5G-SOLUTIONS for European Citizens

D1.4A Methodologies for the validation of 5G and for LL measurements (v1.0)

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3 months before Deliverable's Due Date: 50% should be complete
2 months before Deliverable's Due Date: 80% should be complete
1 months before Deliverable's Due Date: close to 100%. At this stage it sent for review by 2 peer reviewers
Submission month: All required changes by Peer Reviewers have been applied, and goes for final review by the Quality Manager, before submitted

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Table of Contents

List of Figures:

List of Tables:

Glossary of terms and abbreviations used

Abbreviation / Term	Description
5G	Fifth generation wireless technology
API	Application Programme Interface
AUT	Application under test
E2E	End to End
EaaS	Experimentation as a Service
ETSI	European Telecommunications Standards Institute
EUT	Equipment under test
FoF	Factory of the Future
FTE	Full Time Equivalent
FUT	Function under test
GDPR	General Data Protection Regulation
HW/SW	Hardware/Software
IP	Intellectual Property
KPI	Key Performance Indicator
LL	Living Lab
MEAS	Measurement
MLL	Multi – Living Lab
NACE	Nomenclature statistique des **A**ctivités économiques dans la **C**ommunauté **E**uropéenne - European Industry standard classification system
NUT	Network under test
OpenPM2	Project Management Methodology
PMBoK	Project Management Body of Knowledge
QoE	Quality of Experience
SUT	System under test
TaaS	Testing as a service system
TC	Test Case
TMV	Test, Measurement, and KPIs Validation Working Group
TO	Test Objective
TP	Test Point
TRL	Technology Readiness Level

UC	Use Case
UML	Unified Modelling Language
V&V	Verification and Validation
WG	Validation Working Group
WiFi	Wireless Fidelity
WP	Work Package

1 Executive Summary

The first objective of the 5G-SOLUTIONS is to develop realistic, advanced and business relevant innovative use cases in five key vertical industries by developing and providing a representative set of detailed use case scenarios with appropriate metrics to test and validate the performance characteristics of 5G. This objective is achieved through industrial field trials, through the use and adoption of state-of-the-art methodology in service design, innovation and "red-way-of working", as well as facilitating effective ways of innovating with industry expert users and, finally by producing and assessing the methodologies for the testing, validation and benchmarking of the results as well as for the technological and business validation of the use cases which this document, as the fourth deliverable of Work package WP1 of the 5G-SOLUTIONS project, has as its main objective in order to achieve, support the project's goals.

This document is the first version of the deliverable and sets out the foundation for the methodologies to approach testing across the different Living Labs during the trials. It combines the work carried out from two distinct tasks but closely related for the first stage of the project.

First, the task identified by T1.4 and named "Methodology for the definition of Test reports format, parameters and test points, benchmarking for the results" which concentrates on the approach to derive the test cases from the use case scenarios. This approach will define the different templates and formats for the formalization, specification of the test cases while setting out the basis for the different key concepts, entities and the testing process for the lifetime of the project. Finally, it will present a sample of some of the use case scenarios identified as an entry criterion for the next main activity of gathering and formalizing the test cases to start.

Second the task identified by T1.5 and named "Methodology for the technological and business validation of 5G end-to-end (E2E) connectivity" which presents a process where technological and business validation goes hand in hand. Starting with templates for the business validation before the technological validation; hence, we focus on methods for confirming that there is real business value, and how this can be reflected in business metrics. The technological validation methodology includes the adaptation and analysis of possible validation frameworks inspired from ETSI and other 5G research programs. From an overall perspective, the methodology encompasses the analysis of the foundations, including terminology and concepts, the definition and elaboration of methodology that includes the testing regime. We address the verticals needs and requirements beyond the technological validation methods. Here a process describing how business validation opportunities within the 5G-SOLUTIONS living lab UCs is developed using an agile, design thinking and lean start-up methodology.

Even though the two tasks deal with different methodologies, our intention in this first deliverable is to set out the foundations for a unified framework. Starting by pointing out the relationship between business validation and technological validation, and also by developing a single approach for the report formats and the technological validation. Thus, paving the way for the development of a single unified solution that will also include the business validation and will constitute the main goal of the final deliverable D1.4B for the 5G SOLUTIONS project.

As a final note, as the project matures and progresses through the different technology readiness levels (Section 5.6.4), we will also make sure and take the opportunity using the adopted agile approach to reassess, improve and evolve our methodologies and concepts where needed. The corresponding updates and improvements will be presented and described in the future deliverable of the project with interim versions shared internally until the final version D1.4B is delivered, including the official final test reports along with the results for each of the vertical industries.

2 Introduction

As stated in the Executive Summary, the primary objective of this document is to produce and assess the methodologies for the testing, validation and benchmarking of the results as well as for the technological and business validation of the use cases. We will therefore present our strategy to achieve this objective by answering the set of questions below:

From a business validation perspective, we address two vital questions:

- What are the different problems and pain points that the use case stakeholders experience currently?
- What is the value proposition for these use cases within 5G-SOLUTIONS and what is the business potential for such solutions for a use case level, a private firm or public institution level as well as market and industry level?

From a technological validation and the test reports format perspective, the following are addressed:

- What framework can we provide to approach the testing of single vertical domains(LL1-LL4) as well as a multi-vertical domain(LL5)?
- How can we review and analyze what needs to be verified and validated?
- How can we translate the requirements into an executable format to support the test execution as well as the measurements involved?
- What type of test reports could we design to give real insight into the results, as well as to enable and support the project goals? [1] [2]
- What process could we define that would fit neatly into the project's iterative agile process?

Although the detailed use-case scenarios gathering process along with their relevant KPIs and their test bed requirements is still an ongoing-task it can be used as a starting point to define our methodologies which are the primary focus of this interim version of the deliverable. All these questions are addressed by presenting a process where technological and business validation goes hand in hand, focusing on methods for confirming that there is real business value, and how this can be reflected in business metrics. Description of possible validation frameworks inspired from other 5G research programs are also presented.

2.1 Mapping Projects' Outputs

Purpose of this section, is to map 5G-SOLUTIONS Grant Agreement (GA) commitments, both within the formal Deliverable and Task description, against the project's respective outputs and work performed.

Table 1: Adherence to 5G-SOLUTIONS GA Deliverable & Tasks Descriptions

5G-SOLUTIONS Task		Respective Document Chapter(s)	Justification
Task 1.4 – Methodology for the definition of test reports format, parameters and test points, and benchmarking for the results	This task will focus on defining the methodology and toolset for a comprehensive and robust test analysis of the 5G technologies and the vertical use cases being created within the 5G-SOLUTIONS project. Working closely with the partners defining the scenarios to be trialled in the Living Labs environment, we will specify formats for a suite of test cases to measure the functionality and performance of the innovative solutions being put forward. These test artefacts will be captured in a suitable test case management tool that will integrate seamlessly with the development process. Based on the requirement to deliver outputs that have commercial value and potential, there will be a significant emphasis put on Quality of Service (QoS) to give a qualitative measurement of test execution and on Quality of Experience (QoE) to gauge objective human experience. We will also ensure that the test strategy examines the improvement over previous 4G capabilities. Other test methodologies will include resource scaling, cross-domain interaction and entire platform testing. The test process will fit neatly into the project's iterative agile development process and allow for implementation of a Test-Driven Development methodology incorporating unit tests and acceptance tests.	Chapters 3, 5.1 – 5.6	Sets out the foundation for the overall approach: starting with the introduction of key concepts, the testing and test case formalization processes with a set of templates.
		Chapter 5.9	Provides a sample of the initial inputs in terms of use case-scenarios for deriving the test cases.
Task 1.5 – Methodology for the technological and business validation of 5G E2E connectivity and associated management within	The methodology will entail acceptance test procedures for conducting both the technological and business validation of the use cases considering the associated service management. In particular, as far as the technological validation is concerned, we will define the procedures for collecting the data feeds from the ICT-17 measurement portals, stating also how these feeds will be used and analysed by the KPI visualisation system to produce and present the KPI values in a graphical form. Threshold limits for the benchmarking of the results will also be defined per target KPI based on the requirements	Chapter 3 and 4	We present a process where technological and business validation goes hand in hand, as an agile process. Initially we focus on methods for confirming that there is real business value, and how this can be reflected in business metrics. We are leaning on well-known concepts within agile way of work.

and across verticals	stemming from each vertical use case. The methodology will also define how the interaction with the vertical end-users will be achieved taking into consideration the specifics of task T1.1. For the business validation will use the lean start-up methodology that centres around the main motivations of a business. The inputs will include apart from the business case itself, end-user feedback from their direct engagement in the field trials of the vertical use cases. The corresponding outputs will be validations that will allow to identify those use cases that have the highest commercialisation potential so as to progress to the next step of creating a service product portfolio. For this purpose, we will use a set of questionnaires, surveys and focused group workshops directly engaging also the customers of the vertical consortium partners. A detailed set of metric parameters considered for the business validation of each UC will be developed, such as those listed in [2] which will be interrogated and quantified as part of the business validation process with the end-users.		Possible validation frameworks inspired from ETSI and other 5G research programs are presented as well as tools and techniques for the business validation are adopted on from best practices and guidelines from PMBOK and Open PMI.
		Chapters 5.1 – 5.6, 5.7, 5.8	Sets out the foundation for the overall approach and focus on the core concepts for the technological validation methodology. The technological validation methodology includes the adaptation and analysis of validation frameworks inspired from ETSI and other 5G research programs.
5G-SOLUTIONS Deliverable			
D1.4A: Methodologies for the technological/business validation of 5G and for LL measurements: Interim (v1.0) version of report defining the methodologies for the technological and business validation of 5G connectivity and associated management within and across verticals. Also include the definition of test reports format and benchmarking for the validation of the KPIs.			

2.2 Structure of the Document

The main structure of the document is organised as follows:

- **Section 3** gives an introduction and an overall view of the three methodologies namely the business validation, the technological validation and the test reports together and their relationships.
- **Section 4** describes the methodology for business validation. Here a state-of-the-art methodology in service design, innovation, design thinking and lean start-up is adopted. Moreover, the section provides the necessary business framework, strategy in addition to plans and information for identification of post-project opportunities and exploitation of potential market results.
- **Section 5** is dedicated to the task 1.4 for the test reports format as well as part of the task 1.5, for the technical validation starting by presenting the first version of the solution for both methodologies: the test reports and the technical validation with a focus on the initial activities to be carried out along with the necessary templates for task 1.4 and finally concludes with a sample of the use case-scenarios gathered as an entry criterion for the next phase. The technological validation methodology also covers the adaptation and analysis of possible validation frameworks inspired from ETSI and other 5G research programs. From an overall perspective, the methodology encompasses analysis of the foundations; including terminology, concepts, definition and elaboration of methodology that encompasses the testing regime.
- **Section 6** then concludes a summary and the future work.

3 Methodology, Processes and Dependencies

This section briefly introduces the three methodologies adopted for the validation of 5G and for LL measurements, namely business validation, technological validation and test reports methodology. It addresses the objectives (Section 1.1 of 5G-SOLUTIONS DOA) of producing and assessing the methodologies for the testing, validation and benchmarking of the results as well as for the technological and business validation of the UCs through an agile-based iterative process approach. Moreover, to provide the necessary business framework, strategy, plans and information to identify post-project opportunities, exploit potential results and to ensure a long-term sustainability, whilst protecting their IP.

3.1 How Technological Validation and Business Validation go Hand in Hand

In 5G-SOLUTIONS, the strategic vision is that end users will be able to perform advanced technological and business validation of highly innovative and future oriented use cases in near real-time. We carry out technological and business validation relying on methods that come close to agile ways of work. The act of validation is carried out in Living Labs for the specific use cases – see Figure 1. Here, we address how technological and business validation is related.

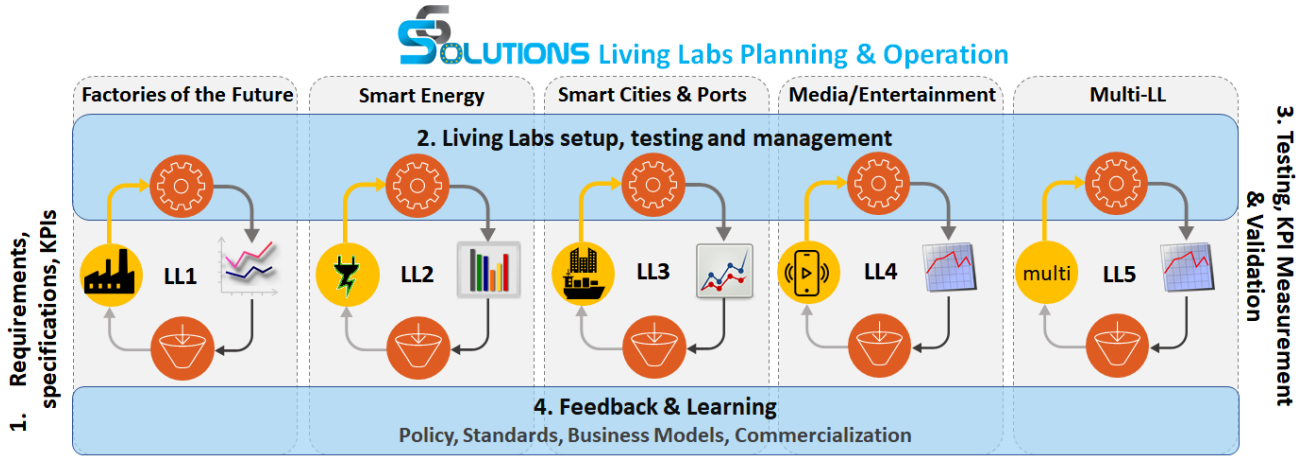

Figure 1: Living Lab – Illustration of way of work

1. The way of work process is initiated through a description of use cases (UCs) and requirements for testing and validation of use cases (technology and businesswise), including Key Performance Indicators (KPIs);
2. Next step is to plan the setup of test procedures and facilitates together with reporting structure for the individual UCs;
3. Then the execution of the test procedures for the UCs, measuring the KPIs and validating the results technologically and businesswise;
4. Based on the validation of technological and business KPIs, decision is made to perform new tests (new iteration of step 1) or to continue with planning further business development/commercialization as well as scale up of production and standardization. Such activities are catered to in WP8 - see DOA - 1.3. Concept and Methodology.

In our proposal, we refer to several methodologies to signal our preferred way of work: agile-based iterative process, agile approach, iterative agile development process, agile methodology, “red-way-of-working”, lean start up methodology, service design, design thinking, and co-creation. Not the least, we refer to Deming’s

Plan-Do-Check-Act as the fundament for Living Labs iterations. These approaches, although different, have four shared components which are essential to 5G-SOLUTIONS.

a. The least controversial component is that the specific use case scenario will be tested and technically validated in several iterations, continuously refining the technological implementation of the scenario.
b. It is also a shared understanding that it is smart to test as cheap as possible in early phases, in order to avoid investments which are not addressing a real user pain point.
c. This brings us to the next component where we need to establish a clear understanding of the stakeholder who has some job-to-be-done or pain point to be addressed. Here, the use of "minimum viable product" method is preferable in order to validate and test what is really the pain point of a stakeholder and whether they are willing to pay to have it solved.
d. Implicitly, it is understood that the problem or pain point to be addressed is stabilized at some point of time, and that the iterations are concentrating on the technical adaptation and validation.

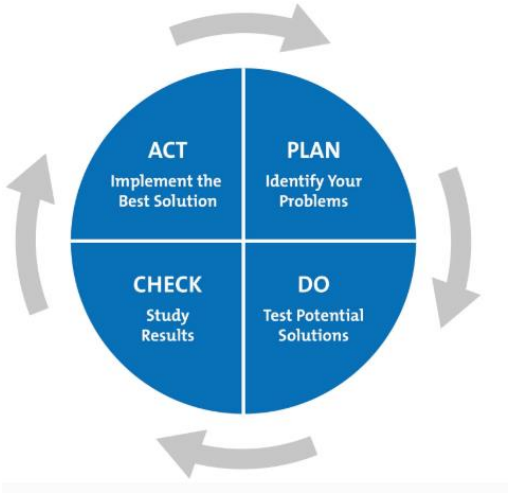

Figure 2 Deming's cycle

Figure 3 Lean start up – agile ways of work

3.2 How to Facilitate Agile Way of Working

These above-mentioned components or phases are usually illustrated with a cycle, as in Deming's cycle[2], Lean Start-up[3] - see illustrations in Figure 2 and 3. When design thinking is integrated as a part of methods used, the cycle will include a stage with a stabilized value problem scenario[4] as shown in Figure 4. Within design thinking approaches we also find the use of personas[5]. Personas are fictional characters, which are created in order to represent the different end-users in a consumer setting or for instance ecosystem actors/stakeholders in a professional setting. Such imaginary personas are thought to develop or use your service, product, site, platform or brand in different ways. Creating personas enables you to better understand pain points, needs, experiences, value perceived, behaviours and goals when developing and testing new product/service or processes.

[2] https://www.mindtools.com/pages/article/newPPM_89.htm
[3] http://theleanstartup.com/principles
[4] https://www.alexandercowan.com/venture-design/
[5] https://www.alexandercowan.com/tutorial-personas-problem-scenarios-user-stories/

With these illustrations and sources, we suggest that technical and business validation refer to two different aspects of working agile. The technical validation is to test if it is possible to solve the pain point technology wise. Technical validation proceeds from and is succeeded by business validation. Before, or at least in parallel with starting technical validation, it has to be established that real pain point exists, and that someone achieves real (business) value from solving this pain. Following technical validation, the business validation process extrapolates the confirmed business value on the level of a specific use case scenario, to a firm and market level. Figure 5 is a high-level simplification of the relationship between business and technical validation, and how they are related. Note that we have included iterative feedback loops to illustrate that test can fail to meet validation requirements and we have to "return to start".Figure 5 is also linked to the overall test and validation process in Figure 1.

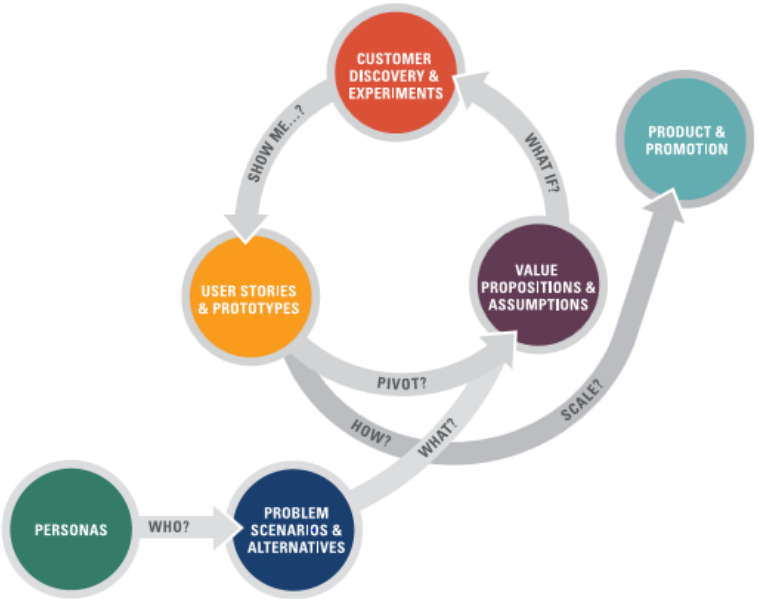

Figure 4 Venture design, Alexander Cowan

The process illustrated in Figure 5 kicks off with an initial business validation based on the presence or not of problems/pain points for different UC stakeholders (personas), e.g. end user subscriber, application providers and content providers. This is where we check if there really is a pain point that someone has, that value will be achieved from solving it, and that the stakeholders in the end will be willing to pay for getting it solved.

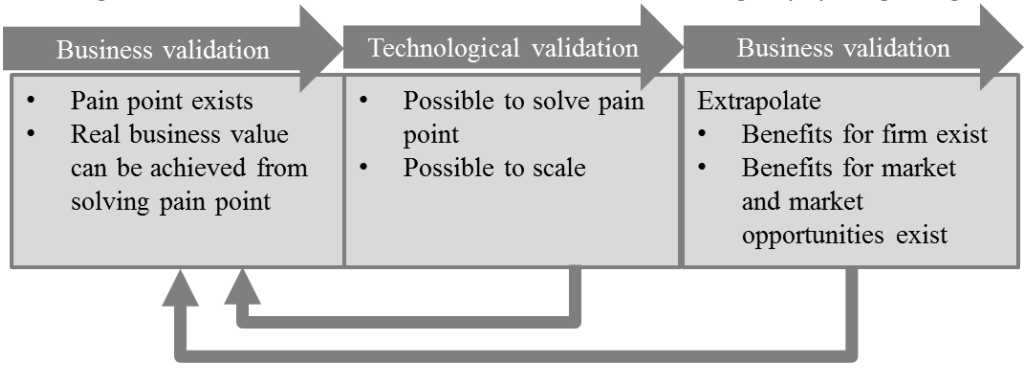

Figure 5: Illustration of relationship between business and technological validation

If the initial business validation parameters are robust, a technological validation process is carried out. This focuses firstly on whether the problems/pain points can be solved using 5G-SOLUTIONS. For instance, will the service required improve the stakeholder/user experience? Will the latency, reliability, coverage and positioning accuracy be improved as compared to current situations? Secondly, the technological validation process scales-up the test facilities to serve a larger number of stakeholders beyond the initial test case context, if feasible If pain points and scale-up are not confirmed, there is a feedback process back to step 1, initiating a new assessment of pain points and value generation for stakeholders.

If the technological validation parameters also are confirmed we continue to a next step of business validation. This is where we go beyond the single UC, and document on an aggregated level the size of the business value and opportunities for the firm (e.g. factory of the future) or a municipality (e.g. smart city), or a specific domain within manufacturing. If markets cannot be confirmed, we return to step 1 or 2. To conclude, note that it is in early phases and it is important to have some indications that the potential market addressed is of some minimal size.

3.3 Introduction to the Business Validation Methodology

Section 4 describes the methodology for the business validation in 5G solutions. The objective is to validate the 20 Use Cases business wise and develop business plans for the Use Cases and respective verticals with the highest commercial potential. Three "organizational" levels are included in the validation methodology:

1. **Use case level**: Problems and stakeholders are identified addressing their current problems and potential benefits from acquiring a 5G based solution and services. In-depth understanding of the problems and benefits are collected through workshops and surveys.
2. **Organizational level**: Here benefits from the single Use Cases are aggregated to an organizational level, e.g. firm level in a Factory of the Future LL. The firm level analysis is based on confirmation of 5G based solution using testing and technology validation methodology.
3. **Market level**: Here the business benefits from the organizational level are aggregated to a market or industry level. The business validation methodology involves cooperation with the 5G-SOLUTIONS WP8 on business plans and commercialization, standardization, assessing the market level impact of the 5G use cases.

This business validation methodology is grounded in agile, design thinking and lean start-up methodologies and supports the methodology presented in 5G-SOLUTIONS work plan, where lean start and agile approaches is advocated. Best Practice tools and techniques and guidelines for management of stakeholder engagement are also included.

3.4 Introduction to the Test Methodology and Benchmarking

In support of 5G-SOLUTIONS vision to enable different end users to conduct a set of experiments of their multiple vertical use cases, Section 5 proposes an approach towards a unified methodology for the test reports formats and the technological validation adapted to the 5G-SOLUTIONS approach.

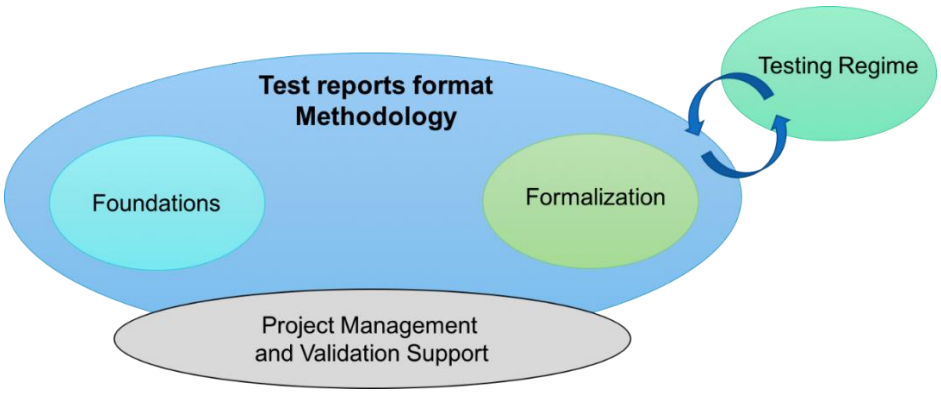

Figure 6: Overall scoping of the Test reports format Methodology

Figure 6 illustrates the main parts of the Test reports format methodology: at its core, it focuses on the formalization process precisely the formalized test case specification phase using as its "Foundations" some key concepts supported by important terminologies definition to help identify the test entities across methodologies. In order to provide a full testing life cycle and all the necessary V&V tools to the 5G SOLUTIONS and with the support of the work from T1.5, a "Project Management and Validation Support" module idea is explored with the definition of its initial requirements.

Furthermore, Section 5 also defines its methodology in detail as a "Use Case driven methodology" with an iterative, structured approach including a number of phases and activities within its process, placing the end users at the center for a unified and reliable outcome. It permits a continuous re-assessment of not only the results against the objectives set out for the trial executions but also the methodology itself during the different cycles.

Its main goal for the first phase of the project and for the first version of this deliverable is to provide to all LL, UC partners a set of templates to enable a) the description, extraction of the scenarios to be validated per use case in the different LLs, b) to conduct a test analysis and provide the steps for deriving gradually the test cases using a formalized test specification format common to all LLs while taking into account their specificities. Figure 7 illustrates the basic entities and their relationships that form the core concepts ("Foundations") that the methodology has been built on.

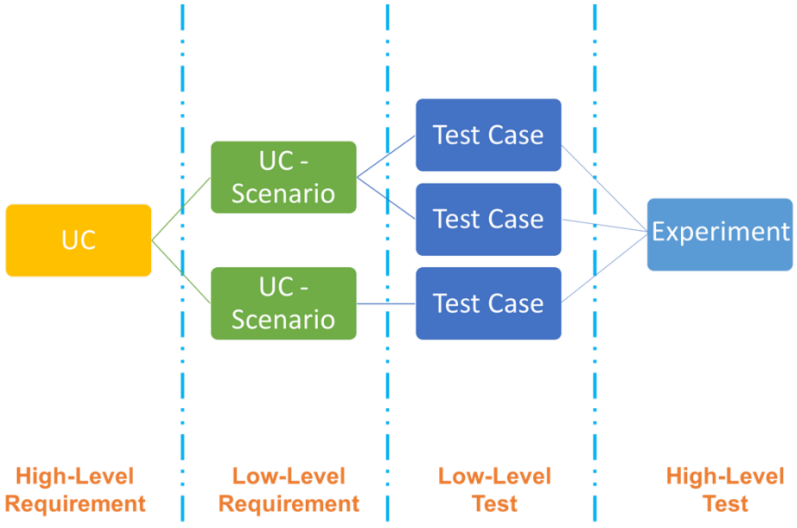

Figure 7: From Use Case to Test Case

To conclude on this brief introduction, once the test executions starts, the test cases will be gathered, collected, analyzed into different test report formats to provide a real insight into the experiments. The results then will form the final report including the methods and formats involved and are not covered in this version but in the final deliverable.

3.5 Introduction to the Technological Analysis and Validation Methodology

As mentioned in the previous chapters we have presented a process where technological and business validation goes hand in hand, starting with templates for the business validation before the technological validation; hence, we focus on methods for confirming that there is real business value, and how this can be reflected in business metrics. In this section, we will present a short introduction of the Technological Analysis and Validation Methodology. This includes adaptation of possible validation frameworks inspired from ETSI and other 5G research programs ([3], [4]).

From an overall perspective, the methodology encompasses analysis of the foundations, including terminology and concepts, definition and elaboration of methodology around a central notion: the testing regime.

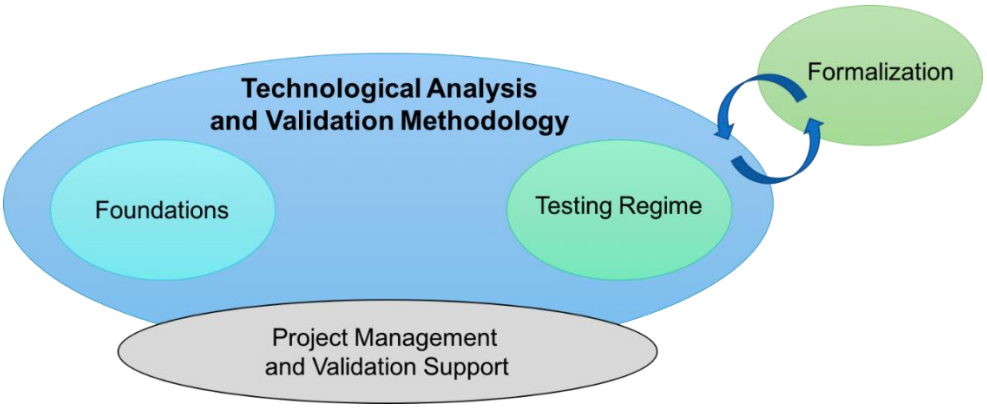

Figure 8: Overall scoping of the Technological Analysis and Validation Methodology

As illustrated, there is a close relationship between this methodology and the methodology for formalization (test report formats, parameters, etc.). As mentioned above, the notion of "testing regime" is the central concept to this methodology. In Figure 9 below, an overall flow of elements and topics to consider and analyze is included. The tests and the final validation steps are provided as an initial example and borrowed from and described for the 5G-VINNI (Verticals Innovation Infrastructure) [5]. Here the testing of the UCs using multiple tool sets is executed in front of the validation of E2E trial of vertical use cases to prove the 5G-VINNI capabilities. The business validation aspects are not explicitly described in the figure, beyond the connection to test case verticals.

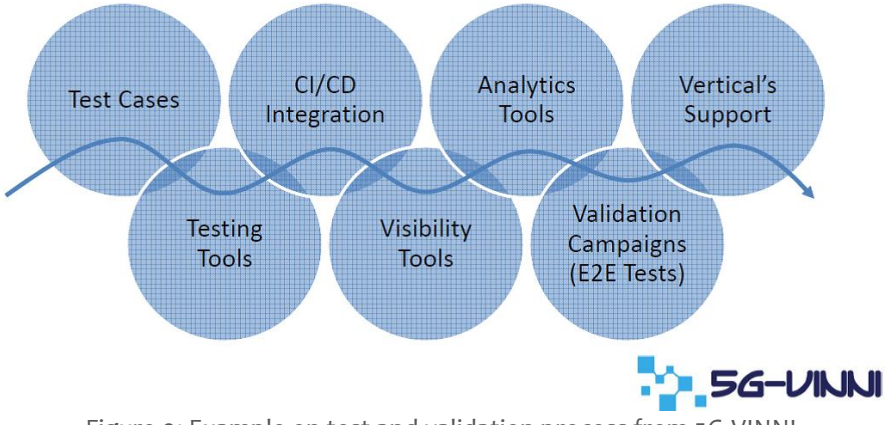

Figure 9: Example on test and validation process from 5G-VINNI

The following topics should be assessed in the technological test and validation process:

- Array of test cases/scenarios and test types covered;
- Different test types and different testing tool types applied;
- Test architecture and systems for visualization of data applied;
- Use of automatically execution of test cases;
- Use of acceptance testing methods.

With respect to acceptance testing methods we find the following types: Use of “Factory acceptance” testing (Alfa testing) for whether or not a component or system satisfies requirements including HW and/or SW. “User acceptance testing (Beta testing) for tests whether the user accepts the solution. “Operational testing “for tests whether processes and procedures are in place and allows a system to be used and maintained, e.g. training, security etc., and finally “Contract and regulation testing for testing whether a system meets governmental, legal and safety standards.

In Figure 10 below ETSI presents their testing as a service system (TaaS). Here different test types as presented, depending on whether they are on network related or application related. For 5G-VINNI performance as tested on both levels using different tool types.

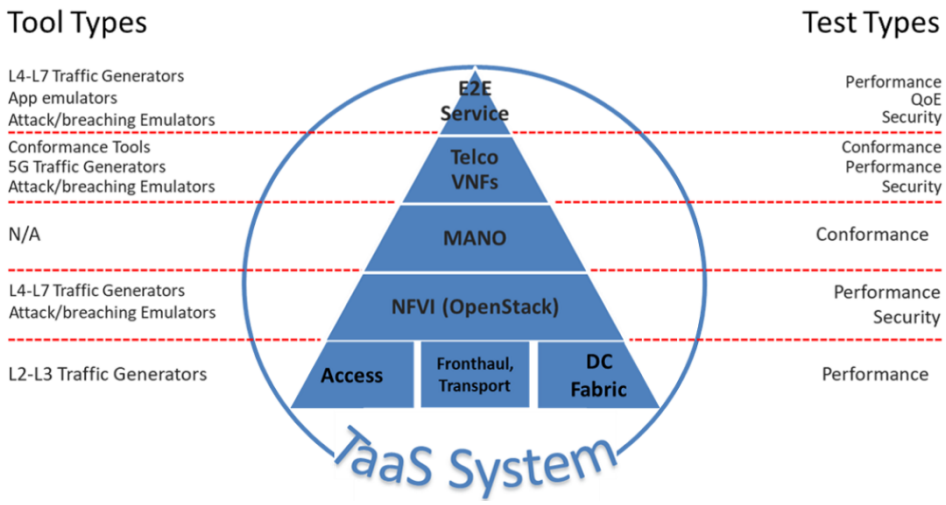

Figure 10: Example of test types and tools from 3GPPP/ETSI/5G-VINNI

Categorization is here based on which technology and tests that are covered; e.g. performance of the NFV Infrastructure (Network Function Virtualization), testing and verifying both the network performance and the service performance using Quality of Experience (QoE) methods for a high level end-to-end (E2E) perspective. Tests cases developed for 5G-VINNI follows the same structure [5]. This structure starts by introducing the pre-conditions, test set-ups and requirements for pre-qualification of the tests, followed by description of the test parameters for the test cases in the test area. Moreover, the method of computing the KPIs from the actual measurements is described. Then all the KPIs are listed for and the required value for each KPI. Finally, the post conditions are listed for all tests and the procedure and requirement of the actions that should be taken after each test case is executed.

A testing architecture should also be illustrated and described. Here data flow from service level, network level and potential cloud infrastructures should be addressed, in addition to role of test executor and other entities. A proposal for automation of the test cases could address topics such as whether test cases are translated to executables files, test steps, the position of the test executor engine, use of API’s and actual drivers translating the equipment API into generic ones.

4 Methodology for Business Validation

This section is related to WP1 Requirement analysis, use cases and methodologies, and more specifically, task 1.5 "Methodology for the technological and business validation of 5G E2E connectivity and associated management within and across verticals."

The objective for the business validation process is "to provide business validation for each use case, directly engaging their real-world customers, and receiving appropriate feedback for further enhancements after their engagement…" and "allowing to identify those use cases that have the highest commercial potential so as to progress to the next step of creating a service product portfolio" [6].

4.1 Introduction to Stepwise Business Validation Methodology

Below a methodology describing a stepwise process for business validation opportunities within the 5G solution Living lab use cases is presented. This methodology is grounded in agile, design thinking and lean start-up methodologies and supports the methodology presented in 5G SOLUTION DOA, where lean start and agile approaches is advocated.

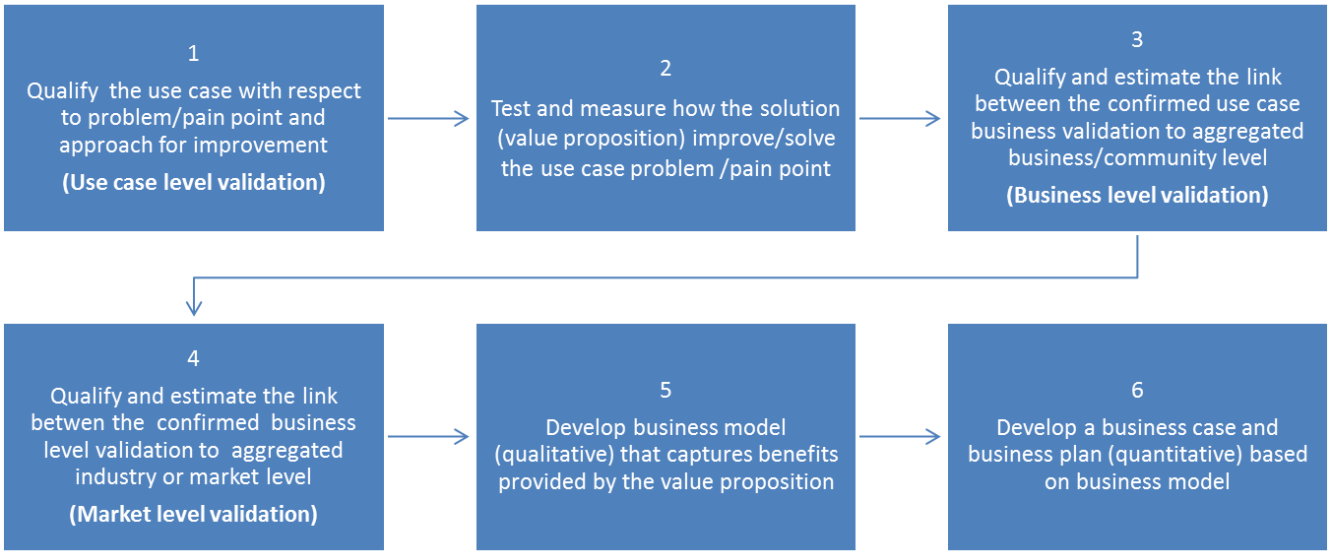

Figure 11: Stepwise methodology for 5G-SOLUTIONS business validation

The method in Figure 11 is linear in the sense that each element will provide input to the following steps; however, it also includes iterations between the steps. That is, value propositions (solutions to problem/pain points) described and tested in step 1 and 2 are to be included in business model framework in step 5; it could also imply to return to step 2 again (for more details see descriptions of steps). The method in figure 7 is aligned with chapter 3 Overall methodology, processes and dependencies.

5G-SOLUTIONS has a goal to create viable business plans for each of the targeted 5G vertical areas that identifies the specific market opportunity, the financial model, operational model and initial go-to-market steps. The creation of those business cases and business plans will be strongly informed by the business outcomes of the 20 UCs distributed across all 4 living labs as well as other market activities (e.g. Market Assessment, Patents, Standardisation etc.) which will all provide unique input to the final business plans. The method in figure 5 will involve cooperation with the 5G-SOLUTIONS WP8 on commercialization, especially with respect to step 4, assessing the market level impact of the 5G use cases. These market activities are handled in different tasks in WP8 (T8.1 – 8.5) in 5G-SOLUTIONS and are illustrated in Figure 12 below. The following paragraphs describe the 6-step methodology from Figure 11 in more detail:

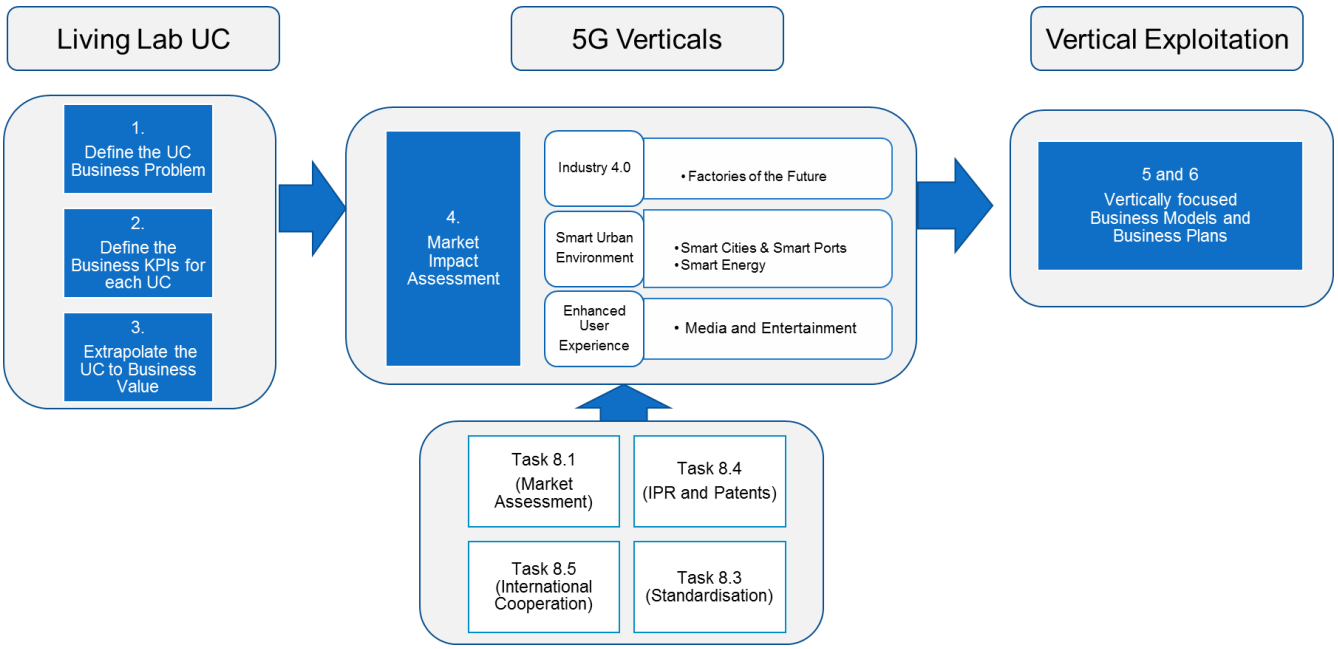

Figure 12: Building Business Plans in 5G-SOLUTIONS

4.2 Step 1 – Qualify the Use Case with Respect to Problem and Value

The objective in this step is to build a Use Case that is to be validated business wise as outlined in Table 2 below. In general, interviews with Use Case "owners" and their contacts, and experts from within and outside their own firm, will provide the primary sources of information. The Business Validation template described in Table 2 will help to deliver an initial level of consistency across each of the Use Cases and provide a solid foundation on which to build further business analysis. It is anticipated that the information gathered from each Use Case will require several iterations (e.g. via calls, face-to-face meetings/works shops and survey data from online questionnaire etc.) to gather sufficient level of detail that will provide the necessary input to the creation of Business Plans in WP8. In chapter 4.7 details on tools and techniques available for management of Use Case stakeholder's / personas engagement are described.

Table 2: Template for UC details for business validation

Background *Please provide a textual description of the business process and context surrounding the UC.*
What is the general context of the UC? (describe the organisation/business situation or the general community/environment in Smart Cities/Smart Ports) *Under what circumstances does the UC arise?* *How often?* *Other information?*
Describe the Personas *Please describe ALL personas who are **directly** impacted by the UC*

Describe <u>each persona</u> of the 5G Application (Consumer? Org/Business operations? Technology? Etc.); Please be as specific and detailed as possible about exactly what each persona does.

*Describe the **end user personas** (e.g. different types of consumers; operators in a FoF setting; citizen in smart city?)*

Persona Name	*Persona Role*

*Describe the **application provider(s)** (who builds and supports the application?)*

Persona Name	*Persona Role*

*Describe **other actors** directly involve/impacted by the UC?*

Persona Name	*Persona Role*

Describe the Problem

Describe in detail the problems that each persona*/stakeholder currently experience (AS-IS today <u>before</u> 5G)*

<u>Personas</u> (who exactly?) experience this **<u>problem</u>** (what exactly?) when doing this **<u>task</u>** (when does it occur?) OR

<u>Personas</u> (who exactly?) experience this **<u>problem</u>** (what exactly?) because of this **<u>constraint</u>** or limitation (when does it occur?)

End user Persona	
Problem	
Task / Constraint	
How is it addressed now? (Pre-5G)	
Application Provider Persona	
Problem	
Task / Constraint	
How is it addressed now? (Pre-5G)	
Other Personas	
Problem	
Task / Constraint	
How is it addressed now? (Pre-5G)	

Describe the Expected Benefit

*Describe the benefit that each persona hopes to achieve from the UC (**<u>after</u>** 5G is implemented). Please try to be specific on the benefits that may apply … Cost? Time? Agility? Safety? Security?*

End user personas	
Describe benefit	
Specific benefit	*Quantify the potential benefit*
Cost reduction?	
Revenue Increase?	
Time saved?	
Faster Time-to-Market?	
Safety?	
Security?	
Accessibility?	
Persona experience?	
Other …	
App. Provider Personas	
Describe benefit	
Specific benefit	*Quantify the potential benefit*
Cost reduction?	
Revenue Increase?	
Time saved?	
Faster Time-to-Market?	
Safety?	
Security?	
Accessibility?	
Persona experience?	
Other …	
Other Personas	
Describe benefit	
Specific benefit	*Quantify the potential benefit*
Cost reduction?	
Revenue Increase?	
Time saved?	
Faster Time-to-Market?	
Safety?	
Security?	
Accessibility?	
Persona experience?	
Other …	

Business KPIs

Please attempt to define the business KPIs that you might use to assess the outcomes from the UC. Each of these will be very specific to your individual use case but some examples are provided to stimulate ideas.

KPI	***Target***	***Business validation Metrics***

Suggestions regarding Personas: Identify all personas (stakeholders) involved in the work flow, external as well as internal, e.g. internal teams such as IT, finance, manufacturing, sales and so on, plus suppliers/vendors, users and customers. Use a Stakeholder Map, see figure 13, if it helps to describe those impacted and those

who will ultimately benefit from an improved future situation based around 5G technology. See links to description on personas in chapter 3.2.

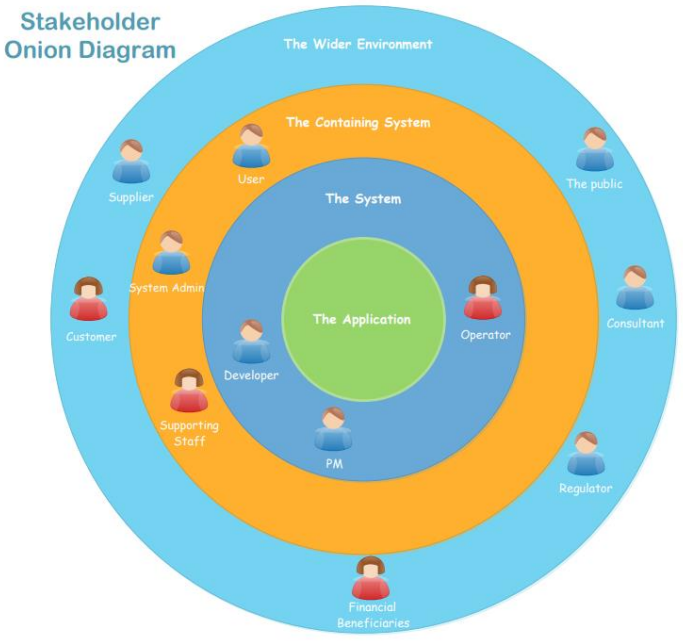

Figure 13: Stakeholder map, example

Suggestions for describing Problem: A description of the working process is preferred e.g. as a flow of tasks and activities, see figure 14.

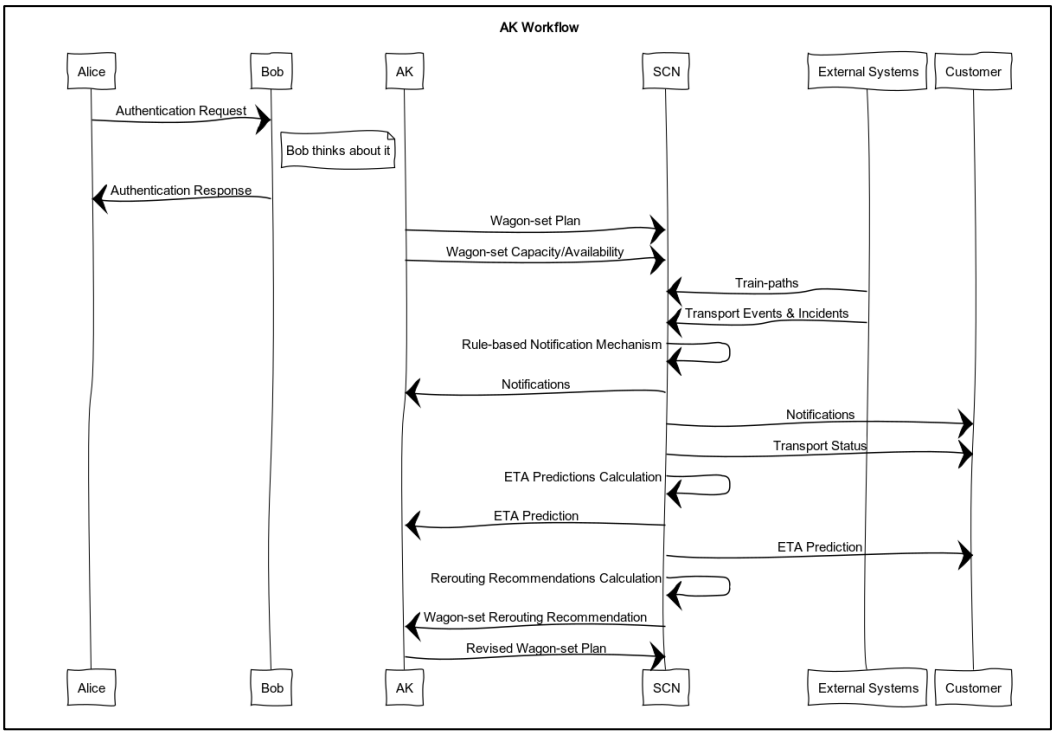

Figure 14: Description of working process using free digital tool (web sequence diagrams)

Here free digital tools can be applied to describe the working process, e.g. "Web Sequence Diagrams[6]" where a storyboard of the use case is developed.

As-Is today before 5G: Describe how the problem and pain points for the persona/stakeholder are solved today (As-Is) for each stakeholder. How are current technologies used (WiFi, 4G etc.) and what are the current equipment deployed (HW/SW)? What are the business limitations that arise from current solutions (volume, throughput, bandwidth, latency, reach, etc.).

Expected Benefits: Describe the potential benefit/value proposition arising from the use-case that could be provided with enhanced 5G based solutions. This defines the "To-Be" situation and again, should demonstrate an updated storyboard with a revised process flow (if relevant) and the potential stakeholder impacts.

In table 3 below the expected benefits, i.e. business validation metrics, from solving the pain points in the UCs with 5G based solutions is summarized, ref. 5G SOLUTIONS DOA. These benefits are presented in six groups (B1-B6):

B1- Personnel cost (People are the biggest cost in most enterprises and SMEs):

- How can we do the same with less resources using 5G enabled technology and services, e.g. estimated personnel cost/FTEs saved (1 FTE - Full Time Equivalent = 1 full time worker/workload);
- How can we do more with the same resources using 5G enabled services, e.g. estimated additional personnel hours/FTEs generated;
- To what extent are more expensive personnel resources required using 5G enabled technology and services? E.g. estimated extra personnel cost/FTEs;
- To what extent are personnel resources/costs/FTEs specialized and hard to find? E.g. 1) Easily available, 2) Partly available, highly unavailable resources.

B2 - Overhead cost (Non-personnel cost):

- How can the application of 5G technology and services in use cases improve rental costs (smarter building), e.g. reduce energy cost, property taxes, insurance, or utilities;
- How can the application of 5G technology and services improve transport, e.g. reduced CO2, less vehicles, less parking?

B3-Time to market:

- How does 5G accelerate the provisioning of product/services in the use cases to customers/citizens/end-users;
- In what way are these products and services critical for business (e.g. competitive differentiation);
- In what way are these products and of services critical for public services (e.g. deliver return on tax to citizen).

B4 –Safety:

- How does 5G improve confidence in technology acceleration with respect of safety of the people, safety of the process, safety of the ecosystem?

B5 -Data Privacy:

- How does 5G technology and services improve confidence in protection of the individual in the digital age of their data and their identity?

B6 – Accessibility:

[6] https://www.websequencediagrams.com/

- How can use of 5G technology and services help a wide community to share the benefits of an enhanced digital age, i.e. more acceptable in cost, types of location, portfolio of device types, access of people with disabilities.

Table 3: Overview of uses cases in different living labs and tentative business validation metrics

Living lab	Use case	B1	B2	B3	B4	B5	B6
LL1: Factory of the Future	1.1 Time critical process optimization inside digital factory	x	x	x	x	-	-
	1.2 None time critical communication inside factories	x	x	x	x	-	-
	1.3 Remote controlling digital factories	x	x	x	x	x	x
	1.4 Connected goods	x	x	x	x	-	x
	1.5 Rapid deployment, auto/re-configuration, test of new robots	x	x	x	x	-	-
LL2: Smart Energy	2.1 Industrial Demand Side Management	x	x	x	-	-	x
	2.2 Electrical Vehicle (EV) Smart Charging	-	x	-	-	-	x
	2.3 Electricity network frequency stability	-	x	-	-	-	x
LL3: Smart Cities and Ports	3.1 Intelligent Street lightning	-	x	-	x	-	x
	3.2 Smart Parking	-	x	-	x	-	x
	3.3 Smart city co-creation	-	x	-	-	x	x
	3.4 Smart buildings/smart campus	-	x	-	-	x	x
	3.5 Autonomous assets and logistics for smart harbor/port	-	x	-	x	-	x
	3.6 Port Safety: monitor and detect irregular sounds	x	x	-	x	-	-
LL4: Media and Entertainment	4.1 Ultra High-Fidelity Media	x	x	x	-	x	x
	4.2 Multi CDN selection	x	x	x	-	-	x
	4.3 On-site Live Event Experience	x	x	x	-	-	x
	4.4 User and Machine Generated Content	x	x	x	-	x	-
	4.5 Immerse and Integrated Media and Gaming	x	x	x	-	x	-
	4.6 Cooperative Media Production	x	x	x	-	x	x

4.3 Measure Use Case Improvement for Problem Defined (step 2)

The process of assessing the improvements delivered from a specific Use Case is assessed from two complementary approaches. The first is focused around Agile development techniques that involve creating a Minimum Viable Product (MVP) and repeatedly validating the impact it delivers to key personas. The core premise is to deliver just enough features in the initial MVP to satisfy the initial stakeholders and gather feedback for future products or solutions. The feedback process and evaluation are primarily interview and observation led (as outlined in Table 4), and effectively deliver a **"Qualitative"** assessment of the Use Case Improvement.

Table 4: A Minimum Viable Product (MVP) approach

#	Activities	Sources of information
1	Key assumption on actors, problems, needs, market and stakeholders	Information from existing products and current market intelligence inputs
2	Describe customer journeys with pain points (flow of activities)	Observe and/or interviews actors and stakeholders

3	Describe the product application with selected features. Define success criteria	Select features according to feedback from observation and interviews
5	Present product to potential uses, and stakeholders	Present product or process solution using simple mock-ups - video, paper sketch etc.
6	Evaluate the MVP solution based on feedback based on MVP test	Users tell us where the product is lacking and ensures market validation.
7	Develop second version, measure and test	Repeat the activities from 1-6

The second business validation method is centered around defining specific validation metrics that can realistically be measured and extrapolated within the Use Case. The business validation metrics are very individual to each Use Case and focus on the specific benefits that will accrue over time. In this case, it is anticipated that the specific business validation metric can be observed, measured and extrapolated to effectively deliver a **"Quantitative"** assessment of the Use Case Improvement.

What is the specific benefit? The business validation metrics for each Use Case describe the business outcome that the stakeholders would like to achieve. The KPI should describe business/operational terms as opposed to technical. For instance, "False-Positive failures in a production Process to be reduced by X% per month". The following tables contain some ideas that will be used during the Use Case description process (as described in section 4.2) to support Use Case owners in defining the problem being addressed to a sufficiently granular level that can subsequently be assessed when the Use Case MVP is applied.

Table 5: Examples of Business KPIs in the use case

#	KPI	Target	Indicative business validation metrics
1	False positive rate	0.01 %	% of good product rejected in value chain sub process
2	Detection success rate	99 %	% of non-compliant goods detected in value chain sub process
3	Scrap reduction	5 %	% of compliant products rejected for each non-compliant product
4	Increased data privacy	100%	% of reduced GDPR violations (Citizens more likely to use the services provided)
5	Scrap cost savings	10 %	% of cost saved from detection of non-compliant products
6	Safety increase	3%	% of HSE incidents reduced using 5G solution
7	Increased media quality	9%	% of individuals with increased live media experience (QoE)
8	Person cost savings	12%	% of FTE's reduced using 5G solution in value chain sub process

4.4 Qualify the Value from Use Case to the Organization (step 3)

Step 3 is to extrapolate the results from Use Case level to an aggregated level within the context studied (e.g. a commercial organisation, a city municipality, a specific community) with a link to the overall business value categories outlined in the 5G Solution DoA. (BI: Personnel cost, B2: Overhead cost, B3: Time to market, B4: Safety, B5: Data privacy, B6: Accessibility and others that may be defined by the Living Labs as being of key importance).

In assessing the value delivered from a Use Case to a wider organization/community, several factors will be referenced. For example, the frequency and scale of a specific use case occurrence should be assessed so that its specific benefit can be extrapolated to an aggregate level.

- Are the benefits rare? And perhaps limited to a small stakeholder group?
- Or do they have a widespread stakeholder impact?

The context surrounding each Use Case will differ between the living labs (see table 6) but all assessment will be aligned to a goal of ultimately assessing the business value that can accrue for each of the 5 target verticals (Factory of the Future, Smart Cities, Smart Ports, Smart Energy, and Enhanced Media).

Table 6: Types of context for business level

	Context	Sources of information
A	Within a business organization (Company/Firm) e.g. Factory of the Future, Smart Energy LL's	• Management /leaders • Accounting / Controllers
B	Within a Community (municipality) e.g. Smart City and Smart Port LL's	• Municipalities, Public agency • Statistical agencies
C	Within the individuals and groups of individuals e.g. for Media and Entertainment LL	• Interest organization, e.g. sport associations • Statistical agencies

On the aggregated level both qualitative and quantitative metrics should be addressed, see table 7 for quantitative KPIs:

Table 7: KPI examples for aggregated level (e.g. type A: Business/Community level)

#	KPI	Target	Indicative business validation metrics
1	Accelerated time	10%	**% reduced hours for maintenance for firm as a whole** (previous speed increase validated in similar working process in use case)
	Scrap cost savings	10%	**% of cost saved from detection of non-compliant products in firm** (previous savings validated in similar working process in use case)
	Increased Co2 Reduction	5%	**% of municipality reduced searching for parking sites** (previous reduction validated in similar working process in use case)
2	Personnel cost savings	12%	**% of FTEs saved in firm** (previous savings validated in similar working processes in use case)
3	Privacy increase	100%	**% reduced GDPR violations reported from live media subscribers** (previous savings validated in similar working processes in use case)
4	Customized products	5 new per year	E.g. Five new products that are defined and launched each year based on agility of setup
5	Citizen Access	5%	An existing urban service can expand to citizens (mobile & real-time) on the move with 5% additional uptake expected per annum
6	Safety increase	3%	**# of HSE incidents reduced in firm** (previous savings validated in similar working processes in use case)

Additional to the quantitative metrics arising from each use case, the project will also follow a qualitative, structured interview/questionnaire process with business leaders in in the LL use cases to understand other business barriers to 5G integration/deployment. This activity will seek to understand other barriers that may exist outside the use case such as health and regulatory issues, see table 8.

Table 8: Qualitative metrics for business barriers for 5G

#	Business barriers for 5G integration	Sources of information
1	Local Labour rule limitations	Interview with managers in use case companies of communities
2	Concerns on 5G health impacts	Interview with managers in use case companies of communities
3	Regulatory approval that may slow process	Interview with managers in use case companies of communities
4	Costs – both direct and indirect	Interview with managers in use case companies of communities
5	A general review of the possible impacts to local adoption	PESTEL analysis from internal and external sources, see table 9 below

Table 9: General analysis (PESTEL) for a country's adaption of 5G

	Factors	Comments
P	Governmental stability	How government intervenes the economy, e.g. tax policy, labor law, tariffs, environmental law, trade restrictions, and political stability. Governments also have a high impact on health, education and infrastructure of a nation
	Tax policy	
	Regulation	
	Infrastructure	
E	Economic growth	Includes economic growth, exchange rates, inflation -and interest rates - affects how businesses operate and make decisions. Interest rates affect a firm's cost of capital and how a business grows and expand. Exchange rates affect cost of exporting goods and price of imported goods.
	Inflation	
	Monetary policy	
	Employment rates	
S	Income distribution	Include cultural aspects and health consciousness, population growth rate, age distribution, career attitudes and emphasis on safety. Trends in social factors affect demand for a company's products and how that company operates.
	Demography	
	Education	
	Lifestyle factors	
T	Intern. Influences	Include technological aspects like R&D activity, automation, technology incentives and the rate of tech. change terminating barriers to entry, minimum efficient production level influence the outsourcing decisions. Technological shifts would affect costs, quality, and lead to innovation
	Tech transfer	
	R&D initiatives	
	Comm. Channel	
E	Environment Restriction	Include ecological and environmental aspects such as weather, climate, and climate change affecting industries such as tourism, farming, and insurance. Awareness of the potential impacts of climate change affects how companies operate, products they offer and creation of new markets
	Climate change	
	Energy saves	
	Workforce health	
L	Regional Laws	Include discrimination law, consumer law, antitrust law, employment law, as well as health and safety law. These factors can affect how a company operates, its costs, and the demand for its products
	Court system	
	Health and Safety	
	Law enforcement	

4.5 Estimate the Effects in the Market (step 4)

Step 4 relates to further extrapolating the results from the organization/community level to an industry, market level, or a society level (Relates to WP.8.1):

- Within the industry as a whole in Europe (e.g. for production facilities ala Glanbia and Proctor & Gamble);
- Within public sector such as ports and smart cities;
- Within the live event entertainment industry as a whole.

Together, business validation on a use case level, organization/community level and general market developments will support the evaluation of a "market opportunity for 5G vertical application" (see WP8.2).

Sources of information:

- Eurostat[7] with NACE codes for industrial activities;
- Industry reports from consultants and research institutes;
- Surveys of market stakeholders including SWOT analysis etc., see table 11.

Table 10: Examples of KPIs to be defined at industry and market level

#	KPI	Target	Indicative business validation metrics
1	Maintenance cost saving	20%	**% of maintenance FTEs reduced within Europe** (based on number of companies within NACE 10.51 Production of diary product- similar to Factories of the Future (FoF) use case with in Glanbia plc)
2	Scrap cost savings	10%	**% of scrap cost savings in Europe** (based on number of companies within NACE 17.22 production of household and sanitary goods – similar to FoF use case within Procter and Gamble)
3	Increased media quality	3%	**% of increased live media experience in Europe** (based on number of companies within NACE or # of similar events occurred)
4	Increased Co2 savings	5%	**% of Co2 savings in Europe** (based on number of municipalities in Europe with similar size as use case municipality)

Table 11: SWOT (Strength, Weakness, Opportunity, Threat) analysis

	Factors	Comments
S	Things the company does well	Cost effectiveness, Innovation etc.
	Qualities that separates from competitors	Mental and physical working environment etc.
	Internal resources	Skills, knowledge, etc.
	Tangible assets	Capital, intellectual property etc.
W	Things the company lacks	Reputation, reference customers etc.
	Lack of working procedures	Templates and tools for development, test etc.
	Resource limitations	Few concessions for production available etc.
	Unclear selling propositions	Limitied customer and stakeholder insight etc.
O	Unserved market for offer /value proposition	Technology (5G/IoT) satisfy unserved demand etc.
	Few competitors in market	High entry cost for entering market etc.
	Emerging need for company products	New technology, new regulations etc.

[7] https://ec.europa.eu/eurostat

	Press/media coverage of company	Innovative product, satisfied customers, etc.
T	Emerging competitors	Low cost/agile competitors etc.
	Changing regulatory environment	Lower prices/profit margins etc.
	Negative press/media	GDPR breach etc
	Changing customer attitude versus company	Increased focus on sustainable solutions etc.

4.6 Business Model and Business Plan Capturing Revenues (step 5 and 6)

In these steps business opportunities for concrete value propositions are detailed using qualitative metrics (step 5); the business model can be further detailed into a business case using quantitative metrics (step 6), see Figure 15 .

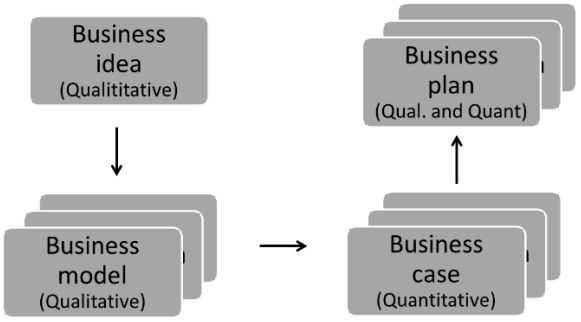

Figure 15: Relations between business idea, business model and business case/plan

A business model describes alternative ways of implementing our business idea, describing the logic of generating a profit from the foundation of a specific business idea. Different "business models" may concern the same basic idea, e.g. SAS vs. Ryan Air within the airway business. A business case contains a number of indeterminate parameters, prices, costs, sales volumes, partnerships, etc. A time period has to be set for the calculation and estimate of the market opportunity for each business case and the "business case" appears by fixing these indeterminate variables to some value over a specific period. Various quantitative and qualitative indicators may be used as metrics to assess the business potential for alternative business cases. The business plan is the plan for implementing a particular business case, based on some business model for a particular business idea, ref. step 6 in the business validation methodology. Activities to be executed when defining a business model are the following, see table 12: (referred to as business model canvas)

Table 12: Activities defining the business model

#	Activities	Source of information
1	**Describe offer and value proposition** • What is the company offering their customers, which problems and pain points are they solving? • Why will the customer prefer the offer rather than the competitor(s)? The customers can also be internal customers within firm.	• Input from use case description - Step 1 business level methodology • Input from SWOT analysis
2	**Describe Customer Interface** • Who are the customers, i.e., the customer segment with needs/ demands the company wants to serve? • How the customers are reached, that is, the means (channels) to reach and address the customers? • How to get them and keep them (i.e., reduce churn), and links	• Input from use case description – Step 1 • Input from SWOT analysis

	between the company and the customer segments.	
3	**Describe Infrastructure management:** • How the firm operates and delivers value to customers (company internal value chain/service platform and delivery system), the key activities and capabilities/resources. • How difficult they are to perform and copy. • Who are the key partners and suppliers, the business eco-system, resources (beyond internal value chain) necessary to perform in order to deliver service to the customers	• Input from use case description • Input from stakeholder analysis • Input from SWOT analysis
4	**Describe Finance** • What are the revenues, the pricing models, how money is made through a variety of revenue flows. • What are the costs and risks, describe the cost structure.	• Input from business level analysis – Step 3 and 4 • Input from accounting and firm legal

The four major activities have 11 different sub tasks or questions to be handled. These sources of information are found in step 1, 3 and 4 in the stepwise methodology ref. figure 9.

The business plan contains concrete actions, milestones and responsibilities for implementing a particular business case. The business plan document will include both a quantitative and qualitative analysis of the specific business case selected and contains at least the sections outlined in Table 13.

Table 13: Build-up of a business plan

#	Items in business plan	Comments
A	**Business**: Description of product portfolio, and risks management, incl. regulations	• Input from step 1 and step 5 • Input from SWOT analysis
B	**Market**: Market research and product targets, Customer and industry actors	• Input from step 4 in methodology • Input from SWOT analysis
C	**Organization**: Overview of organization chart: management and suppliers.	• Input from step 1 in methodology
D	**Future:** Vision, goals, objectives and actions plan for organization incl. supplier	• Input from step 3 in methodology
E	**Finance**s: Describes assumptions, costs, profit, balance sheet, break even analysis	• Input from step 3 in methodology • Input from SWOT analysis

4.7 Tools and Techniques for Stakeholder Engagement Management

Identification of stakeholders/personas is the first activity to be performed in the business validation methodology. Their feedback on use cases and business cases improves the chance to successfully address the needs and commercial potential of a wider market. Maximizing the engagement of these stakeholders/personas is supported through the use of best practice, tools, techniques and guidelines on project management, for example:

i) Project Management Body of Knowledge (PMBoK Guide[8]) from Project Management Institute;
ii) ii) Open Project Management Methodology (OpenPM2 Guide[9]) from Centre of Excellence on PM2.

The PMBoK Guide defines 10 "Knowledge Areas" (i.e. areas of project management defined by knowledge requirements) and for each knowledge area, the guide describes processes, practices, inputs, outputs, tools, and techniques: Project Stakeholder Management is one of these ten knowledge areas.

Stakeholder Management includes the processes required to identify people, groups or organizations that could impact or be impacted by the project, to analyze stakeholder expectations and their impact on the project and to develop appropriate management strategies for effectively engaging stakeholder in project decisions and execution. The Stakeholder Management is defined by four processes using following tools and techniques:

1. **Identify Stakeholders** – is the process of identifying project stakeholders (i.e. people, groups or organizations that could impact or be impacted by decision, activity or outcome of the project) regularly and analyzing and documenting relevant information regarding their interests, involvement, interdependencies, influence, and potential impact on project success. The key benefit of Identify stakeholder process is that it allows the project manager to identify the appropriate focus for each stakeholder or group of stakeholders;
   - Expert judgment; Data gathering by using questionnaires and surveys, brainstorming; Data analysis by performing Stakeholder analysis, Document analysis; Data representation by mapping Stakeholders based on interests and power of influence; Meetings.

2. **Plan Stakeholders Engagement** – is the process of developing approaches to involve project stakeholders based on their needs, expectation, interests, and potential impact on the project;
   - Expert judgment; Data gathering by using benchmarking; Data analysis by using assumption and constraint analysis, root cause analysis; Decision making by using prioritization/ranking; Data representation by using mind mapping, stakeholder engagement assessment matrix; Meetings.

3. **Manage Stakeholders Engagement** – is the process of communicating and working with stakeholders to meet their needs and expectations, address issues, and foster appropriate stakeholder engagement involvement;
   - Expert judgment; Communication skills by using feedback; Interpersonal and team skills by using conflict management, cultural awareness, negotiation, observation/conversation, political awareness; Ground rules; Meetings.

4. **Monitor Stakeholder Engagement** – is the process of monitoring project stakeholder relationships and tailoring strategies for engaging stakeholders through the modification of engagement strategies and plans;
   - Data analysis by using alternatives analysis, root cause analysis, stakeholder analysis; Decision making by using multi-criteria decision analysis, voting; Data representation by using stakeholder engagement assessment matrix; Communication skills by using feedback, presentations;

[8] Project Management Institute – "A Guide to the Project Management Body of Knowledge (PMBOK Guide)". 6th ed. Newtown Square, Pa: Project Management Institute, 2017. See https://www.pmi.org/pmbok-guide-standards (last access on 5/Nov/2019).
[9] Centre of Excellence on Project Management Methodology – "Open Project Management Methodology (OpenPM2 Guide), version 3.0, 2018. See https://ec.europa.eu/isa2/solutions/open-pm2_en (last access on 5/Nov/2019).

Interpersonal and team skills by using active listening, cultural awareness, leadership, networking, political awareness; Meetings.

In a similar way, OpenPM[2] suggests the following five recommended steps for stakeholders' management:

1. **Analyze the expectations, attitudes, level of interest and influence of key project stakeholders**. Beware of stakeholders who are less than enthusiastic or opposed to the project.
2. **Devise communication and management strategies** that encourage stakeholders to get involved and contribute.
3. **Continually monitor stakeholder reactions** or changing attitudes and manage accordingly. A one-off analysis exercise is not enough, especially for longer-term and/or complex projects. Use the Stakeholders Checklist to identify specific actions to be taken at specific moments in the project.
4. **Ensure that any planned stakeholder management activities are time-bound and focused**. Keep in mind that the contribution/involvement of various stakeholders may be different in each project phase.
5. **Align the Communications Management Plan with Stakeholder Management needs**, particularly in the areas of project acceptance, transition, and business implementation.

Both PMBoK and OpenPM[2] agree on identifying all the stakeholders, keep continuously updated the list of stakeholders and their expectations and, last but not least, align the communications plan during the whole lifecycle of the project. This latter remarks the importance and the strong relationships among Stakeholders Management, Business Validation and Exploitation of results, and Communication Management. For this reason, all the 5G-SOLUTIONS WP's influenced by the Business Validation Methodology (i.e. WP1, WP8 and WP 9) will derive benefits by sharing Stakeholders Groups and tools for managing their engagement.

Each group of stakeholders will be invited to join workshops, also co-located with project plenary meetings and special events attended by the project partners. During these workshops, project partners will present results from the experimentations, appropriately collected, organized and adapted with the WP9 experts. Moreover, it is important to invite heterogeneous stakeholders, i.e. persons with different background and expertise in order to get feedbacks from different perspectives such as usefulness, applicability, social acceptability, etc. After the presentations of results, stakeholders will "have the floor" and heterogeneity will ensure to raise feedbacks and debates. Feedbacks from stakeholders need to be properly gathered and collected by using questionnaires and surveys as well.

In this perspective, due to the fact that WP1 is adopting Redmine as a tool for project management and tracking issues (i.e. part of technological validation methodology), it could be favorable to share the same Redmine platform and include polls plug-in (e.g. Basic Polls[10]) that allows to build questionnaires to be submitted to the stakeholders (ante/during/post workshops) as shown in the following Figure 16.

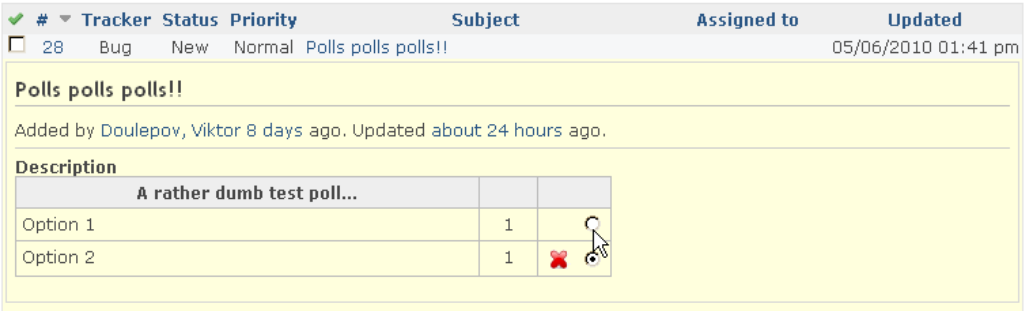

Figure 16: Example of poll in Redmine with plug-in

[10] http://www.redmine.org/projects/redmine/wiki/PluginBasicPolls

5 Methodology for the Test Reports Format, Formalization and the Test Regimes

5.1 Scope for Testing: The Use Cases

As a general reference for the deliverable and a starting point for the methodology defined here, below is the first version of the use cases identified in the proposal [6] and captured in detail in the deliverable D1.1A – Definition and analysis of use cases/scenarios and corresponding KPIs based on LLs. This list represents the entry criteria for this deliverable, as for the methodologies, it begins by analyzing and extracting the scenarios associated with the use cases in order to derive the test cases. A sample of the scenarios is presented in Section 5.9.

Table 14: Use Cases

UC #	UC Title	Class Type
LL1: Factories of the Future (FoF)		
UC1.1	Time-critical process optimisation inside digital factories	eMBB+ URLLC+ mMTC
UC1.2	Non-time-critical communication inside factories	mMTC
UC1.3	Remotely controlling digital factories	eMBB+ URLLC
UC1.4	Connected goods	URLLC
UC1.5	Rapid deployment, auto/re-configuration, testing of new robots	eMBB+ URLLC+ mMTC
LL2: Smart Energy		
UC2.1	Industrial Demand Side Management	URLLC
UC2.2	Electrical Vehicle (EV) Smart Charging	URLLC
UC2.3	Electricity network frequency stability	URLLC
LL3: Smart Cities & Ports		
Smart Cities		
UC3.1	Intelligent Street Lighting	mMTC
UC3.2	Smart Parking	mMTC
UC3.3	Smart city co-creation	mMTC, eMBB
UC3.4	Smart buildings / Smart campus	eMBB+ URLLC+ mMTC
Smart Ports		
UC3.5	Autonomous assets and logistics for smart harbour/port	eMBB+ URLLC+ mMTC
UC3.6	Port Safety: monitor & detect irregular sounds	eMBB+ URLLC+ mMTC
LL4: Media & Entertainment		
UC4.1	Ultra-High-Fidelity Media	eMBB+ mMTC
UC4.2	Multi CDN selection	eMBB
UC4.3	On-site Live Event Experience	eMBB+ mMTC
UC4.4	User & Machine Generated Content	eMBB+ mMTC
UC4.5	Immersive and Integrated Media and Gaming	eMBB+ URLLC+ mMTC
UC4.6	Cooperative Media Production	eMBB+ mMTC

LL5: Multi Living Lab (MLL)
"MLL does not define new UC. The so-called MLL-UC is a mixture of existing UCs defined in LL1 – LL4, i.e., one MLL-UC contains more than one LL<id> UCs. This may also imply multiple concurrent UCs in just one LL. This may be the case where multiple vertical enterprise customers are involved concurrently demanding individual SLAs. The objective is to investigate the performance and behaviour of dynamic network slicing. In 5G network slicing, one big challenge lies in how to dynamically allocate and orchestrate the resources to meet the demands of multiple vertical customers simultaneously. To this end, MLL-UCs are designed to reflect the challenges in orchestration and testing."

5.2 Approach

Figure 17 below is an illustration of the iterative approach adopted for T1.4(Test Reports Format) \T1.5(Technological Validation). With its four main phases at the centre, its relationships with the other 5G projects, 5G-SOLUTIONS work packages and tasks: It allows for incremental and continuous improvements of the methodology itself (both at the overall level as well as at the level of individual use cases) but also of the trials executions using a feedback loop to get real insight and the best results.
The four main phases are further elaborated below in Section 5.6.3 where the overall testing and validation process is elaborated.

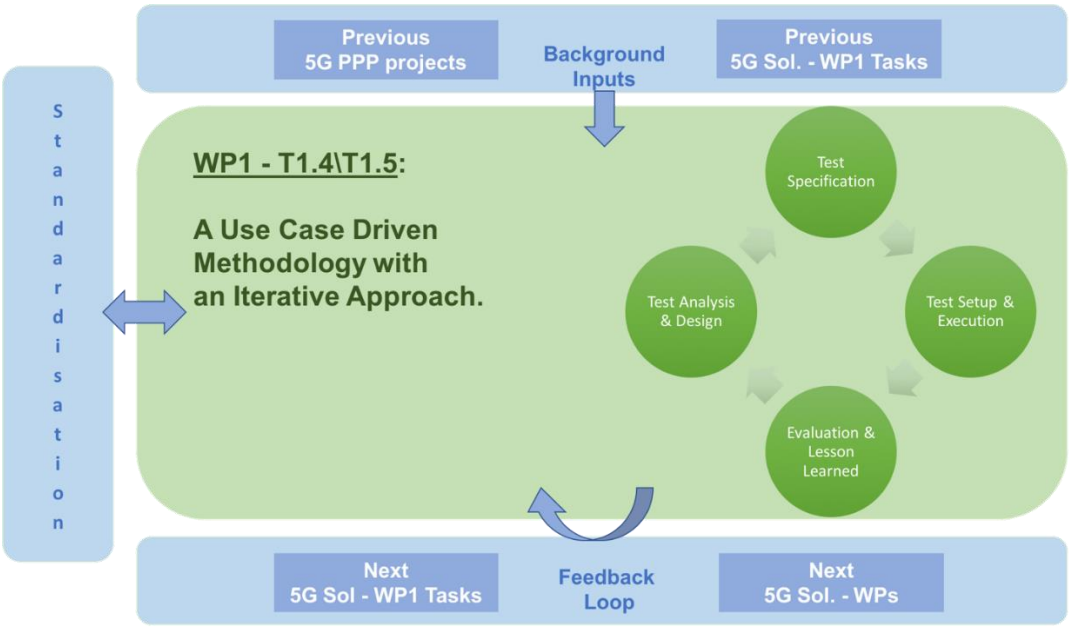

Figure 17: High Level Approach

5.3 Background Inputs

1. **Previous 5G-PPP projects**: The very first activity for taking on the work was to spend valuable time reviewing, analyzing and learning from the various existing documents from other projects. Despite their various approaches and various in-depth levels. It was a real opportunity to get an insight into the different test methodologies defined but also a "how-to" guide for the test specification activity along with the creation of the different required templates.

   With the list of projects provided in the proposal [7] and the work carried out in T1.3 for D1.3A (Leveraging and extending 5G-PPP previous work in 5G-SOLUTIONS): the list below provides a summary

of some of the deliverables reviewed so far and gathered using Annex 1: 5G - PPP Projects. This activity of collecting and reviewing information from the different projects is likely to continue as part of T1.4 and T1.5 as more deliverables will become available over time which will guide our work.

- **5G-TANGO:** An immersive E2E streaming service, able to fuse video streaming as 360° in AR/VR personalized content; VNFs: Content Management, Aggregator, reverse proxy, streaming servers. 5G-TANGO project and its deliverables provide a really good insight on how an advanced V&V platform can be used for their selected use cases. Their test framework uses Model-based testing to generate automatically the tests and also includes a certification platform.
- **5G-EVE:** 5G-EVE facilities: Use of the 5G-EVE Turin facility for conducting field trials for the use cases related to the Smart Energy Living Lab. 5G-EVE deliverables give an overall view of a structured test approach: from test plan to test procedures along with some validation tools and also include a KPI collection framework.
- **5G-VINNI:** 5G-VINNI facilities: Use of the 5G-VINNI facilities for conducting field trials for the use cases related to the Factories of the Future (Ireland, Brussels, Norway), Smart Cities (Ireland), Smart Ports (Norway) and Media & Entertainment Living Labs (Patra and Norway). Another interesting structured test approach with great focus on the formalization process with very detailed templates and initial test reports.
- **TRIANGLE:** Framework for 5G Applications and Devices testing and benchmarking. The deliverables reviewed give a complete and final test specification report with a format that uses a modular approach to the test case formalization.
- **5G-GENESIS:** A large-scale facility and an open set of tools for 5G Experimentation. An in-depth approach is taken on the concept of experimentation with associated procedures and templates with also provide early results from the first cycle of trials.

2. **Previous 5G-SOLUTIONS WP1(Requirements analysis, use cases and methodologies) tasks**:

An important source of information for this interim version of the deliverable D1.4A has been the deliverable D1.1A (Definition and detailed analysis of vertical use cases/scenarios, baseline and corresponding target KPIs). With its analysis of the use cases including an initial version of the KPIs to be measured: it documents, covers the needs and the requirements from an E2E perspective which feed into other critical tasks and certainly sets out a foundation for our tasks.

As for D1.2A (Cross-domain service orchestration and management challenges analysis) has contributed to influencing the testing process as a whole in D1.4A for T1.4 and T1.5 (Methodology for the technological and business validation of 5G E2E connectivity and associated management within and across verticals), also leading to the development of a better understanding of the challenges ahead of providing E2E services in the 5G –Solution ecosystem in a DevOps manner.

And finally, D1.3A: the initial result of T1.3 is already covered in the **Previous 5G-PPP projects** section above.

3. **ETSI Approach to Testing** [8]: With its focus on Conformance, Interoperability, Testing and Standardization (see 5.4) in a multi-vendor, multi-network, multi-service environment, ESTI documents are a good reference for many of the objectives set out in this deliverable: starting from test methodologies, test processes and procedures, test specifications to test case formalization process and test reports but also the key concepts around test environments to enable the control over the test execution and collection of measurements (see Figure 18: ETSI Illustration of an NS under Test). Like any other standards, the work conducted by the different bodies involved can be freely used and will therefore further feed into D1.4A where appropriate.

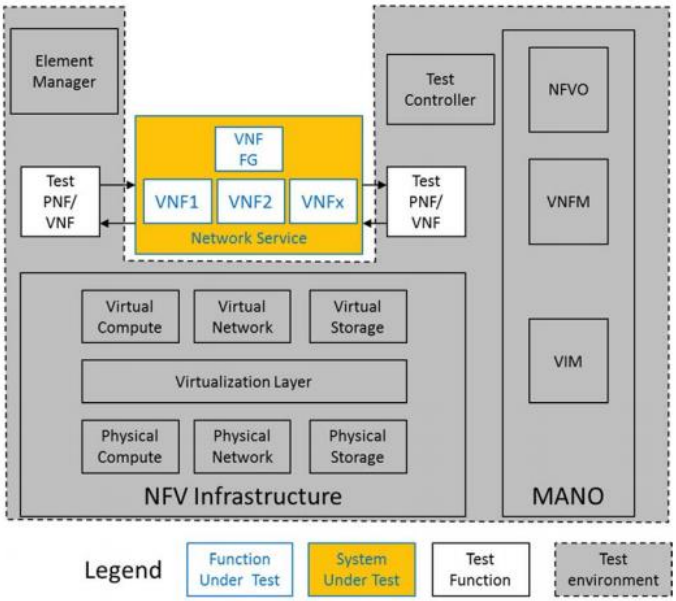

Figure 18: ETSI Illustration of an NS under Test

5.4 Standardization

One of the objectives of 5G-SOLUTIONS is to make use of standardisation as a way to exploit the impacts of the project result. This section outlines the link between T1.4/T1.5 and the standardisation activities within 5G-SOLUTIONS.

1. **Alignment with WP8**: In connection to WP8 an initial list of on-going activities related to the LLs of 5G-SOLUTIONS and the use cases to be tested within each one will be provided in the first stages of the project. The main goals are:
    - To ensure that the work in the project is carried out in line with existing and pre-defined standards.
    - To prioritize testing around standardization priorities and active studies in the related SDOs.
    - To enable the detection of potential results and feedback that could be input to relevant SDOs.

After each round of trials, the different results will be classified according to their relevance either to specific technology standards or to vertical industry interests. A short description of the result and the relevance for standardization will be provided to ease decisions as per Table 19: Test Case Specification (TRL 3). This will be assessed against the on-going activities in the SDOs and, in case the results are detected to be suitable for input to an SDO, the partners' members of the organizations and involved in the trials will generate the corresponding input to standardization. The different study groups will be tracked until the end of the project as well as the impact of each input.

Table 15: Result Description suitable for Standardization

UC ID: Title	
TC:	*TC Identifier: e.g.TC01*
Test Objectives:	*e.g. TO01: To test the stringent requirements for indoor mission–critical process optimisations in a heterogeneous environment.*
Relation to Standardization	*i.e. To which SDO and study topic the test and the use case relates.*
List of measured KPIs:	*e.g.: Data Rate, Latency, Mobility, QoE …*

Type of Result	*Information about the trial and measurement. What kind of result is it? Numerical value to confirm an expected performance? Recommendation on appropriate network configuration for specific performance?*
Feasibility for Standardization Input:	*i.e.: The result and corresponding methodology and technical descriptions can be input to standardization organization.*

2. **Alignment with ETSI**: As covered in 5.3, ETSI Centre for Testing & Interoperability provides a number of resources around standards for expressing test specifications including Test Purposes, Test Descriptions and Test Cases [8]. A number of languages dedicated to the specifications of these documents exist and will help greatly for approaching the test case formalization activity.

3. **Alignment with TMV WG**: 5G-SOLUTIONS is part of the TMV WG: a working group dedicated to the activities and approaches adopted around Test, Measurement and KPIs Validation across projects. As one of its several goals, it acts as a platform where its members can participate in the elaboration of a common test approach and definition of the experimentation methodology. Although the T1.4 methodology is still a proof of concept at the time this deliverable is written, it is inspired in many ways by the work being done within the group and it aims to build on its common approach taken while ensuring the 5G-SOLUTIONS specific needs are met.

5.5 Feedback Loop

This section outlines the importance of getting feedback from the other WPs and T1.5 including the trials by providing an opportunity for partners to give possible solutions, processes and tools for an efficient feedback loop which will guarantee the compliance with the set of objectives for both tasks and beyond. This area will be further developed in the second phase of the project.

1. **Next 5G-SOLUTIONS WP1 task:**

T1.4 is closely related to T1.5 namely Methodology for the technological and business validation of 5G E2E connectivity and associated management within and across verticals which the partner TNOR is responsible for and also a collaborator on this deliverable. Both WIT and TNOR have been working together, having frequent meetings and acting as peer reviewers for providing a complete solution to the methodologies to employ and this will continue throughout the project life time towards a unified framework for the three methodologies.

2. **Next 5G-SOLUTIONS WPs**:

A Perspective from the partner App-Art: The 5G-SOLUTIONS project will be split into 3 phases. After each phase, tests will run to ensure correct and expected functionality is in place. The phased approach will also be used to incorporate more features as the project progresses. Such features are expected to be delivered in one of the next phases. Reaching phase three, the platform will have incorporated the expected functionality as it has been initially designed and progressed during the three phases. It is therefore important to ensure feedback reaches the correct recipients and that we can keep track of the flow until the feedback / issue is somehow resolved. A first step here is to create a mailing list where all partners involved in the feedback loop will be included. Thus, there will be one single point of communication for feedback regarding the platform. Users sending their feedback through this channel will be encouraged to sign up in Redmine (see below) for further feedback. The basic point of feedback however will be the use of Redmine, an issue tracking tool that will ensure proper issue / feature tracking. Redmine is a free, open-source tool which is easy to use that will encourage users to use it.

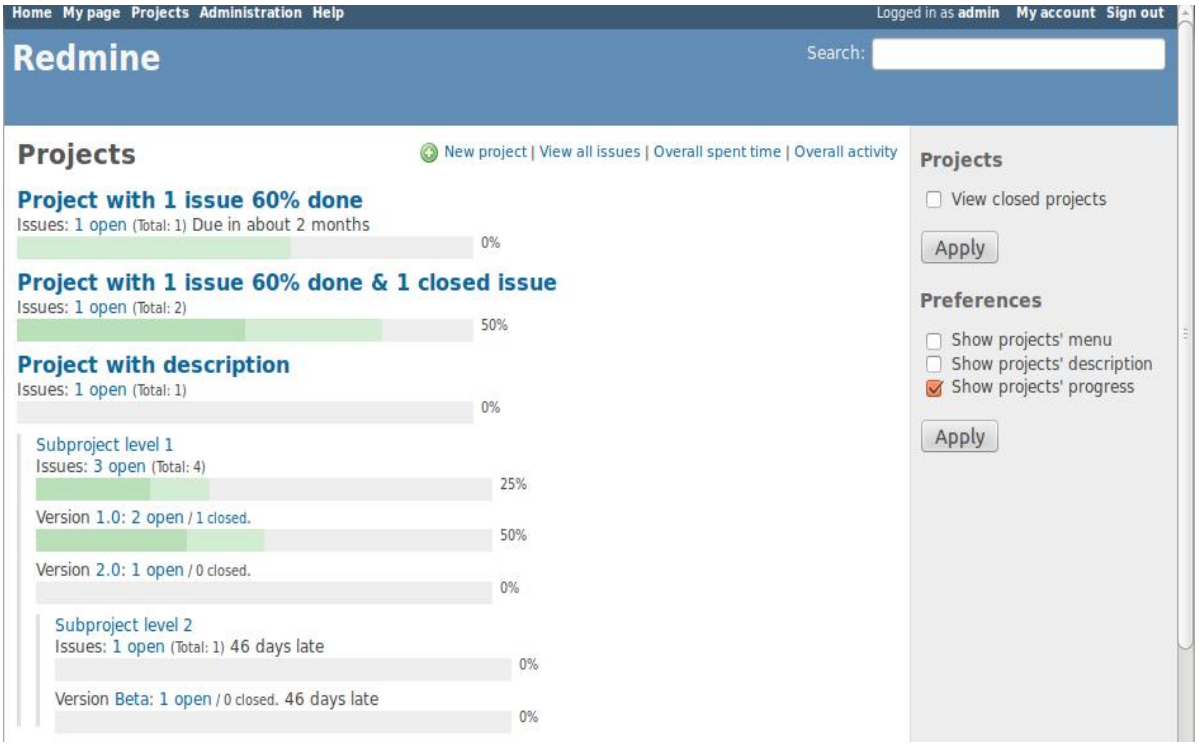

Figure 19: Redmine project management

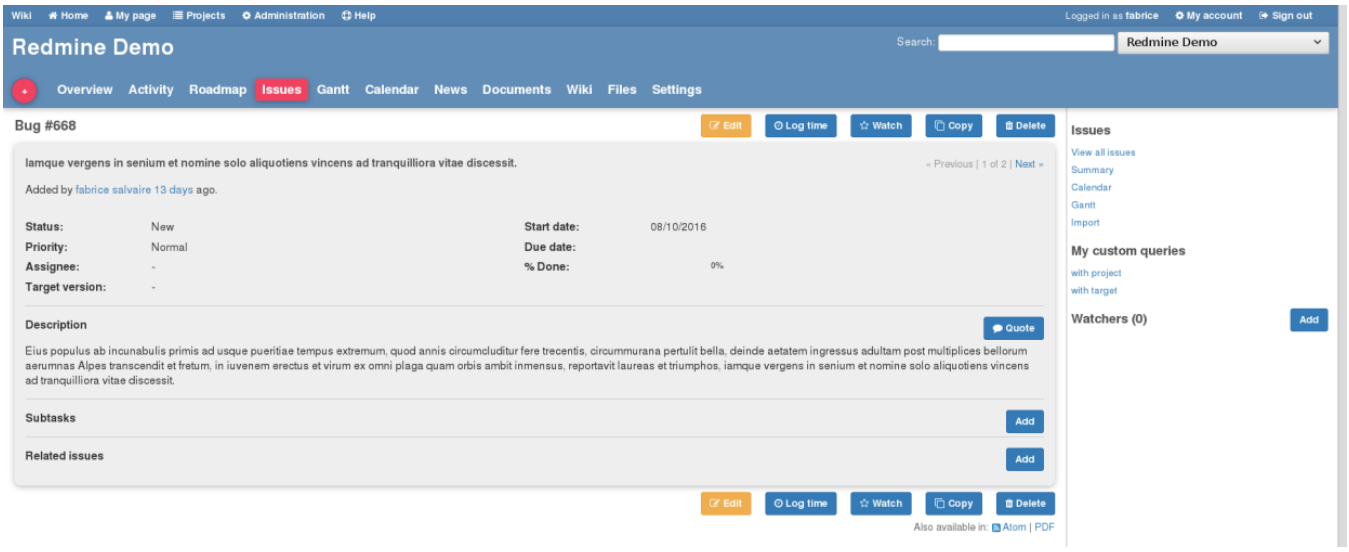

Figure 20: Redmine issue management

Though open source, Redmine offers a number of features that will be utilized within the scope of 5G-SOLUTIONS. Some indicative features are:

- **Role-based access control:** each user is assigned a role which has specific access rights as setup by the system administrator.

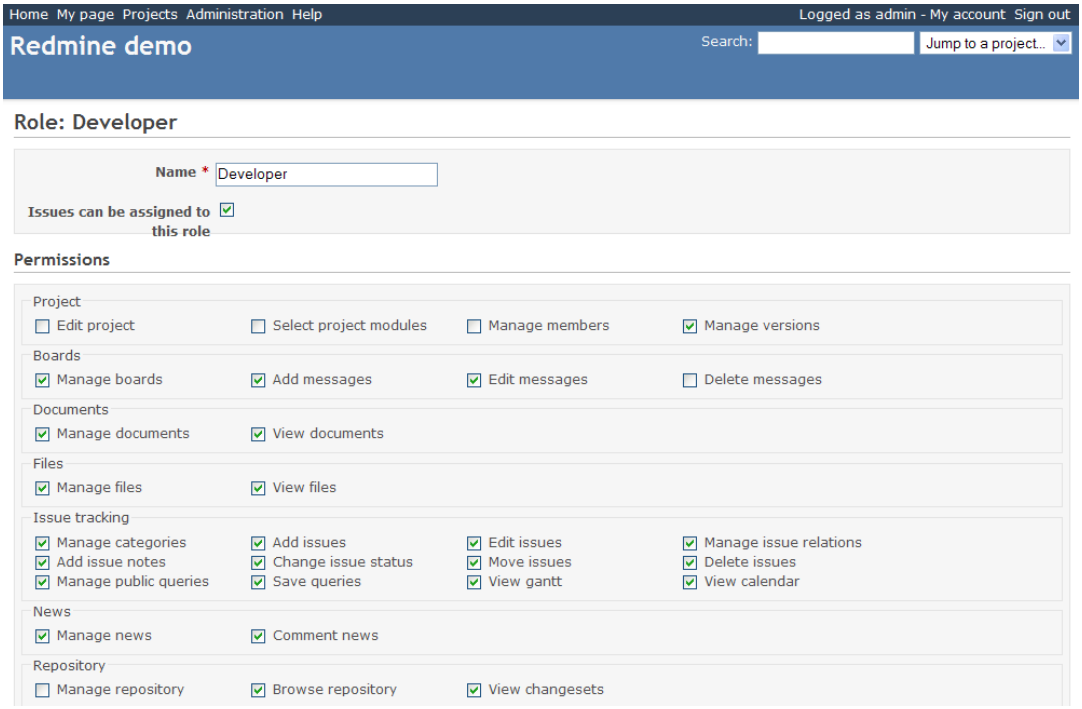

Figure 21: Role rights management

- **Gantt chart and calendar view:** the Gantt chart displays issues that have both start and due date set or are part of a version with a date assigned. Another option for viewing issues is via a calendar view which provides an overview of the issue of the current project in a monthly view.

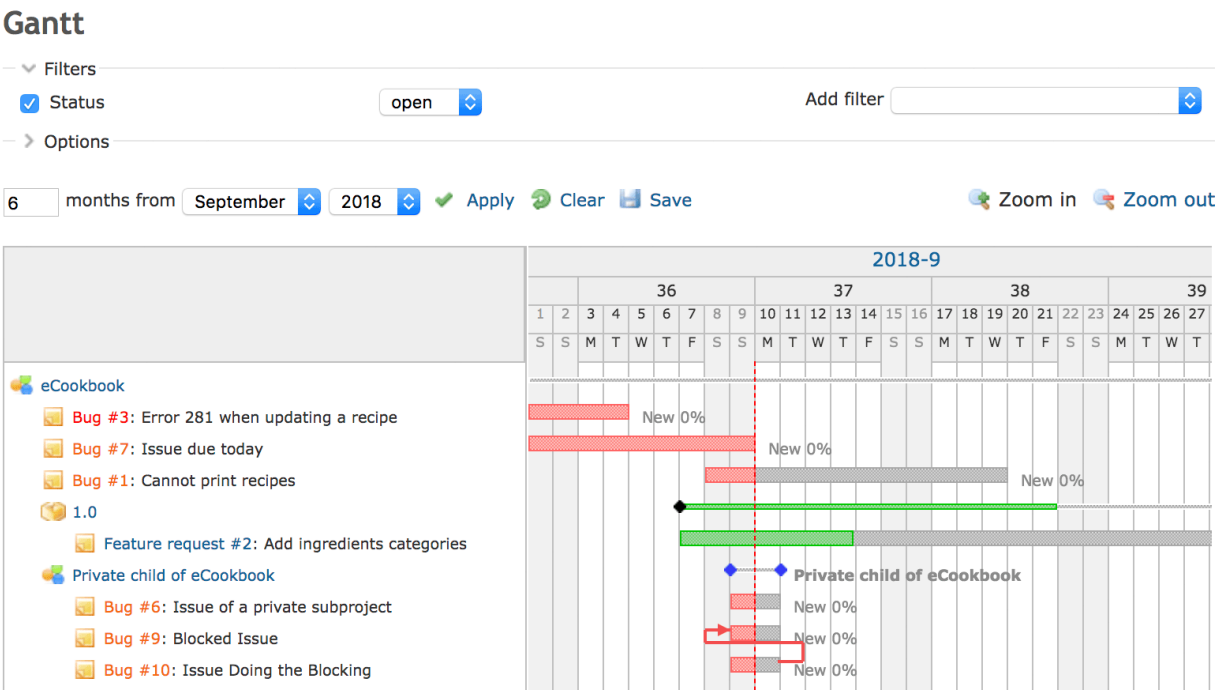

Figure 22: Gantt chart

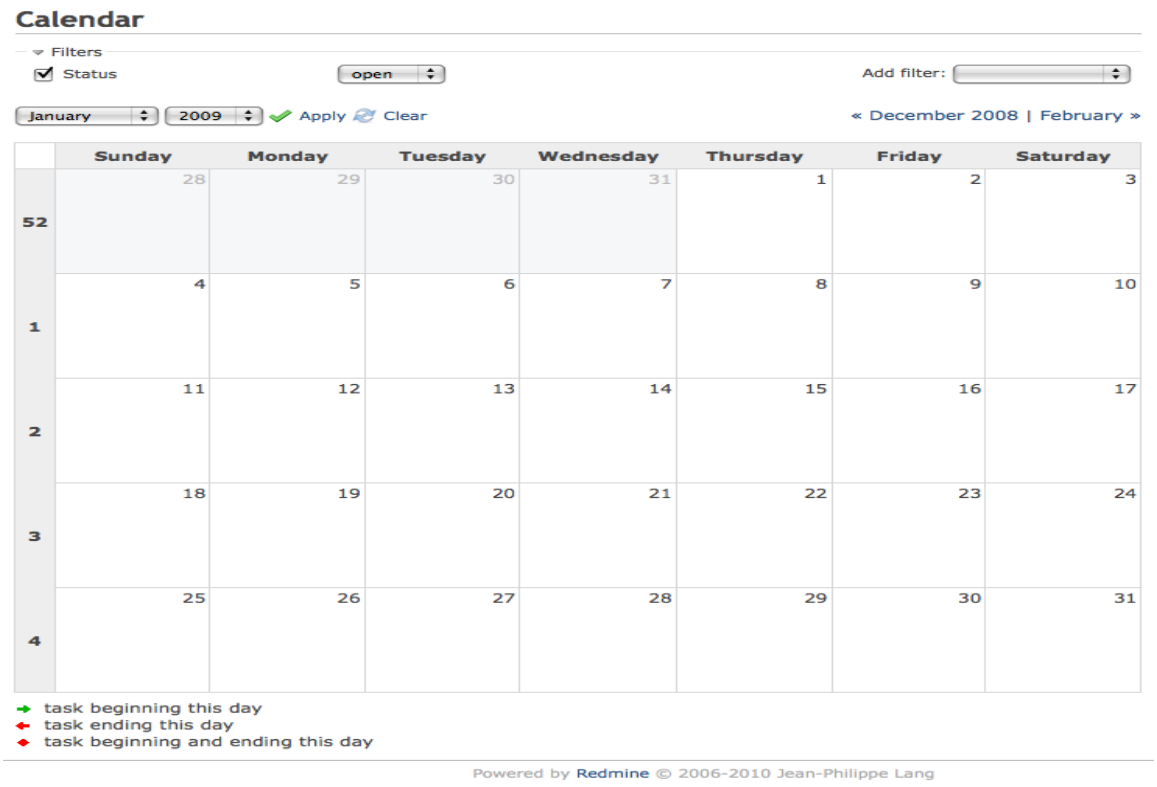

Figure 23: Calendar view

- **File management:** the user can upload files of any kind. This will be useful if the user would like to add a screenshot in the reported issue / feature.

Figure 24: File management

- **Email notifications:** users can choose to be notified of various updates of a tracked issue such as when an issue is added, when it is updated, when there is a comment added etc.

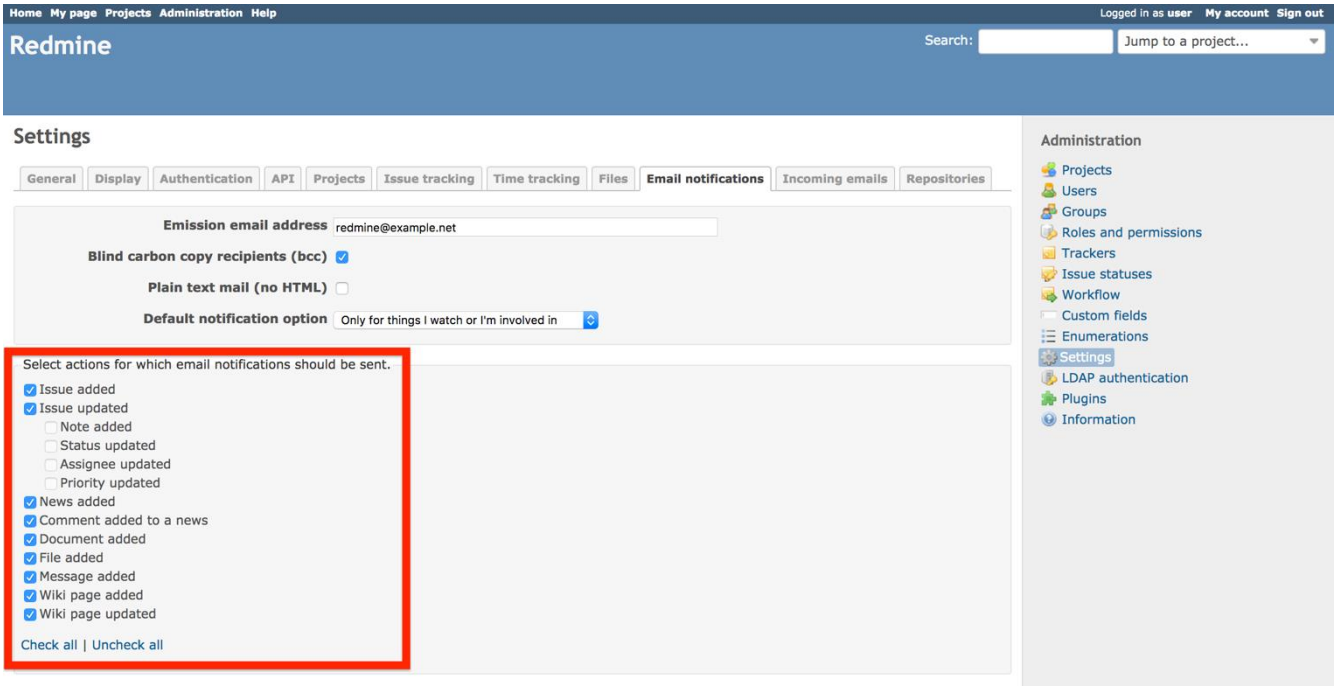

Figure 25: Email notifications

A Perspective from the partner IRIS (Feedback from the verticals): The different phases in which each UC execution is divided are aimed to demonstrate that the underlying ICT-17 facilities are able to cope with the requirements and KPIs set for each LL. Each phase will produce an incremental result (respect to the previous phase). The ICT-17 facilities will see the incremental result as a service, and it will use such a result to leverage the specific 5G capabilities to meet the vertical's requirements. In each phase, the UC performance requirements will be generated feeding the ICT-17 facility with this information in a continuous loop. The ICT-17 facility manager will evaluate the performance identifying areas of improvement to enable a further evaluation of the impact on the UC performance at application level.

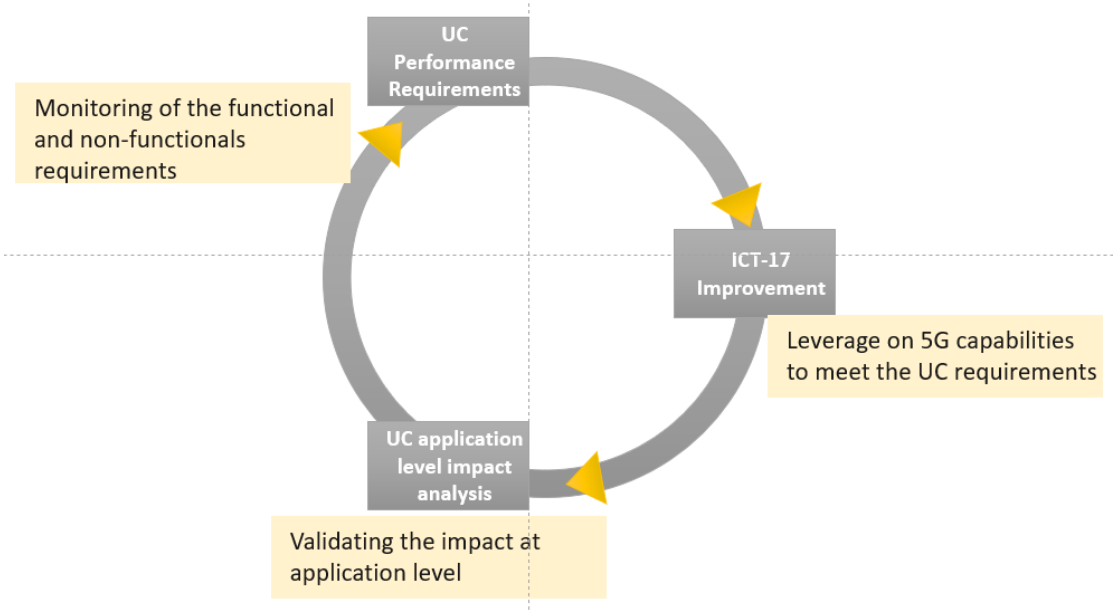

Figure 26: Continuous feedback loop

During each of the phases the LL execution will be monitored under several aspects: functional requirements from the UC will be the first aspect to be analysed, but also non-functional capabilities of each UC will be considered. The impact that the infrastructure improvement will have on the application level will be measured, allowing a continuous refinement.

5.6 Methodology for Testing Process, Concepts and Reporting

This section describes an overview over the testing process proposed as part of the methodology for the definition of the test reports and associated artefacts as well as the methodology for the technical validation. The process flow (***Errore. L'origine riferimento non è stata trovata.***) focuses on the continuity of the test activities, starting from the tasks T1.4, T1.5 and goes beyond the work carried out in WP1, to show how it relates and integrates to the 5G-SOLUTIONS Living Labs – Integrated deployment and evaluation approach [1]. Moreover, the section introduces the key concepts supported and the formats, naming conventions and templates used throughout the Section 5 to gather, analyse the required information in order to define in details the test reports for supporting a successful field trial execution and evaluation in each Living Lab. It also explored in detail core modules such as the testing regime including the concept of testing framework along with the test procedures for the technological validation.

5.6.1 Terminology

This section presents all the terminologies before the test process is introduced. It concentrates on giving a basic definition of the important terms used throughout Section 5 around three key entities: the test basis (the requirements), the test object (or the system under test) and the test case (a broad term to describe the set of test artefacts). Starting with the test basis, the following terms are defined (for more details on the test basis, D1.1A is the primary source):

- **Use Case**: a refined, unique set of requirements with their detailed description, their target KPI and SLA values, requirement analysis and testbed mapping.
- **Service Class**: refers to the ITU-T- service Classes: eMBB, mMTC, URLLC [7] (further work is needed in order to qualify the term for different purposes for instance slice service class or traffic service class).
- **KPI**: refers to the target technology and business key performance indicators associated with a use case.
- **Requirement**: a broad term to denote a piece of requirements as outlined in D1.1A for a particular use case.
- **Scenario (use-case scenario):** for each use case a number of scenarios might need to be validated which could be defined, identified by their respective critical/crucial tasks along with the different actors and their interactions with different systems or applications, including any additional information and will be referred here by a scenario identifier.

As for the test object, the followings are used and required to be defined:

- **SUT (incl. AUT, FUT, EUT, NUT)**: the system under test term might be used as a broad term for the piece of software, hardware or/and network that is being tested, it can also be referred as the test object.
- **Test System**: refers to existing, new test frameworks where the test cases might be stored, compiled, executed from.
- **Test Tool:** equipment (hardware, software or virtualized) used to measure the performance of SUT.
- **Reference Equipment:** a broad term referring to a software, hardware used as part of the test object.
- **Testbed:** refers to the entire platform for conducting the validation of an experiment including the existing 5G-EVE, 5G-VINNI ICT-17 facilities.

- **Test Point:** is identified by its location on the end to end test platform where measurements are collected, the definition of the KPIs will drive its definition. A set of test points will be defined per experiment where their locations could be either the user equipment, or somewhere on the network or on the application server for example.

And finally, the terms around the actual test process, activities and artefacts which are developed in detail further in this document:

- **Test Process**: refers to all the phases and relevant activities identified to produce the desired outcome for this deliverable.
- **Test Analysis and Design:** a phase where the requirements are analyzed and mapped to a set of test cases.
- **Test Specification:** a phase where a set of templates is proposed to translate the use case-scenarios into an executable format: the test case specification.
- **Test Objective:** high level objective of the use-case scenario, additional objective might be identified and mapped to specific test cases.
- **Scenario (network scenario):** refers to a specific network configuration/slice, a test case might be executed under a number of network scenarios, supporting the concept introduced in the white paper on "Validating 5G Technology Performance" [3].
- **Test Case:** an entity that combines information regarding the test objectives, the use-case scenario and network scenarios to be executed, supporting the concept introduced in the white paper on "Validating 5G Technology Performance" [3].
- **Experiment:** combines all information from one or more test cases and their associated network scenarios into one entity.
- **Test Report:** it refers primarily to the set of test cases executed in each Living Lab but a number of reports with different formats will be proposed to provide a very detailed insight into the experiments.

5.6.2 Key Concepts

Although the concepts below are based on an early investigation and a test analysis of the information available at this first period of the project, it is envisaged that they will evolve over time as more details will be gathered mainly to ensure a solid alignment with the work carried from other projects and consolidated through the TMV WG but more importantly to address, prioritise and translate the specificities of 5G-SOLUTIONS into a unified and homogenised solution primarily for the test reports but beyond: ultimately leading towards providing better results for the project.

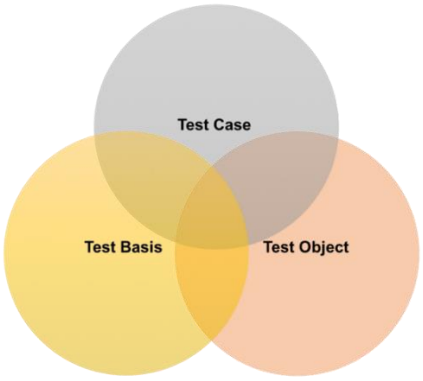

Figure 27: Venn Diagram

Deriving successfully and specifying unambiguously a set of test cases, require a clear understanding of the different entities involved and their relations with each other coming from the test basis (the requirements), the test objects (system, equipment, network under test) and the test cases (to use a broad term).

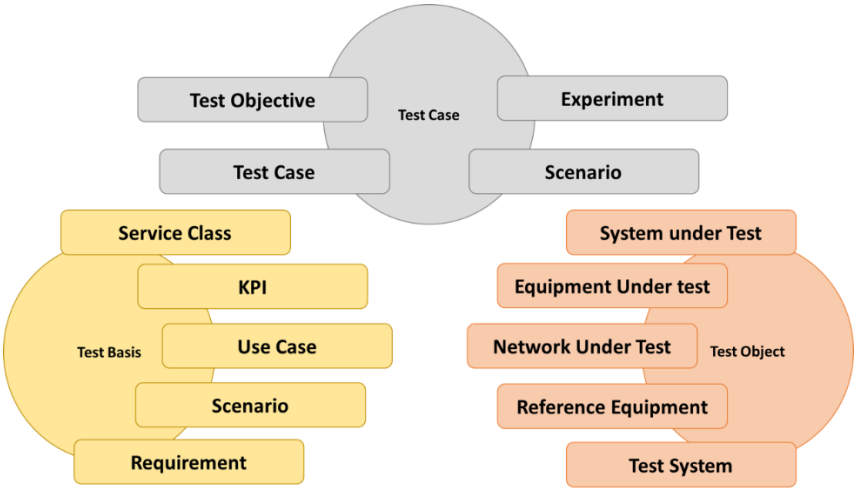

Figure 28: Entities

Figure 27: Venn Diagram and Figure 28: Entities, provide a list of the different entities to be involved in the development of the test specifications. The scope of this section is not concerned with defining the test basis or the test object entities which are covered and worked on as part of the other work packages/tasks but there are used as the source and target where the test entities are derived from or related to. Therefore, a test-oriented view of those entities is taken, centred around their relationship with the test entities. As for the latter, the foundation for their identification and definition are taken from the 5G white paper on "Validating 5G Technology Performance" [3] as a proposal to work towards a pre-standardized set of tests.

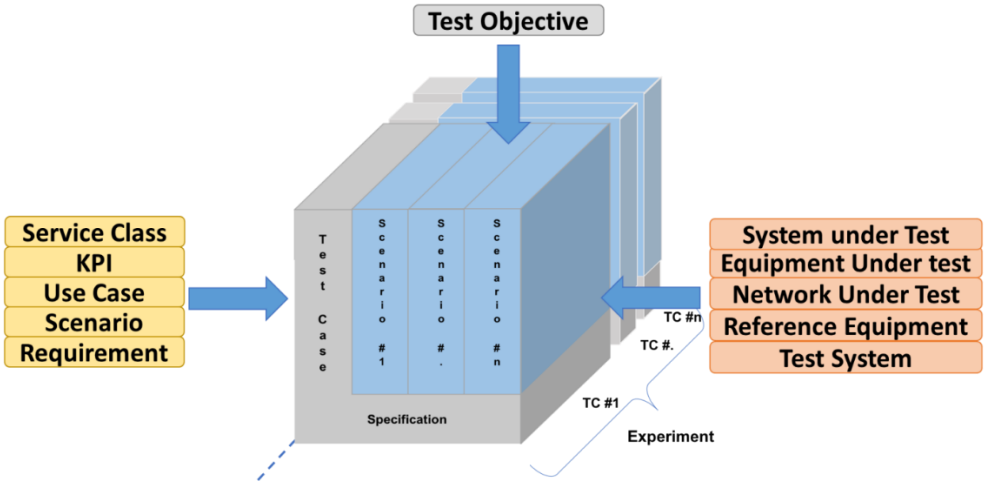

Figure 29: An Experiment Representation

Figure 29: An Experiment Representation above provides a proposed visual representation of the relationship between a test case, a network scenario and an experiment. At the core, we have the concept of an experiment which is a combination of test cases executed under certain network and load conditions: more precisely a set of network configurations or/and slices with some parameter values described as network scenarios.

Prior to fully specifying a test case, there are a number of intermediate steps that are executed iteratively throughout the test execution cycles to ensure the right coverage and traceability all the way back to the initial requirement hence prioritising a feedback look process for continuous results re-assessment and improvement.

First existing and additional test objectives are mapped to a use case-scenario, then a matrix (see Section 5.6.5) is used to decide on the number of test cases required to validate the test objectives and a number of KPIs. A set of network scenarios are also identified and applied to specific test cases which in final give the set of experiments to be executed.

Finally, all the details are worked on and combined using the test case specification template (see Section 5.6.5). The different format designs and specifications required are described in detail in the next section, but the figure above (Figure 29: An Experiment Representation) shows clearly how the different references to the use case (service class, KPI, use case-scenario) and to the system under test can be mapped to an experiment.

5.6.3 Overall Testing and Validation Process Life-Cycle

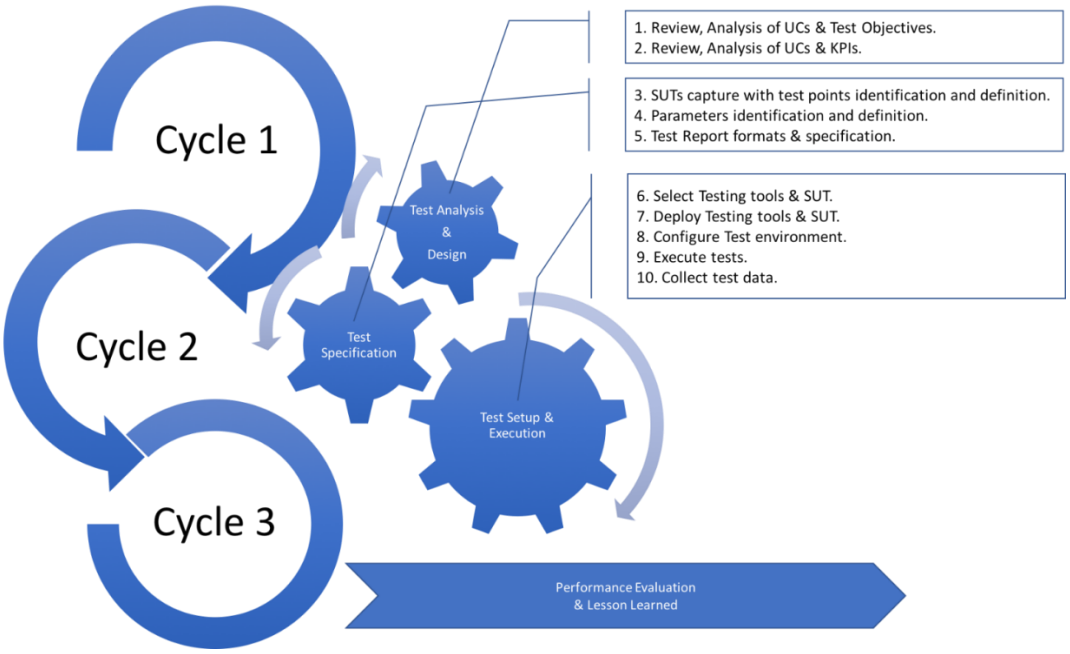

Figure 30: Overall Testing and Validation Process

For the first version(interim) of this deliverable, four key phases have been identified and described below for a successful outcome. Upon an initial extraction of the use case-scenarios, these phases and their relevant activities will be conducted for each of the three project level cycles namely the trials execution. The aim is to continuously provide a way to analyse, review, assess the experiments conducted while capturing them into a formal specification:

a. **Test Analysis and Design phase**: with its two distinct activities, it concentrates on extracting the relevant test objectives, mapped KPIs from which the test cases can be derived, and also conducting a requirement traceability and a testability assessment.

   1.Review and Analysis of UCs and Test Objectives: aim is to analyze and extract a set of test objectives for each use case-scenario, while conducting a summarization and mapping exercise for traceability and testability.

2.Review and Analysis of UCs and KPIs: main goal here is to map out the test objectives to a number of KPIs for each use case-scenario and deciding on the number of test cases for coverage while also conducting a summarization and mapping exercise for traceability and testability.

b. **Test Specification phase**: it aims to translate the use case-scenarios into an executable specification format: the test case specifications, and collect all the necessary parameters, collection points details (variables and their values). In the further work, attention will be put at what can be specified at the project wide level vs. what is specified at the level of the specific use case. For the latter, it will be clarified what must and should be analyzed, designed and specified per use case (testing and validation methodology) prior to entering the specific activities of the use case analysis as of the living lab activities. That is, this will help to draw the line between the tasks 1.4, 1.5 and the LL WPs.

3.SUTs capture with test points identification and definition: this task identifies and tentatively maps the required metrics collection points onto its E2E system under tests and define the parameters associated.
4.Parameters identification and definition: many variables and their exact values need to be identified, defined across all UCs, this task focuses on gathering, extracting the different network configurations, application setups, equipment calibration variables and so on.
5.Test report format and specification: the last activity but also the most important one since it is the main goal of this part of the deliverable, the aim really is to put all the information gathered from the previous activities into a concrete set of test cases using a unified test report format applicable to all the UCs for each LL.

c. **Test Setup & Execution**: The test setup and execution will be performed according to the guidelines provided by the test regime as defined and elaborated below in Section 5.7 . The following process steps has been identified and briefly defined.

6. Select testing tools and SUT based on the test case: The selection of the SUT will follow from the test specification process and the selection of testing tools will be guided by the test regime as defined below.
7. Deploy testing tools and SUT: The deployment of the testing tools and the SUT will be guided by the test regime. The deployment guidelines will be further elaborated in later versions of the test regime.
8. Configure the test environment based on the test case and type: The configuration of the test environment will be guided by the test regime definitions. These guidelines will be further elaborated in later versions of the test regime.
9. Execute the tests: The execution of the tests according to the test scenarios and test specifications will be guided by the test regime definitions. These guidelines will be further elaborated in later versions of the test regime.
10. Collect test data: The collection of the test data will be guided by the test regime definitions. These guidelines will be further elaborated in later versions of the test regime.

d. **Performance Evaluation and Lesson Learned**: The performance evaluation will be based on analysis of the test data and will include performance evaluation and validation according to the KPIs set for the test scenarios. The overall and summarized technological validation of the use case will be conducted by analyzing the corresponding set of test scenarios' performance evaluation and results. Accordingly, the lessons learned will be documented along with the summarized test and validation results and provided as feedback to the next use case testing and validation cycle as well as to the business analysis and validation process. This stage and the more detailed process steps will be detailed in the next versions of this document (internal and final).

5.6.4 Technology Readiness Levels and Templates

In order to be aligned with the different targeted TRLs over the course of the 5G-SOLUTIONS project, different sets of templates are proposed to carry out the work for T1.4 and in accordance with the objectives set out for the methodologies and systems to conduct testing. The aim is to ensure the correct level of details is requested and provided at the right time or phase. For instance, some of the parameters related to the use case-scenarios might be unknown therefore not captured during the first period of the project or even at the start of the first trial cycle, this is the reason why the first set of templates (TRL3 templates) includes a set of questionnaires (Table 16: UC-Scenario Description Template) to enable this type of information gathering: a sort of compromise between looking towards testing while acknowledging the need for further developing and capturing the low level requirements.

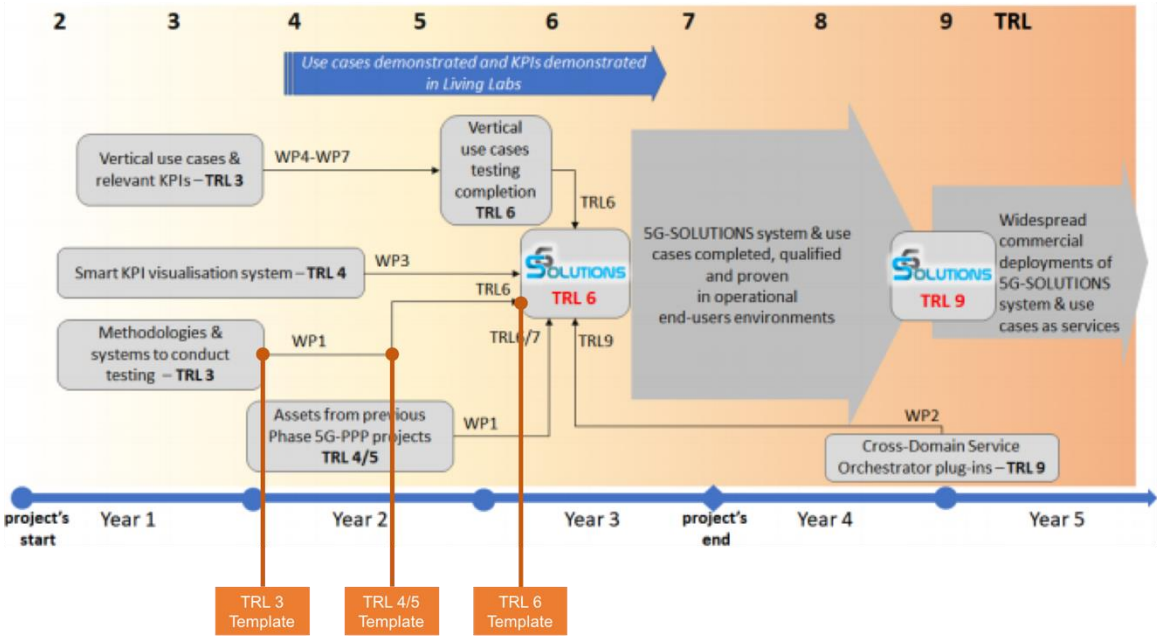

Figure 31: TRL Templates

Each template is presented in the next section with the first set being at a TRL 3 focusing on gathering the relevant information through a proposed set of questionnaires as mentioned below, while setting out the test coverage level and the use case-scenario traceability matrix.

As the project progresses, T1.4 moves towards TRL 4&5: a semi-modularized test specification by listing, defining the required parameters for the SUTs, the network scenarios, and test points as part of the test cases. Finally, TRL 6 level templates will enable working towards the final report for D1.4B. At this stage, the test specification will be fully modularized: making used of additional templates, tables and a set of naming conventions in order to provide great insights and results. It is envisaged that the final format will be similar to ETSI Test Reports and Specifications [8] supporting the goals around pre- and standardization activities within 5G-SOLUTIONS.

It is important to note that this methodology wants to be pragmatic about the different methods it proposes, therefore it is not dictating how those templates should be and rather encourage feedback from the users involved.

5.6.5 Format, Naming Convention and Templates

A number of documents, projects have been reviewed in order to define the proposed formats, templates in this section (See Section 5.3). These templates are the results of combining the findings from those documents but also using a number of existing standards as well [8]. It is envisaged that the proposed templates will be continuously reviewed and improved through different versions as the task T1.4 progresses towards the final report (D1.4B).

As presented in the previous section (5.6.4), the templates are organized, labeled based on their associated TRL (3, 4/5 and 6), and will be stored at an LL level to facilitate the gathering of content and allowing improvements to be made through version control. All the tables below are presented in the order of their TR levels to illustrate a proposed evolution over time: supporting and covering the different activities within the project timeline in the elaboration of the test reports.

The identifiers are created as per the following convention:

TO ID = TO_<SC ID>_<NN>
TC ID = TC_<SC ID>_<NN>
TP ID = TP_<UC ID>_<NN>

Where *<SC ID>* is the use case-scenario id, and <NN> corresponds to a sequential number starting from 1.

a. **UC-Scenario Description:** Prior to the design of the test cases for an experiment, it requires the definition and extraction of the different scenarios with their associated information for a particular use case. The template below uses a questionnaire customized into a UML UC-scenario like table structure to ease the information gathering process. The latter has only started at the time this deliverable was written and will contribute to the next stage of T1.4 but Section 5.9 already presents the basics of information collected as initial inputs from some of the LL participants to start the thought process early.

Table 16: UC-Scenario Description Template

<table>
<tr><td colspan="2">UC ID: Title</td></tr>
<tr><td>UC Owner:</td><td></td></tr>
<tr><td colspan="2">UC Scenarios Description</td></tr>
<tr><td colspan="2">UC Scenario List:
A UC might need more than one scenario in order to be validated. A scenario is more detailed and explicit in terms of tasks to be performed between actors and systems with focus on end-to-end flow along with relevant sequence of actions. UC scenario examples: UC 4.1_1: Network-assisted multi-CDN selection and caching, UC4.1_2: Dynamic Network caching deployment</td></tr>
<tr><td colspan="2"><Summary and list>

<table><tr><td><SCID_1>:</td><td><Scenario Name></td></tr><tr><td><SCID_2>:</td><td><Scenario Name></td></tr></table></td></tr>
<tr><td colspan="2">UC Scenario ID: Name <repeat for each scenario>
UC scenario examples: UC 4.1_1: Network-assisted multi-CDN selection and caching, UC4.1_2: Dynamic Network caching deployment</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Brief description of the UC Scenario:
Textual description, overall summary of the scenario</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Test Objective(s):
Already listed at a UC level in the proposal and in D1.1A but not all the objectives might apply to a particular scenario and by filling out the information required in this template, it might help to identify new ones.

Test Objective ID:	*<TO_SCID_1>*
Test Objective:	

Test Objective ID:	*<TO_SCID_2>*
Test Objective:	

Target KPIs & Measurements:
Some are listed at a UC level in the proposal and in D1.1A but not all of them might apply to a particular scenario and by filling out the information required in this template, it might help to identify new ones.

Primary KPI:	
Measurements:	

Secondary KPI:	
Measurements:	

Critical/crucial tasks to be performed by the different actors (primary, others) as part of the UC Scenario:
Textual name of an interaction/action performed by an actor.

***Primary** User/Actor*	
Tasks	

***Primary** User/Actor*	
Tasks	

***Other** User/Actor*	
Tasks	

Pre-Conditions:
Describe conditions that must be true when the UC scenario starts, e.g. System(s) state, setup, or some pre-steps to perform by a particular actor before the UC scenario starts.

Flow of work/activities/task related to the UC Scenario:
Describe the UC scenario working process including activities and tasks.

Post-Conditions:
Describe conditions that must be true when the scenario ends, e.g. System(s) state, or some post-steps to perform by a particular actor/stakeholder after the scenario ends.

Software/hardware requirements:
Describe which applications, user terminals/equipment, devices etc.

Additional information:
Any other information deemed useful: e.g. Network Configurations and parameters, network slice characteristics, Network status, traffic type

b. **UC, Test Objectives, KPIs & TCs (TRL3, 4/5, 6):** The templates Table 17: UCs - TOs R&A and Table 18: UCs - TOs R&A – Summary presented below will be used primarily from a reporting point of view. It will support the mapping and traceability exercise starting by summarizing the set of test objectives for each use case-scenario per use case and finally

c.

d. Figure 32: UCs & KPIs - R&A - Summary will enable the mapping, design of a set of the test cases using a matrix based on the KPIs (technological and business where applicable) to be measured.

Table 17: UCs - TOs R&A

UC ID: Title	
SC ID: Title	
TO ID	**Test Objective(s)**
TO_<SC ID>_1	*e.g. To test the stringent requirements for indoor mission–critical process optimisations in a heterogeneous environment.*
TO_<SC ID>_2	
TO_<SC ID>_3	
SC ID: Title	
TO ID	**Test Objective(s)**
TO_<SC ID>_1	*e.g. To test the stringent requirements for indoor mission–critical process optimisations in a heterogeneous environment.*
TO_<SC ID>_2	
TO_<SC ID>_3	

Table 18: UCs - TOs R&A – Summary

UC ID	**SC ID**	**TO ID**	**Test Objective(s)**
UC1.1	*<SC ID>*	*TO_<SCID>_1*	*e.g. To test the stringent requirements for indoor mission–critical process optimisations in a heterogeneous environment.*
		TO_<SCID>_2	
		TO_<SCID>_3	
	<SC ID>	*TO_<SCID>_1*	
	<SC ID>	*TO_<SCID>_1*	
UC1.2	*<SC ID>*	*TO_<SCID>_1*	
		TO_<SCID>_2	
UC1.3			
UC1.4			
UC1.5			

Figure 32: UCs & KPIs - R&A - Summary

		Target KPIs - Primary & Secondary	<TC ID>	<TC ID>	<TC ID>	<TC ID>	<TC ID>	<TC ID>	<TC ID>	<TC ID>	<TC ID>	<TC ID>
		Data Rate (Mbps)	*1st*				*1st*					
		Mobility (km/h)			*1st*				*1st*		*1st*	
		Latency (ms)		*2nd*		*2nd*		*2nd*		*2nd*		*2nd*
		Density (devices/m2)										
		Reliability (%)		*1st*		*1st*		*1st*		*1st*		*1st*
		Positioning Accuracy (m)	*2nd*				*2nd*					
		Coverage (%)	*2nd*				*2nd*					
		Autonomy (days)										
		QoE(MOS)	*2nd*	*2nd*	*2nd*	*2nd*	*2nd*	*2nd*	*2nd*	*2nd*	*2nd*	*2nd*
SC ID	**TO ID**	**Test Objective(s)**										
<SC ID>	*TO_<SCID>_1*	*e.g. To test the stringent requirements for indoormission–critical process optimisations in a heterogeneous environment.*	*x*								*x*	
	TO_<SCID>_2	*e.g. To test the stringent requirements for indoormission–critical process optimisations in a heterogeneous environment.*	*x*		*x*							
	TO_<SCID>_3	*e.g. To test the stringent requirements for indoormission–critical process optimisations in a heterogeneous environment.*		*x*								
<SC ID>	*TO_<SCID>_1*	*e.g. To test the stringent requirements for indoormission–critical process optimisations in a heterogeneous environment.*			*x*					*x*		
<SC ID>	*TO_<SCID>_1*	*e.g. To test the stringent requirements for indoormission–critical process optimisations in a heterogeneous environment.*				*x*						

The KPIs (primary and secondary) and the set of objectives will drive the test cases design, allowing a UC owner to have full visibility and control over how the experiments are organized. As part of the process, the network scenarios are also mapped (see the next templates).

The following Sections c), and d) templates present the progression expected in terms of test case specification formats for conducting and reporting on the trial executions, moving from a non-modularised to a semi- modularised (more parameter driven) document.

e. Test Case Specification (TRL 3)

Table 19: Test Case Specification (TRL 3)

UC ID: Title	
SC ID: Title	
TC:	*TC Identifier e.g. TC_<SC ID>_01*
Test Objectives:	*e.g. TO_<SC ID>_1: To test the stringent requirements for indoor mission–critical process optimisations in a heterogeneous environment.*
Applicability:	*i.e. A list of features and capabilities which are required by the system in order to guarantee the feasibility of the test. Or APP01/ APP01*
Network Scenarios:	*e.g. Network Configurations, slices characteristics*
Target KPI & Measurements:	*Primary, Secondary KPI, to be measured, e.g.: Data Rate,* *to be measured (useful to interpret the values of the target KPI and their relation): e.g.: Latency, QoE,* *Information about Measurement Methods & Points: e.g.: Average amount of bytes/seconds transmitted in the downlink in the 5 iterations received at the UE.* *Min, Max, Acceptable Values: e.g. as a basis should match what's in the Proposal: i.e. >100(Mbps), Raw results, counters, KPIs*
Pre-Conditions:	*e.g.: Initial State of SUT, any equipment configuration, traffic description*
Test Case Sequence:	*1. e.g. Start UE trace.* *2. …* *3. …* *4. e.g. Stop UE trace.* *5. …*
Overall Verdict:	*i.e.: QoE, Overall results and any comments*

f. Test Case Specification (TRL 4/5)

Table 20: Test Case Specification (TRL 4/5)

UC ID: Title		
SC ID: Title		
TC:	*TC Identifier e.g. TC_<SC ID>_01*	
Test Objectives:	*e.g. TO_<SC ID>_1: To test the stringent requirements for indoor mission–critical process optimisations in a heterogeneous environment.*	
Applicability:	*i.e. A list of features and capabilities which are required by the system in order to guarantee the feasibility of the test.*	
Network Scenarios:	**Network Parameters:**	**Network Values**

Target KPI & Measurements:	**KPIs:**	**Measurements & Test Points:**	**Expected Values:**
Pre-Conditions (e.g.: Initial State of SUT, any equipment configuration, traffic description):	**Parameters:**	**Values:**	
Test Case Sequence:	***Step Description***		***Result***
	1. e.g. Start UE trace.		
	….		
	….		
	4. e.g. Stop UE trace.		
	….		
Overall Verdict:	*i.e.: QoE, Overall results and any comments*		

Finally, the set of TRL6 Templates are presented: a fully modularized format which will be achieved when the project trial executions have matured enough, ranging from the SUT descriptions to the detailed parameter definitions including what constitute a network scenario and mapped to it use case-scenario.

g. Parameters Definition (TRL 6)

Table 21: SUT State Description

ID	UC<SC ID>	Application State and Conditions
<SUT_STARTED>	*e.g. All*	• *The AUT is installed on the Host Device.* • *The Host Device is configured as specified in….*

Table 22: SUT Flow Description

ID	UC<SC ID>	Application User Flow
<SUT_AUF_01>	*e.g. All*	*e.g. Login* *1. Perform login step and wait for 5 seconds.*
<SUT_AUF_02>		
<SUT_AUF_01>		
<SUT_AUF_02>		
<SUT_AUF_01>		

Table 23: SUT Parameters - I&D

UC ID: Title			
PA ID	**Parameter Name**	**Parameter Definition**	**Parameter Description (Values)**

PA1	*e.g. Power control*	*e.g. This parameter allows to configure the power level used by the UE*	*130 dBm to – 131.21 dBm1 / 180kHz*
PA2	*e.g. Downlink/Uplink Bandwidth*	*e.g. These parameters fix the capacity of the system both in downlink and uplink.*	*Downlink/Uplink Bandwidth 10 MHz*
PA3	*Parameter Name*	*Parameter Definition*	*Parameter Value*
PA4	*Parameter Name*	*Parameter Definition*	*Parameter Value*
PA5	*Parameter Name*	*Parameter Definition*	*Parameter Value*

Table 24: Network Parameters - I&D

UC ID: Title			
NPA ID	**Network Parameter Name**	**Network Parameter Definition**	**Network Parameter Description (Values)**
NPA1	*e.g. Carrier Frequency*	*Network Parameter Definition*	*Network Parameter Value*
NPA2	*e.g. Aggregated system bandwidth*	*Network Parameter Definition*	*Network Parameter Value*
NPA3	*Network Parameter Name*	*Network Parameter Definition*	*Network Parameter Value*
NPA4	*Network Parameter Name*	*Network Parameter Definition*	*Network Parameter Value*
NPA5	*Network Parameter Name*	*Network Parameter Definition*	*Network Parameter Value*

Table 25: TPs Parameters – I&D

UC ID: Title		
TP ID	**Test Point Description**	**Additional Information**
TP1	*e.g. UE transmitting IP packets to the N6 interface.*	
TP2	*Test Point Brief Description*	
TP3	*Test Point Brief Description*	
TP4	*Test Point Brief Description*	
TP5	*Test Point Brief Description*	

Table 26: UCs & Network Scenarios Matrix

Network Scenarios Coverage:	**UC_<SC ID>**	**UC_<SC ID>**	**UC_<SC ID>**	**UC_<SC ID>**
NSC_01: Title	*Y*			
NSC_02: Title		*Y*	*Y*	*Y*
NSC_03: Title		*Y*	*Y*	*Y*
NSC_04: Title			*Y*	*Y*
NSC_01: Title	*Y*			
NSC_02: Title		*Y*	*Y*	*Y*
NSC_03: Title	*Y*	*Y*	*Y*	
NSC_04: Title			*Y*	*Y*

h. **Test Case Specification (TRL 6):** Combined with the other TRL6 Templates above, the proposed Table 27: Test Case Specification (TRL 6) will be used in the final reports in the final deliverable. It is envisaged that it will be continuously reviewed and improved as we progress throughout the project.

Table 27: Test Case Specification (TRL 6)

UC ID: Title			
SC ID: Title			
TC:	*TC Identifier e.g. TC_<SC ID>_01*		
Test Purpose:	*e.g. To measure the End to End performance of UE IP packets transmitted from UE to the N6 interface in the eMBB slice of the 5G network.*		
Test Objectives:	*e.g. TO_<SC ID>_1: To test the stringent requirements for indoor mission–critical process optimisations in a heterogeneous environment.*		
Applicability:	*i.e. A list of features and capabilities which are required by the system in order to guarantee the feasibility of the test. Or APP01/ APP01*		
Network Scenarios:	*Scenario identifiers e.g. NSC_01/NSC_02/NSC_03*		
Target KPI:	*Primary KPI to be measured, e.g.: eMBB.1*		
Secondary KPI(s):	*to be measured (useful to interpret the values of the target KPI and their relation): e.g.: Latency, BR1*		
Measurements:	*Information about Measurement Methods & Points: e.g.: Average amount of bytes/seconds transmitted in the downlink in the 5 iterations received at the UE.*		
Expected KPIs Measured:	*Min, Max, Acceptable Values: e.g. as a basis should match what's in the Proposal: i.e. >100(Mbps), Raw results, counters, KPIs*		
Pre-Conditions:	*e.g.: Initial State of SUT, any equipment configuration, traffic description*		
Test Case Sequence:	***Step***	***Description***	***Result***
	1	*e.g. Start UE trace.*	
	2	*….*	
	3	*….*	
	4	*e.g. Stop UE trace.*	
	5	*….*	
Overall Verdict:	*i.e.: QoE, Overall results and any comments*		

5.6.6 Unified Test Reports and Results

Once the test executions start, the test specifications and results will be gathered and documented in the final deliverable D1.4B. Particular attention will be given on how to present the information gathered in a unified, homogenised way so that real insight can be explored across all and between LLs. Different views via the proposed templates will be presented to provide such ways hence the importance for defining the common entities (see 5.6.2) and their relationships to reinforce the main concept adopted namely the experiment but also to focus on the specificities of the 5G-SOLUTIONS goals.

5.7 Testing regime

Following test analysis, design and specification (**Errore. L'origine riferimento non è stata trovata.**) the testing regime specifies how tests are setup and executed to validate the technology KPIs of each use case and draw conclusions on the performance of the tested use cases and the specific use case scenarios. It can be discussed from several perspectives, for example testing framework, test types, and test tools.

5.7.1 Testing framework

The testing framework specifies the test platform and text execution process. The test platform is shown in Figure 33 (based on 5G-VINNI testing architecture – D1.1)[11]. Basic components include:

- Test portal is the interface with customers. It allows 5G-SOLUTION use cases to define, create and execute test cases.
- Test case repo is the storage where test case scripts can be stored and managed. Once the test is designed in the Design phase, the script will be sent to the test case repo for execution.
- Test executor coordinates and performs the test. It pulls the test case script from the test case repo and coordinates all involved test tools to execute the test.
- Test tools image repo: if the test tools are software-based (e.g., virtual probes), their images should be stored in the test tools image repo and used to instantiate the test tools when needed.
- Test tools are the testing and monitoring tools used to probe and stress the 5G network and infrastructure.
- Results repo stores the results generated by the test tools, altogether with other relevant information such as configuration information or network status information. 5G-SOLUTION visualization system will retrieve testing data from the results repo.
- SUT defines the system under test, which could be network elements, the 5G network (E2E) provided by the ICT-17 platform, or the applications that the 5G-SOLUTION use case provide.

The test execution process includes the following steps:

- **Deployment**: set up the test environment, e.g., deploying the SUT, installing the test tools and connecting them to both the SUT and the test controller, activating the end user device (if there is any) and attaching to the associated network. This is the prerequisite to run the test.
- **Configuration**: configure the parameters of the test environment, e.g., network connectivity (e.g., capacity), the traffic type, the measurement metrics or KPIs to be collected,
- **Test activation and data collection** (if the data is streamed in real-time)
- **Test termination and data collection** (if the data is batched and available off-line)

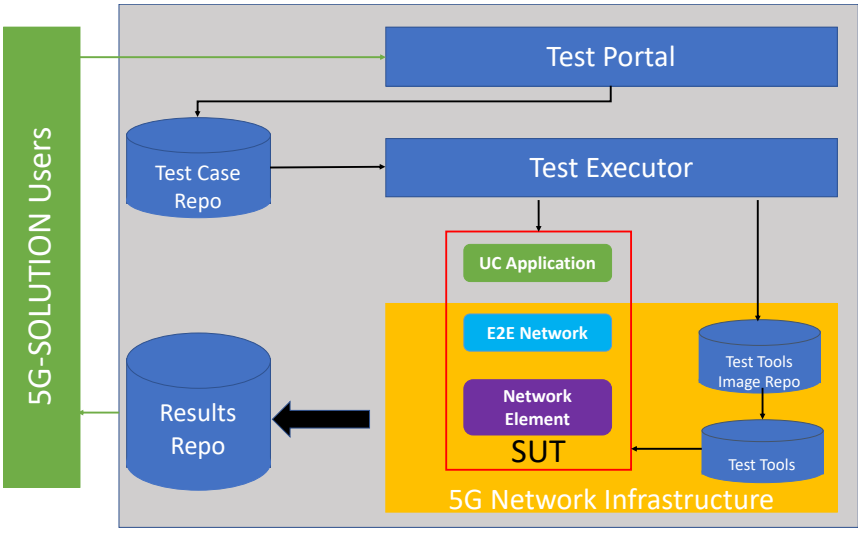

Figure 33: Testing framework

[11] While in this version of D1.4 the reference is here made to 5G-VINNI in the ongoing work the test framework of 5G-EVE is also taken consideration. The outcome of the analysis will be reported in the next version.

The testing framework will be further detailed and extended to be aligned with the ongoing work on the 5G-SOLUTIONS KPI Visualization system. The documentation of the extended framework will be provided in later living document versions (project internal) and in the final version of this deliverable.

5.7.2 Test types and test levels

As this is the first deliverable, the focus is on defining the test cases at an end to end test level and primarily from a performance test type point of view. However, a bottom-up approach is taken to identify new test types and test levels while information is gathered for the test specifications. Therefore, the next deliverable is likely to include reports on test cases conducted at lower test levels but also will include test types other than just performance (see classification below). So far, the test types identified are classified into:

- Acceptance/admission test: verify that the service provisioned to the use case is correctly deployed and activated. A prerequisite for this test is that all components of the provisioned slicing service are correctly on boarded and integrated. All subsequent tests depend on the acceptance test. This test is of particular significance to the Multi-LL when multiple use cases run concurrently in one 5G platform. The first and foremost requirement is that all participating use cases are admitted and their services are activated successfully.
- Performance test: verify the performance of the provisioned service after the service is activated. The performance is measured as KPIs. Depending on the type of SUT, performance test can be further divided into:
    - Network Element performance test: verify the performance of a network element that could be a specific network component or a network domain (such as RAN, Transport network, core network or edge cloud). If a use case has its own VNFs (e.g., application VNFs) or network domain (e.g., 5G NR node) integrated with the 5G network platform (e.g., ICT-17 5G-EVE or 5G-VINNI), then this test is of interest to the use case to improve and/or optimize the performance of the specific VNFs or network domain.
    - E2E Network performance test: verify the performance of the provisioned network slice service. Note that the end point in this E2E test indicates the end of the 5G network. This type of test is supported by the ICT-17 platform (5G-VINNI and 5G-EVE) whereas a series of KPIs (e.g. network QoS) are collected.
    - E2E application performance test: verify the performance of the applications that the use case provides to the end users or end devices. Note that the end point of this E2E test indicates the end user/device and the performance measurement could be application-specific KPIs (refer to D1.1) and even QoE metrics. This type of test will be designed and developed by the use case owner (or LL).

  Note that the higher-level tests (e.g., E2E application performance test) relies on the lower-level tests (e.g., E2E network performance test).

- Scalability test: verify how the provisioned service is scaled under high traffic volume and a large amount of connections.
- Security test: verify the security performance of the E2E applications. For use cases with special security concerns, this test is relevant.

5.7.3 Test tools

Depending on the implementation media, test tools can be divided into physical (hardware-based) and virtual (software-based) test tools. For each test case, the test tools are selected based on the test types. For example, acceptance tests focus on the functionality test and thus require only low-rate traffic that can be achieved by low-cost test tools, e.g., virtual probes (software-based). On the other hand, performance and scalability tests

require high-volume traffic that demands hardware-based test tools, e.g., physical traffic generator and test emulator (5G-VINNI D4.1 Annex A). Test tools can also be classified into:

- Active testing that generates and injects traffic into the network via specific traffic generators. The traffic generated can be configured based on the test objectives. Active testing allows high degree of freedom to select what is tested and measured. Therefore, it is suitable for functionality test and feature test such as acceptance test, scalability test or security test.
- Passive testing that observes what happens in the network and service under the normal operations. It does not have the freedom to configure traffic characteristics. On the other hand, it captures the actual behavior in practical operation. Therefore, passive testing is suitable for performance test.

5.8 Project Management and Validation Support

In order to effectively support the end-to-end test formalization and testing regime life-cycles, 5G-SOLUTIONS will to the extent feasible: analyse, develop and establish use case-oriented project management and validation support processes and tools. This will become more important as the maturity of the use cases and the testing automation develop and there will most likely be needs for additional support as enabled by complementary management and support solutions. These mechanisms and support tools can be seen as potential add-ons to the main testing framework and testing tools. The tools introduced as part of the feedback-loop and process and the tools for stakeholder management (sections 5.5 and 4.7 respectively, above) are examples of tools to be adapted and extended to support the full life-cycle of the test formats and testing artefacts developed along the methodologies developed by 5G-SOLUTIONS. This is the case not only for technological analysis and validation but equally important for effectively supporting business analysis and validation.

In the longer term, and in order to automate and to scale up even further, we anticipate that these support tools will interact with the Business Layer of the ICT-17 Experimentation as a Service (EaaS) solutions, or the sustained versions of the platforms and the associated facilities following from the ICT-17 projects. The detailed processes and support solutions will be developed and addressed in the later version of this deliverable.

5.9 Indicative Contributions from LLs

As a starting point to validate the approach and a way to get testing an early focus, we have reached out to a number of LLs (LL1, LL2, LL4) and have asked from the UC contributors to provide us with some initial inputs and precisely the scenarios to be validated as per UC. The below information collected is meant to be a set of examples or samples not the complete list but the work has started and will continue on:

5.9.1 LL1: Factories of the Future

The UCs belonging to the LL1 – Factories of the Future aim to cover the different characteristic aspects of a modern factory environment. With these UCs different factory environments are considered: from huge 24/7 production lines to constellation of sensors and robotized production plants. The main uses cases explored in this section are the following:

Table 28: LL1 UCs

UC1.1	Time-critical process optimization inside digital factories
UC1.2	Non-time-critical communication inside the factory

UC1.4	Connected goods

5.9.1.1 Indicative LL1 scenarios

UC1.1: Time-critical process optimization inside digital factories, focuses on leveraging on innovative communication technologies to enhance the real-time product and process control, mainly finalized to the product quality assessment. A 24/7 production line, producing consumer goods will be monitored using digital visual inspection techniques. In particular, the hyperspectral imaging (HSI) techniques will be leveraged to inspect the product and detect non-conformities. Due to the high quantity of data to be transferred to have an adequate resolution allowing the data processing to detect small defects and non-conformities, and given the stringent requirements in terms of latency to trigger quality control actions (for instance the product rejection) on a fast-moving belt, this technology has never been suitable for wireless communication system. Typical industrial applications require a high level of reliability, and the HSI itself, being the images sent frame by frame works only with reliable communication channels. The loss of a single frame, in some cases, could cause the system to fail.

UC1.1 consists of 3 interconnected scenarios. The 3 scenarios refer to the same configuration, consecutively adding new features. This is mainly due to the necessity of maintaining the same configuration in order to tune it for the maximum effectiveness.
During the first scenario the monitoring system will be set-up on a full-size and full-working replica of the production line. Preliminary tests will be performed using state-of-the-art technologies to set the baseline. Following, preliminary 5G connection tests between the monitoring system and the 5G node will be performed. Ranging and coverage tests will be also conducted with the aim of evaluate the coverage range that can be reached without forgo the requirements. For this same scenario are also envisioned remote access and remote configuration test using the 5G-VINNI Patras facility.
In the second scenario, the performance of the 5G enabled monitoring system will be evaluated during standard operation of the production line. The performance will be evaluated and the status of each component checked. The data acquired in this scenario will be stored to extract useful statistics to evaluate the process as well as to contribute to the analysis of the business KPIs.
Ultimately, in the third scenario, a rejection system, most probably emulated, will be triggered every time a defected product is detected. Statistics concerning the recurrence of defect and the type of defect detected will be stored and elaborated for future process optimization.

Table 29: LL1 UC1.1 Scenarios

Scenario	**UC1.1_1: HSI monitoring system connection**
Critical tasks	Ensure reliable connection of the HSI system to the 5G private node. Ranging and coverage analysis, resilience to clutter, stability analysis. Test of remote access and configuration of the 5G private node.
Required Software/Hardware	5G Private Node (RAN and EPC) 5G-VINNI Patras facility IRIS HSI Monitoring System supporting the 5G RAN connection
Scenario	**UC1.1_2: Performance and status monitoring**
Critical tasks	Performance and status monitoring during the standard operation of the production line. Measure of throughput, latency, coverage, reliability. Collection of status variable and statistics.
Required Software/Hardware	5G Private Node (RAN and EPC) 5G-VINNI Patras facility IRIS HSI Monitoring System supporting the 5G RAN connection

Scenario	UC1.1_3: Rejection system triggering
Critical tasks	Trigger the signal for a rejection system to take action. Statistic gathering, false negative measure.
Required Software/Hardware	5G Private Node (RAN and EPC) 5G-VINNI Patras facility IRIS HSI Monitoring System supporting the 5G RAN connection

UC1.2: Non-time-critical communication inside the factory, aims to demonstrate the applicability of 5G in industrial physical assets reach of scatter-points for the radio signal, that historically presented a challenge to the provision of reliable network services. The vision for the 5G application is to provide a mobile environment that can provide reliable coverage in an area where mobile technologies have traditionally struggled. 5G will be the primary platform to quickly provision IIoT enable instruments and integrate with existing data collection platforms to provide powerful plant insight and enhance problem solving capability.

The non-time-critical communication inside the factory consist of 3 different scenarios: the first one concerns the set-up of the 5G indoor network evaluating the coverage in the most critical areas of the factory, as well as the proper connection of the 5G enabled sensors with the 5G private node. In this scenario will be evaluated the necessity of an edge gateway functional block for the homogenization of the sensor's traffic.

The second scenario named *flexible mobile condition monitoring* is focused on integrating the new 5G sensors data sources with the existing plant control system. The sensors' data can be divided into two categories: data coming from the current plant control space and wired connected to the plant controller; and the data coming from the living lab space, wirelessly connected to the 5G node. Data are generated by different IIoT toolkits and they have different characteristics. Moreover, it is desirable that the sensors connected to the 5G node could be polled with a higher frequency to better respond the production plant necessities. The two types of data will be integrated to be processed by the MES systems, providing a real-time factory status.

The third scenario envisioned in UC1.2 has been named the *Mobile maintenance toolbox*. This scenario wants to provide powerful plant insight and enhance problem solving capability reducing, at the same time, the time needed by the operator to perform the maintenance action. Current maintenance activity is performed by specialized operators and consists in checking the status of the plant from the control room (located outside of the production plant). In the eventuality of a malfunctioning detected by one of the sensors installed in the production plant, the monitoring system running in the control room report the malfunction and the operator physically leaves the control room to enter the production plant to perform the maintenance actions required. In the context of UC1.2, the operator will be provided by a 5G enable handheld device connected to the in-factory 5G node receiving the information from the same monitoring software running in the control room. The operator, in this case, is already in the production plant reducing the intervention time. Other than this, once the maintenance action has been performed, the operator can immediately check the status of the plant without going back to the control room.

Table 30: LL1 UC1.2 Scenarios

Scenario	UC1.2_1: Multi-sensor connection and coverage evaluation
Critical tasks	Evaluation of the critical areas of the production plant to be covered by the 5G signal. Coverage and RSSI evaluation. Installation and connection of 5G enabled sensor.
Required Software/Hardware	Patras 5G-VINNI (RAN and EPC) 5G enabled sensors
Scenario	UC1.2_2: Enhanced mobile condition monitoring

Critical tasks	Integration of the 5G enabled sensors with the existing PLC-based monitoring platform. Polling rate evaluation. Measure of throughput, latency and evaluation of interleaving issues.
Required Software/Hardware	Patras 5G-VINNI (RAN and EPC) 5G enabled sensors ORBIS MES system
Scenario	**UC1.2_3: Flexible mobile conditioning monitoring**
Critical tasks	Validate the integration of the IIoT toolbox with the MES platform providing a smart status checking system to ease and increase the efficiency of the plant maintenance and fault recovery.
Required Software/Hardware	Patras 5G-VINNI (RAN and EPC) 5G enabled sensors ORBIS MES system 5G enabled handheld devices

UC1.4: Connected goods, will assess the potential for 5G to enable full-duplex communication of appliances such as washing machine in tomorrow's home. The connected goods use case wants to leverage on interoperable IoT building blocks covering Non-Intrusive Load Monitoring (NILM) and smart meter data from home appliance. P&G in collaboration with the University of Gent will build a modular washing machine to enable almost-real-time connectivity to control and optimize the washing process, remotely setting the most suitable wash program and reducing soap, water and electricity consumption.

This Use Case consists of two scenarios: the first scenario is focused on evaluating the status of all the sensors composing the smart appliance, with the final aim of continuously gathering information from those sensors. An algorithm running in the cloud will elaborate the washing process based on the received data and triggering the execution.

The second scenario faces the possibility of updating the washing program and/or the algorithm that generates it with the main aim of optimizing the process or responding to specific user's requests (for instance the user requested to speed-up the washing process) as well as responding to fault such as unexpected interruptions (i.e. electricity black-out). In such cases the process has to be updated according to the last status, following a different procedure.

Table 31: LL1 UC1.4 Scenarios

Scenario	**UC1.4_1: Smart home appliance monitoring and execution**
Critical tasks	Evaluation of the status and collection of the different parameters from the smart appliance. Cloud elaboration and local loading and execution of the washing program. Fault tests
Required Software/Hardware	Patras 5G-VINNI (RAN and EPC) 5G enabled home appliance
Scenario	**UC1.4_2: Washing program algorithm update**
Critical tasks	Validation of the possibility of updating or modifying the algorithm that elaborate the washing program without affecting the process execution.
Required Software/Hardware	Patras 5G-VINNI (RAN and EPC) 5G enabled home appliance

5.9.2 LL2 Smart Energy Living Lab

The main uses cases explored in this section are the following:

Table 32: LL2 UCs

UC 2.1	Industrial Demand Side Management
UC 2.2	Electric vehicle smart charging
UC 2.3	Frequency network regulation

5.9.2.1 Indicative LL2 scenarios

UC 2.1: Industrial Demand Side Management

This use case deals with DSM at the level of business/not residential users (large, medium or small enterprises, offices, others). The focus is on the optimal load scheduling during regular plant operation, the computation and actuation of flexibilities offered on the Dispatching Market and the control actions needed to keep the peak power consumption limited. Tests and critical tasks as well as required software/hardware in line with the use case description are reported in following tables.

Table 33: LL2 UC2.1 Scenarios

Scenario	**UC2.1_1: Heat Pump RTU communication to the Aggregator**
Critical tasks	Evaluate the pros/cons of a 5G communication (compared to 4G) for reliability, flexibility and speed/latency when pushing consumptions data and/or receiving flexibility inputs from the Aggregator or, at local level, from the BMS.
Required Software/Hardware	• 5G EVE facility (Italian Site) • 1 RTU for real-time monitoring and actuation on the Heat Pump • 1 5G router • 1 SIM card • 1 BMS (Siemens Desigo already in place) • 1 RTU supervision Platform (for Aggregator) (Ailux as existing partner/vendor of IREN Aggregator)
Scenario	**UC2.1_2: Electrical monitoring and comfort monitoring devices data pushing**
Critical tasks	Evaluate the pros/cons of a 5G communication (compared to 4G) for reliability, flexibility and speed/latency when pushing consumptions data to the BMS and/or RTU Supervision platform. Post fiscal electrical meters could be installed on the main electrical loads of the building (heat pump, Lighting, elevators, etc.). Comfort monitoring sensors could have a local wireless communication to a concentrator, with 5G embedded.
Required Software/Hardware	• 5G EVE facility (Italian Site) • 1 to 3/4 post fiscal electrical meters with 5G communication (directly embedded or in a dedicated concentrator) • 1 to 3/4 5G router • 1 to 3/4 5G SIM cards • 1 BMS (Siemens Desigo already in place) • 1 RTU supervision Platform (for Aggregator) (Ailux as existing partner/vendor of IREN Aggregator)

UC2.2: Electrical Vehicle Smart Charging

Smart charging is a form of DSM where the choice of the charging station used for recharging a PEV and the power absorbed during the process are under the control of a charging point operator, according to a set of grid boundary conditions and drivers' charging preferences. Also, the driver experience may involve a variety of interactions between the driver and the charging infrastructure through apps and the charging station dashboard, depending on the charging point operational policies and business models.

This new paradigm in mobility implies a strong interaction of EVs systems and energy players (mainly Aggregator), posing new challenges and opportunities in the way the next generation networks will be operated. In this regard, the 5G network can be used for allowing a reliable real-time scheduling of charging sessions and provide a fast reschedule in case of an overload, in case a contractual threshold is overcome due to an excessive number of simultaneous charging sessions, or in case the electric power generated from renewables suddenly falls short of the predictions.

To enable the testing and validation of this use case, a set of drivers' 5G terminals and public charging points equipped with 5G communication devices will be used, under the control of one charging platform, enabling innovative services interconnecting the e-mobility stakeholders. The charging points will need to manage "dynamic charging", even going in the V2G mode if feasible, to manage instant changes in the charging loads based on the external input described above. Discussion and verification with the 5G EVE Italian Site Manager about 5G coverage are still on going.

Table 34: LL2 UC2.2 Scenarios

Scenario	**UC 2.2_1 Electrical Vehicle Smart Charging**
Critical tasks	• Validation of decentralized against centralized smart charging algorithms • Validation of synchronism of communications among agents • Assessment of latency and reliability of communications • Validation of smart charging in relation to actuation of dispatching orders
Required Software/Hardware infrastructures	• 5G EVE facility (Italian Site) integrating Multi-access Edge Computing (MEC) or, alternatively, suitable data storage and processing capability built-in the 5G facility • 5G Terminals • Electric Vehicles charging infrastructure • Smart charging back-end software modules

UC 2.3: Electricity network frequency stability

This UC deals with the integration of power network frequency regulation functions in the operation of electric vehicle charging infrastructure. This integration implies the installation of 5G modems and the implementation of fast smart charging modules (suitably embedded in the charging stations) working on real-time network frequency. A crucial point here is the assessment of communication reliability, which has an impact on the ability of charging infrastructure operator to take commitments on electricity markets.

Table 35: LL2 UC2.3 Scenarios

Scenario	**UC2.3_1: Electricity network frequency stability**

Critical tasks	• Validation of coordination between back end and charging points smart charging modules • Assessment of latency and reliability of communications • Assessment of electric vehicles reaction to fast changes of charging power set points
Required Software/Hardware	• 5G-EVE facility integrating Multi-access Edge Computing (MEC) or, alternatively, suitable data storage and processing capability built-in the 5G facility • 5G Terminals installed in charging points • 5G SIM cards • Electric Vehicles charging infrastructure • Smart charging back-end software modules • Smart charging software modules embedded in charging points • Network frequency meter

5.9.3 LL4: Media & Entertainment

M&E services need to cope with increasing demand in terms of data rates, number of simultaneous users connected and/or more stringent QoS requirements. High quality and high-resolution audio-visual services are important drivers for increased downlink data rates, where 5G promises to provide cost-effective alternatives to today's Content Delivery Network (CDN) approaches. At the same time, user generated content, as well as the use of cellular technology for professional and semi-professional media production are key drivers for increased uplink data rates. Cellular, especially when used in bonding multiple links, has multiple times replaced the traditional uplink method of satellite trucks transmission and enabled live high-quality transmission to all sorts of media content providers. 5G will enable this viable and immensely growing area of cellular and IP-based live media production, supporting new business models, such as production in the cloud, at lower costs. 5G will seamlessly integrate services over different network technologies (fixed, wireless), topologies (including e.g. unicast, multicast and broadcast) and capabilities (e.g. caching and multi-link), which may be needed to cover all M&E use cases. The main uses cases explored in this section are the following:

Table 36: LL4 UCs

UC4.1	Ultra-High-Fidelity Media
UC4.2	Multi CDN selection
UC4.3	On-site Live Event Experience
UC4.4	User & Machine Generated Content
UC4.5	Immersive and Integrated Media and Gaming
UC4.6	Cooperative Media Production

5.9.3.1 Indicative LL4 scenarios

Following the methodology defined above indicative LL4 scenarios are presented below. Please note that scenario templates are evolving towards the trials definition finalization stage.

UC4.1: Ultra-High-Fidelity Media

Table 37; LL4 UC4.1 Scenarios

Scenario	**UC4.1_1: Live content broadcasting and cashing over 5G**

Critical tasks	Broadcast to >=10 users live content in various analysis ranging from standard definition to 4K and measure latency, throughput, density, user experience, etc. Half of the testers will be moving and the rest will maintain their position.
Required Software/Hardware	Patras 5G-VINNI (RAN, cashing, core, etc.) 5G smartphones/tablets 5G SIMS FNET streaming application IRT will provide content and application for linear TV consumption
Scenario	**UC4.1_2: On demand content cashing and delivery over 5G**
Critical tasks	>=10 users request simultaneously on demand content in various analysis ranging from standard definition to 4K and measure latency, throughput, density, user experience, etc. Half of the testers will be moving and the rest will maintain their position.
Required Software/Hardware	Patras 5G-VINNI (RAN, cashing, core, etc.) 5G smartphones/tablets 5G SIMS FNET streaming application
Scenario	**UC4.1_3: Network management/slicing policies of 5G content delivery services**
Critical tasks	>=10 users request simultaneously guarantee quality live content streaming service in various analysis ranging from standard definition to 4K and measure network management & slicing capabilities. Half of the testers will be moving and the rest will maintain their position.
Required Software/Hardware	Patras 5G-VINNI 5G smartphones/tablets 5G SIMS FNET streaming application IRT will provide content and application for linear TV consumption
Scenario	**UC4.1_4: Network management/slicing performance**
Critical tasks	Measure the time to create a slice and the time to release a slice.
Required Software/Hardware	Patras 5G-VINNI

UC4.2: Multi CDN Selection

Table 38; LL4 UC4.2 Scenarios

Scenario	**UC4.2_1: Network-assisted multi-CDN selection**
Critical tasks	A multi-CDN scenario in which content input can be selected among different available sources is tested. Network conditions can be used to predict the quality of service and the way to maximize the overall QoS for all users.
Required Software/Hardware	Patras 5G-VINNI (RAN, cashing, core, etc.) Caching capabilities at the edge or at certain nodes of the network 5G smartphones/tablets 5G SIMS IRT setup for multi-CDN implementation
Scenario	**UC4.2_2: Multi-CDN caching deployment**
Critical tasks	New caches can be instantiated according to pre-scheduling or on-demand according to user density on certain areas of the network

Required Software/Hardware	Patras 5G-VINNI (RAN, cashing, core, etc.) Caching capabilities at the edge or at certain nodes of the network 5G smartphones/tablets 5G SIMS IRT setup for multi-CDN implementation
Scenario	**UC4.2_3: Player based CDN selection**
Critical tasks	The video player at the user will perform a selection of the best content source according to various analytics measured for a range of HD to UHD content. The measurements will involve latency, throughput, density, user experience, etc.
Required Software/Hardware	Patras 5G-VINNI (RAN, cashing, core, etc.) 5G smartphones/tablets 5G SIMS IRT setup for multi-CDN implementation

UC4.4: User & Machine Generated Content

Table 39; LL4 UC4.4 Scenarios

Scenario	**UC4.4_1: Live content upload over 5G**
Critical tasks	>=10 users will upload live in 4K analysis and measure latency, throughput, density, user experience, etc. Test various network conditions e.g. cell-edge, reflections/multi-path, different spectrum bands, etc. Test multilink upload Half of the testers will be moving and the rest will maintain their position.
Required Software/Hardware	Patras 5G-VINNI (RAN, cashing, core, etc.) 5G smartphones/tablets 5G SIMS FNET client and content reception applications IRT audio/video streaming client and server applications
Scenario	**UC4.4_2: Live content upload over 5G with Quality of service**
Critical tasks	>=10 users will upload live in 4K analysis and measure latency, throughput, density, user experience, etc. The network will provide at least 2 slices Test various network conditions e.g. cell-edge, reflections/multi-path, different spectrum bands, etc. Test multilink upload Half of the testers will be moving and the rest will maintain their position.
Required Software/Hardware	Patras 5G-VINNI (RAN, cashing, core, etc.) 5G smartphones/tablets 5G SIMS FNET client and content reception applications IRT audio/video streaming client and server applications

UC4.6: Cooperative Media Production

Table 40; LL4 UC4.6 Scenarios

Scenario	**UC4.6_1: Cooperative production over 5G**
Critical tasks	>=2 users/reporters will upload live in 4K analysis using smartphones and potentially multilink upload equipment. Content will be received to a LIVE U production server where subtitling, commenting, etc. will be produced in real time. Latency, throughput, density, user experience, etc. will be measured Test various network conditions e.g. cell-edge, reflections/multi-path, different spectrum bands, etc. At least 2 network slices should be provided. Half of the testers will be moving and the rest will maintain their position.
Required Software/Hardware	Patras 5G-VINNI (RAN, cashing, core, etc.) 5G smartphones/tablets 5G SIMS LIVE U, FNET client and content reception applications
Scenario	**UC4.6_2: Cooperative production over 5G in a multi RAN environment**
Critical tasks	>=2 users/reporters will upload live in 4K analysis using smartphones and potentially multilink upload equipment. Content will be received to a LIVE U production server where subtitling, commenting, etc. will be produced in real time. Latency, throughput, density, user experience, etc. will be measured Test various network conditions e.g. cell-edge, reflections/multi-path, different spectrum bands, etc. At least 2 network slices should be provided. At least 2 RAN will be provided. Half of the testers will be served by each RAN Half of the testers will be moving and the rest will maintain their position.
Required Software/Hardware	Patras 5G-VINNI (RAN, cashing, core, etc.) 5G smartphones/tablets 5G SIMS LIVE U, FNET client and content reception applications FNET client and content reception applications

6 Conclusions and Next Actions

This deliverable presented the first version of the strategy for producing and assessing the methodologies for the testing, validation and benchmarking of the results as well as for the technological and business validation of the use cases.

The sections relevant to the task 1.4 and part of 1.5 for the technological validation have laid out the foundation for approaching the trials in a structured approach, focusing on defining the initial test phases namely the test analysis, design and test case specification with their respective activities and the production of the different test artefacts such as the necessary templates. The proposed testing process aligns with the agile methodology allowing for incremental improvements within the defined test methodology but also more importantly within the outcomes namely, the tests to be carried out and the results which will be the main focus for the next version of the deliverable.

The next steps regarding the task 1.4 will be to execute the test strategy by conducting the test analysis and deriving a set of test cases with the support of the LLs and UCs owners. As we go through the three planned cycles, we will make use of the test case formalization process for producing the different test reports in the last version of the deliverable which will inform and give a true insight in the 5G-SOLUTIONS put forward aligned with the project goals.

The sections relevant to the task 1.5 have presented a process where technological and business validation goes hand in hand, starting with templates for the business validation *before* the technological validation; hence, we focus on methods for confirming that there is real business value, and how this can be reflected in business metrics. The technological validation methodology includes the adaptation and analysis of possible validation frameworks inspired from ETSI and other 5G research programs. From an overall perspective, the methodology encompasses analysis of the foundations, including terminology and concepts, and definition and elaboration of methodology that encompass testing regime. We also address the methodology *after* the technological validation – methods. Here a six-step model describes how business validation opportunities within the 5G solution living lab use cases is developed using an agile, design thinking and lean start-up methodology.

The next steps regarding task 1.5 will be to further detail the UC for all the LLs with respect to actors/personas and stakeholder roles, problem/pain points, benefits, working processes etc. Building on this detailed case level information enables us to create a baseline for measurement of the improvements generated from solutions using 5G based technologies. Data received from the technical tests (network data and application specific data) enables us to whether the technical KPIs are met or not, while data from surveys, interviews, focus groups and observations of personas/stakeholdersenables us to confirm whether these solutions are actually solving their problems/pain points and real business value can be achieved. We also plan to provide quantitative and qualitative data from firms/ organisations/ industries (Operation, Maintenance, HSE, Finance, Quality, etc.) and data generated from industry/country level (e.g. NACE code statistics) to find the aggregated business potential the 5G UC portfolios.

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[10] 5G-SOLUTIONS for European Citizens - H2020, "Ch. 1.1, and Ch. 3 in 5G solutions proposal, section 1.3.," [Online]. Available: https://5g-ppp.eu/5g-solutions/.

Annexes

Annex 1: 5G - PPP Projects

5G-TANGO[12]
An immersive E2E streaming service, able to fuse video streaming as 360° in AR/VR personalized content; VNFs: Content Management, Aggregator, reverse proxy, streaming servers. **Review Summary**: 5G-TANGO project and its deliverables provide a really good insight on how an advanced V&V platform can be used for their selected use cases. Their test framework uses Model-based testing to generate automatically the tests and also includes a certification platform. **Deliverables**[13]**:** • D2.3[14] (Updated requirements, architecture design and V&V elements) • D3.1[15] (Verification and Validation strategy and Automated metadata management) • D7.1[16] (Evaluation strategy and testbed setup report) • D7.2[17] (Implementation of pilots and first evaluation)
5G-EVE[18]
5G-EVE facilities: Use of the 5G-EVE Turin facility for conducting field trials for the use cases related to the Smart Energy Living Lab. **Review summary**: 5G-EVE deliverables give an overall view of a structured test approach: from test plan to test procedures along with some validation tools and also include a KPI collection framework. **Deliverables**[19]**:** D2.1[20] (Initial architectural facilities description) D5.1[21] (Disjoint testing and validation tools) D1.4[22] (KPI collection Framework)
5G-VINNI[23]
5G-VINNI facilities: Use of the 5G-VINNI facilities for conducting field trials for the use cases related to the Factories of the Future (Ireland, Brussels, Norway), Smart Cities (Ireland), Smart Ports (Norway) and Media & Entertainment Living Labs (Patra and Norway). **Review summary**: Another interesting structured test approach with great focus on the formalization process

[12] https://www.5gtango.eu/
[13] https://www.5gtango.eu/project-outcomes/deliverables.html
[14] https://www.5gtango.eu/documents/D23_v1.pdf
[15] https://www.5gtango.eu/documents/D31_v1.pdf
[16] https://www.5gtango.eu/documents/D71_v1.pdf
[17] https://www.5gtango.eu/documents/D72_v1.pdf
[18] https://www.5g-eve.eu/
[19] https://www.5g-eve.eu/deliverables/#
[20] https://www.5g-eve.eu/wp-content/uploads/2018/10/5geve_d2.1-initial-architectural-facilities-description.pdf
[21] https://www.5g-eve.eu/wp-content/uploads/2019/05/5geve-d5.1-disjoint-testing-and-validation-tools.pdf
[22] https://www.5g-eve.eu/wp-content/uploads/2019/09/5geve_d1.4-5g-kpi-collection-framework.pdf
[23] https://www.5g-vinni.eu/

with very detailed templates and initial test reports.

Deliverables[24]:
D2.1[25] (5G-VINNI Solution Facility-sites High Level Design (HLD))
D4.1[26] (Initial report on test-plan creation and methodology, and development of test orchestration framework)

TRIANGLE[27]

Framework for 5G Applications and Devices testing and benchmarking.

Review summary: The deliverable reviewed below gives a complete and final test specification report with a format that uses a modular approach to the test case formalization.

Deliverables[28]:
D2.6 (Final Test Scenario and Test Specifications)

5G-GENESIS[29]

A large-scale facility and an open set of tools for 5G Experimentation.

Review summary: An in-depth approach is taken on the concept of experimentation with associated procedures and templates with also provide early results from the first cycle of trials.

Deliverables[30]:
D2.3[31] (Initial planning of tests and experimentation)
D6.1[32] (Trials and experimentation - cycle 1)

METIS-II[33]

Summary: Develop the 5G RAN design and provide the technical enablers for an efficient integration and use of the various 5G technologies: spectrum management architecture, air interface harmonization framework, agile Resource Management framework, cross-layer and air-interface system access.
All these outputs are highly relevant for 5GSOLUTIONS and will assist with the definition of a functional architecture, the technical specifications, the network service interfaces, spectrum management, 5G components integration and more.

FLEX5GWARE[34]

Summary: Deliver highly reconfigurable HW platforms together with SW platforms targeting both network elements and devices, and considering increased capacity and reduced energy footprint.

SUPERFLUIDITY[35]

[24] https://www.5g-vinni.eu/deliverables/
[25] https://doi.org/10.5281/zenodo.2668791
[26] https://doi.org/10.5281/zenodo.3345626
[27] https://www.triangle-project.eu
[28] https://www.triangle-project.eu/resources/
[29] https://5genesis.eu
[30] https://5genesis.eu/deliverables/
[31] https://5genesis.eu/wp-content/uploads/2019/02/5GENESIS_D2.3_v1.0.pdf
[32] http://5genesis.eu/wp-content/uploads/2019/08/5GENESIS_D6.1_v1.00.pdf
[33] https://metis-ii.5g-ppp.eu/
[34] https://flex5gware.eu/
[35] http://superfluidity.eu/

Summary: NFVO design; plugin mechanism implemented in CBND NFVO products; Benchmarking various hardware accelerations for NFV use cases. Leveraged OPNFV Yardstick to perform robust cloud performance tests. Use Cloudband & NFVO and create the necessary plugins to orchestrate cross-testbed provisioning and management of various vertical applications (VNFs) being monitored as part of the KPIs validation.
SONATA[36]
Summary: Methodologies, technologies and systems to conduct testing and validation; Testbed and infrastructure for VNF. Development of AI-based algorithms to improve the security of VNFs; Machine Learning components for traffic classification; Wide range of networks and contacts; Network management based on cognitive Machine Learning approaches. Use Machine Learning approaches to analyze 5G KPI metrics and process results from data feeds in real-time; Deploy a testing framework to automate and boost reliable validation of network KPIs; Produce reports for homogenized evaluation based on a consistent contrast of KPIs with normalized and comparable values considering concurrent slices. Enforce testing accountability with auditable validation reports; Practical application of COGNET smart engine in vertical environment.
COGNET[37]
Summary: Methodologies, technologies and systems to conduct testing and validation; Testbed and infrastructure for VNF. Development of AI-based algorithms to improve the security of VNFs; Machine Learning components for traffic classification; Wide range of networks and contacts; Network management based on cognitive Machine Learning approaches. Use Machine Learning approaches to analyze 5G KPI metrics and process results from data feeds in real-time; Deploy a testing framework to automate and boost reliable validation of network KPIs; Produce reports for homogenized evaluation based on a consistent contrast of KPIs with normalized and comparable values considering concurrent slices. Enforce testing accountability with auditable validation reports; Practical application of COGNET smart engine in vertical environment.
5G-EX[38]
Summary: Automated Network Service Orchestration of multi-domain and multi provider Services (compliant with ETSI MANO), with fulfilment & assurance life-cycle loops, implemented, deployed and tested in a distributed large-scale sandbox environment. 5GEx provides concepts and mechanisms for Open Cooperative 5G Service Ecosystems. Leverage multi-party service orchestration abstractions and models for further modelling and design of the APIs needed by the vertical (tenant) enterprise customers. All main 5G-Ex services categories and supporting mechanisms will be considered, such as (i) assured service quality connectivity, NFVI or VNF Slice as a Service, including mechanisms for monitoring and SLA assurance in multi-actor service contexts. The value-added connectivity on-demand concepts, are relevant for validating the cross-border enhanced user experience services.
5G-MONARCH[39]
Summary: Develop prototype implementations and apply these prototypes to representative use cases. Use network slicing, which capitalizes on the capabilities of SDN, NFV, orchestration of access network and core network functions and analytics, to support vertical industries.

[36] http://sonata-nfv.eu/#
[37] http://www.cognet.5g-ppp.eu/
[38] http://www.5gex.eu/
[39] https://5g-monarch.eu/

All these outputs are extremely relevant for 5G SOLUTIONS, especially 5G architecture, slicing, use of SDN and NFV, which will be used as guidelines for the 5G-SOLUTIONS system architecture design and the setting-up and execution of the Living Labs.

5G-TRANSFORMER[40]
Summary: E2E Network slicing schemes. The proposed slicing techniques will serve as a base for advanced SDN-enabled intra and inter-domain slicing schemes for validating the stringent KPIs in the Media & Entertainment Living Lab over heterogeneous NFV-based infrastructures.

[40] http://5g-transformer.eu/