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BIG DATA OCEAN

BigDataOcean

"Exploiting Oceans of Data for Maritime Applications"

D6.1 BigDataOcean Validation Framework

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Executive Summary

The scope of D6.1 "BigDataOcean Validation Framework" is to document the results of the T6.1 - "Pilots Validation and Evaluation Framework Design", which has a twofold objective of firstly developing the evaluation framework and validation methodology, defining the various practices for obtaining feedback from the end-users, and secondly, providing a set of test cases to be executed by the end-users.

Regarding the first part of this document, three evaluation models are used to develop the evaluation framework, based on the International Standards on System and Software Quality Requirements and Evaluation (SQuaRE). The first model concerns the evaluation of the BigDataOcean platform regarding the static properties of the software and the dynamic properties of the computer system. The second is used for the assessment of the actual usage evaluation of the platform and the third, is complementary to the other two and refers to the evaluation of the data provided through the BigDataOcean platform. Following the characteristics and sub-characteristics described in these models and the relevance to the platform specifications, respective lists of indicators have been devised in order to allow the overall assessment of the BigDataOcean platform from the end-users.

As far as the second part of D6.1 is concerned, the user stories that are going to be used for the platform evaluation are listed according to the priority that was set in D2.2 "BigDataOcean Methodology and MVP". This list is going to be further analysed into specific test cases for each pilot while taking into account the pilots' requirements (context of D6.2 "BigDataOcean Pilots Readiness Documentation"). Additionally, a list of test cases for the assessment of the product quality KPIs are also included. These test cases are going to be integrated in the architecture design in terms of Task 4.4.

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Abbreviations

Abbreviation	Description
AIS	Automatic Identification System
API	Application Programming Interface
CPU	Central Processing Unit
D	Deliverable

Abbreviation	Description
DoW	Document of Work
ID	Identifier
IEC	International Electrotechnical Commission
ISO	International Organization for standardization
IT	Information Technology
KPI	Key Performance Indicator
MVP	Minimum Viable Product
NetCDF	Network Common Data Form
RAM	Random Access Memory
US	User Story
WCAG	Web Content Accessibility Guidelines
WebApps	Web Applications
WP	Work Package

1 Introduction

1.1 Objective of the Deliverable

In the context of this deliverable two main subjects are described as they have been elaborated in the Task 6.1 "T6.1 - Pilots Validation and Evaluation Framework Design". Firstly, a detailed description of the evaluation framework and validation methodology is provided, defining the various practices for obtaining feedback from the end-users. The validation strategy is based on models defined in International Standards (ISO [1], [2]) and aims to assess the quality of the BigDataOcean platform in terms of the product quality from a technical point of view, as well as the quality in the actual use of the platform by the end-users. Additionally, since the BigDataOcean main objective is the exploitation of cross-sectorial marine data of high-volume and velocity, an information quality evaluation has also been included.

Since this is the Proof-of-Concept specification step, the definition of the evaluation framework and validation strategy is based on small-scale validation scenarios connected with different user story requirements. These scenarios are used to develop the second part of this document, which is a set of test cases to be executed by the end users.

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1.2 Structure of the Deliverable

The deliverable is structured as follows:

- **Chapter 1** provides an overall introduction of the deliverable objectives and positioning within the project;
- **Chapter 2** documents a detailed description of the evaluation and validation framework design;
- **Chapter 3** provides a list of test cases for evaluation by the end-users;
- **Chapter 4** concludes this deliverable by providing an overview and reporting on future steps to follow.

1.3 Positioning within the project

The work reported in this project is part of the Task 6.1 "Pilots Validation and Evaluation Framework Design" within WP6 "BigDataOcean Ecosystem Pilots and Services Evaluation Phase" which is responsible for the overall planning, management and evaluation of the BigDataOcean ecosystem pilots. In the context of Task 6.1, an inclusive pilots' validation and evaluation framework is extensively studied and defined. The main inputs for this task are the needs and requirements of the end-users as they were reported in the context of WP2 and WP4. Specifically, D2.1 "Analysis Report on Big Data Components, Tools and Methodologies" defines the position of the validation stage within the BigDataOcean requirements Engineering Methodology and the relation to the other stages during

the BigDataOcean implementation. The input of D2.2 "BigDataOcean Methodology and MVP" is very essential, as it provides the four groups of end-users as well as a list of User Stories corresponding to the needs and requirements of each group. In D4.1 "BigDataOcean Technology Requirements and User Stories" and D4.2 "BigDataOcean Platform Architecture, Components Design and APIs v1.00", the User Stories correspond to the respective technological requirements and components which will be evaluated. All this information is combined into a set of test-cases for the end-users. These test-cases will be received along with the evaluation and validation framework as input by Task 6.2 "Pilots Planning and Preparation". This task will elaborate the actual processes for the evaluation and validation of the BigDataOcean platform as these will be realised by the participating pilots.

2 Development of the BigDataOcean Evaluation Framework

2.1 The Evaluation Framework within the BigDataOcean Development Cycle

In WP2 and specifically in D2.1 "Analysis Report on Big Data Components, Tools and Methodologies" the Requirements Engineering Methodology is delivered, which describes in detail the five stages of preparation, elicitation, analysis, specification and validation that are followed. In the last two stages, the position of WP6 tasks is clearly stated and a brief description of the workflow is presented in the following Figure 2-1:

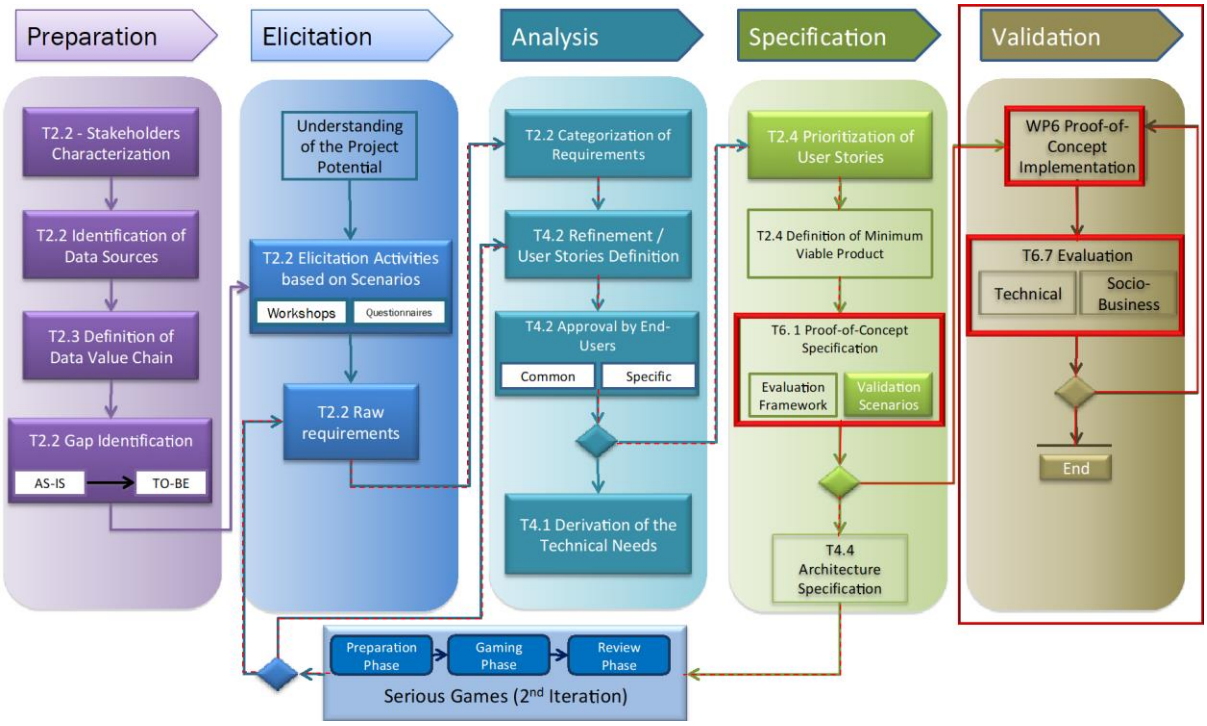

Figure 2-1: WP6 within BigDataOcean Requirements Engineering Methodology (D2.1)

Task 6.1, which provides the context of the deliverable at hand, constitutes the Proof-of-Concept specification step of the methodology. The definition of the Minimum Viable Product (MVP) along with the prioritised user stories, which are provided through Task 2.4, D2.1 and D2.2, are used as input for the development of small validation scenarios that can be performed by the end users.

The end users are forming four stakeholder groups, which represent all anticipated stakeholders involved in the BigDataOcean value proposition and are taken into consideration during the development of the evaluation and validation framework:

1. Data providers,
2. Service providers,
3. Consumers and
4. Software teams.

Although the main target group for the BigDataOcean platform are the consumers, the four stakeholder groups, apart from their individual purposes, they all ultimately intend towards the accomplishment of the easy consumption of maritime data and services.

The evaluation and validation framework combines all this information to define the methodology that will be followed when realising the validation phase of the BigDataOcean platform as shown in the last stage of the requirements engineering methodology.

The Proof-of-Concept is followed by the architecture specification step, which is developed in terms of the Task 4.4 and will be able to identify any discrepancies on the requirements in relation to the planned ideas or concepts that are delivered in Task 6.1. If this is the case, a new development cycle will start which will provide feedback to the elicitation and analysis phases and the process will repeat.

Thus, in order to design the validation framework, apart from the different stakeholders and the requirements engineering methodology, it is important to know the characteristics of the BigDataOcean software development life cycle processes that are used to develop the platform. This lifecycle defines structured activities which are designed to gradually lead to a high quality platform with an added value for the end-user. However, since users often do not know precisely what features they want and how they should look like, devising this lifecycle can be difficult. In addition, developers need to address technical, organisational, economical, and legal constraints that altogether makes the software development of the project very complex. For both these reasons, the platform under development needs to be evaluated on a regular basis considering both its business value (pilot and evaluation activities) and the user's perspective. Both the user's experience and technical implementation must be evaluated.

The basis for the planning of the BigDataOcean evaluation framework needs to be the specifics of the BigDataOcean project itself. Existing software solutions from the partners of the project are reused as subsystems and integrated into a unified platform. As these subsystems were never interconnected before, a high amount of work in the first year consists of adapting and testing them in conjunction (see D2.2 for the architectural details). The co-hosting and sharing of private and personal data over public infrastructure require high security and privacy standards establishing state of the art security and dealing with national data protection laws of the participating partners. For this, the most important aspects of the European data protection law were identified and generalised as a framework for data protection and ethical issues. Security is established by using well proven, standard Web technologies and privacy concepts (e.g. anonymous classification). Nevertheless, high-level privacy and security reviews must be scheduled as part of the evaluation framework, quantifying the risk of private data leakage.

Other constraints for the evaluation framework include the two and a half years project lifespan and the amount of scheduled resources for piloting the project (a total of 113 man-months for the realisation of the four pilot cases). To perform multiple technical and user evaluations during that short period, the development of the platform and its evaluation must be performed in parallel to the implementation. The results of the evaluation are provided as feedback to the development cycle, improving the user experience and detecting open issues. Therefore, after an evaluation is performed, the resulting issues need to be discussed by the consortium and, if needed, to be added to the list of functional requirements for the next software development iteration.

V-model, which is a software development life cycle methodology, describes the activities to be performed and the results that have to be produced during the life cycle of the product ([4], [5]). In this model, the development and quality analysis activities are done simultaneously. As depicted in Figure 2-2 below, the development life-cycle processes combine the V-model process with short, concurrent development cycles. The main targets of the first year of the project's life were the identification of the user requirements, the development of the system requirement specification, the technical architecture, and a first prototype (MVP) that implements the most essential features of BigDataOcean. All partners develop their assigned components in parallel, in short cycles. Depending on the interfaces two or more partners together continuously integrate their components and refine their APIs individually. As each partner is providing the implemented services from the beginning, there is always an integrated system, which gains features over time. Nevertheless, due to their costs, system tests and evaluations must be scheduled with a lower frequency than component and integration tests. In addition, they are performed independently of the shorter component development cycles.

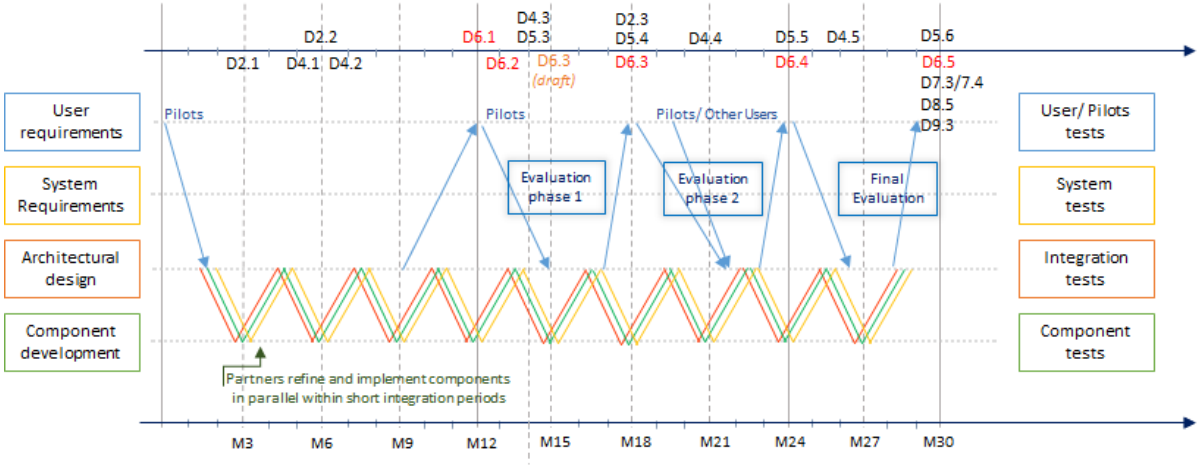

Figure 2-2: BigDataOcean life cycle processes

The evaluation framework provided in this document must be embedded into the presented BigDataOcean development lifecycle and provide:

- facilities to perform evaluations concurrently to the development activities,
- roles that perform the evaluation and feed the results back into the development process,
- a decision scheme to prioritise new or changed user requirements and technical issues.

2.2 BigDataOcean Evaluation Framework Design

This section describes the Assessment Factors which will be used by the consortium to evaluate the performance of the BigDataOcean platform during the operation of the pilots, in order to identify problems and shortcomings. As a result, the outcome of the project will be a fully functional, reliable and stable environment that could serve the needs of the users and could be exploited as a product operationally. As previously stated, during the development of the evaluation framework various factors have been taken into consideration:

1. the structure of the project,
2. the four different stakeholder groups,
3. the conformity and experience of partners on the methodologies used, and
4. the need to evaluate the technical characteristics of the platform, the real usage through the pilots and the quality of the available maritime data of this Big Data platform.

Thus, in this section, the evaluation framework design is described in detail.

For the evaluation of the platform, the ISO/IEC 25010:2011 "Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - System and software quality models" standard[1] was used as a basis, as it is a well-trusted framework that covers both technical aspects and actual usage. In more detail, the ISO/IEC 25010:2011 [1] defines as stated in its official website:

- *A quality in use model (in our case Actual Usage Evaluation) composed of five characteristics (some of which are further subdivided into sub-characteristics) that relate to the outcome of interaction when a product is used in a particular context. This system model is applicable to the complete human-computer system, including both computer systems in use and software products in use.*
- *A product quality model (in our case Technical Evaluation) 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.*

Since the assessment and evaluation of the BigDataOcean platform covers not only the Information Technology (IT) elements that will be delivered, but also the perceived usefulness and appropriateness for use by the pilot users, the evaluation will be conducted following the categories set by both models of the ISO 25010, adapted appropriately to the scope and nature of BigDataOcean.

Moreover, the BigDataOcean project aims at developing an innovative solution that will bring together data from differentiated sources and multiple languages, while offering end-users an efficient and effective way to combine them with their own and come up with innovative services, new knowledge, advanced business intelligence and intuitive analytics, that both data contributors and end-users will totally trust. Thus, it is very important that the quality of the data provided is also evaluated. The ISO/IEC 25012:2008 "Software engineering - Software product Quality Requirements and Evaluation

[1] http://www.iso.org/iso/catalogue_detail.htm?csnumber=35733

(SQuaRE) – Data quality model" standard [2] contains a model for data quality that is complementary to the ISO/IEC 25010:2011 and according to the official website[2], it is described as following:

ISO/IEC 25012:2008 categorizes quality attributes into fifteen characteristics considered by two points of view: inherent and system dependent. Data quality characteristics will be of varying importance and priority to different stakeholders.

Thus, more than one evaluation frameworks are analysed, combined and presented. Then, the assessment of the BigDataOcean platform during its pilot operation is based on an assessment model that includes a set of Key Performance Indicators (KPIs), based on ISO/IEC 25010:2011 and other models, on the user behaviour side. Following the main directions of this standard, different elements and criteria are selected and indicators specific to each element are defined in order to produce an assessment model that can be used for evaluating the technical operation of the BigDataOcean tools.

2.2.1 Technical evaluation - Product quality model

The product quality model describes the internal and external measures of software quality (Figure 2-3). 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.

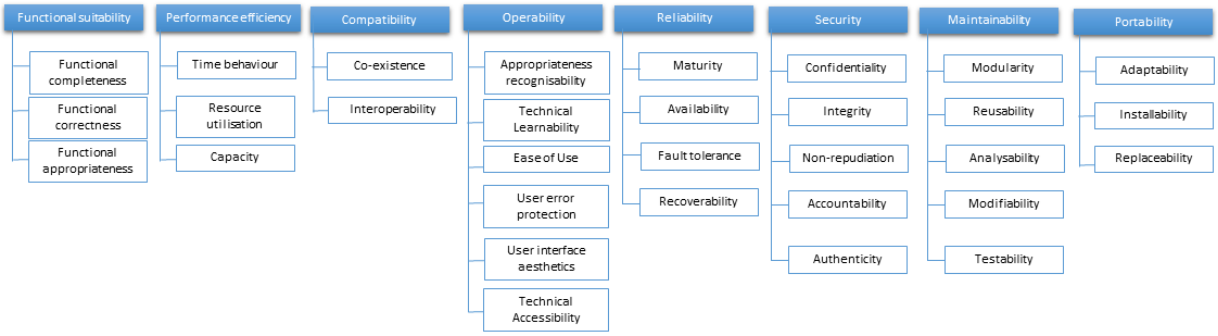

Figure 2-3: ISO/IEC 25010:2011 - Product Quality Model

In general, this model evaluates software quality using a structured set of characteristics (each of them including other sub-characteristics), which are the following:

1. Functional suitability - The degree to which the product provides functions that meet stated and implied needs when the product is used under specified conditions.
2. Performance efficiency - The performance relative to the amount of resources used under stated conditions.
3. 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.
4. 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.

[2] https://www.iso.org/standard/35736.html

5. Reliability - The degree to which a system or component performs specified functions under specified conditions for a specified period of time.
6. 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.
7. Maintainability - The degree of effectiveness and efficiency with which the product can be modified.
8. 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.

The following Table 2-1 showcases the sub-characteristics of each category and indicates their relativity to the BigDataOcean platform.

Sub-characteristics	Definition	Relation to BigDataOcean platform
Functional suitability		
Functional completeness	Degree to which the set of functions covers all the specified tasks and user objectives.	YES
Functional correctness	System provides the correct results with the needed degree of precision.	YES
Functional appropriateness	The functions facilitate the accomplishment of specified tasks and objectives.	YES
Performance efficiency		
Time behaviour	Response, processing times and throughput rates of a system, when performing its functions, meet requirements.	YES
Resource utilisation	The amounts and types of resources used by a system, when performing its functions, meet requirements.	YES
Capacity	The maximum limits of a product or system parameter meet requirements.	YES
Compatibility		
Co-existence	Product can perform its functions efficiently while sharing environment and resources with other products.	YES
Interoperability	A system can exchange information with other systems and use the information that has been exchanged.	YES
Operability		

Appropriateness recognisability	Users can recognise whether a system is appropriate for their needs, even before it is implemented.	YES
Technical Learnability	The system has functions which enable learning specified operations of it.	YES
Ease of Use	System has attributes that make it easy to operate and control.	YES
User error protection	System protects users against making errors.	YES
User interface aesthetics	User interface enables pleasing and satisfying interaction for the user.	YES
Technical Accessibility	System can be used by people with the widest range of characteristics and capabilities.	YES
Reliability		
Maturity	System meets needs for reliability under normal operation.	YES
Availability	System is operational and accessible when required for use.	YES
Fault tolerance	System operates as intended despite the presence of hardware or software faults.	YES
Recoverability	System can recover data affected and re-establish the desired state of the system is case of an interruption or a failure.	YES
Security		
Confidentiality	System ensures that data are accessible only to those authorised to have access.	YES
Integrity	System prevents unauthorised access to, or modification of, computer programs or data.	YES
Non-repudiation	Actions or events can be proven to have taken place, so that the events or actions cannot be repudiated later.	YES
Accountability	Actions of an entity can be traced uniquely to the entity.	YES
Authenticity	The identity of a subject or resource can be proved to be the one claimed.	YES
Maintainability		

Modularity	System is composed of components such that a change to one component has minimal impact on other components.	YES
Reusability	An asset can be used in more than one system, or in building other assets.	YES
Analysability	Effectiveness and efficiency with which it is possible to assess the impact of an intended change.	YES
Modifiability	System can be effectively and efficiently modified without introducing defects or degrading existing product quality.	YES
Testability	Effectiveness and efficiency with which test criteria can be established for a system.	YES
Portability		
Adaptability	System can be effectively and efficiently adapted to different or evolving hardware, software or usage environments	YES
Installability	Effectiveness and efficiency with which a system can be successfully installed and/or uninstalled.	NO
Replaceability	Product can be replaced by another specified software product for the same purpose in the same environment.	YES

Table 2-1: Technical characteristics, sub-characteristics and relevance to the BigDataOcean platform

2.2.2 Usage Evaluation - Quality in use model

Apart from the software quality model for the technical evaluation, which focuses on core IT requirements and performance, the ISO 25010 introduced the Quality in Use model which describes the perception of the quality of the system from a user's perspective (Figure 2-4). 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.

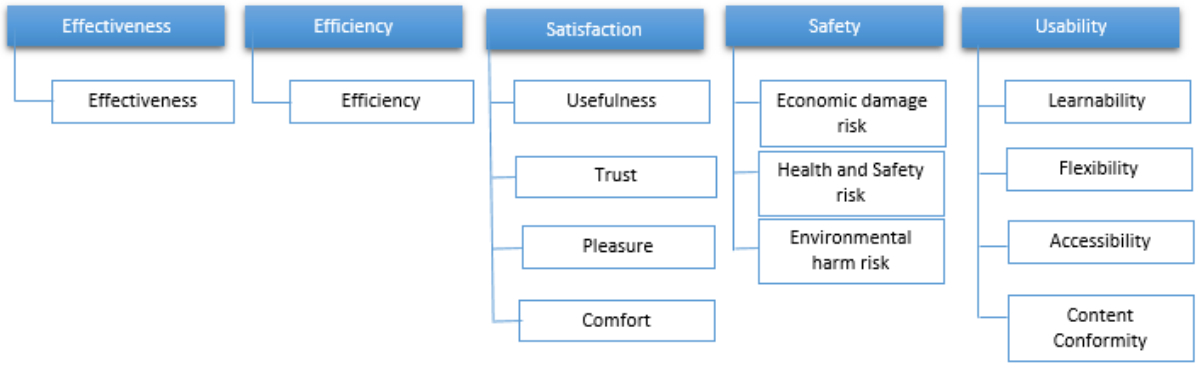

Figure 2-4: ISO/IEC 25010:2011 - Quality in Use Model

As with the previous model, this one assesses software quality (from a user point of view) using the following set of characteristics (each of them including other sub-characteristics):

1. Effectiveness - The accuracy and completeness with which users achieve specified goals.
2. Efficiency - The resources expended in relation to the accuracy and completeness with which users achieve goals.
3. Satisfaction - The degree to which users are satisfied with the experience of using a product in a specified context of use.
4. 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.
5. 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.

Table 2-2 showcases the sub-characteristics of each category and indicates their relativity to the BigDataOcean platform.

Sub-characteristics	Definition	Relation to BigDataOcean platform
Effectiveness		
Effectiveness	The degree at which users achieve their goals accurately when using the system	YES
Efficiency		
Efficiency	The degree to which users find that the software is efficiently covering its intended purpose	YES
Satisfaction		
Usefulness	The degree to which users find useful the software and its operations	YES
Trust	The degree to which users feel that they can trust the system	YES
Pleasure	The degree to which users find the software's functions a pleasure to use (emotionally)	YES
Comfort	The degree to which users think that the system provides the comforts needed (physically)	YES
Safety		
Economic damage risk	Acceptable levels of risk of harm to the operator in the intended contexts of use.	YES
Health and Safety risk	Acceptable levels of risk of harm to the public in the intended contexts of use.	NO

Environmental harm risk	Acceptable levels of risk of harm to property or the environment in the intended contexts of use.	NO
Usability		
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	YES
Flexibility	The degree to which usability and safety requirements are met in all the intended contexts of use	YES
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	YES
Content Conformity	The degree to which usability and safety requirements are met in all the intended contexts of use	NO [will be described in information quality evaluation]

Table 2-2: Quality in use model characteristics, sub-characteristics and relevance to the BigDataOcean platform

2.2.3 Information Quality Evaluation

Complementary to ISO 25010, the ISO/IEC 25012 [2] contains a model for data quality evaluation. This model categorises quality attributes into fifteen characteristics considering inherent and system dependent attributes.

Inherent data quality refers to the degree to which quality characteristics of data have the intrinsic potential to satisfy stated and implied needs when data is used under specified conditions. From the inherent point of view, data quality refers to data itself, in particular to:

- data domain values and possible restrictions (e.g. business rules governing the quality required for the characteristic in a given application);
- relationships of data values (e.g. consistency);
- metadata.

System dependent data quality refers to the degree to which data quality is reached and preserved within a computer system when data is used under specified conditions.

For the evaluation of the BigDataOcean information, an extension of this International Standard is going to be used, as suggested by Rafique I., Lew P., Abbasi Q.M., Li Z., 2012[3] in [3], which retains all fifteen characteristics defined in ISO 25012, but includes two additional characteristics of value added and representational adequacy. Since there are similarities to some of the characteristics, they have been grouped under eight quality indicators (Figure 2-5).

[3] http://xbosoft.com/wp-content/uploads/2014/06/information-quality-evaluation-framework.pdf

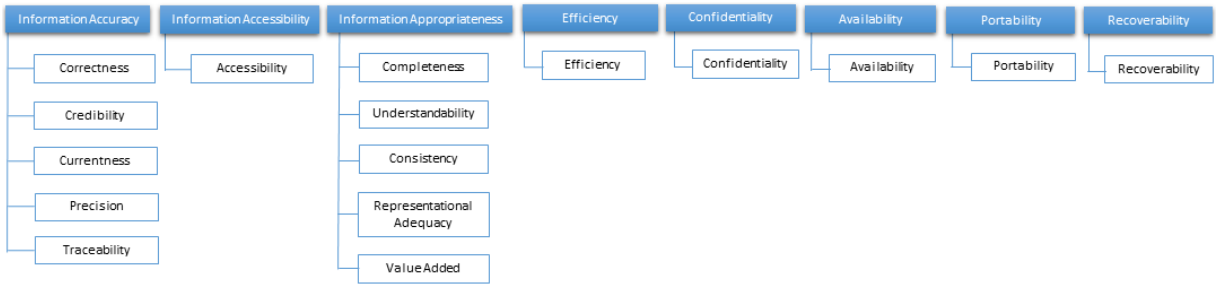

Figure 2-5: ISO/IEC 25012:2008 - Information Quality Model

As a result, the following characteristics are defined with their respective sub-characteristics, as presented in the following model view:

1. Accuracy - The degree to which delivered information is correct, precise, credible, traceable and current in a specific context of use.
2. Accessibility - The degree to which information can be accessed in a specific context of use.
3. 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.
4. 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.
5. Confidentiality - The degree to which information has attributes that ensure that it is only accessible and interpretable by authorised users in a specific context of use.
6. 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.
7. 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
8. 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.

The following Table 2-3 showcases the sub-characteristics of each category and indicates their relativity to the BigDataOcean platform**.**

Sub-characteristics	Definition	Relation to BigDataOcean platform
Information Accuracy		
Correctness	The extent to which information is reliable in the sense of being free of errors	YES
Credibility	The extent to which the information is reputable, objective (unbiased), and trustable (true and believable)	YES

Currentness	The extent to which the information can be identified as up to date.	YES
Precision	The degree to which information has attributes that are exact or that provide discrimination in a specific context of use.	NO
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.	YES
Information Accessibility		
Accessibility	The degree to which information can be accessed in a specific context of use.	YES
Information Appropriateness		
Completeness	The extent to which the information, provided by WebApps is of sufficient breadth, depth, and scope for the task at hand.	YES
Understandability	The extent to which the information, provided by WebApps is of sufficient breadth, depth, and scope for the task at hand.	YES
Consistency	The degree to which information has attributes that are free from contradiction and are coherent with other information in a specific context of use.	YES
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 specified goals.	YES
Value Added	The extent to which data or information are beneficial and provide advantages from their use.	YES
Efficiency		
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.	NO [depends on the way the platform handles the information - covered by the Product Quality metrics]
Confidentiality		
Confidentiality	The degree to which information has attributes that ensure that it is only accessible and interpretable by authorised users in a specific context of use.	YES

Availability		
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.	YES
Portability		
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.	NO [described in 'Replaceability' in product evaluation]
Recoverability		
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.	YES

Table 2-3: Information Quality model characteristics, sub-characteristics and relevance to the BigDataOcean platform

2.2.4 Usage evaluation criteria, targets and evaluation plan for the BigDataOcean platform

Based on the tables presented in the previous sections that reveal which criteria could be measured during the operation of the BigDataOcean project, and based on the fact that the ISO/IEC 25010:2011 and ISO/IEC 25012:2008 standards do not define specific attributes (measuring ways) for each one of the sub-characteristics, the following lists of indicators have been devised in order to allow the technical assessment of the BigDataOcean platform. It needs to be noted that due to the nature of the project and based on the operation conditions of the pilots, some of the below mentioned indicators are considered as optional, as their measurement might not be possible, or might not produce meaningful results.

Moreover, the KPIs referring to the Quality in Use model and the Information quality model are measured in a qualitative manner, using a 1-5 scale response, based on questionnaires that will be provided to the users that will operate the tools. Table 2-4 presents the quantitative evaluation metrics which correspond to the product quality model.

Sub-characteristics	KPIs	Calculation Type	Mandatory/ Optional
Functional suitability			
Functional completeness	Portion of completed User Stories	[Completed User Stories] / [Iteration Cycle of User Stories] * 100%	M
Functional correctness	Portion of User Stories without reported bugs	[Completed User Stories without bugs] / [Iteration Cycle of User Stories] * 100%	M

Functional appropriateness	Straightforward task accomplishment	Are tasks completed without the use of unnecessary steps? [Yes/No]	O
Performance efficiency			
Time behaviour	Average latency	[Total response time] / [Number of requests]	M
	Throughput	[Total Number of Kilobytes] / [Total Time of Operation]	M
Resource utilisation	Mean CPU Utilisation	[Σ[%CPU utilisation probes]] / [Number of probes]	M
	Mean memory usage	[Σ[RAM Megabytes used in each probe]] / [Number of probes]	M
	Maximum memory usage	Maximum % RAM Memory utilisation recorded	M
	Maximum processing power used	Maximum % CPU utilisation recorded	M
Capacity	Maximum filesize upload	Total number of Kilobytes of files	M
	Maximum database size	Total number of Kilobytes of files	M
Compatibility			
Co-existence	Ability to Co-Exist	Can BigDataOcean platform operate in shared environment? [Yes/No]	O
Interoperability	% of APIs coverage	[Number of integrated systems exposing or consuming data through API] / [Total number of integrated systems] * 100%	M
	Ability to handle different datasets	Can BigDataOcean platform consume datasets from different formats (e.g. AIS, NetCDF, etc)? [Yes/No]	M
		Can BigDataOcean platform provide datasets in various formats (e.g. AIS, NetCDF, etc)? [Yes/No]	M
Operability			
Appropriateness recognisability	% Positive feedback on appropriateness poll on the available	[Number of positive response] / [Total number of responses] * 100%	O

	documentation		
Technical Learnability	% Coverage of features with learning documents	[Unique number of help documents mentioning a feature] / [Total number of features available] * 100%	M
Ease of Use	Dashboard availability	Is there an available dashboard or wizard with easy navigation? [Yes/No/Partially]	O
User error protection	% Coverage of input fields with error protection methods	[Number of error protected fields] / [Total number of critical input fields] * 100%	M
User interface aesthetics	% Positive feedback on user interface aesthetics poll	[Number of supported screens] / [Total number of different screens] * 100%	O
	Responsiveness	[Number of supported screens]/[Total number of different screens] * 100%	M
Technical Accessibility	WCAG 2.0 Conformance Level	[None/ A/ AA/ AAA]	M
Reliability			
Maturity	Maximum Concurrent users	Maximum number of concurrent users recorded	M
	Simultaneous requests	Maximum number of simultaneous requests	M
Availability	% Monthly availability	[1-[Downtime in minutes] / [Total month minutes]] * 100%	M
	Success rate	[Number of correctly completed requests] / [Total number of requests]	M
Fault tolerance	% of identified Software problems affecting the platform	[Critical Software Issues] / [Total number of Software faults detected] * 100%	M
	% of identified Hardware problems affecting the platform	[Critical Hardware Issues] / [Total number of Hardware faults detected] * 100%	M
Recoverability	Mean recovery time from Software problems	[Total recovering time from Software issues] / [Total number of Software issues in need of recovery]	M
	Mean recovery time from Hardware problems	[Total recovering time from Hardware issues] / [Total number of Hardware issues in need of recovery]	M

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
Non-repudiation	% Activities reporting	[Number of log categories] / [Total number of system operations]	M
Accountability	User actions traceability	Are usernames included in each activity log entry uniquely? [Yes/No]	M
Authenticity	Level of User authenticity	Can you identify that a subject is the one it claims to be? [Yes/ No/ Partially]	M
Maintainability			
Modularity	% of modularity	[Number of components that can operated individually] / [Total number of components] * 100%	M
Reusability	% of reusable assets	[Number of assets that can or are reused] / [Total number of assets] * 100%	M
Analysability	Level of analysability	Can the changes in the performance of the BigDataOcean platform be efficiently evaluated after each upgrade? [Yes/No]	O
Modifiability	% of update effectiveness	[Number of updates performed without operational issues] / [Total number of updates] * 100%	M
Testability	Level of testing	Are tests able to probe the behaviour of the BigDataOcean platform? [Yes/No]	M
Portability			
Adaptability	Mean number of errors per hardware change/ upgrade	[Total number of errors recorded] / [Total number of hardware changes]	M
	Mean number of errors per software change/ update	[Total number of errors recorded] / [Total number of software changes]	M
Replaceability	% of software products replaceability within BigDataOcean platform	[Number of replaceable software components] / [Total number of used software components] * 100%	M

Table 2-4: Quantitative evaluation Metrics selected for the BigDataOcean platform

Table 2-5 presents the qualitative evaluation metrics which correspond to the quality in use model.

Sub-characteristics	KPIs	Related Question	Mandatory/ Optional
Effectiveness			
Effectiveness	Effectiveness level	Can you accurately complete your goals when using BigDataOcean platform? [1-5]	M
Efficiency			
Efficiency	Efficiency level	Do you think that the BigDataOcean platform is efficiently covering its intended purpose? [1-5]	M
Satisfaction			
Usefulness	Usefulness level	Do you find the BigDataOcean platform useful? [1-5]	M
Trust	Trust level	Do you trust the BigDataOcean platform and the provided results? [1-5]	M
Pleasure	Pleasure level	Does the BigDataOcean platform please you when you use it? [1-5]	M
Comfort	Comfort level	Do you feel that the BigDataOcean platform provides a comfortable UI and workflow? [1-5]	M
Safety			
Economic damage risk	Level of economic damage risk	How sure are you that the BigDataOcean platform protects you from exposing you on economic damage? [1-5]	M
Usability			
Learnability	Learnability level	How easy was it for you to learn how to use the BigDataOcean platform? [1-5]	M
Flexibility	Flexibility level	How much do you believe that the BigDataOcean platform can be used for other purposes than the one you intended to? [1-5]	M
Accessibility	Accessibility level	To which extent do you think that the BigDataOcean platform can be used by users with disabilities? [1-5]	M

Table 2-5: Qualitative evaluation Metrics selected for the BigDataOcean platform

Table 2-6 presents the qualitative evaluation metrics which correspond to the Information quality model.

Sub-characteristics	KPIs	Related Question	Mandatory/ Optional

Information Accuracy			
Correctness	Error-free data	To what extent do you find the provided data reliable in terms of errors? [1-5]	M
Credibility	Acceptable value ranges	To what extent are the data provided within the range of known or acceptable values? [1-5]	M
	Credibility of the data source	To what degree are the data coming from specialised organisations of a country, field, or industry? [1-5]	M
Currentness	Update of the data source	To what extent do you think that the data are regularly updated? [1-5]	M
Traceability	Datasource verification	To what degree do you think that the source of the data can be verified? [1-5]	M
	Datasource relativity	To what degree the data content can be correctly explained according to known or well defined terms, attributes, units, codes, abbreviations, or other information? [1-5]	M
Information Accessibility			
Accessibility	Data access	To what extent is the data access interface providing features friendly to people with specific disabilities? [1-5]	M
	Data policy	To what extent can private and public data be accessed? [1-5]	M
Information Appropriateness			
Completeness	Context of use fitness	To what degree are the retrieved datasets within the retrieval theme needed? [1-5]	M
	Missing expected information	To what degree are all relevant data provided with no missing entries or missing values? [1-5]	M
Understandability	Definition/ Documentation	To what degree the available documentation consists of data specification like data name, definition, ranges of valid values, business rules, etc? [1-5]	M

Consistency	Persistent structure	During a certain time, are data following the defined format and structure? [1-5]	M
	Illegal values	To what extent are the data free of illegal values (e.g. strings instead of numerical values)? [1-5]	M
	Duplicate instances	To what extent did you receive datasets with repeated instances of the same property that should be provided only once? [1-5]	M
Representational Adequacy	Adequate visualisation features	To what degree is the discrete number of provided visualisations satisfactory for the intended context of use? [1-5]	M
	Normative data definition	To what degree are the data (content, format, etc.) clear and understandable? [1-5]	M
Value Added	Benefit for the user	To what extent the data or information are beneficial and provide advantages from their use? [1-5]	M
Confidentiality			
Confidentiality	Authentication functionality	To what degree was authentication requested before retrieving confidential information? [1-5]	M
Availability			
Availability	Data openness	How satisfactory do you find the amount of data types and the volume of the open data provided? [1-5]	M
Recoverability			
Recoverability	Data accuracy & integrity impact	To which degree will the deficiency of a component impact data accuracy and integrity? [1-5]	M
	Multi-component data impact	To which degree the deficiency of a component will impact use of the data for data with multi-component? [1-5]	M

Table 2-6: Data qualitative evaluation Metrics selected for the BigDataOcean platform

3 Test Cases

3.1 Development of the Test Cases

A test case is a set of actions to be performed by the pilots and ultimately the end-users, in order to determine whether the platform satisfies requirements or works correctly. The generation of these cases is based on the platform methodology, the Minimum Viable Product (MVP) definition and the 30 MVP user stories provided in D2.2. Table 3-1 displays the User Stories (US) identified, with an identifier (ID) that follows the priority given during the development of the MVP methodology, and the respective stakeholder group of concern.

MVP user-story ID	User Story	Stakeholder group
US-1	As a data consumer, I want to be able to search for specific datasets, based on various criteria, or browse through a list of existing ones, so that I could easily and efficiently find relevant data to use.	Consumer
US-2	As a data analyst, I would like to have visualisation services, so that I can visually analyse existing datasets.	Consumer
US-3	As a data consumer, I would like to be able to create specific queries, so that I could obtain more relevant answers to reflect my requirements.	Consumer
US-4	As a data consumer, I would like to be able to explore the main properties of the available datasets or browse through a list of existing ones, so that I could easily find relevant data for my requirements.	Consumer
US-5	As a data consumer, I would like to use online tools for monitoring or reporting, so that I can generate relevant reports.	Consumer
US-6	As a manager, I would like the BigDataOcean platform to ensure data availability, so that data is available for data consumers at a required level of performance during normal or extraordinary operation.	Data provider
US-7	As a user, I would like the BigDataOcean platform to ensure data persistence so that I can be confident that my own data, and the data used by my processes/services, is always available and it will be for long time in the future.	Data provider/ Consumer/ Service provider
US-8	As an administrator, I want to be able to create an account to save my searches and preferences in the system, so that I could save my work for later reuse and manage its privacy levels.	ALL

MVP user-story ID	User Story	Stakeholder group
US-9	As a data analyst, I want to find and use credible weather historical data, so that I can correlate them with my company's events' registry and come up with possible insights and/or patterns.	Consumer
US-10	As a data consumer, I want to find and use vessels' positioning information data, so that I can visualise them on a map for an easily digestible overview.	Consumer
US-11	As a data manager, I would like to download the generated reports produced by the system, so that I can self-archive them.	Data provider/ Consumer
US-12	As a data consumer, I want the BigDataOcean platform to ensure data consistency, so that data storage is always conducted according to specific rules, and it is therefore easier to consume the required data.	Consumer
US-13	As a data manager, I would like to be able to manage the datasets to be represented using existing standards, so that it would be easier to consume them in the consequent stages of the data life cycle.	Data provider/ Consumer
US-14	As a data consumer, I would like to receive recommendations about datasets, so that the BigDataOcean platform effectively helps me fulfil my information requirements.	Consumer
US-15	As a data consumer, I would like to be able to use datasets with heterogeneous formats, so that I would not be limited to only consume datasets of only a specific format.	Consumer
US-16	As a service consumer, I want to find and consume the "vessels' certified path" service, so that I can check whether a location for installing offshore equipment is safe.	Consumer
US-17	As a data consumer, I would like to be able to download the generated results of my queries or my services, so that I can store or further process them.	Consumer
US-18	As a data analyst, I would need analytics tools and services that can run on one or multiple datasets, so that I would be able to identify any abnormalities and also extract new knowledge.	Consumer
US-19	As a data manager, I would like to be able explore the service requests that have been received through the BigDataOcean platform, so that availability and management of services can be better planned.	Service provider

MVP user-story ID	User Story	Stakeholder group
US-20	As a data analyst, I would like to be able to create my own dashboards that will visualise existing data, so that I can analyse and compare different data sources.	Consumer
US-21	As a data manager, I would like to be able explore the data transformation requests that have been received through the BigDataOcean platform, so that data transformation and curation of available datasets can be better planned.	Technical Team/ Data provider
US-22	As a data consumer, I would like to view different quality metrics of the datasets, so that I can select the most appropriate data to use for my use case.	Consumer
US-23	As a data manager, I would like to be able explore the dataset requests that have been received through the BigDataOcean platform, so that availability, storage, and management of datasets can be better planned.	Data provider
US-24	As a data consumer, I would like to be able to transform datasets, so that they can be used independently of their original format.	Consumer
US-25	As a service consumer, I would like to be able to configure and personalise existing services offered by the platform. This should be possible with an easy-to-use web interface that allows setting and tuning of variables and parameters of different services in order to better fit my requirements for data consumption.	Consumer
US-26	As a data provider, I would like to be able to describe and register specific datasets, so that I could make available metadata about datasets even if they are not integrated in the platform.	Data provider
US-27	As a data consumer, I would like the BigDataOcean platform to make available free downloading and purchasing of available datasets, so that diverse types of dataset access can be offered by the BigDataOcean platform.	Consumer
US-28	As a data consumer, I would like to be able to affect the results of services depending on varying priorities, so that the results reflect my needs better.	Consumer
US-29	As a data analyst, I want the BigDataOcean platform to have semantic services that allow to access correlated data, so that potentially new insights can be discovered.	Consumer
US-30	As a service developer, I would like to be able to build my own services through an easy-to-use web interface that allows for	Service provider

MVP user-story ID	User Story	Stakeholder group
	mashups and configurations of existing reusable services.	

Table 3-1: Prioritised user stories as provided in D2.2

As stated in the "Releases Plan" described in section 4.5 of D2.2 (as well as in the DoW), four releases of the BigDataOcean Web Platform are planned for months 14th, 18th, 24th and 30th of the project's duration. This means that the test cases should be limited into three evaluation phases, which will evaluate the platform components that will be available after each release phase, as presented in the following Figure 3-1:

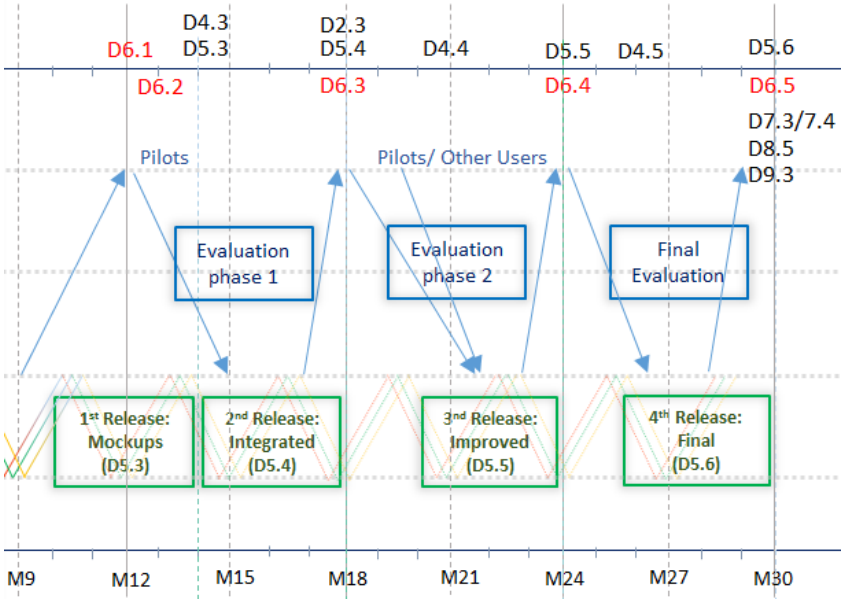

Figure 3-1: Evaluation steps and platform releases relation

Any feedback from each evaluation process will be used initially to update the requirements specifications with adjustments and new features, and then the test cases for the next evaluation phase. That makes the test cases more adaptable to the development process and easier for the development team to align its activities to the pilots.

The Use Model Quality and the Information Quality evaluation processes precede that of the product quality testing. The evaluation of the Use Model and Information quality are based on the user stories already presented in Table 3-1. The test cases are the user stories that have been selected in each iteration. Thus, as described in the "Releases Plan", the first iteration concerns the user stories US-1 up to US-14, the second one the user stories US-15 to US-25 and the last one the user stories US-26 to US-30. However, due to alterations and additions, which might arise in D4.3 (M15) for the user stories and in D2.3 (M18) for their priority, this planning might change as well.

The workflow for running the behavioural, controlled tests is the following:

1. *Give a short description:* Users should land on the platform with a short description on what they can do on BigDataOcean. Not detailed characteristics should be given, as they should be let free to explore what the platform does.

2. *Let them explore*: Let users free to navigate in the website and evaluate how they perform in each user story.
3. *Trigger them to explore more:* For stories not achieved by the users, give them the goal and see how they behave. E.g. "How would you create a new account, where would you look at?"
4. *Document failed stories*: Ask them why they failed to find any useful features, even after the help provided. You may present them the story on your own, to see later if they like it or not.
5. *Report bugs*: It is important to write down bugs automatically, given the context where they occurred. The users should not be occupied with bug reporting, e.g. asking them to capture a screenshot before continuing.
6. *Collect demographics:* Collect the basic information about the user. This step may start in step 1, but it's more efficient to collect user data after they have a first interaction with the platform.
7. *Run Questionnaire:* Collect the answers on the questionnaire.
8. *Tell the complete story*: Give a more detailed view on what the platform will deliver, and what is its objective.
9. *Collect general feedback:* Collect general feedback on the platform based on the discussion enabled.

For each pilot a different set of documents will be produced, to gather the questions asked in a standardised form. This task is the context of D6.2 and will not be further analysed in this document.

On the other hand, the product quality evaluation will not be executed directly by the pilots, but during the use of the platform, a series of technical tests, analytics and bug reporting should take place. Table 3.1 shows the suggested test cases for each indicator of the product quality model described in the evaluation framework. The test cases will be developed in more detail in Task 4.4 "BigDataOcean Scalable Architecture Design".

Sub-Category	Test Cases	Description
Functional suitability	User Stories Auditing	Go through the user stories to see if they are functional for all the stakeholders
Performance efficiency	System analytics	Provide analytics during the operation of the system
	Stress tests	Run extreme cases to see when the system breaks
Compatibility	Compatibility tests	Measure the KPIs during and after the implementation of the system
Operability	Actual usage tests	Using feedback mechanisms to collect opinion from actual users, e.g. a poll on the landing page
	Concept tests	The team releases the concept in a form of text or media
	System audit	Walk through the system to measure the suggested KPIs
	Aesthetics tests	Use tools to cover different devices and user disabilities

Sub-Category	Test Cases	Description
Reliability	System analytics	Provide analytics during the operation of the system
Security	Security Tests	Choose and run a series of system security, both on systems and software. A complete list of the tests need to run is available at OWASP[4].
Maintainability	System audit	Walk through system components to evaluate their behaviour
Portability	Adaptability tests	Measure the KPIs during and after system updates/upgrades

Table 3-2: The test cases on the product quality evaluation framework KPIs

3.2 Evaluation of the Test Cases results

Apart from the qualitative, general characteristics during the usage, the end-user should report specific feedback on each user story where the development of the iteration was based.

- *Completed without/with help*: the user story is evaluated on whether the test user has completed it by himself, or after guideline on what and where he should look for.
- *Completed with number of bugs:* the number and the type of bugs identified during the story tested. The exact bug and the context should be documented as well.
- *Not completed because of bug:* the bug that did not allow the user to conclude the story is reported.
- *Not completed even after help given:* the user did not make it to conclude the story, even after the supervisor told him what to look for or how to perform it.
- *Perceived usefulness:* a scale from 1-5 (not at all – extremely useful) to measure how useful is the story for the user.
- *Perceived ease of use*: a scale from 1-5 (extremely hard – extremely easy) to measure how easy it was for the user to conclude the story.

The feedback should be collected with the following template:

Release Number	Test Case ID	Test Case Title	Completed without Help	Completed with Help	Completed with bugs	Not completed due to bug	Not completed after help	Useful (1-5)	Easy (1-5)
Stakeholder Group Name									
…	Code#	…	…	…	…	…	…	…	**…**
….	Code#	…	…	…	…	…	…	…	…

Table 3-3: Template for test cases evaluation

[4] https://www.owasp.org/index.php/Web_Application_Security_Testing_Cheat_Sheet

4 Conclusions and Next Steps

The scope of D6.1 was to document the results of Task 6.1 - "Pilots Validation and Evaluation Framework Design", which had a twofold objective of firstly developing the evaluation framework and validation methodology, defining the various practices for obtaining feedback from the end-users, and secondly, providing a set of test cases to be executed by the end-users.

The design of the validation and evaluation framework is a living process which will last until the end of the final evaluation phase (M30) and provides a directive for the evaluation activities. The evaluation framework will be set in operation once the pilots evaluation stage starts, during which the end-users and the system engineers are going to provide feedback of their interaction with the integrated BigDataOcean system. The data to be collected should meet the guidelines of the evaluation framework in order to ensure the high quality of the feedback gained and the consistency of the evaluation activities. Based on the acquired feedback, if the analysis results meet the goal, then the evaluated components are valid and have reached their end. If the results do not meet the requirements, then the quality assessment baseline, consisting of the validation framework, the user stories and the provided features of the BigDataOcean platform, might need reformulation and reassessment. When one cycle of evaluation is complete and the feedback has been analysed and properly utilised, the next cycle of evaluation can proceed.

In the second part of D6.1, the user stories that are going to be used for the platform evaluation are listed according to the priority that was set in D2.2. This list is going to be further analysed into specific test cases for each pilot while taking into account the pilots' requirements (context of D6.2). Additionally, a list of test cases for the assessment of the product quality KPIs are also included. These test cases are going to be integrated in the architecture design in terms of Task 4.4.

Annex I: References

[1] ISO/IEC 25010:2011, Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - System and software quality models

[2] ISO/IEC 25012:2008, Software engineering - Software product Quality Requirements and Evaluation (SQuaRE) – Data quality model

[3] Rafique I., Lew P., Abbasi Q.M., Li Z. (2012). Information Quality Evaluation Framework: Extending ISO 25012 Data Quality Model. *International Journal of Computer, Electrical, Automation, Control and Information Engineering, 6*, 568-573

[4] Friedrich J., Hammerschall U., Kuhrmann M., Sihling M. (2009). Das V-Modell® XT - Für Projektleiter und QS-Verantwortliche kompakt und übersichtlich, *Springer-Verlag Berlin Heidelberg*

[5] IABG: Das V-Modell. In Internet: URL: http://www.v-modell.iabg.de/ [as of December 23, 2017]