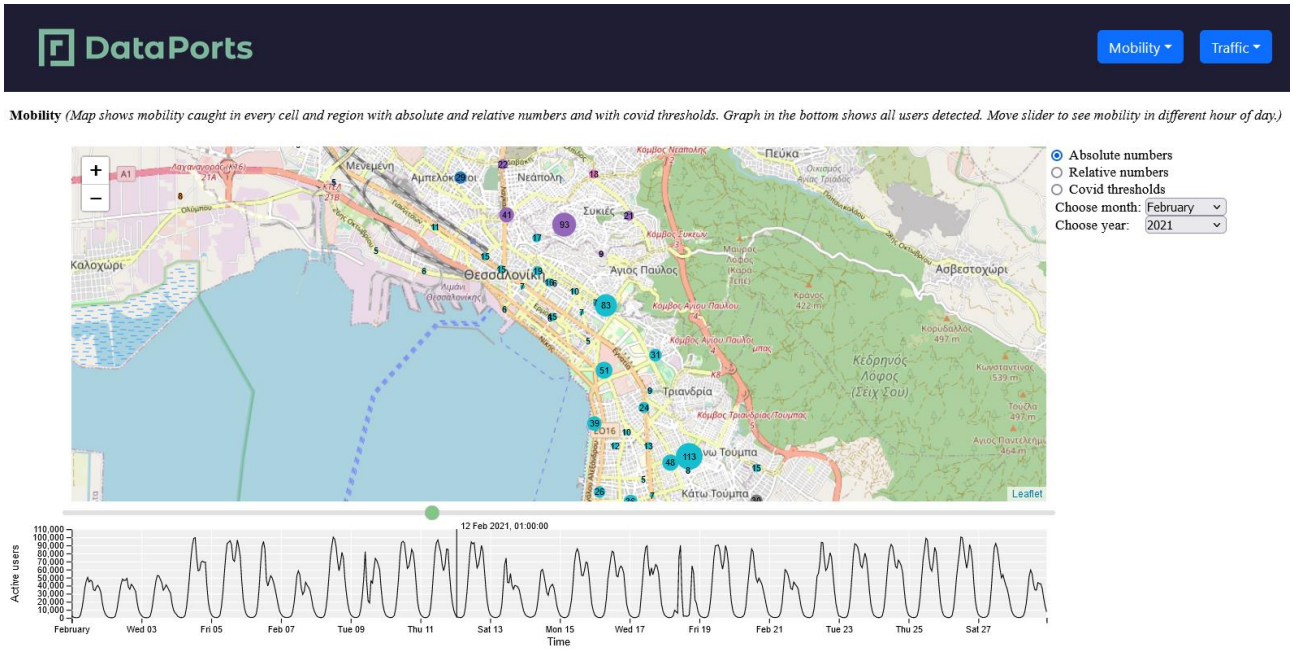


Figure 44 - Mobility monitoring – part of the Passenger Facilitation analytics

The first functionality that comes up when opening the public frontend is Mobility monitoring (Figure 44). Information comes up on a map of Thessaloniki, where numbered nodes are shown, each roughly corresponding to a mobile network cell. The number accompanying each node is the *absolute* number of people caught using their cell phones in that cell, on a specific hour, day, month and year. Alternatively, the user can opt for *relative* numbers by clicking on the appropriate radio button. In this case, the numbers in each node show how much higher or lower the mobility is on a specific hour, day, month and year, compared to the average value for that node. The final option of COVID is in essence the implementation of the Covid-19 statistics use case and will be presented in the next section.

Using the dropdown menus, the user can select a different month and/or year. By moving the slider, the user can select a specific hour and day, and the data inside the map change accordingly.

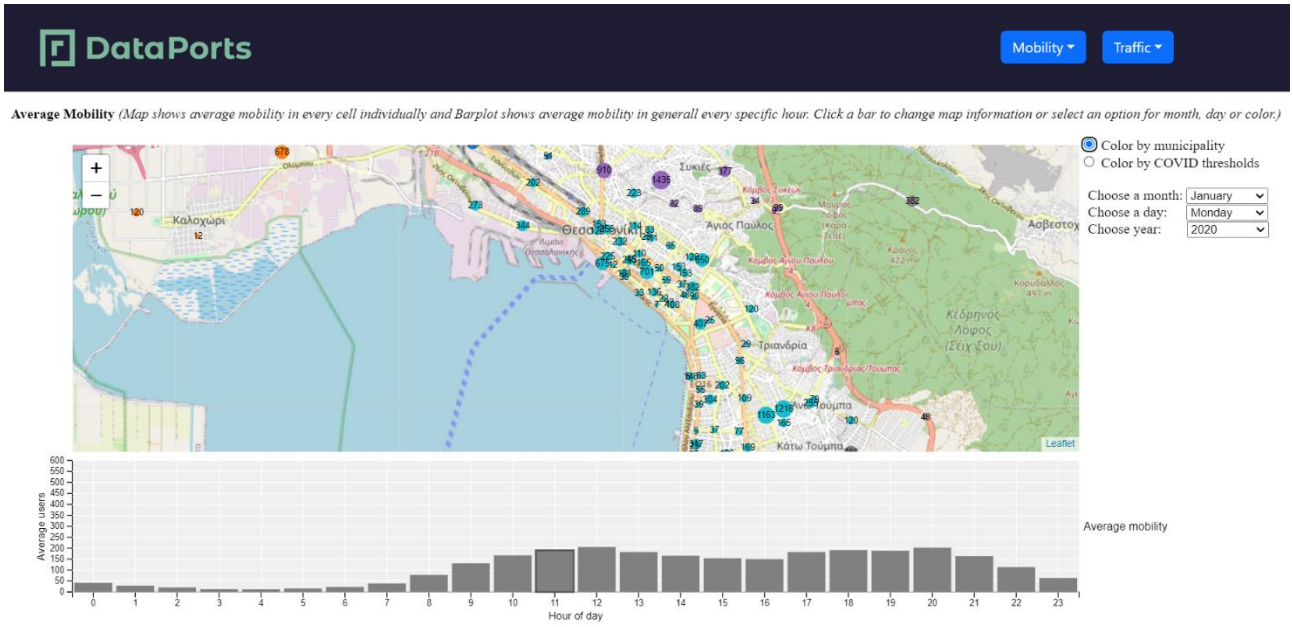


Figure 45 - Mobility statistics – part of the Passenger Facilitation analytics

The next functionality is Mobility statistics. This shows the same map view, but in this case what we see in each node is the average number of people during the selected hour, day, month and year. The user can select the desired month, day and year from the drop-down lists, and the hour by clicking on any of the bars in the bar chart, right below the main map. Each bar corresponds to an hour within the day and shows the average users throughout the city for that hour. The default hour is hour zero (00:00-00:59 in the morning). Clicking on one of the other bars updates the map to show the average values in all nodes for the newly selected hour. There are two options for colouring the nodes: i) by municipality, or ii) by COVID thresholds based on average.

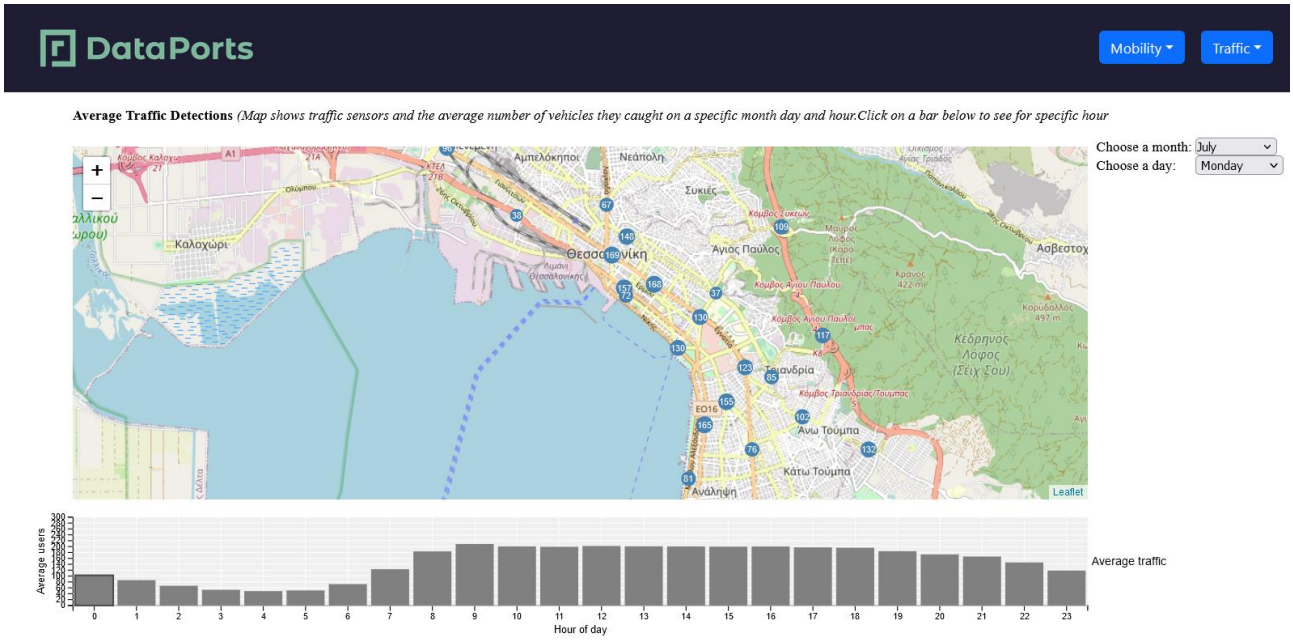


Figure 46 - Traffic statistics – part of the Passenger Facilitation analytics

The third available functionality is Traffic statistics. Again, we see the map of Thessaloniki, in which nodes now represent traffic detector sensors. Inside each node we have the average traffic detected by the sensor

for every hour, day and month, which changes when selecting a different bar from the bar chart, as with mobility statistics. We can change the month and day through the drop-down lists on the right of the map.

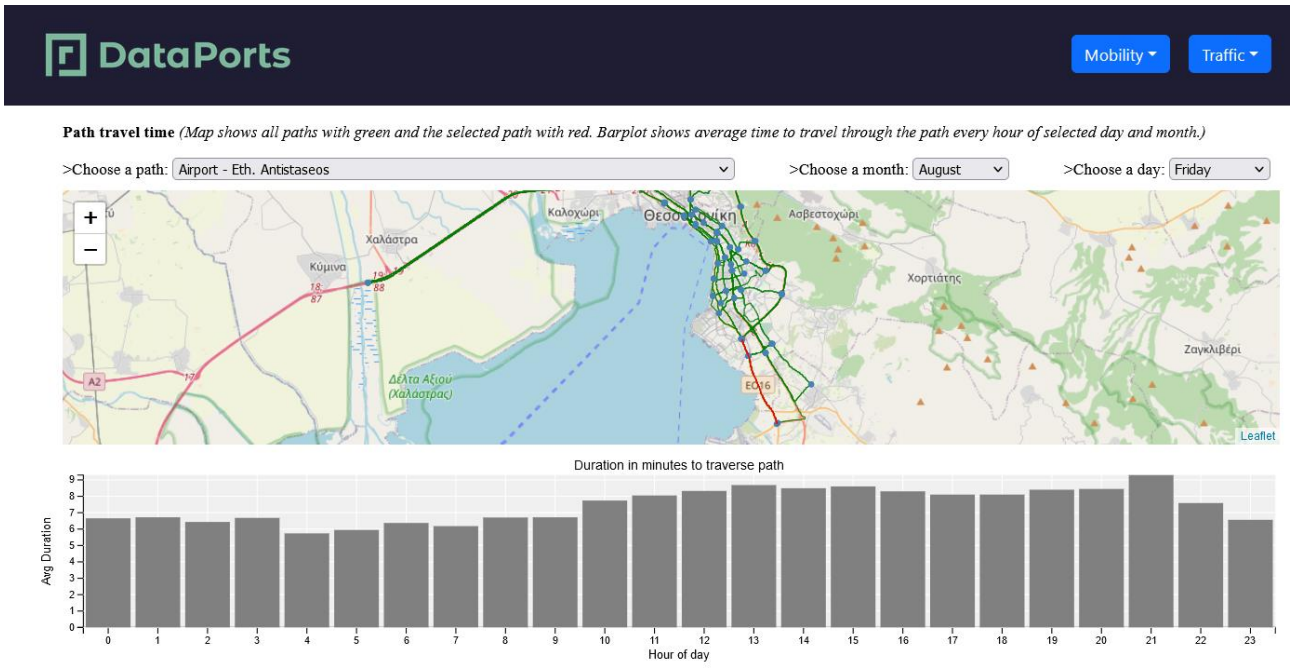


Figure 47 - Traffic travel times – part of the Passenger Facilitation analytics

Next is the Traffic travel times functionality. On the map we see various paths throughout the city streets as lines, connected at various points. All paths appear as green, with only the currently selected path being red. The user can choose the current path from a drop-down list above the map. Below the map we have a bar chart, showing the average travel duration for traversing the selected path during the selected hour, day and month. We can change the month and day through the drop-down lists at the top-right of the map.

Figure 48 - Parking spots – part of the Passenger Facilitation analytics

Finally, we have statistics for Parking spots, relating to the two commercial parking lots situated at the port. We can select whether we are interested in one of the two parking lots, or both, through a drop-down list at the top-left. Right next to that is the total vehicle capacity for our selection.

The main line chart shows how the number of occupied parking spots changes during the day. We can see that usually, peak hour is at 9:00am with a local low at around 3:00pm, then a new peak at 6:00pm and then gradually emptying throughout the evening. The user can adjust the small chart under the main one, in order to isolate just one period of time and hence have better resolution in the main chart.

The bar charts to the right of the main chart show average parking spot occupancy, per hour and day of week.

4.3.1.4 Statistics for Passengers/Visitors - Covid-19

Due to the unforeseen impacts of Covid-19, wants to provide data on mobility to serve as indicators for social distancing. Through the DataPorts solution, this can be accomplished, using mobility data provided by OTE.

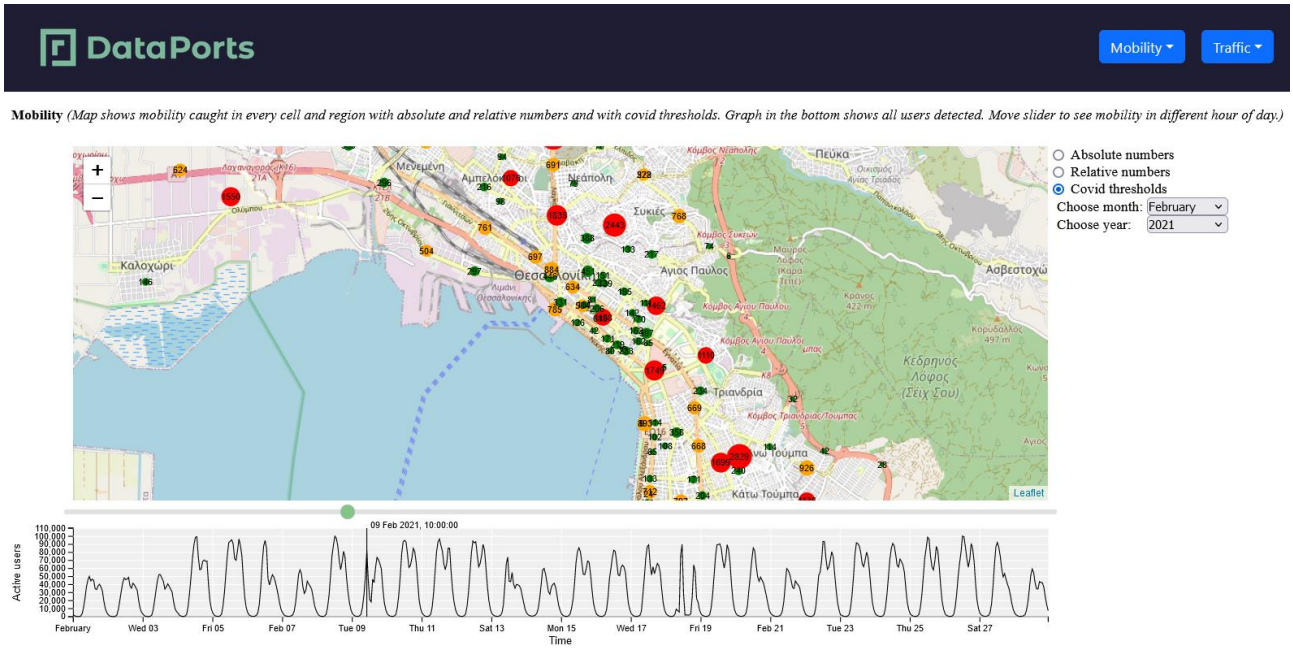


Figure 49 - Mobility monitoring - Covid

The first Covid-related functionality can be found in the Mobility monitoring option of the Mobility menu. Once the Covid thresholds radio button is selected, information comes up on a map of Thessaloniki, where numbered nodes are shown, each roughly corresponding to a mobile network cell (Figure 49). The number accompanying each node is the *absolute* number of people caught using their cell phones in that cell, on a specific hour, day, month and year. In contrast to the absolute numbers option, Covid thresholds display a different colour scheme, where the colours represent different danger levels: green is for low-risk areas, orange for medium-risk and red for high-risk areas. Attributing a colour to a node is not based on just the absolute amount of mobility for that node, but on the difference between the absolute and average values for that node. This way, nodes where big spaces exist and which, therefore, frequently attract large crowds, will not necessarily be considered high-risk.

The second Covid-related functionality can be found in the Mobility statistics option of the Mobility menu. This shows the same map view, but in this case what we see in each node is the average number of people during the selected hour, day, month and year (Figure 50). The user can select the desired month, day and year from the drop-down lists, and the hour by clicking on any of the bars in the bar chart, right below the main map. Each bar corresponds to an hour within the day and shows the average users throughout the city for that hour. The default hour is hour zero (00:00-00:59 in the morning). Clicking on one of the other bars updates the map to show the average values in all nodes for the newly selected hour. Selecting the Covid thresholds radio button displays the same data as in the Colour by municipality option, but in the green-orange-red scheme.

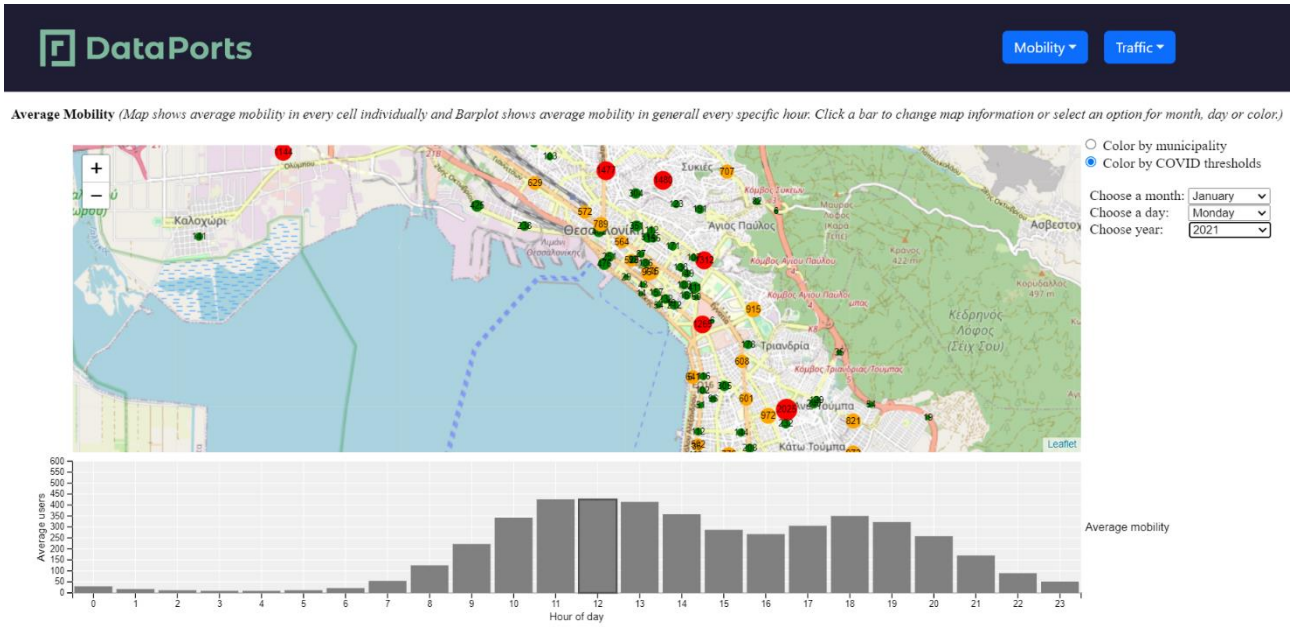


Figure 50 - Mobility statistics – Covid

4.3.2 DataPorts roles

Table 43 shows the organizations that take part in the scenario implementation and their roles:

Organisation	Role
ThPA	ThPA will be the scenario leader, providing the infrastructure and business knowledge to successfully run the demo
OTE	OTE provides the mobility data that is necessary for the development and testing of the "Facilitation of passengers" and the "Statistics for Covid-19" use cases.
CERTH	CERTH has provided the local application frontends and implementation of the analytics applications
PRO	PRO will develop the agents to acquire data at Port premises
UPV	UPV will be in charge of transforming data to a common data model
EVR	EVR will oversee security when it comes to communication with Data Governance, as well as deployment of the Data Governance network

Table 43 – Analytics for ThPA Roles

4.3.3 Activities carried out

Table 44 contains the tasks involved in the implementation of the scenario.

Time	Actors	Actions
M21-M22	OTE	Provided the mobility data
M22-M24	CERTH, ThPA, OTE	CERTH, ThPA and OTE decided on the initial tentative scenario specifications
M22-M28	CERTH	Create the models to generate the services based on Port Authorities needs
M25-M37	ThPA, CERTH,	Deploy the necessary infrastructure for the scenarios and the DataPorts

Time	Actors	Actions
	PRO, UPV, EVR	Components
M25-M37	PRO	Development of the Agents for all the data sources
M26-M30	CERTH, ThPA	CERTH and ThPA decided on the final scenario specifications
M26-M37	CERTH	Develop the applications
M26-M37	CERTH, ThPA	Develop the corresponding frontend

Table 44 – Analytics for ThPA Action Plan Reporting Table

4.3.4 Data Integration

The aforementioned data sources have been connected with the platform with the development of the corresponding agents. The complete list of the agents developed for this scenario is shown in the Table 51.

Agent	Type	Description
OTE	On demand	The agent reads Mobility Data from a CSV file.
Commercial Ship Call	On demand	The agent calls an API for retrieving the vessel calls from the ThPA statistics application.
Booking	On demand	This agent uses an API to get the truck bookings for container pick-up
Parking	On demand	This agent retrieves the parking status calling an existing API.
Traffic – Travel Time	On demand	The agent reads Traffic Data from a CSV file.
Traffic – Traffic Detection	On demand	The agent reads Traffic Data from a CSV file.
Expected Cruise Ship Call	On demand	This agent uses calls an API to get the list of container ships that will call THPA in the near future.
Gate Event	On demand	The agent gets the status of the gates using a provided API.
Posidonia Operations	Publish / Subscribe	This agent subscribes a RabbitMQ broker for Posidonia Operations events. These events are translated into the platform's ontology.
Smart Containers Geolocation	Publish / Subscribe	Agent to integrate containers' positions
Smart Containers Geofencing	Publish / Subscribe	Agent to integrate containers' events for entering or departing zones
Smart Containers Door Opening	Publish / Subscribe	Agent to integration door opening containers' events

Table 45 – Agents implemented in this scenario

4.3.5 Applications

Table 46 describes the applications that are part of the scenario that interact with the platform and have been updated or implemented, along with the links to the documentation.

Application	Action	Status
Statistics for THPA Prediction	New application	100%
The ThPA port authority needs to have insight into the performance of its operations. The application combines the source datasets to produce statistics, metrics and KPIs.		
User documentation can be found in Annex A: 9.2.2.1 Vessel visualization 9.2.2.4 Vehicle traffic 9.2.2.5 Vehicle time at port		
Application	Action	Progress
Queues Predictions	New application	100%
The application will combine input datasets to estimate traffic in and around the port premises, in relation to its operations. Through the DataPorts solution, the Terminal Operator can get queues predictions.		
User documentation can be found in Annex A: 9.2.2.2 Prediction 9.2.2.3 Custom prediction 9.2.2.4 Vehicle traffic		
Application	Action	Progress
Facilitation of Passengers, Professionals, and Visitors of the Port	New application	100%
The application produces information such as traffic and time required to reach the port premises, directed to passengers, professionals, and visitors of the port, based on which they can adjust their visit to the port.		
User documentation can be found in Annex A: 9.2.2.6 Mobility 9.2.2.7 Traffic		
Application	Action	Progress
Statistics for Passengers/Visitors Covid-19	New application	100%
The application provides indicators for social distancing, based on mobile phone network data.		
User documentation can be found in Annex A: 9.2.2.6 Mobility		

Table 46 – Analytics for ThPA Applications

5 GLOBAL USE CASE: SMART CONTAINERS

5.1 APPLICATIONS DEPLOYMENT

The three scenarios selected for the smart container pilot were implemented as planned within the Valencia Port Pilot (refer to section 3 of this document) in the same environment.

The first one concerns the “Raw container location information”. The implementation has been carried out on the raw data: the main benefit is an improvement of the visibility by providing in quasi real time the position of the container and thus the visibility of the tracking of the booking. Other services can be developed based on this data and on Machine Learning algorithms, the benefits will be further developed in the following sections.

The two other scenarios concern notifications for two different use cases: the door opening and the geofencing (or also Gate in / Gate out) notifications. The implementation for these two services was also implemented at the Valencia Port pilot.

To collect and exploit this data, Traxens has installed 40 devices with a departure from the two ports involving into this project: 24 devices was installed in the Valencia port and 16 devices in Thessaloniki port. The Figure 51 and Figure 52 shows the geolocation of the devices installed for the pilot as of the 6th of February 2023.

Figure 51 : Valencia Smart Containers pilot geolocation

Figure 52 : Thessaloniki Smart Containers pilot geolocation

The geolocation data, used as a row data bring us visibility on the position of the container in a near real time, we can also follow the trajectory of the cargo at any time. The Figure 53 and Figure 54 shows examples of container trajectory.

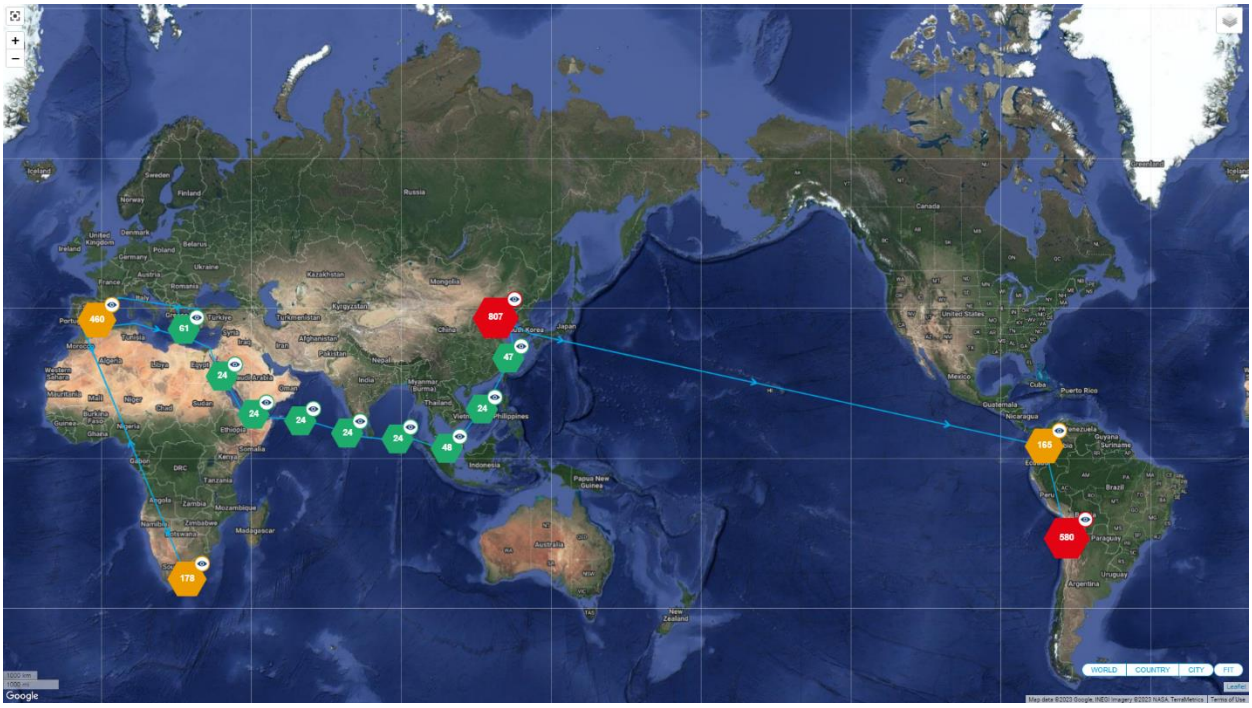


Figure 53 : Container trajectory Example 1

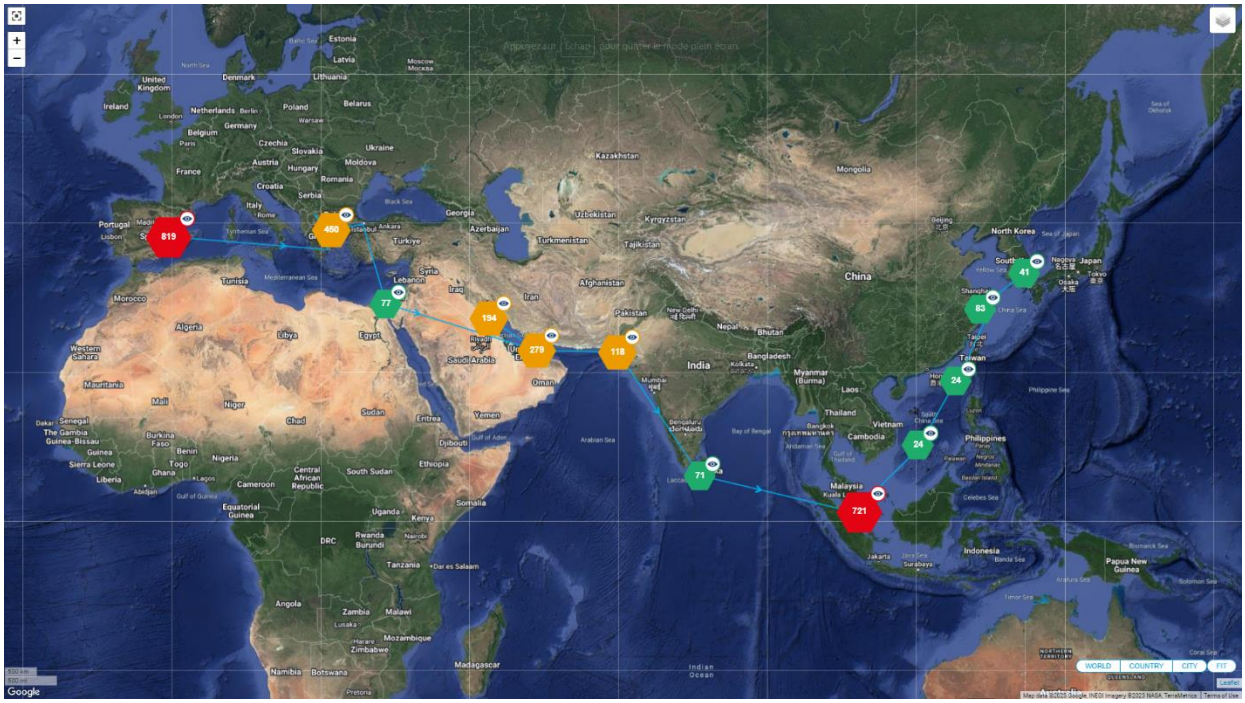


Figure 54 : Container trajectory Example 2

From the date of installation of the pilot until this date, these devices generated more than 80 000 geolocation event, 1500 door opening event and 6000 geofencing events.

The three use cases can be visualised on the “events” section of the Dataports platform. The Figure 55, Figure 56 and Figure 57 bellow shows the different events available on the platform in the event section.

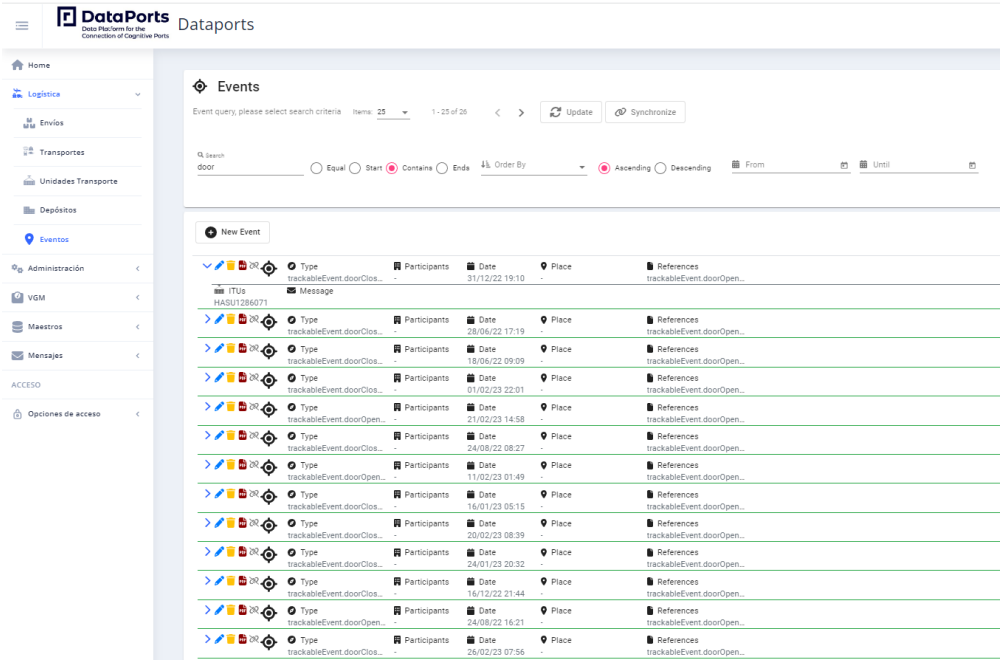


Figure 55 : Door Opening Events

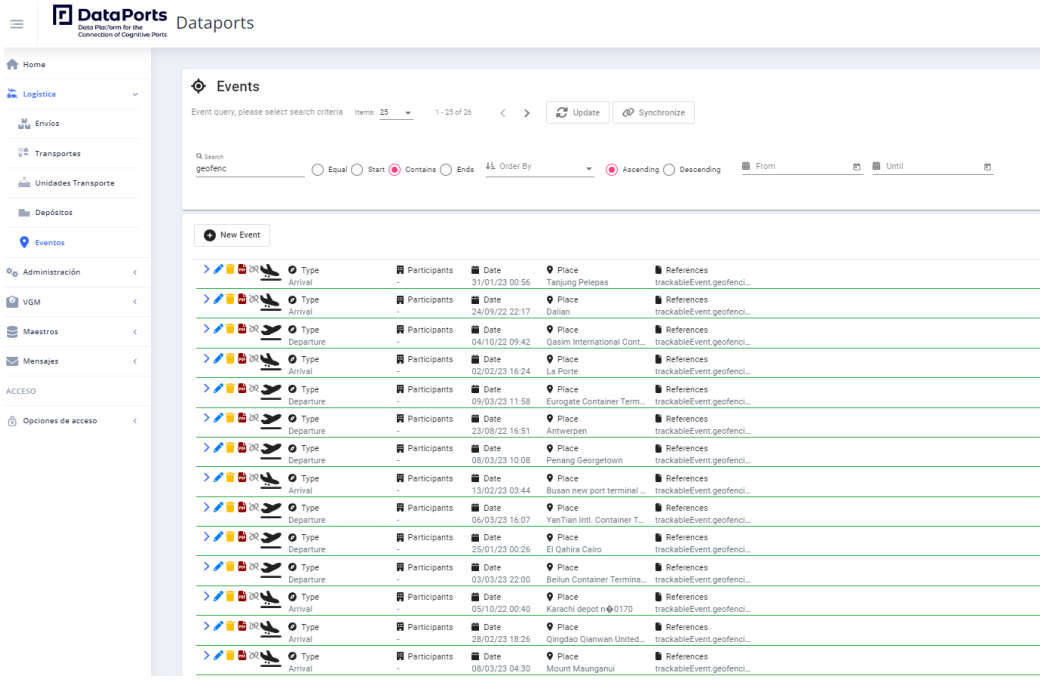


Figure 56 : Geofencing Events

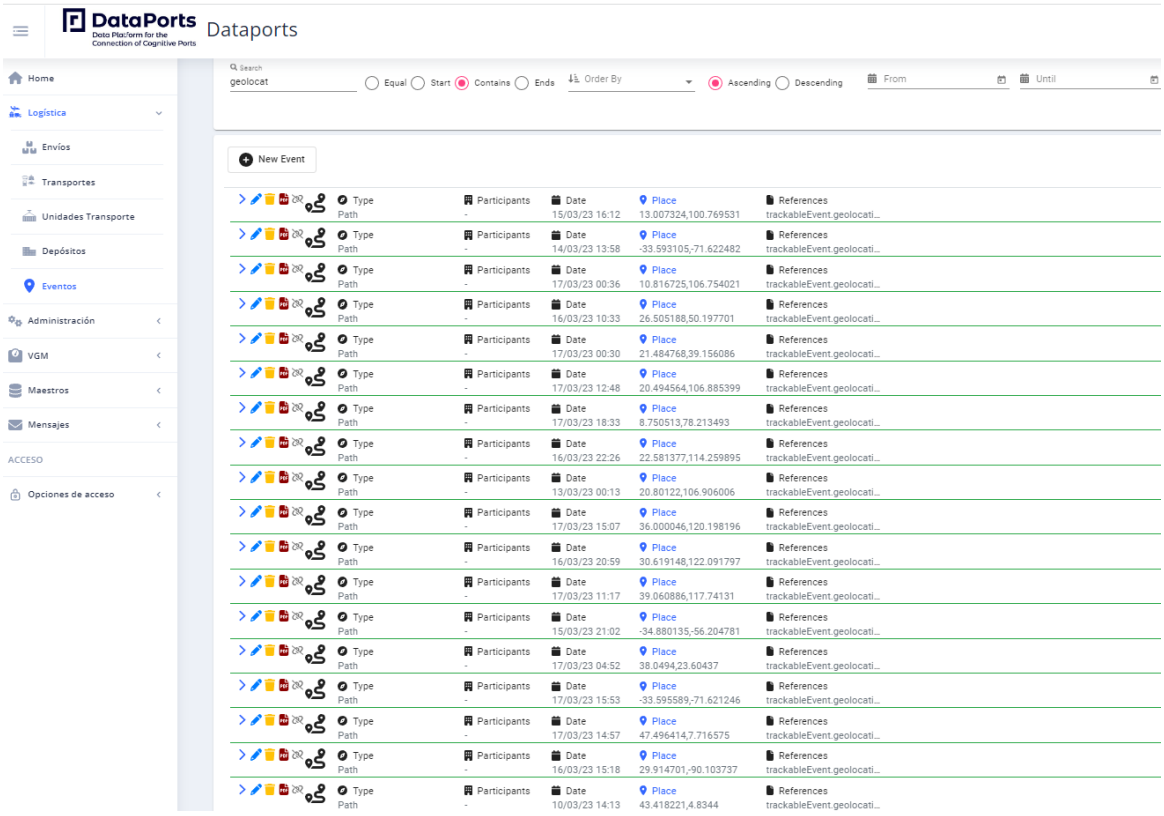


Figure 57 : Geolocation Events

5.2 SMART CONTAINERS

During any given container trip, many transport operators are involved, and no single one has total door-to-door visibility. Hence, as a common asset, a container—once equipped with smart technologies—will enable stakeholders to have better visibility based on additional reliable physical data generated by IoT devices.

Visibility enables actors to enhance their processes, resulting in the reduction of transport lead time and costs.

A “Smart Container” is a marine shipping container, which is fitted with an installed smart monitoring device. A “Smart Device” (aka, IoT device) is an electronic device embedded with a set of sensors, enabling it to measure real-time information such as identifying location, door opening and closing, vibrations, temperature, humidity, and any measured physical parameters of the surrounding environment of the container. The smart device has a communication capability, which enables it to send out the measured data to a collection centre. Using the Smart Container data, new services could be generated: an example is the ETA of the container, which can be compiled based on the current position of the container and the time estimated to get to the next place (e.g., zone of interest).

The use of Smart Containers within the supply chain provides benefits in many ways to the various transport chain stakeholders. The Smart Container provides a complementary source of information for traffic management and traffic management information provides for a better understanding of what movements and operations have occurred linked to the containers. This means that additional awareness of which containers are on the move, their status, as well as opportunities to detect forgotten or delayed ones, can be derived. Smart Container data enables the supply chain stakeholders to understand, predict, anticipate, and take corrective actions to adjust their plans based on well-informed decisions.

Figure 58 - Benefits expected from Smart Containers

Smart Containers can improve:

- The global supply chain: reduce buffer stocks and stock in transit,
- Cargo quality: avoid spoiling and optimize cost of packaging (due to impact of temperature or humidity), alert of damage to goods to react quicker,
- Cargo security: prevent theft or smuggling, can allow to implement fast lanes with customs authorities,
- Transport efficiency: better CO2 impact evaluation, higher level of transparency for detention and demurrage, optimize containers reallocation thanks to route optimization and fleet management,
- Trade finance: improved credit terms and cash management,
- Insurance & process compliance: potential reduction of premiums, easier claim management.

In this Section, we explore how different port stakeholders can benefit from the integration of Smart Containers data in the DataPorts platform.

5.2.1 Scenario Description

In this use case, regular containers have been fitted with permanent IoT devices provided by Traxens. These IoT devices periodically generated and communicated GPS position, informing about the position of the container at a given time.

A container trip plan is an end-to-end routing from first pick-up to last drop-off of the Smart Container. A Trip (voyage, journey) may consist of multiple Segments (a.k.a. legs) or may only be a single Segment. The endpoints of the segments are geographical areas which are a predefined Zones of Interest (ZOI) relevant for tracking a container or other transport equipment/means, along the supply chain.

The geofencing capability is the crossing in/out of a predefined, geofenced Zone of Interest.

By making use of the GPS positions transmitted by the Smart Container and having geofenced key ZOI, it is possible to receive notifications when the position of the subject Smart Container intersects with the geofenced area.

For example, thanks to the Smart Container solution, stakeholders can gain valuable knowledge on the exact whereabouts and status of their container, enabling them to improve their logistics. By receiving a notification that the container has been unloaded from the ship, the user is enabled to proceed to dispatch a truck to pick it up at the optimal time.

Having Smart Container data may also decrease cargo loss, legal costs, insurance fees and investigation processes and damage to goods. At the same time, door-to-door visibility may result in increased cargo security; better service level, on-time deliveries since the processes flow better.

In this global use case, Smart Container solutions provide three types of data to the supply chain stakeholder who will be empowered to react proactively and plan container operations or cargo logistics accordingly.

Service 1: The Gate In/Gate Out to a well-defined geographical zone

A message with the Gate In/Gate Out of the container from a given position can be sent out to the identified actors. When an empty Smart Container enters/departs the premises of a depot, this event can be reported to the container operator and all interested parties. This event reported by the Smart Container might be duplicate to the event that the depot operator should send out, typically by EDI message CODECO, for the same container. Making use of the GPS positions of the Smart Container and geofenced Zone Of Interest (ZOI) identified as a particular depot, the tracking solution will detect entering/departing this given ZOI and generate the Empty gate-in/gate-out at Depot event. As an example, the container operator will be able to check whether the container is back to the depot or has left the depot and at what time without having to go check the container physically.

Service 2: Container door opening or closing notification

A message notifying that the container has been opened or closed can be sent out to the identified actors. The trip plan logic integrated in Traxens' platform thanks to the integration with Shipping Lines allows to share only the trip data with the Beneficial Cargo Owner (Shipper or Consignee) and detect and transmit door openings only during the booking. This information is of interest to the customer because it can inform on stuffing processes efficiency and also unexpected door openings along the trip. It then helps to define responsibility in an intrusion.

Service 3: Raw container location information

A message providing the latest position of the container. Traxens' applications allow to visualize and contextualize the positions, but they can also be transmitted as raw data to customers. This allows to optimize the last-mile and other logistic operations thanks to up-to-date information. It can also allow to retroactively inspect the route of containers to optimize global routing operations.

The following stakeholders are concerned by these services:

- **Requestors**: Parties that will request and order the transportation of cargo and transport units to the carriers, establishing contractual agreements with them. The transport requestor role could be played by: (i) the cargo owners (buyers, sellers or intermediaries), the freight forwarders or cargo agents, the customs agents or officers, the shipping agents and the shippers, as well as the terrestrial carriers that act as requestors with respect to other carriers.
- **Carriers**: Parties that will execute the transportation of cargo and transport units under a contractual agreement established with the transport requestors. The carrier role could be played by road, railway and maritime transport companies as well as by their transport agencies. The freight forwarders and cargo agents can also play the role of carriers with respect to the cargo owners.
- **Shippers**: Parties that will deliver the cargo or transport units to the carriers for its transportation under contractual agreements established between the requestors and the carriers. Shippers can deliver the cargo immediately or can order to depots the delivery of cargo to the carrier. The shipper role could be played by: (i) the cargo owners (sellers or intermediaries), the freight forwarders or cargo agents, the customs agents or officers, the shipping agents and shippers, as well as the terrestrial carriers that act as shippers with respect to other carriers.
- **Consignees**: Parties that will receive the cargo or transport units from carriers at the destinations agreed at the contractual agreements established between requestors and carriers. The consignees could either receive the cargo directly or they could order to a depot its reception and entry to the depot. The consignee role could be played by the cargo owners (buyers or intermediaries), the freight forwarders or cargo agents, the customs agents or officers, the shipping agents and shipper, as well as terrestrial carriers that play the role of recipients with respect to other carriers.

However, in the case of the pilot, the ports will play the role of Requestors, Shippers and Consignees and there will be not billing for the service.

The Figure 59 depicts the workflow and interactions of the scenario:

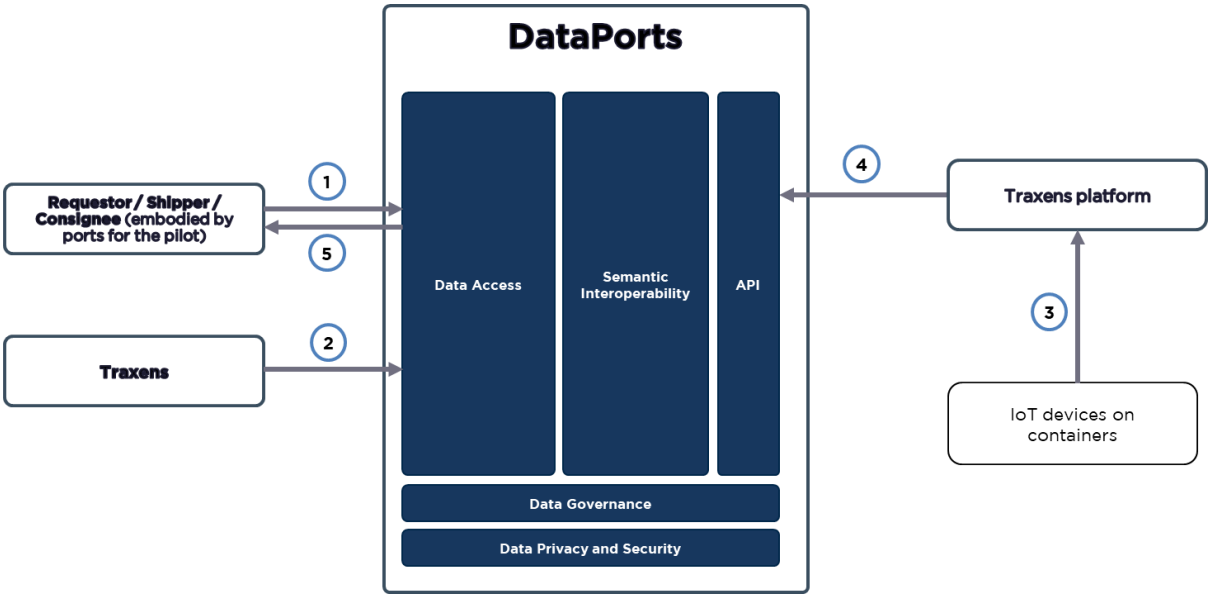


Figure 59 – Smart container workflow

In the case of the pilot, the ports will play the role of Requestors, Shippers and Consignees and there will be not billing for the service.

The Table 47 lists the interactions, events and processes of the scenario:

Step	Description
Pre-condition	An empty Smart container (equipped with an operational IoT device) is available on the port's depot.
1	The container is assigned to a booking and leaves for the trip. The port requests smart container data access which is transferred to Traxens platform.
2	Traxens grants access to data into DataPorts.
3	Smart container generates data integrated into Traxens platform in near real time.
4	Traxens provides trip data for the 3 different services into DataPorts.
5	Port has access Through DataPorts interface (API/UI) to regular events and alerts generated by the container including timestamped GPS positions, gate in/gate out timestamped events and timestamped door opening detections.

Table 47 – Smart Containers Scenario Description

The datasets shown on Table 48 will be used in this scenario:

Datasource	Description of data
IoT devices data for Zone of Interest Get In/Get out **(Service 1)**	Container ID, timestamp, GPS, ZOI ID: The place of the event per the UN/LOCODE (if any such Terminal code, Depot code, GS1 Global Location Number (GLN), etc.), boolean (IN/OUT)
IoT devices data for Container door opening or closing **(Service 2)**	Container ID, timestamp, door opening status (OPEN/CLOSED)
IoT devices data for Raw container location **(Service 3)**	Container ID, timestamp, GPS

Table 48 – Smart Containers Scenario Datasets

For ports, the benefit of this use case is to add a packaged Smart Containers service to their catalogue to gain competitive advantage compared to other ports.

For Requestors, Shippers and Consignees working closely with the ports involved in DataPorts can benefit from a single integration into DataPorts to get Smart Containers data without extra onboarding process.

Traxens can then commercialize the service through another channel and benefit from local shippers around VPF and ThPA to reuse Smart Containers initially equipped at remote origin (Asia, South America…) on a paid service. Moreover, this use case is fully covered by the contracting structure with Carriers as asset owners.

As an opportunity, we will use the pilot to assess improvement of port operations with container IoT devices. Indeed, containers are intermodal (e.g., the door-to-door trip relies on several different modes of transportation: ocean freight, air freight, rail, trucking) by definition, and the terminals are the place where they change transportation modes. Hence, having access to reliable physical data on the trip execution using

the Smart Container technologies can help improve the scheduling of port operations.

Container terminals play an instrumental role in the movement of containerized cargo from consignor to consignee. Smart Container solutions will enable terminal operators to verify the exact location of each container in their yard efficiently, and in real time.

This part of the use case is not planned as a defined service, we expect to exploit data generated during the Door-to-door visibility pilot to evaluate the benefits Smart Containers can bring to the port stakeholders. The benefits can be:

- Increase in container reuse rate in ports: Smart containers enable terminal operators to verify the exact location of each container in real time, to estimate their Estimate Time of Arrival (ETA) for a given containers and plan their operations accordingly.
- Reduction in the number of containers not loaded due to delays in the port: Smart containers enable terminal operators to verify the exact location of each container in real time, to estimate their time of arrivals (ETA) for a given containers and plan their operations accordingly.
- Improvement of berthing/unberthing smart container operations: enable terminal operators to verify the exact location of each container in their yard in real time, advise of mishandling or equipment failures, and assist in locating dangerous goods to enhance safety.

Having enough data to evaluate the benefits requires the deployment of 20 Smart containers in each port with at least one export trip each, ideally several thanks to closed loops.

5.2.2 DataPorts roles

The Table 49 shows the organizations that take part in the scenario implementation and their roles:

Organisation	Role
TRX	TRX will provide the devices on containers and develop the logic to provide smart containers data on-demand from Traxens platform.
VPF	VPF will evaluate the results from data issued by the containers installed in Valencia.
ThPA	ThPA will evaluate the results from data issued by the containers installed in Thessaloniki.
PRO	PRO will develop the agents to integrate smart containers data into DataPorts and share data with ports.
UPV	UPV will be in charge to transform data to a common data model.

Table 49 – Smart Containers Roles

5.2.3 Activities carried out

The Table 50 contains the tasks involved in the implementation of the scenario:

Time	Actors	Actions
M10-M15	TRX	Provide a scenario for the use case review by all partners
M15-M18, delayed to M24	TRX, VPF and ThPA	Deploy the necessary infrastructure of IoT devices on containers
M15-M25	TRX and UPV	TRX and UPV integrate Smart containers data model requirements into DataPorts model

Time	Actors	Actions
M25-M28	PRO and TRX	PRO develops the agents following TRX data sources specifications and requirements
M25-M34, delayed to M38	TRX, VPF and ThPA	Integrate the use case in tracking application and evaluate Smart Containers benefits for the ports

Table 50 – Smart Containers Action Plan Reporting Table

5.2.4 Data Integration

The aforementioned data sources have been connected with the platform with the development of the corresponding agents. The complete list of the agents developed for this scenario is shown in the Table 51:

Agent	Type	Description
Smart Containers Geolocation	Publish / Subscribe	Agent to integrate containers' positions
Smart Containers Geofencing	Publish / Subscribe	Agent to integrate containers' events for entering or departing zones
Smart Containers Door Opening	Publish / Subscribe	Agent to integration door opening containers' events

Table 51 – Agents implemented in this scenario

6 GLOBAL USE CASE: PORT MANAGEMENT SYSTEM INTEGRATION

6.1 APPLICATIONS DEPLOYMENT

This use case is built from two different phases. The first one consists in providing useful data to current pilot users from the ports of Valencia and Thessaloniki. For that purpose, an instance of the vessel flow monitoring application Posidonia Operations has been created and configured for each of the ports, as shown in Figure 60:

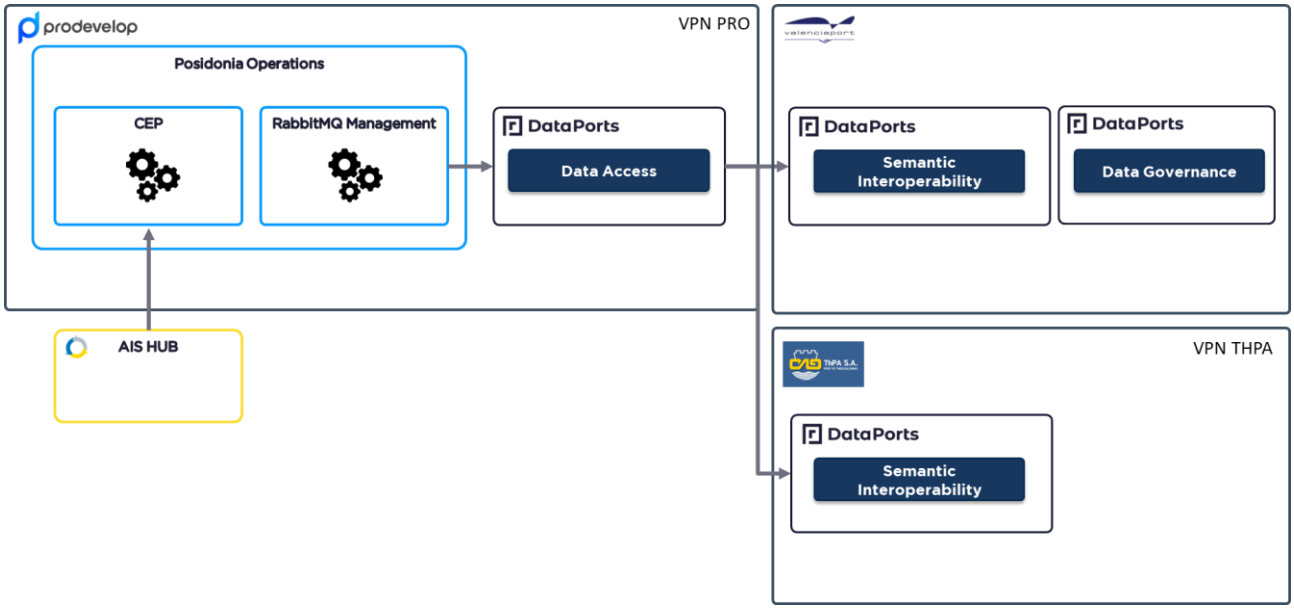


Figure 60 – Posidonia Operations for Valencia and Thessaloniki

Two instances of Posidonia Operations have been deployed and set up in the network of Prodevelop. The application has been modified to enable data from the AISHUB platform **Fuente especificada no válida.**. An instance of the Data Access Component of DataPorts gathers data from Posidonia Operations when a vessel event is processed and sends it to the Semantic Interoperability Component of the corresponding port. Because the data is shared between different networks the communication is done using the security components of DataPorts. This environment is used in the **Tracking of Transport Operations in the port of Valencia** and the **Analytics for the Port of Thessaloniki** scenarios.

On the other hand, there is a second phase in the use case where the platform is deployed for a third port where Posidonia applications are currently in use: the Balearic Port Authority. The Figure 61 depicts the complete services that build this scenario.

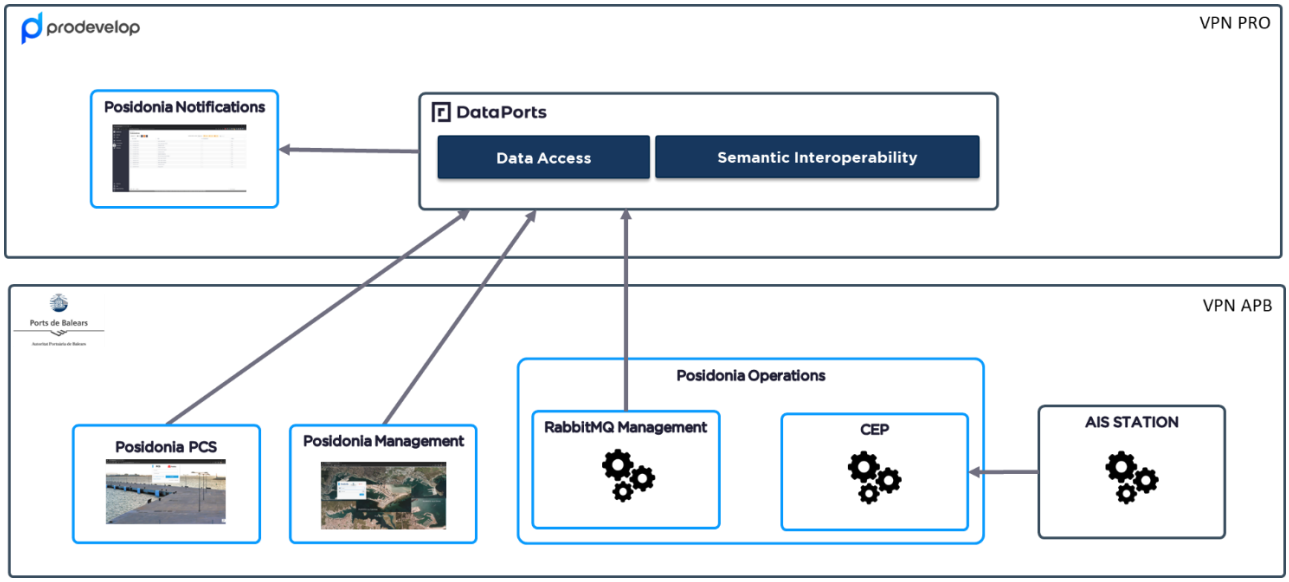


Figure 61 – Port management applications in the Port of Baleares

The applications for the Port Community System (Posidonia PCS) and the port management (Posidonia Management) have been improved to enable the sending of events on given user interactions. These messages are listened by the Data Access Component. In addition, there is an agent that subscribes a RabbitMQ queue for retrieving events generated by Posidonia Operations. Using the DataPorts subscription service provided by the Semantic Interoperability Component these messages are sent to the new alerting application, Posidonia Notifications that exposes and endpoint as the call-back for the subscription. This environment is used in the **Posidonia Notifications** scenario.

6.2 POSIDONIA NOTIFICATIONS

6.2.1 Scenario Description

In this scenario there are integrated up to three different Posidonia Port Solution **Fuente especificada no válida.** applications with DataPorts. Thanks to this integration, the platform is able to publish some of the events that happen due to the user interactions or automatic detections on the Posidonia Port Solution modules. On the other side, Posidonia Notifications retrieves these events and manages an alerting system that informs the users that are interested in the message's subject. The applications that generate or detect the events are Posidonia Management**Fuente especificada no válida.**, Posidonia Operations**Fuente especificada no válida.** and Posidonia PCS**Fuente especificada no válida.**.

The Figure 62 depicts the workflow and interactions of the scenario:

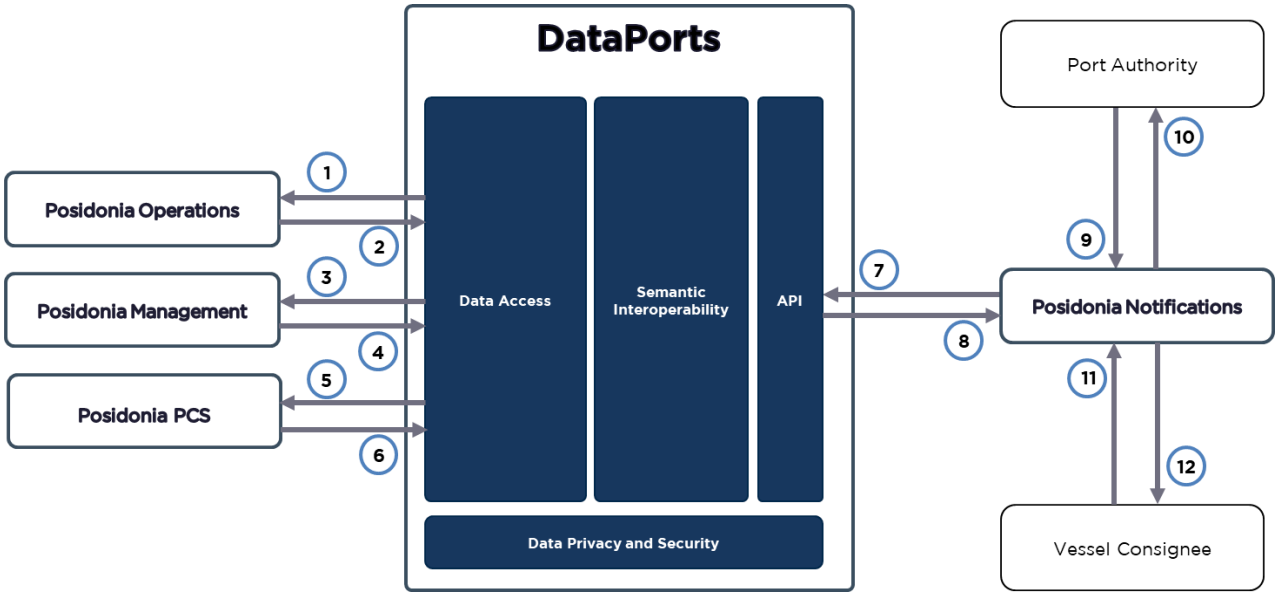


Figure 62 – Posidonia Notifications Workflow

The Table 52 lists the interactions, events and processes of the scenario:

Step	Description
1	An agent from the Data Access Component subscribes to the message queue of vessel events of Posidonia Operations
2	When Posidonia Operations processes a vessel event, it is retrieved by the agent. This data is transformed using the data models of the platform and stored for processing.
3	An agent from the Data Access Component creates an endpoint to receive management events of Posidonia Management.
4	When a user of Posidonia Management generates an event using the application, this event is sent to DataPorts using the endpoint provided by the agent. For example, when the user changes the ETA of a port call. This data is transformed using the data models of the platform and stored for processing.
5	An agent from the Data Access Component creates and endpoint to receive management events of Posidonia PCS.
6	When a user of Posidonia PCS generates an event using the application, this event is sent to DataPorts using the endpoint provided by the agent. For example, when a consignee creates a water supply request. This data is transformed using the data models of the platform and stored for processing.
7	Subscriptions are created through the platform's API setting the Posidonia Notifications application endpoint as target.
8	When any of the subscribed events happen, the Semantic Interoperability Component sends the data to the application.
9	A user of the Port Authority registers into the Posidonia Notifications application and configures its preferred settings for alerts. It also subscribes for change of ETA.
10	When Posidonia Notifications gets a message of ETA change it alerts the user of the Port Authority, for example by email.

Step	Description
11	A vessel consignee registers into the Posidonia Notifications application and configures its preferred settings for alerts. It also subscribes for water supply requests being accepted or denied.
12	When a request is accepted or declined in Posidonia PCS it creates and event that will be sent to Posidonia Notifications, that notifies the vessel consignee by email.

Table 52 – Posidonia Notifications Scenario Description

The datasets shown on Table 53 are used in this scenario:

Datasource	Description of data
Posidonia Management	JSON messages with events for: • ETA/ETD visit changes • Start/End of visit • Visit Authorisation • Manifest Activation
Posidonia Operations	JSON messages with events for vessel flow events, including: • Vessel reaches waypoint • Entering to port • Leaving port • Berthing started • Berthing finished • Anchoring started • Anchoring finished
Posidonia PCS	JSON messages with events for the management of: • Water supply requests • Electricity supply requests • Port surface occupation requests • Waste removal requests • Access to port requests

Table 53 – Posidonia Notifications Scenario Datasets

As result of the integration, users of the Posidonia applications will have the tools to change and improve the way they manage they operations. How to use the new functionalities is usually similar: a stakeholder subscribes for notifications about the topics of interest in Posidonia Notifications, configures how they want to be alerted and then he is able to react in consequence when messages arrive.

6.2.1.1 Posidonia Management

As a vessel consignee, terminal operator or port authority, I want to be aware of changes in the ETA of incoming vessels. This data can be modified through the Posidonia Management application.

The first thing the user needs to do is to log in Posidonia Notifications and subscribe for the Change of ETA topic. In this example, the user subscribes for all the ETA changes of Port Calls at the same port authority (Organization). All events received of this type will be sent to the given email direction.

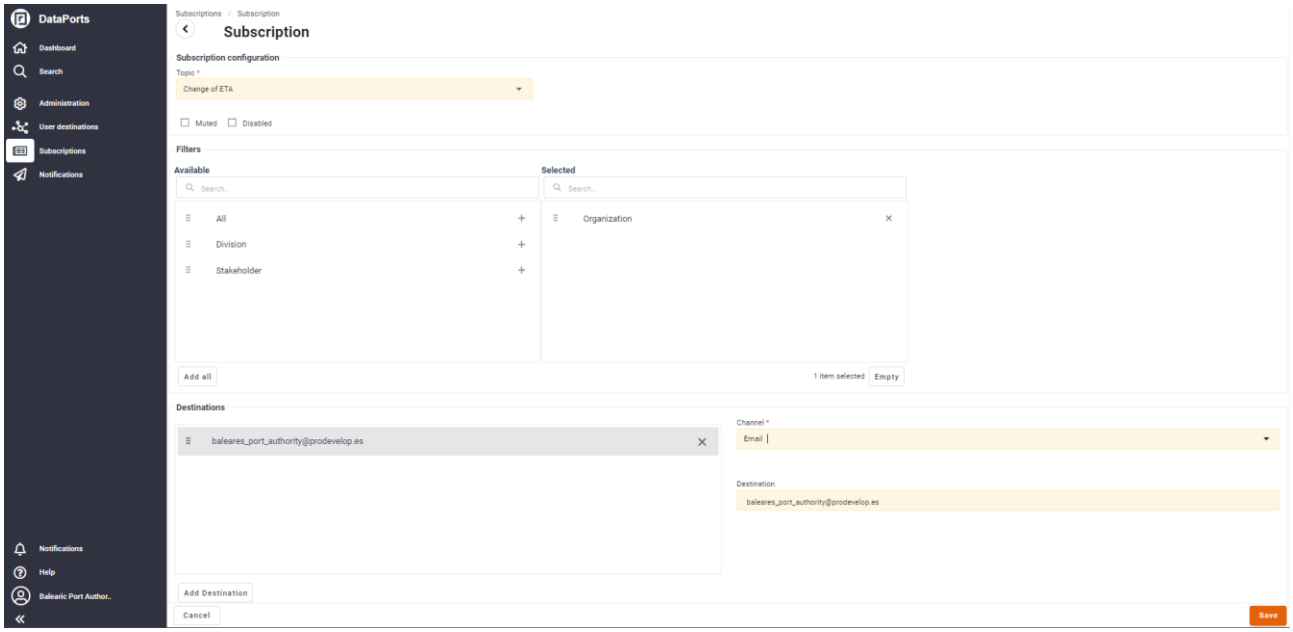


Figure 63 – Subscribing to ETA changes

Once the subscription is completed, the user will start receiving notifications when this event happens.

For this action to happen a user of Posidonia Management will access the application and change the ETA of a visit. For doing this the user will access the Port Call list in the application.

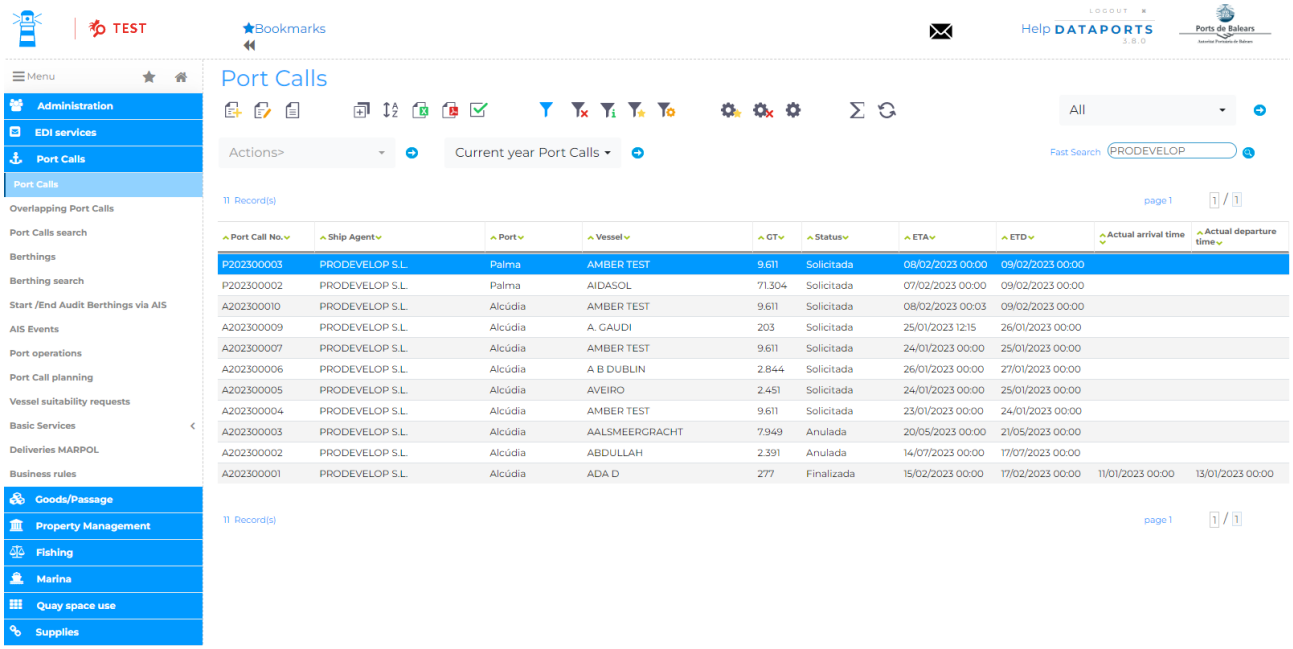


Figure 64 – Port Call list

For running the actions that will send the events to DataPorts, the user will select a Port Call and look into the Actions drop-down list for Edit ETA.

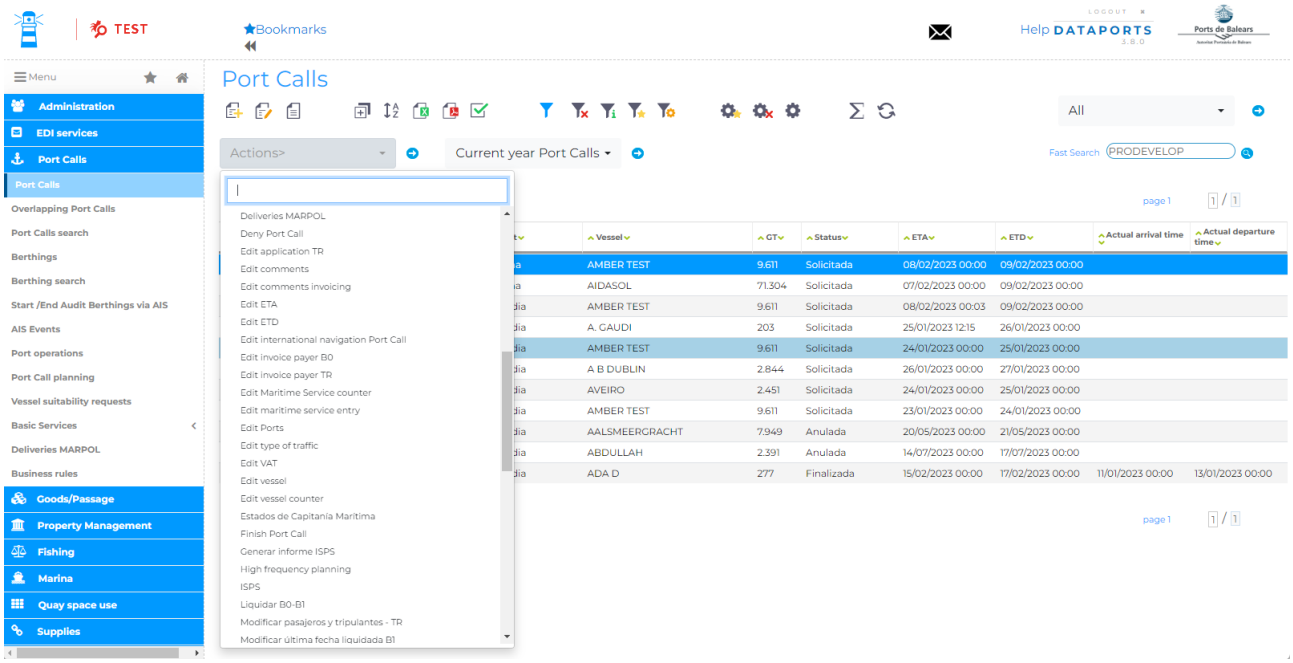


Figure 65 – List of Port Call actions

After selecting the Edit ETA action, a new window will be shown where the user will pick the new date and time.

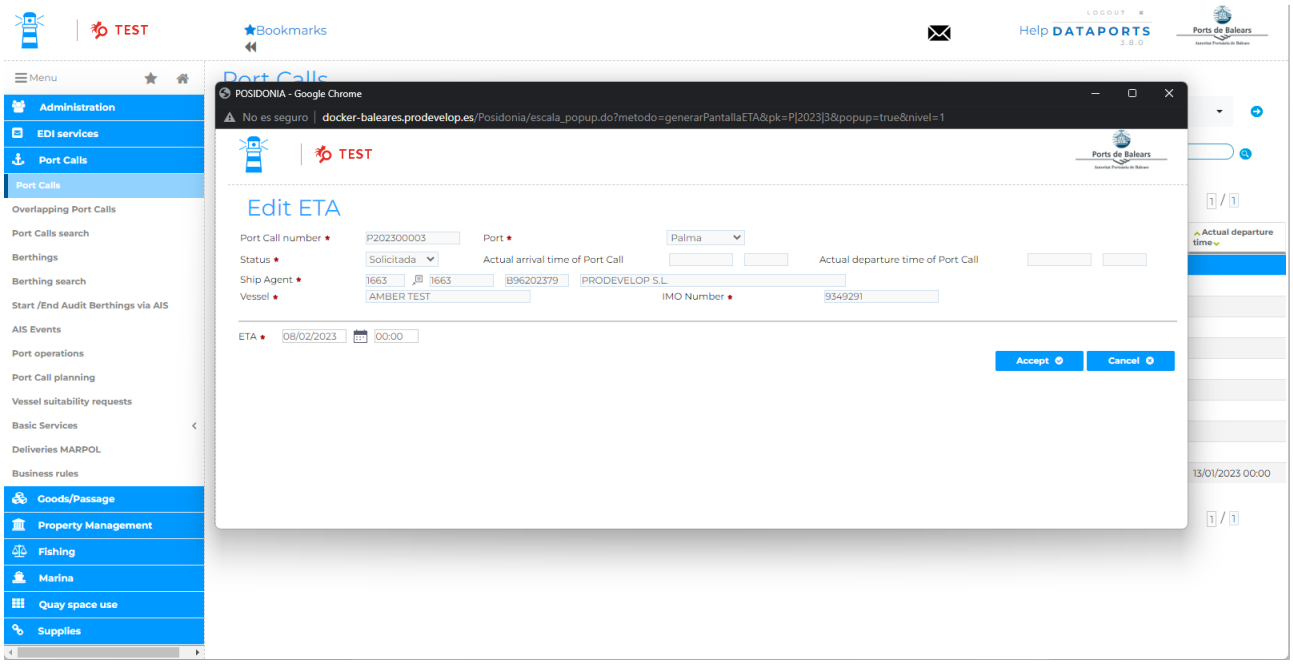


Figure 66 – ETA change of a Port Call

Once it is done, a new notification will be created and sent to all users subscribed to the event that meet the conditions. The alert will be shown both in the notifications panel in Posidonia Notifications and the destination where it was sent.

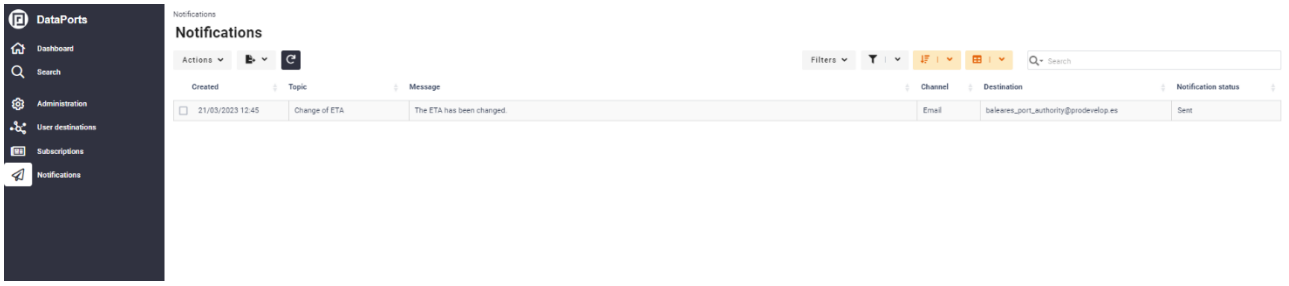


Figure 67 – Notification created

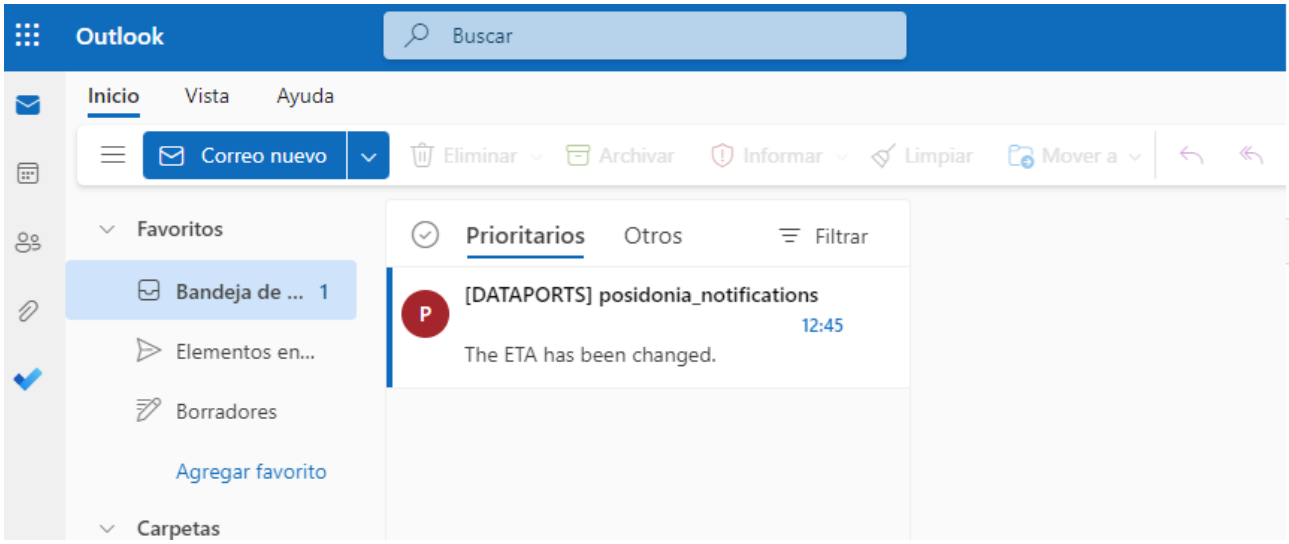


Figure 68 – Inbox of the Port Authority user

When a notification is received, the user can react immediately to the event.

6.2.1.2 Posidonia PCS

In this application the Port Authority can manage some types of professional service requests done by the vessel consignees. Some of the services provided are water and electricity resources, access to port, waste removal and surface occupation. The interaction between users and the required steps are the same. In this example we are showing how will the users take advantage of the new tools to improve the process.

The Port Authority is the responsible of accepting or denying the services, so it is interested in the arrival of new requests. Using Posidonia Notifications, it will subscribe for water requests done for the Baleares Port Authority.

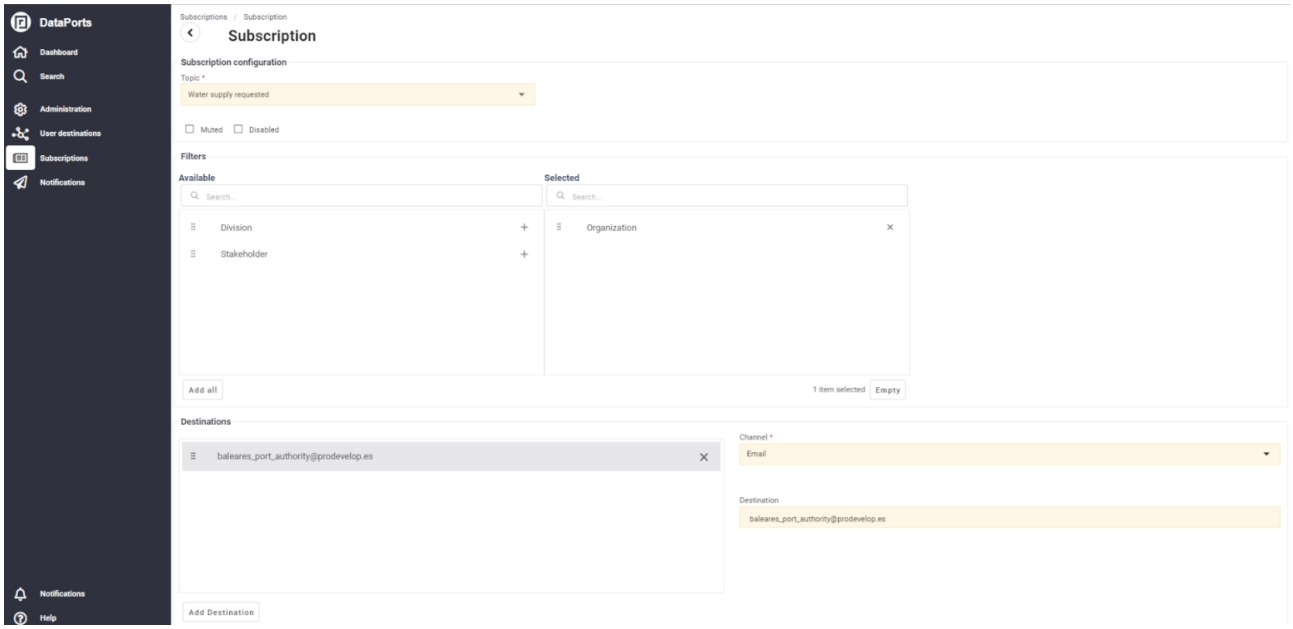


Figure 69 – Subscribing for new water requests

On the other hand, the vessel consignee is the user that creates the request, and wants to be alerted when their requests are accepter of denied. With this objective, it will subscribe in Posidonia Notifications for when their own requests (Stakeholder) have changed their status.

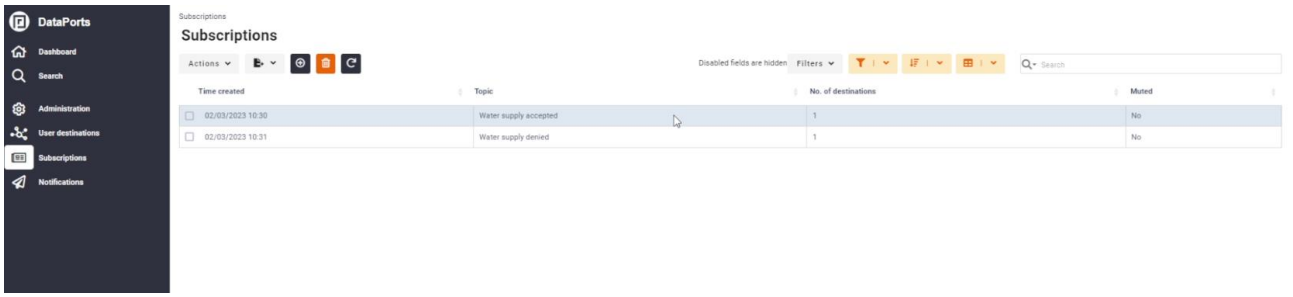


Figure 70 – Subscriptions to water request changes

Now both the vessel consignee and the port authority have everything set up to start receiving alerts. As aforementioned, the vessel consignee will start the process creating a new request. It will navigate to the management of water and electricity section of Posidonia PCS and create a new water request.

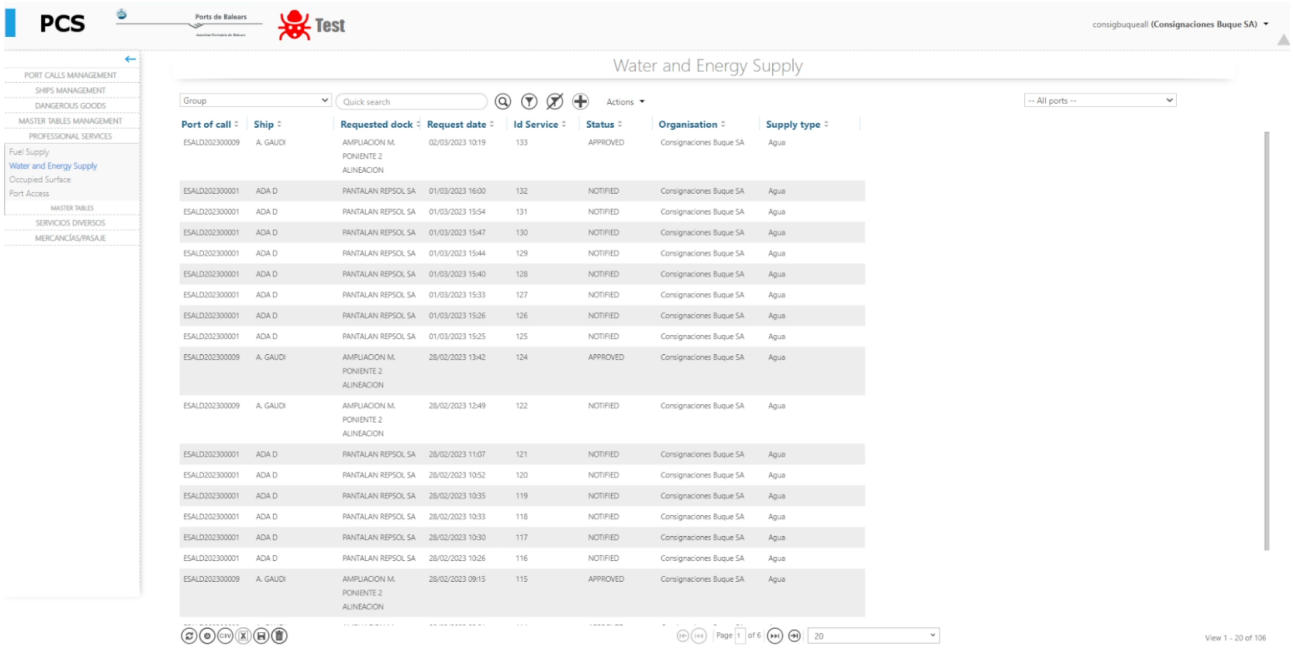


Figure 71 – Water and electricity requests list

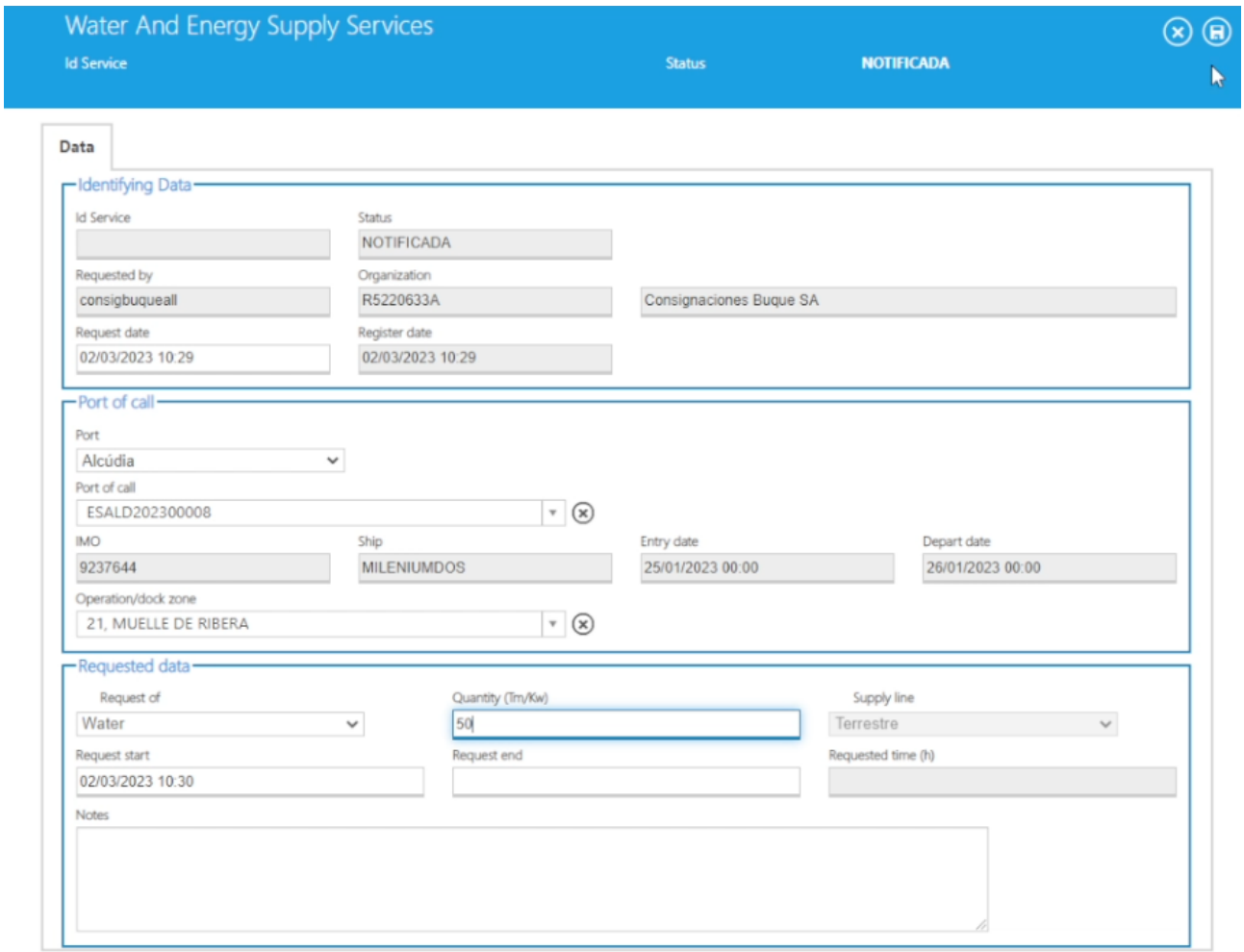


Figure 72 – Water supply request

Once the request is done, a new notification will be created in Posidonia Notifications for the Port Authority.

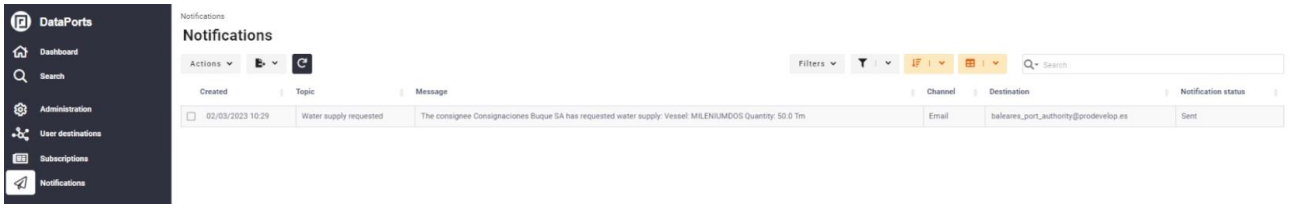


Figure 73 – Notification for new water supply request

And also, the message will arrive to the destination email.

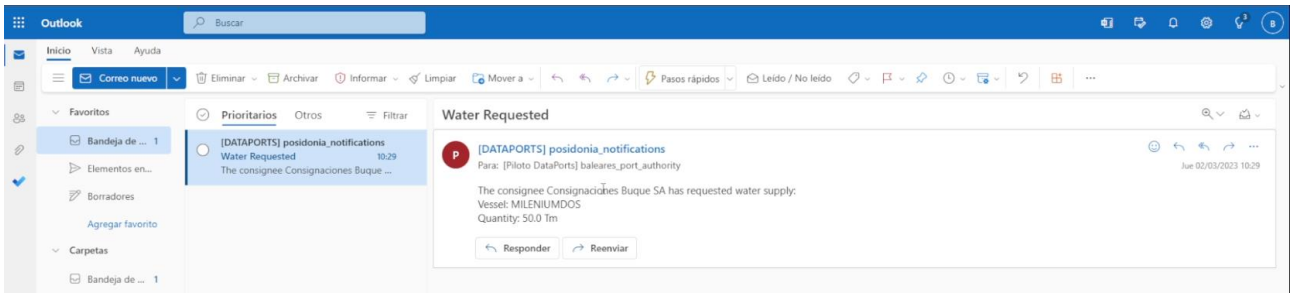


Figure 74 – Inbox of the Port Authority user with the new request

The Port Authority can now manage the request as soon as it is received, thanks to the real time alerting. The user will access to Posidonia PCS application and accept the request from the vessel consignee.

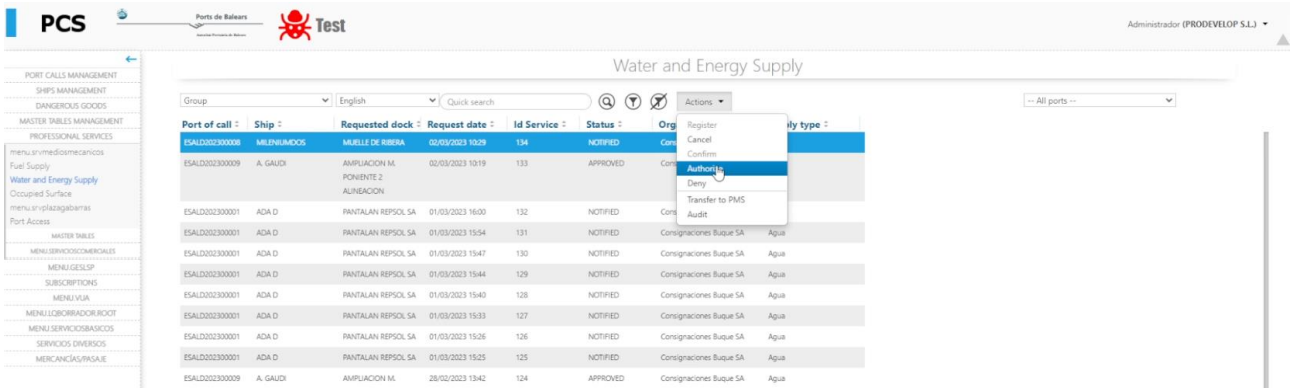


Figure 75 – Managing water supply requests

When the request is accepted, a new notification is created for the vessel consignee in Posidonia Notifications.

Figure 76 – Notification of a water request accepted

And a message will be sent to the destination email of the subscription.

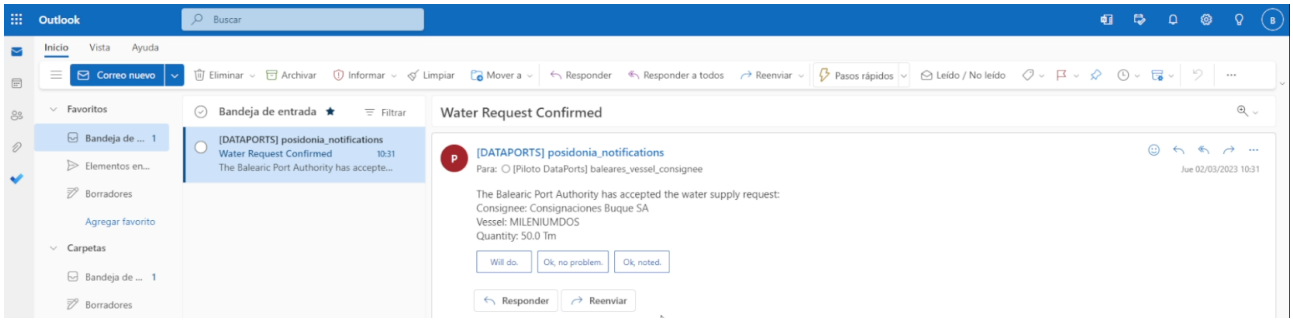


Figure 77 – Inbox of the vessel consignee with the request accepted

Now the vessel consignee is aware of the status as it is changed. Imagine the scenario where the request is denied by the Port Authority. The vessel consignee will be able to make a new request solving the possible issues immediately.

6.2.1.3 Posidonia Operations

This application provides vessel events processed from the AIS messages and the cartography of the port. Thanks to these events users can know when a vessel is near the port, when it arrives, when it started berthing, when it is leaving…and other events. There are many potential stakeholders for this information, like the Port Authority, the vessel consignee, the terminal operators, the shipping line, pilots, stevedores and dock workers, or logistic companies involved.

For start receiving these notifications, the user will subscribe for the desired topics in Posidonia Notifications. In this example, the Port Authority of Baleares subscribes for any arrival of a vessel to any of the ports they manage.

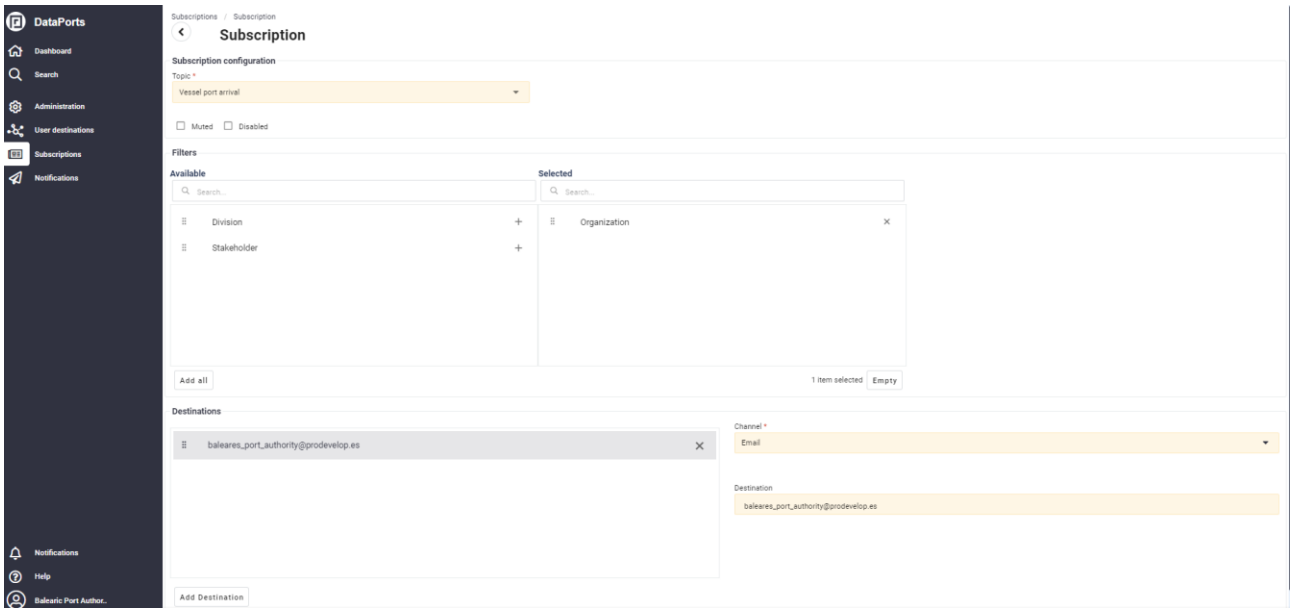


Figure 78 – Subscribing for vessels arrivals

Users can subscribe to all topics they have access to. For each topic they can set how and where to be notified.

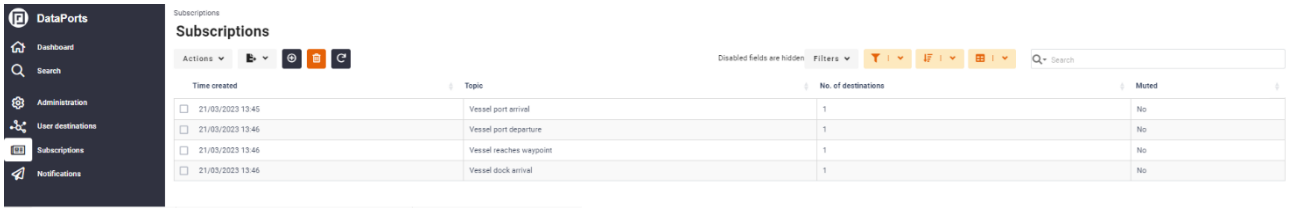


Figure 79 – Subscriptions to vessel events

When the events are sent from Posidonia Operations and received in Posidonia Notifications, alerts will be created and sent to the setup directions.

6.2.2 DataPorts roles

The Table 54 shows the organizations that take part in the scenario implementation and their roles:

Organisation	Role
PRO	Has leaded the use case, implement the agents for acquiring data, provide the data sources applications, modify current and implement new applications for the scenario, define the test cases and evaluate them.
UPV	Has participated in the data model definition for the data sources of this scenario

Table 54 – Posidonia Notifications Roles

6.2.3 Activities carried out

The Table 55 contains the tasks involved in the implementation of the scenario.

Time	Actors	Actions
M12-M15	PRO	PRO provides a scenario specification and it is revised by all participant partners
M12-M18	PRO	PRO involves the Baleares Port Authority in the project in order to use its environment, data and events in the pilots
M18-M27	PRO and UPV	PRO and UPV analyse the requirements for the semantic transformation and representation of the data
M23-M34	PRO	PRO develops the Agents for the integration of the data sources following the specifications and requirements. The agents are listed on the section 6.2.4 Data Integration.
M25-M27	PRO	PRO modifies the Posidonia Operations application to being able to process data from the AISHUB platform. Change log: OPE.1
M25-M36	PRO	PRO extends the current Posidonia Management application so when the events that need to be shared happen, it gathers all the needed information, builds a JSON message and sends it to a DataPorts endpoint. Change log: MNG.1, MNG.2, MNG.3, MNG.4, MNG.5
M25-M35	PRO	PRO extends the current Posidonia PCS application so when the events that need to be shared happen, it gathers all the needed information, builds a JSON message and sends it to a DataPorts endpoint. Change log: PCS.1, PCS.2, PCS.3, PCS.4, PCS.5, PCS.6
M23-M36	PRO	PRO develops an alert application, making the analysis, design, implementation and integration with DataPorts.
M30-	PRO	PRO deploys all the required components and applications for the

Time	Actors	Actions
M36		scenario demonstration.
M36-M39	PRO	PRO creates the user manuals, application change logs

Table 55 – Posidonia Notifications Action Plan Reporting Table

6.2.4 Data Integration

The aforementioned data sources have been connected with the platform with the development of the corresponding agents. The complete list of the agents developed for this scenario is shown in Table 56.

Agent	Type	Description
Posidonia Management	Publish / Subscribe	This agent exposes an endpoint and translates data from Posidonia Management events into the platform's ontology.
Posidonia PCS	Publish / Subscribe	This agent exposes an endpoint and translates data from Posidonia PCS events into the platform's ontology.
Posidonia Operations	Publish / Subscribe	This agent subscribes a RabbitMQ broker for Posidonia Operations events. These events are translated into the platform's ontology.

Table 56 – Agents implemented for this scenario

6.2.5 Applications

The Table 57 describes the applications that are part of the scenario that interact with the platform and have been updated or implemented, along with the links to the documentation.

Application	Action	Status
Posidonia Management	Modification	100%
The Posidonia Management application will build and send a JSON message with all the required data for each of the events that will publish in DataPorts. The new functionality will collect all the relevant information about the event that is going to be published in DataPorts and publish it into a RabbitMQ **Fuente especificada no válida.** message broker from where the agent of the platform will get it. This will be repeated for each of the events.		
User documentation can be found in Annex A: 9.3 Posidonia Management		
Change log can be found in Annex B: 10.5		
Application	Action	Progress
Posidonia PCS	Modification	100%
The Posidonia PCS application will build and send a JSON message with all the required data for each of the events that will publish in DataPorts. The new functionality will collect all the relevant information about the event that is going to be published in DataPorts and publish it into a RabbitMQ message broker from where the agent of the platform will get it. This will be repeated for each of the events.		

User documentation can be found in Annex A: 9.4 Posidonia PCS		
Change log can be found in Annex B: 0		
Application	Action	Progress
Posidonia Operations	Modification	100%
The application Posidonia Operations has been updated to support messages not only from AIS stations but also for consuming events from AISHUB **Fuente especificada no válida.**. Thanks to this upgrade, the application is able to process messages without any additional local integration for the ports that are publishing their data in the platform, like for the ports of Valencia and Thessaloniki.		
Change log can be found in Annex B: 10.6		
Application	Action	Progress
Posidonia Notifications	New application	100%
A new interface will be implemented for the configuration and sending of alerts, in this scenario of events in the Posidonia applications. This application will use the DataPorts platform for subscribing to events and sending notifications about the selected topics in the chosen communication channel. Users of the application, like the Port Authority or consignees, will be able to set up their contact data, like email or phone number, and the default way of notification.		
User documentation can be found in Annex A: 9.5 Posidonia Notifications		

Table 57 – Posidonia Notifications Applications

7 CONCLUSIONS

For more than three years, partners from different parts of Europe have collaborated to build the DataPorts platform and demonstrate the benefits of its use through pilots in two major European ports, Valencia and Thessaloniki, and two global use cases involving major maritime technology companies such as Traxens and Prodevelop.

This document gathers the work carried out and the final status of the integration of DataPorts in each of the ports and more specifically in the different scenarios that have been proposed as part of the final demonstration of the project.

In each of the pilots, numerous tasks ranging from infrastructure provisioning to application development have been carried out. The objectives of each of the pilots have been successfully met, demonstrating that the platform enables the sharing of information from multiple sources, regardless of the owner, technology or type of data it contains, in a secure, transparent and controlled manner, while ensuring that only permitted users have access to it. In addition, the platform provides cognitive data analytics and machine learning services, providing the ports with powerful decision-making tools. All of the above takes these ports to a new level of data management and use, paving the way for the digitisation of new processes related to both service provision and freight logistics.

As a result of the project, not only solutions have been developed to improve efficiency in the ports, reducing the time needed to manage operations and other derived benefits, but also the necessary knowledge and methodologies have been acquired to continue improving new scenarios in the future. In addition, the deployment of DataPorts in different environments and the diversity of connectors required to access the data sources has been a challenge we have overcome not without effort. As part of the actions carried out during the integration of the platform and the development of the pilots, we can highlight the following acquired know-how:

- Definition, building and management of data models.
- Acquisition and processing of data from heterogeneous sources, both technologically and semantically.
- Data filtering, cleaning and preparation.
- Security in federated systems, with IAM integration and a single point of access interface.
- Implementation of services for training models and predictions through Machine Learning.

As future lines of work, it is suggested to those responsible for the different components and applications involved to continue integrating new data sources, building new agents and completing the corresponding data models, thus extending the semantics of the platform. More organisations can also be involved, both data providers and stakeholders, in order to enrich the catalogue of available data. With these actions, new scenarios could be improved, meaning the optimisation of the management processes carried out in ports as well as the positive effects these activities may have on external elements.

8 ACRONYMS

8.1 ACRONYMS

Acronym List	
API	Application Programming Interface
COREOR	Container Release Order
CP	Consortium Plenary
CPU	Container Pick-Up
DoA	Description of Action
EC	European Commission
eFTI	Electronic Freight Transport Information
ETA	Estimated Time of Arrival
GAS	Gate Access System
GDPR	General Data Protection Regulation
HIT	Hellenic Institute of Transport (part of CERTH)
IDS	International Data Spaces
IMO	International Maritime Organization
IoT	Internet of Things
JSON	JavaScript Object Notation
ML	Machine Learning
MVP	Minimum Viable Product
PC	Project Coordinator
PCS	Port Community System
PMB	Project Management Board
PPR	Project Periodic Report
QM	Quality Management
RM	Risk Management
SOLAS	Convention on the Safety of Life at Sea
TAS	Truck Appointment System
TM	Technical Manager
TOS	Terminal Operating System
VGM	Verified Gross Mass
WPL	Work Packages Leaders
ZOI	Zones of Interest

Table 58 – Acronyms

9 ANNEX A: USER MANUALS

9.1 PORT OF VALENCIA

9.1.1 Tracking of transport operations

The tracking application allow the user to different data related to transport operations and tracking.

The “Shipments” section shows the list of all the shipments including all the all the messages received if we expand one of them.

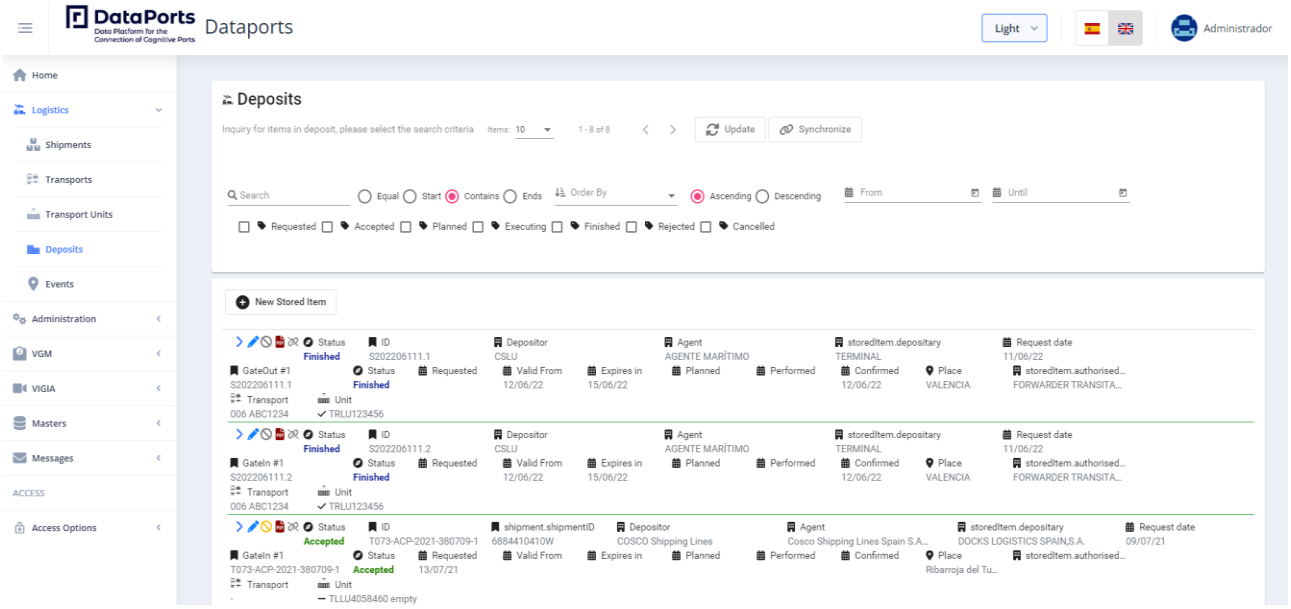


Figure 80 – Shipment list

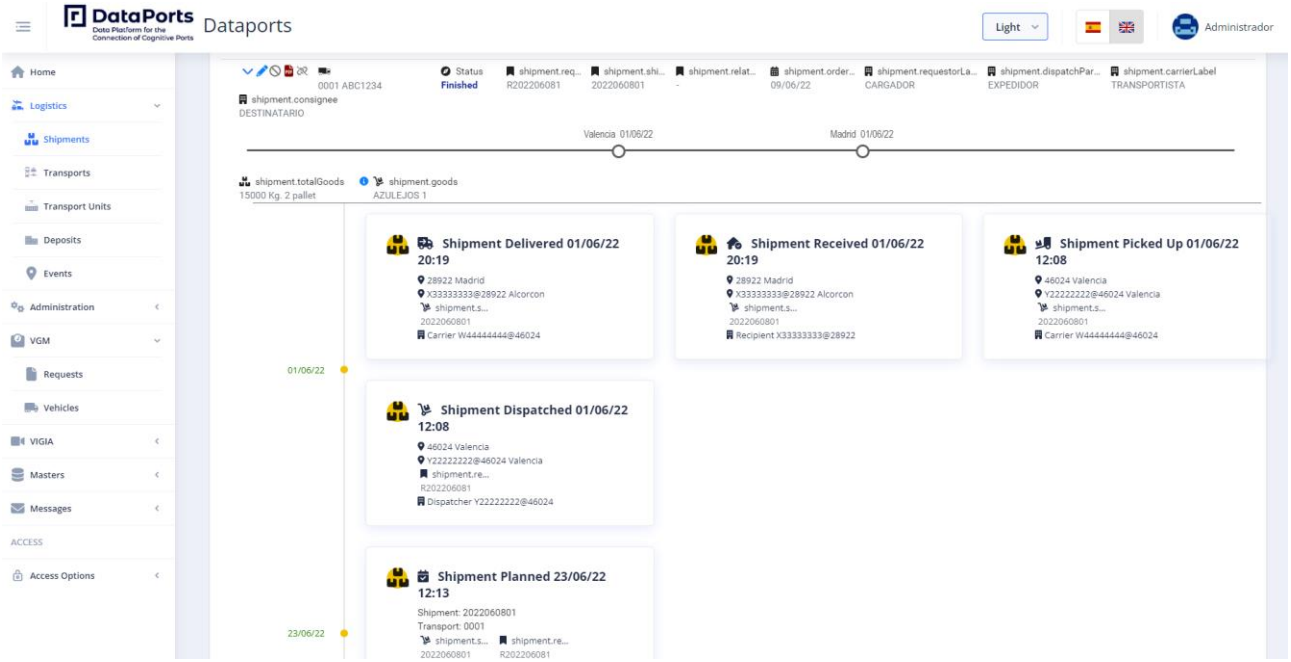


Figure 81 – Shipment details

The “Transports” section shows the transports included in the shipments presented before. If a shipment is divided in three different transport services (road, train, and maritime) these are showed separately.

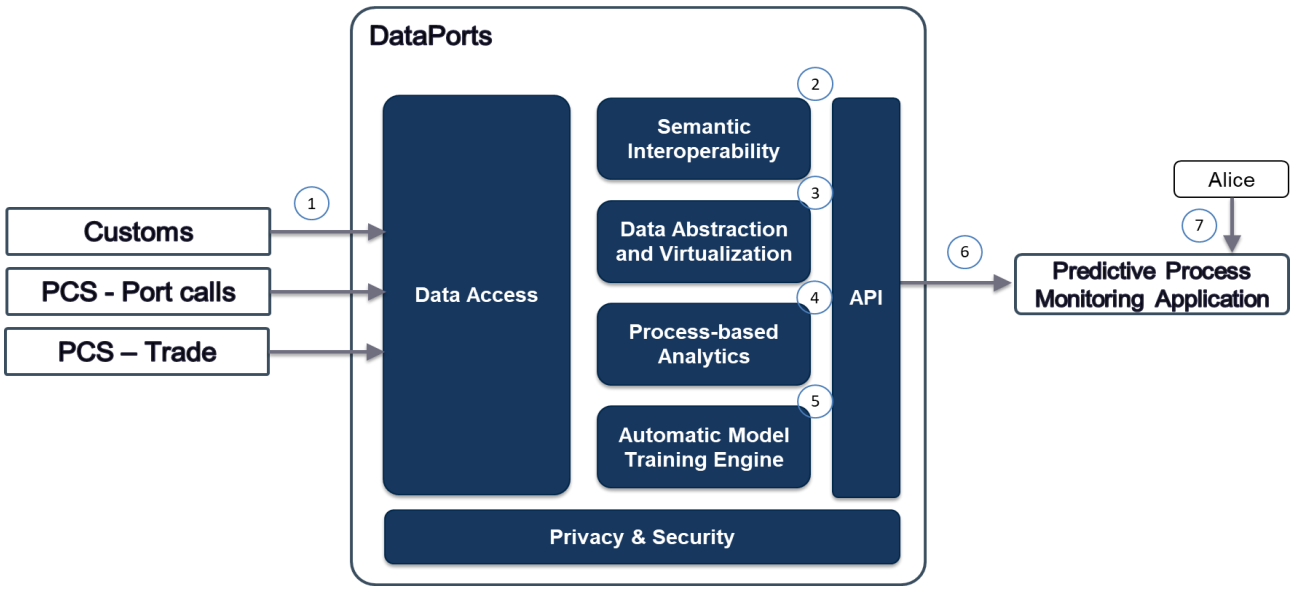


Figure 82 – Transport units list

The “Transport Units” section shows all the containers from the registered shipments.

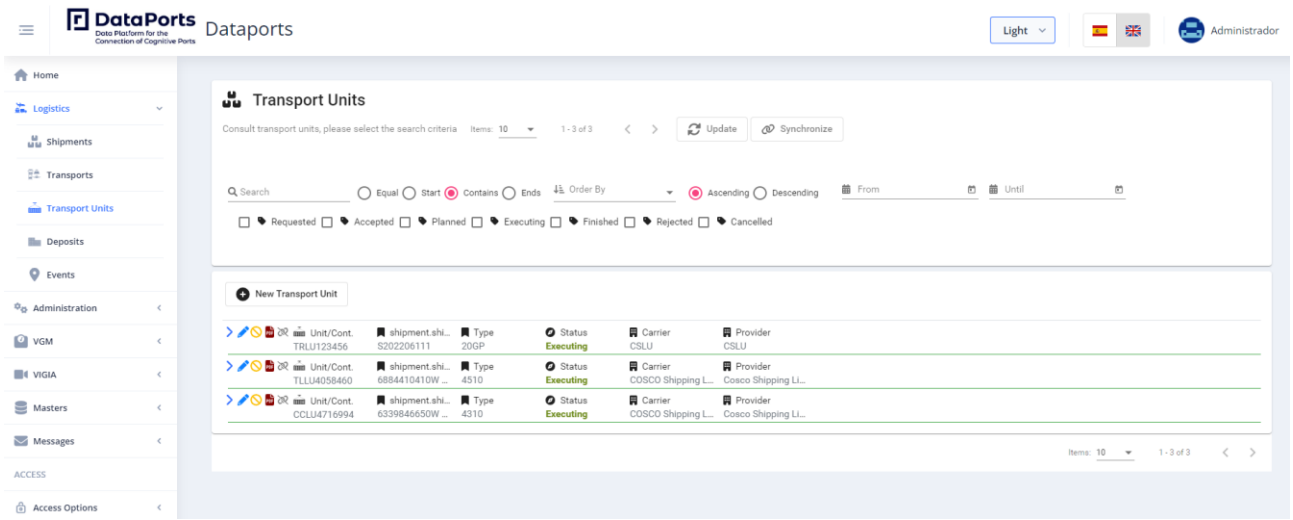


Figure 83 – Transport units list

The “Deposits” section shows the gate in and gate out orders from the registered shipments.

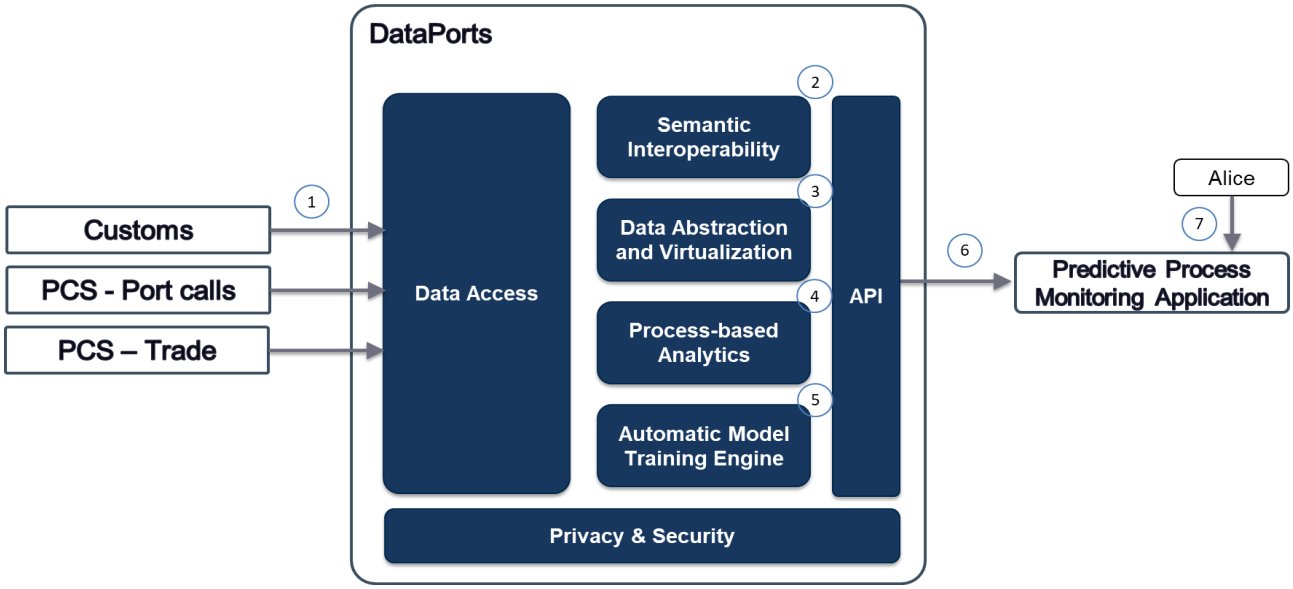


Figure 84 – Gate in and gate out orders list

The "Events" section shows the individual operations of each shipment. In addition, it also includes events from other data sources such as vessel location from Posidonia, container location from Traxens, and truck entering and leaving the port.

Figure 85 – Events list

9.1.2 Port authority data sharing and analytics services

To create a new cognitive service, select the tab "**Create**" available on the selectable menu on the left-hand side.

In the first step of the wizard, "**Task**", define a service name and its description. Then, the wizard provides several cognitive services to fulfil a specific type of prediction, thereby select **"Vessel Time of Departure Estimator"**

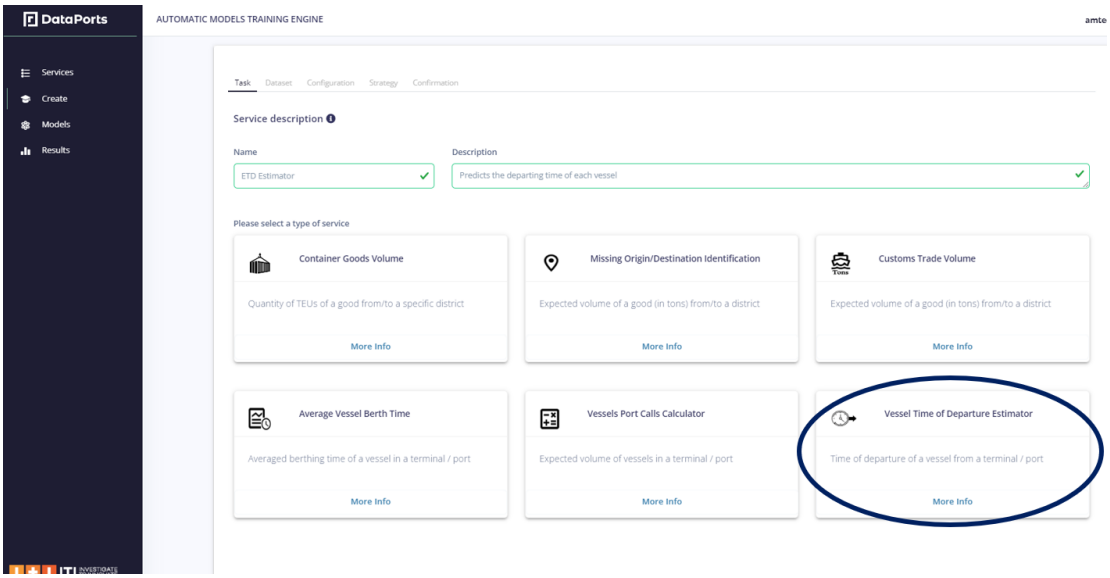


Figure 86 – Predictive Process Monitoring Application: Creation wizard

The second step of the wizard is named "**Dataset**".

In this step, a searchable list of available datasets in DataPorts' platform is presented, which provides the data required to create the service. In this case, only datasets with historical records of the arrival and departure of vessels are shown. Select the dataset shown in the picture below.

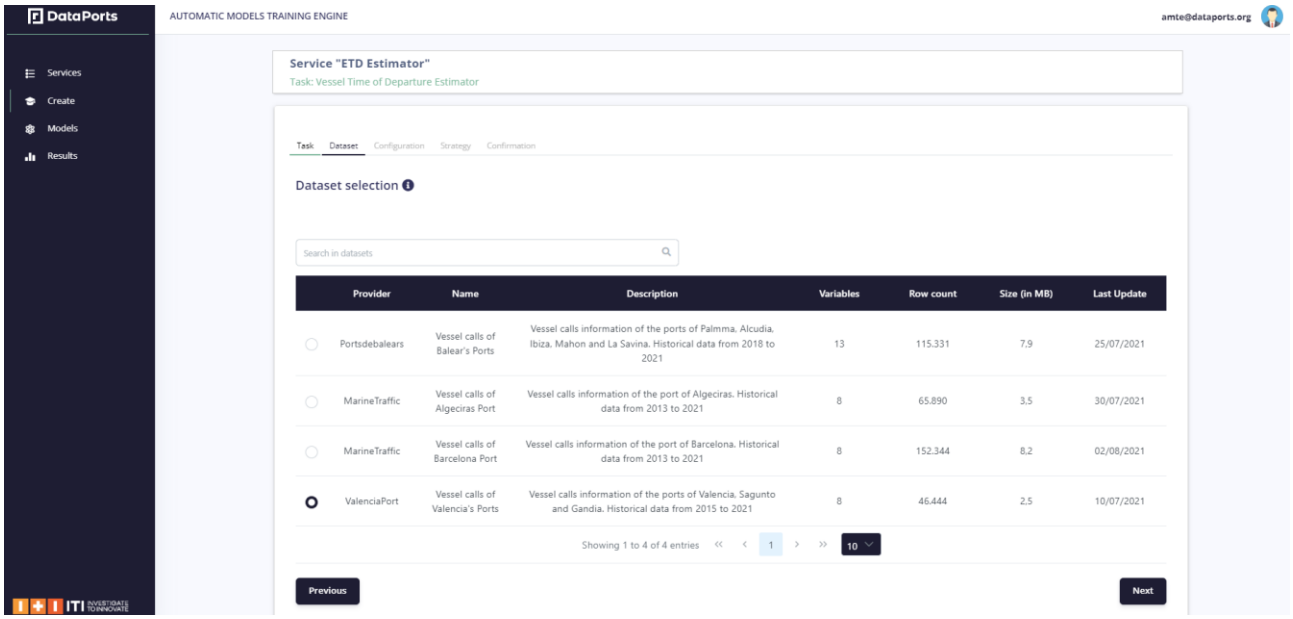


Figure 87 – Dataset selection

The third step, called **"Configuration"** (see figure below), and it's specific for each service. In this screen,

the user can choose additional information or options to be considered to train the underlying models. A proper configuration of such options could greatly impact the model's accuracy. In the case of the configuration of Cognitive Services associated with a time variable, the option "Consider only last year of data for training" will be available. Hence, more accurate models may be trained as the training data is closer to the time of the prediction. It is worth to mention, that only options relevant to the end-user expertise are available, avoiding options related with the underlying ML training process.

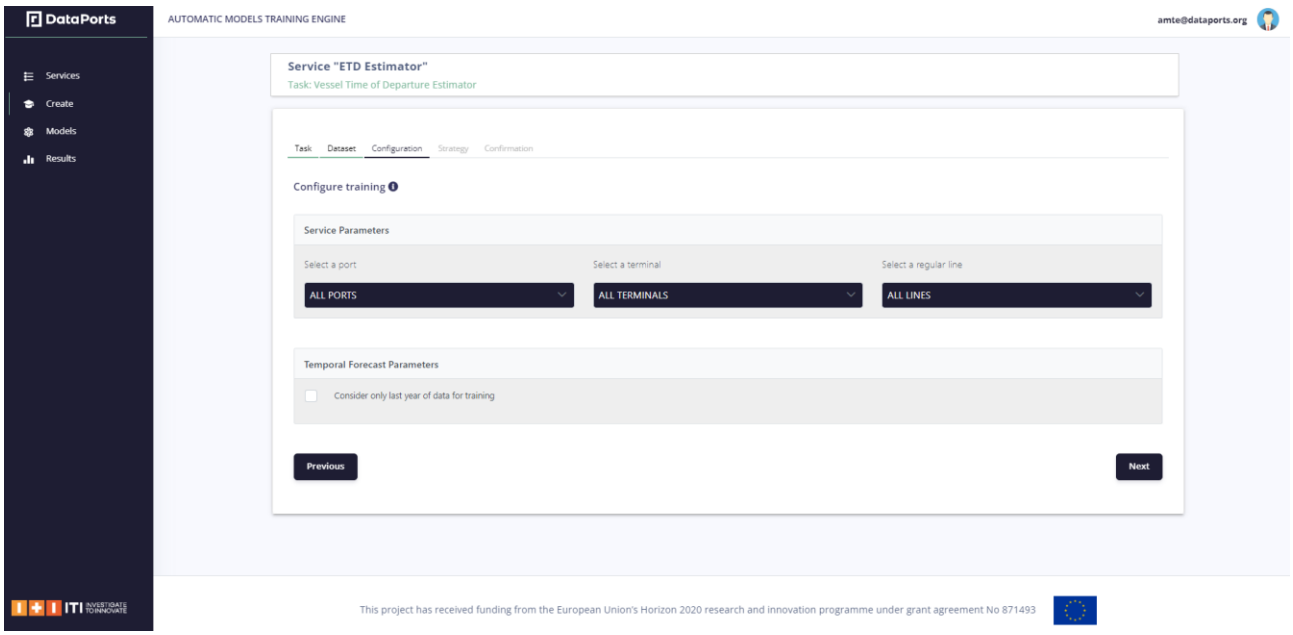


Figure 88 – Cognitive service configuration

The fourth step is named **"Strategy"**.

This screen shows a list of the different training strategies. The end-user must select any of them depending on its time availability and performance requirements. Depending on the strategy selected, a specific set of algorithms and associated parameters will be automatically chosen by the training engine.

In this case, select the strategy "**Standard".**

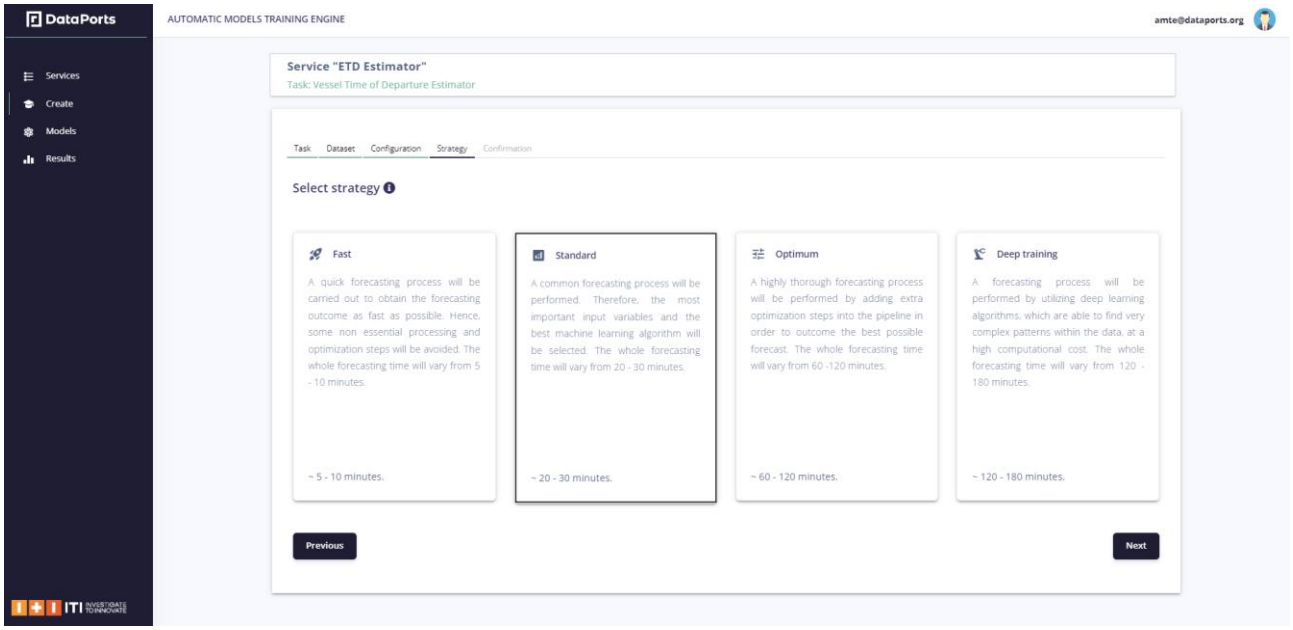


Figure 89 – Training strategy selection

The final step is named **"Confirmation"**.

In this step, the detailed information of all the choices and selections made during the wizard are presented for reviewing. Once confirmed, the button Train Service starts the distributed training process of a ML model that implements the required service.

Click the button "**Train Service".**

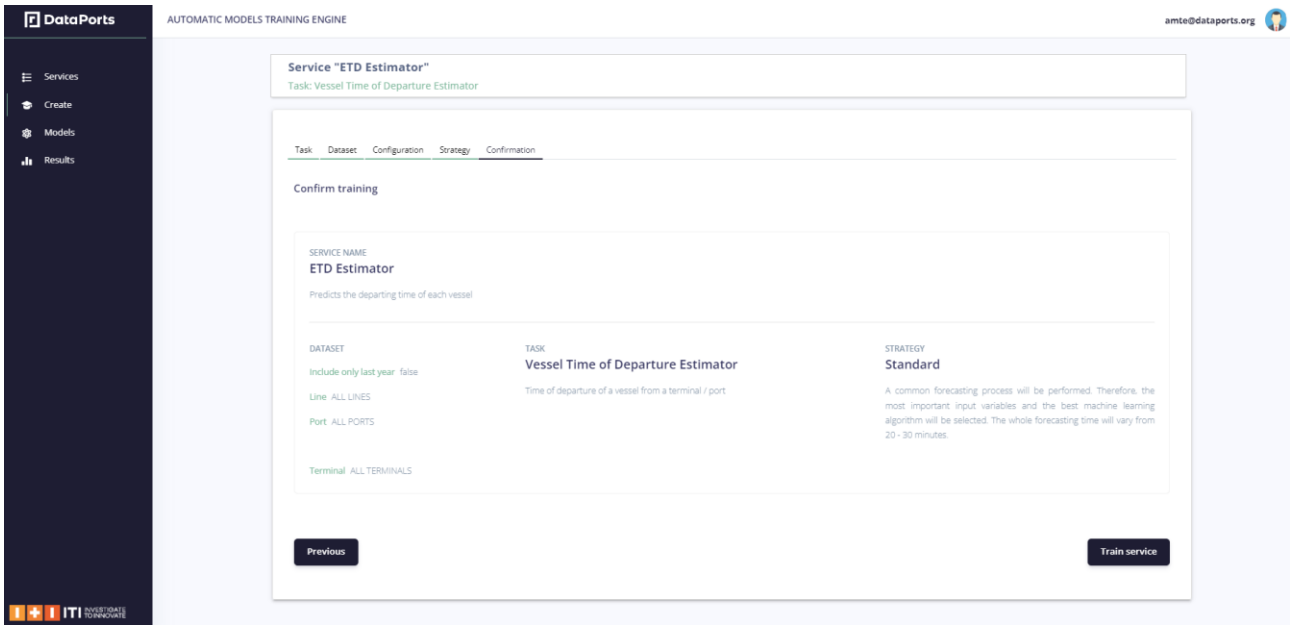


Figure 90 – Training confirmation

Automatically, the tab "**Services**" is shown and you will see the new created cognitive Service appended in the list and being trained.

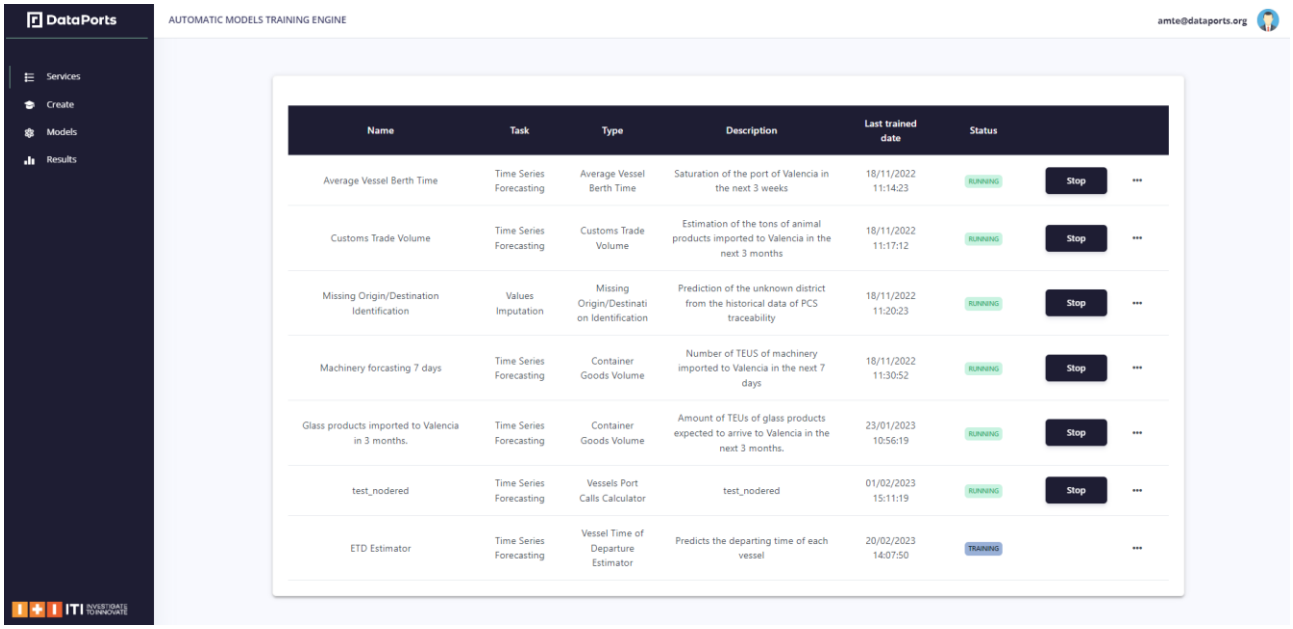


Figure 91 - Predictive Process Monitoring Application: Cognitive services list

Wait until its status changes to "**Ready"** in yellow color, and then click on the button "**Deploy**".

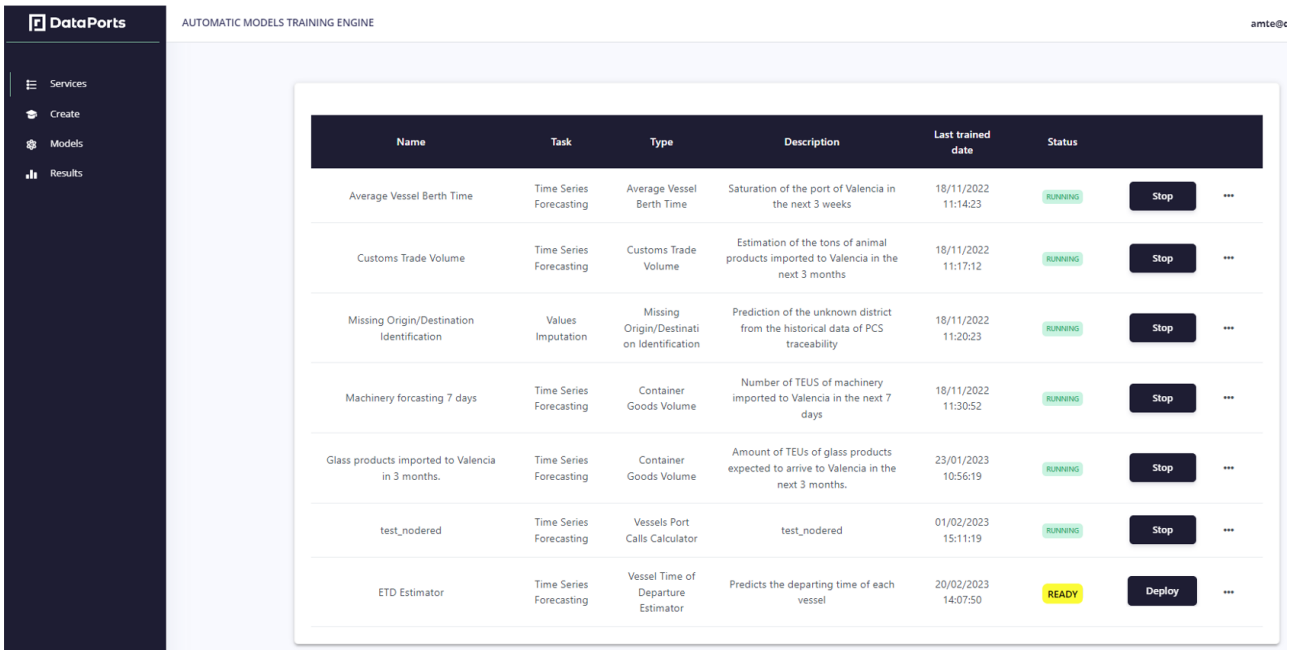


Figure 92 – Service ready to deploy

Then, the status should change to "**Running"** in green color.

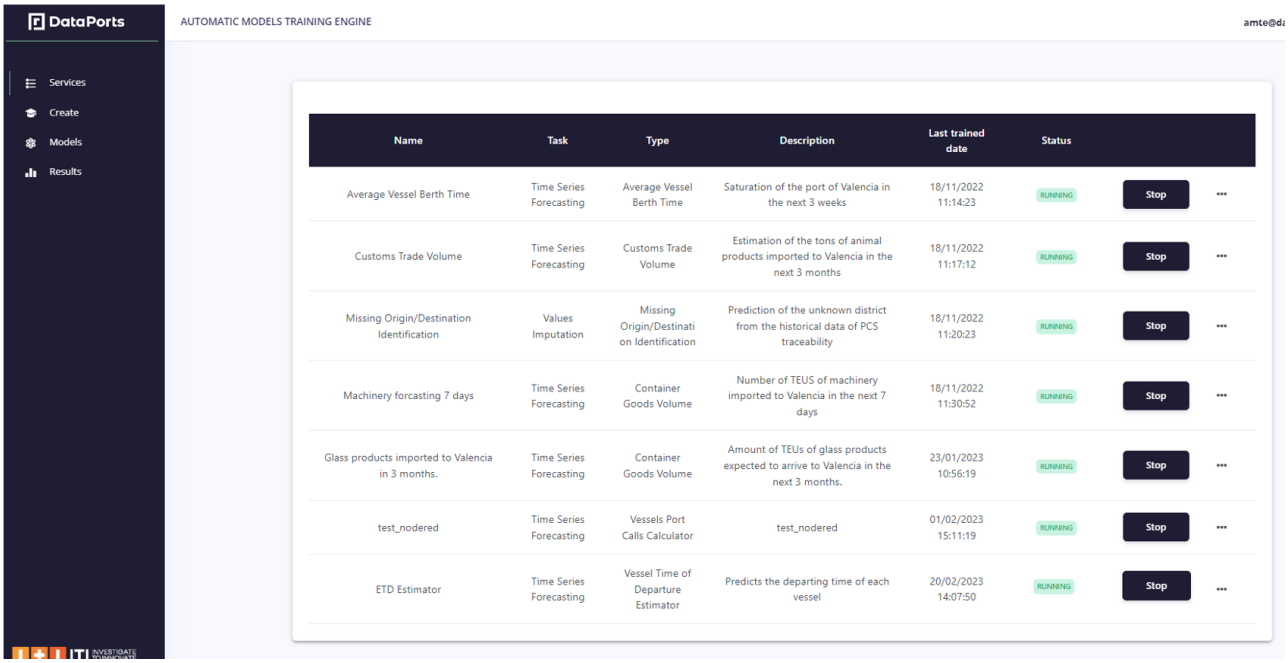


Figure 93 – Service running

Then, go to "**Results"** tab and click on the button "**View full table**" attached to the cognitive service just created.

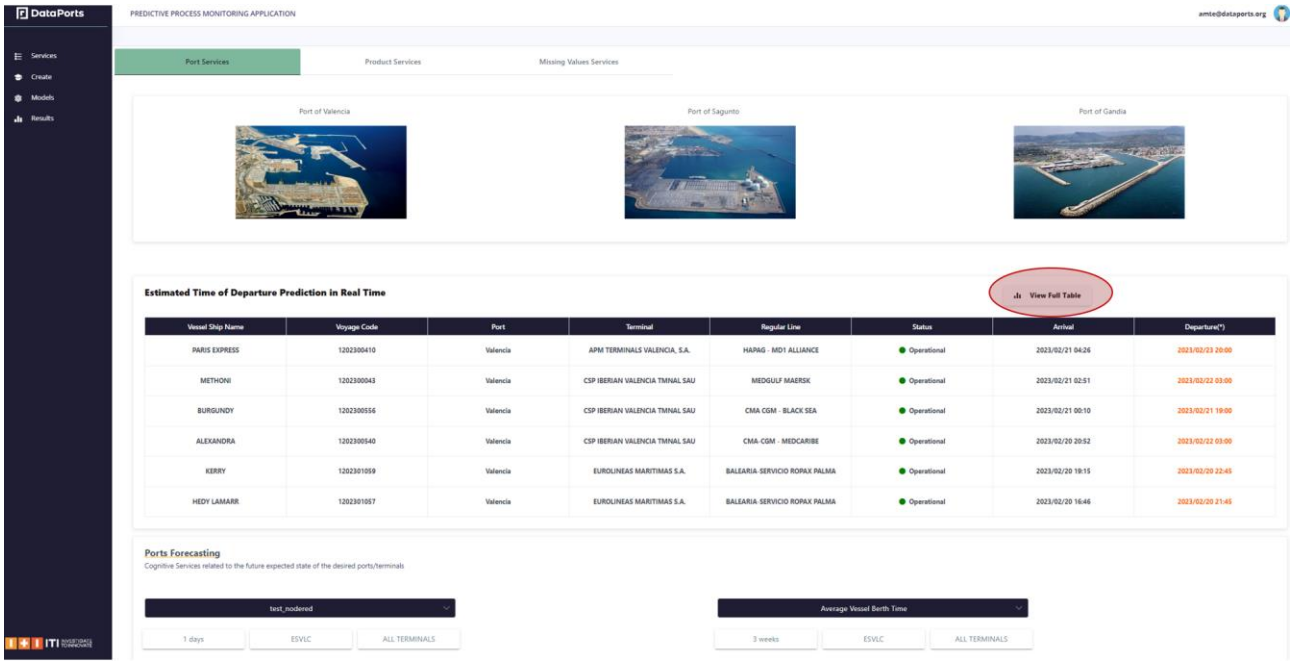


Figure 94 - Predictive Process Monitoring Application: Results – Port Services

Finally, the results of the cognitive service are visualized. The data showed is a list of the real data extracted from the PCS Calls in Real Time, whereas the last column is calculated by the best predictive model trained in the cognitive service and represents the expected time of departure of a vessel as illustrated in the next picture:

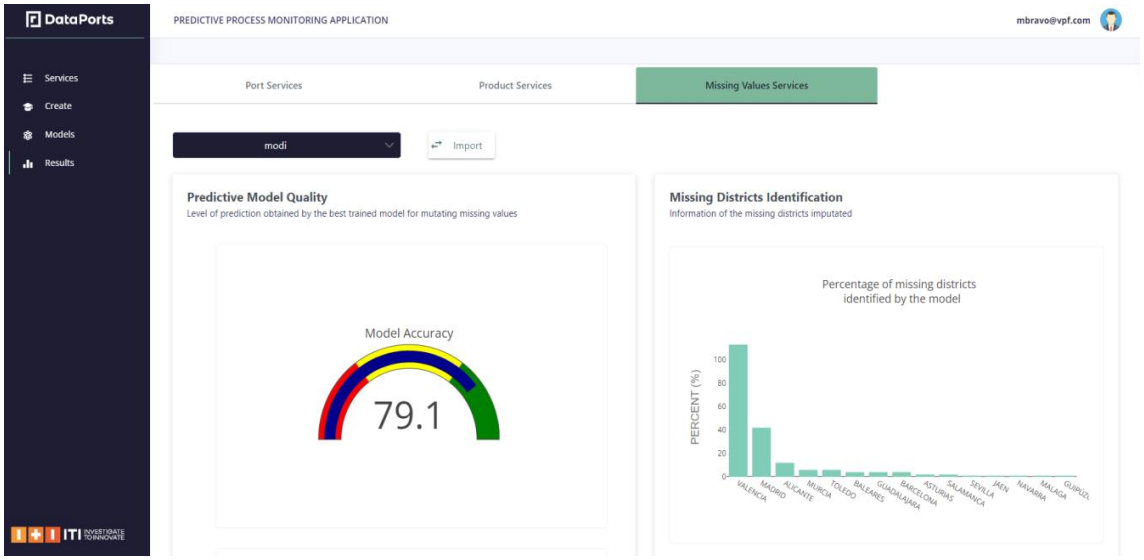


Figure 95 - Predictive Process Monitoring Application: Results – Product Services

9.1.3 Sharing Verified Gross Mass

Before any weight request, the vehicle and the trailer should be registered in the “Vehicles” section.

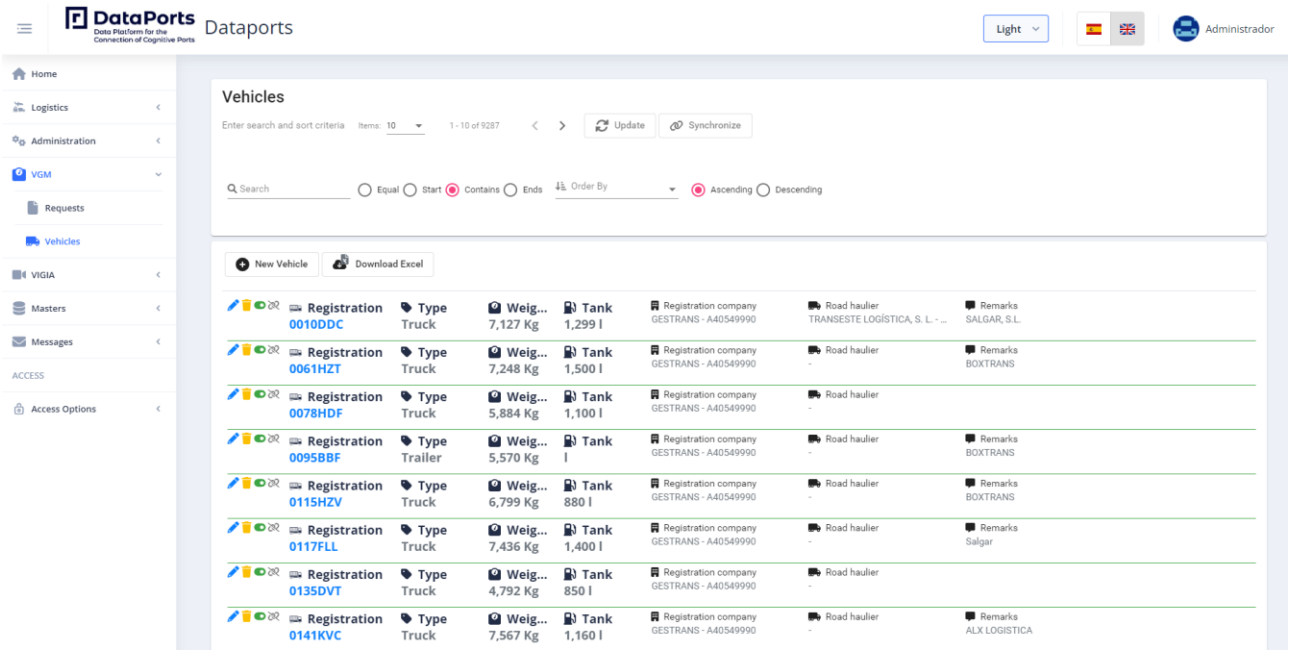


Figure 96 – Registered vehicles

The “Request” section shows the list of VGM request and the current status.

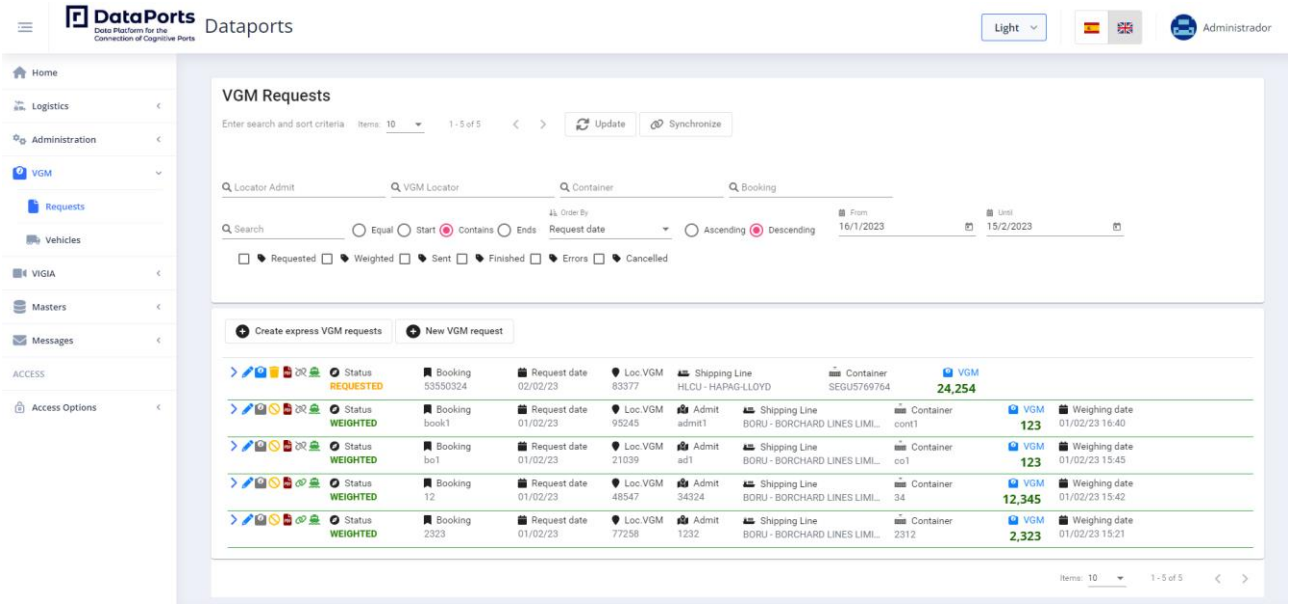


Figure 97 – VGM requests list

By clicking to “New VGM request” a new request can be created.

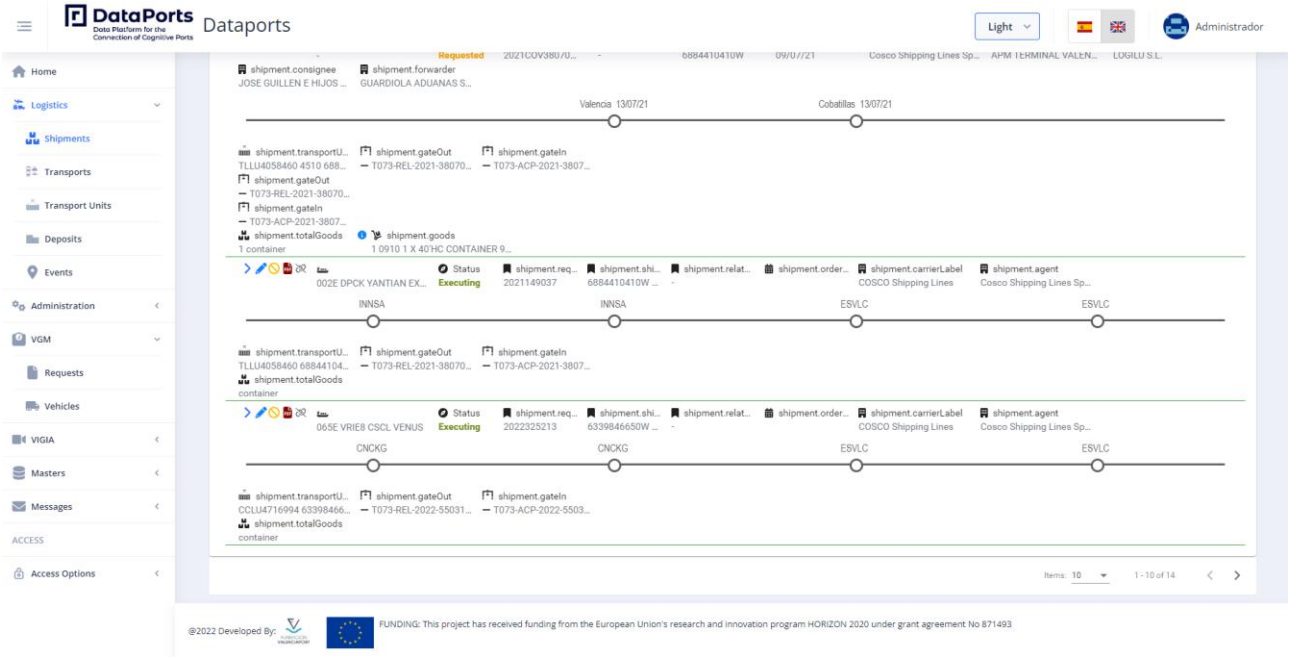


Figure 98 – Create new VGM request

9.1.4 Digital Consignment Note

In each of the shipments listed in the “Shipments” section there is a pdf icon which allows to generate the Digital Consignment Note with all the available data.

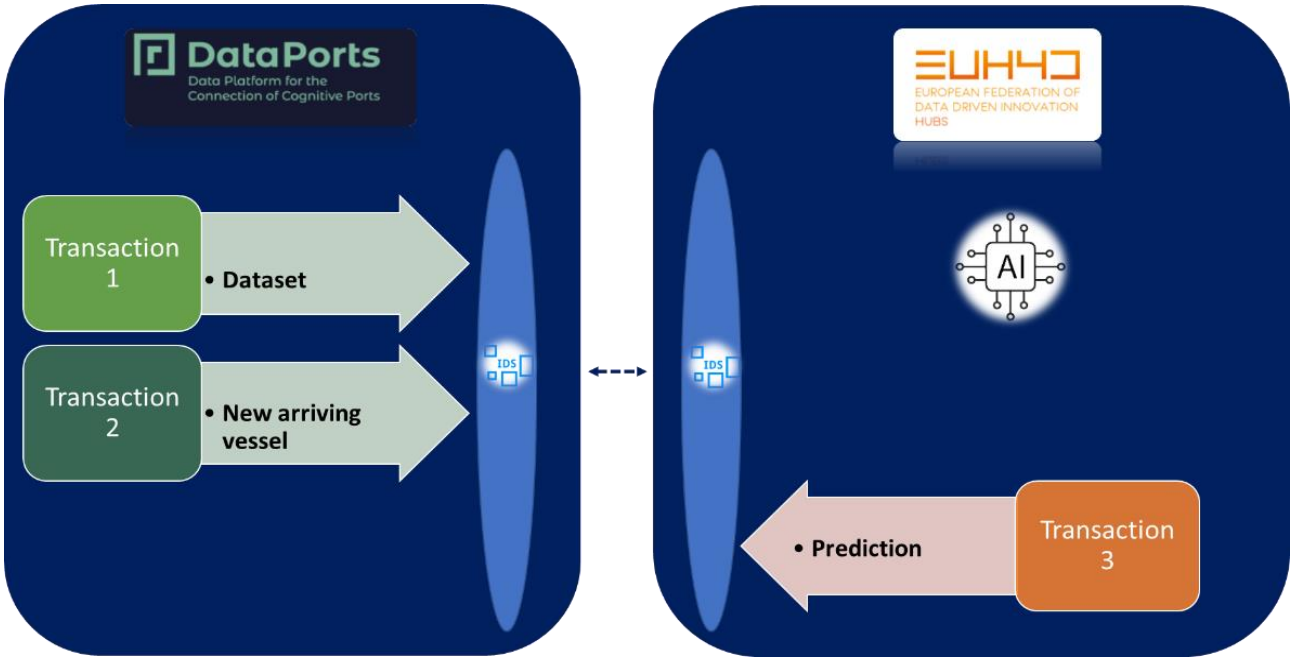


Figure 99 – Shipment list with the Digital Consignment Note button

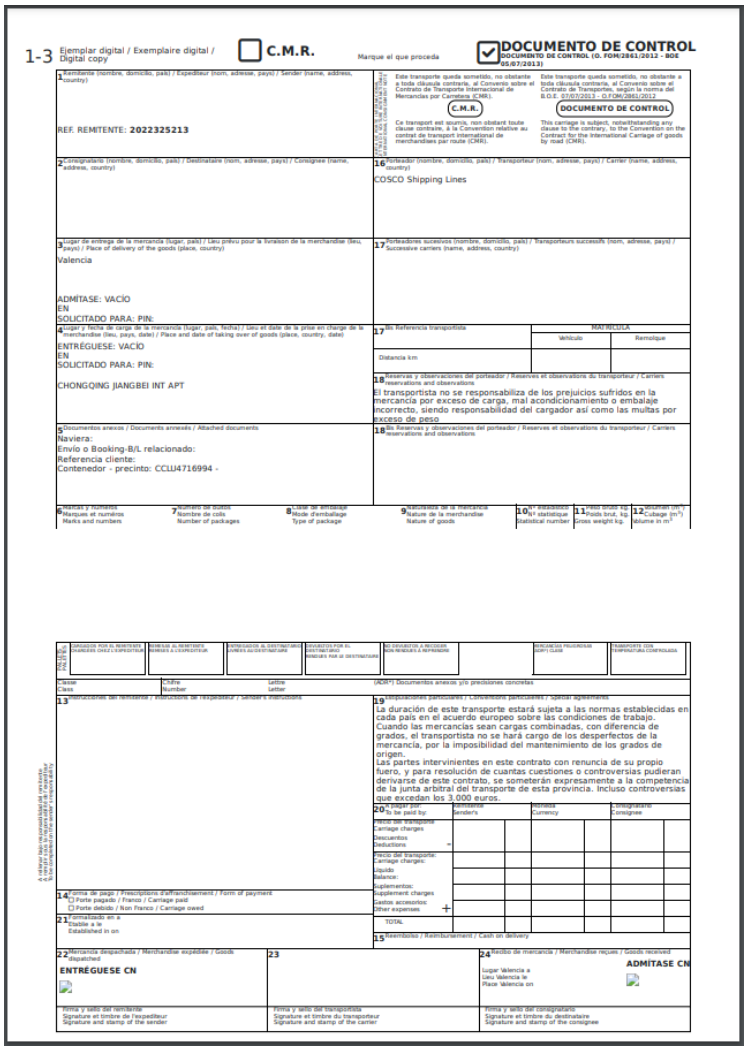


Figure 100 – Digital Consignment Note

9.2 PORT OF THESSALONIKI

9.2.1 Container pick-up

The functionality of the Container Pick-Up (CPU) application comprises three different frontends, which share common features: the shipping agent frontend, the port authority frontend and the trucking company frontend. All shipping agent and trucking company users automatically get the corresponding functionality in their frontends. Port authority users, on the other hand, are able to access the CPU functionality only if they have the coreor-user role. In order to access the functionality, all users must first login to the frontend. Once login has taken place, all CPU functionality is accessed through two items in the frontend's main menu: COREOR Requests and Booking Requests (orange rectangle in Figure 101).

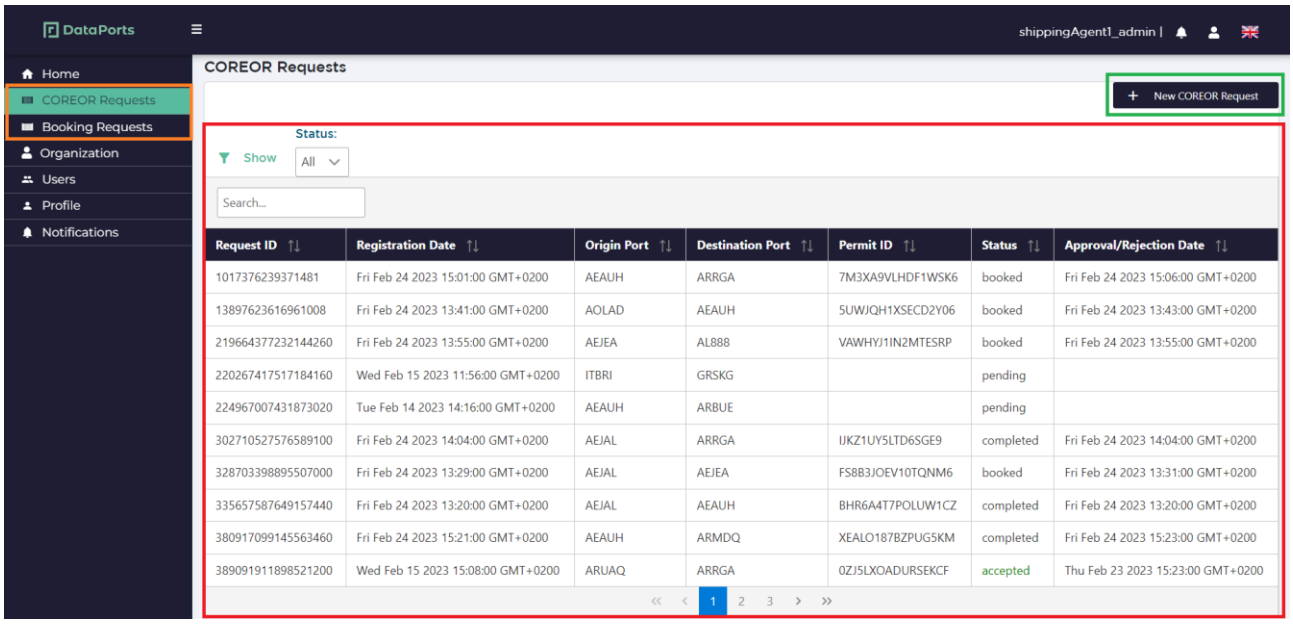


Figure 101 - COREOR Requests view

9.2.1.1 COREOR Requests menu

The COREOR Requests menu is visible to only shipping agent and port authority users. Selecting the COREOR Requests item shows a sortable and searchable table of COREOR requests in the main view (red rectangle in Figure 101). The table contains the most important COREOR attributes, like Registration Date, RequestID, Permit ID (if it has been issued), Status etc. Status is especially helpful, since, by looking at it, we can quickly have an understanding about the condition of the COREOR. The different statuses are: pending, rejected, accepted, booked, completed (see Table 59).

	COREOR	Booking
Pending	Waiting to be evaluated by the port	Waiting to be evaluated by the port
Accepted	Accepted by the port, but no booking exists for it	Accepted by the port

Rejected	Rejected by the port. No booking can be created for it	Rejected by the port. New booking must be created for COREOR
Booked	Accepted, with corresponding booking created	N/A
Completed	Corresponding booking has been completed	Designated truck has left the port with the container
Failed	N/A	The date of the booking has passed and the designated truck never came to the port

Table 59 - COREOR and Booking statuses explained

Clicking on a line in the table displays the selected COREOR's details in the main view.

There is also a button, specifically for shipping agents, for creating new COREOR requests (green rectangle in Figure 101). Port authority users do not see such a button.

Clicking on the "New COREOR Request" button presents the user with a form, which contains UI elemets (text fields, lists etc) for all fields present in a COREOR request. These are contained in two tabs named "Step 1" and "Step 2". The user needs to fill in the required information from both steps and click on "Submit". As soon as the new request is submitted, it is saved in the blockchain and also forwarded to the port's systems. It is worth noting that each COREOR contains the name of the trucking company charged with removing the container from the Port.

The significance of the "COREOR Requests" menu for shipping agents is that through it they can create new COREORs and view the status of previously created COREORs. The port authority, on the other hand, can view all COREORs created for it by all shipping agents dealing with the port. Accepting a COREOR is done through the port's systems and the COREOR application is notified through its API.

9.2.1.2 Booking Requests menu

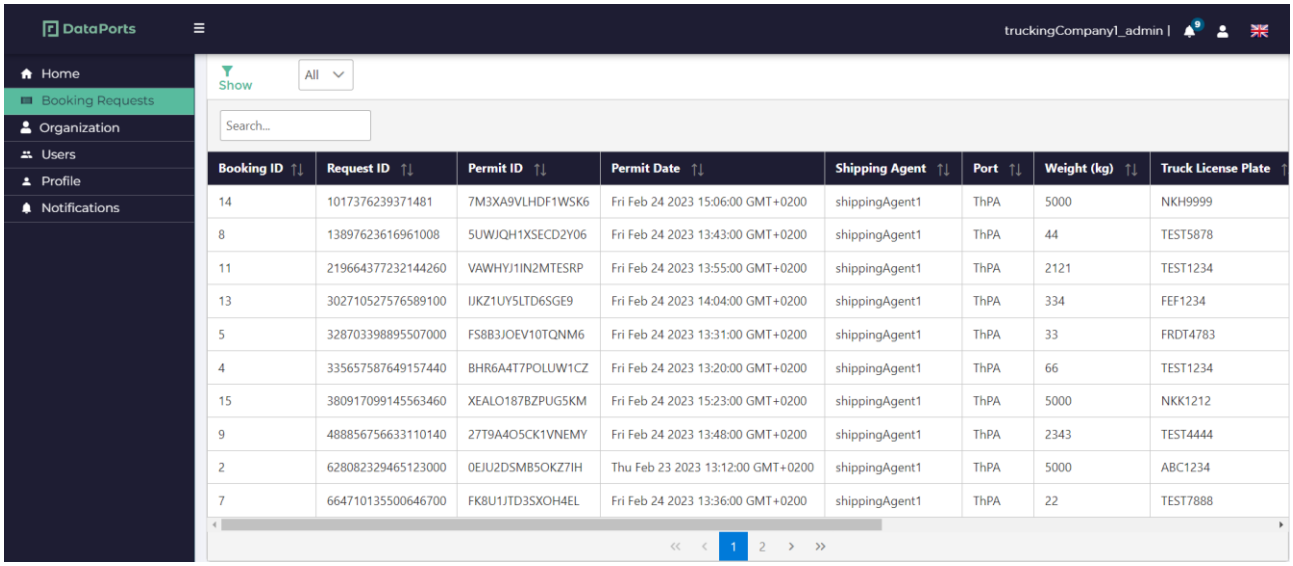


Figure 102 - Booking Requests view

The Booking Requests menu is available to the users of all the organisations involved, i.e. shipping agents, port authority and trucking companies (Figure 102). Shipping agents can use this menu to view the bookings made for their COREORs and thus be better informed about the progress of their COREOR request. Trucking companies can inspect their own bookings and their status. It is worth noting that the actual bookings are done using the TAS port system, however the COREOR frontend provides notification functionality to the trucking company user, as described in 9.2.1.3. Finally, port authority users can view all bookings made by all trucking companies. Accepting a booking, however, is done through the port's systems and the COREOR application is notified through its API.

Clicking on a row in the booking requests table switches the view to show its details. For a booking that has been accepted, "Booking details" tab contains the QR code necessary for the truck driver to enter the Port (Figure 103).

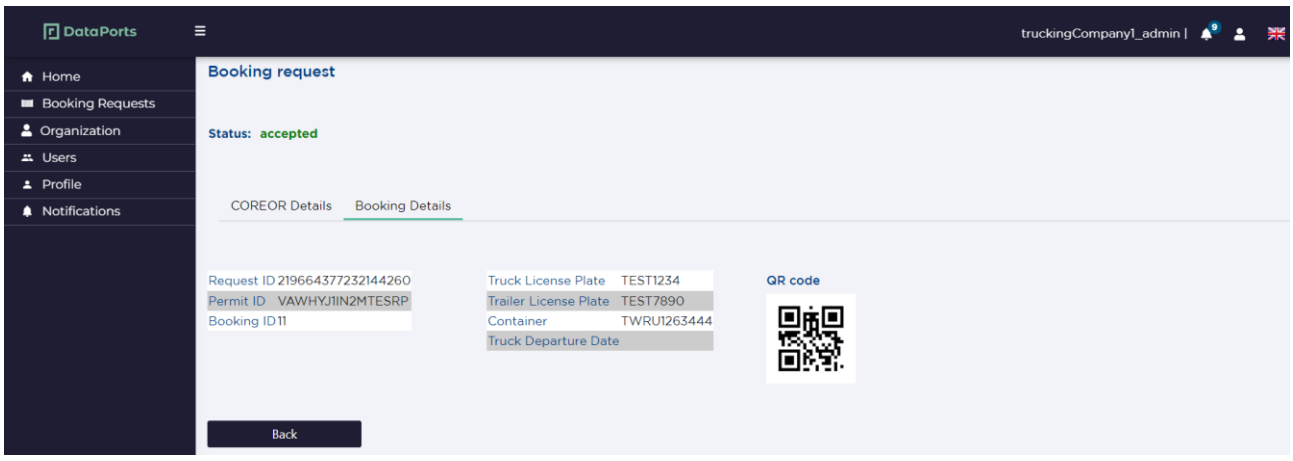


Figure 103 - QR code in accepted booking request

9.2.1.3 Notifications

The trucking company user receives notifications for accepted COREORs that refer to their company for removing the container from the Port. These notifications are shown on the bell icon in the upper right corner and also in the Notifications view accessible through the main menu (Figure 104). Such a notification prompts the trucking company user to enter a new booking through the TAS port system.

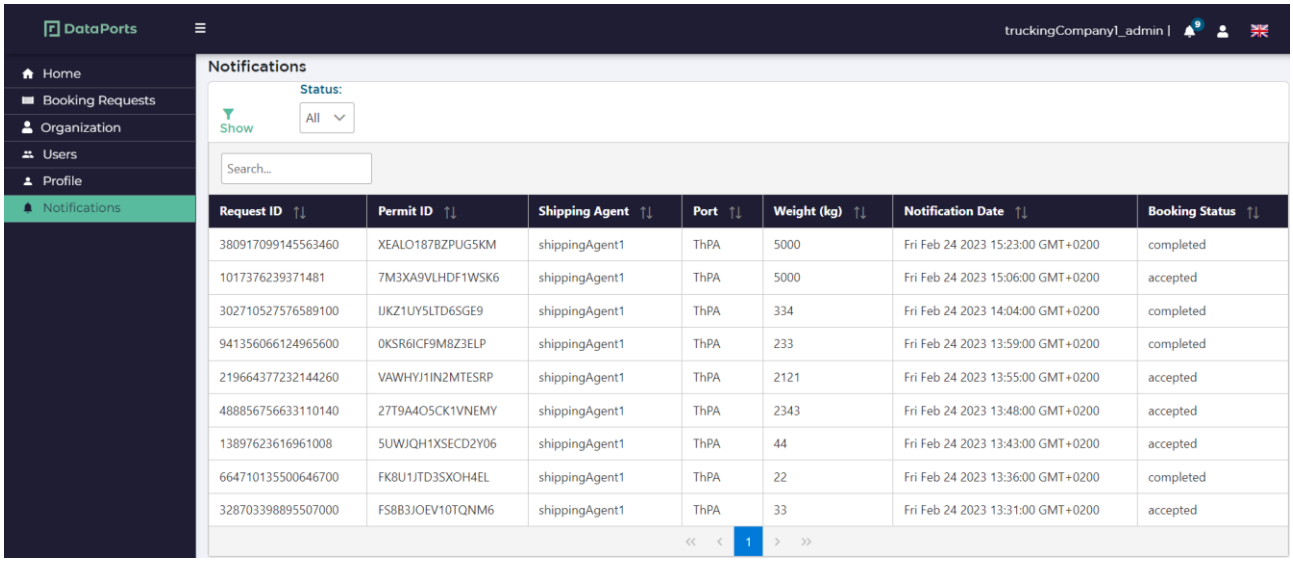


Figure 104 - Notifications for trucking company user

9.2.2 ThPA Analytics Applications

All analytics applications have been specifically created for the Port Authority. Therefore, they are available to only port authority users. However, access to analytics is restricted to only those port authority users that have the analytics-user role. In order to access the functionality, all such users must first login to the frontend. Once login has taken place, all analytics functionality is accessed through the Analytics menu item in the frontend's main menu (Figure 105).

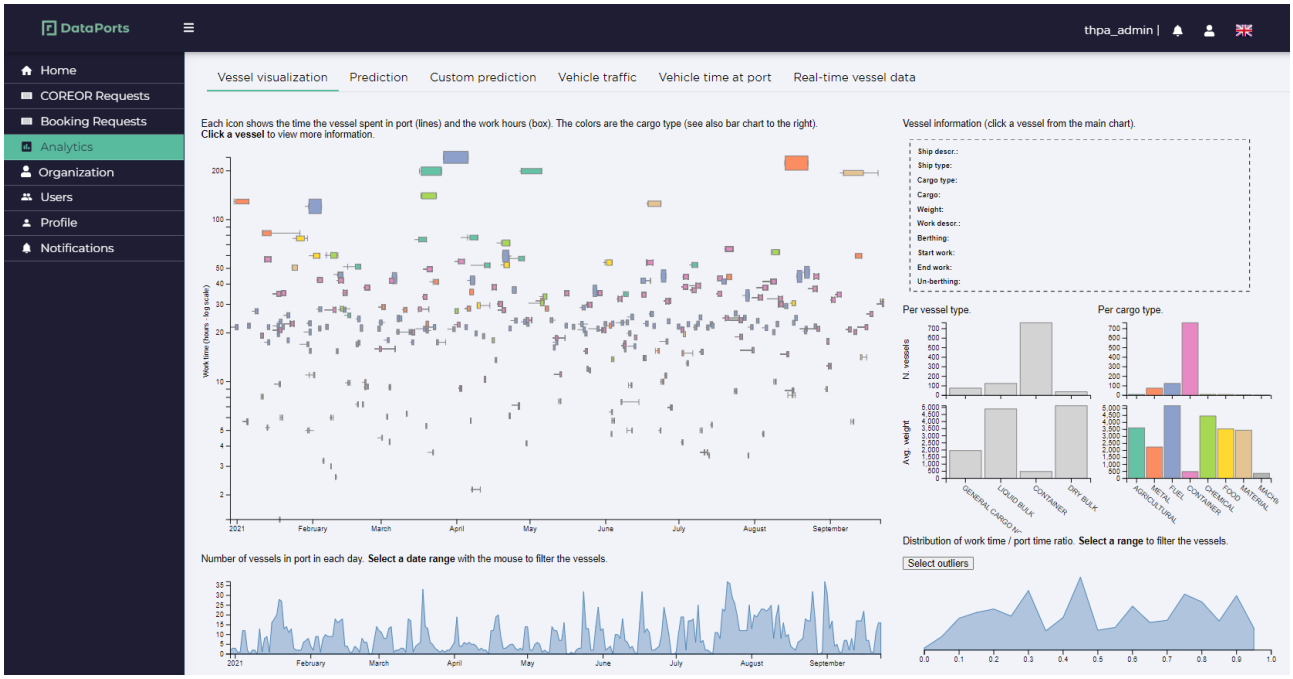


Figure 105 - Analytics menu

9.2.2.1 Vessel visualization

In the “Vessel visualization” tab the user can see a scatterplot of vessels at the top left (largest panel in the screen), with a special icon per vessel; by clicking on a vessel, an information panel at the top right is presented, showing details for the selected vessel.

In addition, in the dashboard the user is able to see an area plot at the bottom left, showing the number of vessels at the port each day, four bar charts at the middle right, showing the number and average weight of vessels per vessel type and cargo type and an area plot at the bottom right, showing the distribution of the work time ratio, while a button “Select outliers” above the work time ratio plot is also available for the user.

In the vessel number per day plot (bottom left), the user can select with the mouse a date range, clicking at a point and dragging to the right or left. Consequently, the selected date range is highlighted on top of the area plot, while the rest of the plots are updated, presenting only the selected period. More specifically, the date limits of the main scatterplot (horizontal axis) are limited to the selected range, while the bar plots at the middle right and work time area plot at the bottom right, are updated to cover only vessels handled within the selected date range, as presented below.

If the user then moves the selected date range to the left or right, by clicking and dragging it with the mouse, the rest of the plot are updated accordingly. Finally, by clicking outside the selected date range, the previously selected date range is un-highlighted and the views of the scatterplot, bar charts and work time plot are reset to cover all available data.

Finally, as in the vessel number per day plot, in the work time ratio plot (bottom right), the user can select a horizontal range, by clicking with the mouse and dragging to the right or left, so that the selected value range is highlighted; consequently, the rest of the plots are updated based on the selected value range. For them to be restored, the user simply clicks outside the selected value range. In the work time ratio plot, the user may also utilize the “Select outliers” button above it, which highlights the range from 0 to 0.2, that is the idle vessels. The scatterplot and bar chart views are updated accordingly, to cover only the vessels with a work time ratio less than 0.2.

9.2.2.2 Prediction

Next to the Vessel visualization tab, the user can find the Prediction tab, where he can explore the vessel prediction capabilities of the platform.

By selecting the preferred date, the results table that contains all the ships in port in the selected date is presented, along with information like Ship Name, Ship Type, Cargo, Arrival, Mooring and Work. If then the user selects a vessel from the table, he is presented with the following screen.

Two tables are presented under the main one, with information about containers of the selected ship and another with the time predictions for three procedures in port. The left side table named “Containers”, is filled with data on the number of empty and non-empty containers along with their cargo and weight, for the selected vessel. The table on the right side called ‘Predictions for “Ship Name”, contains time predictions for turnaround, mooring, and work procedures of the vessel in average with a min-max range, and an estimated date if the start date of the procedure is known, based on historical data of the vessel from past port calls. It must be noted that if a procedure in the selected date is already done, predictions will not take place.

Finally, when the user selects a tab number from the ‘Containers’ table to see the rest cargos of the vessel, the ‘Container’ table turns page with the rest information of the cargos.

9.2.2.3 Custom prediction

For the prediction of vessels, the user may also utilize the next tab, called “Custom prediction”, where a form is displayed in the left side with eleven fields to be filled in and in the right side an empty table called ‘Predictions’, for the results to be presented.

The user can then fill the form data, with at least the predefined ones as necessary to proceed (those with an ‘*’, 6 in total) and then clicks submit below the form. The predictions table is consequently filled with time predictions for the procedures of turnaround, mooring, and work procedures of the ship, in average with a min-max range, and an estimated date if the start date of the procedure is known.

Finally, when selecting the ‘Clear’ button below the form, the form is cleared. The custom prediction tab, is presented below.

9.2.2.4 Vehicle traffic

In the Analytics page, when the user clicks on the “vehicle traffic tab”, is presented with the following screen.

The vehicle traffic tab, contains a map view (top left part) showing the positions of the port gates as circular marks, with embedded numbers of the total number of trucks that entered through each gate, a set of 7 bar charts showing the temporal patterns of truck arrivals (top right). There is one bar chart per day of week. Each bar chart shows the number of trucks entering the port through all gates at the considered time period and a timeline plot (bottom). In X-axis there are the days in this timeframe and in Y-axis there is the number of trucks in port. In the background there is a light blue line, that is the bookings of trucks that took place, while the darker blue is how many trucks where actually each day in port. Another capability the user has, is that by clicking on a node of the plot graph, which is a specific day, a red line is presented, depicting the prediction regarding the number of trucks that will be in the port in the next 10 days. A separate chart below shows this prediction line in more detail.

In the map view (top left), when the user clicks on one of the circular marks (gate positions), the bar charts (top right) are updated to show statistics for only the trucks that passed through the selected gate. In the case that the user wants to see both gates, he can then hold Ctrl and click on another of the circular marks.

9.2.2.5 Vehicle time at port

In the Analytics page, when the user selects the “Vehicle time at port” tab from the menu, he is presented with the following screen, depicting the number of vehicles parked in the port premises grouped, according to the duration of their stay.

Then, when the user selects month, day or hour, the vehicles for that given duration are presented. In addition, when selecting a time category bar, he is presented with a new graph under the main, presenting each type of vehicle i.e. car, motorcycle etc… that stayed in that period.

Finally, when the user selects the “no specific month/day/time chosen” button, the process is reset and the starting interface is presented.

9.2.2.6 Mobility

A visitor interested in visiting the port can access the DataPorts platform, the following screen is presented, containing dropdown options “mobility” and “traffic”, and Covid-related statistics. The following visualizations are presented, updated in real-time, according to user input.

When selecting “mobility” dropdown option, two more clickable options appear, "Mobility monitoring" & "Mobility Statistics". When selecting the “Mobility monitoring” option, the user can see a map interface of mobility in Thessaloniki created with historical data. Visitor can choose to see mobility with absolute or relative numbers and is also capable of seeing COVID thresholds. By changing timeline slider, in graph of active users, visitor is able to see mobility per hour of day.

In the “Mobility statistics” option a new map interface of Thessaloniki shows up. Visitor can choose to see the map by average numbers or by COVID thresholds colours i.e. red = too much users, orange = medium mobility, green = safe places. Visitor can also choose month and day to see average mobility in bar plot, where he can also choose a specific hour to see in the map average mobility, for every cell individually, and decide whether or not visit a specific area.

9.2.2.7 Traffic

In the “Traffic” dropdown option, three more clickable options appear: “Traffic statistics”, “travel times” and “parking spots”. When selecting the “Traffic statistics” option the following screen is presented.

The user can then select through the month or day dropdown, to see the average traffic in the map and in a bar plot of 24 hours of day. If the visitor clicks a bar from the average users Bar Plot, he can see the average traffic for a specific hour of day into the map and decide whether or not to visit an area.

Through the “travel times” option, the visitor can select a route from a dropdown option and the selected path with red colour is presented and the average duration to traverse it, is presented in a bar plot. If then the visitor selects a month or day from the dropdown options, average travel time for every hour during the selected month and day is presented for the selected path.

Finally, in the “parking spots” option, the average number of visitors for the two parking lots that ThPA handles, for each day of the week and each hour of day, are presented. The user may choose from a dropdown menu, to see the parking lot he is interested in. The main chart shows visitors that stayed parked in the port's parking lots and the small chart under it, can be used to adjust the main chart for a better analysis, by cropping or moving it. The “parking spots” screen is presented below.

9.3 POSIDONIA MANAGEMENT

9.3.1 Access to the application

The first page that appears when a user accesses the application is the login window. The user will fill the user and password fields for being authenticated and the applications will grant the access and available functionalities depending on the user privileges and access rights.

Figure 106 – Posidonia Management login interface

9.3.2 Initial page

Once we login the main page of the application is shown. On top right we can find data about the user. On the left there is the main menu and, in the centre, there is the main work area.

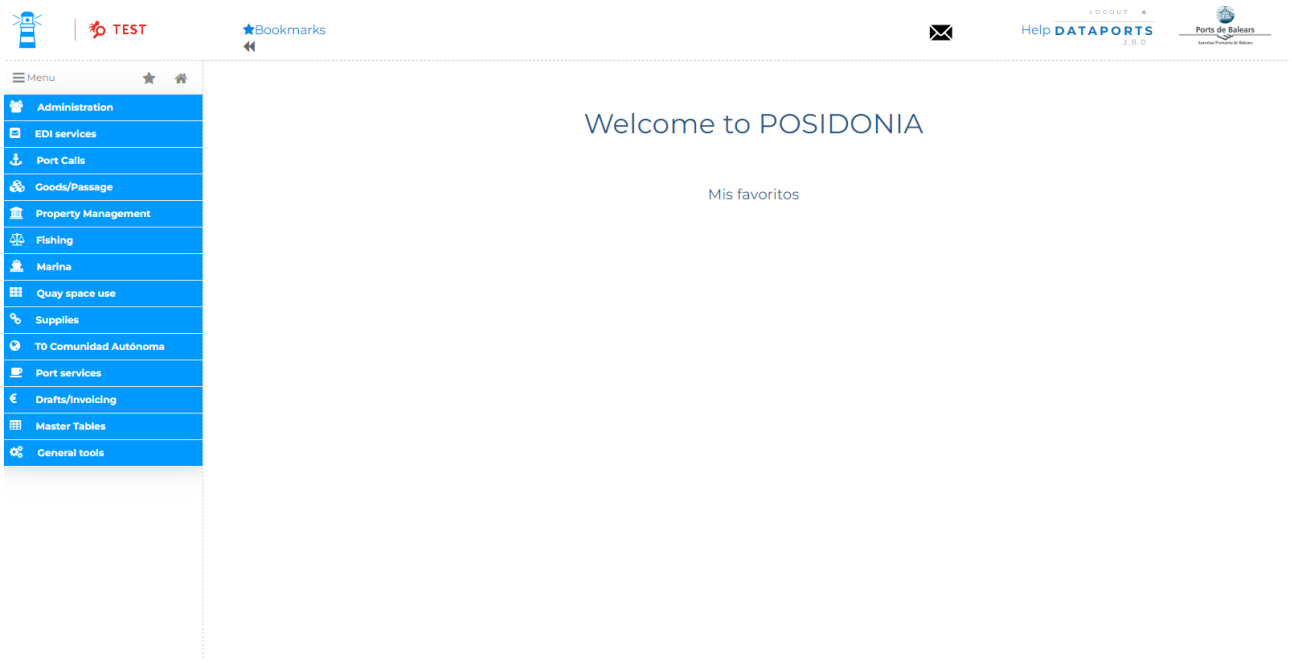


Figure 107 – Posidonia Management welcome page

9.3.3 Port call modification

For managing the Port Calls there is an option “Port Calls” in the main menu, that contains an option, called again “Port Calls” that opens the list of the Port Calls of the current year by default.

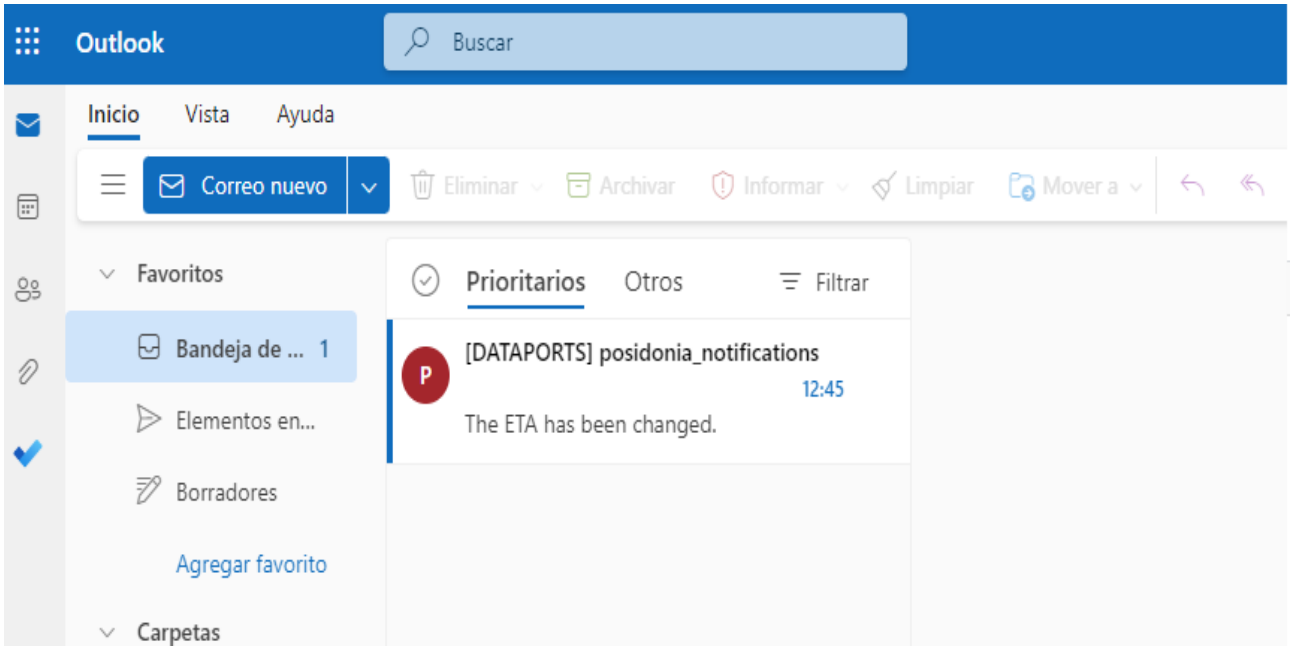


Figure 108 – List of Port Calls in Posidonia Management

For running the actions that will send the events to DataPorts, we can select a Port Call and we will find in the Actions drop-down list the Edit ETA and Edit ETD options.

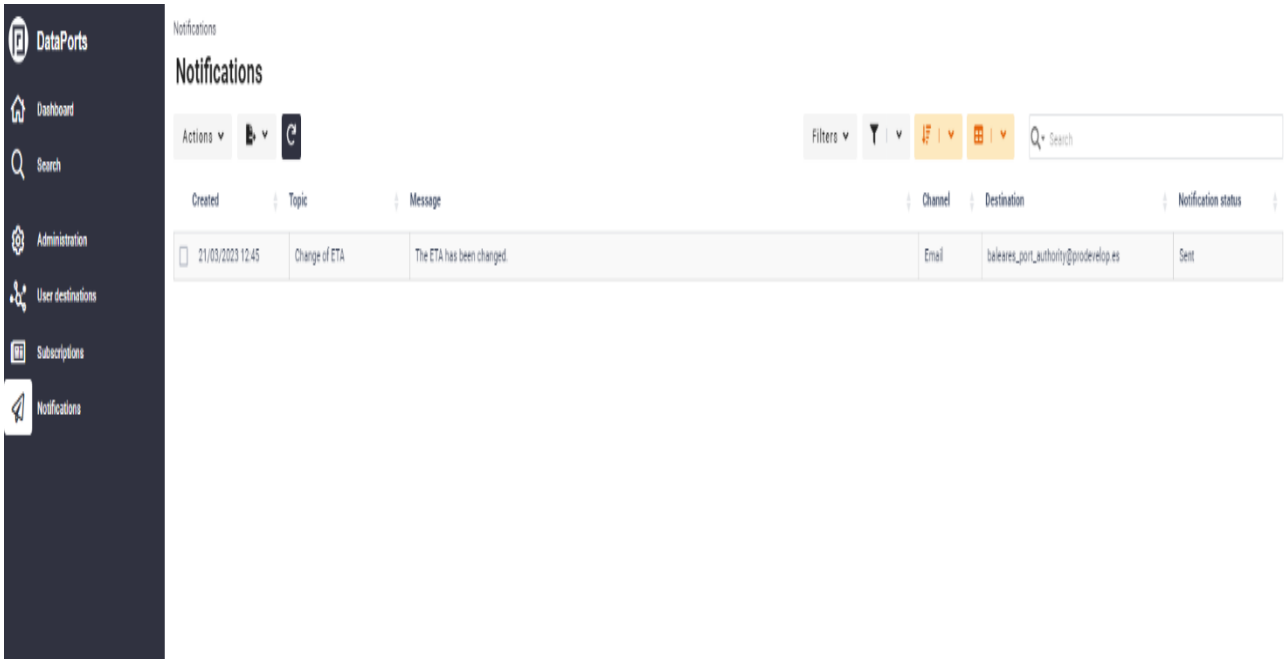


Figure 109 – Executing actions in Posidonia Management

The Change ETA action will ask for the user confirmation and if granted, open a pop-up dialog where a new ETA can be introduced. This new value must be a before date than the ETD date.

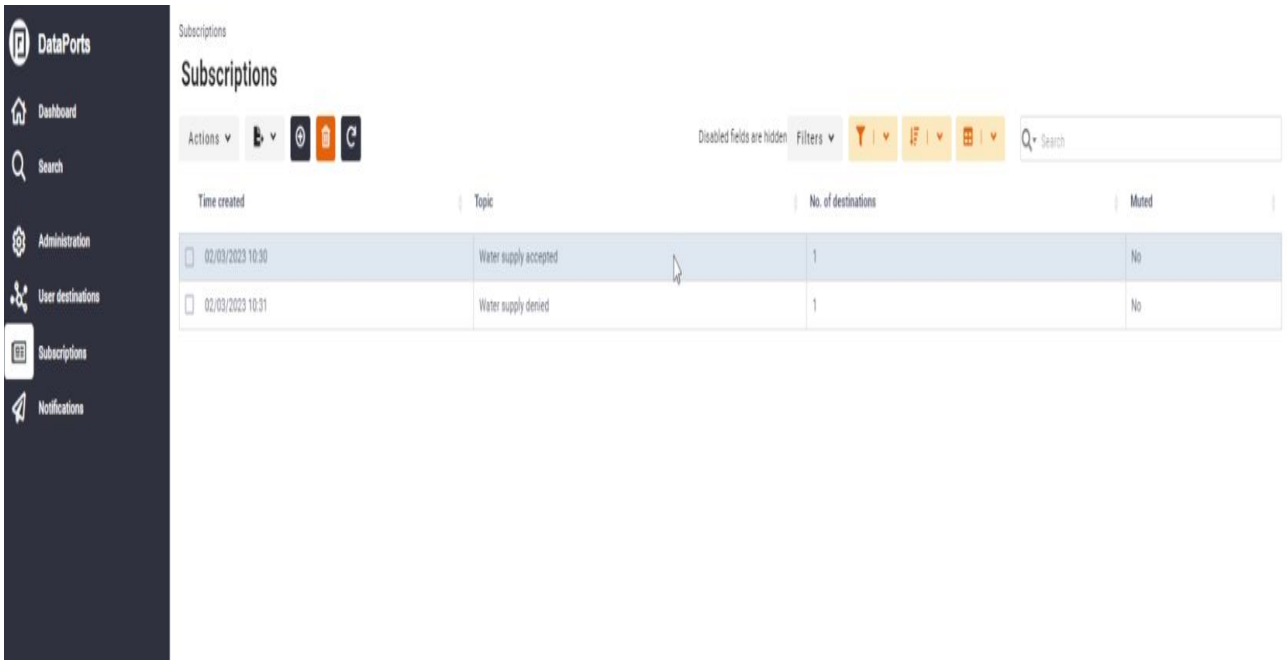


Figure 110 – ETA change assistant in Posidonia Management

Once the date has been set the action can be finished pressing the Accept button. A confirmation message will tell us that the actions has been completed. If there is an error or the action cannot be done, this window will show a message error.

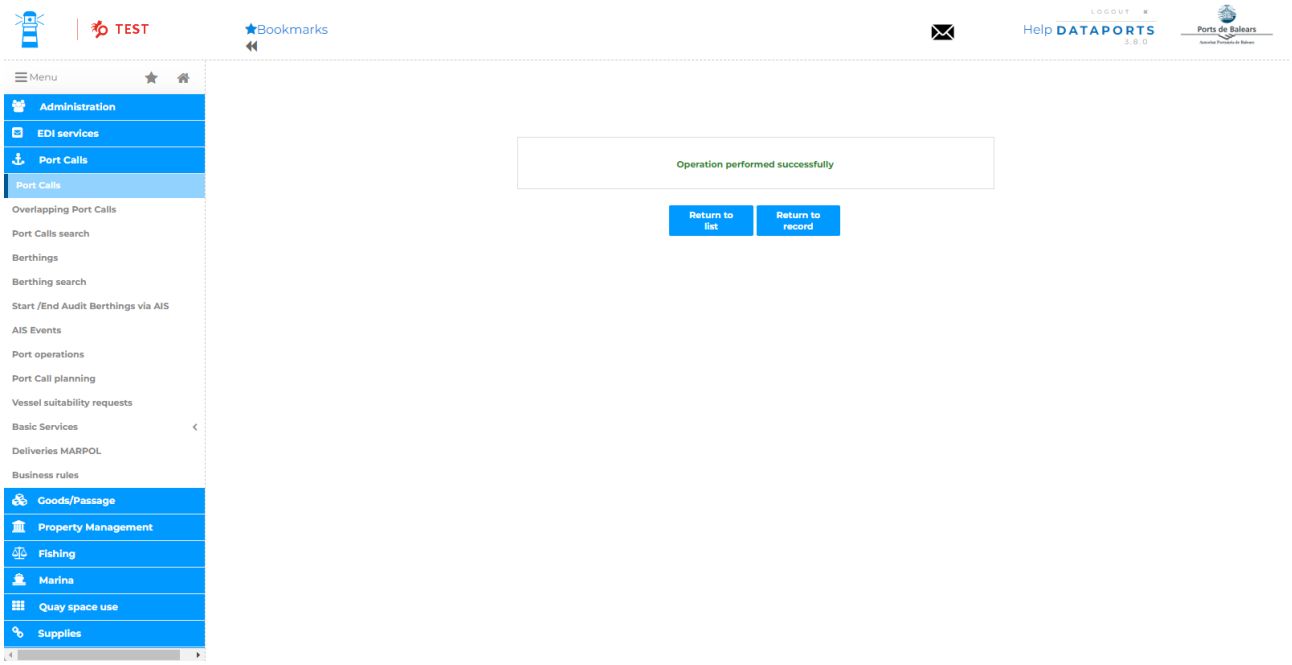


Figure 111 – Action result feedback in Posidonia Management

9.4 POSIDONIA PCS

9.4.1 Access to the application

The first page that appears when a user accesses the application is the login window. The user will fill the user and password fields for being authenticated and the applications will grant the access and available functionalities depending on the user privileges and access rights.

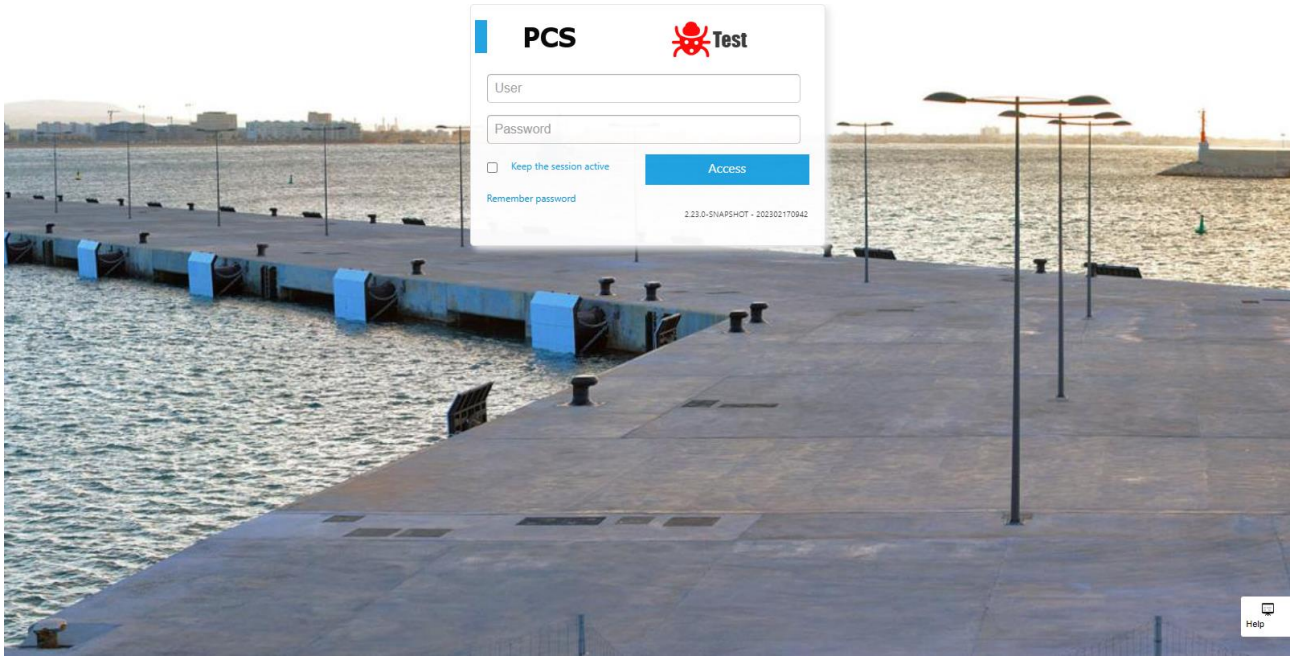


Figure 112 – Posidonia PCS login interface

9.4.2 Initial page

Once we login the main page of the application is shown. On top right we can find data about the user. On the left there is the main menu and, in the centre, there is the main work area that shows the list of Port Calls.

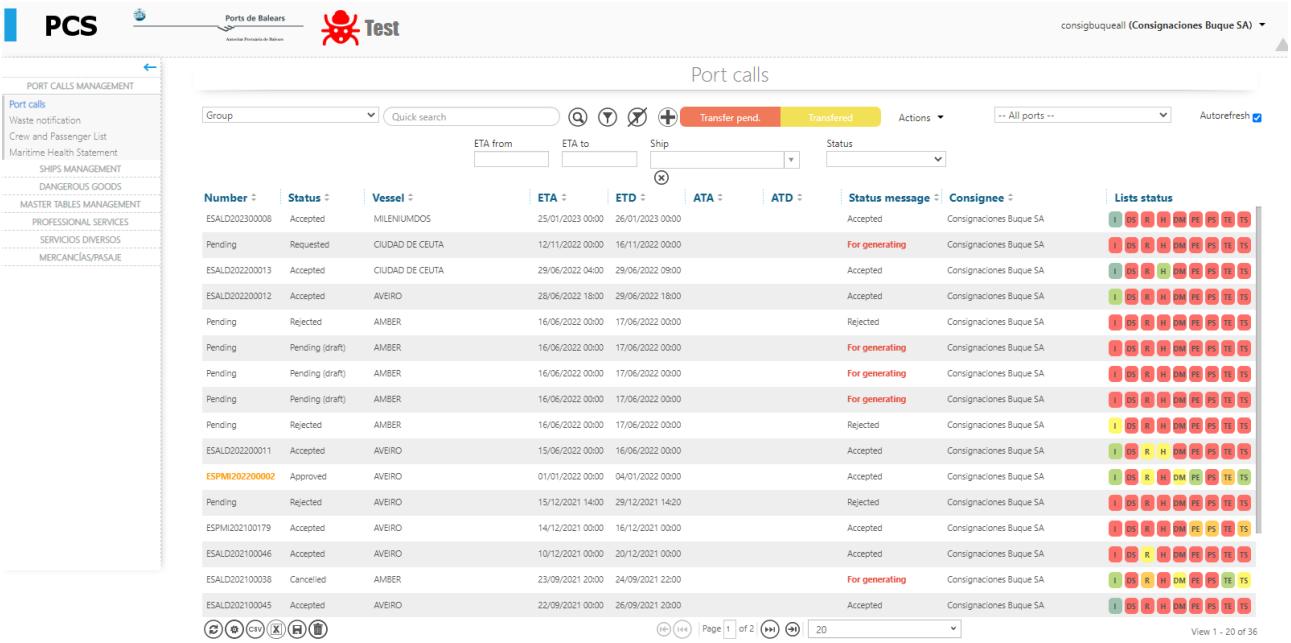


Figure 113 – Port Calls list in Posidonia PCS

9.4.3 New Requests

If the user is a vessel consignee there will be enabled the functionalities for creating new requests. For the requests of supplies or other services, we have to look for the Professional Services entry in the main menu of the application. In this menu we will find different kind of resources to request, for example water and energy.

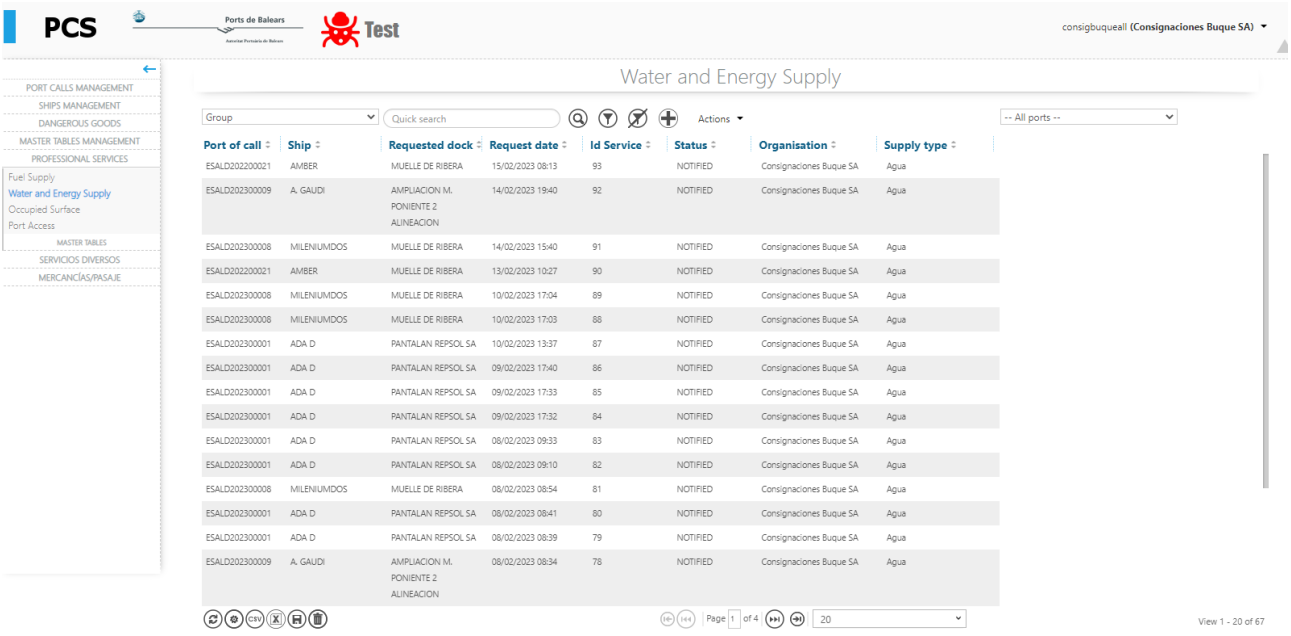


Figure 114 – Water and energy request management in Posidonia PCS

In the table there is a list with all the existing requests. We can create a new one pressing the ⊕ button on the top of the table. A new window will be shown.

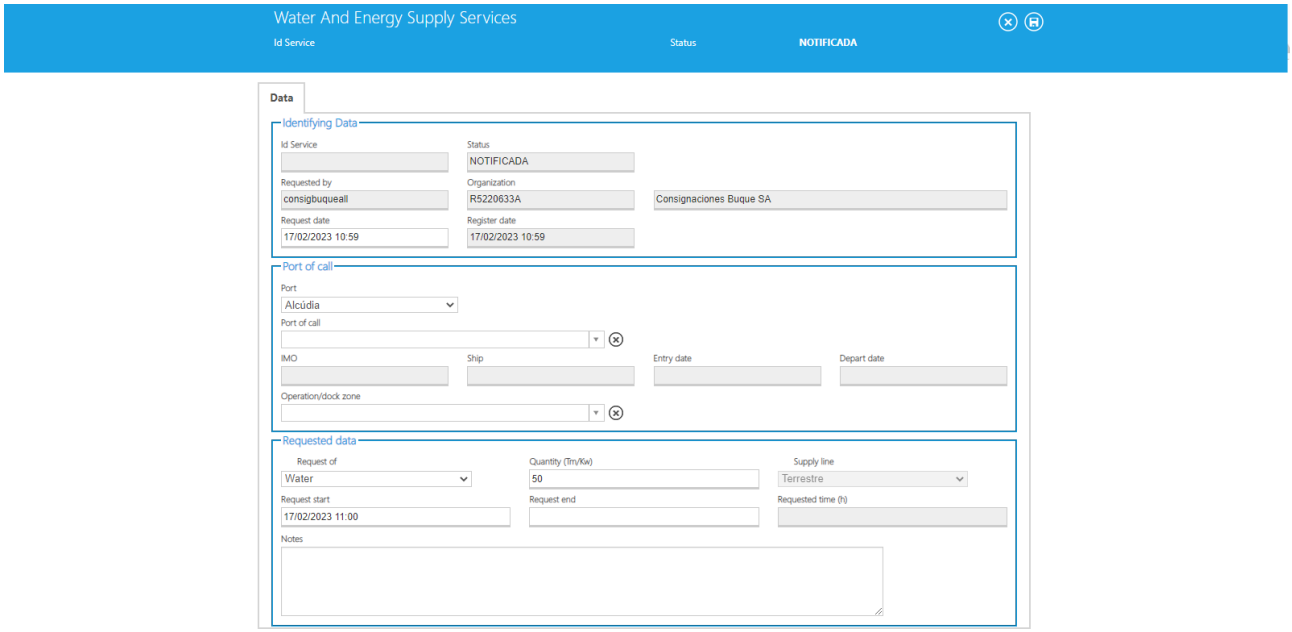


Figure 115 – Requesting water in Posidonia PCS

In this form we will select the Port and Port Call we want to request a service for. Then we will fill the Request data section choosing the kind of resource and the amount. For finishing the request, we will press the save button ( ) on the top right of the window.

Once the action is finished the list will be shown again and will contain the new request.

9.4.4 Request Management

If the user has the rights to manage the requests, new options will appear on the application. Navigating to the water and energy request list, we will be able to pick a request and authorise or deny it.

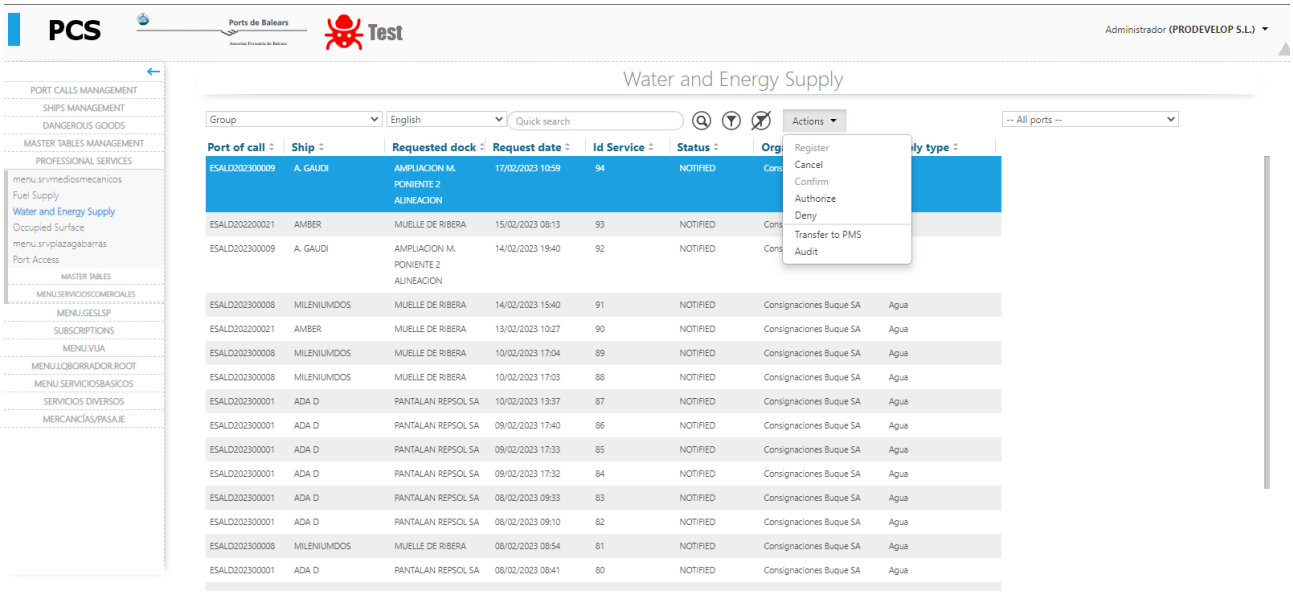


Figure 116 – Accept or deny requests in Posidonia PCS

Input and confirmation will be requested from the application in order to finish the action.

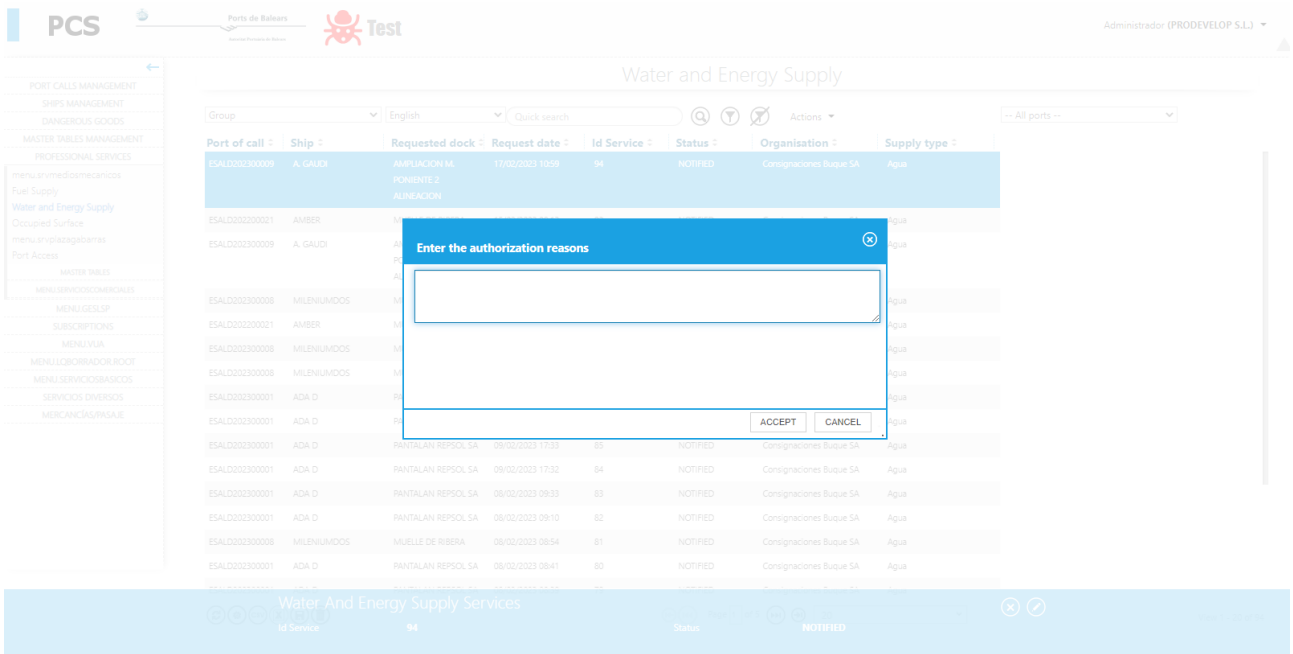


Figure 117 – Accept or deny requests detailed justification

9.5 POSIDONIA NOTIFICATIONS

9.5.1 Login

When a user accesses the application, the first required action before being able to use it is the authentication. So, in the first page the user will have to enter his authentication data to log. There is also have a button that can be select in case he wants to keep the session open:

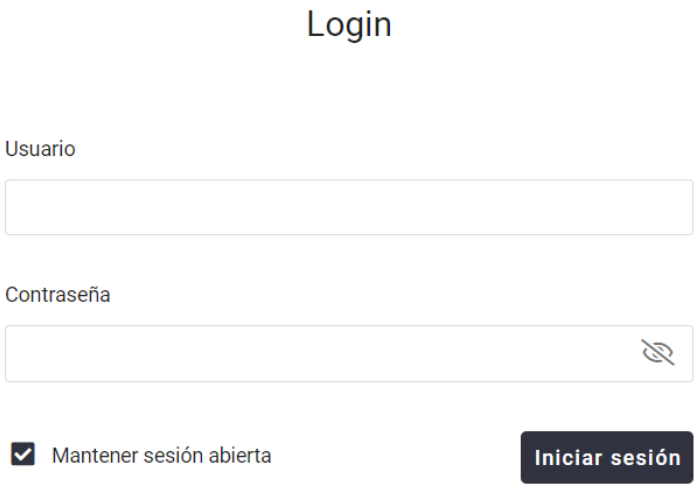


Figure 118 – Posidonia Notifications login interface

9.5.2 Common actions

In the application you can find buttons that have common functionalities in different views of the application, to use them well we have to see their functionality.

To access the different views just select them from the respective side menu to the left:

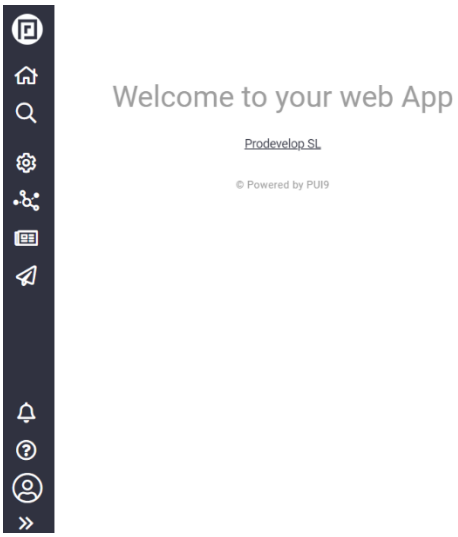


Figure 119 – Posidonia Notifications welcome page

Each of these buttons performs the following functions:

- Actions: Here are indicated all the actions that we can perform to the elements of the table, in this case (subscriptions).

  - Disable/enable subscriptions: Allows us to activate or deactivate subscriptions, if a subscription is deactivated, the notification is not made.

  - Disable/enable the mute in the subscriptions: Mute as opposed to unmute if they will be done but you will not receive a notification of these.

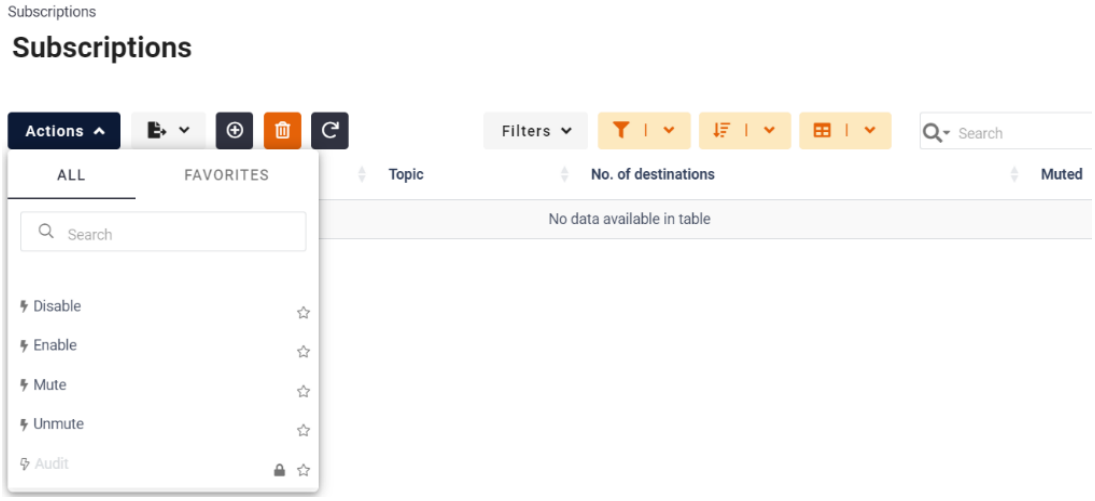


Figure 120 – Posidonia Notifications common actions

- The following button will allow us to export to the indicated formats, the content of the table:

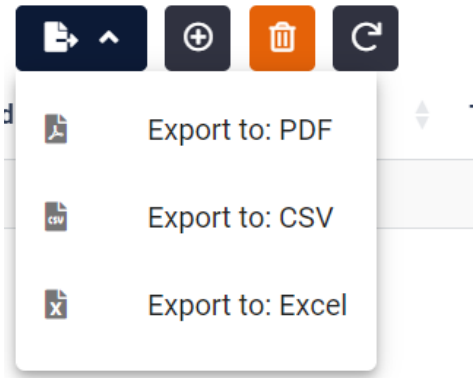


Figure 121 – Posidonia Notifications common tools

- The next button (new record) will allow us to create an element to the table.

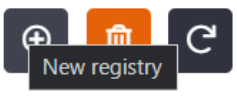


Figure 122 – Posidonia Notifications create registry functionality

- The red trash can icon allows us to select which elements we want to delete.

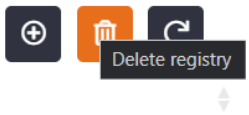


Figure 123 – Posidonia Notifications delete registry functionality

- The next button is used to refresh the table, in case you have updated data.

Figure 124 – Posidonia Notifications refresh list functionality

- Filters: Here the saved filters will be shown, both those created by the user and those created by the system.

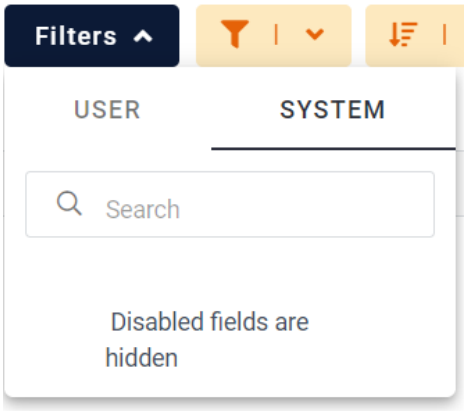


Figure 125 – Posidonia Notifications filters

- The next button on the left allows us to activate and deactivate the filters, and the drop-down menu allows us to create our own filters.

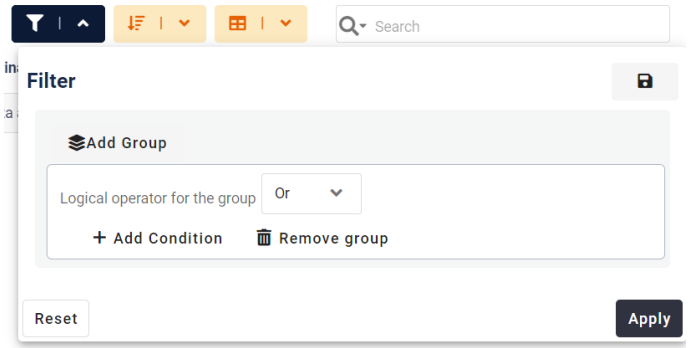


Figure 126 – Posidonia Notifications advanced filters

- The next pair of buttons are used to toggle and modify the sorting of the columns.

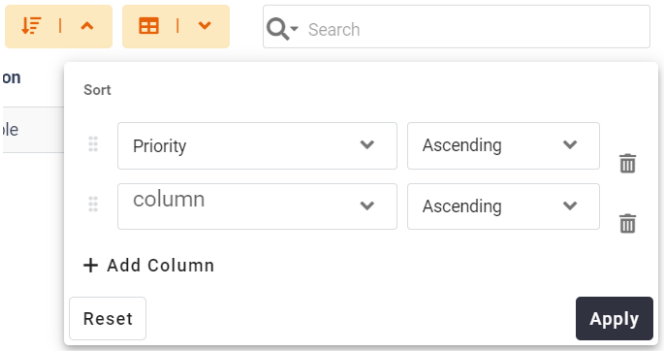


Figure 127 – Posidonia Notifications list sorting

- The last pair of buttons allow us to hide or show columns of the table, as well as to save our column configurations.

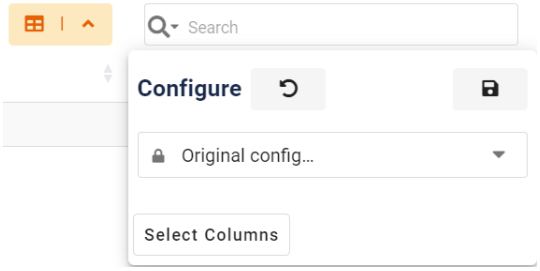


Figure 128 – Posidonia Notifications column selection

- Finally, we have a search bar that allows us to search among the various elements, as well as a drop-down that allows us to select on which columns to search.

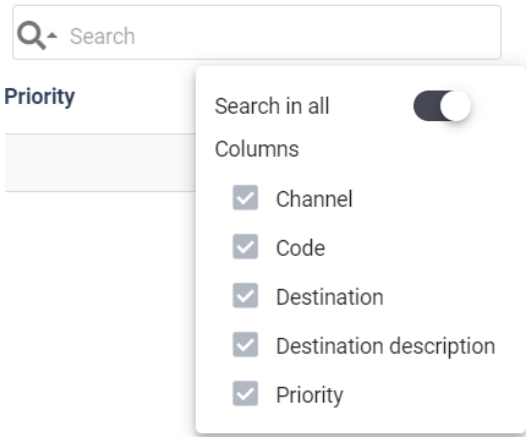


Figure 129 – Posidonia Notifications quick search

9.5.3 User Destinations

It allows us to create destinations where the notifications will arrive, if we select the add button, we can create a new element for the table.

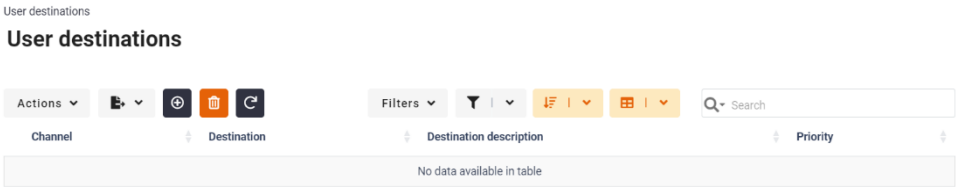


Figure 130 - User destinations list

Once here we have to fill in the mandatory data (marked with a red *) and click on save to create a new element.

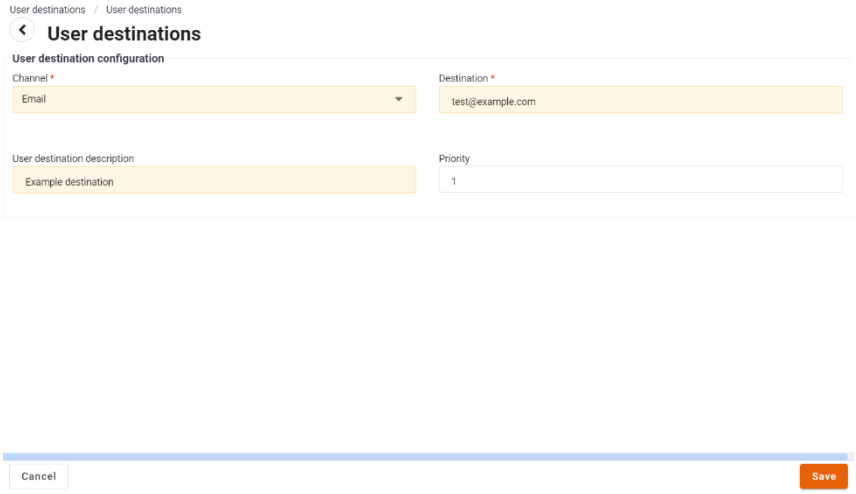


Figure 131 – Creating a new user destination

Once the element is saved it will appear in the table (In case the table has not been updated we can always use the refresh button).

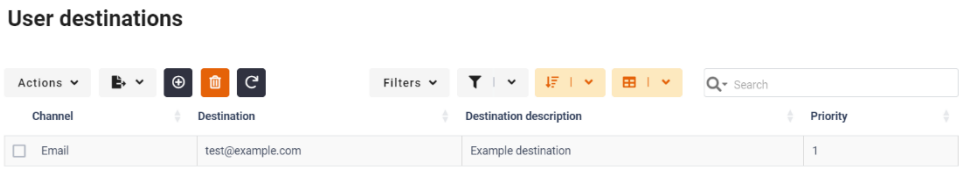


Figure 132 – List after creating a new user destination

9.5.4 Subscriptions

If we select in the side panel subscriptions, we will go to the subscriptions view where we will be able to create, activate/deactivate, mute/unmute, delete our subscriptions.

To create a subscription just click on the add button.

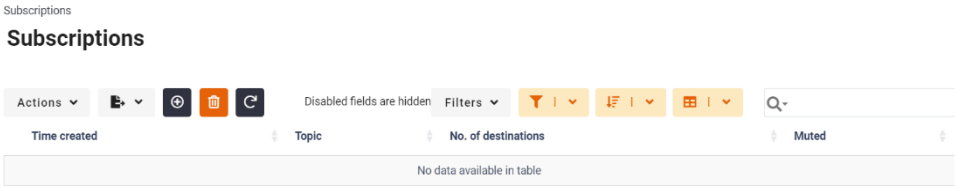


Figure 133 – List of user subscriptions

In this view we will have to fill in the necessary data to create a subscription.

In the filters section we can indicate at which level we want the subscription.

If we select organization level, we will receive all the notifications of events that have taken place in our organization (port authority in this pilot), if we select division, we will receive all the notifications that happened in the same division of the user (port in this pilot). Stakeholder will create notifications only if our user is sent as part of the input event.

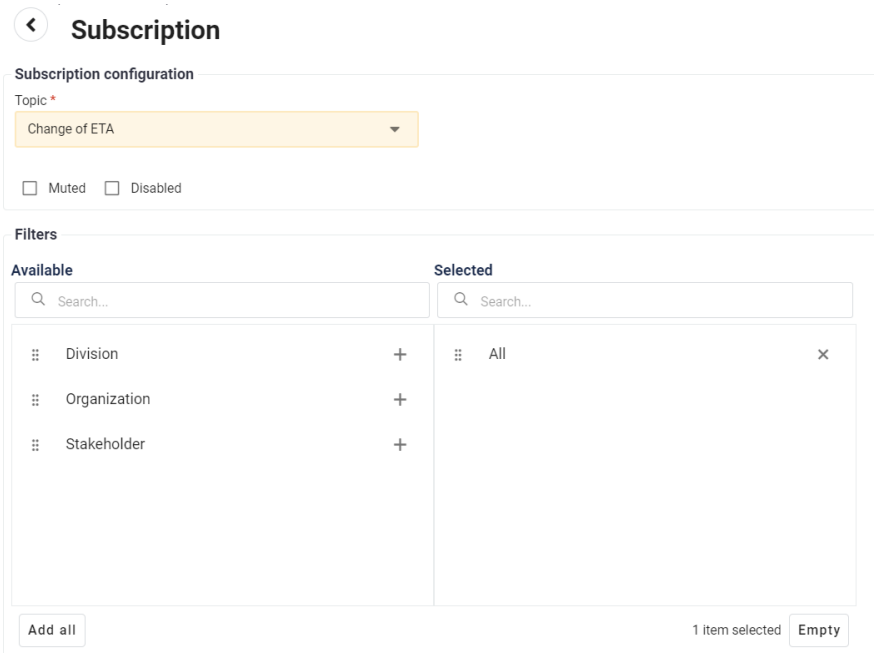


Figure 134 – Creating a new subscription

We also set the destinations where the notifications will arrive.

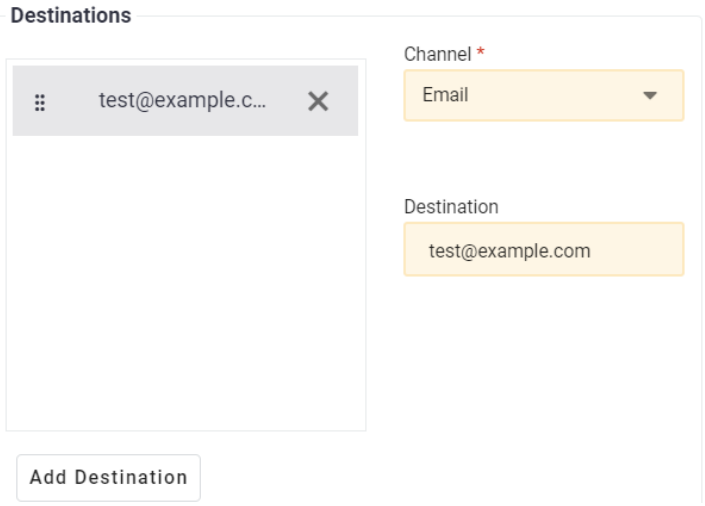


Figure 135 – Adding destinations to a subscription

Once all required fields have been filled in, we can proceed to save the subscription.

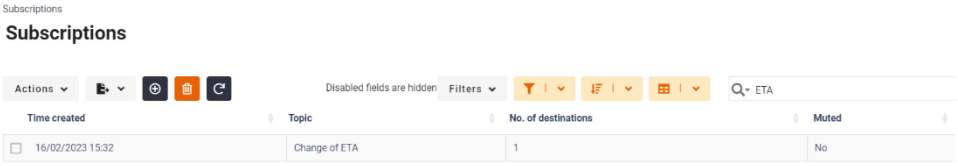


Figure 136 – Result of creating a subscription

9.5.5 Notification

If we select notifications in the side menu, we can access the view that shows us all the notifications of the subscriptions we have.

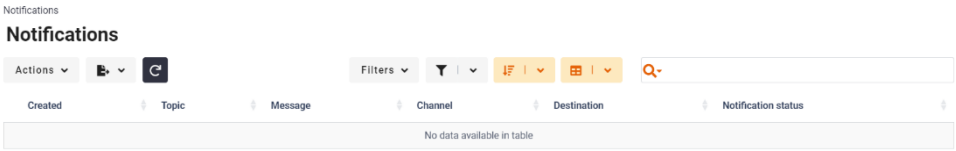


Figure 137 – List of user notifications

If a notification arrives at any level (according to the test subscription that has been created above) it will be displayed here, like this:

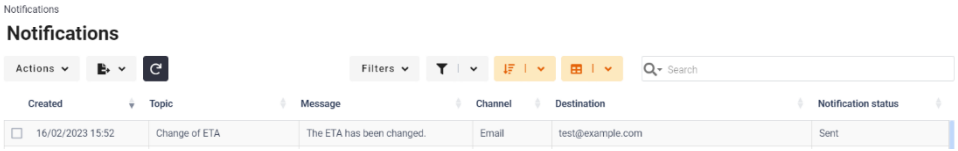


Figure 138 – List of user notifications after receiving the first one

10 ANNEX B: CHANGE LOGS

10.1 CPU

Change ID	Description
CPU.1	The blockchain has been deployed in ThPA.
CPU.2	The COREOR application has been deployed in ThPA.
CPU.3	The application now POSTs a COREOR request to the ThPA backend API.
CPU.4	The application now receives COREOR acceptance/rejection through a POST call.
CPU.5	The application now receives booking requests through an POST call.
CPU.6	The application now receives booking acceptance/rejection through a POST call.
CPU.7	The application now receives truck departures through a POST call.

Table 60 – THPA CPU changelog

10.2 THPA ANALYTICS

Change ID	Description
CPU.1	The analytics applications have been deployed in ThPA.
CPU.2	Analytics now receive their respective datasets through the DAV component.
CPU.3	ThPA statistics and Queues Predictions are now available through the same authentication-based frontend used in the COREOR use case.
CPU.4	Passenger and COVID statistics are now available through a publicly available webpage.

Table 61 – THPA Analytics changelog

10.3 TOS

Change ID	Description
TOS.1	Created endpoint to accept new COREOR request XML.
TOS.2	Created functionality to send COREOR permit ID to CPU application.
TOS.3	Created functionality to send COREOR request rejection to CPU application.
TOS.4	Created functionality to send new booking request to CPU application.
TOS.5	Created functionality to send acceptance for new booking to CPU application.
TOS.6	Created functionality to send booking rejection to CPU application.

TOS.7	Created functionality to send truck departure info to CPU application.

Table 62 – THPA TOS changelog

10.4 POSIDONIA PCS

Change ID	Description
PCS.1	Created the functionality to send a POST request to an API on demand.
PCS.2	The application sends events on Water Supply requests changes.
PCS.3	The application sends events on Electricity Supply requests changes.
PCS.4	The application sends events on Port Access requests changes.
PCS.5	The application sends events on Waste Removal requests changes.
PCS.6	The application sends events on Surface requests changes.

Table 63 – Posidonia PCS changelog

10.5 POSIDONIA MANAGEMENT

Change ID	Description
MNG.1	Created the functionality to send a POST request to an API on demand.
MNG.2	The application sends events when a visit/port call starts or ends.
MNG.3	The application sends events when the ETA or ETD of a visit changes.
MNG.4	The application sends events when the cargo manifest has been activated.
MNG.5	The application sends events when a visit to port has been authorized.

Table 64 – Posidonia Management changelog

10.6 POSIDONIA OPERATIONS

Change ID	Description
OPE.1	The application can read data from AISHUB.

Table 65 – Posidonia Operations changelog