This project has received funding from the European's Union Horizon 2020 research innovation program under grant agreement No. 769355

D3.2 – PIXEL Requirements Analysis

Deliverable No.	D3.2	**Due Date**	30/03/2019
Type	Report	**Dissemination Level**	Public
Version	1.0	**Status**	Final Version
Description	The deliverable includes the analysis of the requirements, transform them into pilots, as well as the dependencies and interrelationship among them.		
Work Package	WP3		

Authors

Name	Partner	e-mail
Carlos E. Palau	P01 UPV	cpalau@dcom.upv.es
Ignacio Lacalle	P01 UPV	iglaub@upv.es
Benjamin Molina	P01 UPV	benmomo@upvnet.upv.es
Jose Clemente	P02 PRO	jclemente@prodevelop.es
Flavio Fuart	P03 XLAB	flavio.fuart@xlab.si
Gasper Vrhovsek	P03 XLAB	gasper.vrhovsek@xlab.si
Marjan Šterk	P03 XLAB	marjan.sterk@xlab.si
Gilda De Marco	P04 INSIEL	gilda.demarco@insiel.it
Paolo Casoto	P04 INSIEL	paolo.casoto@gmail.com
Erwan Simon	P05 CATIE	e.simon@catie.fr
Charles Garnier	P05 CATIE	c.garnier@catie.fr
Marc Despland	P06 ORANGE	marc.despland@orange.com
Luka Traven	P08 MEDRI	luka.traven@medri.uniri.hr
Andrea Chinese	P09 SDAG	a.chinese@sdag.it
Cinzia Ninzatti	P09 SDAG	c.ninzatti@sdag.it
Tamara Corsano	P09 SDAG	t.corsano@sdag.it
Andrea Chinese	P09 SDAG	a.chinese@sdag.it
Christos Papadopoulos	P10 - ThPA SA	cpapadopoulos@thpa.gr
Eirini Tserga	P10 - ThPA SA	etserga@thpa.gr
Eva Vafaki	P10 - ThPA SA	evafaki@thpa.gr
Maria Pelteki	P10 - ThPA SA	mpelteki@thpa.gr
Stella Fassa	P10 - ThPA SA	sfassa@thpa.gr
Thanassis Chaldeakis	P11 PPa SA	ahaldek@gmail.com
Stefano Bevilacqua	P12 ASPM	s.bevilacqua@monfalconeport.it
Michel Le Van Kiem	P13 - GPMB	m-le-van-kiem@bordeaux-port.fr
Leonida Pitsikas	P14 IPEOPLE	lpitsikas@peoplegroup.gr

History

Date	Version	Change
15-July-2018	0.1	Table of Contents and first content related to methodology
04-February-2019	0.2	Added workflow and first gathering of requirements

13-February-2019	0.3	Review and integration of requirements and add
18-February-2019	0.4	Review and integration
28-February-2019	0.5	Review and integration
18-March-2019	0.6	Review and integration
29-March-2019	0.7	Review and integration
13-April-2019	1.0	Official release

Key Data

Keywords	Requirements, process, functions, organization, data
Lead Editor	Gilda De Marco, P04 INSIEL
Internal Reviewer(s)	Marc Despland, P06 ORANGE Cinzia Ninzatti, P09 SDAG

Abstract

The Requirement Analysis is aimed at providing a detailed analysis of requirements (in accordance with the VOLERE Methodology) needed by the set of tools which will be developed by the PIXEL project. Collected and analyzed requirements provide a comprehensive coverage of each different use case involving PIXEL's partners and stakeholders, as described in detail in deliverable D3.4.

Requirement elicitation and analysis have been performed by involving all different stakeholders of the PIXEL project, such as ports, technical partners, research and academicals partners. The use cases of each stakeholder have been analyzed in order to describe the functionalities the PIXEL tools must provide and how such tools must work in order to satisfy both project's goals and users' expectations. Requirements are classified in functional requirements, non-functional requirements and constraints.

An iterative process has been exploited in order to improve both quality and soundness of collected requirements. Requirements analysis represents, in fact, one of the most important task of each project concerning software development and impacts significantly on the quality and effectiveness of the overall project. The definition of rigorous requirements can reduce the development effort, by minimizing the risk of re-design, re-coding and re-testing to take place, by allowing project managers to estimate both time and cost of required development tasks. Finally, the requirements can set the evaluation and validation criteria to obtain a quality product.

In order to optimize the outcomes of WP3, in PIXEL a standardized and largely adopted methodology for requirements analysis has been adopted: the VOLERE Methodology. Described in detail in Chapter 2 of this document, VOLERE Methodology represents a leading solution in requirements analysis, by allowing its practitioners to collect, classify and analysis requirements in a systematic way. In particular, an ad-hoc template, based on the standard VOLERE template, has been proposed in order to include specific information related with the PIXEL project and its deliverables. VOLERE Methodology, already known by several partners of the Consortium, has been effectively exploited by adopting the JIRA tool.

This deliverable represents a description of the results generated by task T3.4 but, at the same time, it should be seen as a synergistic path with the other tasks of the WP3. In particular deliverables D3.1, D3.2 and D3.4 represent the starting point for interviews with stakeholders, by describing the different use case each partner is interested in.

Statement of originality

Table of contents

List of tables

List of figures

List of acronyms

Acronym	Explanation
ACS	Access control System
ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road
AP+	Cargo Community System connected to the VIGIEsip PCS and used in Port of Bordeaux
API	Application Programming Interface
ASPM	Azienda Speziale Porto di Monfalcone
BOD	Biological Oxygen Demand
BTEX	Benzene, toluene, and the three xylene isomers
CEP	Complex Event Processing
CO	Carbon monoxide
COD	Chemical Oxygen Demand
CSS	Cascading Style Sheets
CSV	Comma-Separated Values
ETA	Estimated time of arrival.
FVG	Friuli Venezia Giulia
GCS	Gate Control System
GDPR	General Data Protection Regulation
GPMB	Grand Port Maritime de Bordeaux - Port of Bordeaux
GPS	Global Positioning System
HMI	Human-Machine Interface
HTML	HyperText Markup Language
HTTPS	Hypertext Transfer Protocol Secure
ICT	Information and Communication Technology
INSIEL	INformatica per Il SIstema degli Enti Locali
IoT	Internet of Things
KPI	Key Performance Indicator
LNG	Liquefied Natural Gas
ML	Modelling Language
NMS	National Meteorological Service
NO	Nitrogen monoxide
NO2	Nitrogen dioxide
NOx	Nitrogen oxides
O3	Ozone
OT	Operational Tool
PC	Personal computer
PEI	Port Environmental Index
PIXEL	Port IoT for Environmental Leverage
PM10	Particulate Matter 10um
PM2,5	Particulate Matter 2,5um
PMIS	Port Management Information System
PMS	Port Management System
PPA	Piraeus Port Authority SA
RFID	Radio-Frequency Identification

SAP	Systeme, Anwendungen, Produkte in der Datenverarbeitung
SDAG	Stazioni Doganali Autoportuali Gorizia
SILI	Sistema Informativo Logistico Integrato (Integrated Logistic Information System)
SMS	Short Message Service
SO2	Sulfur dioxide
SOx	Sulfur oxides
TDS	Total Dissolved Solids
THPA	Thessaloniki Port Authority
TMC	Traffic Management Centre
TOS	Terminal Operating System
TOS	Terminal Operating System
UI	User Interface
VHF	Very High Frequency – band of radio spectrum
WP	Work Package
XML	eXtensible Markup Language

1. About this document

The scope of this deliverable is to provide PIXEL requirements to support the design and the implementation of the PIXEL solutions in order to meet the pilots' needs. In this deliverable have been collected and classified, using the VOLERE methodology, all requirements identified by pilot partners, with the support of all project partners, that will guide the next technical stages of PIXEL with a focus on the peculiarity of each pilot partner and the related needs and its position within PIXEL platform. For the requirements gathering has been used JIRA in order to allow to each pilot to insert its own needs and to share them with all partners in order to detail the requirements and to refine them in the PIXEL perspective. Moreover, part of the content of the deliverable received input from D3.3 and its final version D3.4, and the interviews of the pilots, allowed to better specify their needs and to carry out the requirements.

1.1. Deliverable context

Keywords	Lead Editor
Objectives	*Objective 1: Enable the IoT-based connection of port resource, transport agents and city sensor networks.* The deliverable specifies the requirements that describe which data from which devices will be sent to IoT platform in order to meet the ports needs. *Objective 2: Achieve an automatic aggregation, homogenization and semantic annotation of multi-source heterogeneous data from different internal and external actors* The deliverable provides the data, the data-sources and the flows of the data exchange among actors. *Objective 3: Develop an operational management dashboard to enable a quicker, more accurate and in-depth knowledge of port operations* The deliverable includes the expected functionalities of the dashboard from the pilot partners *Objective 4: Model and simulate port-operations processes for automated optimisation* The deliverable includes several requirements describing modelling functionalities needed by Ports in order to fulfil their respective use-cases. Objective 5: Develop predictive algorithms The deliverable does include only some specifications about input and output of models. *Objective 6: Develop a methodology for quantifying, validating, interpreting and integrating all environmental impacts of port activities into a single metric called the Port Environmental Index (PEI).* The deliverable includes requirements related with PEI calculation and visualization.

Exploitable results	There are no exploitable results from the work reported at this deliverable. Nevertheless, its content is highly relevant for the exploitation of PIXEL
Work plan	This deliverable is strongly linked with task 3.3 and its two deliverables D3.3 and D3.4, that are input for it and the reference point to check the coherence of the requirements with the description of the use-cases and scenario. It is the main input for WP4, task 5.3 of WP5, WP6 that will take into consideration all requirements collected and detailed in it to design and develop all PIXEL components. Moreover, this deliverable is linked with WP7 and WP8, as feedback point.
Milestones	MS3
Deliverables	Detected input: D3.1: Stakeholders and market analysis report: This deliverable presents the relevant stakeholders and their role in ports activities that must be taken into consideration to collect requirements. D3.3: Use cases and scenarios manual v1 describe the scenario and the use case that must be translated into requirements. D3.4 Use cases and scenarios manual v2 extends and completes the previous version (D3.3) with more detailed information on the target use cases and scenarios to refine the requirements. Detected output D8.1: Evaluation plan will be based to assess PIXEL impact on the expressed requirements listed and described in D3.2 D5.2 and D5.3. PEI definition and algorithms will consider PEI requirements contained in D3.2 in terms of functionalities and qualities of the PEI D7.1 and D7.2 Integration Report will receive input from D3.3 D6.1, D6.2: PIXEL Information system architecture and design will take into consideration the requirements listed and described in D3.2 D6.3 and D6.4: PIXEL data acquisition, information hub and data representation will receive input from D3.2 in terms of data, data-sources and needed functionalities D4.1 D4.2: PIXEL Models will be defined based on expresses requirements described in D3.2
Risks	The D3.2 is linked to the following risks with related mitigation measures: Risk 6: Technical activities are not completed on time, are not aligned with the main objective, are not accurate or present a lack of consistency. Mitigation measures: each task in the technical WPs will be carry out by at least three project partners Risk 8: Requirements fail to align with ICT systems

	Mitigation measures: the process modelling and the development, foreseen in WP6, will start after a deep analysis of the ICT component in use cases to deploy PIXEL and in generic port technological solutions.

1.2. The rationale behind the structure

The document is divided into three sections. The first section describes the methodology exploited for defining the requirements and their maintenance. In the second section, all the requirements, grouped by the scenarios, corresponding to the 4 pilot ports, Monfalcone/SDAG, Piraeus, Thessaloniki, Bordeaux and the common product that is the PEI, have been listed and analyzed in order to meet the guide the design and the development stage of PIXEL. The third section provides an overall vision of the requirements specifications that support the understanding of the PIXEL platform and how it meets the ports of the future needs.

2. Deliverable-specific sections

2.1. Methodology

The identification, communication and management of the requirements within PIXEL project follow the VOLERE methodology. VOLERE has been used by thousands of organizations around the world in order to discover, define, communicate and manage all the necessary requirements for any type of system development (e.g. software, hardware, commodities, services, organizational, etc.). VOLERE can be applied in almost all kinds of development environments, with any other development methods or with most requirements tools and modeling techniques. To produce accurate and unambiguous requirements, the VOLERE methodology uses techniques that are based on experience from worldwide business analysis projects and are continually improved.

The VOLERE methodology provides several templates to deal with the different techniques and activities that it includes. In a quick view, the VOLERE Requirement Process[1] suggests a methodology that can be summarized as follows:

1. Define the Purpose of the Project (done in the Proposal);
2. Stakeholders Identification and Analysis (T3.1);
3. Business Use Cases (T3.1 and T3.3);
4. Scenarios (T3.3);
5. Writing the Requirements: functional requirements and non-functional requirements (**T3.4**);
6. Validation of requirements: completeness, relevance, testability, coherency, traceability, and several other qualities before such requirements are used by developers (**T3.4**);
7. Communicating the Requirements (**T3.4**);
8. Requirements Completeness (WP4, WP5, WP6, WP8 and WP9). The following tasks will examine in depth the requirements collected in this task **T3.4** for continuous improvement.

[1] Volere Requirements: How to Get Started "http://www.volere.co.uk/pdf%20files/VolereGettingStarted.pdf"

In task T3.4, VOLERE methodology applies when establishing templates for the requirement identification, the identification and completion themselves, the validation and compilation grouped by agreed types and priorities.

2.1.1. Requirements

Various definitions exist of what is a requirement. In this study, we agreed to use the definitions of ISO and INCOSE:
"*A requirement is Statement that identifies a product (includes product, service, or enterprise) or process operational, functional, or design characteristic or constraint, which is unambiguous, testable or measurable, and necessary for product or process acceptability.*" (ISO/IEC 2007)[2]

"*A requirement is a statement that identifies a system, product or process characteristic or constraint, which is unambiguous, clear, unique, consistent, stand-alone (not grouped), and verifiable, and is deemed necessary for stakeholder acceptability*." (INCOSE 2010)[3]

Based on the definition of requirement and its role in the development and implementation of a solution, it is possible to identify the main following requirements characteristics:

- **Necessary**

The requirement defines an essential capability, characteristic, constraint, and/or quality factor. If it is not included in the set of requirements, a deficiency in capability or characteristic will exist, which cannot be fulfilled by implementing other requirements.

- **Appropriate**

The specific intent and amount of detail of the requirement is appropriate to the level of the entity to which it refers (level of abstraction). This includes avoiding unnecessary constraints on the architecture or design to help ensure implementation independence to the extent possible.

- **Unambiguous**

The requirement is concisely stated. It expresses objective facts, not subjective opinions. It is subject to one and only one interpretation.

- **Complete**

The requirement sufficiently describes the necessary capability, characteristic, constraint, or quality factor to meet the entity need without needing other information to understand the requirement.

- **Singular**

The requirement should state a single capability, characteristic, constraint, or quality factor.

- **Feasible**

The requirement can be realized within entity constraints (e.g., cost, schedule, technical, legal, or regulatory) with acceptable risk.

- **Verifiable**

The requirement is structured and worded in such a way that it is possible to verify its accomplishment, as well as the degree of customer's satisfaction regarding its realization.

- **Correct**

The requirement must be an accurate representation of the entity need from which it was transformed.

[2] ISO/IEC. 2007. Systems and Software Engineering -- Recommended Practice for Architectural Description of Software-Intensive Systems. Geneva, Switzerland: International Organization for Standards (ISO)/International Electro technical Commission (IEC), ISO/IEC 42010:2007.
[3] INCOSE. 2010. Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities. Version 3.2.1. San Diego, CA, USA: International Council on Systems Engineering (INCOSE), INCOSE-TP-2003-002-03.2.1: 362.

- **Consistent**

The requirement does not contradict any other requirement and is fully consistent with all authoritative external documentation.

- **Comprehensible**

The set of requirements must be written such that it is clear as to what is expected by the entity and its relation to the system of which it is a part.

2.1.2. Requirements classification

The VOLERE methodology classifies each requirement into several groups[4]:

- **Functional requirements** are the fundamental subject matter of the system and are measured by concrete means like: data values, decision-making logic and algorithms. They describe what the system has to do, the rules that it has to carry out or what processing actions it must take.
- **Non-functional requirements** are the behavioral properties that the specified functions must have, such as performance, usability, etc. Non-functional requirements can be assigned to a specific measurement. The VOLERE methodology includes a rich catalogue of non-functional, described in detail in 2.1.2.2.
- **Project constraints** identify how the system must fit into the world. For example, the product might have to interface with or use some existing hardware, software or business practice, or it might have to fit within a defined budget or be ready by a defined date. Each constraint imposes restriction on the solution;
- **Project drivers** are the business-related forces. For example, the purpose of the product is a project driver, as are all of the stakeholders -each for different reasons.
- **Project issues** define the set of conditions under which the project will be done. Issues provides a list of all factors that contribute to the success or failure of the project. Project managers can use such requirements as an input to improve project management.

2.1.2.1. Functional requirements

The VOLERE methodology defines functional requirements as the fundamental subject matter of the system: an action that the product must be able to take, something that the product must do. VOLERE Methodology classifies them in the following two groups:

- **Functional Requirements**: to specify the details for each individual functional requirement, that must be supported by the system.
- **Data Requirements**: a specification of the essential subject matter/business/objects/ entities/classes, which are germane to the system. These requirements clarify the system's subject matter and thereby trigger requirements that have not yet been thought of.

The functional requirements are highly dependent on pilot use cases defined in PIXEL, such as Energy Demand, Intermodal Transport, Port City Integration and Port Environmental Index. PIXEL use-cases have been defined and detailed in deliverables D3.3 and D3.4, already completed by the Consortium. Functional requirements considered in the project must mandatorily draw from these sources. Additionally, several (functional) technological requirements will be also included in the final portfolio. These latter will come from technical partners, mostly focused in WP6.

2.1.2.2. Non-functional requirements

The VOLERE methodology defines non-functional requirements as the behavioral properties that the specified functions must have, such as performance, usability, etc. Non-functional requirements describe how the system works and properties that the final product needs to have in order to fulfill project constraints and drivers. In particular the VOLERE methodology defines following groups of non-functional requirements:

[4] Volere Requirements Specification Template - Edition 18 — 2017 by James & Suzanne Robertson principals of the Atlantic Systems Guild

- **Look and Feel**
  - Interface: to ensure the appearance of the product. There are requirements relating to the interface, such as corporate branding, style, colors to be used, degree of interaction and so on. These requirements capture the needs for interface to ensure that the appearance of the product conforms to the organization's expectations.
  - Style of the product: a description of salient features of the product that are related to the way a potential customer will see the product.

These requirements will guide the designers to produce a product as it is envisioned by your client. They seek to determine precisely how the product shall appear to its intended consumer.

- **Usability**
  - Ease of use: describes your user's aspirations for how easy it will be, for the intended users of the product, to operate it. The product's usability is derived from the abilities of the expected users of the product and the complexity of its functionality. It is necessary to ensure that it has been considered the usability requirements from the perspective of all the different types of users.
  - Personalization and internalization requirements: describe the way in which the product can be altered or configured to take into account the user's personal preferences. The personalization requirements should cover such things as languages, currencies (including the symbols and decimal conventions), personal configuration options, etc.
  - Ease of learning: how easy it should be to learn to use the product. To quantify the amount of time that your client feels is allowable before a user can successfully use the product. This will range from zero time for products intended for placement in the public domain to a considerable time for complex, highly technical products. This requirement will guide designers in how users will learn the product. For example, the designers may build elaborate interactive help facilities into the product, or the product may be packaged with a tutorial.
  - Accessibility requirements: how easy it should be for people with common disabilities to access the product. (i.e. sight, physical disablement, hearing, cognitive, or others).
- **Performance**
  - Speed and latency requirements: Specify the amount of time available to complete specified tasks. These often refer to response times. They can also refer to the product's ability to fit into the intended environment. Some products, usually real-time products, must be able to perform some of their functionality in a given time slot.
  - Safety critical requirements: Quantification of perceived risk of possible damage to people, property and environment. To understand and highlight the potential damage that could occur when using the product within the expected operational environment. If it has been building safety critical system then the relevant safety critical standards are already well specified.
  - Precision requirements: Quantification of the desired accuracy of the results produced by the product. To set the client and user expectations for the precision of the product.
  - Reliability and availability requirements: quantify the necessary reliability of the product. This is usually expressed as the allowable time between failures, or the total allowable failure rate. It also quantifies the expected availability of the product.
  - Robustness requirements: specifies the ability of the product to continue working under abnormal circumstances.
  - Capacity requirements: specifies the volumes that the product must be able to deal with and the numbers of data stored by the product.
  - Scalability or extensibility requirements: specifies the expected increases in size that the product must be able to handle. As business grow (or are expected to grow), software products must increase their capacities to cope with the new volumes.
- **Operational**

- Expected physical environment: To highlight conditions that might need special requirements, preparations or training. These requirements ensure that the product is fit to be used in its intended environment. It should also be taken into consideration that there are users with disabilities other than the commonly-described, such as for low-visibility and poorly lit environments.
- Expected technological environment: To identify all the components of the new system so that the acquisition, installation and testing can be effectively managed. It may be that the operating environment is complex, and becomes a subject of requirements study itself. Special considerations should also be given if the product is to be embedded in a device.
- Partner applications: Requirements for interfacing to other applications often remain undiscovered until implementation time.
- Production requirements: Any requirements needed to make the product distributable or saleable. It is also appropriate to describe here the operations to be performed to have a software product successfully installed. Some products have special needs to turn them into a saleable, or usable product. You might consider that the product has to be protected such that only paid-up customers can access it. This might be implemented as a dongle, a daily keyword, a check that no other copy of the product is running on the network at the same time.

- **Maintainability and Support**
  - How easy must be to maintain this product. A quantification of the time necessary to make specified changes to the product. There may be special requirements for maintainability, such as whether this product must be maintained by its end-users, or developers who are not the original developers. This has an effect on the way that the product is developed, and there may be additional requirements for documentation or training.
  - Special conditions that apply to the maintenance of this product. To make everyone aware of how often it is intended to produce new releases of the product.
  - Supportability: This specifies the level of support that the product requires. This is often done using a help desk. If there are to be people who provide support for the product, this will be a part of the product and there will be requirements for that support. You might also build support into the product itself, in which case this is the place to write those requirements.
  - Portability requirements: Description of other platforms or environments to which the product must be ported.
- **Security**
  - Access requirements: Specification of who has authorized access to the product, and under what circumstances that access is granted, and to what parts of the product access is allowed.
  - Integrity requirements: Specification of the required integrity of databases and other files, and of the product itself. To specify what the product will do to ensure its integrity in the case of an unwanted happening such as an attack from the outside or an unintentional misuse by an authorized user.
  - Privacy requirements: Specification of what the product has to do to insure the privacy of individuals that it stores information about. The product must also ensure that all laws about privacy of individual's data are observed.
  - Audit requirements: Specification of what the product has to do (usually retain records) to permit the required audit checks.
  - Immunity requirements: The requirements for what the product has to do to protect itself from infection by unauthorized or undesirable software programs, such as viruses, worms, Trojan horses and others.
- **Cultural and Political**
  - Requirements that are specific to the sociological and political factors that affect the acceptability of the product. If you are developing a product for foreign markets, then these requirements are particularly relevant.
- **Legal**

- The system falls under the jurisdiction of any law. A statement specifying the legal requirements for this system.
- Some standards with which we must comply. A statement specifying applicable standards and referencing detailed standards descriptions.

FUNCTIONAL	NON FUNCTIONAL
Functionalities	Look and feel
Data requirements	Usability
	Performance
	Operational Maintainability
	Security
	Legal/Standard

Figure 1: Requirements classification.

2.1.3. Requirements workflow

In order to properly collect, formalize and analyze requirements concerning the pilot use cases defined in PIXEL (e.g.: Energy Demand, Intermodal Transport, Port City Integration and Port Environmental Index), an iterative workflow has been adopted. Such workflow has been defined according to the VOLERE methodology and tailored in order to involve the different stakeholders (as project drivers) of PIXEL (e.g.: port authorities, technical partners, domain experts).

The workflow adopted to produce a set of harmonized requirements is reported in the following figure

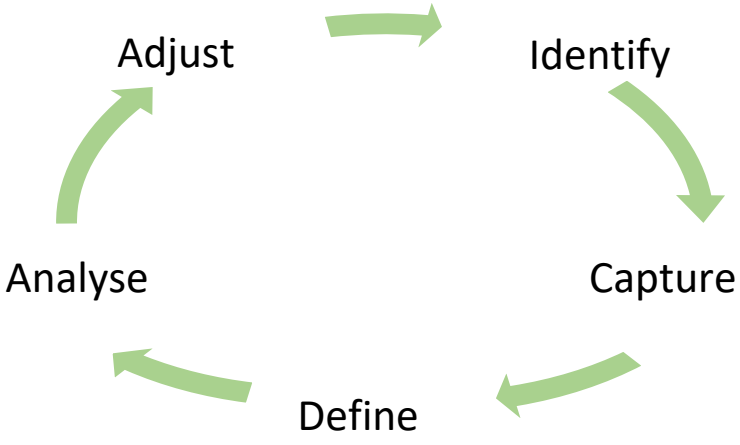

Figure 2. Requirements workflow.

In particular, the requirements workflow is composed by the following steps:

1. Identify sources of requirements: these were the sources of information to collect requirements such as previous research projects, our own knowledge, stakeholders, regulation, standards, etc.;

2. Capture the requirement: this step generated an inventory of identified requirements by pilot, including requirement name and brief description;
3. Define a detailed requirement specification following the requirement template (ref section 2.1.5) and taking into account the characteristics of VOLERE requirements specification;
4. Analyze and assess the requirements obtained by a dedicated workgroup for each pilot site;
5. Adjust requirements in order to integrate feedbacks and suggestions provided by different stakeholders for each pilot use cases defined in PIXEL.

The above described process **must be repeated** as additional requirements are identified or, on the other hand, when an already described requirement needs to be re-worked (in order to improve its soundness).

In particular the following workflow has been defined in order to clearly understand when a new iteration is required for some particular requirements, in order to improve their effectiveness.

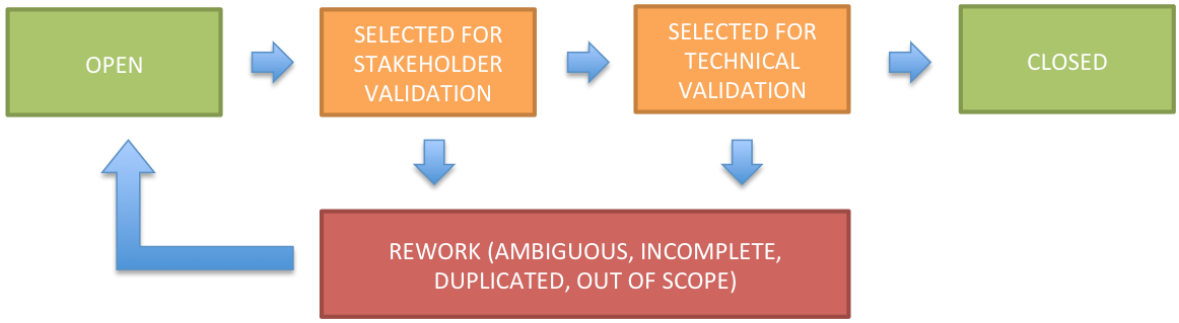

Figure 3: Requirement states represented in JIRA.

Following states has been defined:

- **Selected for Stakeholder Validation**: requirement requires stakeholders and domain experts to analyze and assess its soundness according with each use case pilot;
- **Selected for Technical Validation**: requirement requires technical partners to analyze and assess its feasibility, issues and technical constraints. Technical partners can improve requirements analysis by providing, according to already collected functional requirements, the non-function requirements of the PIXEL solution;
- **Ambiguous**: requirement is not clear;
- **Out of Scope**: requirement in not related with use case pilot;
- **Incomplete**: requirement template is missing some important information and cannot be used for further activities;
- **Duplicate**: requirement is duplicated by another too similar requirement;
- **Closed**: requirement does not require any additional rework and can be proficiently adopted for system analysis and design.

Following task forces have been developed in order to identify, collect, describe and evaluate requirements for each PIXEL use case pilot:

Table 1: Task forces for PIXEL use case pilots.

Workgroups			
Port of Bordeaux **Energy Demand**	**Port of Monfalcone - SDAG**	**Port of Thessaloniki** **Port-City Interaction**	**Port of Piraeus** **Port-City Interaction**

	Intermodal Transport		
X-Lab	**Insiel**	**Insiel**	**Insiel**
GPMB	**ASPM, SDAG**	**ThPA - UVP**	**PPA**
Pro-Develop	**X-Lab**	**Catie**	**Orange**

In particular, within the task 3.4 “Requirements specification”, each workgroup worked, under the supervision of INSIEL, on:

- Improving the quality of the description;
- Correcting and homogenizing the relevant classifications;
- Grouping similar requirements;
- Validating the requirements;
- Detecting new requirements not identified in other sources of information.

2.1.4. Requirement prioritization

In order to better organize the design and development activity, the VOLERE methodology suggests to assign a priority to each collected requirement. The method applied to prioritize the PIXEL requirements is **MoSCoW**. MoSCoW was developed by Dai Clegg of Oracle UK in 1994 and it gained popularity in the DSDM methodology (Dynamic Software Development Method). The MoSCoW method is a prioritization technique used in management, business analysis, project management, and software development to reach a common understanding with stakeholders on the importance they place on the delivery of each requirement - also known as MoSCoW prioritization or MoSCoW analysis.

MoSCoW is a fairly simple way to sort features into priority order - a way to help teams quickly understand from the customer’s view what is essential for launching product and what is not.

The term MoSCoW itself is an acronym derived from the first letter of each of four prioritization categories (Must have, Should have, Could have, and Won't have).

The categories are typically understood as:

- **Must have:** requirements labeled as MUST have to be included in the current delivery time box in order for it to be a success. If even one MUST requirement is not included, the project delivery should be considered a failure. It is good to have clarity on this before a project begins, as this is the minimum scope for the product to be useful. MUST can also be considered an acronym for the Minimum Usable SubseT;
- **Should have:** SHOULD have requirements are also critical to the success of the project, but are not necessary for delivery in the current delivery time box. SHOULD requirements are as important as MUST, although SHOULD requirements are often not as time-critical or there may be another way to satisfy the requirement so that it can be held back until a future phase. Therefore, it could be considered SHOULD are features that are not critical to launch, but are considered to be important and of a high value to the user;
- **Could have:** requirements labeled as COULD are desirable but not necessary, and could improve user experience or customer satisfaction for little development cost. These will typically be included if time and resources permit;
- **Won't have**: requirements labeled as WON'T have been agreed by stakeholders as the least-critical, lowest-payback items, or not appropriate at that time. As a result, WON'T requirements are not planned into the development schedule for the delivery time box. WON’T requirements are either dropped or reconsidered

for inclusion in later phases or projects. This, however, doesn't make them any less important. Alternately described as "Would like to have" in the future.

All requirements are important, but they are prioritized to deliver the greatest and most immediate business benefits early. Developers will initially try to deliver all the Must have, Should have and Could have requirements but the Should and Could requirements will be the first to be removed if the delivery timescale looks threatened.

Thus, this ranking helps everyone (stakeholders, project manager, designer, developers) understand the most important requirements, in what order to develop them, and what not to deliver if there is pressure on resources.

2.1.5. Requirements template in PIXEL

In PIXEL project a specific template based on the VOLERE methodology has been created, in order to collect the requirements, described in Table 2. Such template has been implemented, in a digital way, by adopting the JIRA platform described in chapter 2.2.

Table 2: PIXEL Requirements Template.

PIXEL REQUIREMENT			***Requirement's identifier:***	*# ..*
Requirement's name	*Name of the requirement*			
Category	***Type***	***Priority***	***Status***	
Functional/ NF /constraint	*Type within mapping*	*M / S / C / W*		
Product	***Use-case***	***Scenario***		
Product applying	*Which one (if any) or GENERIC*	*Which one (if any) or GENERIC*		
Rationale: *Why must this requirement be considered for the project.*				
Requirement description:				
Acceptance criteria:				
Customer Satisfaction:				
Customer Dissatisfaction:				
Requires ethics observance: *Mark and write if considered,.*				

Requirements included in following chapters have been described in detail by including the most significant fields of the proposed template. A paragraph devoted to ethical observance is aimed at describing requirements with relevant issues in terms of ethics observance.

2.1.5.1. Product

As an outcome of the PIXEL project, following products will be developed:

Product	Description
Pixel Data Acquisition Layer (DAL)	Provides the IoT field network, connecting sensors and gateways to a common broker for further processing. It is mainly based on FIWARE components Typically linked to: IH

Pixel Operational Tools (OT)	Provides a high level wrapper/interface for using the models and predictive algorithms. It also includes event processing (stream analytics) engine to configure KPIs and alarms. Typically linked to: MO,PA, IH,DAL
Predictive algorithms (PA)	Provides predictions about forecasted maritime traffic and road traffic at ports, as well as energy prediction for renewable energy transition. Typically linked to: IH
PIXEL Information Hub (IH)	Provides the means for collecting and storing different data sources into a common repository, providing short and long-term storage functionalities. It will typically feed other PIXEL components in the architecture Typically linked to: DAL, ID, OT
PIXEL Integrated Dashboard and Notification (ID&N)	Provides the general UI to access and visualize the high level functionalities to be used/managed by port operators. It also includes a notification system. Typically linked to: DAL, IH, OT
Port Environmental Index (PEI)	Provides a way of getting PEI values (current value, predictive value) and potentially associated parameters to monitor (specific for each port) specially Typically linked to: MO, OT
Models (MO)	Models to simulate energy demand, environmental pollution, and multimodal transport, as well as a common environmental model. Typically linked to: DAL, OT

Each requirement will be assigned to one or more specific products in order to better describe its contribution to the overall PIXEL project. Generic requirements, which cover several products, are classified as part of the **PIXEL platform** seen as a whole.

2.1.5.2. Use-case

PIXEL project exploits 4 different use cases:

- **Energy management**: characterization of energy needs within the ports to better plan and manage port activities and adequately dimension the introduction of (green) renewable energy. This use case will be applied in the Port of Bordeaux.
- **Intermodal transport**: development of different algorithms to monitor and simulate traffic according to certain policies to reduce congestion, specially between ports and inland ports. This use case will be applied in the Port of Monfalcone and SDAG.
- **Port-city integration**: implementation of sustainable and environmental friendly measures regarding transport demand between port and nearby city. This use case will be applied in the two Greek ports: The Port of Piraeus and the Port of Thessaloniki.
- **Port Environmental Index (PEI)**: generation of one single environmental metric that summarizes the environmental impact. It is a transversal use case to be implemented on all the four pilot ports.

2.1.5.3. Scenario

Deliverables D3.3 and D3.4 provided significant added value to this document, by focusing on the different scenario exploited by each port according with their specific needs and constraints, moving from energy management to intermodal transportation, from port-city interaction to environmental protection. In particular,

in order to provide an homogeneous and comprehensive analysis, with respect to previously cited deliverables, each requirement has been assign to one or more scenarios. A GENERIC value is assigned to cross-scenario requirements (e.g.: non-functional or functional requirements common to each use case).

A detailed description of each scenario is available in D3.4; moreover a brief description of supported scenarios is listed for each port.

2.1.5.4. Customer Value

Customer Value is a measure of how much customers care about each requirement. It is composed by two different grades: **Customer Satisfaction** and **Customer Dissatisfaction**.

Customer Satisfaction is evaluated on a scale from 1 to 5 where 1 means mild interest if this requirement is satisfactorily implemented, and 5 means stakeholders will be very happy if this requirement is satisfactorily implemented. On the other hand Customer Dissatisfaction is graded, in a similar way, on a scale from 1 to 5 where 1 means that it hardly matters, and 5 means that they will be extremely displeased if this requirement is not satisfactorily implemented.

Customer value is aimed at allowing stakeholders to focus deeply on requirements and provide a prioritization based on what they care at most.

2.1.5.5. Ethical Observance

In order to effectively represent the impact of each requirement on ethics and allow designers and developers to properly deal with them, the requirement template adopted by the PIXEL projects includes, for each requirement, answers to the following questions:

- Are there humans involved in this requirement?
- Is this requirement relevant for personal data?
- Is this requirement relevant for sensitive data protection?
- Does this requirement contain environmental ethics concerns?

Such answers will be used during design and development activities in order to identify and to adopt best solutions (at both architectural and technological level) aimed at dealing with them and at minimizing risks.

2.2. Requirements Management Tools

In order to provide to each stakeholder a common tool to collect, describe and share PIXEL requirements (by respecting the VOLERE methodology and the proposed requirements template), the JIRA platform has been adopted as main requirement management tool for the PIXEL project.

An access to the JIRA platform, available via Web, has been provided to each actor of the project (e.g.: stakeholders, technical partners) in order to allow each of them to be directly part of the requirement elicitation and analysis process. The project repository keeps updated and easily accessible the details of stakeholders, market analysis identified products, scenarios, requirements and use cases. Each time one of such artifact evolves (e.g.: due to improved analysis), the project repository keeps track of such update and shares such information among all stakeholders. Additional credentials will be released in the future in order to allow external reviewers to access collected data.

The JIRA platform[5] is a commercial software manufactured by Atlassian, representing one of the prominent leaders worldwide for issue tracking in software development. JIRA can be licensed for running on-premises or as a hosted application. JIRA provides bug tracking, issue tracking, and project management functions. The main features of JIRA for agile software development are to plan development iterations, generate iteration reports and bug tracking functionality.

Insiel, in order to perform task T3.4 in an effective way, provided access to an instance of JIRA hosted on its server infrastructure, available at https://jiraeu.insiel.it.

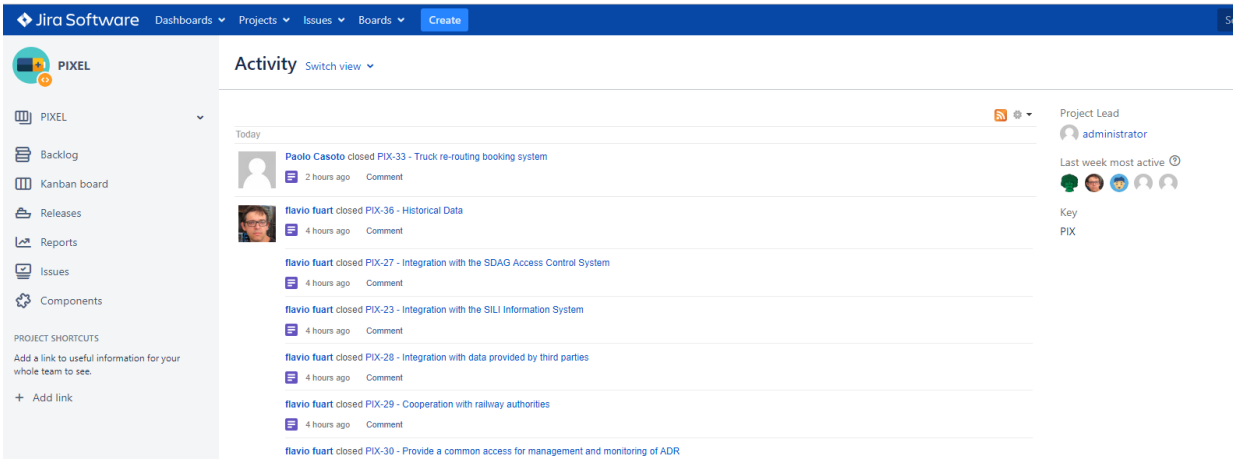

Figure 4: JIRA home page for PIXEL project.

The JIRA home page clearly and effectively reports recent activities performed by each user on the set of collected requirements, in a transparent way. **The activities stream is aimed at improving social collaboration between stakeholders**. By switching to statistics view, each user can visualize the status of collected requirements, according to their priority, classification, state and assignee (the user which is currently working on the requirement).

[5] https://www.atlassian.com/software/jira

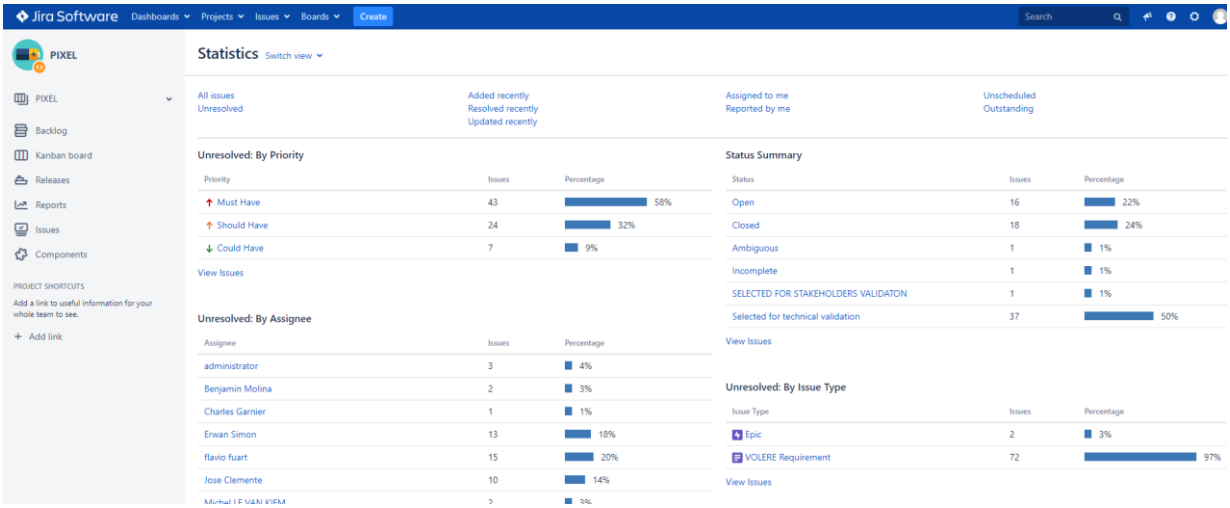

Figure 5: Requirements statistics in JIRA.

In order to allow users to easily navigate between requirements, JIRA present a complete set of search filters, customized according to the VOLERE template (e.g.: Scenario).

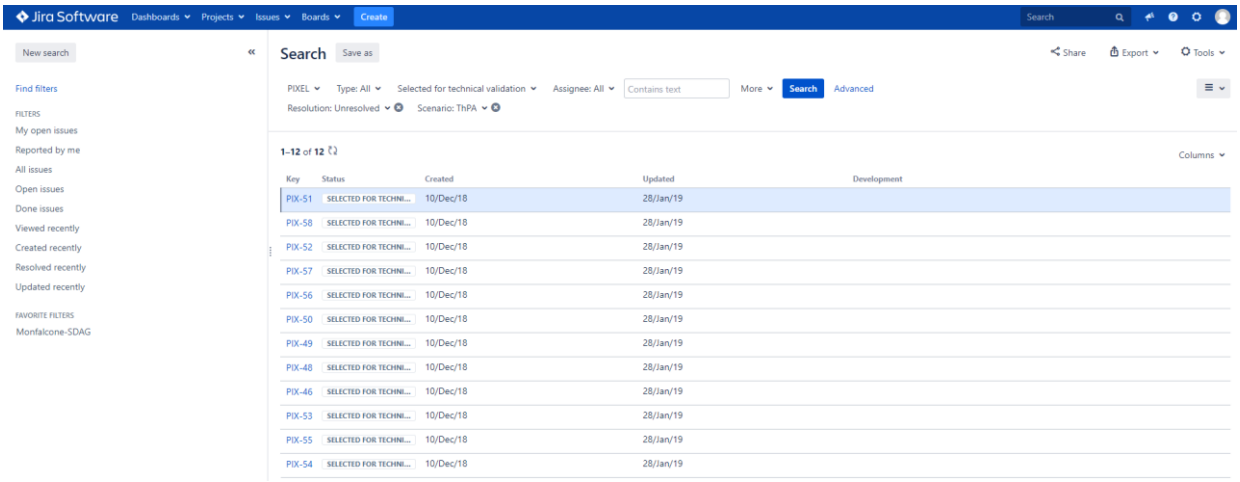

Figure 6: Search and filters.

The state of each requirement, with respect to the proposed requirements workflow (described in detail in 2.1.3), need to be clearly visualized: each stakeholder should be able to identify the current state of its requirements and which actions could be applied in order to complete requirements validation. A customized **JIRA Kanban Board** has been defined in order to represent such information simply and in an effective way: requirements are divided by columns, each one representing a particular state (e.g.: selected for stakeholder validation). The column tagged as **REWORK** aggregates all requirements with state AMBIGUOUS, INCOMPLETE, OUT OF SCOPE and DUPLICATED.

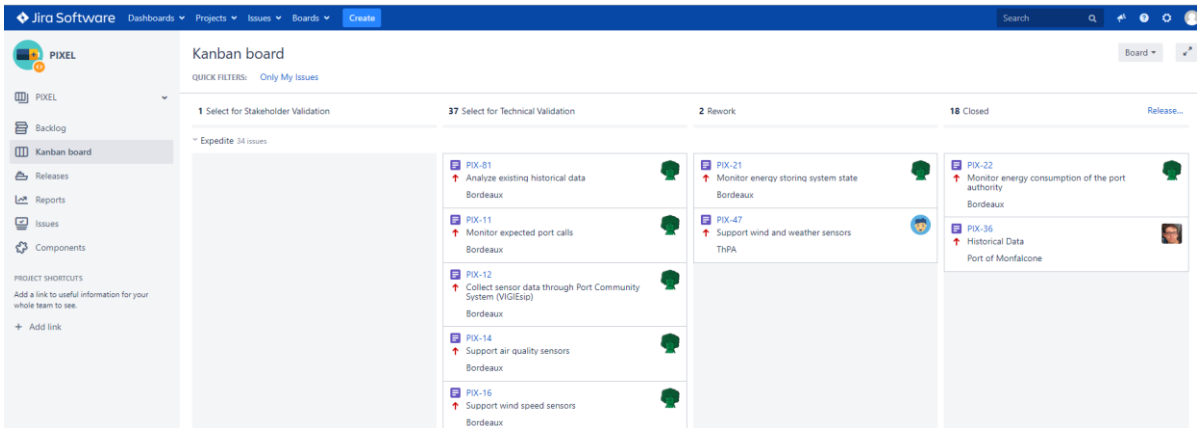

Figure 7: Kanban board.

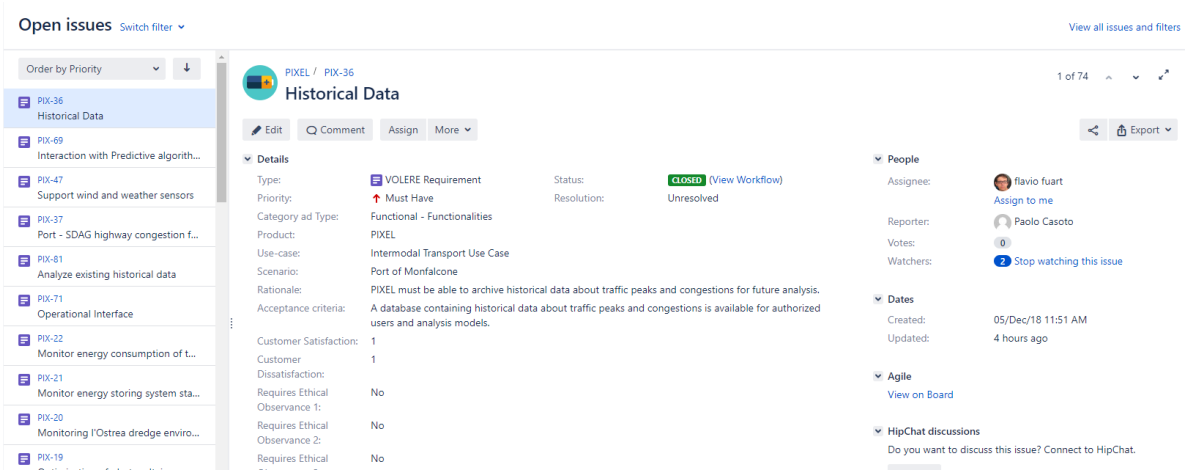

Figure 8: Detail view of a requirement with respect to VOLERE Methodology.

Forms used to create and edit requirements in JIRA have been personalized by INSIEL in order to provide all custom field introduced by the VOLERE methodology and included in the requirement template exploited for the PIXEL project. In particular several multi-value fields (e.g.: requirement category, requirement type, priority, use case) have been defined in order to allow further aggregation and analysis of collected requirements.

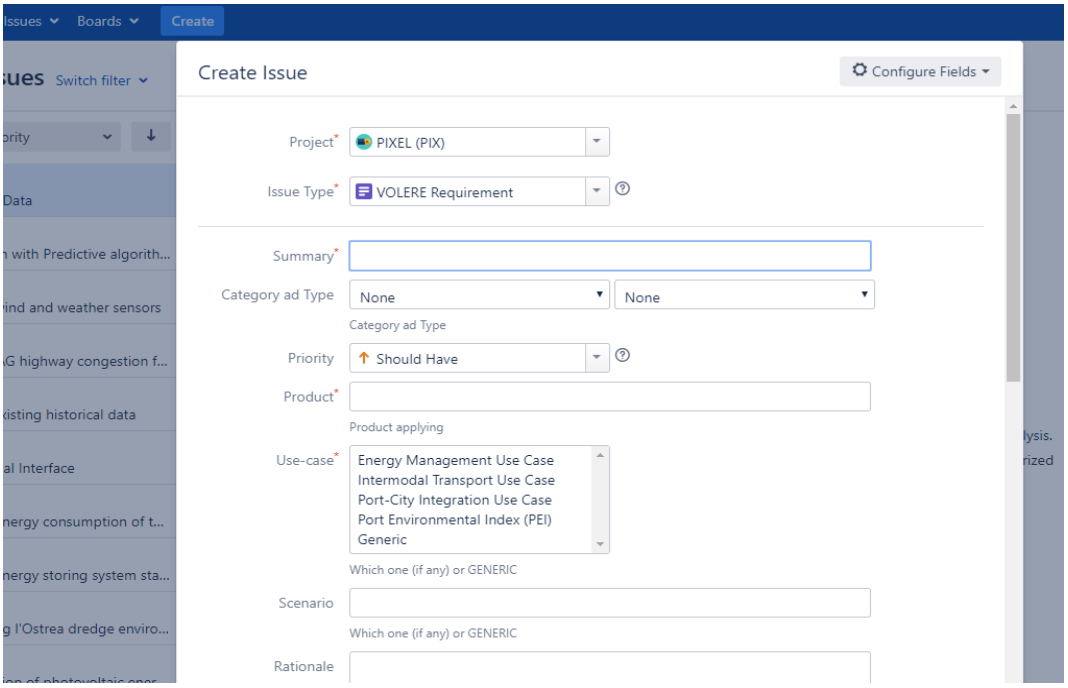

Figure 9: Requirement creation form.

3. Requirements identification

This section is aimed at listing the set of requirements collected, for each PIXEL use case.

Use cases and scenarios are methodologies used in software analysis, aimed at describing systems, roles and interactions of a large and complex project from different perspectives. Such tools have been adopted in order to deal with the complexity of the PIXEL project; in particular 4 use cases, to be mapped to 4 pilot ports within the Consortium, have been identified:

- **Energy management**: characterization of energy needs within the ports to better plan and manage port activities and adequately dimension the introduction of (green) renewable energy. This use case will be applied in the Port of Bordeaux.
- **Intermodal transport**: development of different algorithms to monitor and simulate traffic according to certain policies to reduce congestion, specially between ports and inland ports. This use case will be applied in the Port of Monfalcone and SDAG.
- **Port-city integration**: implementation of sustainable and environmental friendly measures regarding transport demand between port and nearby city. This use case will be applied in the two Greek ports: The Port of Piraeus and the Port of Thessaloniki.
- **Port Environmental Index (PEI)**: generation of one single environmental metric that summarizes the environmental impact. It is a transversal use case to be implemented on all the four pilot ports.

Moreover, in this section are included generic requirements, concerning the architecture of the proposed PIXEL solution and its tools. The set of requirements defines how PIXEL should work, in terms of the different products, from the point of view of end users, suppliers and developers.

3.1. Non-functional requirements

Compliance [38]
PIXEL must respect all different compliances, laws and regulations concerning port facility management, goods transportation and GDPR. Information access must be limited only to authorized users and in accordance with their respective roles. Information concerning dangerous transportations and environmental risks need to be carefully managed in order to keep them private if required.
Acceptance criteria: PIXEL must satisfy all related compliance assessments.
MoSCoW Priority: MUST HAVE
Category and Type: Non-functional - Legal / Standard
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: PIXEL must respect all different compliances, laws and regulations concerning port facility management, goods transportation and GDPR.
Customer Satisfaction: 4
Customer Dissatisfaction: 4

Multilanguage support [43]

The PIXEL Platform supports multiple languages for both UI and notifications.
Acceptance criteria: The UI can be configured to show messages at least in English, Spanish, Italian, French and Greek.
MoSCoW Priority: MUST HAVE
Category and Type: Non-functional - Usability
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: The UI should be designed to work with different languages in order to guarantee transferability.
Customer Satisfaction: 4
Customer Dissatisfaction: 4

Interoperability [59]
PIXEL platform must be interoperable with existing platforms in the port. As there are virtually infinite possible platforms, PIXEL must ensure good interfaces to integrate the already existing ICT systems and be compatible with well-known communication standards and message formats.
Acceptance criteria: PIXEL integrates with different information systems provided by each port.
MoSCoW Priority: MUST HAVE
Category and Type: Non-functional - Operation Maintainability
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: PIXEL must ensure the access to the existing data in ports for a better availability of information related to environmental management and issues.
Customer Satisfaction: 3
Customer Dissatisfaction: 2

Scalability [60]
Pixel should be scalable in terms of growth needs or the large amount of data you can work with in the future.
MoSCoW Priority: MUST HAVE
Category and Type: Non-functional - Performance
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: PIXEL must be scalable according to growth needs.
Customer Satisfaction: 3
Customer Dissatisfaction: 2

Security communications between components [68]
Due to the privacy and variety of data involved in the platform is very important security within the platform. PIXEL must ensure end-to-end security.
Acceptance criteria:
MoSCoW Priority: MUST HAVE
Category and Type: Non-functional - Security
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: Due to the privacy and variety of data involved in the platform is very important security within the platform.
Customer Satisfaction: 3
Customer Dissatisfaction: 3

Data source API documentation [83]
Each data source that should be connected to the PIXEL infrastructure has to provide an API documentation in order to be able to build the acquisition connector.
Acceptance criteria:
MoSCoW Priority: SHOULD HAVE
Category and Type: Non-functional – Operation Maintainability
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Data source API versioning [84]
Each data source connected to PIXEL infrastructure should provide version management for its API in order to detect and anticipate change format issue.
Acceptance criteria:
MoSCoW Priority: SHOULD HAVE
Category and Type: Non-functional – Operation Maintainability
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Data source API connectivity [85]
Each Data Source API needs a network connectivity to the PIXEL Infrastructure that match the security requirement of the data exposed by this API. Secure and encrypted link should be preferred (HTTPS for example).
Acceptance criteria:
MoSCoW Priority: SHOULD HAVE
Category and Type: Non-functional - Security
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Access Security [97]
Access Security is the extent to which the system is safeguarded against deliberate and intrusive faults from internal and external sources.
Acceptance criteria: PIXEL must provide features required to prevent deliberate and intrusive faults from internal and external sources in order to be compliant with at least the state of the art.
MoSCoW Priority: MUST HAVE
Category and Type: Non-functional - Security
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Availability [98]
Availability is the degree to which users can depend on the system to be up (able to function) during “normal operating times.” PIXEL must grant availability, in order to allow data collection, model calculation and PEI evaluation to take place, by minimizing data loss and downtime.
Acceptance criteria:
MoSCoW Priority: MUST HAVE
Category and Type: Non-functional – Performance
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Customer Satisfaction: 3
Customer Dissatisfaction: 3

Integrity [99]
Integrity is the degree to which the data maintained by the software system are accurate, authentic, and without corruption. PIXEL Hub must provide data integrity for each collected set of data, in order to improve trust perceived by stakeholders in: • model evaluation; • PEI calculation.
Acceptance criteria:
MoSCoW Priority: MUST HAVE
Category and Type: Non-functional - Legal / Standard
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Customer Satisfaction: 4
Customer Dissatisfaction: 3

Web UI [100]
PIXEL must provide, for each of its tools, a Web based User Interface. In particular, in order to be used by as many stakeholders as possible, PIXEL Tools must be accessible by means of a standard web browser, without requiring any additional software to be installed on operator's computer. A Web UI must be developed by considering, at the same time: • adoption of web standards (e.g.: HTML, CSS, Javascript); • portability on different devices (e.g.: responsiveness); • readability; • easy to use.
Acceptance criteria: a WEB UI is available for each PIXEL's tool.
MoSCoW Priority: MUST HAVE
Category and Type: Non-functional – Look and feel
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Customer Satisfaction: 3
Customer Dissatisfaction: 2

Deployment environments [101]
Ports have different rules and needs regarding how should the PIXEL system be deployed. Some ports would require on-premise installations managed by their ICT support team, while others may prefer public cloud deployments, maybe even managed by external organisations.

For this reason, PIXEL has to support both private and public cloud deployments in a unified way (e.g. as Docker containers deployed through Ansible scripts or similar).
Acceptance criteria: PIXEL components can be seamlessly deployed either on-premise on public clouds, compliant with a given set of minimum technological constraints.
MoSCoW Priority: SHOULD HAVE
Category and Type: Non-functional - Operation Maintainability
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: Ports will have different needs regarding system deployment, thus on-premise and cloud deployment should be considered.
Customer Satisfaction: 2
Customer Dissatisfaction: 4

Open source licensing [102]
PIXEL partners have committed to pursue an open source strategy for all developed components to the maximum extent possible. During development, special attention should be devoted to the assessment of 3rd party libraries in light of their compatibility with the Apache 2.0 license. In case no suitable alternatives are available the issue should be solved at PCC level (e.g.: publish the software under a different license).
Acceptance criteria: Majority of PIXEL components published under the Apache 2.0 or similar licenses.
MoSCoW Priority: SHOULD HAVE
Category and Type: Non-functional - Legal / Standard
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: PIXEL partners committed to publishing software under the Apache 2.0 license when possible.
Customer Satisfaction: 3
Customer Dissatisfaction: 3

Portability [103]
PIXEL components need to be generic enough to be easily deployable for any port. This should be supported through well-documented extension mechanisms (like plug-ins, generic interfaces, abstract classes and similar).
Acceptance criteria: PIXEL implements generic extension mechanisms and the deployment in a new port environment is relatively easy.
MoSCoW Priority: MUST HAVE
Category and Type: Non-functional - Usability
Product: PIXEL platform

Use-case: Generic
Scenario: GENERIC
Rationale: PIXEL committed to providing a generic solution that can be deployed by virtually any port.
Customer Satisfaction: 3
Customer Dissatisfaction: 5

3.1.1. Non-functional requirements by type

The set of non-functional requirements described in the previous paragraph can be classified according to their type, as listed in the following table. Distribution of non-functional requirements between different types defined by VOLERE Methodology is fair. **Security** and **Operation Maintainability** represent the key areas of interest for project's stakeholders.

Table 3: Non-Functional Requirements by Type.

Type	Requirements
Legal/Standard	• **[38] Compliance;** • **[99] Integrity;** • **[102] Open Source Licensing.**
Usability	• **[43] Multilanguage Support;** • **[103] Portability.**
Operation Maintainability	• **[52] Interoperability;** • **[83] Data source API Documentation;** • **[84] Data source API Versioning;** • **[101] Deployment Environments.**
Performance	• **[60] Scalability;** • **[98] Availability.**
Security	• **[68] Security communications between components;** • **[85] Data source API connectivity;** • **[97] Access Security.**
Look and Feel	• **[100] WEB UI.**

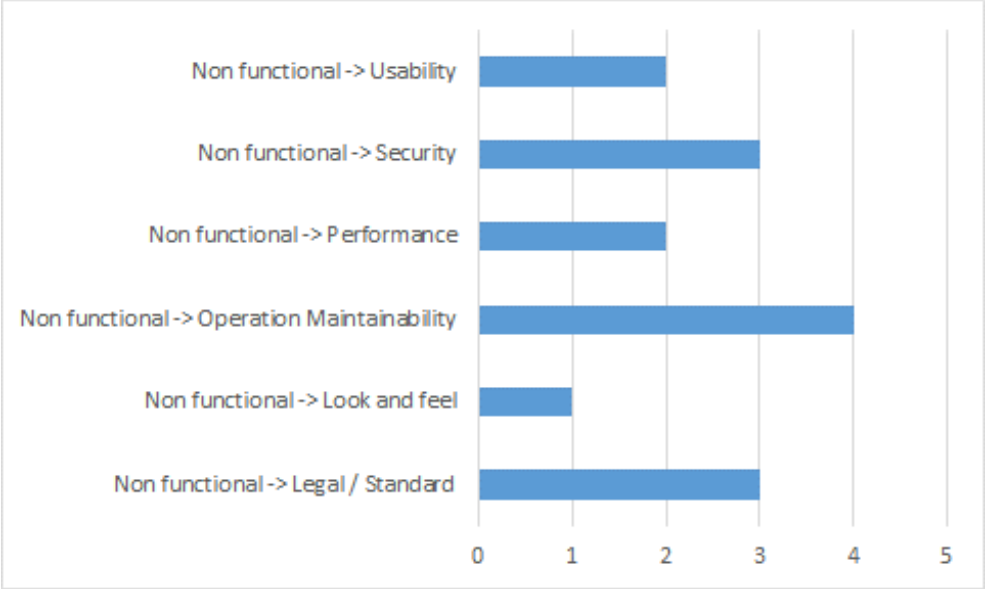

Figure 10: Non-functional requirements by type.

3.1.2. Analysis

In this section non-functional requirements are analyzed in detail in order to extract relevant information, which could be useful to support the next phases (design, modelling and development) of the lifecycle of PIXEL platform. **In particular non-functional requirements are relevant across the different products and the different use cases which will be exploited by the PIXEL projects**.

The priority of the non-functional requirements can be analysed according to Moscow methodology, as described in Figure 11. Most of the non-functional requirements (67%) describe properties, which the system must comply in order to fulfil stakeholders' expectations. "Should have" requirements represent the 33% of the non-functional requirements.

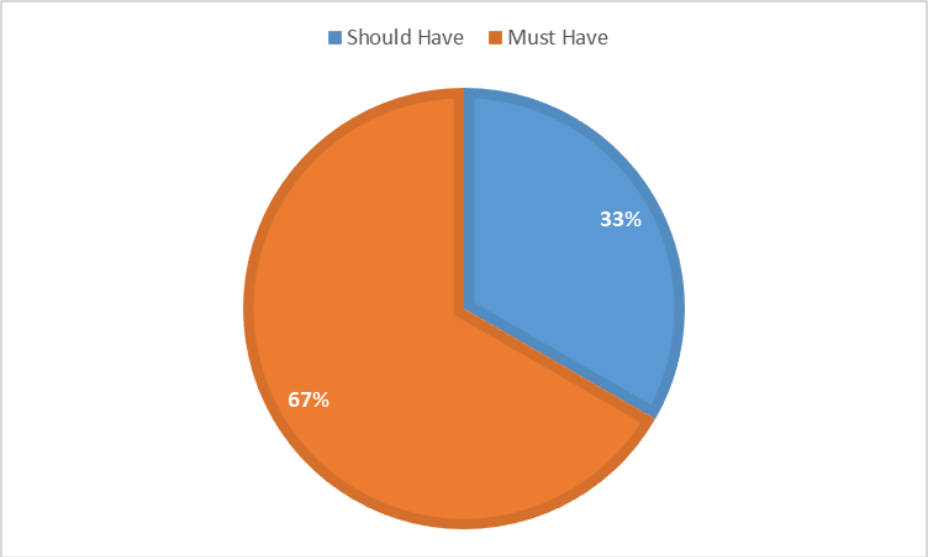

Figure 11: Non-functional requirements by priority.

3.1.3. Ethical Observance

Following non-functional requirements require, according to VOLERE Methodology, ethical observance in terms of both **Personal Data** and **Sensitive Data Protection**:

- **[38] Compliance;**

- **[59] Interoperability;**
- **[68] Security communications between components;**
- **[85] Data source API connectivity;**
- **[97] Access Security.**

3.1.4. Legal Requirements

PIXEL platform must respect all different compliances, laws and regulations concerning port facility management, goods transportation and GDPR. In particular each tool and product needs to be designed and developed by focusing on the "privacy-by-design" principle: the availability of each information must be limited to the minimum valuable set of users.

Ports' daily operations, in fact, are based on several types of data; some of them need to be carefully managed, especially when related with Ship Calls, Passenger List, Timetables, Dangerous and Valuable goods or environmental issues. Information access must be limited only to authorized users and in accordance with their respective roles.

In T3.2, such legal requirements and issues have been collected for each port, in order to identify legally available legislation and compliances at European, National and Local level and related Authorities. Such compliances spread between several different aspects regulated in a general way at European level and implemented nationally by each country with respective laws and regulations.

In order to deal with such issues an ad-hoc non-functional requirement has been defined

Use Case Regulatory Context Compliance [118]
Acceptance criteria: PIXEL must satisfy all compliance assessments related to each use case.
MoSCoW Priority: MUST HAVE
Category and Type: Non-functional - Legal / Standard
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: PIXEL must be compliant with the specific set of regulations and compliances for each defined use-case. It specializes the focus of requirement [38] by looking at specific fields of interest, specialized according to the use cases and the local laws of each port.
Customer Satisfaction: 4
Customer Dissatisfaction: 5

The European regulatory context analysed in T3.2 and described in detailed in D3.4, refers to the areas related to:

- The Vessel traffic monitoring in EU waters and the (SafeSeaNet) network aiming to link the European maritime authorities for the provision and exchange of information on ships, ship movements, and dangerous cargoes
- The European maritime single window environment in order to simplify and harmonize the administrative procedures applied to maritime transport
- The Air Emissions standards for the regulation of the ship generated specific emissions and discharges
- The Air Pollution legislation to achieve emission reductions of the main pollutants
- The Greenhouse Gas directives aiming to improve and extend the greenhouse gas emission allowance trading scheme.

- The Sulphur Directive for the reduction of Sulphur Dioxides (SO2)
- The Alternative Fuels directive aiming to substitute fossil oil sources in the energy supply to transport
- The Port Reception Facilities regulations to limit and control the discharges generated at sea
- The European Commission, Transport regulation for the ports development
- The EU data protection rules related for the protection of natural persons regarding the personal data processing and also the free movement of personal data.

The national regulatory context has been examined for France, Italy, Spain and Greece and refers to:

- Environment (waste, pollution) legislation
- Transportation legislation
- Safety and security legislation
- Personal data management legislation

The legislation, policies and regulations at local pilot port level has been examined by the PIXEL pilot ports of Bordeaux, Monfalcone, Piraeus and Thessaloniki in the areas related to the use cases as follows:

- Environment policies and regulations
- ISO certification for Environmental Management
- The processing of personal data and on the free movement of such data
- The regulatory/supervisory bodies in each pilot area

D3.4 includes a comprehensive and detailed list of related compliances each port needs to cope with (according to its specific use case) and a definition of international and national regulatory bodies. Legal departments in each pilot port will define a proper strategy in order to involve national regulatory bodies in legal requirements validation, for each use case.

During the requirements gathering and related analysis, Insiel, as Data Controller for the ICT services provided within the Agreement between Insiel and the Autonomous Friuli Venezia Giulia Region, contacted the Regional Directorate of Infrastructure and Territory of the Autonomous Friuli Venezia Giulia Region in order to involve it in PIXEL activities. In particular, the link with the mentioned Directorate allows to have an additional contact point for the following domains: territorial infrastructures, freight mobility, port activities, data protection and treatment and the related policies and strategies. Moreover, Insiel contacted the **Regional Agency for Environmental Protection of the Autonomous Friuli Venezia Giulia Region (ARPA)** in order to establish a link with it on environmental topic, in particular ARPA is the regional reference point for the environmental data and their correlation with the population health status.

3.2. Functional requirements

3.2.1. Common functional requirements

This section is aimed at listing the set of common functional requirements collected from the analysis of the different use cases exploited by the PIXEL project. In particular common functional requirements deal with PIXEL architecture, modules and infrastructure, by focusing on the set of services and functionalities each different user case requires in order to provide users expected capabilities and features (as output of the PIXEL project).

Import historical data [36]
PIXEL must be able to archive historical data provided by each stakeholder (according to its specific use case) as aggregated data or raw data collected by a set of IoT oriented devices (e.g.: sensors). Such data will be used by PIXEL for analysis and modeling purposes (e.g.: PEI evaluation). Data include analytical data (e.g.: length of the unloading activities for a given vessel) and user provided data (e.g.: a description, written in natural language, of a critical event that took place). Such data could be proficiently exploited by model-based analysis or, on the other hand, by users. Stakeholders will share their own data into the PIXEL platform in order to improve the effectiveness of developed models. Historical data consists of several Excel, Access, CSV, TXT data sources or other databases collected by port authorities, describing each loading and unloading activity taking place inside the port facility, the amount of trucks available inside the parking lot, energy consumption, etc.
Acceptance criteria: A database containing use case dependent historical data is available for authorized users and analysis models.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: PIXEL must be able to import and archive historical for future analysis.
Customer Satisfaction: 3
Customer Dissatisfaction: 3

Interaction with models [41]
In order to perform predictive analysis through simulation, the Simulation Engine, based on its configuration: • obtains data from the Pixel hub, if necessary; • invokes the models attaching the necessary input data; • obtains a response (and, potentially, sends/triggers notification).
Acceptance criteria: • The Simulation Engine is able to discover available models in the PIXEL platform; • The Simulation Engine executes the involved model(s) and obtains a valid response.
MoSCoW Priority: MUST HAVE

Category and Type: Functional – Functionalities
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: The Simulation engine from the Operational Tools must discover and invoke the models delivered by WP4 in order to perform analysis and predictions.
Customer Satisfaction: 4
Customer Dissatisfaction: 2

Anomaly and event list [44]
In order to detect anomalies, every port must provide a list of potential anomalies to be tracked and detected. The Complex Event Processing (PEC) Engine must know which variables/parameters/sensors to track in order to detect the anomalies.
Acceptance criteria: Each port provides a list of anomalies with the associated information to be tracked.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: The CEP must know which variables/parameters/sensors to track in order to detect the anomalies.
Customer Satisfaction: 3
Customer Dissatisfaction: 3

Anomaly and event detection [45]
The Operational Tools of PIXEL could include a Complex Event Processing (PEC) Engine in order to detect complex events (anomalies) relevant for the operations at ports, given a set of rules defining relevant events for each port, according with their respective use cases.
Acceptance criteria: It is possible to insert and activate all relevant events/anomalies in the CEP for each port and a result (e.g. notification) is obtained.
MoSCoW Priority: COULD HAVE
Category and Type: Functional – Functionalities
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: In order to help optimizing the management operations at ports, it is important to monitor (part of) the available data in order to detect special events or anomalies.
Customer Satisfaction: 3
Customer Dissatisfaction: 1

Homogenize Data [61]
Due to the big amount of data source, PIXEL must transform the data to a homogenize format. This process takes care of the structural and content translation to unify its format.
Acceptance criteria:
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: PIXEL must have a catalogue of models from WP4.
Customer Satisfaction: 3
Customer Dissatisfaction: 2

Catalogue of models [62]
PIXEL must incorporate a catalogue with the models that meet the requirements of the WP4. Using the model's catalogues: simulations or future predictions (ML) can be made.
Acceptance criteria:
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: PIXEL partners committed to publishing software under the Apache 2.0 license when possible.
Customer Satisfaction: 3
Customer Dissatisfaction: 2

Detection of anomalies [63]
Early detection of anomalies (data peaks, bottlenecks) will allow a quick response to these situations. Reducing costs and time.
Acceptance criteria: PIXEL must be able to identify anomalies and notify them to selected stakeholders.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: Early detection of anomalies (data peaks, bottlenecks) will allow a quick response to these situations. Reducing costs and time.

Customer Satisfaction: 3
Customer Dissatisfaction: 3

Feedback [64]
PIXEL must have a feedback system. Not only with the intention of asking the user if it has been easy to use if it would improve something of this process.
Acceptance criteria: A feedback system is available.
MoSCoW Priority: SHOULD HAVE
Category and Type: Functional – Functionalities
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: Pixel needs a feedback system.
Customer Satisfaction: 4
Customer Dissatisfaction: 2

Centralized user administration system [65]
The management of users who will interact with the PIXEL platform must be centralized to facilitate the management with these records.
Acceptance criteria: A centralized user administration system is available.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: Due to the great variety of actors that influence port activities, it is important to have centralized the management of these users.
Customer Satisfaction: 3
Customer Dissatisfaction: 1

Configurable Dashboard [66]
PIXEL dashboard must be configurable. Allow to incorporate widgets to visualize a great amount of information. There will be a series of widgets that can be added to the dashboard to display different information / graphics. Therefore, it must be configurable.
Acceptance criteria:
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities

Product: IDN&N, OT
Use-case: Generic
Scenario: GENERIC
Rationale: PIXEL dashboard must be configurable. Allow to incorporate widgets to visualize a great amount of information.
Customer Satisfaction: 4
Customer Dissatisfaction: 2

UI Notification System [67]
PIXEL must have a notification system. This system will facilitate a quick response of the operations personnel.
Acceptance criteria:
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: PIXEL must have a notification system. This system will facilitate a quick response of the operations personnel.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Port Operational KPI list [70]
The Operational Tools will include a CEP in order to detect complex events (KPIs) relevant for the operations at ports. In order to help optimizing the management operations at ports, it is important, each port has to provide a list of relevant KPIs to be monitored.
Acceptance criteria: It is possible to insert and activate all relevant events associated to a port KPI in the CEP for each port and a result (e.g. notification) is obtained.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IDN&N, OT
Use-case: Generic
Scenario: GENERIC
Rationale: In order to help optimizing the management operations at ports, it is important, each port has to provide a list of relevant KPIs to be monitored.
Customer Satisfaction: 4
Customer Dissatisfaction: 2

Operational Interface [71]
The Operational Tools must provide a UI for user interaction.
Acceptance criteria: The user (port operator) is able to configure and run a model, a prediction and a rule, and obtain a valid response for each of them.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PIXEL platform
Use-case: Generic
Scenario: GENERIC
Rationale: Port operators must have a UI to use the operational tools (to operate with models, predictions and event rules).
Customer Satisfaction: 4
Customer Dissatisfaction: 2

Analyze historical data [81]
PIXEL should be able to process existing historical data (call length, cargo, ship type and model, etc.) and use it in calculating statistics and prediction algorithms according to the specific use case and model.
Acceptance criteria: • Historical data available in database or through API call; • Enough computing power for the calculations to be carried out in a timely manner.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH,OT
Use-case: Generic
Scenario: GENERIC
Rationale: To be able to use and analyse existing historical data according to a specific model.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Support for manually provided data [86]
PIXEL must be able to collect manually provided data, aimed ad feeding PIXEL's models, when real time data provided by sensors constituting the IoT infrastructure are not available. A set of customized and effective forms needs to be provided to different users in order to collect required information for each different use case.
Acceptance criteria: To be able to collect manually provided data, aimed ad feeding PIXEL's models, when real time data provided by sensors constituting the IoT infrastructure are not available.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL

Use-case: Generic
Scenario: GENERIC
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Discovery service for data [104]
PIXEL must provide a service in which the port agent entering the PIXEL system could visualize all data that is being integrated into PIXEL platform coming from different sources related to their port: - Data from ICT systems already existing in the port (TOS, PMS, etc.); - Data from sensors (environmental, fuel consumption, energy, wind, images, etc.); - Data from external sources; The aim is to collect, monitor and publish real time traffic and environmental data. PIXEL must provide, as output: - A service with access to the different data and their location in the PIXEL hub, their last value received details.
Acceptance criteria: An accessible API and screen for discovering data.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PIXEL
Use-case: GENERIC
Scenario: GENERIC
Customer Satisfaction: 2
Customer Dissatisfaction: 1

Visualization of data [105]
PIXEL must provide a means of visualizing the discovered data The aim is to allow a graphical view of relevant information that comes from models and other high-level services in the PIXEL platform. This will be part of the Dashboard. PIXEL must provide, as output: - A tool for visualizing data with different visualization options for a better readability
Acceptance criteria: The user can access and visualize the relevant data for him/her in a selectable option
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IDN&N, OT
Use-case: GENERIC
Scenario: GENERIC
Customer Satisfaction: 3

Customer Dissatisfaction: 2

3.2.1.1. Analysis

In this section common functional requirements are analyzed in detail in order to extract relevant information, which could be useful to support the next phases (design, modelling and development) of the lifecycle of PIXEL platform. **Even common functional requirements are (similarly to previously described non-functional requirements) relevant across the different products and the different use cases which will be exploited by the PIXEL projects**.

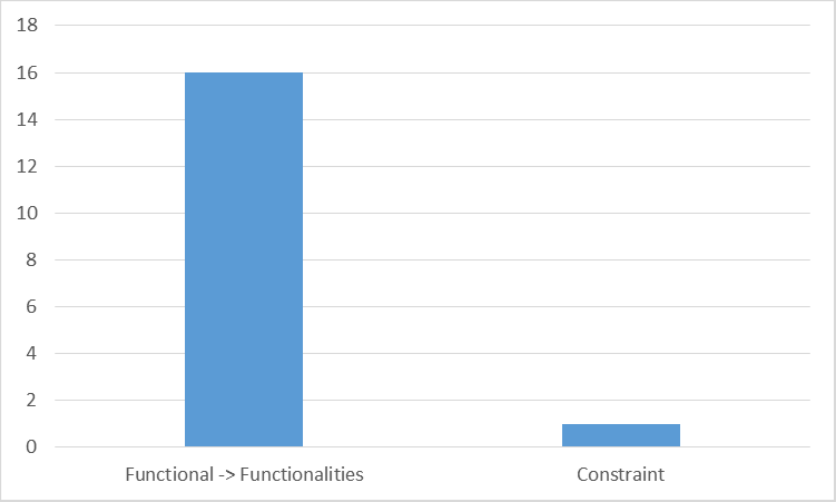

Figure 12: Common functional requirements by type.

A single requirement ([44] Anomaly and event list) has been classified as a constraint (according to the VOLERE Methodology) by stakeholders and validators.

The priority of the common functional requirements can be analysed according to Moscow methodology, as described in Figure 13. Most of the common functional requirements (88%) describe properties, which the system must comply in order to fulfil stakeholders' expectations. "Should have" requirements represent the 6% of the common functional requirements.

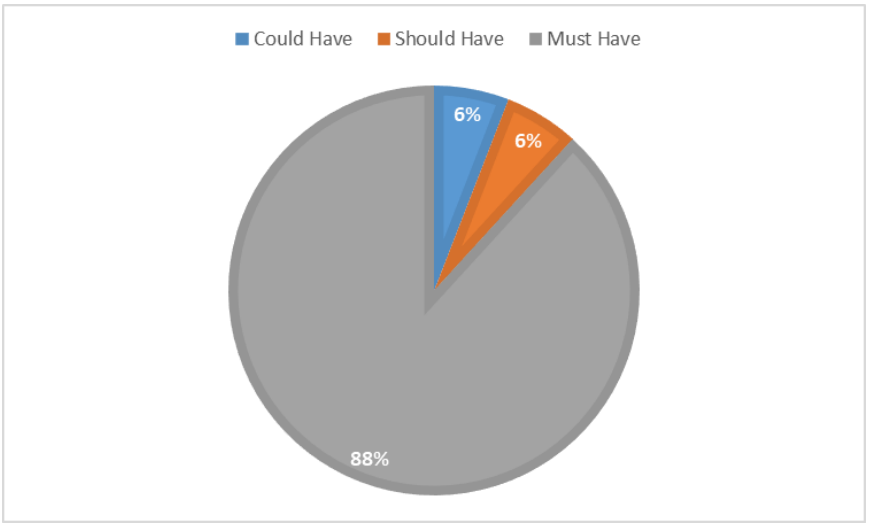

Figure 13: Common functional requirements by priority.

3.2.2. Port of Bordeaux – Energy Management Use Case

This section is aimed at listing the set of functional requirements collected from the analysis of the Energy Management Use Case. The Port of Bordeaux (GPMB) needs to align with the development of its territory and especially of Bordeaux Metropolis. In order to achieve such goal, following main challenges have been identified:

- A safer port;
- A greener and more cost attractive port;
- A more citizen-friendly port;
- A wiser investor port.

Getting more physical and operational data from port activities and port environment to take better decisions is definitely one of the paths that GPMB has chosen to face these challenges. The use case of the Port of Bordeaux (GPMB), described in detail in D3.4, is aimed at monitoring, analysing and improving several key port processes by using PIXEL's IoT and big data platform. For example, GPMB can pinpoint its energy needs/uses and the impact of the provided services on consumption.

In order to measure the environmental efficiency of the port processes and to improve the acceptance of port activities, GPMB would like to adopt a systematic procedure of measuring the environmental impact proposed by PIXEL's PEI (Port Environment Index).

In particular requirements described in this paragraph provide support to the following user stories and scenarios:

Table 4: Energy Management Use Case.

Partner	User story	Scenario
GPMB	**Statistics Manager**	GPMB-StM-1
	Energy Manager	GPMB-EM-1
		GPMB-EM-2
	IT Manager	GPMB-IT-1
	Environmental Manager	GPMB-EnvM-1
	Port Manager	GPMB-PM-1
	Software Editor	GPMB-SE-1
	Port Agent	GPMB-PA-1

Support electricity consumption sensors [9]
PIXEL must be able to read/receive data from a set of interconnected electricity consumption sensors or by means of an existing database collecting such data from different sources.
Acceptance criteria: Energy consumption data available through an API call.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: DAL
Use-case: Energy Management Use Case
Scenario: GPMB-EM-1
Rationale: To be able to use electricity consumption data in prediction algorithms, calculation of PEI, dashboard status updates, etc.

Customer Satisfaction: 5
Customer Dissatisfaction: 1

Access to traffic data [10]
PIXEL platform must be able to integrate with VIGIEsip. VIGIEsip sends information about the ship calls which is stored in the PIXEL hub. In particular PIXEL must be able to collect: • FAL Forms (date of arrival/departure, cargo info, dangerous goods, etc.); • Statistics on calls; • Characteristics of vessels. In addition, it should also be able to read and use live/current data on vessel position and speed. It should also be able to read and use river port dues (date of arrival/departure, cargo info, etc). This communication must use appropriate data formats to send port's traffic statistics, expected port calls and sensors data to the PIXEL platform. These formats can rely on existing formats (XML files used between VIGIEsip and AP+). PIXEL should be able to interface with already existing web services developed in GPMB: • https://bordeaux.vigiesip.eu/vigiesip-webservice-bordeaux/nonauthent/export_demandes • https://bordeaux.vigiesip.eu/vigiesip-webservicebordeaux/nonauthent/export_demandes_facturation • https://bordeaux.vigiesip.eu/vigiesip-webservicebordeaux/nonauthent/navires_a_quai
Acceptance criteria: • PIXEL must be able to access FAL Forms available in VIGIEsip database, accessible via API; • PIXEL must be able to access calls statistics available in VIGIEsip database, accessible via API; • PIXEL must be able to access characteristics of vessels available in VIGIEsip database, accessible via API, additionally access to Lloyd' registers about specific engine data.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH
Use-case: Energy Management Use Case, Modelling
Scenario: GPMB-StM-1
Rationale: To be able to use traffic statistics data in prediction algorithms, calculation of PEI, etc.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Monitor expected port calls [11]
PIXEL must have access to expected port call data in VIGIEsip.
Acceptance criteria: PIXEL being able to collect port call data stored in VIGIEsip exposed through API.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities

Product: PA(maritime traffic)
Use-case: Energy Management Use Case
Scenario: GPMB-StM-1
Rationale: To be able to better predict and optimize port operations (ship loading/unloading) and also use port call data in analysis for prediction.
Customer Satisfaction: 3
Customer Dissatisfaction: 1

Collect sensor data through Port Community System (VIGIEsip) [12]
The Port Community System (VIGIEsip) collects some of the physical measurements in GPMB. PIXEL must have access to sensor data from VIGIEsip in order to harvest such data and integrate them inside the PIXEL hub, which acts as a unified IoT platform for each use case exploited by the PIXEL project.
Acceptance criteria: PIXEL being able to collect data exposed by VIGIEsip.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Energy Management Use Case
Scenario: GPMB-IT-1
Rationale: To use Port Community System (VIGIEsip) as an intermediate collector of physical measurements in a port. This new functionality of VIGIEsip will be a key component for the communication of data to PIXEL.
Customer Satisfaction: 5
Customer Dissatisfaction: 1

Support Air Quality Sensors [14]
In GPMB the air quality monitoring is performed by an association, ATMO Nouvelle-Aquitaine. GPMB is establishing a collaboration with ATMO in order to define some new processes to get air quality data (Open Data) automatically from them. PIXEL must be able to read/receive data from ATMO air quality sensors.
Acceptance criteria: Air sensor data available through an API call.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Energy Management Use Case, Port Environmental Index (PEI)
Scenario: GPMB-EnvM-1
Rationale: To be able to use air quality sensor data in PEI calculation and prediction algorithms.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Modelling and analysis of energy consumption during ship handling procedures [15]
PIXEL should be able to model and analyse energy consumption for all five categories of ship handling taking place in GPMB: • Import / Exports of containers; • Imports of handled solid bulks: • Exports of handled solid bulks; • Imports / Exports of non-handled solid bulks; • Imports / Exports of liquid bulks. PIXEL tools must be able to predict: • energy consumption related to ships operations and involved logistics chain; • energy to cover consumption needs of the port (how much green energy could the port provide and anticipate how much will be needed). Modelling should include the following sources of information: • lightning; • buildings near the area of loading/unloading ships; • reefers consumption; • weather and other contextual information; • consumption of different engines of machinery when loading/unloading cargo to/from vessels.
Acceptance criteria: • Sensors for measuring energy consumption of ship handling procedures; • data from all energy measuring sensors available in database accessible via API.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: MO (energy demand),PA (energy)
Use-case: Energy Management Use Case, Port Environmental Index (PEI), Modelling
Scenario: GPMB-EM-1
Rationale: To be able to monitor energy consumption on all stages, on all tools of all five categories of ship handling, which will yield necessary data for prediction, optimization and calculation of PEI.
Customer Satisfaction: 5
Customer Dissatisfaction: 3

Support wind speed sensors [16]
PIXEL must be able to read/receive data from wind speed sensors (new or existing).
Acceptance criteria: Wind speed sensor data available through an API call
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Energy Management Use Case, Port Environmental Index (PEI)
Scenario: GPMB-EnvM-1

Rationale: To be able to use wind speed sensor data in predictive algorithms, in dashboard status updates (live wind speed data), etc.
Customer Satisfaction: 3
Customer Dissatisfaction: 1

Support weather sensor/service [17]
PIXEL must be able to read/receive weather data from sensors and/or services (new or existing), such as: • https://donneespubliques.meteofrance.fr/?fond=produit&id_produit=90&id_rubrique=3 • https://public.opendatasoft.com/explore/dataset/arome-0025-sp1_sp2/table/?location=6,46.00538,2&basemap=jawg.streets
Acceptance criteria: Weather sensor/service data available through API.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Energy Management Use Case, Port Environmental Index (PEI)
Scenario: GPMB-EnvM-1
Rationale: To be able to use weather data in prediction algorithms, dashboard status updates, etc.
Customer Satisfaction: 5
Customer Dissatisfaction: 1

Support old sensors (gauge stations network) [18]
Some sensors are already deployed at GPMB premises. However, the cost of connectivity is one-to-one which does not scale in terms of cost and maintenance. In this sense, it is planned to bring new communication functionalities to old sensors. Instead of changing tide level sensors, new communication abilities (with new standards such as 5G) will be added, and it will be much more useful to follow this approach. In order to connect a few old-fashioned sensors (without any communication stack but serial connection) to the PIXEL IoT-like platform, new devices able to send data via standard protocols and via ports means of communication (VHF) will be identified. Enabling the modern transmission of data to IoT platforms by old sensors thanks to cheap equipment should be a key element for spreading the use of PIXEL in ports. Sensors in a nearby area will be aggregated by means of an IoT gateway, which will form part of the PIXEL data acquisition layer. The IoT gateway will then communicate with the PIXEL hub for proper storage (or any other management action). As an end-user, GPMB expects to exploit this gateway ("sensor IoT connector") and to use it for replacing the current PC dedicated to these means.
Acceptance criteria: Device connected to old sensors thanks to bus interfaces (RS232 or RS485) and able to send the sensors measurements thanks to new communication technologies
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: DAL
Use-case: Energy Management Use Case, Port Environmental Index (PEI)
Scenario: GPMB-IT-1

Rationale: To connect "old sensors" (such as tidal sensors) to an IoT platform.
Customer Satisfaction: 5
Customer Dissatisfaction: 3

Optimization of photovoltaic energy production and consumption [19]
GPMB aims to know in advance what will be the potential of energy production using solar panels. PIXEL must provide simulation/prediction tools, based on data coming for external resources, historical data sets or based on results on a weather simulation tools or service. It should be able to use this data to predict photovoltaic energy production and help to optimize usage of photovoltaic. This will be used to analyse the gap between tools like PVGIS (http://re.jrc.ec.europa.eu/pvg_static/methods.html) or similar tools estimations and the real situation.
Acceptance criteria: • Photovoltaic energy production data available accessible through API; • energy consumption data available in database or accessible through API; • weather data/forecast available in database or accessible through API.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PA (energy)
Use-case: Intermodal Transport Use Case
Scenario: GPMB-EM-2
Rationale: To be able to optimize consumption of photovoltaic energy by predicting and analysing photovoltaic energy production. To be able to adjust tariffs based on consumption and production analysis. To be able to avoid peak consumption based on production and consumption prediction.
Customer Satisfaction: 4
Customer Dissatisfaction: 1

Monitoring l'Ostrea dredge environmental impact [20]
PIXEL should be able to acquire data about NOx and SOx levels along with l'Ostrea dredge LNG consumption. The data would be used to calculate emission level trends in connection with dredging activity, LNG consumption trends, etc. The data could be also used to define dredging optimization strategies and strategies for environmental impact optimization.
Acceptance criteria: • NOx emission level data available in database through API call; • l'Ostrea dredge LNG consumption data available through API call.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PEI,IH
Use-case: Energy Management Use Case, Port Environmental Index (PEI)
Scenario: GPMB-EnvM-1

Rationale: To be able to monitor l'Ostrea dredge environmental impact by monitoring NOx and SOx emission levels and dredge LNG fuel consumption.
Customer Satisfaction: 4
Customer Dissatisfaction: 1

Monitor energy consumption of the port authority [22]
PIXEL should be able to acquire data about the port authority energy consumption and use that data in the optimization of port authority procedures.
Acceptance criteria: Port authority energy consumption data available through API
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: DAL, PA (energy)
Use-case: Energy Management Use Case
Scenario: GPMB-EM-1
Rationale: To be able to optimize processes in the port authority after studying port authority energy consumption data.
Customer Satisfaction: 4
Customer Dissatisfaction: 2

Expose data to VIGIEsip system [82]
PIXEL should be able to expose some of its data through an API. This data can then be used by other systems like VIGIEsip. These systems can use this data to enrich their UI components, or use it in further analytical processes. The following data need to be accessible through an API by VIGISip: • Statistic data about boat calls; • Ship calls forecast; • Ships characteristics; • Ship calls in a period; • Energy consumption; • Sensors measurements (including weather station); • Computation requests; • Models results. The results may be retrieved by logistic chain or by item, supported by the API. The API should also support editing the model in case something changes. For example, whenever a crane is changed for a better one that consumes less energy (or an existing diesel-based is replaced with an electric one), so that the consumption on the logistics chain evolves; • The environmental manager accesses VIGIEsip and requires some information regarding environmental performance or status before taking a decision on a particular action. Through VIGIEsip, the PEI value and the results of environmental models (with strong connection to the PEI) are retrieved through a standard API; • The port manager accesses VIGIEsip and triggers the action of estimating energy viability. Some internal information available in VIGIEsip may be potentially added to the request towards the OT

API. The estimation is calculated and forwarded back to VIGIEsip, which presents it to the port manager.
Acceptance criteria: Ability to expose data through different API calls
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH
Use-case: Energy Management Use Case
Scenario: GPMB-SE-1
Rationale: To be able to enhance VIGIEsip dashboard data with data exported by PIXEL platform.
Customer Satisfaction: 5
Customer Dissatisfaction: 1

3.2.2.1. Requirements by type

The set of requirements described in the previous paragraph for GPMB can be classified according to their type, as listed in the following table.

Table 5: GPMB Requirements by Type.

Type	Requirements
Data Requirements	• **[10] Access to traffic data;** • **[12] Collect sensor data through Port Community System (VIGIEsip).**
Functionalities	• **[9] Support electricity consumption sensors;** • **[11] Monitor expected port calls;** • **[14] Support air quality sensors;** • **[15] Modelling and analysis of energy consumption during ship handling procedures;** • **[16] Support wind speed sensors;** • **[17] Support weather sensor/service;** • **[18] Support old sensors (gauge stations network);** • **[19] Optimization of photovoltaic energy production and consumption;** • **[20] Monitoring l'Ostrea dredge environmental impact;** • **[22] Monitor energy consumption of the port authority;** • **[82] Expose data to VIGIEsip system.**

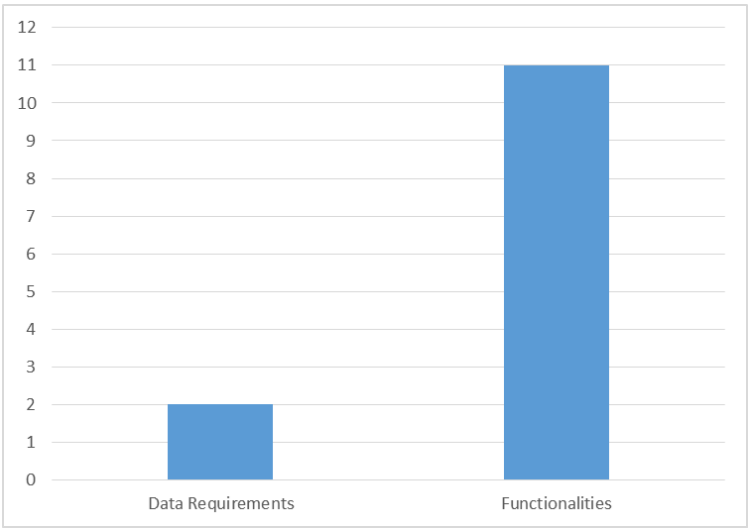

Figure 14: GPMB functional requirements by type.

3.2.2.2. Analysis

In this section GPMB functional requirements are analyzed in detail in order to extract relevant information, which could be useful to support the next phases (design, modelling and development) of the lifecycle of PIXEL platform.

The priority of the requirements can be analysed according to Moscow methodology, as described in Figure 15.

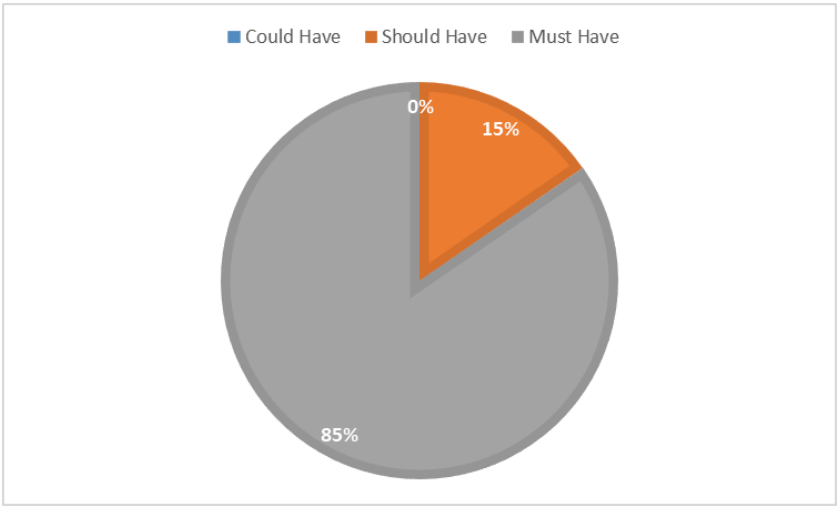

Figure 15: GPMB functional requirements by priority.

Most of the functional requirements (85%) describe properties, which the system must comply in order to fulfil stakeholders' expectations. "Should have" requirements represent the 15% of the functional requirements provided by GMPB.

3.2.3. Port of Monfalcone – SDAG – Intermodal Transport Use Case

This section is aimed at listing the set of functional requirements collected from the analysis of the Intermodal Transport Use Case. The use case of the Port of Monfalcone and SDAG, described in detail in D3.4, is aimed at taking advantages from the PIXEL solution in order to handle the freight traffic in urban and surrounding area, through the creation of an IoT platform to share data and make interoperable different types of information and sensor systems. The use case will focus on understanding and measuring the benefits coming from a new model of logistic solutions and the related impact on the environment.

In particular requirements described in this paragraph provide support to the following user stories and scenarios:

Table 6: Intermodal Transport Use Case.

Partner	User story	Scenario
ASPM	**Gate/Access Manager**	PoM-GM-1
	Environmental Manager	PoM-EM-1
	Software editor	PoM-SE-1
SDAG	**Parking area manager**	SDAG-PM-1
		SDAG-PM-2
		SDAG-PM-3

Integration with the SILI Information System [23]
PIXEL must be able to acquire data provided by the SILI Information System, aimed at planning, monitoring and recording transits of people and trucks inside and outside the facility. The SILI information system, developed by Insiel as part of the SEC project is able to: • Receive and save all traffic transits of car and truck; • Identify the vehicle transit, saving number plate, date, time, transit location; • Detect and identify the type of dangerous freight (material code, danger code); • Track all vehicles that transit in the monitoring points and identify those transporting dangerous freights; • Manage the database of dangerous freights transport; • Analysis and statistic of traffic data. PIXEL should use information provided by SILI in order to monitor real-time peaks of traffic and, on the other hand, to forecast and to alert congestions in a short time range.
Acceptance criteria: Data extracted from SILI automatically available inside the PIXEL infrastructure for modelling purposes.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Intermodal Transport Use Case
Scenario: PoM-SE-1
Rationale: To be able to ingest information provided by the SILI Information System in order to improve congestions detection and forecast.
Customer Satisfaction: 3
Customer Dissatisfaction: 2

Integration with the PMIS2 Information System [24]
PIXEL should be able to acquire data provided by the PMIS2 Information System provided by the National Authority for marine traffic. The PMIS2 provides useful information about:

• Vessels which will reach the port in a few days (middle term planning), including size and classification of carried goods (e.g.: cars, coils); • Vessels which are currently reaching the port (short term planning), including size and classification of carried goods (e.g.: cars, coils); • Vessels which are leaving the port; • Current position and estimated arrival time of vessels (call to port). Such data should be used by PIXEL in order to estimate the daily workload (and the related traffic) of the port and alert about congestions. In particular information concerning carried goods should be considered in order to clearly identify critical events (e.g.: a vessel which requires several temporary storage areas in order to be unloaded or loaded). Integration with PMIS2 could present several issues during development phases, because a link with national maritime department may be required. If such integration could not be feasible, Port of Monfalcone will provide manually such information, used nowadays to feed its website.
Acceptance criteria: Data extracted from PMIS2 Information System automatically available inside the PIXEL infrastructure for modelling and planning purposes.
MoSCoW Priority: SHOULD HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Intermodal Transport Use Case
Scenario: PoM-SE-1
Rationale: To be able to ingest information provided by the PMIS2 Information System in order to improve congestions detection and forecast.
Customer Satisfaction: 3
Customer Dissatisfaction: 2

Integration with ASPM video monitoring system [25]
PIXEL should be able to interact with the ASPM Video Monitoring System, which will be acquired by the Port of Monfalcone as part of the project. Such solution will estimate, according to a set of monitoring cameras, the amount of available parking lots and identify traffic congestions. PIXEL should use information provided by the ASPM Video Monitoring System in order to monitor real-time peaks of traffic and to forecast (in accordance with data provided by both SILI and PSIM2) peaks of traffic which could take place. The ASPM Video Monitoring System is based on a set of advanced cameras, which will be installed at main entrances of the parking lot, able to perform image recognition. In particular such network of advanced sensors will be exploited in order to identify truck motion inside the port facility and estimate traffic jam and congestion.
Acceptance criteria: Data (video and meta-data) extracted from ASPM Video Monitoring System automatically available inside the PIXEL infrastructure for monitoring, modelling and planning purposes.
MoSCoW Priority: MUST HAVE

Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Intermodal Transport Use Case
Scenario: PoM-SE-1
Rationale: To be able to ingest information provided by the ASPM Video Monitoring System in order to improve congestions detection and forecast.
Customer Satisfaction: 3
Customer Dissatisfaction: 2

Traffic peak and congestion monitoring at the port facility [26]
PIXEL must be able to monitor (by integrating data provided by both SILI gates and ASPM video monitoring system) traffic congestions at the entrance of the port facility. PIXEL should provide the ability to analyze (e.g.: by counting the mean time spent by trucks in order to leave the port in the last 30 minutes) such events in soft real time. Stakeholders could be informed effectively and plan contingency actions in order to prevent or solve the congestion.
Acceptance criteria: Identify a traffic congestion at the entrance of the port facility.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: MO (transport)
Use-case: Intermodal Transport Use Case
Scenario: PoM-GM-1
Rationale: Be able to properly and effectively identify when a traffic peak or congestion happens in order to plan an emergency set of activities and act them.
Customer Satisfaction: 4
Customer Dissatisfaction: 3

Integration with the SDAG Access Control System [27]
PIXEL should be able to acquire data provided by the Access Control System adopted by SDAG, aimed at planning, monitoring and recording transits of trucks inside and outside the facility. Data include information collected by video-surveillance cameras and access control sensors like truck plates and Kemler codes. ACS includes video surveillance and ticket management. In particular PIXEL should be able to collect data provided by the IoT infrastructure composed by several cameras and sensors located inside the SDAG Parking Lot, at SDAG Entrance and along the regional highway (by means of advanced cameras aimed at identifying trucks with dangerous codes). PIXEL should use information provided by SDAG Access Control System to support decision makers when an emergency plan is required in order to prevent or mitigate peaks of traffic inside the Port of Monfalcone (or, generally speaking, inside each of the nodes involved in inter-modal logistic at regional level).
Acceptance criteria: Data extracted from SDAG Access Control System automatically available inside the PIXEL infrastructure for modelling and planning purposes.
MoSCoW Priority: SHOULD HAVE

Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Intermodal Transport Use Case
Scenario: PoM-SE-1, SDAG-PM-1, SDAG-PM-2
Rationale: To be able to ingest information provided by the SDAG Access Control System in order to improve congestions detection and forecast.
Customer Satisfaction: 3
Customer Dissatisfaction: 3

Integration with data provided by sensors, cameras and feeds by third parties [28]
PIXEL should be able to integrate data flows provided by different stakeholders of the regional inter-modal logistic infrastructure, such as highway authorities (e.g.: Autovie Venete). Such data may include: highway traffic congestion or peaks, traffic bans, weather conditions, etc. Data can be collected by means of networks of cameras and interconnected sensors. Information provided by external stakeholders should be used by PIXEL in order to support decision makers when a contingency plan is required (e.g.: when trucks need to be re-routed from the Port of Monfalcone to SDAG or to another node of the regional inter-modal logistic infrastructure). In particular following 3rd party providers are available: • FVG Strade; • Autovie Venete; • Società Autostrade. Such providers will provide: • real time traffic information on regional highways and high capacity freeways; • planned traffic bans (e.g.: due to road work); • estimated time required to move between two points of the regional highway, according to real time traffic. Such data, in textual format, are already used to feed this website: https://www.infoviaggiando.it/
Acceptance criteria: Data extracted from such flows (e.g.: feeds, stream generated by sensors) automatically available inside the PIXEL infrastructure for effective decision support.
MoSCoW Priority: SHOULD HAVE
Category and Type: Functional – Functionalities
Product: DAL
Use-case: Intermodal Transport Use Case
Scenario: PoM-SE-1
Rationale: To be able to ingest information provided by third parties involved in the regional inter-modal logistic infrastructure.
Customer Satisfaction: 3
Customer Dissatisfaction: 2

Cooperation with railway authorities [29]
PIXEL could be able, in the future, to cooperate with the information systems provided by railway authorities (e.g.: ADRIAFER) in order to support railway convoy planning and management. In particular, PIXEL could be able to suggest decision makers when railway transportation may represent an optimal or suboptimal solution in order to implement contingency plans. No standard is currently available to cooperate and exchange data with railway authorities. No previous experience is available. Due to such critical aspects concerning data availability, from both technical and political point of view, the requirement has been marked as "Could Have".
Acceptance criteria: PIXEL could be able to extract information about railway convoy availability and planning by means of cooperation with information systems adopted by railway authorities.
MoSCoW Priority: COULD HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Intermodal Transport Use Case
Scenario: PoM-GM-1
Rationale: To be able cooperate with the information systems provided by railway authorities in order to achieve a complete multi-modal logistic infrastructure.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Provide a common access for management and monitoring of ADR [30]
PIXEL should provide to both Port of Monfalcone and SDAG a common point of access to information concerning ADR (dangerous freights) and to effectively report operators when a dangerous freights transport between Port of Monfalcone and SDAG will take place (e.g.: re-routing of trucks towards SDAG when a traffic peak is having place at the Port). PIXEL should be able to manage such information in order to provide both Port's and SDAG's operators with the ability to manage incoming dangerous freights (e.g.: by allocating specific area devoted to dangerous goods). Such information may become particularly critical during heavy workload days, when the Port facilities are significantly stressed by loading and unloading activities. Currently, by integrating both SILI and SDAG Access Control System, following data are available: • Number plates of truck entering and leaving SDAG and Port of Monfalcone; • ADR hazard symbol and plates, automatically recognized by a set of networking advanced cameras located on different hot spots along the regional highway. Collected data need to be shared by stakeholders according with international compliance only for internal usage; no information concerning number plates need to be shared publicly.
Acceptance criteria: Data related to ADR automatically available inside the PIXEL infrastructure for effective monitoring and planning.
MoSCoW Priority: SHOULD HAVE
Category and Type: Functional – Functionalities
Product: MO (transport)

Use-case: Intermodal Transport Use Case
Scenario: PoM-SE-1, SDAG-PM-2
Rationale: Provide a common access for management and monitoring of ADR, currently managed by different and isolated solutions (SILI for the Port of Monfalcone, SDAG Access Control System for SDAG) not able to share information each other.
Customer Satisfaction: 2
Customer Dissatisfaction: 2

Truck re-routing alerting system for operators [31]
PIXEL should be able to provide an alert, by exploiting several information channels (e.g.: email, SMS), to each different stakeholder (e.g.: Port authorities, SDAG operators, railway authorities, etc.) involved in the inter-modal logistic scenario when a re-routing of trucks is suggested by the decision makers. Personal information concerning communication channels (e.g.: phone number, email) must be managed in the proper and safe way, according to international compliances and GDPR.
Acceptance criteria: When a re-route is suggested PIXEL should notify such information to each stakeholder.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IDN&N, OT
Use-case: Intermodal Transport Use Case
Scenario: SDAG-PM-2
Rationale: Provide a fast and effective alert to each stakeholder involved in the inter-modal logistic scenario.
Customer Satisfaction: 4
Customer Dissatisfaction: 4

Truck re-routing alerting system for final users [32]
PIXEL should be able to provide an alert, by exploiting several information channels (e.g.: email, SMS) including an ad hoc mobile application (or mobile web site) to the final users (e.g.: truck companies) when a re-route is suggested, in order to prevent traffic peaks or congestions. PIXEL should be able to notify information required to reach the new destination (e.g.: address, estimated time to arrival, GPS position). Information about trucks moving towards the port or the SDAG facility could be extracted by PIXEL from both the SILI information system and the SDAG Access Control System (e.g.: truck plate, driver name and ID, driver phone number, driver license number, etc.) when available. Personal information concerning communication channels (e.g.: phone number, email) must be managed in the proper and safe way, according to international compliances and GDPR.
Acceptance criteria: When a re-route takes place PIXEL should notify such information to the involved transportation companies (e.g.: truck companies).
MoSCoW Priority: COULD HAVE
Category and Type: Functional – Functionalities

Product: IDN&N, OT
Use-case: Intermodal Transport Use Case
Scenario: SDAG-PM-2
Rationale: Provide a safe and effective way to notify to different truck companies that a re-route is suggested in order to avoid to be involved in a traffic congestion.
Customer Satisfaction: 4
Customer Dissatisfaction: 4

Truck re-routing booking system [33]
When a re-routing is suggested from Port of Monfalcone to SDAG, a parking lot may need to be reserved for the trucks. PIXEL should be able to submit a reservation request to SDAG operators, by providing all information required to identify the incoming trucks. Such data are provided by truck companies. Reservation request could be notified by email; by using a web interface SDAG's operators should be able to confirm the reservation and provide an alert to the truck company (e.g.: providing parking lot number). In particular, PIXEL must be able to clearly report if each truck has dangerous goods or requires particular facilities in order to be hosted. Personal information concerning communication channels (e.g.: phone number, email) must be managed in the proper and safe way, according to international compliances and GDPR.
Acceptance criteria: When a re-route is suggested PIXEL sends an estimated reservation request to SDAG's operators.
MoSCoW Priority: COULD HAVE
Category and Type: Functional – Functionalities
Product: IDN&N, OT
Use-case: Intermodal Transport Use Case
Scenario: SDAG-PM-2
Rationale: Provide a safe and effective way to notify truck companies that a re-route is suggested in order to avoid to be involved in a traffic congestion.
Customer Satisfaction: 4
Customer Dissatisfaction: 4

Port congestion forecasting [34]
PIXEL must be able to forecast the probability of a traffic peak to take place in a specific time frame (e.g.: on a daily basis), in accordance with: • planned arrivals and departures of vessels; • complexity of loading and unloading activities (e.g.: unloading activities requiring special equipment or large temporary storage area); • overlapping unloading activities between multiple vessels; • historical data (based on Excel and Access data sources collected by port authorities, describing each loading and unloading activity taking place inside the port facility). PIXEL must be able to analyze such data and provide stakeholders with a model representing the forecast of traffic peaks and congestions in a given time frame.

Data required by the model will be automatically provided by the PMIS2 System (if available) or manually inserted by stakeholders of the port on a daily basis. An example of such data (including goods and weight of each vessel, in addiction to ETA) is available here: http://www.porto.monfalcone.gorizia.it/sailinglist.asp. Information is nowadays manually collected in order to update both the port website and the set of historical data.
Acceptance criteria: Forecast a possible traffic congestion inside the port facility.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PA (road traffic)
Use-case: Intermodal Transport Use Case
Scenario: PoM-GM-1
Rationale: Be able to analyse if a traffic peak or congestion will probably take place in order to adopt a contingency plan.
Customer Satisfaction: 4
Customer Dissatisfaction: 3

Port congestion simulation [35]
PIXEL must provide the operators with the ability to simulate the probability of a traffic peak to take place in a specific time frame (e.g.: on a daily basis), in accordance with: • changes to planned arrivals and departures of vessels; • changes to planned arrivals and departures of trucks. The PIXEL should be able to support the operators during the analysis of each WHAT-IF scenario. For example, PIXEL should be able to simulate if traffic peaks will take place when a vessel will reach the port with a 6 hours delay due to sea and weather conditions.
Acceptance criteria: Simulate a scenario where possible traffic congestion could take place inside the port facility.
MoSCoW Priority: SHOULD HAVE
Category and Type: Functional – Functionalities
Product: MO (transport)
Use-case: Intermodal Transport Use Case
Scenario: PoM-GM-1
Rationale: Be able to simulate, by changing values under analysis, if a traffic peak or congestion will probably take place in order to adopt a contingency plan.
Customer Satisfaction: 2
Customer Dissatisfaction: 1

Port - SDAG highway congestion forecasting [37]

PIXEL must be able to forecast the probability of a traffic peak to take place in a specific time frame (e.g.: on a daily basis) on the local highway network . In particular PIXEL must be able to integrate information gathered from different sources (e.g.: Autovie Venete) in order to identify already planned or identified traffic peaks, accidents or temporary driving bans. In particular, following 3rd party data and sensors providers are available: • FVG Strade; • Autovie Venete; • Società Autostrade. Such providers will provide: • real time traffic information on regional highways and high capacity freeways; • planned traffic bans (e.g.: due to road work); • estimated time required to move between two points of the regional highway, according to real time traffic. Such data, in textual format, are already used to feed this website: https://www.infoviaggiando.it/ PIXEL should be able to forecast if re-routing (suggested in order to handle a traffic peak of trucks inside the port) may negatively impact on the regional highway system.
Acceptance criteria: Forecast a possible traffic congestion on local highway network.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: MO (transport), PA (road traffic)
Use-case: Intermodal Transport Use Case
Scenario: PoM-GM-1, SDAG-PM-3
Rationale: Be able to analyse if a traffic peak or congestion will probably take place on local highway network when re-routing of incoming truck is suggested.
Customer Satisfaction: 4
Customer Dissatisfaction: 4

3.2.3.1. Analysis

In this section requirements provided by ASPM-SDAG are analyzed in detail in order to extract relevant information, which could be useful to support the next phases (design, modelling and development) of the lifecycle of PIXEL platform. **All requirements defined for ASPM – SDAG have been classified by stakeholders as functional requirements related with functionalities.**

The priority of the requirements can be analysed according to Moscow methodology, as described in Figure 16. There is a fair distribution of priority between identified requirements, with 43% of "Must Have" requirements and 36% of "Should Have" requirements. Requirements with lowest priority are related to integration or cooperation issues (e.g.: cooperation with railway authorities) at both legal and technical level.

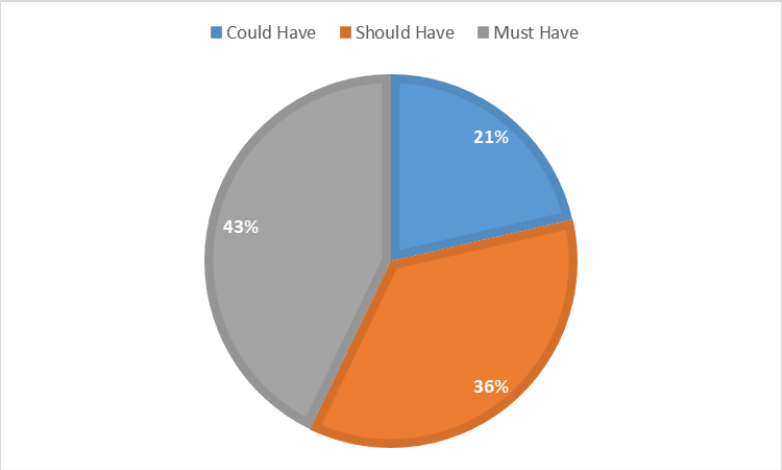

Figure 16: ASPM-SDAG functional requirements by priority.

3.2.3.2. Ethical Observance

Following requirements require, according to VOLERE Methodology, ethical observance in terms of **Personal Data**, **Sensitive Data Protection and Environmental related Data**:

- **[27] Integration with the SDAG Access Control System;**
- **[30] Provide a common access for management and monitoring of ADR**
- **[32] Truck re-routing alerting system for operators;**
- **[33] Truck re-routing alerting system for Final Users.**

3.2.4. Port of Thessaloniki – Port City Integration Use Case

This section is aimed at listing the set of functional requirements collected from the analysis of the Port City Integration Use Case applied to the Port of Thessaloniki (ThPA). ThPA, as operator of the port of Thessaloniki, is responsible for the protection and conservation of port environment and for ensuring that necessary social and environmental considerations, are included in any decision-making process regarding port operations. Despite possible increase of revenues, or technological advances, protection of port environment from all forms of pollution, continues to be a central objective of ThPA.

In this framework, ThPA will rely on PIXEL's PEI (Port Environment Index), using it to evaluate environmental efficiency on port operations. Furthermore, gathering operational data from port activities, measuring its environmental state and the consolidation of all, in one single platform, is sure to assist in the decision-making process. PIXEL project will support ThPA in achieving its goals, by improving its capacity to handle the freight traffic in the surrounding area, through the creation of an IoT platform to share data and make interoperable different types of information and sensor systems.

In particular requirements described in this paragraph provide support to the following user stories and scenarios:

Table 7: Port City Integration Use Case.

Partner	User story	Scenario
ThPA	**Terminal Operator**	ThPA-TO-1
	Environmental Manager	ThPA-EM-1
		ThPA-EM-2

Integration with ThPA information system [46]
PIXEL must be able to interact with an heterogeneous set of information systems adopted by ThPA and city of Thessaloniki, including: • the Traffic Management Centre (TMC) of the city of Thessaloniki, • the Terminal Operating System (TOS) of the port; • the Gate Control System (GCS) of the Thessaloniki port. Integration provided by PIXEL must facilitate fast gate in/out operations and alleviate traffic congestion by establishing a smoothed arrival/departure pattern for trucks to/from.
Acceptance criteria: Data extracted from ThPA Information System available inside the PIXEL infrastructure for modelling purposes.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH
Use-case: Port-City Integration Use Case
Scenario: ThPA
Rationale: To be able to homogenize and integrate data from several information systems adopted by ThPA and city of Thessaloniki in order to optimize port activities and minimize generated noise and pollution.
Customer Satisfaction: 3
Customer Dissatisfaction: 2

Support wind and weather sensors [47]
PIXEL must be able to read/receive data from wind and weather sensors such as: • Wind direction • Wind speed • Temperature • Relative humidity available in real-time or in batch mode (e.g.: by using TXT files exported by the weather station data logger, CSV). PIXEL must be able to deal with different units of measure (m/s, knots, °C, etc.) and formats. The wind data are obtained by using two different sensors. The first sensor is placed on gantry crane in the container terminal. An application talks to the sensor and dumps raw data into a database with just one table. A second sensor is placed on the rooftop of the technical services building. For this sensor, data are downloaded manually on a daily basis. The objective is to give access to the downloaded file in a public repository in order to be able to pull this data to the PIXEL Hub. The raw data is text in a CSV format. This wind sensor is also coupled with temperature and humidity measurements.
Acceptance criteria: Wind and weather sensors data available through an API call.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities

Product: IH,DAL
Use-case: Port-City Integration Use Case
Scenario: ThPA-EM-1, ThPA-EM-2
Rationale: To be able to use wind and weather sensors data to forecast how noise and pollution generated by the port will affect the city and which areas will be mostly interested.
Customer Satisfaction: 5
Customer Dissatisfaction: 5

Support air quality sensors [48]
PIXEL must be able to read/receive data from air quality sensors such as: • PM10; • PM2,5; • SO2; • NO2; • CO; available in real-time or in batch mode (e.g.: by using TXT files exported by the air quality data logger). Four analysers of air quality are available nowadays in THPA. The analyser sends data directly to the logger website, where data can be access by logging in and downloading the data in CSV format, static file. THPA cannot give the credentials for the site. Moreover the website does not have an API and the data need to be manually downloaded. The data that are analysed are NO, NO2, NOX, SO2, CO, PM10, PM2.5, temperature and relative humidity. Since a direct access to data is not possible, it is planned to upload the downloaded file in a public repository that can be accessed by PIXEL partners.
Acceptance criteria: Air sensor data available through an API call
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Port-City Integration Use Case
Scenario: ThPA-EM-1
Rationale: To be able to use air quality sensors data to forecast how pollution generated by the port will affect the city and which areas will be mostly interested.
Customer Satisfaction: 5
Customer Dissatisfaction: 5

Support water quality sensors and data [49]
PIXEL must be able to store water quality data. Data are collected by networking sensors or inserted manually according to the set of samplings executed every six months on four prefixed points.
Acceptance criteria: Water quality data available through an API call
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities

Product: IH,DAL
Use-case: Port-City Integration Use Case
Scenario: ThPA-EM-2
Rationale: To be able to use water quality data to monitor water pollution.
Customer Satisfaction: 4
Customer Dissatisfaction: 4

Support noise sensors and data [50]
PIXEL must be able to store noise data. Data are collected by networking sensors or inserted manually according to the set of samplings executed every year on ten prefixed points.
Acceptance criteria: Noise data available through an API call
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Port-City Integration Use Case
Scenario: ThPA-EM-2
Rationale: To be able to use noise data to monitor noise pollution and to forecast how noise and pollution generated by the port will affect the city and which areas will be mostly interested.
Customer Satisfaction: 4
Customer Dissatisfaction: 4

Support real-time fuel consumption sensors [51]
PIXEL must be able to read/receive data from real-time fuel consumption sensors available inside ThPA. ThPA monitors the consumption of fuel in real-time, using a system comprising of: • RFID rings & sensors installed on fuel nozzles and vehicles' reservoirs; • GAS Station application, developed by the company Logicom. The application includes a number of modules, related to syncing the nozzle data, the fuel availability, linking to SAP, etc.
Acceptance criteria: Real-time fuel consumption sensors data available through an API call.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Port-City Integration Use Case
Scenario: ThPA-TO-1
Rationale: To be able to use real-time fuel consumption sensors data to monitor, at the same time, energy consumption, pollution and traffic.
Customer Satisfaction: 4
Customer Dissatisfaction: 4

Support real-time gate surveillance sensors [52]
PIXEL must be able to read/receive data from gate surveillance sensors already available at several gates of the ThPA port facility: • RFID readers (CS203ETHER), one per lane. In Gate 16 (main gate) there are three (3) lanes for entry, and one (1) for exit. In Gate 10A there is one (1) lane for entry and one (1) for exit. All vehicles have an RFID tag located on their windshield. • Data is stored on a MySQL relational database. The data can be shared via a web call (JSON, direct CSV download, etc.). Several gate surveillance sensors will be installed on the remaining gates in the next few years. Weight in motion sensors, moreover, provide information about the weight of each loaded and unloaded vehicle.
Acceptance criteria: Real time gate surveillance sensors data available through an API call.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Port-City Integration Use Case
Scenario: ThPA-TO-1
Rationale: To be able to use real-time gate surveillance sensors data to monitor each truck and car entering or leaving the port facility.
Customer Satisfaction: 4
Customer Dissatisfaction: 3

Support wind and weather data provided by third party [53]
PIXEL must be able to read/receive data several data source (in particular freely available open data) such as: • Primary weather data from NMS stations; • Thessaloniki's municipality open data; • Weather data of stations. Summary per months; • Thessaloniki's municipality open data on meteo. Such data should be used to improve the effectiveness of forecasting process, by enriching models developed by the PIXEL project.
Acceptance criteria: Data available through an API call.
MoSCoW Priority: SHOULD HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Port-City Integration Use Case
Scenario: ThPA-EM-1, ThPA-EM-2
Rationale: To be able to use wind and weather data provided by third party to forecast how noise and pollution generated by the port will affect the city and which areas will be mostly interested.
Customer Satisfaction: 4
Customer Dissatisfaction: 3

Support air quality data provided by third party [54]
PIXEL must be able to read/receive several data source (in particular freely available open data) such as: • Thessaloniki's city atmospheric pollution. SO2, PM10, PM2,5, NO, CO, NO2, O3; • Greek Ministry of Environment and Energy air pollution data. Such data should be used to improve the effectiveness of forecasting process, by enriching models developed by the PIXEL project.
Acceptance criteria: Data available through an API call.
MoSCoW Priority: SHOULD HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Port-City Integration Use Case
Scenario: ThPA-EM-1
Rationale: To be able to use air quality data provided by third party to forecast how noise and pollution generated by the port will affect the city and which areas will be mostly interested.
Customer Satisfaction: 4
Customer Dissatisfaction: 3

Support traffic data provided by third party [55]
PIXEL must be able to read/receive traffic data from both: • the Traffic Management Centre (TMC) of the city of Thessaloniki; • a set of IoT sensors for traffic monitoring in the city. Traffic data should be considered by PIXEL's model in order to support trucks movements optimization. In particular PIXEL will be exploited in order to minimize environmental impact of the trucks movements to/from the port and of the mechanical equipment used for the port operations.
Acceptance criteria: Data available through an API call.
MoSCoW Priority: SHOULD HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Port-City Integration Use Case
Scenario: ThPA-TO-1
Rationale: To be able to use traffic data provided by third party to forecast how noise and pollution generated by the port will affect the city and which areas will be mostly interested.
Customer Satisfaction: 4
Customer Dissatisfaction: 3

Estimate air pollution impact of handling cargo [56]

PIXEL must be able to estimate the air pollution impact of handling cargo (loading / unloading) to the city due to specific/bad forecasted weather conditions, for the next day. Model used for estimation must consider: • weather data (coming from sensors or third party); • air quality data (coming from sensors or third party); • traffic data. PIXEL must provide, as output: • a clear picture of air pollution impact generated by the port operations on the city; • a clear picture of the parts of the city that are affected by port operations (e.g.: by means of dust and pollution transported by wind).
Acceptance criteria: A model for air pollution forecasting is available.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: MO (pollution)
Use-case: Port-City Integration Use Case
Scenario: ThPA-EM-1
Rationale: To be able to estimate how port operations will impact air quality of the city at a given day according to weather and planned activities.
Customer Satisfaction: 5
Customer Dissatisfaction: 4

Estimate noise pollution impact of handling cargo [57]
PIXEL must be able to estimate the noise pollution impact of handling cargo (loading / unloading) to the city. Model used for estimation must consider: • noise data (coming from sensors or third party); • traffic data. PIXEL must provide, as output: • a clear picture of noise pollution impact generated by the port operations on the city; • a clear picture of the parts of the city that are affected by port operations.
Acceptance criteria: A model for noise pollution forecasting is available.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: MO (pollution)
Use-case: Port-City Integration Use Case
Scenario: ThPA-EM-2
Rationale: To be able to estimate how port operations will impact noise of the city at a given day according to weather and planned activities.
Customer Satisfaction: 5

Customer Dissatisfaction: 4

Estimate air pollution impact of bulk cargo operations [58]
PIXEL must be able to estimate the air pollution impact of handling bulk cargo (loading / unloading) to the city due to specific/bad forecasted weather conditions, for the next day. Model used for estimation must consider: • weather data (coming from sensors or third party); • air quality data (coming from sensors or third party); • traffic data; • bulk nature (e.g.: size and kind of material involved in bulk operations for fugitive emissions) PIXEL must provide, as output: • a clear picture of air pollution impact generated by the port operations on the city; • a clear picture of the parts of the city that are affected by port operations (e.g.: by means of dust and pollution transported by wind).
Acceptance criteria: A model for air pollution forecasting is available.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: MO (pollution)
Use-case: Port-City Integration Use Case
Scenario: ThPA-EM-1
Rationale: To be able to estimate how bulk cargo port operations will impact air quality of the city at a given day according to weather and planned activities.
Customer Satisfaction: 5
Customer Dissatisfaction: 4

Visualize the traffic status [106]
PIXEL should provide an interface for visualizing of entry/exit gates and traffic congestion inbound and outbound the surroundings of the access to the port. This information must be synced with the data coming from the Information Hub and with the results from executing traffic modelling in THPA provided by PIXEL models and Operational Tools. PIXEL must provide, as output: • A simulation map of the surroundings of the port, indicating the gate status and the forecast of evolution. • A bar-chart graphic representing past, present and future forecasted traffic evolution.
Acceptance criteria: An accessible screen with different options for visualization
MoSCoW Priority: SHOULD HAVE
Category and Type: Functional – Functionalities
Product: IDN&N, OT
Use-case: Port-City Integration Use Case

Scenario: ThPA-TO-1
Customer Satisfaction: 4
Customer Dissatisfaction: 3

Visualize the pollution [107]
PIXEL must provide an interface in order to visualize the quantity and parts of the city that are affected by the pollution generated by THPA. This information must be graphed through a dispersion map. The tool must offer the options to check the pollution impact due to both air and noise.
Acceptance criteria: A specific screen that can be accessed from several points of PIXEL environment (Dashboard, Operational Tools, PEI interface)
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IDN&N, OT
Use-case: Port-City Integration Use Case
Scenario: ThPA-EM-2
Rationale: PIXEL must provide an interface in order to visualize the quantity and parts of the city that are affected by the pollution generated by ThPA. This information must be graphed through a dispersion map. The tool must offer the options to check the pollution impact due to both air and noise.
Customer Satisfaction: 4
Customer Dissatisfaction: 3

3.2.4.1. Analysis

In this section ThPA requirements are analyzed in detail in order to extract relevant information, which could be useful to support the next phases (design, modelling and development) of the lifecycle of PIXEL platform. **All requirements defined for ThPA have been classified by stakeholders as functional requirements related with functionalities.**

The priority of the requirements can be analysed according to Moscow methodology, as described in Figure 17. Most of the functional requirements (73%) describe properties, which the system must comply in order to fulfil stakeholders' expectations. "Should have" requirements represent the 27% of the functional requirements provided by ThPA.

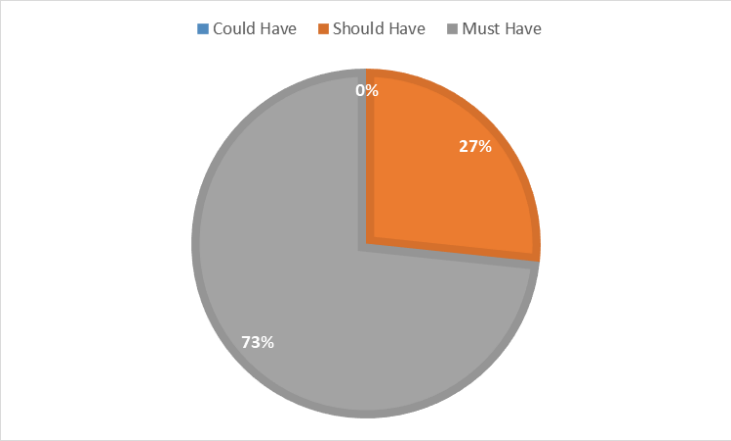

Figure 17: ThPA functional requirements by priority.

3.2.5. Port of Piraeus – Port City Integration Use Case

This section is aimed at listing the set of functional requirements collected from the analysis of the Port City Integration Use Case applied to the Port of Piraeus. The port of Piraeus, as described in detail in D3.4, is very near to the city of Athens, and there are residential areas very near of the port. During all holiday periods, a lot of traffic is experienced in the terminal, and affect the living of the people living around, in terms of both **noise and air pollution**.

When lots of cruises arrive and it coincides with current traffic in the city, the touristic busses are not able to reach the Acropolis in a reasonable time for tourist to really spend time in the place. It also implies more traffic congestion, noise pollution and overall environmental impact. This use case does not involve only cruises but also container and coastal (passenger) traffic operations.

PPA will benefit from PIXEL in order to **improve the access to the seaport** so that it can ensure sustainable economic growth in the port city of Piraeus, leveraging enabled communications at data level proportioned by PIXEL.

In particular PPA will utilize the Port Environmental Index, the PIXEL Platform and its associated interface (HMI) to self-monitor and appraise of different mitigation measures in order to define and apply effective mobility management measures in the port surrounding area. Such politics are aimed at improving the air quality, reducing energy consumption and noise and consolidating relationship with local community.

In particular requirements described in this paragraph provide support to the following user stories and scenarios:

Table 8: Port City Integration Use Case.

Partner	User story	Scenario
PPA	**Environmental Manager**	PPA-EM-1
		PPA-EM-2

Support air quality sensors [73]
PIXEL must be able to read/receive data from air quality sensors such as: • BTEX; • CO;

• NOx; • SO2; • O3; • PM10; available in real-time or in batch mode (e.g.: by using TXT files exported by the air quality data logger).
Acceptance criteria: Air sensor data available and storable through an API call
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: DAL
Use-case: Port-City Integration Use Case
Scenario: PPA-EM-1
Rationale: To be able to use air quality sensors data to forecast how air pollution generated by cruise and passengers ships will affect the city.
Customer Satisfaction: 4
Customer Dissatisfaction: 2

Support water quality data [75]
PIXEL must be able to store water quality data. Data are inserted manually according to the set of samplings executed every year on 40 different sampling points inside the port area. The analysed parameters include: pH, turbidity, salinity, BOD, COD, enterococci, E. coli, total coliforms, TDS and heavy metals.
Acceptance criteria: Water quality data available and storable through an API call.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: DAL
Use-case: Port-City Integration Use Case
Scenario: PPA-EM-1
Rationale: To be able to use water quality data to monitor water pollution.
Customer Satisfaction: 4
Customer Dissatisfaction: 2

Integration with the PMIS SPARC N4 [76]
PIXEL should be able to acquire data provided by the Port Management Information System (PMIS), aimed at: • operation planning, such as yard planning (dynamic storage area allocation); • berth planning (berth allocation to vessel and crane allocation to berths); • ship planning (loading &unloading plan optimization with respect to cargo compatibility and stability limitations); • rail-terminal operations planning; • dangerous cargoes monitoring;

• high value cargoes monitoring. PIXEL should use information provided by SPARC N4 in order to monitor vessels and operations (both in container and coastal areas) in real time and to model impact on city and coastal areas (in terms of pollution and noise)
Acceptance criteria: Data extracted from PMIS available inside the PIXEL infrastructure for modelling purposes.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: IH,DAL
Use-case: Port-City Integration Use Case
Scenario: PPA
Rationale: To be able to ingest information provided by the PMIS in order to improve modelling and forecasting abilities.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Estimate air pollution impact of cruise and passengers ships related activities [78]
PIXEL must be able to estimate air pollution impact of cruise and passengers ships related activities (bus, taxi, etc.) to the city due to specific/bad forecasted weather conditions, for the next day. Model used for estimation must consider: • air quality data (coming from sensors or third parties); • traffic data; • vessels data. PIXEL must provide, as output, a clear picture of pollution impact generated by the cruise and passengers ships related activities on the city.
Acceptance criteria: A model for air pollution forecasting is available.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: MO (pollution)
Use-case: Port-City Integration Use Case
Scenario: PPA-EM-1
Rationale: To be able to estimate how cruise and passengers ships related activities will impact the city in terms of pollution at a given day according to weather and planned activities.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Measure real-time air pollution impact of cruise and passengers ships related activities [79]
PIXEL must be able to collect data related to air pollution impact of cruise and passengers ships related activities (bus, taxi, etc.) to the city, in terms of nitric oxide (NO), nitrogen dioxide (NO2), sulphur dioxide (SO2), PM10, BTEX.

Such requirement allows PPA to identify the impact of cruise and passengers ships related activities and to refine forecasting models. In fact, while there are a variety of emissions sources in the PPA region, most maintain relatively constant schedules over time, with the exception of cruise ships and their associated bus traffic.
Acceptance criteria: Air pollution estimation data available via API.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: MO (pollution)
Use-case: Port-City Integration Use Case
Scenario: PPA-EM-1
Rationale: To be able to measure how cruise and passengers ships related activities will impact the city in terms of air pollution.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Support noise sensors and data [87]
PIXEL must be able to store noise data. Data are collected by networking sensors (which could be installed in the future) or inserted manually according to the set of samplings executed every year on ten prefixed points inside the port area.
Acceptance criteria: Noise data available through an API call
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: DAL
Use-case: Port-City Integration Use Case
Scenario: PPA-EM-2
Rationale: To be able to use noise data to monitor noise pollution and to forecast how noise and pollution generated by the port will affect the city and which areas will be mostly interested.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Support pollution and traffic data provided by third party [88]
PIXEL must be able to read/receive traffic and pollution data from several sources such as: • City of Athens; • Athens Highway Authority. In particular PIXEL will be exploited in order to minimize environmental impact of both cargo (noise) and passengers (air) ships.
Acceptance criteria: Data available through an API call.
MoSCoW Priority: SHOULD HAVE
Category and Type: Functional – Functionalities

Product: IH,DAL
Use-case: Port-City Integration Use Case
Scenario: PPA-EM-1
Rationale: To be able to use traffic data provided by third party to forecast how noise and pollution generated by the port will affect the city and which areas will be mostly interested.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Measure real-time noise pollution impact of cargo ships related activities [89]
PIXEL must be able to collect data related to noise pollution impact of cargo ships related activities to the city. Such requirement allows PPA to identify the impact of cargo ships related activities and to refine forecasting models. In fact, while there are a variety of emissions sources in the PPA region, most maintain relatively constant schedules over time, with the exception of cargo ships. PPA will install in the future a large set of noise sensors aimed at collecting data in real-time from different locations inside the cargo area.
Acceptance criteria: Noise pollution estimation data available via API.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: MO (pollution)
Use-case: Port-City Integration Use Case
Scenario: PPA-EM2
Rationale: To be able to measure how cargo ships related activities will impact the city in terms of noise.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Estimate noise pollution impact of cargo ships related activities [90]
PIXEL must be able to estimate noise pollution impact of cargo ships related activities to the city due to specific/bad forecasted weather conditions, for the next day. Model used for estimation must consider: • noise data; • traffic data; • vessels data. PIXEL must provide, as output, a clear picture of pollution impact generated by cargo ships related activities on the city.
Acceptance criteria: A model for noise pollution forecasting is available.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: MO (pollution)
Use-case: Port-City Integration Use Case
Scenario: PPA-EM2

Rationale: To be able to estimate how cargo ships related activities will impact the city in terms of noise.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

Port - City road congestion forecasting [91]
PIXEL must be able to forecast the probability of a traffic peak to take place in a specific time frame (e.g.: on a daily basis) on the roads connecting the port of Piraeus with the city of Athens. In particular, the PIXEL platform should be able to: • estimate the impact of passengers ships on city traffic in the next few hours; • identify traffic congestions which may take place inside or outside the port due to traffic jam, accidents or road works. PIXEL must be able to integrate information gathered from different sources in order to identify already planned or identified traffic peaks, accidents or temporary driving bans.
Acceptance criteria: Forecast a possible traffic congestion on roads connecting the port with the city.
MoSCoW Priority: SHOULD HAVE
Category and Type: Functional – Functionalities
Product: PA (road traffic)
Use-case: Port-City Integration Use Case
Scenario: PPA-EM1
Rationale: Be able to analyse if a traffic peak or congestion will probably take place on road connecting port and city.
Customer Satisfaction: 1
Customer Dissatisfaction: 1

3.2.5.1. Analysis

In this section PPA requirements are analyzed in detail in order to extract relevant information, which could be useful to support the next phases (design, modelling and development) of the lifecycle of PIXEL platform. **All requirements defined for PPA have been classified by stakeholders as functional requirements related with functionalities.**

The priority of the requirements can be analysed according to Moscow methodology, as described in Figure 18. Most of the functional requirements (70%) describe properties, which the system must comply in order to fulfil stakeholders' expectations. "Should have" requirements represent the 30% of the functional requirements provided by PPA.

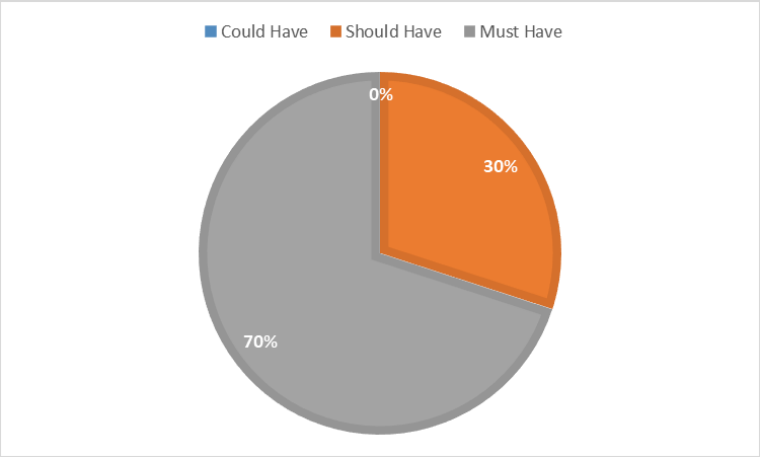

Figure 18: PPA functional requirements by priority.

3.2.6. Port Environmental Index Use Case

This section is aimed at listing the set of functional requirements collected from the analysis of the Port Environmental Index Use Case. Such use case reflects in several of the previously listed use cases and defines how data collected by sensors and external sources must be used in order to properly calculate an overall value describing the environmental footprint of each port with respect to surrounding areas.

PEI Evaluation [92]
PEI should be automatically evaluated on a monthly basis according to the availability of the required data, according to methodologies and algorithms which will be described in detail D5.2 and D5.3. In particular PEI evaluation model will focus on several aspects of environmental impact, by aggregating such partial results in the overall Port Environmental Index.
Acceptance criteria: A model for PEI evaluation is available.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PEI,OT
Use-case: Port Environmental Index (PEI)
Scenario: GENERIC
Rationale: To be able to automatically evaluate the PEI of each partner according with available data, collected by means of IoT sensors, third party data providers or manually inserted aggregated information.
Customer Satisfaction: 3
Customer Dissatisfaction: 3

PEI Data Sources [93]
- PIXEL should allow PEI to be calculated according to business rules and algorithms defined in detail D5.2 and D5.3, for each use case, by integrating the following: • heterogeneous data collected by a wide set of interconnected sensors (e.g.: air quality sensor, water quality sensor), aimed at feeding the Pixel Information Hub in real-time on a monthly basis;

• historical data, already available at each stakeholder or provided by third parties; • manually provided aggregated data; • simulated data (average of values, common values, etc.) in case that some necessary inputs are not available and cannot be entered manually neither.
Acceptance criteria: PEI input data available through an API call.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PEI,IH
Use-case: Port Environmental Index (PEI)
Scenario: GENERIC
Rationale: To be able to different sources of information required by PEI calculation.
Customer Satisfaction: 3
Customer Dissatisfaction: 3

PEI Notification [94]
PIXEL must provide users with a simple and effective web interface aimed at collecting aggregated data. PIXEL should, in particular, be able to notify stakeholders when new inputs are required in order to keep PEI updated.
Acceptance criteria: Notification are generated when data is required in order to perform PEI calculation.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PEI,ID&N
Use-case: Port Environmental Index (PEI)
Scenario: GENERIC
Rationale: To be able to notify stakeholders when new inputs are required in order to keep PEI updated.
Customer Satisfaction: 3
Customer Dissatisfaction: 3

PEI Dashboard [95]
The PIXEL dashboard/user interface should visualize both the PEI and the constituent sub-indices. PIXEL should provide, for each input field, a brief description of the impact of the field for PEI evaluation.
Acceptance criteria: A dashboard aimed at navigating PEI and constituent sub-indices is available.
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PEI,ID&N
Use-case: Port Environmental Index (PEI)
Scenario: GENERIC

Rationale: To be able to provide stakeholders with a significant set of information about current PEI and its constituent sub-indices.
Customer Satisfaction: 4
Customer Dissatisfaction: 4

PEI Dashboard – Time series [96]
PIXEL must provide an effective web interface to present to the stakeholders the calculated PEI, for each use case including the evolution of PEI over time. In particular, the interface should visualize (by means of drill down operations) data in order to identify events which significantly affected a change in the calculated PEI value. Drill-down will focus on business rules and algorithms which will be described in detail D5.2 and D5.3.
Acceptance criteria: A dashboard aimed at visualizing PEI values over time is available
MoSCoW Priority: MUST HAVE
Category and Type: Functional – Functionalities
Product: PEI,ID&N
Use-case: Port Environmental Index (PEI)
Scenario: GENERIC
Rationale: To be able to provide stakeholders with a significant set of information about current PEI and its constituent sub-indices over time.
Customer Satisfaction: 3
Customer Dissatisfaction: 2

3.2.6.1. Analysis

Port Environmental Index related requirements represent one of the pillars of the PIXEL project; in particular they focus on how PEI must be calculated and which kind of data will be part of such evaluation (as described in detail in D5.2 and D5.3). **The importance of such requirements got the PIXEL project is reflected by their priority: all of them have been classified as "Must Have".**

4. Requirements Analysis

The PIXEL project is strongly based on three main pillars: **IoT**, **modelling** and **PEI calculation**. In order to provide a better understanding of how functional requirements fit into such topics, diagram in Figure 19 has been defined. Requirements' distribution between the three pillars clearly shows how such topics are strongly interconnected each other and cooperate in order to achieve project's goals. Both modelling and PEI calculation deeply depend on sensors, data and third party systems described in detail in IoT related requirements. This set of heterogeneous information is collected by PIXEL inside the PIXEL Hub and used, when required, for both modelling and PEI calculation purposes, in a unified and transparent way. Such relationship between requirements and topics occur in a similar way in each analyzed use case.

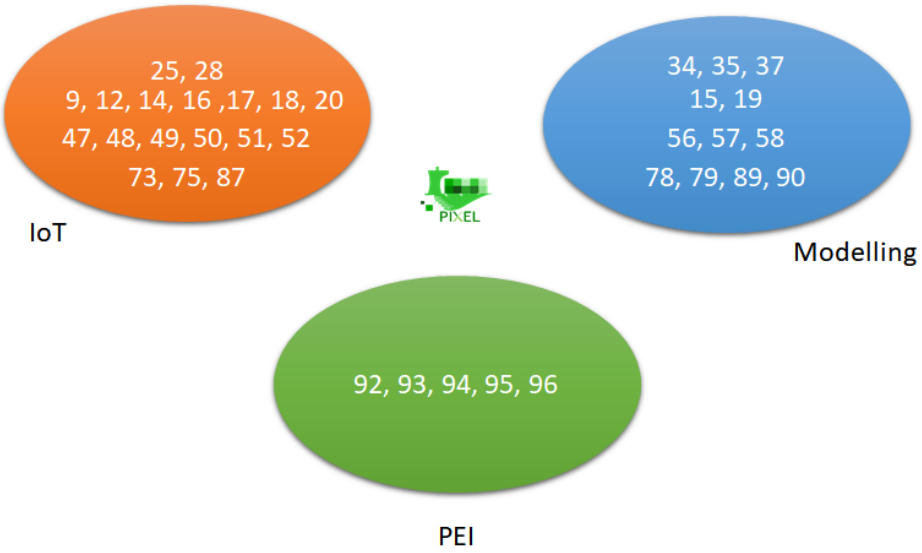

Figure 19: Requirements classification according to PIXEL's pillars.

Several requirements do not fit well inside such classification (e.g.: non-functional requirements, common functional requirements and, more specifically, requirements concerning integration with a specific third party system such as SILI, VIGIESIP, etc.).

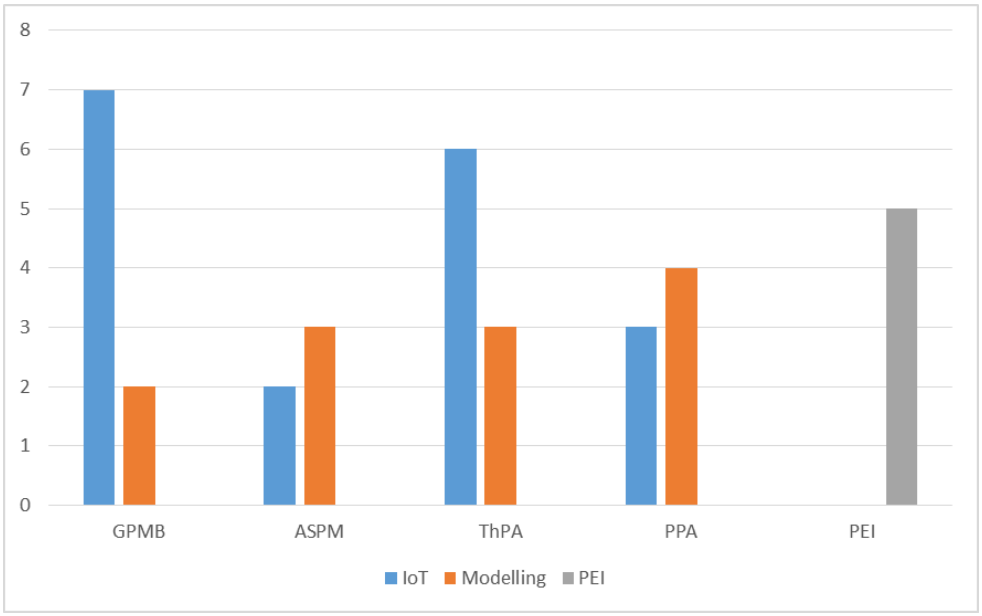

Figure 20: Requirements by pillar for each Use Case.

Figure 20 provides a clear representation of requirements identified by each partner with respect to the three pillars of PIXEL's project.

Figure 21, Figure 22 and Figure 23 describe the different category and type assigned to each requirement (according to the VOLERE methodology and the classification schema described in detail in 2.1.2) considering the whole set of requirements covering the five use cases, the common functional requirements and the non-functional requirements. Functional requirements represent the most significant category of requirements collected by PIXEL's stakeholders; non-functional requirements are limited to 17% of the total amount of collected requirements.

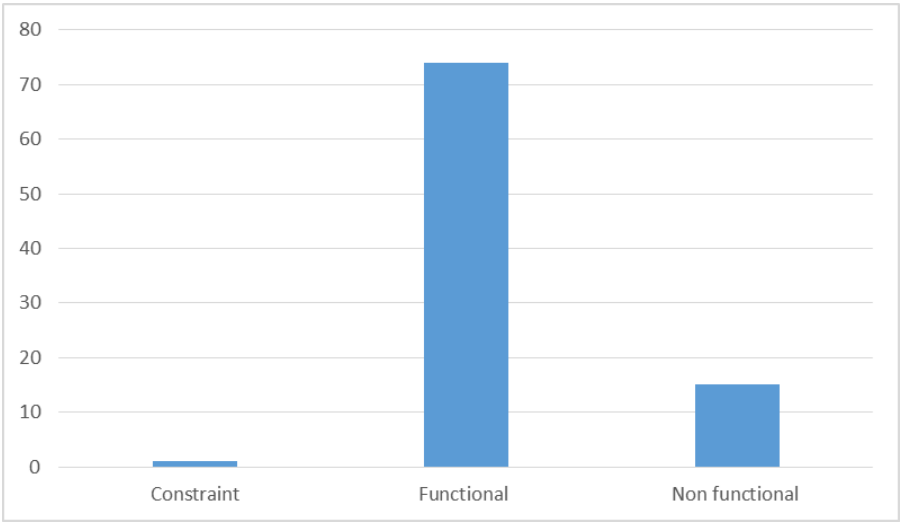

Figure 21: Requirements by category.

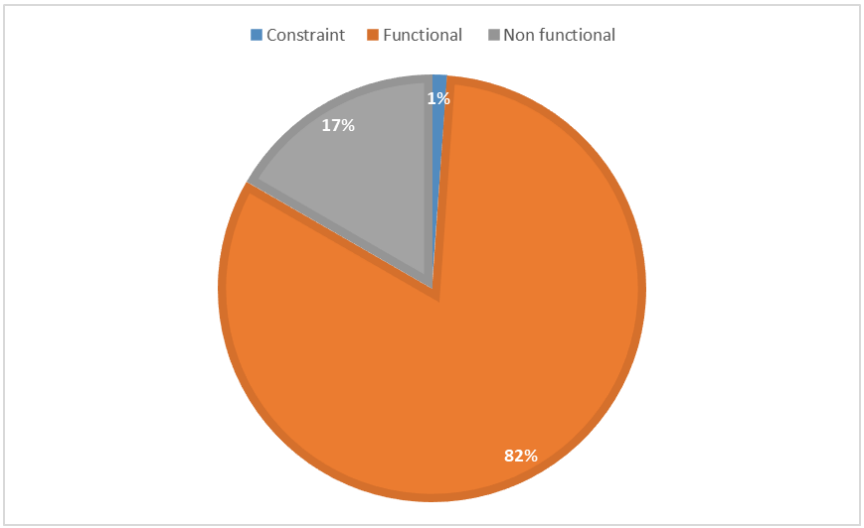

Figure 22: Requirements by category.

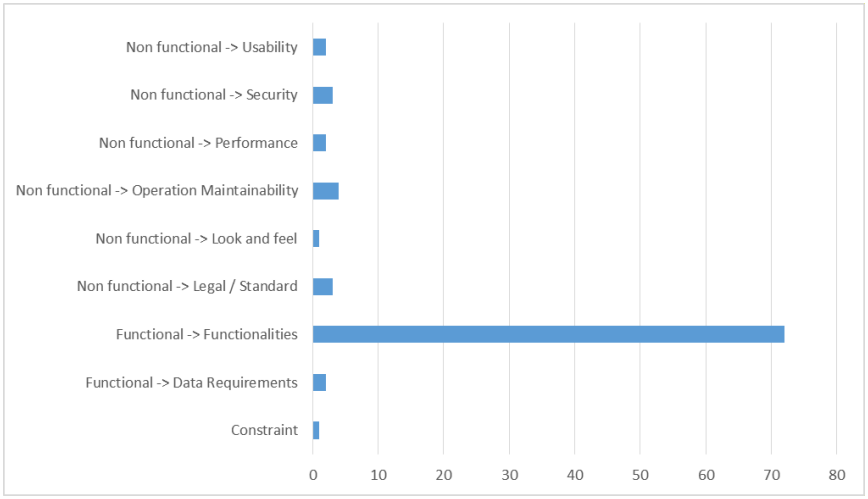

Figure 23: Requirements by category and type.

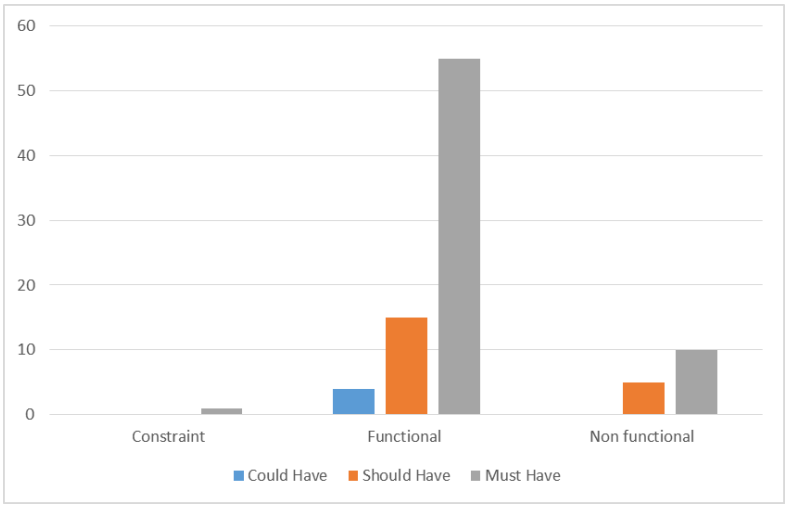

Figure 24: Requirements by priority and category.

The priority of the requirements can be analysed according to Moscow methodology. **The priority of most requirements is perceived as very high by stakeholders for each category, including non-functional requirements**. Such distribution is common also when functional requirements are aggregated according to their respective use case, as shown in Figure 25. ASPM presents, as an anomaly, 3 requirements classified as "Could Have", which covers optional area of investigation of the PIXEL project. Due to integration issues (at both political and technological level) such requirements could not be properly investigated and satisfied by PIXEL platform and solution.

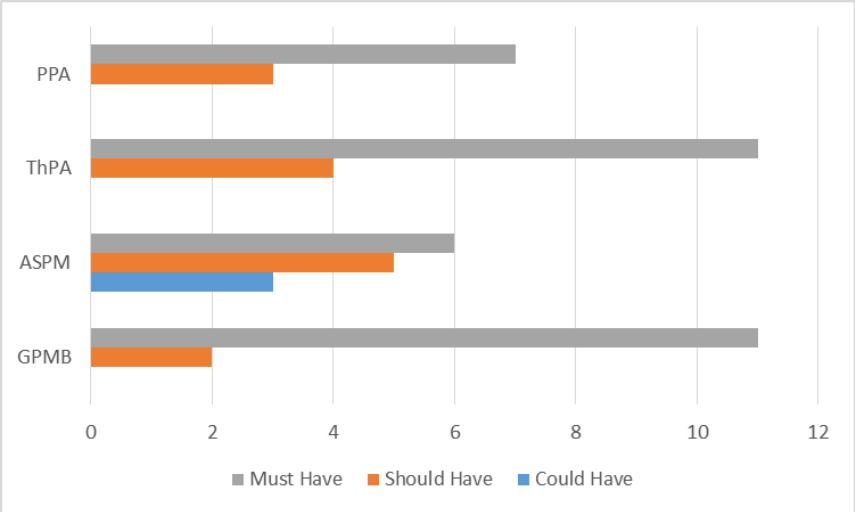

Figure 25: Requirements by priority and use-case.

Another clear clue of the relevance of collected requirements is provided by the analysis of Customer Value assigned by stakeholders to each requirement. By filtering out requirements with a Customer Value equals to 1 in terms of both Customer Satisfaction and Customer Dissatisfaction (not provided by requirements authors and validators), the average **Customer Value assigned to each requirement is 3,6** (expressed in terms of Customer Satisfaction) **and 3** (expressed in terms of Customer Dissatisfaction). Collected requirements express, in fact, ports' needs and expectations: PIXEL products will be designed and developed focusing on such feedback and on priorities expressed by stakeholders.

In order to provide a better understanding of how PIXEL outcomes will cope with collected requirements, diagram in Figure 26 has been included. IH and DAL are the modules, which will impact at most on the port activities, allowing them to collect, integrate and aggregate an heterogeneous set of data sources, including IoT sensors, data feeds, existing archives. IH and DAL can be seen as the modules of the PIXEL architecture aimed at implementing IoT support and features, one of the pillars of the PIXEL project.

Another relevant aspect of the PIXEL project, concerning modelling and forecasting, is represented by requirements covering both MO and PA. Such products, in fact, deal with modelling and forecasting activities, by providing ports with a set of tools aimed at proficiently cope with respective use cases. In particular PA and MO will be proficiently exploited in order to perform:

- Transport Modeling;
- Pollution Modeling;
- Energy Modeling;
- Traffic Forecasting.

Requirements associated with OT and IDN&N cope with the needs, expressed by each port, to be able to visualize, analyze and manage data (in terms of collected data, forecasted data, simulated data, PEI calculation) in a centralized and effective way.

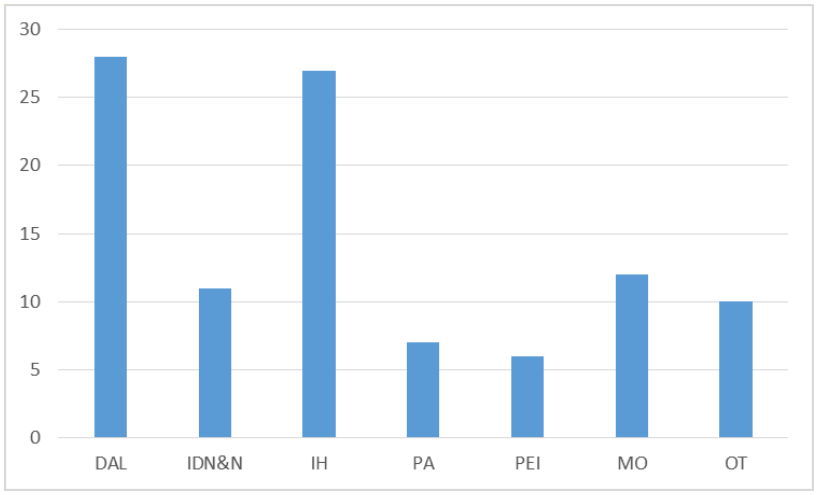

Figure 26: Requirements by product.

Figure 27 describes how requirements related with specific products of the PIXEL platform are classified according to their use-case. According to previous assumptions, DAL and IH are most relevant products in each use case, by allowing ports to integrate several different information systems already used for each port's operations. While GPMB is more focused the PA module, aimed at providing prediction and forecasting capabilities (in terms of energy consumption and production with respect to planned port activities), ASPM, THPA and PPA are more interested in modeling optimization and analysis (in terms of pollution and traffic modeling).

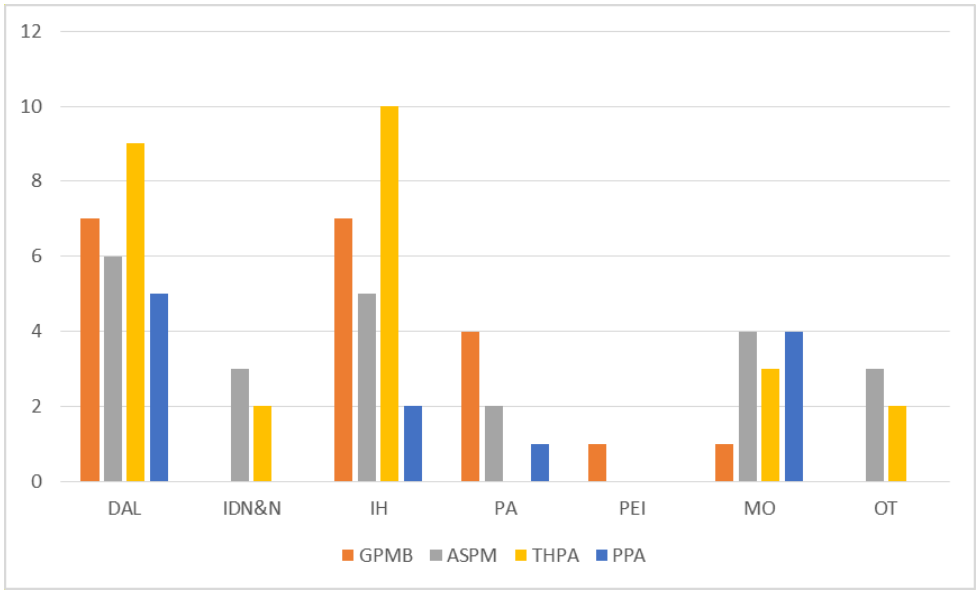

Figure 27: Requirements by product and use-case.

5. Conclusions

Requirements collection and analysis performed as part of T3.2 represent one of the cornerstones of PIXEL's project; thanks to the outcomes of such analysis, in fact, we are able to describe in detail what different stakeholders want to achieve thanks to the set of PIXEL tools. By knowing such set of features and functionalities a more effective design and development of PIXEL tools could be performed. T3.2 is aimed, more specifically, at bridging between use cases (as described in D3.2 and D3.4) and development activities (which will be part of next work packages, involving both modelling and platform development).

In order to minimize risks, optimize effectiveness and development time, a formal and standardized approach, based on the VOLERE Methodology, has been adopted by the Consortium. Different stakeholders involved in the PIXEL project (e.g.: ports, technological partners) have been involved in the requirement collection and analysis process, by asking them to provide their own contents, validate such contents each other and cooperate in a collaborative environments. Such approach provides an effective mechanism for requirement validation and identification of missing information. In order to achieve stakeholders' active collaboration, the JIRA platform (tailored to manage the VOLERE template described in detail in Chapter 2) has been adopted; it acts as a web-based centralized repository requirements, where each stakeholder can provide her/his own contents and validate what already provided by the other users. Such tools proficiently supported stakeholders during the iterative workflow adopted for requirements collection and validation.

PIXEL's stakeholders provided more than 100 validated requirements, covering all different use cases defined by the project for each port and for the PEI calculation process. In particular such set of requirements includes both functional requirements (what the system must do) and non-functional requirements (which properties the solution must be able to provide), which will be used as a reference during both design and development activities. Such set of requirements may change during the life-cycle of the PIXEL project, due to the iterative nature of requirement analysis process; in order to support future evolution of requirements the JIRA platform will stay active until the end of the project and work as a knowledge base for each stakeholder involved in the project.

Most of the collected requirements are functional requirements: they are used by stakeholders to describe the functionalities that PIXEL tools must provide in order to allow use cases to be effectively exploited. In particular such requirements, for each port, cover several aspects related with IoT (integration with sensors or existing systems, providing information), modelling (which models are required by each use-case in to provide a value to each stakeholder according to its context) and data availability.

Non-functional requirements, collected mostly by technical partners, describe, on the other hand, which properties the proposed set of tools must achieve in order to implement required functionalities and grant interoperability and portability (in particular by considering that the PIXEL project is aimed at being adopted by several small or medium European ports).

The priority of most requirements is perceived as very high by stakeholders for each category, including non-functional requirements. PIXEL project, in fact, impacts on several aspects of ports 'activities, for each proposed use-case, and requires several information (provided by sensors of third party entities) to be collected in order to train and feed advanced models and generate relevant information (e.g.: PEI calculation, impact of port air pollution on the city, port energy consumption, etc.).

Legal compliance and issues have been considered as part of T3.2 in order to identify and describe related non-functional requirements. In particular impact of GDPR on proposed use-cases has been evaluated.