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D8.1 – Evaluation Plan

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Abstract

The goal of the present report is to formulate and explain a concrete methodology for the evaluation of the PIXEL Project in terms of the technical functioning and interoperability of all components of PIXEL, in terms of usability and finally regarding its results. More specifically, the evaluation plan aims to provide guidelines for the evaluation of the PIXEL enabling IT infrastructure and the PIXEL use cases ICT solutions. This evaluation strategy is structured around three main pillars, namely:

- The Technical Impact Assessment (connected to D8.2 and D8.3)
- The Business and Economic Impact Assessment (connected to D8.4) and
- The PIXEL Proof of Concept and future R&D potential (connected to D8.5).

The approach followed for the evaluation of each one of the above pillars is based on a common rationale, which has taken into consideration the FESTA (Field opErational teSt supporT Action) Methodology for assessing Field Operational Tests, and includes the following steps:

- Identification of goals and expected impacts;
- Identification of KPIs and associated targets;
- Identification of necessary data to be collected, allocation of roles among partners and formulation of relevant time plans.
- Identification of potential limitations.

A time plan for all of the above action is also proposed in each one of the separate chapters, as well as complete time plan for all of the actions of WP8.

As regards the Technical Impact Assessment, this comprises Task 8.2 and aims to assess the technical performance of the PIXEL enabling IT infrastructure and of the ICT solutions implemented within each use case, namely the Port of Bordeaux, the Port of Monfalcone, the Port of Piraeus and the Port of Thessaloniki. Based on the methodology to be implemented, which is explicitly mentioned in the present report, the technical evaluation will focus on the technical performance, the user acceptance and the information security and robustness. The methodology has been based on three evaluation models; the ISO/IEC 25010 Product Quality Method, the ISO/IEC Quality in Use Model and the ISO/IEC 25012 Data Quality Model. Specific KPIs and expected benefits have been identified for both the PIXEL Platform and the ICT solution, while the data to be collected and responsible parties have been identified. The main limitations foreseen are related to overlapping with other project actions, as well as lack of available and suitable data.

Following, the Business and Economic Impact Assessment aims to assess the impacts of the ICT solutions implemented in each use case, focusing on operational issues, organizational issues and societal-environmental issues. The business and economic impact of the measures implemented in the four pilot sites will be assessed through the conduction of a typical Cost-Benefit Analysis, which will be conducted based on the "Guide to Cost-Benefit Analysis of Investment Projects" published by the European Commission (EC). For each one of the ports, specific cost items have been identified, along with expected quantitative and qualitative benefits. Moreover, the evaluation criteria are identified, per port, along with data collection time plans and responsibilities. The main limitations mentioned are related to lack of data (due to lack of statistical data and/or lack of high number of respondents), as well as to the lack direct economic benefits accruing from the implementation of the measures.

Finally, the third pillar of the evaluation methodology is dedicated to the Proof of Concept of the PIXEL solution, by widening the assessment scope, taking into account wider user community requirements that exist today or are emerging, and inquiring if the PIXEL concept can cover those as well. More specifically, the methodology described aims to identify future research directions and extend the assessment/evaluation by building a proof-of-concept (PoC) in external ports. The Proof-of-Concept foresees the participation of external ports, while the transferability approach included the following steps: short analysis of existing use cases and developed technologies; identification of candidate external ports/port entities; selection of candidate external ports/port entities; engagement of external ports/entities; definition of (small) use cases and requirements;

deployment (and training, if required); test & Evaluation (KPIs). The main limitations foreseen are related to lack of willingness on behalf of external ports to participate, timing issues, data availability and costs.

Statement of originality

Table of contents

Table of contents 5
List of tables 7
List of figures 8
List of acronyms 9
1. Introduction 11
1.1. Objectives & scope of the document 11
1.2. Deliverable context and structure 11
1.3. Intended audience 12
2. Evaluation approach & interrelation to other WPs 13
2.1. Overall evaluation approach 13
2.2. Interrelation with other WPs and/or Tasks 15
3. Technical Impact Assessment 16
3.1. Technical Impact assessment of the PIXEL Platform 17
3.1.1. Aim and scope 17
3.1.2. Expected impacts 18
3.1.3. Evaluation methodology 18
3.1.4. Evaluation criteria (KPIs) and performance targets 21
3.1.5. Measure methods & responsible parties 24
3.1.6. Implementation actions and time plan 26
3.1.7. Potential limitations and related contingency plans 28
3.2. Technical impact assessment of the PIXEL Use Cases 28
3.2.1. Aim and scope 28
3.2.2. Expected impacts 28
3.2.3. Evaluation methodology 29
3.2.4. Evaluation criteria (KPIs) and performance targets 30
3.2.5. Data collection methods & responsible parties 33
3.2.6. Implementation actions and time plan 33
3.2.7. Potential limitations and related contingency plans 34
4. Business and economic impact assessment of the PIXEL Use Cases 35
4.1. Aim and scope 35
4.2. Evaluation methodology 35
4.3. Expected impacts 36
4.4. Evaluation criteria (KPIs) 38
4.5. Data collection methods & responsible parties 45
4.6. Implementation actions and time plan 45
4.7. Potential limitations and related contingency plans 46

5. Proof of Concept and future R&D potential 47
5.1. Aim and scope 47
5.2. Methodological approach 47
5.2.1. Future R&D potential 47
5.2.2. Proof of Concept 48
5.3. Data collection methods & responsible parties 52
5.3.1. Proof of Concept 52
5.3.2. Future R&D potential 53
5.4. Implementation actions and time plan 54
5.4.1. Future R&D potential 54
5.4.2. Proof of Concept 54
5.5. Potential limitations and related contingency plans 55
6. Conclusions and next steps 57
References 59
Appendix A – ISO/IEC 25010:11 – Product Quality Model 60
Appendix B – ISO/IEC 25010:11 – Quality In Use Model 62
Appendix C – ISO/IEC 25012:08 – Data Quality Model 63
Appendix D – Technical Impact Assessment Survey 64
D.1. Survey about the Technical Impact Assessment 64

List of tables

Table 1. Deliverable context 11
Table 2: Consortium answers to the application of Product Quality Model characteristics to PIXEL platform (green: must be assessed, yellow: should be assessed, orange: could be assessed, red: won't be assessed) 20
Table 3: Identified KPIs for each sub-characteristic of the Product Quality Model 21
Table 4: Expected PIXEL software components and partners responsible for technical evaluation 24
Table 5: KPI evaluation for PIXEL tasks results 25
Table 6: Consortium answers to the application of "Quality In Use Model" and "Data Quality Model" characteristics to PIXEL platform use cases (green: must be assessed, yellow: should be assessed, orange: could be assessed, red: won't be assessed) 29
Table 7: Port users' classification 31
Table 8: Quality In Use Model evaluation criteria 31
Table 9: Data Quality Model evaluation criteria 32
Table 10: Cost items and expected benefits per pilot site 36
Table 11: KPIs for the Port of Bordeaux 39
Table 12: KPIs for the Port of Monfalcone 41
Table 13: KPIs for the Port of Piraeus 42
Table 14: KPIs for the Port of Thessaloniki 43
Table 15: Data collection responsibilities for Task 8.3 45
Table 16: Sample table for future R&D potential 48
Table 17: UC analysis for transferability purposes 49
Table 18: PIXEL product analysis for transferability purposes 49
Table 19. Data collection for PoC 52
Table 20. Data collection for R&D 53
Table 21. Future R&D time plan 54
Table 22. PoC time plan 55

List of figures

Figure 1: Applying FESTA to formulate the PIXEL evaluation methodology 14
Figure 2: Interrelation of the Evaluation Methodology with other WPs 15
Figure 3: ISO/IEC 25010:11 - Product Quality Model 18
Figure 4: Global Architecture: technical impact assessment will be done for each module 19
Figure 5: Evaluation steps and platform releases relation 27
Figure 6: Implementations actions and time plan for the PIXEL platform use-cases impact assessment..... 34
Figure 7: Expected Time-Plan for Task 8.3 46
Figure 8: TIDE methodology schema(7) 52
Figure 9: Consolidated Gantt chart for WP8 58

List of acronyms

Acronym	Explanation
AB	Advisory Board
API	Application Programming Interface
ASPM	Azienda Speciale per il Porto di Monfalcone
CBA	Cost-Benefit Analysis
CPU	Central Processing Unit
CSA	Coordination and Support Action
DoW	Description of Work
DSS	Decision Support System
EC	European Commission
ESPO	European Sea Ports Organisation
FESTA	Field opErational teSt supporT Action
FOT	Field Operational Test
FVG	Friuli Venezia Giulia Region
GA	Grant Agreement
GCS	Gate Control System
GHG	GreenHouse Gases
GPMB	Grand Port Maritime de Bordeaux - Port of Bordeaux
GUI	Graphic User Interface
ISO	International Organization for Standardization
IoT	Internet of Things
KPI	Key Performance Indicator
MC	Mobility Case
MS	Milestone
OS	Operating System
PCT	Port City Terminal
PCS	Port Community System
PEI	Port Environmental Index
PIXEL	Port IoT for Environmental Leverage
PoC	Proof of Concept
PPA	Piraeus Port Authority SA
PQM	Product Quality Model
RAM	Random Access Memory
SQUARE	Software Quality Requirements and Evaluation

Acronym	Explanation
ThPA	Thessaloniki Port Authority
TEN-T	Trans-European Transport Networks
TMC	Traffic Management Centre
WCAG	Web Content Accessibility Guidelines
WP	Work Package

1. Introduction

1.1. Objectives & scope of the document

The present report comprises the first outcome of WP8, dedicated to the Assessment and Expansion Plan of the PIXEL Project and its specific results. The main goal of the document is to formulate and explicitly describe the evaluation plan that will be implemented in order to assess:

- The PIXEL enabling IT infrastructure
- The PIXEL use cases ICT solutions.

More specifically the evaluation approach that comprises the content of this document will be structured around 3 main pillars:

- Technical evaluation of PIXEL Platform and use cases' ICT solutions
- Business and Economic Impact of the PIXEL use cases
- Proof of concept and R&D Impact of the PIXEL Platform

Based on the above, D8.1 presents the goals to be met, the key parameters to be assessed and the data to be collected, along with the corresponding data sources and data collection methodologies for each one of the different pillars. Specific and concrete timeframes and related deadlines are foreseen for all the actions to be undertaken, so that the evaluation is realized in a timely and efficient manner. Allocation of roles and responsibilities among partners are also dealt with in this document.

Once the evaluation methodology described hereafter has been implemented, the outcomes will be presented in four different deliverables:

- D8.2 and D8.3 – Technical Evaluation;
- D8.4 Business and economic assessment report
- D8.5 PIXEL external evaluation and proof of concept report

1.2. Deliverable context and structure

The positioning of the document in the overall Project Work Plan, in terms of the objectives to which it is related, the results expected and the relevant milestones and deliverables, is explained in the following Table 1.

Table 1. Deliverable context

Keywords	Lead Editor
Objectives	The overall goal of WP8 is to evaluate the project in terms of (i) technical functioning and interoperability of all PIXEL Components, (ii) usability and (iii) results. The scope of D8.1 is to formulate a concrete methodology that will enhance the previously mentioned evaluation. In this respect, the present report is relevant to all seven of the Project objectives, set in the GA, as it will provide the guidelines for testing if they have in fact been met.
Exploitable results	This deliverable contributes to all the exploitable results in the sense that it provides the roadmap for the evaluation of achieved results and the provision of recommendations for corrective actions which, once implemented, will ensure the achievement of the set objectives. This report also paves the way through the Proof of Concept and future R&D potential assessment for the real deployment of project results in external to the project ports.

Keywords	Lead Editor
Work plan	This deliverable has close links and interrelations with all the technical WPs. More specifically D8.1 is related to: • WP3 through tasks 3.3 and 3.4 and deliverables D3.2, D3.3 and D3.4 • WP4 through all of the tasks and the specific reports D4.2 and D4.4 • WP5 through tasks 5.4 and 5.5 and specifically D5.4. • WP6 which is fed by WPs 4 and 5 through the previously mentioned tasks • WP7 through all of the foreseen tasks as those are dealing with the pilot trials. Finally, the present report is expected to provide guidance for and input to the Business and Exploitation Plan to be formulated in the framework of WP9.
Milestones	MS10 – Final Evaluation (Means of verification: D8.5 and D8.6 released and approved).
Deliverables	Detected inputs from D3.2, D3.3, D3.4, D4.2, D4.4, D5.4 Detected outputs to D8.2 – D8.5, D9.7, and D9.8.
Risks	During the timeframe that this report is being prepared several other reports related to the PIXEL platform and the individual pilot cases are also in the making. The risk that this fact entails is the difficulty in finalizing the specific Key Performance Indicators (KPIs) to be measured and assessed for each one of the three pillars. The technical partners involved in the formulation of D8.1 are taking all the necessary actions to define as explicitly as possible these KPIs.

1.3. Intended audience

The scope of the present report is to define the methodology to be implemented in order for the PIXEL platform and the individual pilot cases to be evaluated and as such, it is intended to be reviewed and implemented by all Project partners. More specifically, the audience to which this deliverable is addressed includes:

- The partners responsible for the three pillars of the evaluation (CATIE, CERTH and UPV);
- The rest of the technical partners involved in all the technical actions of the project such as definition of the use cases, PEI definition and adoption and PIXEL Platform designing;
- The PIXEL partners in each pilot site, namely ThPA, PPA, ASPM and GPMB).

Apart from the above, this report is also addressed to the European Commission (EC) and specifically the Project Officer responsible for ensuring that the project objectives are met in the most efficient and effective manner.

2. Evaluation approach & interrelation to other WPs

2.1. Overall evaluation approach

The main goal of WP8 as this is defined in the GA is to evaluate the project concerning the technical functioning and interoperability of all components of PIXEL, the usability and the achieved results. The steps to be taken towards this direction include:

- The development of an evaluation plan to guide the assessment activities of the project outputs;
- The assessment of the technical performance of the PIXEL 'enabling IT infrastructure' and of the ICT solutions implemented within each use case.
- The identification and improvement of possible system gaps (e.g., flexibility, reliability, scalability, safety, etc.).
- The definition of the business potential and the economic impact of PIXEL.
- The specification of scalable transferability of the results to other ports with independence of the size.
- The provision of evidence of PIXEL's proof of concept and R&D potential.

Based on the above and as already mentioned, the PIXEL evaluation approach will be structured around 3 main pillars, namely:

- Technical impact assessment (Task 8.2);
- Business and economic impact assessment (Task 8.3) and
- PIXEL Proof of Concept and future R&D potential (Task 8.4).

Each one of the above pillars will comprise a different chapter of the present report. However, the approach to be followed is structured following a common rationale and it is expected to deal with the issues mentioned below:

- Identification of the project goals and associated expected impacts in relation to each one of the assessment categories.
- Identification of specific and concrete evaluation KPIs and related performance targets in each case. As targets are considered the ones mentioned in the relevant section of the Grant Agreement (GA).
- Identification of the kinds of data that is necessary to be collected in order to measure the identified KPIs for each one of the pillars.
- Allocation of responsibilities among partners for the data collection procedure and specification of the methods that should be followed.
- On time identification of potential limitations that may come up in regards to the above actions and formulation of the relevant contingency plan.
- Time plan formulation to achieve all the above goals in due time.

The specific evaluation approach for each of the three pillars is explained in the chapters that follow. An overall common approach will be followed however which has taken into consideration the FESTA (Field opErational teSt supporT Action) Methodology for assessing Field Operational Tests (1). The application of the FESTA Methodology in order to formulate the evaluation methodology of the PIXEL Project is depicted in Figure 1 that follows:

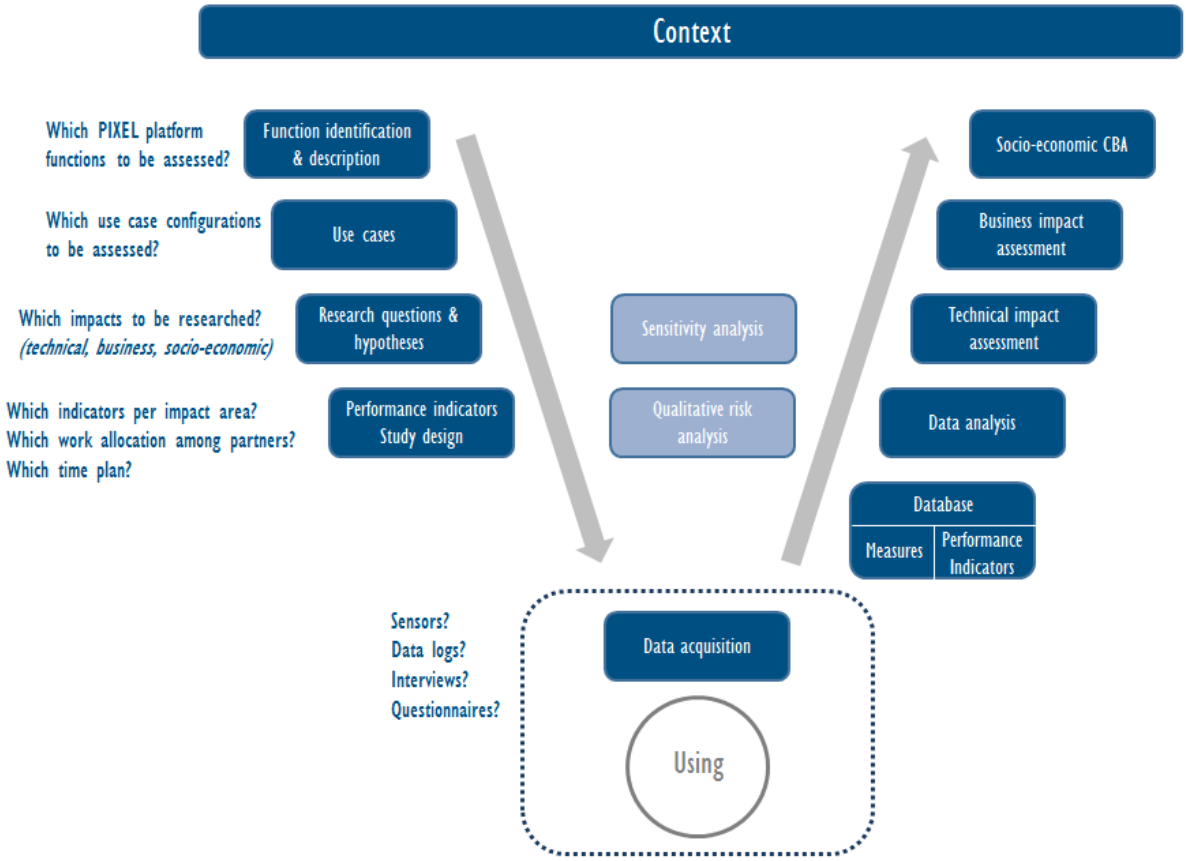


Figure 1: Applying FESTA to formulate the PIXEL evaluation methodology

Based on the figure above, the first step to be taken regards the identification of the functions of the PIXEL platform, as well as of the use cases that will be assessed. This part is mostly related to the technical evaluation. Following, the expected impacts that have been foreseen at the GA it will be discussed and finalized in terms of which one will be finally researched and examined as regards the degree of their achievement. This part is relevant to both the technical and business and economic assessment.

The next step of the evaluation includes the identification of the evaluation KPIs per assessment category, meaning per pillar. At this point, the partners will also define the allocation of work among the responsible parties, the data collection procedures and the relevant time plans.

Once the three different tasks dedicated to each one of the assessment pillars have started, the data collection procedure will also commence. This will be done following the methods, responsibilities and time plans defined at the earlier step. The data collection methods will include sensors, data logs, personal interviews, group questionnaires and any other type proposed and accepted by the responsible partners. The data collected will be stored in suitable for each kind of information data bases and hence the analysis will start. The final products of this procedure will be as follows:

- The analysis of the technical data will lead to the technical assessment of the PIXEL Platform and use cases and to the provision of recommendations for further improvement.
- The analysis of business, economic and socio-economic data will lead to a socio-economic cost-benefit analysis (CBA) providing insight to the actual benefits that a port may acquire from the proposed by the PIXEL Project interventions.
- Finally, the Proof of Concept analysis will conclude on whether or not the PIXEL Concept will be able to cover the extended and emerging community requirements, as well as try and demonstrate the validity of the PIXEL Concept and its potential to be used in major European ports.

2.2. Interrelation with other WPs and/or Tasks

Given the fact that WP8 aims to evaluate the project outcomes, it is by default interrelated to almost all the other WPs, several Tasks and associated deliverables. The following Figure 2 has been prepared to graphically demonstrate the many interrelations of the evaluation task with the rest of the project actions.

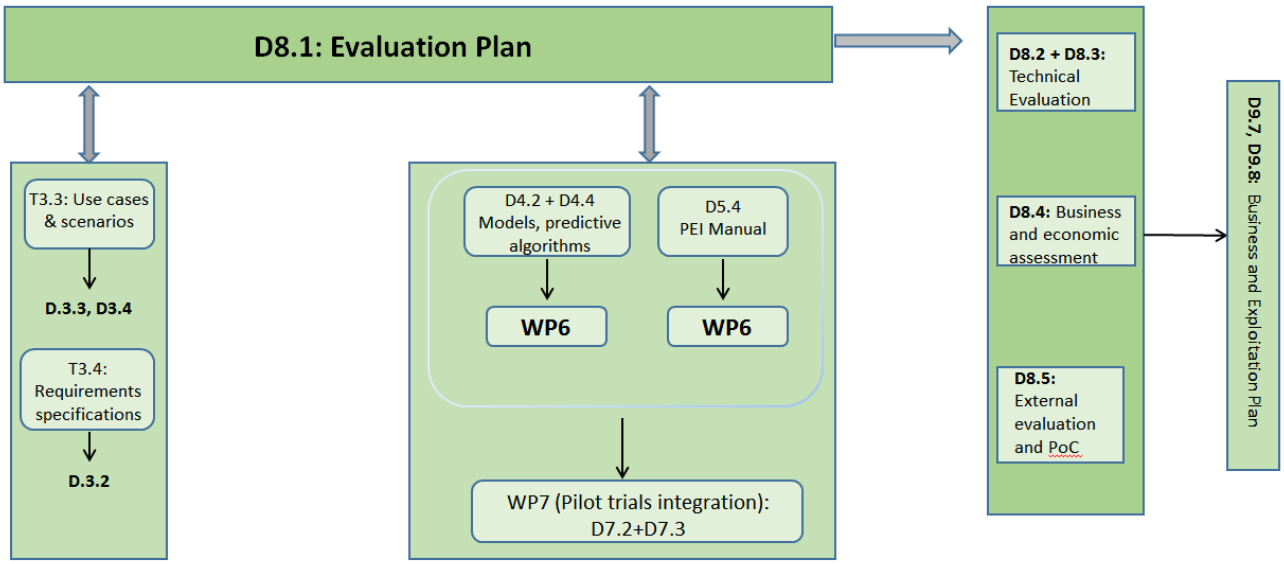


Figure 2: Interrelation of the Evaluation Methodology with other WPs

In the framework of Task 3.3 the definition of use cases and scenarios for port environmental issues took place, whereas during Task 3.4 the requirements were specified. Both of these tasks have set the basis for the definition of evaluation KPIs in the framework of Task 8.1 and hence the present evaluation plan. The detected needs and use cases mentioned in the reports deriving from these two tasks, namely D3.2 and D3.4, will be updated if needed during the project and as the evaluation plan is being implemented.

The PIXEL Models (D4.1 and D4.2) and the Predictive algorithms (D4.3 and D4.4) comprise the output of WP4. Along with the output of WP5, being the development of the PEI (D5.3 and D5.4), they feed WP6 which delivers the enabling ICT infrastructure framework (D6.1-D6.4). All these will lead to the pilot trials integration and deployment (D7.2 and D7.3) which will be evaluated in the framework of WP8 implementing the evaluation methodology described in the present report. From the three pillars structuring the evaluation methodology, the most relevant in this case is the technical evaluation.

Following, D8.1 is the basis of the rest of the reports to be produced in the framework of WP8, specifically D8.2-D8.5, which will include the technical evaluation (v1 and v2), the business and economic assessment and the external evaluation and proof of concept. The latter is also related to D3.1 which contains the state of the art review and stakeholders and market analysis in regards to the PIXEL technologies and proposed solutions. Once the proof of concept has been validated during the evaluation procedure, information deriving from the D3.1 will be updated in the framework of D8.5.

Finally, it should also be mentioned that D8.4 that will include the socio-economic CBA will provide input to the Business and Exploitation plan (D9.7 and D9.8) scheduled to be produced in the framework of WP9 (Exploitation, dissemination and communication).

3. Technical Impact Assessment

The Technical Impact Assessment will be conducted for both the PIXEL Platform (for the evaluation of the IT part of the PIXEL project) and the PIXEL use cases (for the evaluation of the user acceptance and data quality). It will focus on:

- Technical performance;
- User acceptance;
- Information security and robustness.

Investment and operational costs, however, will be assessed in the business and economic part.

To develop the technical impact assessment framework, we will base our work on three evaluation models: These models are based on the International Standards on System and Software Quality Requirements and Evaluation (Square):

- The first model (ISO/IEC 25010 Product Quality Method) is related to the evaluation of the PIXEL platform in regards to the properties of the software and the dynamic properties of the system.
- The second model (ISO/IEC Quality in Use Model) is directly linked with the assessment of the usage evaluation of the platform by end-users (ports for PIXEL).
- The last model (ISO/IEC 25012 Data Quality Model) is somehow complementary with the two others since it refers to the evaluation of the data provided by PIXEL platform.

For the technical impact assessment of PIXEL these models will be used, adapted or modified to our specific context. The ISO standard defines a list a characteristics and sub-characteristics for each of the three models. In order to clearly identify which ones of these characteristics are applicable to PIXEL, a survey (available in Annex) has been shared with the whole consortium. Results of this survey are described and analysed in the following section. We will use them as a basis for the technical impact assessment.

For each characteristics or sub-characteristics listed in the ISO standards, PIXEL consortium has agreed on which ones must be assessed and established how to measure them. The objective of the following section is to describe what are the evaluation criteria, how they will be evaluated and collected and the associated schedule.

The technical impact assessment will be done in two phases, one in M20 and one in M36, each one leading to the creation of a technical assessment report (D8.2 and D8.3). Because of the early release date, the first impact assessment phase is more subject to encounter problems than the second one. However, for both phases' problems, alternative solutions will be able to be found in order to assist the consortium in evaluating the platform. They will be defined in the appropriate sessions about the potential limitations and the related contingency plans.

The main inputs for the Technical Impact Assessment will come from two different sources (later in this document, it is explained how and when these inputs are used for the technical impact assessment):

- The needs and requirements of the end-users (ports):
    - Deliverable D3.2 "PIXEL Requirements Analysis" which includes an analysis of the requirements.
    - Deliverable D3.4 "Use cases and scenarios Manual" which defines the use cases and different scenarios to deploy the PIXEL proposal.
- The technical work implemented in PIXEL (WP4, WP5, WP6 and WP7) and especially the following deliverables:
    - Deliverable D4.2 "PIXEL Models" which describes the overall methodology for environmental management of port and models description.
    - Deliverable D4.3 and D4.4 "Predictive Algorithms" which contains the development of new prediction and forecasting algorithms in the ports.
    - Deliverables D5.2 and D5.3 "PEI Definition and algorithms" which include a manual detailing the methodology for PEI, associated algorithms, and a software for PEI computation.

- Deliverable D6.1 and D6.2 "PIXEL Information system architecture and design" which includes a report about all the analysis and design activities performed to precisely specify the implementation tasks.
- Deliverables D6.3 and D6.4 "PIXEL data acquisition, information hub and data representation" which is the main asset of software documentation of the project, including data sources, collecting mechanisms, technologies, protocols, the operational analytics engine and tools and the visualization and notification module.
- Deliverable D6.5 "APIs and documentation for software extension" which is a technical specification of developed methods and services.

- Deliverables D7.1 and D7.2 "Integration report" which report about the integration activities including technical, organisational and operational aspects.

As WP7 will conduct the integration in the different port, they will have to calculate some KPIs about the IT performance and user-acceptance and reuse/overlap some calculation methods presented in the following. It is worth noticing that the work that will be done in WP7 and WP8 are complementary:

- WP8 defines the KPIs and evaluation criteria to measure and will assess them.
- WP7 will perform "integration and user acceptance tests" and "individual tests to software modules". Thus, WP7 will set up more of an iterative design of the integration of the PIXEL platform than of a real assessment. It is more a specific or particular pre-assessment rather than a global assessment (WP8).
- In WP7 "key integration metrics such as performance, availability, and reliability will be established and tackled". To do this WP7 will be based on the evaluation criteria defined in WP8. In addition, the technical assessment done in WP8 will cover the PIXEL platform (IT part) either on a laboratory or/and on the port level, depending on the progress WP7.

3.1. Technical Impact assessment of the PIXEL Platform

3.1.1. Aim and scope

For the evaluation of the PIXEL platform, the consortium agreed to use the ISO/IEC 25010:11 "Systems and software engineering – Systems and software Quality Requirements and Evaluation (SQuARE) – System and software quality models" standards as a basis. The ISO standard is a well-known and well-trusted framework and used in many technical impact assessments. For the evaluation of the PIXEL platform, we will use the "Product Quality Model". This model is defined in the ISO/IEC 25010:11 as "a model composed of eight characteristics (which are further subdivided into sub-characteristics) that relate to static properties of software and dynamic properties of the computer system. The model is applicable to both computer systems and software products."

The evaluation of the PIXEL platform will have a close interaction with WP6 and with WP7 to its integration. The evaluation will be done by the technical partners of PIXEL. The time plan for this evaluation will follow the time plan of WP6 (software development advancements) and WP7 (integrations advancements). However, some interaction with WP4 and WP5 are also planned since performance of models, predictive algorithms and PEI software will also be assessed.

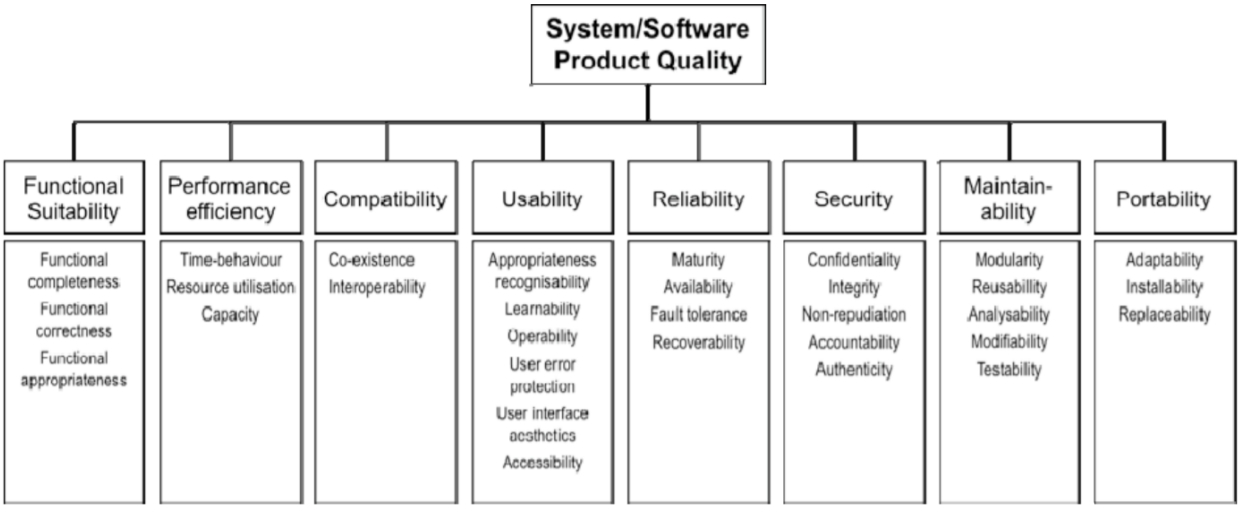


Figure 3: ISO/IEC 25010:11 - Product Quality Model

3.1.2. Expected impacts

PIXEL is creating technology enabled solutions which contribute to environmental control and port-city communication enabling better integrated services across different application domains. Technical developments of PIXEL are subordinated to business, economic, environmental and societal goals of ports, with special emphasis given on small and medium European ports. Thus, the expected impact of technical developments is to be derived from those higher-level goals of the project.

Technical results of PIXEL will provide interfaces, methods, and tools to further extend IoT usage and interoperability between different information sources and application domains. It is crucial to address different data types and origins to extend the impact of the project results by establishing a de-facto standard for operational data integration within the port area and related transport and city services. Once data is available, modelling, prediction and operational tools are going to be provided to leverage gathered data and provide actionable information to port stakeholders and decision-makers.

Thus, the main expected technical impacts are:

- Data sources integration among all actors involved in ports' environmental impacts (Port Authorities, terminal operators, shipping companies, customs, security forces, city authorities, etc.)
- Integration of IoT platforms and legacy data to address complex problems that require the management of a multitude of heterogeneous smart objects, devices and systems. These data sources include PMS, SCADAs, environmental information, sensors and remote sensing information. (PIXEL Data Acquisition)
- Fusion and mining of the produced heterogeneous data streams (modelling, trends, predictions, PIXEL Information Hub, PIXEL Operational Tools)
- Facilitation of critical decision-making by provision of integrated dashboards, notifications and operational tools for modelling, simulation and prediction of port operations in a single DSS (Decision Support System).

3.1.3. Evaluation methodology

The product quality model describes eight characteristics for system and software quality. Each of these characteristics is decomposed in a set of related sub-characteristics. Their descriptions proposed by ISO/IEC 25010:11 is available in appendix.

The product quality model is focused on computer systems and software products and useful to establish measures and perform quality evaluations. In PIXEL, the Product Quality Model will be used to ensure a comprehensive treatment of quality requirements. As described in deliverable D6.1 "PIXEL Information System Architecture and Design v1.0", the global architecture of the PIXEL platform is composed of five modules:

- PIXEL Data Acquisition
- PIXEL Information Hub
- PIXEL Operational Tools
- PIXEL Integrated Dashboard and Notifications
- PIXEL Security and Privacy

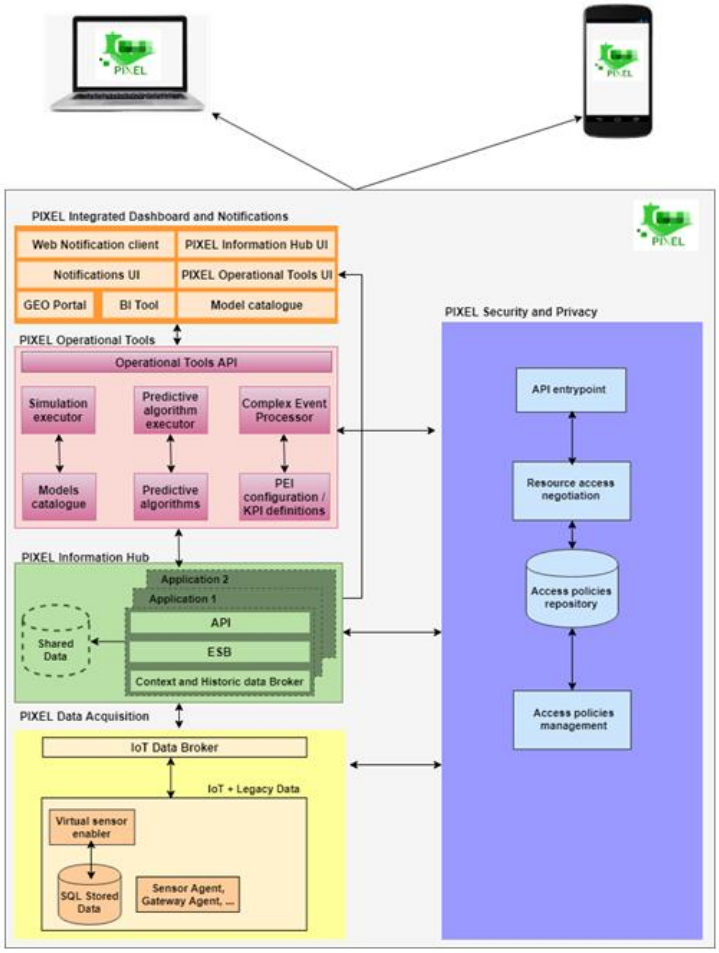


Figure 4: Global Architecture: technical impact assessment will be done for each module

Since each of these modules have their own components and in order to have a more precise technical impact assessment, we will apply the product quality model to each of the PIXEL modules. The same methodology will be applied to the different modules, but results may vary from one module to another. For all modules, the same characteristics and sub-characteristics will be assessed but the evaluation criteria may be relevant only for some module (this is defined later in this document). Thus, the technical impact assessment of the PIXEL platform will be composed of the independent evaluation of its different modules.

The technical assessment of PIXEL's models and predictive algorithms and the PEI software will also be evaluated. For this we will just focus on the IT part since evaluation (precision, accuracy, etc.) of model, predictive algorithms and PEI software will be already done inside WP4 and WP5.

In order to identify which characteristics or sub-characteristics are relevant for PIXEL, a survey has been shared with all partners. The objective was to select the most adequate characteristics and sub-characteristics.

Results of the study are shown in table 2.

Table 2: Consortium answers to the application of Product Quality Model characteristics to PIXEL platform (green: must be assessed, yellow: should be assessed, orange: could be assessed, red: won't be assessed)

Product Quality Model		
Functional suitability		
Functional appropriateness	92%	
Functional completeness	83%	
Functional correctness	50%	
Performance Efficiency		
Capacity	75%	
Time behaviour	67%	
Resource utilisation	67%	
Compatibility		
Interoperability	100%	
Co-existence	33%	
Operability		
Ease of use	83%	
Technical Accessibility	75%	
User interface aesthetics	50%	
User error protection	42%	
Appropriateness recognisability	33%	
Technical Learnability	33%	
Reliability		
Maturity	83%	
Availability	83%	
Recoverability	50%	
Fault tolerance	17%	
Security		
Confidentiality	100%	
Integrity	100%	
Authenticity	67%	
Accountability	42%	
Non-repudiation	25%	
Maintainability		

Product Quality Model		
Modularity	92%	
Reusability	83%	
Modifiability	75%	
Analysability	58%	
Testability	42%	
Portability		
Adaptability	92%	
Installability	75%	
Replaceability	17%	

Only characteristics and sub-characteristics that are at least considered to be "Could have" by partners are evaluated. Evaluation criteria will be defined and assess only for them. They are:

- **Product Quality Model**:
  - *Functional suitability*: Functional appropriateness, Functional completeness
  - *Performance Efficiency:* Capacity, Time behaviour, Resource utilisation
  - *Compatibility:* Interoperability
  - *Operability*: Ease of use, Technical Accessibility
  - *Reliability:* Maturity, Availability
  - *Security:* Confidentiality, Integrity, Authenticity
  - *Maintainability:* Modularity, Reusability, Modifiability, Analysability
  - *Portability:* Adaptability, Installability

3.1.4. Evaluation criteria (KPIs) and performance targets

The definition of KPIs is based on the BigDataOcean Validation Framework (2), Section 2.2.1, Table 2-1.

Table 3: Identified KPIs for each sub-characteristic of the Product Quality Model

Sub-characteristics	KPIs	Calculation Type	Priority[1]
Functional suitability			
Functional appropriateness	Straightforward task accomplishment	Are tasks completed without the use of unnecessary steps? [Yes/No]	M
Functional completeness	Portion of completed requirements	$\frac{\text{Completed functional requirements}}{\text{Total number of functional requirements}} \times 100$ Note: Only "Should have" and "Must have" functional requirements that are defined in D3.2 will be taken into account for calculation.	M
Performance efficiency			
Capacity	Maximum number of	Total number of connected data sources	S

[1] **M**ust be assessed, **S**hould be assessed, **C**ould be assessed

Sub-characteristics	KPIs	Calculation Type	Priority[1]
	connected data sources		
	Maximum database size	Database size in Kilobytes	
Time behaviour	Average latency	$\frac{\text{Total response time}}{\text{Number of requests}}$	S
	Throughput	$\frac{\text{Total number of Kilobytes}}{\text{Total time of operation}}$	
Resource utilisation	Mean CPU Utilisation	$\frac{\sum \text{\% CPU utilisation probes}}{\text{Number of probes}}$	S
	Mean memory usage	$\frac{\sum \text{RAM Megabytes used in each probe}}{\text{Number of probes}}$	
	Maximum memory usage	Maximum % RAM Memory utilisation recorded	
	Maximum processing power used	Maximum % CPU utilisation recorded	
Compatibility			
Interoperability	% of APIs coverage	$\frac{\text{Number of integrated systems in ports exposing or consuming data through API}}{\text{Total number of identified systems}} \times 100$	M
	Ability to acquire data from different data formats	$\frac{\text{Number of supported data formats}}{\text{Total number of identified data formats}} \times 100$	
	Ability to support different IoT platforms	$\frac{\text{Number of supported IoT platforms}}{\text{Total number of relevant IoT platforms}} \times 100$	
	Ability to export different data formats	$\frac{\text{Number of supported data formats}}{\text{Total number of identified data formats}} \times 100$	
Operability			
Ease of Use	Dashboard availability	Is there an available dashboard with easy navigation? [Yes/No/Partially]	M
	Notifications system availability	Is there an available notifications system? [Yes/No/Partially]	
	GUI module availability	Is there a GUI to cover all functionalities for different user types as defined in relevant deliverables (administrators, stakeholders, operators, general public, …)? [Yes/No/Partially]	

Sub-characteristics	KPIs	Calculation Type	Priority[1]
Technical Accessibility	WCAG 2.0 Conformance Level[2]	[None/ A/ AA/ AAA]	S
Reliability			
Maturity	Maximum Concurrent users	Maximum number of concurrent users recorded	M
	Simultaneous requests	Maximum number of simultaneous requests	
Availability	% Monthly availability	$(1-\frac{\text{Downtime in minutes}}{\text{Total month minutes}}) \times 100$	M
	Success rate	$\frac{\text{Number of correctly completed requests}}{\text{Total number of requests}}$	
Security			
Confidentiality	Incidents of ownership changes and accessing prohibited data	Number of recorded incidents	M
Integrity	Incidents of authentication mechanisms breaches	Number of recorded incidents	M
Authenticity	Level of User authenticity	Can you identify that a subject is the one it claims to be? [Yes/ No/ Partially]	S
Maintainability			
Modularity	% of modularity	$\frac{\text{Number of components that can operate individually}}{\text{Total number of components}} \times 100$	M
Reusability	% of reusable assets	$\frac{\text{Number of assets that can be or are reused}}{\text{Total number of assets}} \times 100$	M
Modifiability	% of update	$\frac{\text{Number of updates performed without uperational issues}}{\text{Total number of updates}} \times 100$	S
Analysability	Level of analysability	Can the changes in the performance of the PIXEL platform be efficiently evaluated after each upgrade? [Yes/No]	C
Portability			
Adaptability	Mean number of errors per hardware or OS change/ upgrade	$\frac{\text{Total number of errors recorded}}{\text{Total number of hardware changes}}$	M

[2] **M**ust be assessed, **S**hould be assessed, **C**ould be assessed

Sub-characteristics	KPIs	Calculation Type	Priority[1]
	Mean number of errors per software change/ update	$\frac{\text{Total number of errors recorded}}{\text{Total number of software changes}}$	
Installability	Mean number of errors per software install	$\frac{\text{Total number of errors recorded}}{\text{Total number of software installations}}$	S
	Mean number of errors per software uninstall	$\frac{\text{Total number of errors recorded}}{\text{Total number of software uninstalls}}$	

3.1.5. Measure methods & responsible parties

KPIs will be calculated for each identified PIXEL software module and then combined in the overall KPI for PIXEL. KPIs will be evaluated where relevant. For example, data sources will be counted in the PIXEL Data Acquisition Layer only, while Latency may be calculated for all modules.

The table below defines the software components expected as output of WP4, WP5, WP6.

Table 4: Expected PIXEL software components and partners responsible for technical evaluation

WP	Task	Module	Lead partner
WP4	T4.1	Port and City Environmental Management Model	IPEOPLE
WP4	T4.2	Energy Demand Models	CATIE
WP4	T4.3	Hinterland multimodal transport Models	INSIEL
WP4	T4.4	Environmental Pollution Models	MEDRI
WP4	T4.5	Vessel ETD prediction from FAL forms	XLAB
WP4	T4.5	Vessel short-term ETD prediction from AIS data	XLAB
WP4	T4.5	Vessel detection from remote sensing	XLAB
WP4	T4.5	Port events detection from AIS Data	PRO
WP4	T4.5	Traffic predictions module – ASPM/SDAG	XLAB
WP4	T4.5	Traffic predictions module – PPA	PRO
WP4	T4.5	Traffic predictions module – THPA	UPV
WP4	T4.5	Prediction of renewable energy production	CATIE
WP5	T5.3	PEI software module	MEDRI
WP6	T6.2	PIXEL Data Acquisition	ORANGE
WP6	T6.3	PIXEL Information Hub	XLAB
WP6	T6.4	PIXEL Operational Tools	UPV
WP6	T6.5	PIXEL Integrated Dashboard and Notification	PRO
WP6	T6.6	PIXEL Security and Privacy Module	ORANGE

The table below shows the relation between software modules developed in specific tasks and KPIs to be evaluated for those modules.

Table 5: KPI evaluation for PIXEL tasks results

KPIs	T4.1	T4.2	T4.3	T4.4	T4.5	T5.3	T6.2	T6.3	T6.4	T6.5	T6.6
Straightforward task accomplishment	X	X	X	X	X	X	X	X	X	X	X
Portion of completed requirements	X	X	X	X	X	X	X	X	X	X	X
Maximum number of connected data sources					X		X				
Maximum database size					X						
Average latency					X	X	X	X	X	X	
Throughput					X		X	X			
Mean CPU Utilisation	X	X	X	X	X	X	X	X	X	X	
Mean memory usage	X	X	X	X	X	X	X	X	X	X	
Maximum memory usage	X	X	X	X	X	X	X	X	X	X	
Maximum processing power used	X	X	X	X	X	X	X	X	X	X	
% of APIs coverage							X				
Ability to acquire data from different data formats							X				
Ability to support different IoT platforms							X				
Ability to export different data formats							X				
Dashboard availability									X	X	
Notifications system availability										X	
GUI module availability						X	X	X	X	X	X
WCAG 2.0 Conformance Level						X	X	X	X	X	X
Maximum Concurrent users											
Simultaneous requests	X	X	X	X	X	X	X	X	X	X	X
% Monthly availability							X	X	X	X	X
Success rate							X	X	X	X	X
Incidents of ownership changes and accessing prohibited data											X
Incidents of authentication mechanisms breaches											X
Level of User authenticity											X
% of modularity	X	X	X	X	X	X				X	X
% of reusable assets	X	X	X	X	X	X				X	X

% of update										X	X
Level of analysability										X	
Mean number of errors per hardware or OS change/ upgrade										X	X
Mean number of errors per software change/ update										X	X
Mean number of errors per software install										X	X
Mean number of errors per software uninstall										X	X

3.1.6. Implementation actions and time plan

As already said the technical impact assessment of the PIXEL platform is closely related with WP6 and WP7 developments and advancements. The task 8.2 is fully dedicated to the technical implementation assessment and starts in M14 and ends in M36. As stated in the DoW, five deliverables are planned for WP6:

- D6.1 PIXEL Information system architecture and design V1 in M12
- D6.3 PIXEL Data acquisition, information hub and data representation v1 in M16
- D6.2 PIXEL Information system architecture and design V2 in M18
- D6.4 PIXEL Data acquisition, information hub and data representation V2 in M 26
- D6.5 APIs and documentation for software extension in M26

Two deliverables are planned for WP7:

- D7.1 Integration Report V1 in M18
- D7.2 Integration Report V2 in M27
- D7.3 Pilots and Cross Pilot Collaboration Reports

While it is related to WP6 developments, we will also evaluate other technical modules. Thus, we also consider WP4 and WP5 deliverables:

- D4.1 PIXEL Models v1 in M9
- D4.3 Predictive Algorithms v1 in M12
- D4.2 PIXEL Models v2 in M18
- D5.2 PEI Definition and Algorithms v1 in M18
- D4.4 Predictive Algorithms v2 in M24
- D5.3 PEI Definition and Algorithms v2 in M24

Concerning the technical impact assessment, two deliverables are planned in M20 and M36. This means that the technical impact assessment of the PIXEL platform will cover two evaluation phases. The PIXEL platform modules will be evaluated after each release phase. This is summarized in the following figure.

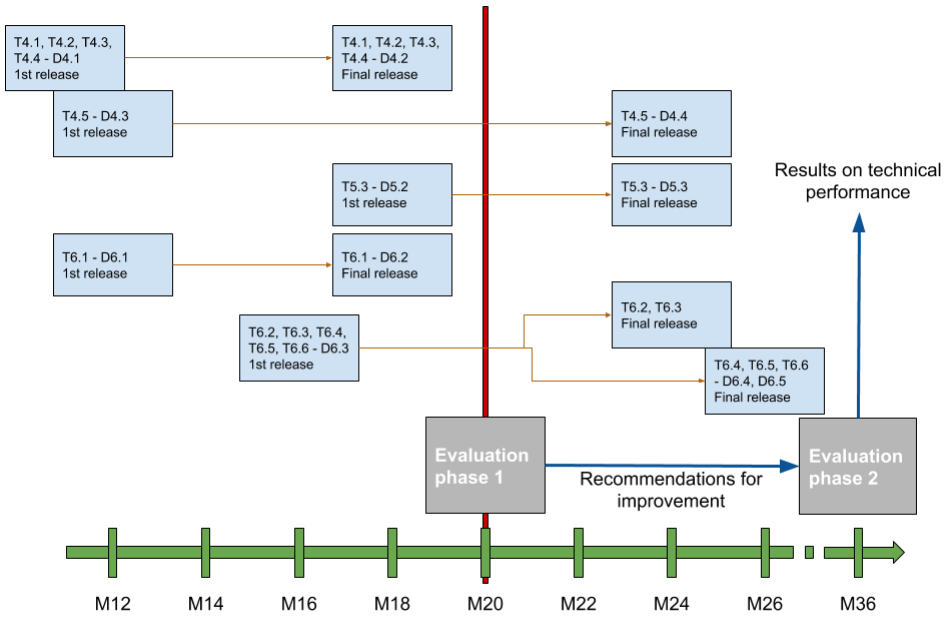


Figure 5: Evaluation steps and platform releases relation

The first evaluation of the technical impact assessment of the PIXEL platform will be based on the first developments and implementations of the PIXEL modules:

- T6.2 PIXEL Data Acquisition
- T6.3 PIXEL Information Hub
- T6.4 PIXEL Operational Tools
- T6.5 Integrated Dashboard and Notification
- T6.6 PIXEL Security and Privacy.

Other modules will also be evaluated only in the first evaluation since no iteration could be planned:

- T4.1 Port and City Environmental Management Models
- T4.2 Energy Demand Models
- T4.3 Hinterland multimodal transport Models
- T4.4 Environmental Pollution Models
- T6.1 PIXEL Information system design and architecture

The deliverable D8.1 Technical Evaluation V1 will contain the following points with on objective of improving the PIXEL platform:

- Analysis of the first developments and implementation;
- First assessment of evaluation criteria and KPIs;
- Technical recommendations for improving the PIXEL platform and PIXEL modules.

The second evaluation of the PIXEL platform will be based on the final developments and implementation of the PIXEL modules. T4.5 Predictive Algorithms and T5.3 PEI development will be also evaluated in this second version. The main objective of the deliverable D8.3 Technical Evaluation V2 will be to provide clear results on the real technical performance of the PIXEL platform.

3.1.7. Potential limitations and related contingency plans

The following points have been identified as potential limitations for the technical impact assessment of the PIXEL platform:

- According to the time plan, no iteration will be done for models and the PIXEL architecture and design after the Evaluation phase 1. Thus, there is a risk that those modules will not be well adapted and not technically performant. In order to contingence this risk, technical partners in charge of those modules will be fully aware of the evaluation criteria and a close interaction between WP8 and other WPs will be put in place.
- WP8 technical impact assessment of the PIXEL platform depends on what have been done in WP6 and WP7 and then it is worth noticing that a delay in one of those WPs will directly impact WP8. We aim to do the first evaluation on a port level if WP7 have been developed well enough, or on a laboratory level otherwise.
- There are still too few perspectives on the platform, so the evaluation criteria may not be precise enough. If we consider that some evaluation criteria are not precise enough, we will adapt them in the deliverable D8.2.

3.2. Technical impact assessment of the PIXEL Use Cases

3.2.1. Aim and scope

The PIXEL project is conducted by multiple partners who work in the aim of building an IoT platform for the port of the future. This project targets four use-cases and implements its solution within them. Since each port has its own needs and infrastructure the implementation of the PIXEL platform in each port may differ from one port to another. WP3 has defined different use-cases and scenarios towards which the PIXEL platform is going to be applied and used.

This part defines the steps to follow in order to assess the defined use cases. For the technical impact assessment of the PIXEL Use Cases we will focus on the user acceptance and satisfaction and on the data quality. Thus, we will follow the ISO standards as a basis:

- ISO/IEC 25010:2011 “Quality In Use Model” that relate to the outcome of interaction when a product is used in a particular context of use.
- ISO/IEC 25012:2008 “Data Quality Model” which defines a general model for data retained in a structured format within a computer system.

Even if each PIXEL use-cases and PIXEL integration in port will be done for each port independently, the same methodology and evaluation criteria will be used. The aim here is to provide feedback for the PIXEL integration in order to improve the user acceptance and data quality of the PIXEL platform.

3.2.2. Expected impacts

PIXEL Use Cases aim to provide a concrete environment in which the platform can be used by end-users with real world needs and data.

As such, PIXEL Use Cases will help to detect that:

- PIXEL platform is concretely applicable to real world use cases.
- PIXEL platform is useful to end-users.

Usefulness is the main point, and if we want the PIXEL platform to be technically efficient, it has to be largely adopted. Thus, the main impacts are that users:

- Are satisfied with the PIXEL platform.
- Find the PIXEL platform easy to use, so that no intensive training is needed.

- Would recommend the PIXEL platform so it will easily spread among other operators and stakeholders.
- Think that the PIXEL platform potentially fit in other ports, so it will facilitate transferability or engagement of external ports.

3.2.3. Evaluation methodology

The quality in use model describes five characteristics for system and software quality. Each of these characteristics is decomposed in a set of related sub-characteristics:

- Effectiveness
- Efficiency
- Satisfaction: Usefulness, Trust, Pleasure, Comfort
- Freedom from risk: Economic risk mitigation, Health and safety risk mitigation, Environmental risk mitigation
- Context coverage: Context completeness, Flexbility

Their descriptions, proposed by ISO/IEC 25010:11, is available in appendix.

Besides that, the data quality model describes seven characteristics for system and software quality. Each of these characteristics is decomposed in a set of related sub-characteristics:

- Information accuracy: Currentness, Correctness, Credibility, Precision, Traceability
- Information accessibility
- Information Appropriateness: Understandability, Value added, Representational adequacy, Consistency, Completeness
- Efficiency
- Availability
- Portability
- Recoverability

Their description, proposed by ISO/IEC 25012:08, is also available in appendix.

In order to identify which characteristics or sub-characteristics are relevant for PIXEL, a survey has been shared with all partners. The objective was to select the most adequate characteristics and sub-characteristics. Results of the study are shown in Table 6.

Table 6: Consortium answers to the application of "Quality In Use Model" and "Data Quality Model" characteristics to PIXEL platform use cases (green: must be assessed, yellow: should be assessed, orange: could be assessed, red: won't be assessed)

Quality in Use Model				**Data Quality Model**		
Effectiveness				**Information Accuracy**		
Effectiveness	100%			Currentness	83%	
Efficiency				Correctness	75%	
Efficiency	100%			Credibility	75%	
Satisfaction				Precision	75%	
Usefulness	92%			Traceability	58%	
Trust	92%			**Information Accessibility**		
Comfort	42%			Accessibility	92%	
Pleasure	17%			**Information Appropriateness**		
Safety				Understandability	100%	

Quality in Use Model		
Environmental harm risk	42%	
Economic damage risk	33%	
Health and safety risk	33%	
Usability		
Flexibility	83%	
Learnability	75%	
Accessibility	67%	
Content conformity	67%	

Data Quality Model		
Value Added	92%	
Representational Adequacy	83%	
Consistency	75%	
Completeness	58%	
Efficiency		
Efficiency	58%	
Availability		
Availability	100%	
Portability		
Portability	75%	
Recoverability		
Recoverability	50%	

Only characteristics and sub-characteristics that are at least considered to be "Could have" by partners are evaluated. They are:

- **Quality In Use Model**:
  - *Effectiveness*: Effectiveness
  - *Efficiency*: Efficiency
  - *Satisfaction*: Usefulness, Trust
  - *Context coverage*: Context completeness, Flexibility
- **Data Quality Model**:
  - *Information accuracy*: Currentness, Correctness, Credibility, Precision, Traceability
  - *Information accessibility*: Accessibility
  - *Information appropriateness*: Understandability, Value added, Representational adequacy, Consistency, Completeness
  - *Efficiency*: Efficiency
  - *Availability*: Availability
  - *Portability*: Portability

3.2.4. Evaluation criteria (KPIs) and performance targets

Before defining evaluation criteria for the PIXEL use-cases we need to clearly define who is going to be the user evaluating it. We consider that the evaluation of the PIXEL use-cases should be internal to PIXEL. Indeed, the evaluation of the PIXEL use-cases will be based on requirements, user stories and scenarios that have been described internally. Moreover, we propose that the evaluation should be done by the one interacting directly with the PIXEL platform. In our case, this means that the evaluation (at least the answers to calculate KPIs) will be provided by ports. Analysis and recommendations of improvements will be done by all partners. In the Quality in Use Model three different types of users are identified:

- Primary User: a person who interacts with the system to achieve the primary goals;
- Secondary User: a person who provides support;

- Indirect User: a person who receives output but does not interact with the system.

For each port, we classify the users defined in the user stories of the deliverable D4.3 in one of the three categories. If a port doesn't have any secondary or indirect user based on user stories, ports will have to be defined and identified them.

Table 7: Port users' classification

Port	Primary Users	Secondary Users	Indirect Users
GPMB	Statistics Manager Energy Manager Port Manager	IT Manager Software Editor	Environmental Manager Port Agent/Operator
ASPM	Environmental Manager Parking area Manager	Software Editor	Gate/Access Manager
PPA	Environmental Manager Management team	IT Department	Quality Assessement
ThPA	Environmental Manager	IT Manager	Terminal Operator

For each KPIs defined thereafter, we define the user that should evaluated it.

Exposed below are calculation methods for the different KPIs and what impact they aim to predict. Some of the calculation methods are extracted from other EU projects. We will use Deliverables D3.2 and D3.4 as basis for the user acceptance of the PIXEL platform.

Even if the ISO document gives characteristics and sub-characteristics to be evaluated, it doesn't provide any evaluation method. For some characteristics, we will be able to collect numerical data, such as the number of completed user stories. However, for most of the characteristics, no numerical value can be gattered because they more relate to the "feeling" of the user of the platform.

Thus, we decided to rely on existing, proven, well-documented and state-of-the-art questionnaires, to evaluate those characteristics:

- The TAM 3(3) questionnaire for the Quality In Use Model.
- The AIMQ (4) questionnaire for the Data Quality Model.

TAM 3 and AIMQ questions that are used to define characteristics and sub-characteristics are directly written in the questionnaires that are provided in annex. However, because the provided questionnaires are generic, we were not able to match all the characteristics of the ISO norms to characteristics in the questionnaires. Indeed, for the missing characteristics, we try to reproduce questions that are like those defined in the questionnaires. For the Data Quality Model questionnaire in particular, Vaziri & Mohsenzadeh. (2012) (5) proposed to ask direct, reverse, synonymy and definition questions.

Table 8: Quality In Use Model evaluation criteria

Sub-characteristic	KPIs	Calculation Type	Priority	User evaluating
Effectiveness				
Effectiveness	% of completed user stories	$\frac{\text{Number of completed user stories}}{\text{Total number of user stories}} \times 100$	M	Primary
	Output Quality	TAM 3 questionnaire		Primary / Indirect
Efficiency				

Efficiency	Efficiency level (Uses the *Number of end-users* KPI)	$(\frac{\text{Real number of end users}}{\text{Planned number of end users}})\times\text{Effectiveness}$	M	Primary / Secondary
Satisfaction				
Usefulness	Usefulness level	$\frac{\sum_{\text{Implemented requirements}} \text{CI}\times\text{CD}}{\sum_{\text{Defined requirements}} \text{CI}\times\text{CD}}$ Note: CS: Customer Satisfaction CD: Customer Dissatisfaction	M	Primary
	Perceived usefulness	TAM 3 questionnaire		Primary / Indirect
Trust	Trust level	TAM 3-like questionnaire	M	Primary
	System Anxiety	TAM 3 questionnaire, switching "computer" for "PIXEL platform".		Primary
Context coverage				
Context completeness	Completeness level	TAM 3-like questionnaire	S	Primary
Flexibility	Flexibility level	TAM 3-like questionnaire	M	Primary

Table 9: Data Quality Model evaluation criteria

Sub-characteristic	KPIs	Calculation Type	Priority	User evaluating
Information Accuracy				
Currentness	Timeliness	AIMQ questionnaire	M	Primary / Indirect
Correctness	Free of errors	AIMQ questionnaire	S	Primary / Indirect
Credibility	Believability	AIMQ questionnaire	S	Primary / Indirect
Precision	Precision	AIMQ-like questionnaire	S	Primary / Indirect
Traceability	Traceability	AIMQ-like questionnaire	C	Primary / Secondary
Information Accessibility				
Accessibility	Accessibility	AIMQ questionnaire	M	Primary
Information Appropriateness				
Understandability	Understandability	AIMQ questionnaire	M	Primary / Indirect
Value Added	Advantage	AIMQ-like questionnaire	M	Primary / Indirect
	Relevancy	AIMQ questionnaire		Primary / Indirect
Representational Adequacy	Concise representation	AIMQ questionnaire	M	Primary / Indirect
	Interpretability	AIMQ questionnaire		Primary / Indirect

Consistency	Consistent representation	AIMQ questionnaire	S	Primary / Indirect
Completeness	Number of sensors / devices connected to the local IoT platform	Count the number of sensors connected to the local IoT platform.	C	Secondary
	Number of types of data (sensors) connected to the local IoT platform.	Count the number of different sensors connected to the local IoT platform.		Secondary
	Completeness	AIMQ questionnaire		Primary / Indirect
Efficiency				
Efficiency	Ease of Operation	AIMQ questionnaire	C	Primary
Availability				
Availability	Availability	AIMQ-like questionnaire (reworked from Security)	M	Primary
	Security	AIMQ questionnaire		Primary
Portability				
Portability	Portability level	AIMQ-like questionnaire	S	Primary / Secondary

3.2.5. Data collection methods & responsible parties

The evaluation will be done by end-users of the platform, which means, the primary, secondary and indirect users defined above. The results will be analysed by the partners involved in T8.2.

KPIs defined in the above part are all evaluated for every use case, but each use case may work differently as WP7 has a task for each. As such, we need to evaluate each use case independently. Here we define which partner is responsible for the different use cases:

- Energy Management Use Case: GPMB, CATIE
- Intermodal Transport Use Case: INSIEL, ASPM, SDAG
- Port City Integration Use Case: THPA, PPA, UPV, PRO
- Port Environmental Index (PEI) Use Case: MEDRI, CREOCEAN, ASPM, GPMB, THPA, PPA

For each of the above use-cases, port users will have to answer to a questionnaire.

3.2.6. Implementation actions and time plan

As we have seen in the previous parts, the evaluation phase will be mainly based on questionnaires around the use of the PIXEL platform. As it requires stakeholders to gain some maturity with the platform, we need to leave them some time to master what they can achieve with PIXEL system. As such, we plan to collect data (collectable data as well as answer to questionnaires) up to three months after the start of the trials for each use case.

Once the data is collected, it will be used to build impact assessment KPIs for the PIXEL platform use cases, and we will use this data for the redaction of the deliverables. Thus, we can split the actions in three main phases:

- For D8.2, due date of D7.1 at the end of M18 will assess that the integration of PIXEL components reached a sufficient reliability for us to release the study.

- M21 to M32 will then allow for an improvement and corrections of the integration and, more generally, of the structure of some PIXEL platform components in order to correctly allow users to exploit the platform in the way it was intended to be.
- Then, it will be possible to collect new data in order to assess the PIXEL platform use-cases and build D8.3 at the end of M36.

All the above explanations are summarised in Figure 6 below.

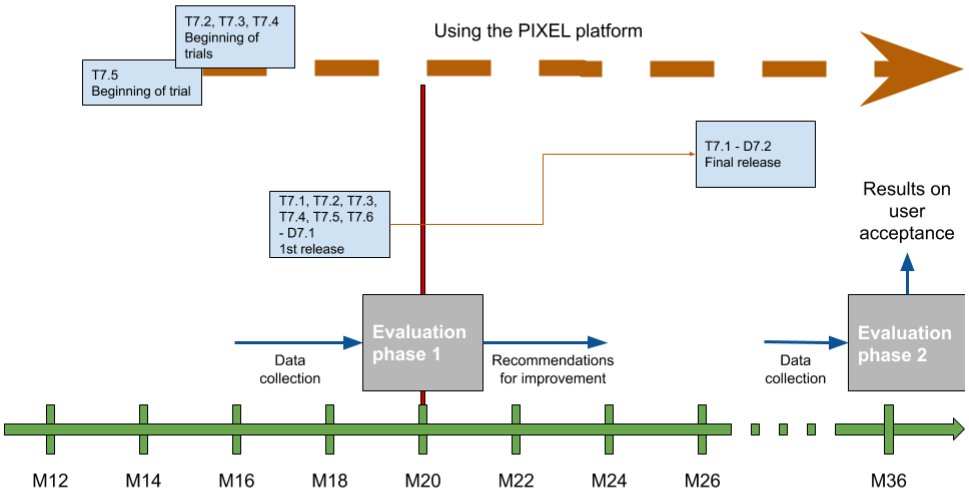


Figure 6: Implementations actions and time plan for the PIXEL platform use-cases impact assessment

3.2.7. Potential limitations and related contingency plans

Principal stakeholders for this part are users of the platform. As such, the main risk would be to not have enough information provided by those users in order to study the impact. This may be caused by three reasons:

- Not enough users respond to questionnaires: It is a fact that the technical impact assessment of the PIXEL use cases will be based to a significant extent on information gathered through questionnaires and surveys. In the case that not enough users respond to those, the project partners will use all their networking capacities to attract as much as possible, as well as organize dedicated workshops in the ports to make sure that the proper information is collected.
- T7.1 (Integration of PIXEL components) encountered problems and platform trials beginning delays. Regardless of any possible lack of information, there will still be enough data in order to assess and correct the already implemented part. Such a risk would be identified by the previous impact assessment part relative to the PIXEL platform infrastructure.
- There is a risk that the technical evaluation of the PIXEL platform will not be correctly done because of not taking the integration in the ports into account. To compensate this, it is proposed to do, during the integration phase, a verification of the availability of the technical evaluation criteria.

4. Business and economic impact assessment of the PIXEL Use Cases

4.1. Aim and scope

The main goal of Task 8.3 "Business and Economic Impact Assessment" is to assess the business & economic impacts of the ICT solutions implemented in the four ports/use cases of the project. Also, qualitative benefits accruing from the implementation of the PEI will be investigated.

The main questions to be addressed in the framework of this Task will be:

- Which are the **business impacts** of the **operational** results of the use cases', i.e. quality improvements and cost efficiencies achieved in day-to-day operations?
- Which are the **business impacts** of **organizational** aspects of the use cases', i.e. wider changes in the way the various stakeholders operate and cooperate?
- Which are the **economic impacts** of the use cases' **societal** aspects, i.e. environmental & social benefits to the citizens?

The responses to the above mentioned questions will lead to the formulation of a CBA.

Given that the fours ports participating in the Project are quite different in size and scope, each one of the above issues will be dealt in a different manner in each pilot site, following however the same rationale. Also, it should be noted that, as PIXEL is a research Project, emphasis will not be placed only on the CBA being of a positive result. The societal and environmental benefits that may come up for the wider community through the measures undertaken in each port will be of great importance.

4.2. Evaluation methodology

As mentioned previously, the business and economic impact of the measures implemented in the four pilot sites will be assessed through the conduction of a typical Cost-Benefit Analysis. According to the "Guide to Cost-Benefit Analysis of Investment Projects" published by the European Commission (EC) (2), "*The purpose of CBA is to facilitate a more efficient allocation of resources, demonstrating the convenience for society of a particular intervention rather than possible alternatives*". This statement also demonstrates and supports the notion mentioned in the previous section, that the benefits expected and hopefully achieved should not be dealt with only in a strictly financial manner, but take into serious consideration environmental and societal gains for the wider community.

A separate CBA will be conducted for each port, as all four of them differ in both size and types of operations and services provided, as well as in regards to the measures that each one of them has selected to implement. However, the rationale followed will be the same and following the Project Appraisal Steps mentioned in the Guide of the EC. These are briefly explained below:

1. **Description of the context:** the current situation of each port will be described as a first step, meaning the provision of information having to do with existing infrastructure, operations taking place and services that are provided, level and quality of these services, problems occurring in a daily basis that have led to the participation in the PIXEL Project and hence to the implementation of measures, as well as expectations of the Port Authority and of the wider community. Any other information that may assist in painting a more specific and sufficient picture will of course be included.

2. Definition of objectives: Having set the scene in the previous step, this second one will clarify further the objectives sought for through the implementation of the selected in each port measures.

3. Identification of the project: This part will report on the measure(s) that will have been implemented in the ports, focusing on:

- the description of the actual interventions made and their scope;

- the body responsible for the implementation and surveillance of the proper continuation of the measures;
- the area of impact aimed in terms of categories of people aimed to be affected, geographical area as well as services and operations altered.

4. Technical feasibility & Environmental sustainability: the goal of this step will be two-fold. On one hand the demand analysis of each port will take place taking into consideration both current data and future forecasts and on the other hand, the environmental aspect will be introduced. The expected benefits for the environment accruing from the implemented measures will be examined and assessed.

5. Financial analysis: Here, the cost calculation will take place, taking into consideration investment costs relevant to the implementation of each measure (per port), operational costs, as well as costs related to the maintenance of equipment and/or software bought for the project's purposes. The financial revenues (if any) expected from the implementation of measures implemented in the framework of the project and overall operational changes made in the port will be examined also during the specific step of the CBA.

6. Economic analysis: the main direct benefits will be assessed in this pre-final step coming from the measure's implementation. As mentioned in the relevant guide, in transport projects these benefits mainly have to do with increase in demand, fares paid by users, increase in perceived or actual safety, and variation in noise and GHG emissions and variation in air pollution. An attempt will be made to monetarize these benefits so as to assess them against the costs made.

7. Risk assessment: the final step of the CBA will be dedicated to assessment of the risk related to the measures implemented in the four pilot sites. The risk assessment may include a sensitivity analysis and/or a qualitative analysis risk analysis.

4.3. Expected impacts

In order to proceed with the Business and Economic Assessment of the measures to be implemented in each pilot site, it is necessary to define what will be the expected benefits (quantitative and qualitative) in each port. In regards to the CBA steps mentioned in the previous section, the identification of the benefits expected is related to step 2, having to do the definition of objectives and step 3 dealing with identification of the project.

In order to define these benefits, along with the related anticipated costs per site, we have taken into consideration two sources:

- The Expected Impacts as those have been defined in the relevant section of the Grant Agreement (pages 29-33);
- The actual measures that the pilot sites have finally chosen to implement.

It should also me mentioned at this point that, apart from purchases to be made (i.e. sensors), as anticipated costs are considered expenses made in order to implement the various systems, from human resources spent to any updates made in computers or software bought.

Based on the above, the cost items and related expected benefits per pilot site are shown in Table 10 below:

Table 10: Cost items and expected benefits per pilot site

Port of Bordeaux		
Cost Items	**Expected Benefits – Quantitative**	**Expected Benefits - Qualitative**
Anticipated cost 1. Implementation of PIXEL algorithms (based on past data); 2. Implementation of PEI; 3. Setting of IoT platform and connection of existing and new sensors 4. Design of simulation algorithms	• More physical measurements in the port; • Some possible optimizations of port operations; • Advanced port statistics analysis; • Measuring of green policy outcomes;	• Improved decision making capacity of the port (due to additional data provided as a result of PIXEL and due to traffic forecasting & energy demand estimation); • Communication of decrease of environmental impact, due to investments and actions, to the citizens;

5. Development of API between VIGIEsip and PIXEL 6. Collection of historical data (datasets) for models and algorithms **Cost items (to be purchased)** 1. New sensors; 2. Solar panel; 3. Weather station; 4. New communication functionalities to old sensors.	• Improved quay productivity (due to port traffic forecasting) • Less maintenance costs for each sensor • An updated version of VIGIEsip including new functionalities coming from PIXEL's works • Reduced electricity consumption thanks to better energy management	• Improved port image as an environmentally responsible actor • Improved port-city relations (due to more environmentally friendly port operations) • Increased social acceptance – new opportunities due to high achieved PEI • Efficient contributor to the development of the Atlantic corridor
Port of Monfalcone		
Cost Items	**Expected Benefits – Quantitative**	**Expected Benefits - Qualitative**
Anticipated Cost 1. Implementation of PIXEL Platform; 2. Interoperable IoT platform for data exchange between Port of Monfalcone and SDAG; 3. Implementation of PEI; 4. Integration of SDAG system to SILI for traffic data sharing; 5. Collection of historical data for modelling and algorithm creation; 6. Monitoring of ADR (dangerous freights transport) by integrating SDAG and Monfalcone systems. **Cost items (to be purchased)** 1. One or more parking sensors; 2. Automatic booking system; 3. Environmental stations integration.	• Improvement in waiting times for trucks; • Reduction of environmental impact deriving from the automated re-routing of trucks; • Less fuel consumption; • Forecast regarding expected peak of traffic;	• Improvement in parking congestion/occupation; • Improvement in road traffic; • Improved port image as an environmentally responsible actor; • Improved port-city relations; • Increased social acceptance.
Port of Piraeus		
Cost Items	**Expected Benefits – Quantitative**	**Expected Benefits - Qualitative**
Anticipated Cost 1. Implementation of PIXEL Platform; 2. Implementation of PEI; 3. Formulation of PIXEL Mobility Case (MC); 4. Establishment of air quality improvement plan 5. Feasibility of noise monitoring system 6. Collection, subscription of data for models **Cost items (to be purchased)** 1. Air Quality Monitoring System with sensors (air monitoring sensor); 2. Noise monitoring system consisted of suitable sensors	• Mitigation of noise levels through the implementation of evaluated and proper measures • Mitigation of air pollution levels through the implementation of evaluated and proper measures • Reduction of residential area complaints in regards to noise levels	• Sustainable economic growth in Port city; • Improved monitoring and control of environmental quality parameters and their externalities; • Improvement of the social profile of the port and relationship with the city • Dispersion model for the assessment of the of the noise and air pollution levels by the port activities to the neighbour city

3. Road traffic data subscription 4. AIS data subscription		
Port of Thessaloniki		
Cost Items	**Expected Benefits – Quantitative**	**Expected Benefits - Qualitative**
Anticipated Cost 1. Implementation of PIXEL Platform 2. Implementation of PEI; 3. Integration of existing systems to PIXEL 4. Collection of data for modelling and algorithms **Cost items (to be purchased)** 1. Air quality and noise sensors 2. Environmental stations (to be confirmed)	• Reduction in GHG emissions; • Air quality improvement; • Reduction of acoustic pollution; • Reduction of truck queues at gates (?)	• Improved decision making capacity of the port (due to additional data provided as a result of PIXEL); • Enhancement of the port's competitive position; • Minimization of nuisance and environmental caused by port operators; • Improvement of economic efficiency; • Optimization of traffic between the city and the port to minimize bottlenecks caused by operations; • Optimization of inbound and outbound truck traffic

4.4. Evaluation criteria (KPIs)

Based on the cost items and the related expected benefits, the pilot leaders have identified the Key Performance Indicators (KPIs) to be measured per pilot sits in order to fulfil the goals and scope of the Business and Economic Evaluation of the four pilot sites and of the overall PIXEL Project. These KPIs will lead to the final outcome of D8.4 which will be the Cost Benefit Analysis if the various measures that will have been implemented.

In Table 11, Table 12, Table 13 and Table 14 that follow, the KPIs, for each one of the pilot sites, have been mapped against the expected impacts. The unit and mean of measurement for each KPI have been also defined. The information provided has been grouped in the four impact categories foreseen by the partners in the Grant Agreement.

Table 11: KPIs for the Port of Bordeaux

I1 Climate change and environment			
Expected pilot impacts	**KPIs**	**Units of measurement**	**Means of measurement**
Reduced electricity consumption thanks to improved knowledge and energy management	Quantity of electricity consumed yearly by port authority	kWh	Data coming from electricity consumption sensors
I2 Operational and infrastructural costs			
Expected pilot impacts	**KPI**	**Units of measurement**	**Means of measurement**
Reduced maintenance cost of the sensors system (tidal level, energy consumption)	Average maintenance costs of each sensor system	€/year	Port statistics
I3 Logistics efficiency / port attractiveness			
Expected pilot impacts	**KPI**	**Units of measurement**	**Means of measurement**
Enhanced decision-making capacity of the port due to additional data/information provided as a result of PIXEL	Decision-making capacity of the port	Predicted tonnage per type of cargo Economic trends of the territory	Port statistics (tonnage, m² rented…)
I4 Port integration in the surrounding socio-economic area			
Expected pilot impacts	**KPI**	**Units of measurement**	**Means of measurement**
Improved acceptance of the port as an environmentally responsible actor	Green Marine Level	Improved Green Marine Level due to PIXEL (level before/level after)	Green Marine Assessment
	Port image	Acceptance of the port as an environmentally responsible actor	Surveys (port authority, citizens, other stakeholders)
Improved port-city integration	Level of port-city relations	Likert scale (1-5)	Surveys (port authority, citizens, other stakeholders)
	Joint planning initiatives based on data sharing	• Number of municipalities involved in joint planning initiatives with the port	Surveys (port authority, municipalities)

		• Number of joint planning initiatives between the port and municipalities	Dashboards included in PIXEL
Economic contribution to the local economy	Direct employment as a result of PIXEL	• Direct employment increase (full-time employees) • Direct employment increase (%)	Survey of port authority
	Indirect employment as a result of PIXEL	• Indirect employment increase (full-time employees) • Indirect employment increase (%)	Survey of port authority Survey of EIG VIGIE ports

Table 12: KPIs for the Port of Monfalcone

1 Climate change and environment			
Expected pilot impacts	**KPIs**	**Units of measurement**	**Means of measurement**
Reduced emissions & congestion due to trucks re-routing to SDAG	Estimated waiting time for trucks entering / exiting the port due to congestion	• Trucks re-routed to SDAG before entering the port (no & %) • Congestion events measured	Port statistics
	Estimated waiting time for trucks entering the port parking	Parking occupancy related to trucks gate flux	Port statistics
	CO_2 emissions	Estimated CO2 emissions (kg)	Conversion of energy usage due to additional estimated waiting times into CO_2 emissions
	Congestion around the port	Congestion level around the port area before/after PIXEL (5-scale congestion bands)	Traffic estimation
I3 Improvement of logistics efficiency			
Expected pilot impacts	**KPIs**	**Units of measurement**	**Means of measurement**
Enhanced decision-making capacity	Decision-making capacity of the local bodies	Likert scale (1-5)	Port authority survey
I4 Better integration of the port in the surrounding socio-economic area			
Expected pilot impacts	**KPIs**	**Units of measurement**	**Means of measurement**
Improved acceptance of the port as an environmentally responsible actor	Port image	Acceptance of the port as an environmentally responsible actor	Surveys (port authority, citizens, other stakeholders)
Improved port-city integration	Level of port-city relations	Likert scale (1-5)	Surveys (port authority, citizens, other stakeholders)
	Cooperation cases	Number of cooperation cases between the port and municipalities	Surveys (port authority, municipalities)

Table 13: KPIs for the Port of Piraeus

I1 Climate change and environment			
Expected pilot impacts	**KPIs**	**Units of measurement**	**Means of measurement**
Mitigation of port activity air pollution levels due to selection of appropriate measures as a result of the pixel model measurable parameters evaluation and assessment	Air quality parameters (NO_x, SO_x)	• Air quality parameters (ppm)	Air quality monitoring system
	Poor Air quality	• Number of air quality complaints raised in a year • Differentiation from previous year-on-year complaints (%)	Port statistics
Mitigation of port activity noise levels due to selection of appropriate measures as a result of the pixel model measurable parameters evaluation and assessment	Noise levels (L_{DEN}, $L_{Aeq)}$	• Noise levels (LAeq) • Noise levels (Lden)	• Noise level measurements
	Noise complaints	• Number of noise complaints raised in a year • Differentiation from previous year-on-year complaints (%)	Port statistics
I2 Operational and infrastructural costs			
Expected pilot impacts	**KPIs**	**Units of measurement**	**Means of measurement**
Maintenance cost of the sensors system (air & noise quality)	Total maintenance costs of the sensors system	€/year	Expenditures
I3 Logistics efficiency			
Expected pilot impacts	**KPIs**	**Units of measurement**	**Means of measurement**

Enhanced decision making capacity of the port due to additional data/information provided as a result of PIXEL	Decision-making capacity of the port	• Likert scale (1-5)	Port authority survey
I4 Port integration in the surrounding socio-economic area			
Expected pilot impacts	**KPIs**	**Units of measurement**	**Means of measurement**
Improved acceptance of the port as an environmentally responsible actor	Best practices (the best practices are referenced to PERS report)	• No of Best practices Improved Green Marine Level due to PIXEL (level before/level after)	Review of PERS certification every two years
Improved port-city integration	Level of port-city relations	• Likert scale (1-5)	Surveys (port authority, citizens, other stakeholders)
	Joint planning initiatives based on data sharing	• Number of joint planning initiatives between the port, logistic operators and other city authorities	Surveys (port authority, operators, other authorities)

Table 14: KPIs for the Port of Thessaloniki

I1 Climate change and environment			
Expected pilot impacts	**KPIs**	**Units of measurement**	**Means of measurement**
	CO_2 emissions	• CO2 emissions (kg)	Measurements with sensors
Reduced air quality impact of bulk operations as a result of actions undertaken (sprinkling, reduce number of operations, etc.) when specific/bad forecasted weather conditions, for the next day are expected	Air emissions (PM10)	• micrograms per cubic meter (μg/m3)	Air emissions measurement
Reduced air quality impact of non-bulk operations as a result of actions undertaken (reduce number of operations, etc.) when	Air emissions (NOx, SOx)	• Parts per million (ppm)	Air emissions measurement

specific/bad forecasted weather conditions, for the next day are expected			
	Environmental complaints	• Number of air quality complaints raised in a year • Differentiation from previous year-on-year complaints (%)	Port statistics
Reduced noise disturbance from cargo handling equipment	Noise levels	• Noise levels (dc)	Noise level measurements
	Noise complaints	• Number of noise complaints raised in a year • Differentiation from previous year-on-year complaints (%)	Port statistics
I3 Logistics efficiency			
Expected pilot impacts	**KPIs**	**Units of measurement**	**Means of measurement**
Decision making capacity of the port (due to additional data provided as a result of PIXEL and due to traffic forecasting & energy demand estimation)	Decision-making capacity of the port	• Likert scale (1-5)	Port authority survey
I4 Port integration in the surrounding socio-economic area			
Expected pilot impacts	**KPIs**	**Units of measurement**	**Means of measurement**
Improved acceptance of the port as an environmentally responsible actor	Green Marine Level	• Improved Green Marine Level due to PIXEL (level before/level after)	Green Marine Assessment
Improved port-city integration	Level of port-city relations	• Likert scale (1-5)	Surveys (port authority, citizens, other stakeholders)
	Joint planning initiatives based on data sharing	• Number of joint planning initiatives between the port and the municipality	Surveys (port authority, municipality)

4.5. Data collection methods & responsible parties

The data to be collected in the framework of T8.3 will be both quantitative and qualitative. In this respect, data will be collected based on its type and using the following methods:

Quantitative data will be collected through:

- Historical data from existing port statistics;
- On site measurements using the sensors to be implemented in the specific pilot sites (ports)

Qualitative data will be collected through:

- Personal interviews with high-level representatives from Port Authorities, Municipalities and other relevant bodies;
- Surveys through specific questionnaires (port authorities, municipalities, other relevant bodies/authorities, end users, other stakeholders, citizens, etc.).

The preparation and scheduling of the whole data collection procedure will be done by the task leader (CERTH) who will also be responsible for the formulation of the questionnaires and overall survey. On the other hand, the responsibilities among partners for each one of the four pilot cases in terms of data collection, along with the technical partner responsible for each port are provided in Table 15 below:

Table 15: Data collection responsibilities for Task 8.3

Pilot site	Responsible for data collection	Technical supervisor
Bordeaux	Bordeaux	CATIE
Monfalcone	Monfalcone, SDAG, INSIEL	INSIEL
PPA	PPA	PRO
ThPA	ThPA	UPV

It is important to note that, while the pilot site leaders will be responsible for the collection and provision of the requested data, the technical partners along with the Task leader (CERTH) will be responsible for the provision of the necessary guidance and support throughout the whole procedure.

4.6. Implementation actions and time plan

As mentioned previously, all the Tasks included in WP8 are directly related to the Tasks of WP7, in the framework of which the pilot trials integration, deployment and evaluation will take place. In this respect, the time-plan to be followed in Task 8.3 is highly depended on the efficient and on time delivery of the expected outcomes of WP7.

More specifically, the Business and Economic Impact Assessment (Task 8.3) officially starts in M19 – November, 2019 and its completion coincides with the completion of the PIXEL Project in April, 2021, when the relevant deliverable D8.4 “Business and Economic Assessment Report” is expected to be delivered. The involved partners however will make sure to start preparing themselves before the official starting date of the Task 8.3 and during the initiation of Tasks 7.2-7.4, so that they are in the position to overcome any obstacles occurring from the delays encountered in WP7.

The first action to be undertaken by the responsible partners will be the design of the evaluation implementation, meaning the formulation of the necessary questionnaires and the measurements and data collection scheduling. Following, the questionnaires will be disseminated to the necessary parties, while the pilot sites will be supported in the data collection procedure. Once the first results have started to be gathered, both quantitative and qualitative, the involved parties will start analysing them. The data collection and data analysis procedure

will continue hand in hand until close to the ending date of the project and task, when the responsible partner (CERTH) will start compiling D8.4. CERTH will make sure that there is enough time for reviewing and hence correction/updating/improvement of the document, prior to its final delivery expected in M36.

The expected time-plan for the above mentioned actions is shown in Figure 7 below:

Time Plan for Task 8.3

	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36
Use cases trials in ports (T7.2 - 7.4)																					
Inter-pilot integration & collaboration (T7.6)																					
Business and Economic Evaluation (T8.3)																					
Formulation of questionnaires																					
Data collection organization																					
Dissemination of questionnaires																					
Data collection and measurements																					
Data analysis																					
1st draft of D8.4																					
Review of 1st Draft																					
Final version of D8.4 ready for submission																					

Figure 7: Expected Time-Plan for Task 8.3

4.7. Potential limitations and related contingency plans

The outcome of Task 8.3 will be D8.4 which has been scheduled to be delivered at the end of the Project (M36). This is an important advantage of the specific task, as any problem that may have occurred with the implementation of the PIXEL Platform as well as with the implementation of the various measures in the four pilot sites, will have been dealt with. However, the specific task is possible to encounter problems and limitations that included the following:

- Lack of available statistical data: the ports have already verified that they are in the possession of the statistical data that will be necessary for the various assessments to be made once the measures are implemented. The measures have in fact been selected having as a goal also to avoid this danger.
- No direct economic benefits expected: the measures that will be implemented may not have direct cost-related benefits. In fact, some of the measures that will be implemented will have to do with the acquisition of better and richer information, which at a first glance, doesn't lead to economic gains. In this case, a more qualitative approach will be followed aiming to assess the future situation that will be established through the use of this new type of information.
- Not enough users respond to questionnaires: It is a fact that the business and economic assessment will be based to a significant extent on information gathered through questionnaires and surveys. In the case that not enough users respond to those, the project partners will use all their networking capacities to attract as much as possible, as well as organize dedicated workshops in the ports to make sure that the proper information is collected.

5. Proof of Concept and future R&D potential

5.1. Aim and scope

The aim of this section is to provide a specific plan for targeting Task 8.4. As stated in the Grant Agreement, WP8 will use PIXEL use cases and involved stakeholders to assess its impacts in technical, business and economic terms. Task 8.4 will widen the assessment scope by taking into account wider user community requirements that exist today or are emerging, and will inquire if the PIXEL concept can cover those as well. The extended requirements will come as a result of the Task 3.1 and will be validated/enhanced with the help of external to the project stakeholders, being experts from the business community. Moreover, Task 8.4 will identify the future research directions that can become feasible as a result of the implementation of the PIXEL concept. Members of the research community will be the main stakeholders involved in that. This task will also look for proof of concept and real deployment in external ports (ports out of the PIXEL consortium) in order to demonstrate the validity of the general approach in PIXEL, spreading the use of the PEI and the PIXEL technologies towards a major European and Global uptake of the results. This will be mainly drive by participant industries, leveraging the wide contact and customer network.

In summary, there are two main aspects to cover/plan for Task T8.4:

- **Identify future research directions**: PIXEL being a research project, it is important to present the output of the project from a research perspective, analysing the two main areas where PIXEL is contributing: technical and environmental (even sometimes coupled). On each of them, PIXEL specific research lines will be specified (e.g. IoT architectures, energy management, etc.) and will be put in context regarding general research directions for ports (Port of the Future) with the main aim of highlighting the main impacts from PIXEL to the port community.
- **Extend the assessment/evaluation by building a proof-of-concept (PoC) in external ports**: uses cases tested and validated in PIXEL should be as much as possible transferred to other external ports in order to increase its usefulness. The PEI use case, being a transversal one, is more prone to be easily transferred to and tested in other ports, as there will be a specific methodology to collect and develop the data. Regarding the other use cases, which can be somehow coupled with pilot ports, at least part of the developed technology may be tested. The PoC should be performed in strong collaboration with external stakeholders, mainly with the business community, who should suggest additional requirements that will make their transferred use case more attractive to the port community in terms of exploitation opportunities.

5.2. Methodological approach

5.2.1. Future R&D potential

In order to evaluate the potential of future research lines, it is important to establish a proper framework and categorize the different areas and scopes PIXEL is targeting. The approach will be top-down, starting from the main areas, then with the general research areas for ports and finally with the specific areas covered in PIXEL. By putting and linking them all together the PIXEL partners will be able to set potential scores, which will be also checked with external persons, mainly from the research community.

Regarding the main research areas, two of them have been already identified:

- Technical: refers to all technical work and research carried out within PIXEL
- Environmental: refers to all aspects that somehow tackle an environmental aspect in order to minimize the (negative) impact.

It is important to note that there may be some overlap between both areas, as some environmental challenges are targeted by means of technical components. However, as our main goal relates to the environmental field, we will highlight here all relevant components (technical or not) dealing with it from a research perspective.

Regarding the general research areas for ports, some of them have been also identified:

- For the technical area, we can list Industrial IoT, Cybersecurity, Cloud computing, Artificial Intelligence, 5G, and block chain. Note that some of these areas are not covered by PIXEL, but it is important to have a wide perspective in order to set scores (in the end) more accurately.
- For the environmental area, we can list mobility management, environmental models, environmental sustainability and methodologies.

Regarding the specific research areas for ports, some pre-work has also been done:

- For the technical area, we can list IoT architectures, Decision Support Systems, Security, interoperability and process modelling.
- For the environmental area, we can list energy management, intermodality (transport), pollution models and PEI with its methodology.

The main goal is to consolidate and complete the previous areas and end up with a summary classified table. An example of this table is shown below for some technical specific areas.

Table 16: Sample table for future R&D potential

Main areas	General Port Area	Specific area in PIXEL	Contribution	Research lines
Technical	Industrial IoT	IoT architecture	Paper/Conference, Open software	Further work from papers Further tests/scenarios from open source, considering our UCs and PoC tests
	Data analytics	Predictive algorithms	Paper/Conference Open software	Further work from papers (new PAs detected, increasing accuracy, etc.) Further tests/scenarios from open source, considering our UCs and PoC tests
		Models	Paper/Conference Open software	Further work from papers (new PAs detected, increasing accuracy, etc.) Further tests/scenarios from open source, considering our UCs and PoC tests

Note that most of the research directions can easily be listed if the PIXEL consortium does enough scientific dissemination in PIXEL. In order to promote and align this, the same leader has been appointed within the consortium for both tasks (Task T8.4 and Task T9.2).

5.2.2. Proof of Concept

The Proof-of-Concept is the most important and complex activity in this task (T8.4) as it implies the participation of external ports, whose involvement may be limited so as our knowledge of their internal operations. Anyway, the transferability approach follows a step-by-step process:

- Short analysis of existing use cases and developed technologies
- Identification of candidate external ports/port entities
- Selection of candidate external ports/port entities
- Engagement of external ports/entities
- Definition of (small) use cases and requirements
- Deployment (and training, if required)
- Test & Evaluation (KPIs).

Each step will be described in detail below. The last 3 steps are also grouped into a certain methodology by itself so that any port can potentially follow, besides the ones selected for the PoC validation in this task.

1) **Short analysis of existing use cases and developed technologies**: In order to transfer something, we need to have a good picture of what we have available and its potential to be transferred. This is also linked with task T9.4 (exploitation), where we analyse the different PIXEL components from a business perspective.

   For the different use cases, we need a summary table as depicted below. Some of the information is already available or can be extracted from deliverables and/or tasks. For the specific use cases (energy/transport/port-city) there are two aspects to consider:

   a. Establish some port profiles according to our use cases (UCs). In deliverable D3.1 there were some port types but the classification criteria were operations, category, size, region and geography from a general perspective. Probably we should narrow the criteria to our UCs.

   b. Identify some preliminary KPIs or objectives that can be considered as natural extension from the KPIs already defined in each port. It enriches the target scope of the UC but may potentially require extra work and devices not considered in our trials. So this is considered a preliminary study without any binding action unless the target external port is able to support the needed requirements.

   For the PEI use case, considered it as a transversal one, the work may be a little bit different as we can better extract commonalities for the four ports, and therefore consider ports in the range of best and worst case scenarios.

Table 17: UC analysis for transferability purposes

Use case	Objectives	Impact	Business KPIs	Analysis questions
Energy/Transport/ Port-city	From D3.4	From D3.4	From T8.3	Does another port work in a similar way and benefit from this UC? → Profiling What alternative objectives/KPIs might be of interest for a port? → Extension
PEI	From D3.4	From D3.4	From T8.3	Extract commonalities from the 4 ports and find: (i) similar ports, to have a best case scenario (ii) dissimilar ports (or entities), to have a worst case scenario and check the influence in the calculation of PEI when parameters vary

For the different technologies developed, and similar to the use cases, a similar process follows, as depicted in the Table below. Such analysis cannot be performed currently, but at the start of task T8.4, when the software is mature enough to be sure about both its functionalities and limitations.

Table 18: PIXEL product analysis for transferability purposes

Technology	Description	Technical KPIs	Analysis questions
DAL/IH/OT/Models	From T9.4	From T8.2	Does another port benefit from this technology? → Profiling What alternative technical KPIs might be of interest for a port using this technology? → Extension

Note therefore that transferability may occur at use case level and/or technology level; we cannot anticipate which one will be selected as such decision is on the candidate external port. We can make some preliminary analysis and draft some profiling so that interested ports may identified themselves better for selecting one transferability approach or another.

2) **Identification of candidate external ports/port entities**: during the project, the PIXEL Consortium will establish links with other ports. Different possibilities are identified:
    a. Through the **PoF network** (CSA), PIXEL is joining a cluster of research projects related to defining the Port of the Future, thus potentially interested in exchanging ideas and participating. Furthermore, some of the software bundles originally tested in a port for one port entity may be also tested from another port entity. This potentially facilitates the deployment scenario and enhances the validation promoting the port ecosystem interoperability. An example of this approach is the Port of Piraeus, participating in the PIXEL project as Port Authority (PPA) and, at the same time, participating in the COREALIS project as Terminal Operator (PCT).
    b. Some of the partners within the PIXEL Consortium are port authorities and have **close connections with other ports** of the same or different country to be exploited. Most ports tend to build internal networks to face common problems and know therefore similarities and dissimilarities among them, which will help better identify candidate ports.
    c. The PIXEL **Advisory Board (AB)** may also suggest candidate ports where PIXEL outputs (software bundles) may potentially fit. They are experts from the port community. Note also that the Port of Valencia and the Port of Algeciras are represented through the AB.

    Though PIXEL is primarily intended for small and medium ports, it is important to consider also big ports as candidates. This will also help assessing the transferability at various scopes (small, medium and big ports).

3) **Select the most suitable external ports**: the selection criteria should be based on:
    a. Real willingness of the candidate port. Real commitment from ports will help (i) solving problems or accelerating the solution when they appear, and (ii) promoting the results to society. A possible indicator to measure this is the availability of a clear administrative contact point as well as a clear technical contact point with real authority in the port.
    b. Feasibility from ports/ port entities point of view. External ports should provide a written statement, even generic, showing the main objectives and resources. The PIXEL Consortium will then evaluate the technical, administrative and legal difficulties to reach the expectations (e.g. access to data, access to servers, etc.)
    c. Internal PIXEL's priorities. The PIXEL Consortium can prioritize some software bundles from others; this can be the case of PEI usage. The consortium will also decide if the deployed technologies are really providing impact to the selected port and they can benefit from it.
4) **Engagement of external ports/entities.** This phase is really crucial as without real involvement of ports there is nothing to do. This implies contacting port representatives, explaining the PIXEL project and use cases and how they can benefit from the results in form of a guided fully-supported transferability trial. This is a step that typically takes time as several internal checks must be performed in ports before providing a definitive answer. This phase ends successfully with a binding written document where the target port expresses its commitment to participate and the main objectives to achieve.

5) **TIDE-based transferability methodology (**Figure 8**)**: This methodology is based on the TIDE project (8) and encompasses the last three steps listed at the beginning of this section. This methodology tries to answer the following question to port: What are the steps to follow if I want to transfer successfully any of the PIXEL products in my port? The schema is presented in the Figure below, and it covers several steps:

a. *Mission statement*: write down a concise short document with the specific objectives to fulfil. Part of this document may have been done in step 4) for PIXEL. Besides, here it is important to set the scope in a realistic way, initial abstract ideas should now become concrete.

b. *Impacts*: write down the expected impacts of the proposed trial. Such impact should be quantifiable e.g., in terms of efficiency, safety, environmental reduction, etc. The concept of 'measure' from the TIDE methodology in Figure 8 translates into a PIXEL component in our context. Depending on the objectives (impacts) of ports, one or more components of the PIXEL solutions (technical and environmental) will be used. More concrete to our PIXEL project, we expect that interested ports state impacts from a business/economic perspective (similar to section 4) rather than from a technical one (section 3). Anyway, the definition of KPIs, either technical or business oriented, takes place during this phase.

c. *Scalability*: this concept is slightly changed when applied to PIXEL. It implies considering the implementation size on how scalability applies to all sizes of ports (small, medium and small). In the context of PIXEL, the envisioned components will mainly require a single port and its area. Required data from other ports (if any) are supposed to be available through the PCS or PMIS without any additional requests from those pots from other ports.

d. *Components*: this step refers to a technical and managerial analysis of all requirements needed. Deploying PIXEL products implies interacting with different components of a port, which may also impact others. Therefore, it is important to list: (i) what infrastructure port components need to be involved in the trial, (ii) what specific characteristics do we need for each component and (iii) identify any missing component and characteristic

e. *Relevance*: The previous analysis may potentially end up with a large list of requirements, and therefore it is important to set priorities for each of them (e.g. low/medium/high). This is similar as what has been done in deliverable D3.2 regarding priorities. The analysis also allows iterating and reducing or increasing the scope depending on size, time and available resources. Furthermore, the previously identified KPIs may need a review if some of them cannot be (relatively easily) obtained.

f. *Assessment*: Assessment of the characteristic in the context of adapter port (instead of "city" mentioned in Figure 8). The PIXEL product is evaluated in terms of the defined KPIs specified in the *Impacts* step. Moreover, a subjective assessment will be made in order to state whether the strong support or strong constraints for transferability applies.

g. *Conclusions*: summary document including some discussion about the key success factors and key barriers.

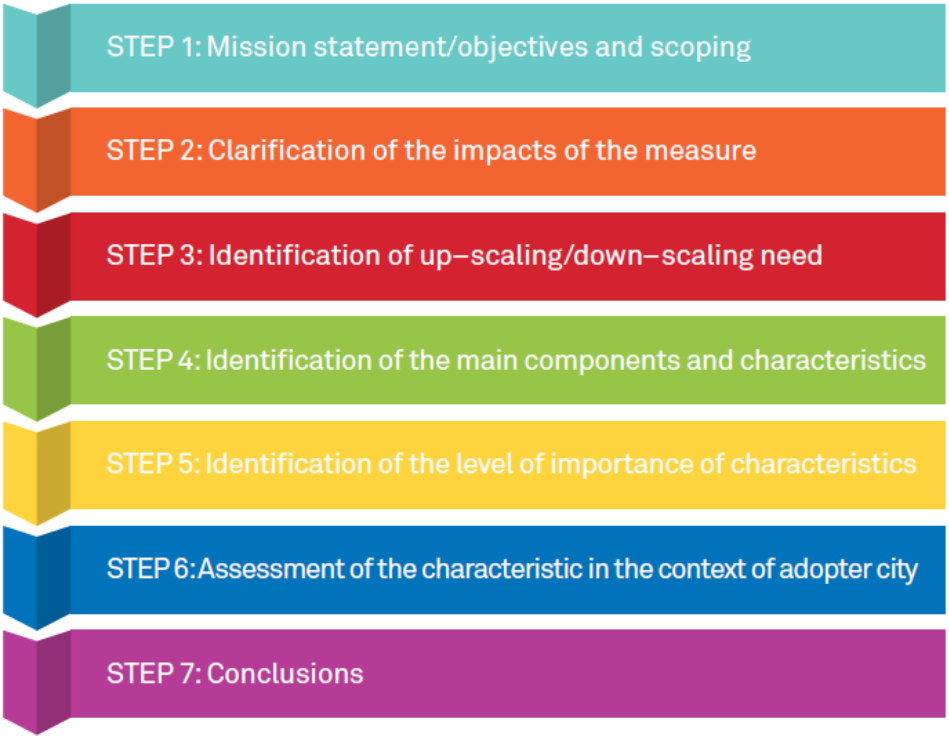


Figure 8: TIDE methodology schema(7)

5.3. Data collection methods & responsible parties

5.3.1. Proof of Concept

The participation of external stakeholders is crucial and there should therefore be various engagement means possible: (i) PIXEL newsletter, (ii) mailing lists, (iii) workshops and (iv) webinars. Some external stakeholders are already available for the PIXEL project: (i) Advisory Board, and (ii) members of the PIXEL sister project (CSA DocksTheFuture, Corealis, Port-Forward) building the Port of the Future cluster. A summary table is depicted below, grouping the 5 different steps described in section 5.2.2.

Table 19. Data collection for PoC

Activity	**Data collection method or means to approach**	**Involved partners/parties**	**Responsible partner**
Preparation (1&2)			
Use Case analysis	D3.4, D8.1	UPV, ports	UPV
PIXEL component	T9.4,D8.1	UPV, Technical Manager, Innovation Manager	UPV
Identification of candidate ports	Previous contacts/collaborations with other ports Advisory Board recommendation	All. Some examples: UPV →Port of Valencia, Container Terminal in Valencia PRO →Port of Malta Mon → Trieste GPMB →Port of Quebec	UPV
Recruitment (3&4)			

Activity	Data collection method or means to approach	Involved partners/parties	Responsible partner
Port engagement	Newsletter e-mail invitation webinar (if necessary) YouTube channel	All	UPV
Confirmation from ports	e-mail (written confirmation)	Delegated contact from each partner	UPV
Methodology (5)			
Mission statement	Dedicated telco or workshop	Target port, Delegated contact from each partner, CERTH, Technical Manager, UPV	UPV+CERTH
Impacts	Dedicated telco or workshop	Target port, Delegated contact from each partner, CERTH, Technical Manager, UPV	UPV+CERTH
Components, characteristics and importance	Dedicated telco or workshop	Target port, Delegated contact from each partner, Technical partners, Technical Manager, UPV	UPV+PRO
Deployment and assessment		Target ports, Technical partners	Technical partner

5.3.2. Future R&D potential

For the identification of future research lines most of the activity and data collection strategies can be carried out internally. However, in order to widen the scope and get a more general view, we will also contact external researchers from the port community to consolidate the results. A summary table is depicted below.

Table 20. Data collection for R&D

Area	Data collection method	Involved partners/parties	Responsible partner
Main	Questionnaire Internal telco	PIXEL research and technical partners	UPV/CERTH
General for ports	Questionnaire (Excel sheet, Google Forms)	PIXEL research partners Advisory Board External researchers CSA and RIAs	UPV/CERTH
	Scientific conferences attended Literature review	PIXEL research partners	
Specific for PIXEL	Papers published throughout the project Scientific conferences attended	Pixel research partners	UPV/CERTH

Area	Data collection method	Involved partners/parties	Responsible partner
	Developed software in PIXEL Internal work/telcos		

5.4. Implementation actions and time plan

5.4.1. Future R&D potential

Following the methodological approach described in section 5.2.1, and considering that task T8.4 starts at M25 and ends at M36, a tentative schedule is depicted in **¡Error! La autoreferencia al marcador no es válida.**:

- The two months are dedicated to consolidate the main areas, general research areas and specific research areas.
- Afterwards, there will be a 2-month analysis for correctly classifying all research areas.
- The identification of the research lines will start at M29 and will last until M35. Even if such identification can be performed after the classification, it has to be updated throughout the project as result of the delivered research papers and also software products.
- In order to feed deliverable D8.5 (M36) in time, the written results of this activity will start three months in advance.

Table 21. Future R&D time plan

Research directions	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36
Main areas consolidation												
General research areas in ports												
Specific research areas in PIXEL												
Classification of specific areas												
Identification of research lines (initial proposal, update with papers)												
Summarize results for deliverable (D8.5)												

5.4.2. Proof of Concept

Following the methodological approach described in section 5.2.2, and considering that task T8.4 starts at M25 and ends at M36, a tentative schedule is depicted in Table 22. The complete action plan is divided into three main blocks (preparation, recruitment and methodology):

- The preparation phase starts with an internal check and update of the whole methodology; the reason behind is that task T8.4 starts significantly later than this document plan and some changes may provide an impact in the schedule. Probably it will take less than one month, but it does not affect the rest of the action items.
- In parallel with the previous update, and as result of the analysis of use cases and technologies (see transferability steps in section 5.2.2), PIXEL will provide a list of transferability examples and how PIXEL products can be useful for external ports. This profiling information will help identifying potential candidate ports.
- The recruitment phase starts on M27 and lasts for three months; For practicality reasons, final confirmation from ports might be a lengthy process, therefore constant communication with emails and webinars would be employed (if necessary) in order to market the PIXEL outcomes and attract more ports in the testing procedure.
- The methodology phase can start once a port has confirmed real commitment, which may typically take 2 months at least. After that, important work has to be done between the PIXEL consortium and the target port, in order to establish objectives, impacts (KPIs) and requirements. For all these activities, a timeframe of 4 months is envisioned.
- Afterwards, there is a timeframe of 5 months for deployment and testing. Note that this timeframe may appear short, but it will probably be sufficient as it is likely that external ports will offer a reduced time

period (days/weeks) for testing. We should therefore be pretty much concrete with the products to be tested in the trials. Note also that there are two possible ways envisioned for assessing the trial: internal assessment and external. In principle the external port is interested in its own KPIs, but probably the PIXEL consortium, if allowed by the external port, will be also able to assess some technical and/or business KPIs used in the PIXEL's use cases, so that we can gather a better vision of the transferability.

- The summary document will be performed during the last month, when all trials are finished. However, some initial work can be done once an external trial finishes, in order not to delay deliverable D8.5.

Table 22. PoC time plan

PoC	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36
Preparation												
Metodology approach/update												
Transferability examples (PEI,IoT platform, models..)												
Identification of candidate external ports												
Recruitment												
Contact ports distributing some preparation material (e-mail, webinar)												
Confirmation from ports												
Methodology												
Mission statement/objectives												
Impacts of the products for the external port												
Identification of components and characteristics												
Level of importance of components and characteristics												
Deployment and internal assessment												
External assessment												
Summary and conclusions												

5.5. Potential limitations and related contingency plans

Regarding the research directions, no major limitations or risks are identified so far. Main inputs should come from papers, conferences and even developed software. For that PIXEL has an extensive dissemination plan identifying more than 60 potential events (covering both industrial and scientific dissemination) to get feedback. Currently there are two scientific papers already published and other two are ongoing. Publication rate should increase for the incoming years, as more results will be provided within the project. In a worst case scenario where the amount of published papers may seem limited, a research study can also be performed. In fact, it can also be considered an internal (non-official) task to better understand the project from a research perspective.

Regarding the Proof-of-Concept (transferability) aspect, there are several relevant risks to consider:

1) **Ports may not be willing to test PIXEL**: Even if ports might be interested in PIXEL outcomes, it is possible that the implications (in terms of privacy and security) of deploying PIXEL in their own premises arises. Ports have their own policies and handling data may require an internal in-depth study taking much time and/or resources, shifting the transferability action in a low priority item for them. PIXEL (having applied generic models through the participation of four different ports) will be able to minimize the required input by providing the option for the provision of a more generic and less specific solution.
2) **Timing issues**: task T8.4 starts in M25, but trials in WP7 may be running until M33. We can infer therefore that software products may probably not be mature enough until M30 to be offered to external ports. In this case we propose to employ a combination of *avoidance and minimization strategy*: we will start testing PIXEL products that are more mature than others; however, as the choice of PIXEL products may also depend on the external port, if a not so mature product has to be tested, the assessment scope will have to be reduced to its basic functionality.

   Another timing limitation refers to the fact that external ports may be willing to perform tests at a particular period for a particular reason, which will potentially decrease the amount of available time within the project lifetime. We will *minimize the impact* by reducing the amount of days/weeks for testing the product; this means that assessment will be performed within a limited and reduced timeframe. This was also reflected in the time plan in the previous chapter.

3) **Data availability:** considering that currently it is difficult to get all data from ports, at least live time in real time, it is not possible to anticipate how long it will take for external ports or entities, either due to technical or privacy concerns. The best case scenario relates to a port with an already IoT platform deployed and good flexibility to access the data. The worst case scenario, on the contrary, involves a port with no IoT platform (or low availability of required data) and severe security and privacy data access policies. In such cases, risk can be mitigated by either choosing ports with high data availability or by providing generic models.
4) **Cost:** software costs can be minimized if we use the FIWARE cloud as we are using in PIXEL; however, hardware costs (equipment and sensors) have not been considered in the project budget and may be an issue if external ports require it. This risk can be minimized either by selecting ports with sufficient infrastructure or by inserting simulating data extracted from open or historical data.

Considering the envisioned limitations for PoC transferability, most of them are dependent on external entities (ports) with reduced room for manoeuvre from the PIXEL consortium. Therefore, it is important for the PIXEL consortium to establish, at least, good transferability guidelines or methodology with real examples as a basis to be followed by any port interested in transferring any of the developed components in PIXEL. This work will therefore reach a wider reachability.

6. Conclusions and next steps

The scope of the present report is to depict the methodology that will be implemented in order to evaluate the project in terms of technical functioning and interoperability of all components of PIXEL and its results. By this, we mean the PIXEL "enabling IT infrastructure" and the ICT solutions to be implemented in the four use cases (Port of Bordeaux, Port of Monfalcone, Port of Thessaloniki and Port of Piraeus).

The overall evaluation methodology is structured around 3 main pillars:

- The technical impact assessment of the PIXEL Platform and the ICT solutions;
- The business and economic impact assessment of the ICT solutions;
- The PIXEL Proof of Concept and future R&D potential

Each one of the above pillars comprises a specific Task of WP8 and for this reason it has been dealt with separately in the report. The three tasks will follow a separate and described above time plan, applying specific in each case methodology and following different data collection methods. In order however to apply an efficient overall evaluation methodology, the partners will make sure to coordinate data collection actions (eg. Questionnaires) so as to minimize the effort and maximize the quality and quantity of information collected.

Time wise, the first part of the evaluation that will commence is Task 8.2 dedicated to the technical impact assessment. This task will start in M14 (actually ongoing at the delivery date of the present report) and will include the evaluation of the technical performance, the user acceptance and the information security and robustness. Investment and operational costs (related to hardware/software), however, will be assessed in the business and economic part. The technical assessment will be based on three evaluation models, all of them based on the International Standards on System and Software Quality Requirements and Evaluation (SQuaRE). Several risks related to the technical assessment have been mentioned in the relevant sections most of them related to other WPs being late, or connected tasks starting at around the same dates. Specific contingency plans have been foreseen ensuring that the two related deliverables (D8.2 and D8.3) will finally provide a robust and concrete technical evaluation.

Following and during M19, the second part of the evaluation related to the business and economic impact assessment will start and will continue until the end of the project. During this task the partners will evaluate the business impacts of the operational results of the use cases, the business impacts of organizational aspects of the use cases and the economic impacts of the use cases' societal aspects, i.e. environmental & social benefits to the citizens. This analysis will lead to a complete Cost Benefit Analysis which will be done following the guidelines included in the "Guide to Cost-Benefit Analysis of Investment Projects" published by the European Commission. All of the four ports have identified specific expected benefits and associated KPIs which will be assessed in order to form the CBA. The provisional risks in this case are related mostly to lack of historical and/or new statistical information, for which the partners have come up with specific solutions and contingency plans.

The final part of the evaluation is related to the widening of the assessment scope by taking into account wider user community requirements that exist today or are emerging, and to inquiring if the PIXEL concept can cover those as well. More specifically, the scope will be on one hand to identify future research directions and to extend the assessment/evaluation by building a proof-of-concept (PoC) in external ports on the other. This final task will start in M25 and continue until the end of the project. The main risks related to this part of the evaluation have to do with external to the project ports not being willing to test the PIXEL results, timing issues, lack of data and necessary costs. To overcome these risks, the partners consider necessary to establish good transferability guidelines or methodology with real examples as a basis to be followed by any port interested in transferring any of the developed products in PIXEL

Task 8.2: Technical Impact Assessemnt	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36
Questionnaires creation																								
Questionnaires diffusion							D8.2								D8.3									
KPIs data collection																								
Questionnaires response collection																								
KPIs calculation																								
Task 8.3: Business & Economic Evaluation	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**M21**	**M22**	**M23**	**M24**	**M25**	**M26**	**M27**	**M28**	**M29**	**M30**	**M31**	**M32**	**M33**	**M34**	**M35**	**M36**
Formulation of questionnaires																								
Data collection organization																								
Dissemination of questionnaires																								
Data collection and measurements																								
Data analysis																								
1st draft of D8.4																								
Review of 1st Draft																								
Final version of D8.4 ready for submission																								
Task 8.4: PoC	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**M21**	**M22**	**M23**	**M24**	**M25**	**M26**	**M27**	**M28**	**M29**	**M30**	**M31**	**M32**	**M33**	**M34**	**M35**	**M36**
Preparation																								
Methodology approach/update																								
Transferability examples (PEI,IoT platform, models..)																								
Identification of candidate external ports																								
Recruitment																								
Contact ports distributing some preparation material																								
Confirmation from ports																								
Methodology																								
Mission statement/objectives																								
Impacts of the products for the external port																								
Identification of components and characteristics																								
Level of importance of components and characteristics																								
Deployment and internal assessment																								
External assessment																								
Summary and conclusions																								

Figure 9: Consolidated Gantt chart for WP8

References

1. FOT-Net Data Project "D5.4 – Updated version of the FESTA Handbook" European Commission, DG Connect, January, 2017.
2. Sotiropoulou M, Chalkiopoulos A. D6.1 BigDataOcean Validation Framework. Attiki (Greece): Hellenic Centre for Marine Research; 2017 Dec. Grant Agreement No.: 732310. Sponsored by the European Union.
3. Venkatesh, V. & Bala, H. (2008). TAM 3: Advancing the Technology Acceptance Model with a Focus on Interventions. Decision Sciences, 39, 273-315.
4. Lee, Yang & M. Strong, Diane & Kahn, Beverly & Y. Wang, Richard. (2002). AIMQ: A methodology for information quality assessment. Information & Management. 40. 133-146. 10.1016/S0378-7206(02)00043-5.
5. Reza Vaziri and Mehran Mohsenzadeh. International Journal of Database Management Systems (IJDMS) Vol.4, No.2, April 2012.
6. European Commission, Directorate-General for Regional and Urban policy "Guide to Cost-Benefit Analysis of Investment Projects - Economic appraisal tool for Cohesion Policy 2014-2020", Brussels, 2015.
7. Transport Innovation Deployment for Europe (TIDE) EU project [http://www.tide-innovation.eu/]. Official website no longer available, only through webarchive snapshots [https://web.archive.org/web/20170421145002/http://www.tide-innovation.eu/en/]

Appendix A – ISO/IEC 25010:11 – Product Quality Model

The Product Quality Model has been proposed in the norm ISO/IEC 25010:11. It defined some characteristics along with their sub-characteristics that are exposed below:

- **Functional suitability**: degree to which a product or system provides functions that meet stated and implied needs when used under specified conditions.
    - *Functional appropriateness*: degree to which the functions facilitate the accomplishment of specified tasks and objectives.
    - *Functional completeness*: degree to which the set of functions covers all the specified task and user objectives.
    - *Functional correctness*: degree to which a product or a system provides the correct results with the needed degree of precision.
- **Performance efficiency**: performance relative to the amount of resources used under stated conditions.
    - *Capacity*: degree to which the maximum limits of a product or system parameter meet requirements.
    - *Time behaviour*: degree to which the response and processing time and throughput rates of a product or a system, when performing its functions, meet requirements.
    - *Resource utilisation*: degree to which the amounts and types of resources used by a product or system, when, performing its function, meet requirements.
- **Compatibility**: degree to which a product, system or component can exchange information with other products, systems or components, and/or perform its required functions, while sharing the same hardware or software environment.
    - *Interoperability*: degree to which two or more systems, products or components can exchange information and use the information that has been exchanged.
    - *Co-existence*: degree to which a product can perform its required functions efficiently while sharing a common environment and resources with other products, without detrimental impact on any other product.
- **Operability**: degree to which the product has attributes that enable it to be understood, learned, used and attractive to the user, when used under specified conditions.
    - *Ease of use:* System has attributes that make it easy to operate and control
    - *Technical Accessibility:* System can be used by people with the widest range of characteristics and capabilities.
    - *User interface aesthetics:* User interface enables pleasing and satisfying interaction for the user.
    - *User error protection:* System protects users against making errors.
    - *Appropriateness recognisability:* Users can recognise whether a system is appropriate for their needs, even before it is implemented.
    - *Technical Learnability:* The system has functions which enable learning specified operations of it.
- **Reliability**: degree to which a system, product, or component performs specified functions under specified conditions for a specified period of time.

  - *Maturity*: degree to which a system, product or component meets needs for reliability under normal operation.
  - *Availability*: degree to which a system, product or component is operational and accessible when required for use.
  - *Fault tolerance*: degree to which a system, product, or component operates as intended despite the presence of hardware or software faults.
  - *Recoverability*: degree to which, in the event of an interruption or a failure, a product or system can recover the data directly affected and re-establish the desired state of the system.
- **Security**: degree to which a product or system protects information and data so that persons or other products or systems have the degree of data access appropriate to their type and levels of authorisation.
  - *Confidentiality:* degree to which a product or system ensures that data are accessible only to those authorised to have access.
  - *Integrity*: degree to which a system, product or component prevents unauthorised access to, or modification of, computer programs or data
  - *Non-repudiation*: degree to which actions or events can be proven to have taken place, so that the events or actions cannot be repudiated later
  - *Accountability*: degree to which the actions of an entity can be traced uniquely to the entity.
  - *Authenticity*: degree to which the identity of a subject or resource can be proved to be the one claimed.
- **Maintainability**: degree of effectiveness and efficiency with which a product or system can be modified by the intended maintainers.
  - *Modularity*: degree to which a system or computer program is composed of discrete components such that a change to one component has minimal impact on other components.
  - *Reusability*: degree to which an asset can be used in more the one system, or in building other assets.
  - *Analysability*: degree of effectiveness and efficiency with which it is possible to assess the impact on a product or system of an intended change to one or more of its parts, or to diagnose a product for deficiencies or causes of failures or to identify parts to be modified.
  - *Modifiability*: degree to which a product or system can be effectively and efficiently modified without introducing defects or degrading existing product quality.
  - *Testability*: degree of effectiveness and efficiency with which test criteria can be established for a system, product or component and test can be performed to determine whether those criteria have been met.
- **Portability**: degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another.
  - *Adaptability*: degree to which a product or system can effectively and efficiently be adapted for different or evolving hardware, software or other operational or usage environments.
  - *Installability*: degree of effectiveness and efficiency with which a product or system can be successfully installed and/or uninstalled in a specified environment.
  - *Replaceability*: degree to which a product can replace another specified software product for the same purpose in the same environment.

Appendix B – ISO/IEC 25010:11 – Quality In Use Model

The Quality In Use Model has been proposed in the norm ISO/IEC 25010:11. It defined some characteristics along with their sub-characteristics that are exposed below:

- **Effectiveness**: accuracy and completeness with which users achieve specified goals.
- **Efficiency**: resources expended in relation to the accuracy and completeness with which users achieve goals.
- **Satisfaction**: degree to which user needs are satisfied when a product or system is used in a specified context of use.
    - *Usefulness*: degree to which a user is satisfied with their perceived achievement of pragmatic goals, including the results of use and the consequences of use.
    - *Trust*: degree to which a user or other stakeholder has confidence that a product or system will behave as intended.
    - *Pleasure*: degree to which a user obtains pleasure from fulfilling their personal needs.
    - *Comfort*: degree to which the user is satisfied with physical comfort.
- **Freedom from risk**: degree to which a product or system mitigates the potential risk to economic status, human life, health, or the environment.
    - *Economic risk mitigation*: degree to which a product or system mitigates the potential risk to financial status, efficient operation, commercial property, reputation or other resources in the intended contexts of use.
    - *Health and safety risk mitigation*: degree to which a product or system mitigates the potential risk to people in the intended contexts of use.
    - *Environmental risk mitigation*: degree to which a product or system mitigates the potential risk to property or the environment in the intended contexts of use.
- **Context coverage**: degree to which a product or system can be used with effectiveness, efficiency, freedom from risk and satisfaction in both specified contexts of use and in contexts beyond those initially explicitly identified.
    - *Context completeness*: degree to which a product or system can be used with effectiveness, efficiency, freedom from risk and satisfaction in all the specified contexts of use.
    - *Flexibility*: degree to which a product or system can be used with effectiveness, efficiency, freedom from risk and satisfaction in contexts beyond those initially specified in the requirements.

Appendix C – ISO/IEC 25012:08 – Data Quality Model

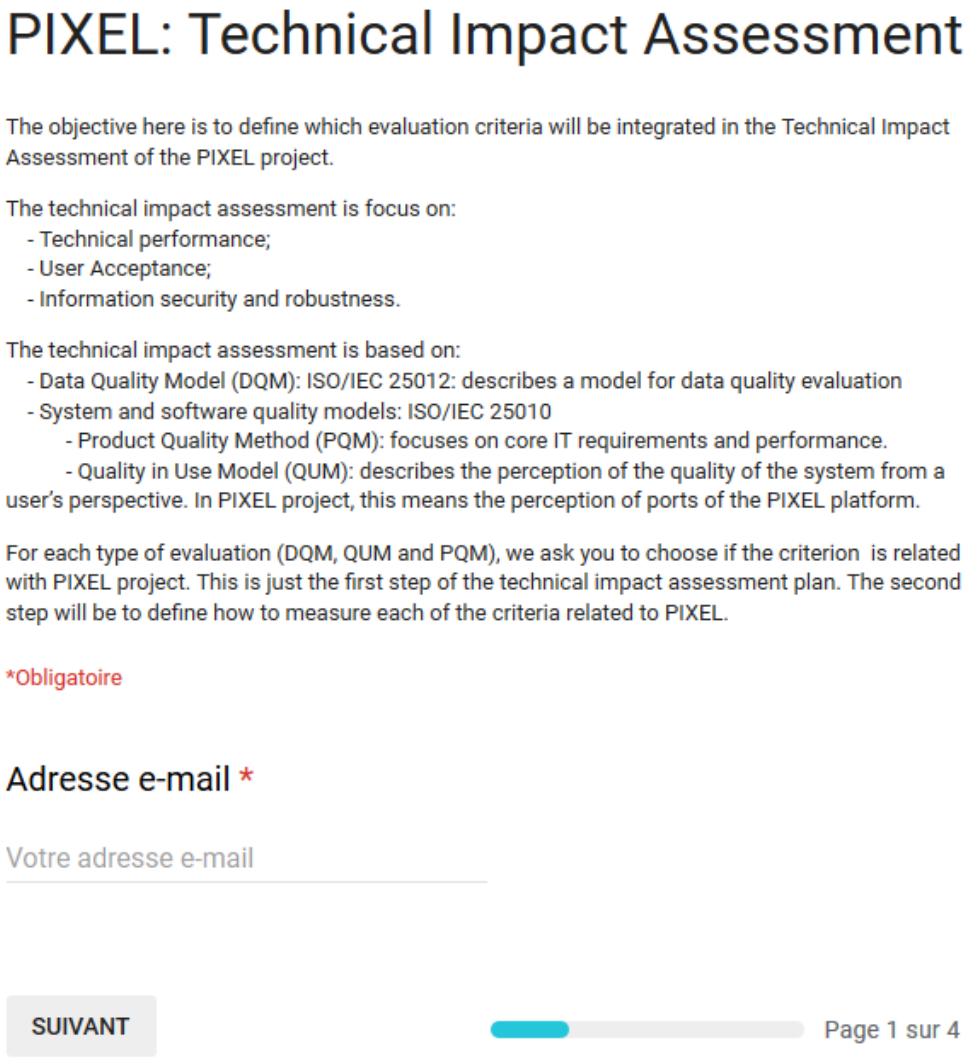
The Data Quality Model has been proposed in the norm ISO/IEC 25012:08. It defined some characteristics along with their sub-characteristics that are exposed below:

- **Information Accuracy**: the degree to which data has attributes that correctly represent the true value of the intended attribute of a concept or event in a specific context of use.
    - *Currentness*: the degree to which data has attributes that are of the right age in a specific context of use.
    - *Correctness*: the extent to which information is reliable in the sense of being free of errors.
    - *Credibility*: the degree to which data has attributes that are regarded as true and believable by users in a specific context of use. Credibility includes the concept of authenticity (the truthfulness of origins, attributions, commitments).
    - *Precision*: the degree to which data has attributes that are exact or that provide discrimination in a specific context of use.
    - *Traceability*: the degree to which data has attributes that provide an audit trail of access to the data and of any changes made to the data in a specific context of use.
- **Information Accessibility**: the degree to which data can be accessed in a specific context of use, particularly by people who need supporting technology or special configuration because of some disability.
- **Information Appropriateness**: The degree to which the delivered information is complete, consistent, understandable, represented adequately and have added value for the user, considering the specified user tasks and goals.
    - *Understandability*: the degree to which data has attributes that enable it to be read and interpreted by users, and are expressed in appropriate languages, symbols and units in a specific context of use.
    - *Value Added*: the extent to which data or information are beneficial and provide advantages from their use.
    - *Representational Adequacy*: the extent to which data or information is represented in a concise, flexible and organized way with due relevancy to the users' goals to help user to achieve their specified goals.
    - *Consistency*: the degree to which data has attributes that are free from contradiction and are coherent with other data in a specific context of use. It can be either or both among data regarding one entity and across similar data for comparable entities.
    - *Completeness*: the degree to which subject data associated with an entity has values for all expected attributes and related entity instances in a specific context of use.
- **Efficiency**: the degree to which data has attributes that can be processed and provide the expected levels of performance by using the appropriate amounts and types of resources in a specific context of use.
- **Availability**: the degree to which data has attributes that enable it to be retrieved by authorized users and/or applications in a specific context of use.
- **Portability**: the degree to which data has attributes that enable it to be installed, replaced or moved from one system to another preserving the existing quality in a specific context of use.
- **Recoverability:** the degree to which data has attributes that enable it to maintain and preserve a specified level of operations and quality, even in the event of failure, in a specific context of use.

Appendix D – Technical Impact Assessment Survey

D.1. Survey about the Technical Impact Assessment

This survey had been sent to PIXEL consortium in order identify which characteristics of the ISO Standards are related to PIXEL project.



PIXEL: Technical Impact Assessment

The objective here is to define which evaluation criteria will be integrated in the Technical Impact Assessment of the PIXEL project.

The technical impact assessment is focus on:
- Technical performance;
- User Acceptance;
- Information security and robustness.

The technical impact assessment is based on:
- Data Quality Model (DQM): ISO/IEC 25012: describes a model for data quality evaluation
- System and software quality models: ISO/IEC 25010
    - Product Quality Method (PQM): focuses on core IT requirements and performance.
    - Quality in Use Model (QUM): describes the perception of the quality of the system from a user's perspective. In PIXEL project, this means the perception of ports of the PIXEL platform.

For each type of evaluation (DQM, QUM and PQM), we ask you to choose if the criterion is related with PIXEL project. This is just the first step of the technical impact assessment plan. The second step will be to define how to measure each of the criteria related to PIXEL.

*Obligatoire

Adresse e-mail *

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Page 1 sur 4

Data Quality Model

The Data Quality model represents the grounds where the system for assessing the quality of data products is built on. In a Data Quality model, the main Data Quality characteristics that must be taken into account when assessing the properties of the intended data product are established.

The Quality of a Data Product may be understood as the degree to which data satisfy the requirements defined by the product-owner organization. Specifically, those requirements are the ones that are reflected in the Data Quality model through its characteristics (Accuracy, Completeness, Consistency, Credibility, Currentness, Accessibility...).

Information Accuracy

The degree to which delivered information is correct, precise, credible, traceable and current in a specific context of use.

Which sub-characteristics is related to PIXEL?

- [ ] Correctness: The extent to which information is reliable in the sense of being free of errors.
- [ ] Credibility: The extent to which the information is reputable objective (unbiased), and trustable (true and believable)
- [ ] Currentness: The extent to which the information can be identified as up to date
- [ ] Precision: The degree to which information has attributes that are exact or that provide discrimination in a specific context of use.
- [ ] Traceability: The extent to which the source of information, including owner and/or author of the information, and any changes made to the information can be verified.

Information Accessibility

Which sub-characteristics is related to PIXEL?

- [ ] Accessibility: The degree to which information can be accessed in a specific context

Information Appropriateness

The degree to which the derived information is complete, consistent, understandable, represented adequately and have added value for the user, considering the specified user tasks and goals.

Which sub-characteristics is related to PIXEL?

- [ ] Completeness: The extent to which the information provided is of sufficient breadth, depth and scope for the task at hand.
- [ ] Understandability: The extent to which the information provided is understandable by end-users.
- [ ] Consistency: The degree to which information has attributes that are free from contradiction and are coherent with other information in a specific context.
- [ ] Representational Adequacy: The extent to which data or information is represented in a concise, flexible and organised way with due relevancy to the users' goals to help them to achieve their specific goals.
- [ ] Value added: The extent to which data or information are beneficial and provide advantages from their use.

Efficiency

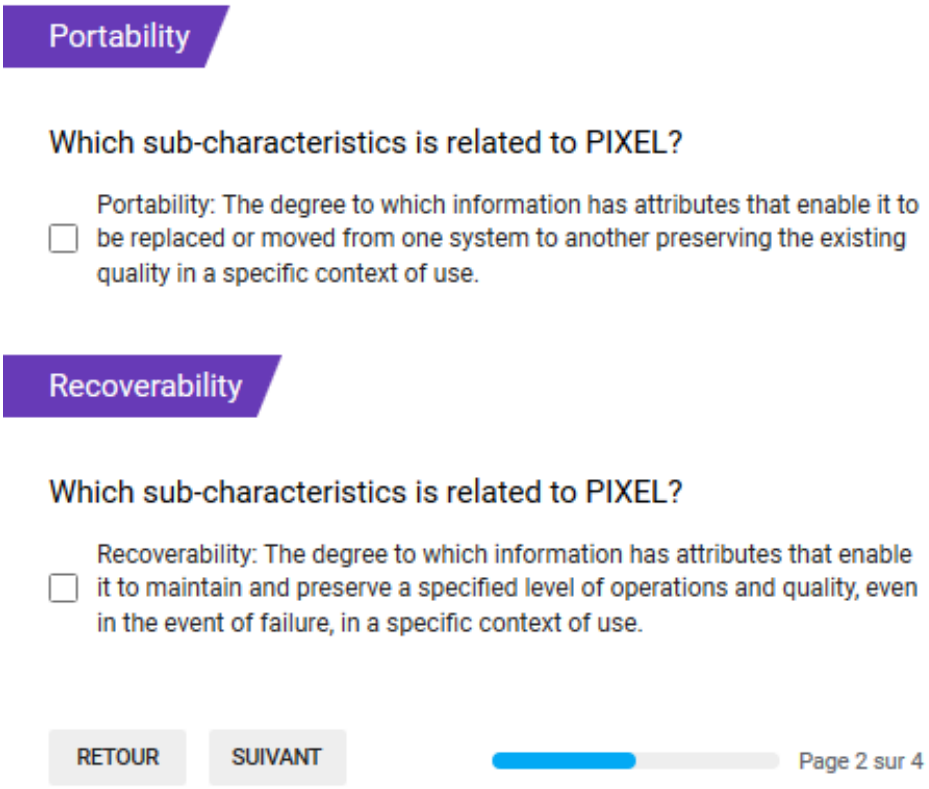
Which sub-characteristics is related to PIXEL?

- [ ] Efficiency: The degree to which information has attributes that can be processed and provide the expected levels of performance by using the appropriate amounts and types of resources in a specific context of use.

Availability

Which sub-characteristics is related to PIXEL?

- [ ] Availability: The degree to which information has attributes that enable it to be retrieved by authorised users and/or applications in a specific context of use.


Portability
Which sub-characteristics is related to PIXEL?
Portability: The degree to which information has attributes that enable it to be replaced or moved from one system to another preserving the existing quality in a specific context of use.
Recoverability
Which sub-characteristics is related to PIXEL?
Recoverability: The degree to which information has attributes that enable it to maintain and preserve a specified level of operations and quality, even in the event of failure, in a specific context of use.
RETOUR
SUIVANT
Page 2 sur 4

Product Quality Model

The product quality model describes the internal and external measures of software quality. Internal measures describe a set of static internal attributes that can be measured. The external measures focus more on software as a black box and describe external attributes that can be measured.

Functional suitability

The degree to which the product provides functions that meet stated and implied needs when the product is used under specified conditions.

Which sub-characteristics is related to PIXEL?

- [ ] Functional completeness: Degree to which the set of functions covers all the specified tasks and user objectives.
- [ ] Functional correctness: System provides the correct results with the needed degree of precision
- [ ] Functional appropriateness: The functions facilitate the accomplishment of specified tasks and objectives.

Performance efficiency

The performance relative to the amount of resources used under stated conditions.

Which sub-characteristics is related to PIXEL?

- [ ] Time behaviour: Response, processing times and throughput rates of a system, when performing its functions, meet requirements.
- [ ] Resource utilisation: The amounts and types of resources used by a system, when performing its functions, meet requirements.
- [ ] Capacity: The maximum limits of a product or system parameter meet requirements.

Compatibility

The degree to which two or more systems or components can exchange information and/or perform their required functions while sharing the same hardware or software environment.

Which sub-characteristics is related to PIXEL?

- [ ] Co-existence: Product can perform its functions efficiently while sharing environment and resources with other products.
- [ ] Interoperability: A system can exchange information with other systems and use the information that has been exchanged.

Operability

The degree to which the product has attributes that enable it to be understood, learned, used and attractive to the user, when used under specified conditions

Which sub-characteristics is related to PIXEL?

- [ ] Appropriateness recognisability: Users can recognise whether a system is appropriate for their needs, even before it is implemented.
- [ ] Technical Learnability: The system has functions which enable learning specified operations of it
- [ ] Ease of Use: System has attributes that make it easy to operate and control.
- [ ] User error protection: System protects users against making errors.
- [ ] User interface aesthetics: User interface enables pleasing and satisfying interaction for the user.
- [ ] Technical Accessibility: System can be used by people with the widest range of characteristics and capabilities.

Reliability

The degree to which a system or component performs specified functions under specified conditions for a specified period of time.

Which sub-characteristics is related to PIXEL?

- [ ] Maturity: System meets needs for reliability under normal operation.
- [ ] Availability: System is operational and accessible when required for use.
- [ ] Fault tolerance: System operates as intended despite the presence of hardware or software faults.
- [ ] Recoverability: System can recover data affected and re-establish the desired state of the system is case of an interruption or a failure.

Security

The degree of protection of information and data so that unauthorised persons or systems cannot read or modify them and authorised persons or systems are not denied access to them.

Which sub-characteristics is related to PIXEL?

- [ ] Confidentiality: System ensures that data are accessible only to those authorised to have access.
- [ ] Integrity: System prevents unauthorised access to, or modification of, computer programs or data.
- [ ] Non-repudiation: Actions or events can be proven to have taken place, so that the events or actions cannot be repudiated later.
- [ ] Accountability: Actions of an entity can be traced uniquely to the entity.
- [ ] Authenticity: The identity of a subject or resource can be proved to be the one claimed.

Maintainability

The degree of effectiveness and efficiency with which the product can be modified.

Which sub-characteristics is related to PIXEL?

- [ ] Modularity: System is composed of components such that a change to one component has minimal impact on other components.
- [ ] Reusability: An asset can be used in more than one system, or in building other assets.
- [ ] Analysability: Effectiveness and efficiency with which it is possible to assess the impact of an intended change
- [ ] Modifiability: System can be effectively and efficiently modified without introducing defects or degrading existing product quality.
- [ ] Testability: Effectiveness and efficiency with which test criteria can be established for a system.

Portability

The degree to which a system or component can be effectively and efficiently transferred from one hardware, software or other operational or usage environment to another.

Which sub-characteristics is related to PIXEL?

- [ ] Adaptability: System can be effectively and efficiently adapted to different or evolving hardware, software or usage environments
- [ ] Installability: Effectiveness and efficiency with which a system can be successfully installed and/or uninstalled.
- [ ] Replaceability: Product can be replaced by another specified software product for the same purpose in the same environment

RETOUR SUIVANT Page 3 sur 4

Quality in Use Model

The Quality in Use model describes the perception of the quality of the system from a user's perspective. The different characteristics and sub-characteristics of this model are derived from testing or observing the results of real or simulated use of the system

Effectiveness

The accuracy and completeness with which users achieve specified goals.

Which sub-characteristics is related to PIXEL?

- [ ] Effectiveness: The degree at which users achieve their goals accurately when using the system.

Efficiency

The resources expended in relation to the accuracy and completeness with which users achieve goals.

Which sub-characteristics is related to PIXEL?

- [ ] Efficiency: The degree to which users find that the software is efficiently covering its intended purpose:

Satisfaction

The degree to which users are satisfied with the experience of using a product in a specified context of use.

Which sub-characteristics is related to PIXEL?

- [ ] Usefulness: The degree to which users find useful the software and its operations
- [ ] Trust: The degree to which users feel that they can trust the system
- [ ] Pleasure: The degree to which users find the software's functions a pleasure to use (emotionally)
- [ ] Comfort: The degree to which users think that the system provides the comforts needed (physically)

Safety

The degree to which a product or system does not, under specified conditions, lead to a state in which human life, health, property, or the environment is endangered.

Which sub-characteristics is related to PIXEL?

- [ ] Economic damage risk: Acceptable levels of risk of harm to the operator in the intended contexts of use.
- [ ] Health and Safety risk: Acceptable levels of risk of harm to the public in the intended contexts of use.
- [ ] Environmental harm risk: Acceptable levels of risk of harm to property or the environment in the intended contexts of use.

Usability

The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.

Which sub-characteristics is related to PIXEL?

- [ ] Learnability: The extent to which a product can be used by specified users to achieve specified learning goals with effectiveness, efficiency, safety and satisfaction in a specified context of use.
- [ ] Flexibility: The degree to which usability and safety requirements are met in all the intended contexts of use.
- [ ] Accessibility: The extent to which a product can be used by users with specified disabilities to achieve specified goals with effectiveness, efficiency, safety and satisfaction in a specified context of use.
- [ ] Content Conformity: The degree to which usability and safety requirements are met in all the intended contexts of use.

RETOUR ENVOYER Page 4 sur 4