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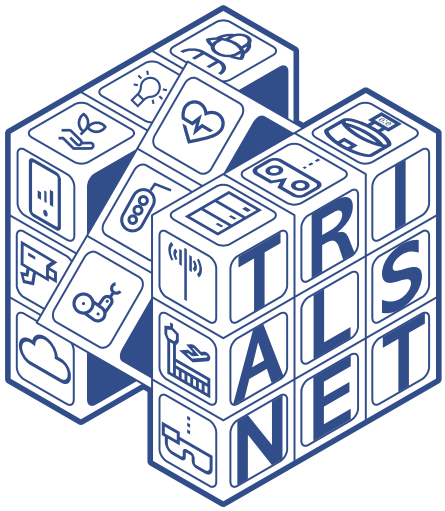

TrialsNet: TRials supported by Smart Networks beyond 5G

Deliverable D6.1

First report on validation and dissemination activities

Project Details

Call	HORIZON-JU-SNS-2022
Type of Action	HORIZON-JU-IA HORIZON JU Innovation Actions
Project start date	01/01/2023
Duration	36 months
Grant Agreement No.	101095871

Deliverable Details

Deliverable WP:	WP6
Deliverable Task:	T6.2, T6.3, T6.4
Deliverable Identifier:	TrialsNet D6.1
Deliverable Title:	First report on validation and dissemination activities
Editor(s):	Paolo Giaccone (CNIT) Maurizio Matteo Munafò (CNIT)
Author(s):	Valerio Palestini (CNIT) Hassan Osman (RW) Aruna Prem Bianzino (UC3M) Andreas Georgakopoulos (WINGS) Andrea Basso (CROSEU)
Reviewer(s):	Giancarlo Sacco (TEI) Albert Vidal Palma (TID)
Contractual Date of Delivery:	31/10/2023
Submission Date:	31/10/2023
Dissemination Level:	PU
Status:	Final
Version:	1.0
File Name:	2023-10-31_TrialsNet_D6.1_First report on validation and dissemination activities.docx

Deliverable History

Version	Date	Modification
V1.0	*31/10/2023*	*Final version, submitted to EC through SyGMa*

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List of Acronyms and Abbreviations

Acronym	*Description*
3GPP	3rd Generation Partnership Project
4G	Fourth generation of mobile communications
5G	Fifth generation of mobile communications
5G NR	5G New Radio
5G PPP	5G Infrastructure Public Private Partnership
6G	Sixth generation of mobile communications
AI	Artificial Intelligence
AIA	Athens International Airport SA
AR	Augmented Reality
B5G	Beyond 5G mobile network
CNIT	Consorzio Nazionale Interuniversitario per le Telecomunicazioni
COTO	Comune di Torino
DAEM	Dimos Athinaion Epicheirisi Michanografisis
DT+	Design Thinking+
eMBB	Enhanced Mobile Broadband
EMF	Electric and Magnetic Field
ETSI	European Telecommunications Standards Institute
EuCNC	European Conference on Networks and Communications
eURLLC	Enhanced Ultra-Reliable and Low-Latency Communications
IIT	Fondazione Istituto Italiano Di Tecnologia
IoT	Internet of Things
ITU	International Telecommunication Union
KPI	Key Performance Indicator
KV	Key Value
KVI	Key Value Indicator
MCI	Mass Casualty Incident
ML	Machine Learning
mMTC	Massive Machine-Type Communications
NFV	Network Function Virtualization
NGMN	Next Generation Mobile Networks Alliance
NTN	Non-terrestrial Network
ORO	Orange Romania SA
QoE	Quality of Experience
QoS	Quality of Service
RW	Real Wireless Limited
SDG	Sustainable Development Goal
SDN	Software Defined Networking
SNS JU	Smart Networks and Services Joint Undertaking
TEI	Ericsson Telecomunicazioni S.p.A.
TIM	Telecom Italia S.p.A.
TMO	Technology, Market, and Organizations
TMOG	Technology, Market, Organization and Governance
UC	Use Case
UC3M	Universidad Carlos III de Madrid
UE	User Equipment
UN	United Nations
V2I	Vehicle to Infrastructure
VF	Virtual Functions
VR	Virtual Reality
WINGS	WINGS ICT Solutions
WP	Work Package
XR	Extended Reality
YBVR	Yerba Buena Virtual Reality

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Executive Summary

This deliverable reports the progress of the validation and dissemination activities of TrialsNet project that are in charge of Work Package 6 (WP6) “Validation & Dissemination”.

The WP6 covers many transversal activities such as the management of the trials, the technical validation and assessment of the results coming from the trials activities, the analysis of the societal and business aspects on the basis of identified Key Values (KVs), the dissemination and standardization activities, and the exploitation of the project’s results. On such basis, WP6 covers a crucial role across all the technical WPs of the project through the interaction with the domain WPs (i.e., WP3, WP4 and WP5) to define common Key Performance Indicators (KPIs) and Key Values Indicators (KVIs) frameworks and the corresponding assessment methodologies for the use cases, as well as with WP2 for what concern the specific KPIs and KVIs related to the platform and network solutions that will be deployed in the different clusters. A coherent definition of the KPIs and KVIs is crucial for the validation of all the use cases, also the ones proposed in the Open Call, managed in WP7.

WP6 is also responsible to interact with the SNS-JU program at different levels including joint dissemination activities and program representations. Furthermore, synergies with the relevant 6G-IA and European Community groups are investigated, with possible co-organization of events.

In the context of the activities related to the technical definition and assessment methods for the KPIs, starting from deliverables D3.1 [1], D4.1 [2] and D5.1 [3], the WP6 analyzed all the KPIs defined in the different use cases in order to define a common terminology to use as a reference for the next phases of the project’s activities. As a result, this deliverable identify a set of 18 different KPIs divided in the following categories: capacity, latency, compute, availability/reliability, and localization. Further interactions between the concerned WPs (including WP2) will be carried out to consolidate such KPIs in the different use case as well as to identify (if necessary) additional ones.

Concerning the activities on KVIs, this deliverable provides a common framework for their definition and analysis, that is required to share a coherent validation approach in the whole project. The framework will be adopted by each use case to define KVs, the corresponding KVIs, and related (technological) enablers. The relevant domains for KVs have been identified according to the Sustainable Development Goal (SDG) societal, economical and environmental areas, under the common umbrella of sustainability. Furthermore, the Technologies, Markets, Organizations and Governance (TMOG) framework is introduced as part of the KVs assessment methodology across the UCs of the project. This work will also help to address the business aspects and related impacts.

One innovation introduced by TrialsNet in the context of the use cases design, is the adoption of the so called Design Thinking+ (DT+) methodology, consisting in a human-centered design process that will be adopted for the correct definition of KVs and therefore the design of the corresponding use cases. With respect to traditional Design Thinking, this deliverable defines the Design Thinking+ by the introduction of a new step, denoted as “map”, that identifies business constraints, user constraints, technology constraints, and KV constraints, and allows to better address the specific requirements of each use case. The proposed methodology is adopted in the definition of the KVs for some of the use cases in which the final users can be actually involved in their design process.

Finally, this deliverable collects the dissemination, publication and standardization activities occurred in this first period of the project. In particular, despite the initial phase of the project, many important dissemination activities have been performed, including the participation at EuCNC (European Conference on Networks and Communications) & 6G Summit 2023 with a booth in which some live demos have been already shown.

1 Introduction

This deliverable reports on the activities of the project performed in the context of WP6 "Validation and Dissemination" that is responsible for the validation and dissemination of the results coming from the trials activities. WP6 is divided into 5 tasks, three of which have started in the first months of the project's activities and which initial results are reported in this document.

Task 6.2 (T6.2), started on M3 and lasting until the end of the project, is on the technical definition and assessment methods for the KPIs. TrialsNet objectives are targeted using definitions of measurable results for the targeted 6G applications and Use Cases (UCs). This task defines the master list of KPIs for all the UC applications developed and demonstrated. It develops a universal taxonomy of KPIs for the deployed applications, distinguishing between general and use case-specific KPIs, and a first version is presented in the current deliverable. This task provides the required abstractions to define KPIs and the methodology to measure them, such that it is possible to define properly the network KPI requirements for the deployed infrastructure.

Task 6.3 (T6.3), started on M3 and lasting until the end of the project, is on the analysis from social and business perspectives and thus deriving the KVs (Key Values) and the corresponding KVIs. This task develops and uses a KVI framework that includes business and societal value along with the definition of proper levels for Quality of Service (QoS) and Quality of Experience (QoE). This task defines an initial set of KVIs to assess the view of market stakeholders in the early stages and refined as TrialsNet progresses. The analysis of user research activities (questionnaires and other mechanisms) involved in the task assures consideration of user KVs (like flexibility, trustworthiness, and acceptance) and of how to take them into account in industry sectors. Depending on the business models that are identified and applied in the KVI framework, then the task addresses appropriate factors such as willingness to pay, Total Cost of Ownership vs Benefit, Environment, Sustainability, and Governance frameworks.

Task 6.4 (T6.4), started on M3 and lasting until the end of the project, is on the dissemination activities that will promote the project results and on the plans of standardization of project solutions, in order to boost industrial, scientific and standardization impact of TrialsNet. This task created the TrialsNet public website to communicate the project vision, objectives, consortium and provide public deliverables, publications, and videos. It started to disseminate outcomes to the general public using social media like YouTube, LinkedIn and Twitter. This task participates in focused dissemination activities in collaboration with the relevant industrial actors in the 5G/6G ecosystem and disseminates the project results in conferences, journals, and European industrial events. Finally, the task is responsible to organize technical workshops at major events/conferences and industrial workshops at the trial sites and participates in all relevant SNS-JU ecosystem activities.

The other two tasks will start later, and these include Task 6.1 (T6.1) on trials management and Task 6.5 (T6.5) on exploitation. Specifically, T6.1 will address the trials execution phase for each of the use cases consisting in the planning out of the trials activities, the definition of the test and data acquisition protocols, and the methodology for the evaluation of the results based on the time-plan defined in D3.1 [1], D4.1 [2] and D5.1 [3] and that will be updated according to the progress of the activities. Based on the results coming from the trials activities, T6.5 will define the proper exploitation plans and any subsequent refinements as the project matures. More in detail, this task will coordinate the exploitation activities to ensure progress in areas such as studying the feasibility of the proposed use cases, developing prototypes for new products, testing new services, and studying the impact on customers.

In this document, Section 2 presents the activities of T6.2 about the technical KPIs, describing the methodology to define KPIs and their measurement, and providing a harmonized list of KPIs to be used as a reference for all the use cases.

Section 3 is related to the activities in T6.3 regarding the business models and the framework to define the KVs and validate the corresponding KVIs.

Section 4 reports on the activities performed in T6.3 regarding the Design Thinking+ methodology, which is applied to different use cases of the project. The initial outcome of the process will be included in the following WP6 deliverable D6.2.

In Section 5, the activities of T6.4 regarding dissemination, publication, and standardization activities by all the partners are presented.

Finally, the conclusions section provides the main outcomes of the deliverable D6.1 and introduces the next steps related to WP6 activities.

2 Technical KPIs

In the context of TrialsNet's activities, both KPIs and KVIs will be defined and measured to validate the proposed use cases. As shown in Figure 1, KPIs enable a quantitative analysis at network level and at application level, in order to assess the achieved level of Quality of Service (QoS) and thus validate the use case from a technical perspective. In addition, it should be noted that "application KPIs" are collected at the user's equipment and typically cannot be inferred directly from the "network KPIs". For example, when evaluating the latency experienced by a user interacting with an application, the latency must be evaluated at application layer, taking into account, for example, the effects of the different levels of resource virtualization through which the hosting machine runs the application. Such effects are typically not negligible for strictly low-latency applications.

On such basis, it is clear that KPIs affect the perceived Quality of Experience (QoE) by each user, which can be evaluated by leveraging the user's feedback (e.g., through surveys and interviews on a statistically meaningful population). The actual impact of each use case on the society, the environment and the economy are then evaluated through specific KVIs, as detailed in Section 3.

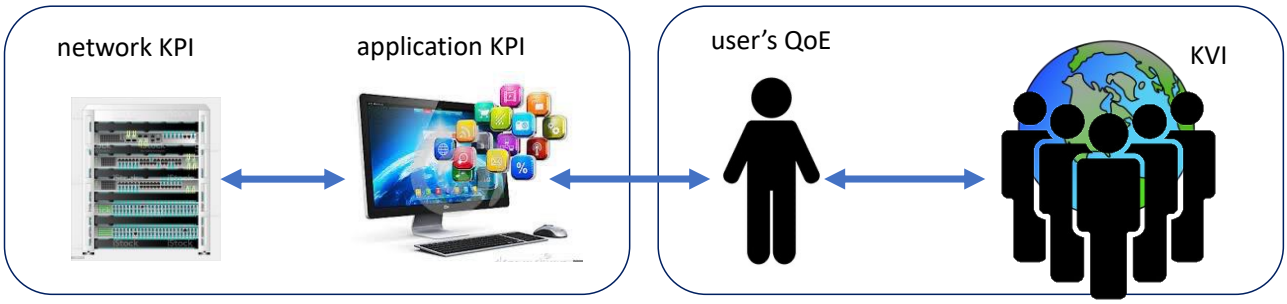

Figure 1. Relation between KPIs and KVIs.

TrialsNet project aims at achieving measurable results for the targeted 6G applications and use cases. In this section, by reporting the progress in task T6.2, a harmonized list of KPIs is defined as reference for all the use case applications developed and demonstrated in the whole project. A recommended taxonomy of KPIs for the deployed applications is also reported.

2.1 Literature review on KPIs

As mentioned before, the definition of "measurable" KPIs highlights the fundamental role of the methodology adopted to measure the KPIs, both in terms of scenarios and of tools. Also in this case, reference documents from International Telecommunication Union (ITU), European Telecommunications Standards Institute (ETSI), 5G Infrastructure Public Private Partnership (5G PPP) are guiding the choice of measurement tools and the validation process, favoring open-source tools. In the following sections relevant documents produced by standardization bodies/alliances that have been used by TrialsNet as basis to develop its work on KPIs are reported.

2.1.1 First 5G PPP white paper

The white paper by 5G PPP [4] analyses different vertical use cases, in different domains, and identifies their performance KPIs and their mapping to 5G network KPIs. The aim of the document is to understand the impact of the network KPI to the service performance and user perceived quality (i.e., QoE). This allows to validate the 5G technology and to prove the need to support new vertical services with 5G, thanks to the 5G enabled technologies that were missing in 4G networks.

The white paper collects definitions and information from relevant 5G PPP projects and standardization bodies and alliances, e.g., ITU, Next Generation Mobile Networks (NGMN). It identifies the relevant KPIs for each vertical service (denoted as "service KPIs", "vertical KPIs" or "application-level

KPIs") and maps them on the respective "network KPIs" (also denoted as "core KPI"), which impact the operation of the architectural elements providing the service.

The white paper analyzes different vertical and use cases: Industry 4.0, Smart Cities and Utilities, Transportation, Automotive, Media & Entertainment, Agriculture and Agri-food, Smart (Air)ports, E-health & Wellness. For each of them, the paper identifies the service KPIs and their mapping to network KPIs. The network KPIs are also defined (e.g., end-to-end latency, packet loss, guaranteed data rate, data volume, jitter, availability, area network capacity, coverage, reliability) and target values are identified for each vertical application.

Even if the white paper provides an interesting methodology to relate service KPIs to network KPIs, it lacks a harmonization of the definitions across all the services, since some definitions appear as incoherent or incomplete.

2.1.2 ETSI technical report

More recently with respect to [4], ETSI made available a technical report [5] on the methodologies for end-to-end testing and validating vertical applications. It provides recommendations on (i) Beyond 5G (B5G) capabilities and enablers, (ii) on testing and validation frameworks, (iii) on relevant KPI mechanisms and (iv) on the design of tests for vertical applications. The adopted methodology is generic and can be applied to any vertical application, independently from its service domain.

The technical report analyses some European infrastructure (related to 5G EVE, 5G-VINNI, 5GENESIS and 5GinFIRE projects) and provides general recommendations based on the different approaches adopted in each project. It also highlights the role of the stakeholders which must be involved in the validation process of the vertical. Their complementary intents for testing and for experimentation are considered and must be combined with the planning and dimensioning of the network and of the services. The complementary roles of vertical KPIs and of network KPIs are also highlighted in the validation process, coherently with [4]. Interestingly, the technical report refers also to "business/economic KPIs" related to the technologies involved, which anticipate the KVIs discussed in Section 3.
The proposed KPI validation methodology requires to define:

- The vertical application;
- The application specific KPIs and their expected end-to-end performance; this requires a clear definition of the KPI, of the measurement methodology and of the observation points;
- The range of application-specific operation conditions for the validation;
- The 5G network setup and configuration;
- The application implementation and deployment model on the 5G network.

The validation process is iterative, suggesting a validation cycle involving both vertical providers and network providers. Validating the verticals through specific tests is presented as a fundamental service model, denoted as Testing as a Service (TaaS), supporting different levels of customization for the definition of the test experiments.

Notably, the technical report provides a comprehensive state-of-the-art survey, covering standard bodies as 3GPP, ITU, ETSI. Finally, it presents the recommendations regarding Virtual Function (VF) deployments and 5G capabilities and enablers, e.g., 5G New Radio (NR), network slicing, edge computing, Network Function Virtualization (NFV), Software Defined Networking (SDN) and diagnostic capabilities.

For different kinds of vertical applications, it describes the list of sensitive KPIs and irrelevant KPIs, and it provides some guidelines for the kind of network slices more suitable for each application. In addition to highlight the importance of the measurement methodology (e.g., where to place the observation points), the document describes the recommended methodology to manage KPI data (collection, storage, indexing, analysis, and visualization).

Coherently with [4], a mapping between vertical KPIs to service KPIs is provided and described through an ad-hoc matrix.

2.1.3 Second 5G PPP white paper

In the whitepaper [6], 5G PPP complemented the information in [4] and presented an overview of B5G and 6G KPIs derived from 5G PPP phase III projects related to the ICT-52 call, reported here: Hexa-X, 6G-BRAINS, AI@EDGE, DAEMON, DEDICAT 6G, REINDEER, RISE-6G, MARSAL, B5G-OPEN, Tera-Flow. These KPIs includes not only the KPIs defined for 5G, described in the previous cited documents, but also the evolution of them to tailor the B5G and 6G scenarios and technologies. The ambition of the document is to provide an early analysis of possible 6G KPIs. Notably, true 6G KPIs do not still exist in standard documents related to 5G (which would imply that they could be derived from 5G) and the document tries to highlight their role with respect to standard 5G KPIs.

The document is divided in two parts. The first part provides an overview of the network KPIs, the methodologies to measure them and the corresponding target values that were defined for 5G networks. The second part provides some tables collecting the KPIs defined for the specific ICT-52 call projects, aimed at B5G and 6G scenarios. The most interesting contribution of such tables is that KPIs were clustered based on KPI type or context, creating a taxonomy which TrialsNet can leverage to define and harmonize the KPIs in the developed use cases, as shown in the following Section 2.2.
The recommended taxonomy for each KPI is according to the following main fields:

- **KPI category**: chosen by a given set of categories described below.
- **KPI name**: given in the context of the project.
- **KPI definition**: detailed definition of KPIs, eventually taking into account the use cases.
- **KPI measurements**: information on where and how the KPIs are measured.

The following categories for KPIs have been identified and the corresponding network KPIs are defined according to ITU, ETSI and 5G PPP recommendations. In some scenarios (e.g., enhanced Mobile Broadband – eMBB) the minimum requirements are also provided.

- **Latency category**: it comprises end-to-end latency and specific latency components. User-plane latency is distinct from control-plane latency.
- **Capacity category**: it is related to the amount of network resources provided to end-users, e.g.,: bandwidth per user (peak data rate, user experienced data rate), bandwidth per area or per node (e.g., node capacity, area traffic density/capacity), number of connections per area (e.g., connection density).
- **Packet Loss category**: it is related to network-level statistics.
- **Compute category**: it refers to generic computing resources.
- **Energy category**: it refers to energy efficiency (i.e., efficient transmission and low consumption when idling) at network level and in the context of NFV.
- **Security category**: it refers to security, anomaly detection, privacy.
- **Channel category**: it refers to communication channel and communication efficiency.
- **Electric and Magnetic Field (EMF) category**: it refers to EMF exposures.
- **Localization category**: it refers to localization accuracy obtained through the 5G network.
- **Availability and Reliability category**: it refers to service availability and reliability of the communication (peak spectral efficiency, 5th percentile user spectral efficiency, average spectral efficiency).

The document refers also to QoE and notices that its definition is subjective, because of its relationship with user's viewpoint, expectations, and context. Finally, all the KPIs defined for ICT-52 projects were clustered in [6] based on the above classification.

2.1.4 Third 5G PPP white paper

Similarly, the white paper [7] by 5G PPP summarizes the 5G KPIs identified in several ICT-17, ICT-19, and ICT-52 projects [8], comprising 5G EVE, 5G-VINNI, 5GENESIS, 5G-TOURS, 5G-HEART, Int5Gent, 5GASP, 5G-LOGINNOV, and 5Growth. Furthermore, it describes the measurement tools that have been utilized and the adopted measurement methodologies. The document highlights the limitations of currently available tools for 5G KPI measurements and provides insights on future enhancements or even complete redesign of new tools to support measurements in 6G networks.

Two complementary perspectives of the KPIs are identified (i.e., vertical/customer perspective, and network/service providers perspective), and for of each of them specific tools are required. A common taxonomy is provided to identify:

- **KPI name** (e.g., "one-way-latency")
- **KPI unique id** (e.g., "KPI-1")
- **KPI description**
- **Unit of measurement** (e.g., "ms")

The KPIs can be measured at different network points, based on the positioning of the measurement probes. The document highlights different function network segments of a 5G system, comprising: user equipment (UE), 5G radio, EDGE, transport, 5G core, public/private cloud.

In addition to provide standard ways of defining and measuring KPIs, the document highlights the importance of standardized ways for creating the experimental context around the measurement. As an example, 5G-TOURS defined “Testing Scenario Templates” to address this issue. Such templates comprise not only the complete settings of the measurement experiments, but also the criteria to validate the KPI (e.g., a constraint on the maximum latency) and the adopted data processing scheme (e.g., compute the average).

The document also presents the available measurement tools, running on probes that can be either passive or active, either hardware or software. Five types of deployment patterns are defined for the measurement tools:

- Client and server-based tools
- Single node tools
- In-network tools
- In-hypervisor tools
- Hardware tools

A list of (i) open-source tools, (ii) tools developed in EU project and (iii) commercial tools is provided. Notably, a summary table maps each open-source tool to the corresponding KPIs. Finally, some relevant open platforms for data collections and for data visualization are discussed.

2.2 Methodology and KPIs analysis

The definition of measurable KPIs plays a crucial role since it enables the validation of the proposed experimental methodology. The definition regards not only each specific KPI term, but also the methodology and the tools to measure it. In summary, each KPIs should be provided with:

- A detailed definition of it;
- The methodology to measure it in terms of tools and testing environment;
- The unit of measurements;
- The validation methodology;
- The use cases scope.

Based on this, TrialsNet provides a synoptic view of the different KPIs that have been defined in the different use cases. To harmonize the definition of the different KPIs, TrialsNet adopted an iterative methodology, mixing a bottom-up with a top-down approach. Each use case initially defines the relevant KPIs, based on its own specific requirements in terms of QoE and validation (i.e., following a bottom-up approach). These definitions are reported in the deliverables D3.1 [1], D4.1 [2], and D5.1 [3] on the use cases definition. Then, by collecting the list of the KPIs across all the use cases, each KPI is classified according to a generic taxonomy detailed in the following. In the case of conflicting or incoherent definitions, 5G PPP reference documents, discussed in Section 2.1, are adopted to properly define the KPIs and merge equivalent definitions.

As anticipated, deliverables D3.1 [1], D4.1 [2], and D5.1 [3] provide the description of TrialsNet use cases and the list of KPIs to validate each use cases. Some KPIs are detailed also in terms of definition and measurement methodology. On such basis, a specific sheet has been created (denoted as "KPI ANALYSIS", and shared in the project folder) to collect the list of all the defined KPIs, according to the following fields:

- **ID**: it is local identifier obtained as a sequence number to identify the KPI and the use case where it was referred
- **Deliverable**: it refers to the deliverable (i.e., D3.1 [1], D4.1 [2], and D5.1 [3]) in which the KPI has been defined
- **Section / Table**: it refers to the specific section or table of the deliverable where the KPI was referred
- **Use case**: it refers to the specific UC where the KPI was referred
- **KPI name**: it is the name of the KPI
- **KPI definition**: it provides the definition of the KPI
- **KPI category**: it provides the category of the KPI based on classification list provided in [6] (i.e., latency, capacity, packet loss, compute, energy, security, channel, EMF, localization, availability and reliability), as described in Section 2.1.
- **Measurement methodology/tools**: it describes the methodology and/or the tools adopted for the measurement
- **KPI target in the UC**: it specifies the eventual target values to validate the KPI in the considered use case
- **Note**: it provides additional notes useful for the analysis. E.g., inherent definitions or definitions to be modified are commented here.

2.3 Harmonized KPIs

The analysis through the table described in the previous section highlighted some incoherence between the KPI naming (i.e., same KPI named in different ways), KPI definition (i.e., same KPI defined in different ways) and KPI measurement (i.e., same KPI using different measurement tools/methodology). Such incoherence was expected due to the lack of a-priori coordination between the different use cases, and the current deliverable aims to provide some level of coordination to address this issue.

It is worth noticing that many KPIs did not specify either the measurement methodology/tools, while instead specifying the target values. Thus, the aim of the KPI synthesis is to provide a guidance on the methodology/tools to adopt for the KPI validation phase.

To summarize the KPIs and made them coherent in the whole project, two spreadsheets were shared in the project folders, derived from the spreadsheet "KPI ANALYSIS":

- **KPI SUMMARY**: summary of the KPI specified in “KPI ANALYSIS”. All the identical KPIs are gathered, despite the different names. In case of missing/unclear/incoherent fields, the

original KPI inherits the fields from other use cases. The spreadsheet includes also new fields, denoted as "5G PPP Name", "5G PPP ID", "5G PPP Definition" and "5G PPP Unit", with the information regarding the KPI defined in [7], as discussed in Section 2.1.

- **KPI HARMONIZATION**: based on "KPI SUMMARY", the final list of KPI name, definition and measurement methodology/tools is provided, together with the eventual reference to the ones in [7]. The use cases for which the KPI is adopted are also identified, and each KPI is defined as generic or use case specific depending on its actual scope.

Starting from an initial list of 92 KPIs present in "KPI ANALYSIS", a final list of 18 KPIs were identified in "KPI HARMONIZATION" and reported in Table 1. This table is shared to all the TrialsNet use cases in order to adopt to these current definitions and eventually provide some feedback to WP6, in order to refine such list. It should be noted that the list if harmonized KPIs should not be considered as finalized and that further updates will be possible according to the progress of the use cases implementation, testing activities and trials execution phases. From this perspective, KPIs from the network perspective defined in the context of WP2 could be also included.

Regarding the management process of this task, Table 2 reports an overview of the process of KPI definition. Thanks to the KPIs harmonization process, the future deliverables will refer to such common list of KPIs.

Table 1. KPIs definition and measurement.

KPI Name	KPI Definition	KPI Category	Measurements methodology/tools	Use Cases
Downlink throughput per user	Sustained throughput experienced from a user to receive data	Capacity	Tools: probes, iPerf and Ookla	UC1 (Madrid), UC5, UC10, UC12, UC13 (Torino, Athens)
Uplink throughput per user	Sustained throughput experienced from a user to send data	Capacity	Tools: probes, iPerf and Ookla	UC1 (Madrid), UC5, UC9, UC10, UC12, UC13 (Turin, Athens)
Downlink aggregate throughput	Sustained throughput, aggregated on multiple users, to receive data in the considered application	Capacity	Tools: probes, iPerf and Ookla, or ad-hoc solutions	UC5, UC6, UC7, UC10, UC12, UC13 (Turin, Athens)
Uplink aggregate throughput	Sustained throughput, aggregated on multiple users, to send data in the considered application	Capacity	Tools: probes, iPerf and Ookla, or ad-hoc solutions	UC6, UC8, UC9, UC10
Downlink throughput per device	Sustained throughput at device level to receive data	Capacity	Tools: probes, iPerf and Ookla	UC2, UC3, UC6, UC11

Uplink throughput per device	Sustained throughput at device level to send data	Capacity	Tools: probes, iPerf and Ookla	UC2, UC3, UC6, UC11
Coverage	Geographic area where a network signal can be received and used by a device	Capacity		UC1 (Madrid)
Application round-trip latency	Amount of time it takes for the application to receive a response or output after sending a request or input to a server or network.	Latency	Measured through the use of tagged (timestamp, sequence) messages	UC1 (Madrid, Iasi), UC2, UC3, UC4, UC5, UC6
Application one-way latency	Amount of time it takes at application level from the source to the destination application	Latency	Measured through the use of tagged (timestamp, sequence) messages	UC1 (Iasi), UC2, UC3, UC4, UC5, UC6 (MCI, Evacuation), UC7, UC8, UC9, UC11, UC12, UC13 (Torino, Athens)
Accuracy	Proportion of correct predictions made by the algorithm.	Compute	Calculated as number of correct predictions divided by the total number of predictions made.	UC1 (Madrid)
Precision	How often the algorithm is correct when it predicts a positive outcome.	Compute	Calculated as number of true positives divided by the sum of true positives and false positives.	UC1 (Madrid)
Recall	How often the algorithm correctly predicts a positive outcome out of all the actual positive outcomes.	Compute	Calculated as number of true positives divided by the sum of true positives and false negatives.	UC1 (Madrid)
F1 score	Harmonic mean of precision	Compute	Calculated as: 2*(precision * recall)/ (precision + recall).	UC1 (Madrid)
Communication reliability	Success probability of transmitting a layer 2/3 packet within a maximum latency required by the targeted service (ITU-R M.2410)	Availability Reliability	Calculated based on packet loss and round-trip time (RTT) latency measurements.	UC2, UC3, UC6

Service reliability	Period of time for which the service satisfies the required performance constraints (downlink/uplink capacity, E2E latency)	Availability Reliability	Calculated based on packet loss and latency measurements.	UC1(Iasi), UC4
Communication availability	Capability of transmitting a given amount of traffic within a predetermined time duration with high success probability	Availability Reliability	Calculated based on packet loss	UC2, UC3, UC6
Service availability	Ratio between the amount of time during which a specific component of the use case (application, server, network function, etc.) is responding to the received requests, and the total amount of time that the component has been deployed.	Availability Reliability	Calculated as: uptime/(uptime+downtime). Tools: iperf, netem, ostinato, moongen, ntopng, cilium, twamp.	UC1 (Madrid, Iasi), UC4, UC7, UC8, UC9
Location accuracy	Accuracy in the positioning of the device obtained through the 5G network	Localization	Calculated as the difference between the position of a device estimated by the overall system and the actual position	UC2, UC3, UC6, UC10, UC11

Table 2. KPI definition management process.

Action	Status	Deliverable
Initial definition of KPI for each use cases	Completed	D3.1, D4.1, D5.1
Revision of KPI definitions across all use cases	Completed	D6.1
Interaction with use cases for final definition of KPIs	Planned	-
Adoption of common KPI definitions	Planned	D3.2, D4.2, D5.2, D6.2

3 Business models and KVIs

This section focuses on the business models and the KVIs definition, and it is organized as follows.

In Section 3.1 the value aspect of wireless technology is explored, analysing the relation between technology, business, and value. There is an intricate relationship between technology advancement, business growth and value, each of which influences the development of society in a dynamic and interdependent manner. As technology advances, it opens new avenues for businesses to innovate, streamline processes, and reach new and wider markets. This growth in turn creates economic opportunities that shape societal values and expectations. Concurrently, the values held by businesses and societies influence the direction of technological development, as they both ideally drive demand for ethically aligned solutions and sustainable practices. In addition, willingness to pay by the end user can be considered in some cases as an assessment of the KVs considered. Section 3.1.2 presents relevant frameworks for business model options that have been considered as reference by TrialsNet. These are based on the experience developed during the 5G-TOURS project and are required to ensure that advances in wireless technology are translated into sustainable deployments and uses, whereas benefits can be sufficiently translated into revenue streams to balance against costs.

Section 3.2 presents a literature review of KVs and KVIs that are studied in the technological context of 6G. In particular, the analysis done in 6G-IA and other EU projects on KVs and KVIs are presented. A summary on socioeconomic value in the wireless sector addressed in the context of different EU projects is also reported. Section 3.3 presents the KVs, KVIs and KV enablers definitions that will be adopted in TrialsNet project. In addition, several categories of values in the technological 6G context are also presented.

3.1 Business model, value, and technology

In this section the link between business, value and technology is presented, and an overview of business models and innovation frameworks is also shown.

3.1.1 Relationships between Technology, Business and Value

The relationship between technology, business, and value is intricate and mutually influential. Technology has become a critical enabler and driver of growth in the business world. In the case of wireless technology, this may be via enabling operational efficiencies in existing or new business processes and/or providing the ability to deliver new services and experiences. It has transformed the way businesses operate, communicate, and deliver products and services. By leveraging technological advancements, businesses can streamline operations, enhance productivity, and tap into new market opportunities. At the same time, technology itself is shaped and driven by the needs and demands of the business world and society, as companies drive innovation through research and development, investment[1] and market competition. One of the ways technology adds value to businesses is through increased efficiency and productivity as shown in Figure 2.

[1] In classical economics the means of production are the resources and tools that make it possible for products and services to get created. Fundamentally this boils down to Land, Labour and Capital, by the time of early industrial society, the means of production included the machinery and raw materials in a factory. Now it also includes offices, computers, and other technology.

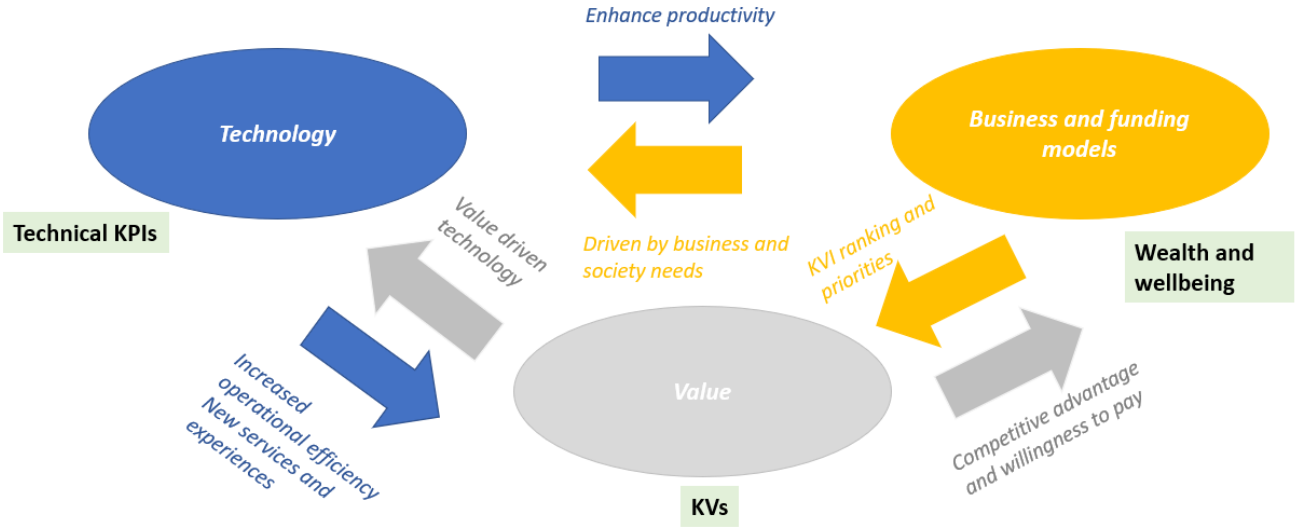

Figure 2. Links between technology innovation, value generation, and business and funding models.

The relationship between technology and value is significant and multifaceted. Technology plays a crucial role in creating, enhancing, and capturing value across various domains, including economies, societies, environment and individuals. Technology, in particular innovation in wireless technology, contributes to value creation by improving efficiency and productivity. Through automation and process optimization, and the use of advanced tools and systems in the wireless sector, this can potentially reduce operational costs and improve network performance. This enhanced efficiency translates into greater customer satisfaction and a higher probability of willingness to pay. By leveraging technology, businesses can achieve higher levels of productivity and ultimately deliver more value to their customers and stakeholders which in return will translate into sustainable revenue stream and funding models in the wireless sector and in the related verticals.

In addition to business related values, technology also has a broader societal impact. It has the potential to address social challenges, improve quality of life, and create positive change. Wireless technologies in areas such as healthcare, education, energy, and transportation have the power to save lives, increase access to services, and promote sustainability. By leveraging these technologies for social good, organizations can generate value that extends beyond financial metrics, contributing to the betterment of communities and societies.

However, it is important to recognize that the value derived from technology is not automatic or inherent. It depends on how technology is utilized, implemented, and managed. The successful integration of technology requires strategic planning, alignment with organizational goals, investment in skills and capabilities, and continuous adaptation to emerging trends and challenges. Furthermore, ethical considerations, such as privacy, security, and inclusivity, must be addressed to ensure that technology-driven value creation is sustainable and beneficial for all stakeholders.

Technology also opens up new opportunities for innovation. It enables the development of new products, services, and business models, leading to market differentiation and competitive advantage. Innovative technologies such as artificial intelligence, machine learning, blockchain, and the Internet of Things (IoT) have the potential to transform industries, create new markets, and drive economic growth. Companies that successfully embrace and harness these technologies can generate significant value by being at the forefront of innovation.

Automation and digitalization have revolutionized various aspects of operations, ranging from manufacturing and supply chain management to customer service and administrative tasks. By deploying advanced technologies like Artificial Intelligence (AI), Machine Learning (ML), robotics, and data

analytics, businesses can optimize processes, reduce costs, minimize errors, and enhance overall productivity. This increased efficiency often translates into higher profitability, competitive advantage, and improved customer satisfaction.

Moreover, technology has opened up new avenues for business growth and expansion. The digital age has given rise to an interconnected global marketplace, where businesses can reach a wider audience and explore untapped markets. Technology has also enabled the development of innovative business models, such as subscription-based services, sharing economy platforms, and on-demand marketplaces, which have disrupted traditional industries and created new sources of value. Technology, while often hailed for its many positive contributions to society, can also be wielded with malicious intent. It underscores the importance of responsible innovation, ethical considerations, and robust security measures to safeguard against the dark side of technology.

However, it is crucial to note that the value derived from technology is not solely dependent on its adoption but also on its strategic implementation and alignment with business objectives. Businesses need to carefully assess their specific needs, evaluate the potential benefits and risks of technology investments, and develop a comprehensive digital strategy. This strategy should encompass areas such as infrastructure, talent acquisition and development, data management, cybersecurity, and ongoing innovation. Effective integration of technology within the business ecosystem requires strong leadership, collaboration across departments, and a culture of continuous learning and adaptation.

In conclusion, technology plays a pivotal role in value creation across multiple dimensions. It enhances efficiency, drives innovation, facilitates collaboration, and addresses societal needs. Value can help in leveraging technology effectively in the telecom sector, and drives businesses and funding models, in return this translates into unlocking new opportunities, drive growth, and achieve sustainable development. However, realizing the full potential of technology requires a thoughtful and strategic approach that aligns technological advancements with broader business goals and values. Private and public investors in technology need to be mindful of the wider impacts and the need to create wider pools of value. Hence in the following section business models and Technology, Market, Organization and Governance (TMOG) frameworks are introduced.

3.1.2 Frameworks and business models

A business model is a comprehensive framework that outlines how a company creates, delivers, and captures value. It encompasses various elements, including the company's target customers, the value it provides to those customers, their willingness to pay, the way it generates revenue, and the strategies it employs to sustain its operations and growth. In essence, a business model serves as a blueprint that defines the fundamental structure and approach a business takes to operate profitably and successfully in its chosen industry or market. There are several business models that an organization in the technology sector could employ, the business model will describe how a vertical related organization creates, delivers, and captures value, in economic, social, cultural and other contexts. In particular the framework business models will establish which use cases have the potential for the greatest value creation, a literature review of business models was presented in deliverable D8.1 of 5G-TOURS [9], these frameworks include:

- Business Model Canvas
- Value Chain
- V4 Business Model

The business model canvas is a template for developing new or documenting existing business models. It is a visual chart with elements describing an organization or product's value proposition, infrastructure, customers, and finances as shown in Figure 3.

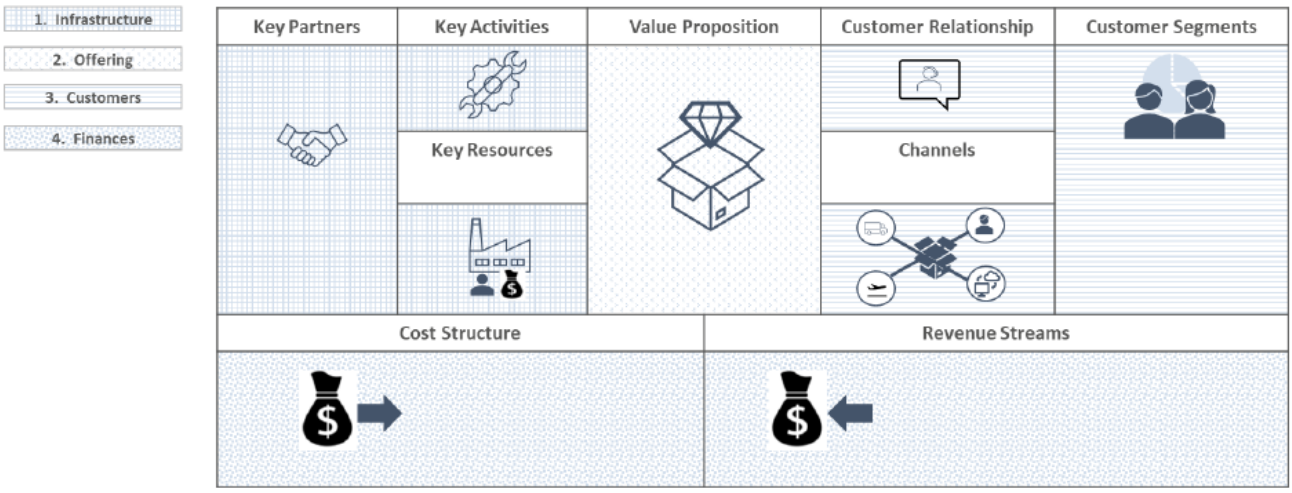

Figure 3. Business model Canvas.

The use of the business model Canvas was recommended in the original proposal [10] as the primary tool for understanding an organisation "money earning logic" and as a means of analysing the following four aspects of the business process and determining the value proposition, as traditional business models tended to prioritize short-term profits and overlook long-term sustainability. However, with growing awareness of environmental and social challenges, there is a need to shift towards models that balance economic viability with responsible practices.

The role of business models in encouraging sustainable innovation is vital in today's rapidly changing world. As technological advancements continue to shape industries and societies, businesses must adapt their models to ensure responsible and sustainable practices.

The TMOG framework shown in Figure 4. TMOG framework. was introduced in 5G-TOURS for the innovation assessment. Originally this framework was introduced by Oxford University as TMO (Technologies, Markets & Organisations) as part of the content for its Strategy & Innovation courses [11], the "G" part, i.e. governance, was added in 5G-TOURS. This framework recognises the huge variety of scale and scope that exists within the innovation space and in particular across these several dimensions. This empowers managers to develop robust strategies that support successful innovation and deliver greater value for their organisations, their partners and their stakeholders. As explained in Section 5.1 of deliverable D2.3 in 5G NORMA [12], the three pillars of value creations are government (political benefits), private companies (private benefits) and consumers (common or social benefits).

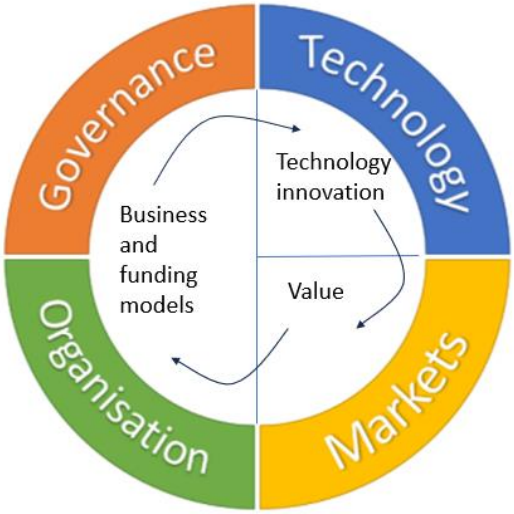

Figure 4. TMOG framework.

The European Commission's stated aims include achieving sustainable development and social progress and protecting and improving the quality of the environment. TMOG allows for innovations to be rated on the basis of their impact on the environment and on society. Additionally, it is designed to mirror the values, ethics, and incentives of the organizations and individuals engaged in implementing and leveraging innovations. This aspect has grown in significance within the realm of investment decision-making. For more information about the framework readers may refer to deliverable D8.5 of 5G TOURS [13].

The TMOG framework is introduced in the TrialsNet project as part of the KVs assessment methodology across the UCs of the project. As illustrated in the previous paragraph, there is a strong link between technology, business and value. Commercial value is important for business prosperity, however by recognising and targeting wider value it is possible to achieve long-term sustainability and positive societal impact.

3.2 Literature review on KVs and KVIs

The terms KVs and KVIs were recently introduced in the telecoms sector as part of 5G-advanced/6G visions. There are several projects, reports and white papers that have analysed the aspect of KVs and KVIs. A comprehensive literature review was done on these subjects and is presented in this section. At the end of this section a summary of the work performed in previous EU projects (5G NORMA, 5G-MoNArch and 5G-TOURS) on the analysis of the socio-economic value in the wireless sector and how this value can be translated into willingness to pay is reported.

3.2.1 Hexa-X project

Hexa-X is an EU funded project where several aspects of KVs and KVIs are analysed. According to their analysis in order to comprehensively evaluate the scope of 6G, it is essential to consider KVIs that encompass a broader range of impact dimensions beyond traditional deterministic performance measures. These dimensions include sustainability, digital inclusion, and trustworthiness. To effectively quantify and compare the contributions of technical enablers to each relevant key value target, novel KVIs are derived. The link between KVIs, KPIs and new capabilities are also analysed in the project. While some of KVIs may be evaluated directly, in most cases, they are associated with a set of KPIs that serve as proxies for the respective KVIs. These KPIs represent the characteristics or capabilities necessary for realizing specific use cases and their associated values as shown in Figure 5.

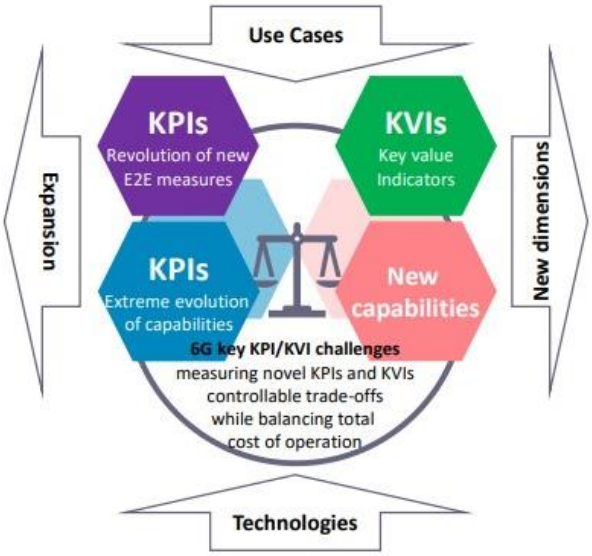

Figure 5. Key value and performance indicators.

The assessment of different types of KPIs in relation to quantifying a target, such as Sustainable Development Goals (SDGs) or additional targets driven by use cases and societal needs, leads to the definition of KVIs. These KVIs play a crucial role in quantifying the societal value that 6G will bring beyond communication-related technical KPIs. The application of this methodology also extends to addressing sustainability within the context of 6G.

The establishment and consideration of these KVIs, as described in [14], contribute to economic growth and value expansion. It emphasizes the shift in the fundamental network design paradigm pursued by initiatives like Hexa-X, which aims to transform the focus from purely performance-oriented network design to a holistic approach that incorporates both performance and value considerations.

The introduction of the innovative concept of KVIs incorporates the essential aspects of trustworthiness, inclusiveness, and sustainability. This concept highlights the impact of key enabling technologies on the creation of value for products, services, and society as a whole.

Figure 6 illustrates the key value areas as stated in the Hexa-X vision and associated KPIs and capabilities. Each key value area reflects multifaceted aspects for which KVIs need to be developed [15]. The key values are sustainability, inclusiveness and trustworthiness, where sustainability is explicitly considered from two perspectives in Hexa-X 6G in itself needs to be sustainable, this can for example be mapped to the network energy efficiency as a KPI. In addition, 6G is an enabler for sustainability and sustainable growth in other markets and value chains, potentially covering aspects of inclusiveness and trustworthiness.

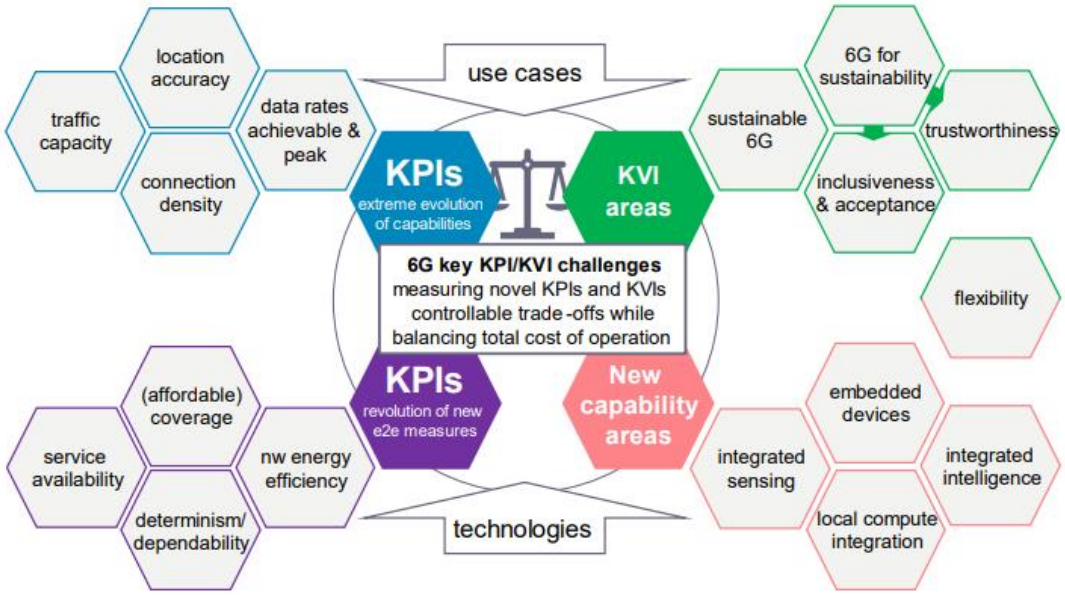

Figure 6. Clustering of KPIs and KVIs.

3.2.2 6G-IA white paper

The document [16] introduces why the societal values are important and being discussed. The 6G-IA paper outlines a societal value-driven approach to technology development, which builds upon the concept of KVIs and complements the existing performance-based approach that employs KPIs. KVIs serve as indicators of pertinent societal values that can be enabled or influenced by future technology, particularly the novel services offered by 6G.

The performed analysis demonstrates the connection between the studied use case areas and the key societal values that can be facilitated by future 6G networks. Moreover, it is feasible to define KVIs to assess the impact of these values. To enhance this analysis, ongoing development involving subject matter experts and its application in forthcoming 6G research projects were proposed.

According to the paper, the utilization of KVIs in the development of 6G serves two main purposes: first, to demonstrate and validate that 6G can effectively address societal needs, and second, to steer technology development towards directions that yield value-driven benefits.

The framework proposed in the study aims to define value creation and enhancement in the context of 6G integration and operation within the realm of smart services in cities and metropolitan areas. The white paper clarifies that KVIs differ from KPIs as they provide deeper insights into factors related to human experiences and may require open conversations and creative thinking for their emergence.

In the paper, the SDG criteria are categorized into three areas: economical, societal, and environmental as shown in Figure 7.

Figure 7. Illustration of the SDGs ordered in three areas.

It is worth noting that analysts often view the SDGs in isolation, which leads to a focus on individual goals, the interdependency between SDGs is critical for a comprehensive and successful study.

KVIs revolve around comprehending the contextual factors in which technologies operate and recognizing the resulting societal value they offer. To gain insights into such environments, it is crucial to seek feedback from the various stakeholders involved. In situations involving significant ethical and legal challenges, an approach that incorporates human practices and expertise becomes particularly valuable. Methodologically, this presents an opportunity to utilize recommended techniques in technology development, such as conducting interviews or focus groups to assess user reactions to prototypes. These methods generate qualitative data that can be insightful and provide specific perspectives. However, working with such data can pose challenges when attempting to quantify it. As the paper points out, KVIs provide a means to capture a broader perspective, contextual information, and human insights or expertise, while leveraging a combination of qualitative and quantitative metrics to demonstrate value.

The paper recommends that KVI should represent a measurable quantity or requirement that, in some manner, provides an estimation of the affected societal value. This enables the formulation of targets using KVIs, such as determining the number of service users meeting a specific condition or assessing the perceived fulfilment of the required value through service usage.

When analysing a use case, this process involves examining which KPIs would serve as useful indicators for estimating the related KVI. However, depending on the nature of the KVI, it may not always be feasible or meaningful to establish a direct relationship with specific KPIs.

As mentioned in the paper, the work is presented as a trigger and invitation for further discussions and collaboration to improve this analysis. The framework and methodology are also relevant for evolved 5G, and interaction and results transfer between the more near term (higher technology readiness level) and the long term (lower technology readiness level) analysis can be considered.

The approach shown in Figure 8 and presented in 6G-IA paper is applied to the analysis, as detailed in Section 3.3.

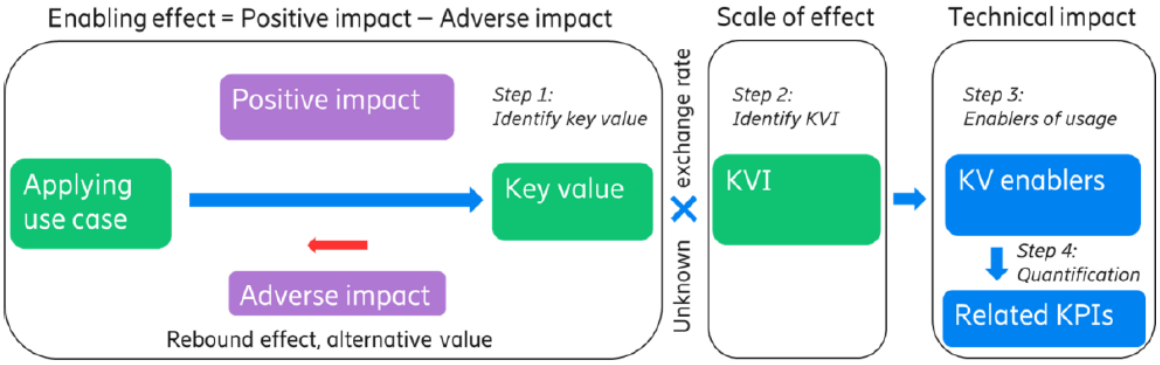

Figure 8. Overview of the KVI analysis in four steps.

3.2.3 Other KVIs work in the wireless industry

According to the white paper [17] published by Nokia, 6G demonstrates its difference from previous generations by recognizing from the beginning the need for defining KVIs such as sustainability, trustworthiness and digital inclusion to drive key challenges of research, as well as to enable various use case families of the 2030s. New terminologies such as "societal pull" and "technology push" are introduced in the paper in the context of 6G technological journey, in other words, considerations of both “societal pull” and “technology push” drive the 6G research journey in scope and substance. In addition, a new class of evaluation criteria KVIs that assess sustainability and trustworthiness should be understood, developed and adopted in the system architecture design evolution to 6G.

The paper emphasizes that in order to satisfy the new requirements that include both KPIs and KVIs, the 6G architecture should evolve in six key areas as shown in Figure 9.

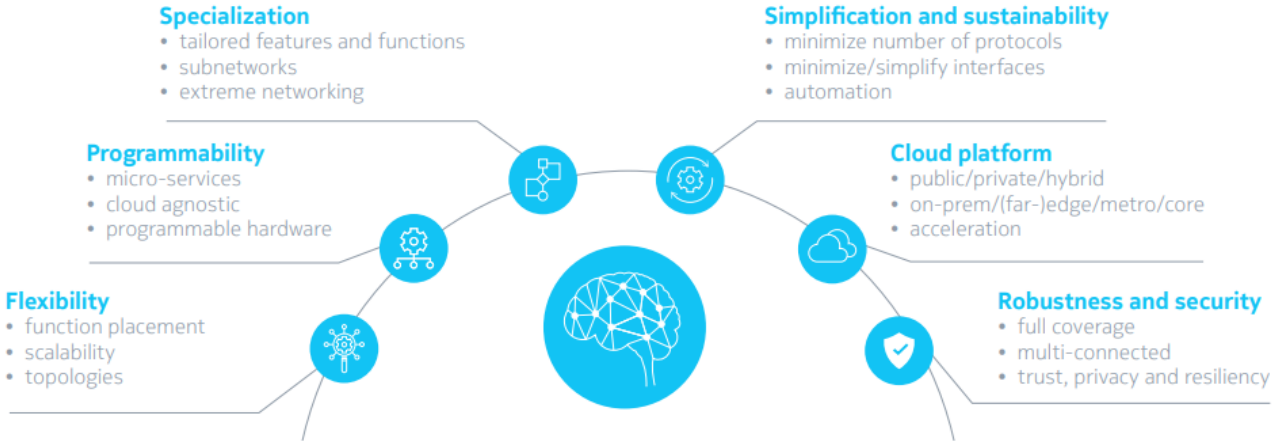

Figure 9. 6G design goal.

Beyond the terrestrial network, [18] claims that contribution to KVIs' could also be done by Non-Terrestrial Network (NTN) since satellite communication is considered as part of 6G technology. The KVIs of satellite communications being ubiquity, continuity, scalability & resilience stand to play a central role in 6G networks as shown in Figure 10.

Figure 10. Contribution of NTN to KVIs [18].

An approach to KVIs and KPIs mapping was introduced in DEDICAT 6G project [19], summarized in 6 steps as shown in Figure 11. This includes identification of KVIs and mapping of technical enablers for H2020 and SDGs societal challenges, the approach also includes the mapping of KPIs to SDGs challenges. The analysis focuses on the societal KVs side only.

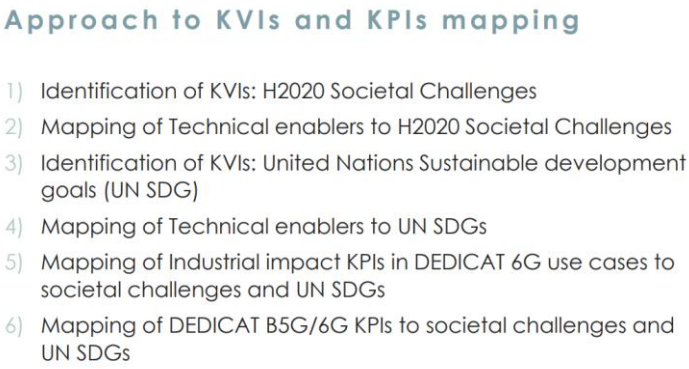

Figure 11. Approach to KVIs and KPIs mapping [19].

In [20] a list of KVs was presented in a table format as shown in Figure 12. These KVs are associated to several verticals and given a priority score compared to 5G, i.e., high, nominal and low, against each of the vertical. According to the white paper, ethics, for example, has nominal priority in industry mMTC (massive Machine-Type Communications) and high priority in the industry eURLLC, (enhanced Ultra-Reliable and Low Latency Communications) mobility, finance and eHealth.

Vertical	Ethics	Trust	Privacy	Security	Inclusion
Industry mMTC	Nominal	High	High	High	Low
Industry eURLLC	High	High	High	High	Low
Mobility	High	High	High	High	High
eHealth	High	High	High	High	High
Energy	Nominal	High	High	High	Nominal
Finance	High	High	High	High	High
Public Safety	High	High	High	High	Nominal
Agri-business	Nominal	High	Nominal	Nominal	High

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Figure 12. Key values as presented by [20].

3.2.4 Work on socio-economical value in other EU projects

Over the last decade many European projects (like 5G NORMA, 5G-MoNArch, and 5G-TOURS) studied the effect of technology on value and how to quantify it, with a specific focus on analysis of the socioeconomic value impact within the wireless industry and how this can be quantified in terms of willingness to pay.

In Sections 4.2 and 4.3 of [12], the revenues from Vehicle to Infrastructure (V2I) services and smart city services were evaluated, while in Section 5 the socio-economic value across both of these service types was analyzed and conclusions were drawn on actions needed to realize social values, this includes public private partnerships.

In Section 3.3 of [21], the operational and economic benefits of port services, e.g., port of Hamburg, were quantified. The benefits from an Augmented Reality (AR) in tourism app and V2I services were assessed. Section 7 of [22] analyzed the commercial and socio-economic benefits and value across an airport, museum and hospital settings; the key findings concluded that some use cases have a high socio-economic but low commercial value and vice versa.

In summary, some use cases generate considerable economical value however others deliver more socio-economic benefits, and these will not be realized without public intervention. In the context of this project's analysis, the links between socio-economical values and willingness to pay are identified.

3.3 Definitions of KVs, KVIs and enablers

A value is a fundamental concept in various fields including mathematics, philosophy, economics, and more. In a general sense, a value represents a principle, belief, or quality that is considered important or desirable. As shown in Figure 13 there are a few contexts in which the term value could be used:

- **Mathematics**: In mathematics, a value is a numerical quantity that can be assigned to a variable or used in calculations.
- **Economics**: In economics, value refers to the worth of a good or service in terms of its usefulness, utility, or desirability.
- **Ethics and Philosophy**: In ethics and philosophy, values are the principles or beliefs that guide individuals' actions, decisions, and judgments. These can include values such as honesty, compassion, freedom, and justice.
- **Computer Programming**: In computer programming, a value is a piece of data that can be stored and manipulated by a program.
- **Cultural and Societal Contexts**: Values can also refer to cultural, societal, or personal beliefs about what is right, wrong, important, or meaningful. These values shape behaviors and decisions within societies.
- **Environmental**: It refers to the worth or significance of natural resources, ecosystems, and the overall environment to individuals and communities. It encompasses the various benefits and services that the environment provides to both human beings and the planet's ecosystems.

The meaning of value can vary based on the context in which it is used. It generally relates to the significance, worth, or importance assigned to something, whether it is a number, a belief, an object, or a concept.

In Figure 14, over 130 values are shown [23]. These values are divided into 4 categories:

- **People**: Social
- **Planet**: Environmental
- **Profit**: Economic viability
- **Progress**: Technological feasibility

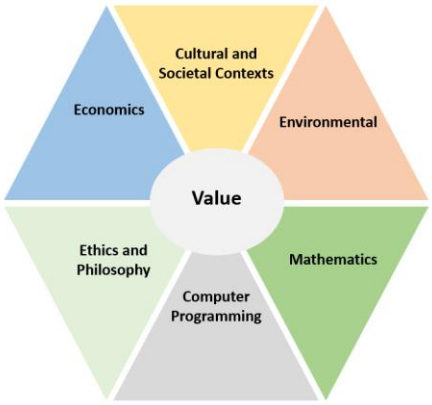

Figure 13. Value and context.

The work in [23] explains the relation between value creation and innovation, the values in this context are linked to the business side and unique benefits of a technology or a product. Some of the values shown in Figure 14 could be applied to some of the use cases of TrialsNet, this depends on the considered vertical and the related UC.

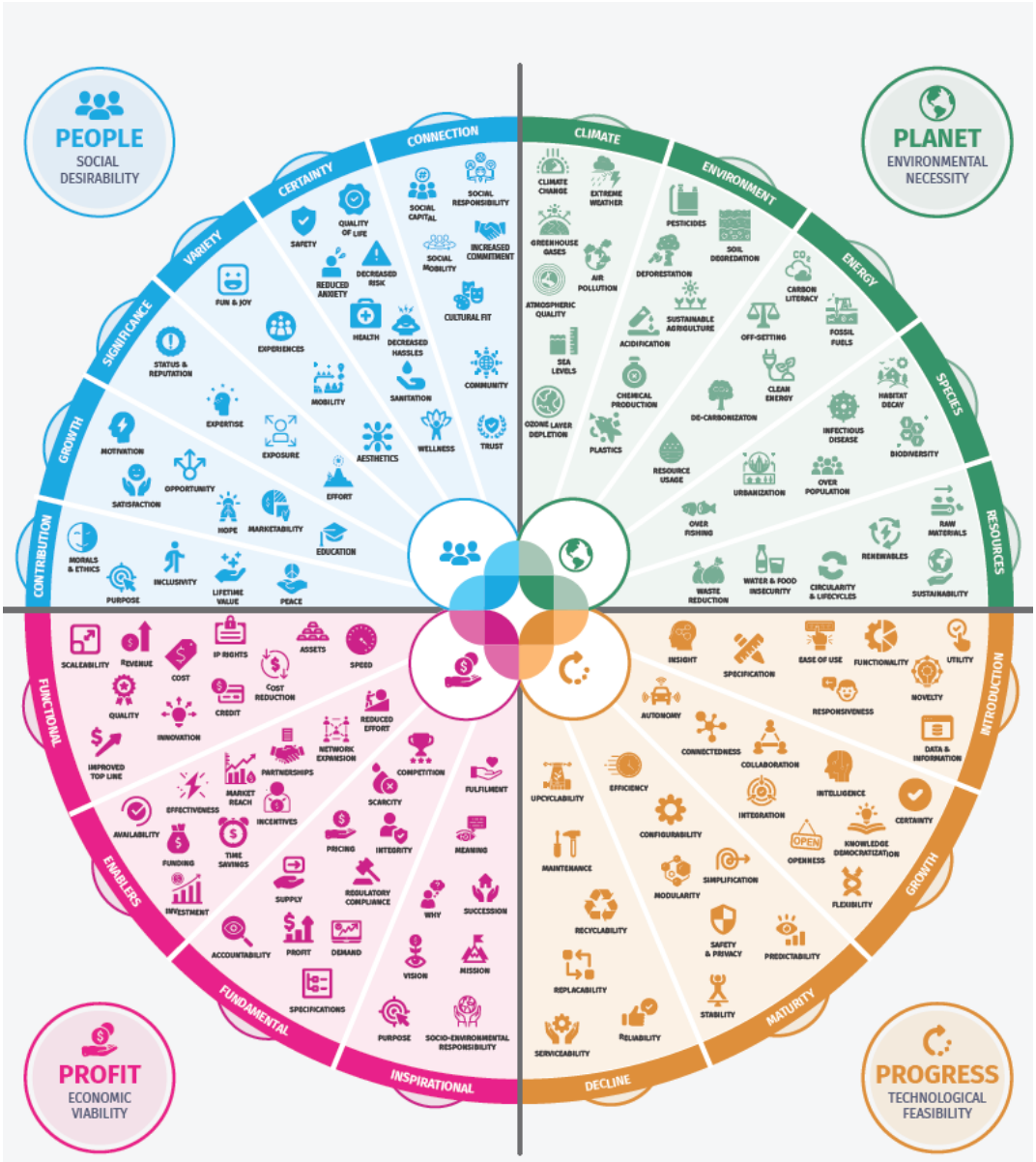

Figure 14. Value types wheel [23].

The TrialsNet project acknowledges the intricate relationship between enabled business models and societal benefits, which influences technology acceptance models by taking into consideration the environmental impacts. The use cases identified and described in the project have a socio-economic and environmental effects. TrialsNet aims to establish a strong connection between technology and its positive impact on society, environment and economy, hence the project analyzes the values according to these three categories. The project focuses on developing assessment frameworks that enable the evaluation of use case dynamics for societal and environmental acceptance, specifically in the context of 6G solutions. Hence the concept of KV will be analyzed across the UCs in the project, this increased visibility not only benefits the wireless industry but also aids non-technical adopters, such as users in the public, commercial or environmental sectors, in understanding the advantages. As shown in the previous sections, the concept of KV and KVI were recently introduced in the several research works [24] and [25]. According to 6G-IA, the utilization of KVIs in the development of 6G serves two main purposes: first, to demonstrate and validate that 6G can effectively address societal needs, and second, to steer technology development towards directions that yield value driven benefits, as highlighted in Section 3.2. Figure 15 shows the steps and the questions to address to properly define the link between KVs and KPIs.

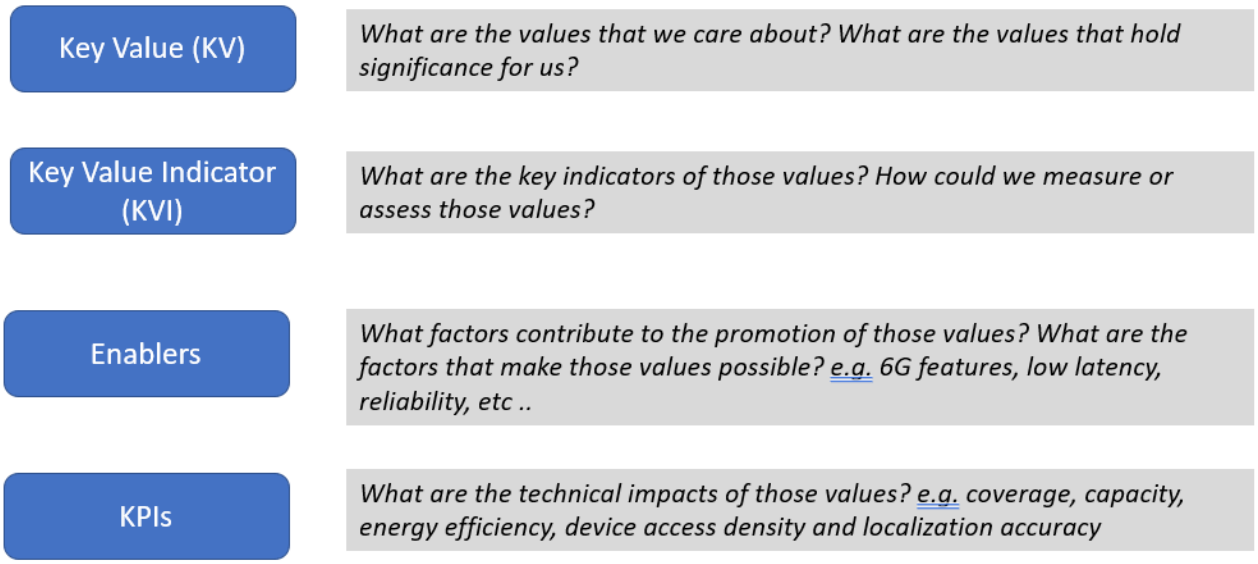

Figure 15. Steps and questions to define KPIs from KVs.

As shown in Figure 2, the adopted methodology starts by defining the KVs that are relevant to the project UCs, and then provides an assessment of those values, i.e., KVIs. It is also worth analyzing the enablers of these KVs and the technical impacts of the values, i.e., KPIs. For example, in the case the environmental sustainability is considered as a KV, KVI could be assessed by measuring the CO_2 emissions of a mobile network. The enablers of such KV would be developing a more efficient radio network and the impacted KPIs are received bits/Joule.

In the previous deliverables of the project D3.1 [1], D4.1 [2], and D5.1 [3], a list of KVs were provided for each use case. The total number KVs defined in TrialsNet is close to 50 and these are distributed across 13 UCs. Note that the same KVs may be present in several UCs. Some of these values can be translated into willingness to pay and revenues that feed into commercial business models and make new technological innovations commercially available and sustainable. Others can be used to show organizational, societal and governance targets being met, depending on the environment that the new technology is being used in. Depending on the business and funding model being used to drive the realization of new technologies, there will be a natural ranking and prioritization across the identified KVs.

The framework proposed in TrialsNet categorizes the values as illustrated in Figure 16, with the resulting categories of:

- Economical
- Environmental
- Societal

This categorization will ideally help with the prioritization of KVs for each use case depending on the direction of the business and funding model.

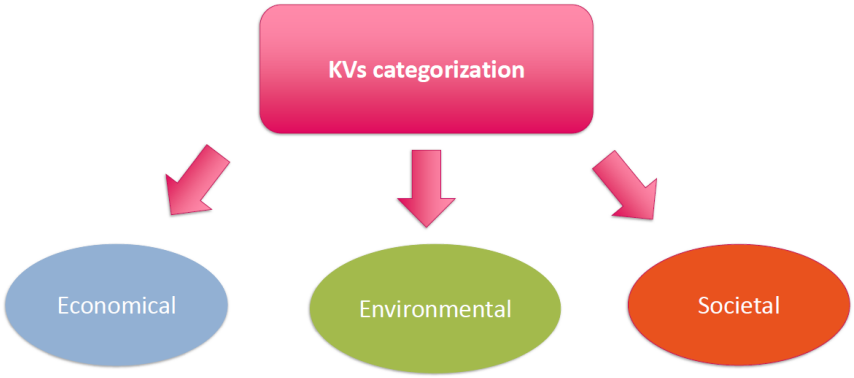

Figure 16. Categories of KVs.

Some values may belong to one category, two categories or even three categories. Some KVs have an economical value by generating business benefits and at the same time have societal value by contributing to the well-being of the society. For example, the KV "business effectiveness" belongs principally to the economical category, as businesses are more efficient and productive, hence eventually a higher growth and profit occurs. However, this KV has also a positive effect on the well-being and development of the society, a lower unemployment rate is recorded when businesses grow.

In future deliverables, the KVs proposed in the project will be analyzed further and classified according to the categories presented in this section. In previous deliverables D3.1 [1], D4.1 [2], and D5.1 [3] preliminary definitions of KVIs for the different use cases were provided but not yet categorized with the framework presented in this document. To achieve this, the management process shown in Table 3 will be pursued.

Table 3. KVs and KVIs definition management process.

Action	Status	Deliverable
Definition of KV, KVIs and KVs enablers	Completed	D6.1
Acknowledge issues in KVIs definition in previous TrialsNet deliverables	Completed	D6.1
Rectify definitions of KVs and KVIs	Planned	D6.2
Analysis and categorization of KVs across UCs	Planned	D6.2/D6.3
TMOG framework and links to willingness to pay	Planned	D6.2/D6.3

4 Design Thinking methodology

Design Thinking (DT) is a well-established problem-solving approach that combines creativity, empathy, and logic to come up with innovative solutions [26] [27] [28] [29] [30]. It is a human-centred design methodology that can be applied to any problem, from product design to organizational change. The process consists of several stages, including empathize, define, ideate, prototype, and test as illustrated in Figure 17 and described hereafter:

- **Empathize**: The first step in the DT process is to gain a deep understanding of the people you are trying to help. This involves observing, listening, and learning about their needs, motivations, and pain points. This stage helps to ensure that the developed solution is based on real needs and not just assumptions.
- **Define**: In this stage, what has been learned in the empathy stage is used to define the problem to solve. The problem should be clearly articulated in a way that is easy to understand and communicate. This stage helps to ensure that everyone is working towards a common goal.
- **Ideate**: In this stage, as many ideas as possible are generated to solve the problem. This is a time to be creative and think outside the box. A wide range of ideas, from the practical to the fantastical is encouraged. This stage is about coming up with as many possible solutions as possible.
- **Prototype**: In this stage, a tangible representation of the solution is created. This can be anything from a physical model to a digital prototype. The goal of this stage is to create something that can be tested and iterate upon.
- **Test**: In the final stage, the prototype is tested with real users to see how well it solves the problem. This stage is critical for identifying any weaknesses or limitations in your solution and for making improvements. One should be prepared to make changes based on the received feedback.

The DT process is iterative, meaning that is possible to go through these stages multiple times before arriving at a final solution. It is important to be open to feedback and to be willing to make changes along the way. The goal of the process is to develop a solution that meets the needs of the users and that solves the problem in a creative and innovative way.

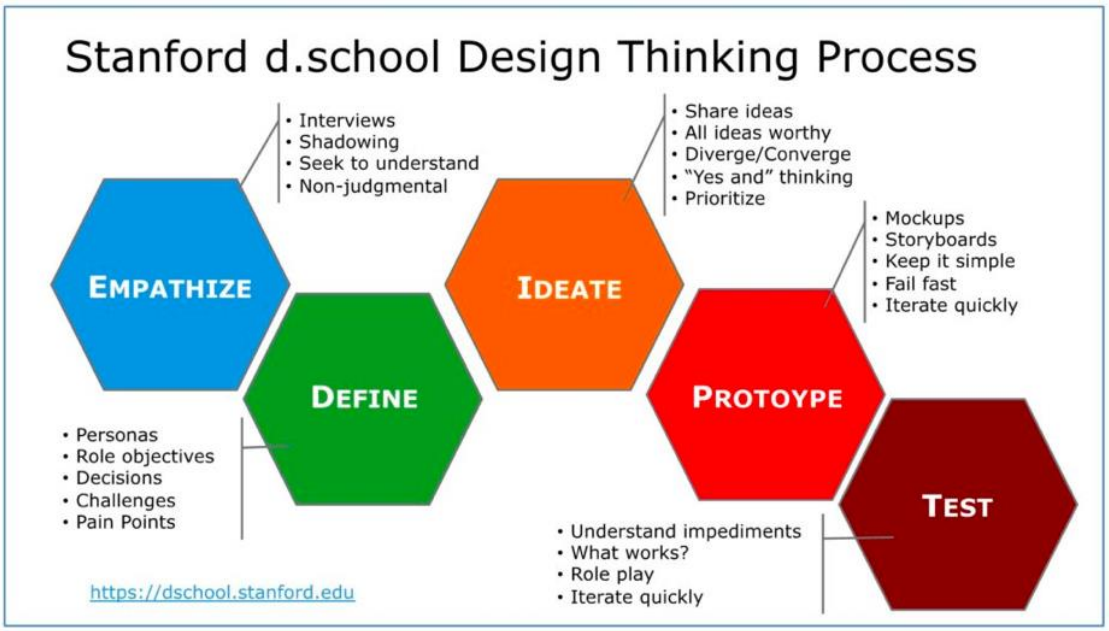

Figure 17. The Design Thinking process.

4.1 Opportunities of Design Thinking

The DT process offers many opportunities for individuals and organizations to solve problems in innovative and effective ways. Some of the key opportunities include:

- **Empathy-driven problem-solving**: By starting with empathy, DT ensures that solutions are based on a deep understanding of the people and their needs. This leads to solutions that are more relevant and effective.
- **Innovation**: DT encourages a wide range of ideas and encourages creativity, leading to innovative solutions that might not have been considered using more traditional approaches.
- **Collaboration**: DT requires collaboration among team members from different backgrounds and perspectives, leading to a more diverse and well-rounded solution.
- **User-centered approach**: By putting the user at the center of the problem-solving process, DT ensures that solutions meet the needs of the people they are intended to help.
- **Iterative process**: DT is an iterative process, allowing for the continuous refinement and improvement of solutions. This leads to better outcomes and more effective solutions.
- **Improved decision-making**: The DT process allows for the rapid prototyping and testing of solutions, providing data-driven insights into what is working and what isn't. This leads to more informed decision-making.
- **Increased adaptability**: The DT process helps individuals and organizations to become more adaptable and agile in their approach to problem-solving, allowing them to quickly respond to changing circumstances and challenges.
- **Enhanced customer experience**: By focusing on the user and their needs, DT leads to solutions that improve the customer experience, leading to increased satisfaction and loyalty.

4.2 Challenges of Design Thinking

The DT is a powerful approach to problem-solving, but it also comes with its own set of challenges. Some of the main challenges of DT include:

- **Resistance to change**: DT often requires individuals and organizations to change their mindset and approach to problem-solving. This can be challenging, as many people are resistant to change and may not be familiar with the DT process.
- **Time constraints**: The DT process can be time-consuming, especially when it involves multiple stages and iterations. In fast-paced environments, it can be difficult to allocate enough time for the process.
- **Lack of structure**: DT can sometimes be perceived as unstructured and chaotic, making it difficult for some people to understand and embrace. This can be especially challenging for organizations that are used to more traditional approaches to problem-solving.
- **Balancing creativity and practicality**: DT encourages creativity, but it also needs to result in practical solutions. Finding the right balance between creativity and practicality can be challenging, especially when dealing with complex problems.
- **Managing stakeholder expectations**: DT often involves a lot of collaboration, which can lead to conflicting opinions and expectations. It can be challenging to manage these expectations and ensure that everyone is working towards a common goal.
- **Ensuring long-term success**: DT is a process that is meant to produce innovative solutions, but it is also important to ensure that these solutions are sustainable and effective in the long term. This requires careful consideration of the feasibility and impact of the solution.

These challenges can be overcome by having a clear understanding of the DT process, being open to change and feedback, and having strong leadership and collaboration skills.

4.3 Extending Design Thinking to support context constraints

DT is a human-centered approach to problem-solving that involves understanding user needs, prototyping and testing solutions, and iterating until a successful solution is found. However, the DT process can be constrained by various factors such as time, budget, resources, and organizational culture. Here is a deeper look at how the DT process can be adapted to meet these constraints:

- **Time constraints**: When time is limited, the DT process must be streamlined to focus on the most critical and impactful aspects of the problem. This might involve conducting a rapid user research study that focuses on a specific aspect of the problem, simplifying prototypes to test only the most critical components of a solution, and making decisions more quickly. Designers can also prioritize their work and focus on the most critical aspects of the problem to ensure that they deliver a solution within the available time frame.
- **Budget constraints**: When budgets are tight, designers must be resourceful in finding low-cost solutions. This might involve using open-source tools, leveraging existing resources, conducting user research with low-cost methods like surveys or online forums, and working with stakeholders to reprioritize the budget. Designers can also look for creative solutions that can be implemented quickly and with limited resources, such as crowd-sourcing ideas or engaging with a network of volunteers.
- **Resource constraints**: When resources are limited, designers must prioritize their work and focus on the most critical aspects of the problem. This might involve outsourcing certain tasks, collaborating with other departments, or finding creative solutions to resource constraints. Designers can also look for ways to optimize their existing resources, such as finding ways to reuse existing materials or finding new ways to leverage existing technology.
- **Cultural and social constraints**: Harnessing the power of DT for innovation holds the promise of inspiring profound positive social and cultural transformations. Within this creative framework, the dynamic interplay of social constraints becomes an opportunity for fostering collaboration and empathy. It encourages organizations to flatten hierarchies and promote diverse participation, ultimately leading to more inclusive and equitable solutions. Moreover, DT embraces cultural richness as a source of inspiration rather than a hindrance. By respecting and celebrating cultural nuances, it can generate innovations that resonate deeply with diverse communities, contributing to a more culturally aware and harmonious world. In this light, DT emerges as a catalyst for not only addressing societal challenges but also nurturing a global tapestry of innovation that celebrates the diversity of our planet.

Ultimately, the success of the DT process depends on the ability of designers to work within the constraints imposed by the context, while still maintaining the core principles of empathy, experimentation, and iteration. This may require a combination of creativity, flexibility, and resourcefulness, as well as strong communication and collaboration skills to engage stakeholders and build support for the DT process. By adapting the DT process to meet the constraints of each unique context, designers can create impactful solutions that meet the needs of their users and deliver real value to their organizations.

4.4 Design Thinking in practice

DT is a human-centered, iterative, and solution-focused approach to problem-solving. The three key elements of desirability, feasibility, and viability form the basis for evaluating the potential success of a solution:

- **Desirability** is focused on understanding and empathizing with the users and creating solutions that meet their needs, wants, and desires. This element involves researching and observing users, gathering feedback and insights, and ideating and prototyping solutions that are desirable

to the users. The focus is on creating a solution that is not only functional but also appealing and appealing to the users.

- **Feasibility** is about determining whether a solution can be technically and logistically implemented. It involves evaluating the technical and operational constraints of a solution, as well as assessing the availability of resources and the necessary expertise to bring the solution to life. Feasibility analysis helps to identify potential roadblocks and challenges that need to be addressed, and to determine whether a solution is practical and realistic.
- **Viability** relates to evaluating the financial and business aspects of a solution. It relates to assessing the potential profitability and sustainability of a solution, as well as determining whether it is viable from a financial and business perspective. Viability analysis helps to determine whether a solution is economically viable and whether it has the potential to generate a return on investment.

Desirability, feasibility, and viability are interdependent and must be balanced on all the DT process from the selection of the facilitator to the selection of the participants to create a successful solution. A solution that is desirable but not feasible or viable will not be successful, and a solution that is feasible and viable but not desirable will not be successful either.

4.4.1 Organization of a Design Thinking session

Organizing a DT session involves the following steps:

- **Define the problem**: Clearly define the problem to be solved and ensure that all participants understand the purpose of the session.
- **Choose a facilitator**: Select a neutral facilitator who has strong facilitation skills, DT expertise, and the ability to communicate effectively and manage group dynamics. This step is detailed in Section 4.4.2.
- **Select participants**: Choose a diverse group of participants who have a direct connection to the problem, are available and willing to participate, and have the necessary expertise and enthusiasm. This step is detailed in Section 4.4.3.
- **Schedule the session**: Choose a time and location that is convenient for all participants and allocate sufficient time for the session.
- **Prepare materials**: Prepare any materials that will be needed for the session, including flip charts, markers, sticky notes, and any other tools or materials required for the DT process.
- **Set the agenda**: Plan the agenda for the session, including the steps of the DT process and any specific activities or exercises.
- **Facilitate the session**: The facilitator should lead the group through the DT process, ensuring that each step is completed and that the group stays on track. They should also facilitate group discussions, manage group dynamics, and provide guidance and support when needed.
- **Capture outputs**: Ensure that the outputs from the session are captured and documented, including any prototypes, sketches, and notes from the ideation and testing phases.

4.4.2 Selection of the facilitator

When selecting a facilitator for a DT session, it is important to consider the following factors:

- **Facilitation skills**: He/she should have strong facilitation skills, including the ability to lead group discussions, manage group dynamics, and keep the group on track. They should also be able to manage time effectively and facilitate the design DT in a structured and efficient manner.
- **Design Thinking expertise**: The facilitator should have a good understanding of the design thinking process and be able to guide the group through each step. They should also be able to answer questions and provide guidance when needed.

- **Neutrality**: It is important that the facilitator is neutral and not have a vested interest in the outcome of the DT session. This helps to ensure that the process remains objective, and the solution is based on the needs of the users, rather than the opinions of the facilitator.
- **Communication skills**: The facilitator should have strong communication skills and be able to communicate effectively with the group, as well as manage group dynamics and build consensus.
- **Adaptability**: He/she should be adaptable and able to handle different situations and group dynamics. They should also be able to adjust the DT process as needed to meet the needs of the group and ensure a successful outcome.

4.4.3 Selection of participants

When selecting participants for a DT session, it is important to consider the following factors:

- **Diversity**: It is important to have a diverse group of participants, including people with different backgrounds, skills, and perspectives. This helps to bring a wide range of ideas to the table and ensures that the solution will be relevant to a variety of users.
- **Relevance:** Participants should have a direct connection to the problem being solved. For example, if the problem is related to customer experience, participants who are customers or have experience working with customers should be included.
- **Availability**: Participants should be available to attend the design thinking session and participate fully. It is important to choose participants who can commit to the entire process.
- **Expertise**: Participants should have the necessary expertise and knowledge related to the problem being solved. For example, if the problem involves technology, participants with technical expertise should be included.
- **Enthusiasm**: Participants should be enthusiastic about the DT process and willing to contribute their ideas and perspectives.

It is important to strike a balance between these factors, as it will lead to a more productive and successful design thinking session.

4.5 Design Thinking+ and TrialsNet project

Based on the considerations arisen in Section 4.3, an adaptation of the design thinking process, called Design Thinking+ (DT+), is proposed as part of the DT process applied across the activities of the TrialsNet project. DT+ introduces a further step in the process outlined in Figure 17, adding a Mapping step called MAP as indicated in Figure 18, as detailed in the following section.

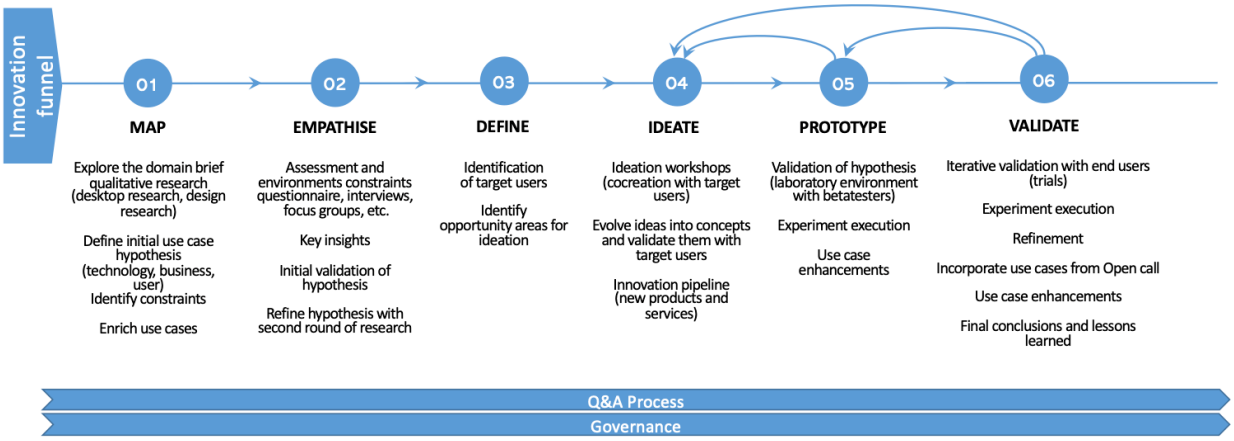

Figure 18. Design Thinking+ process applied to TrialsNet.

4.5.1 The MAP step

Adding an initial map of resources to a DT process can offer several opportunities, including:

- **Better planning**: An initial map of resources can help designers plan and prioritize their work more effectively. This may include identifying any resource constraints early on, such as limited time or budget, and adjusting the DT process accordingly. By having a clear understanding of the resources available, designers can also make more informed decisions about how to allocate their time and budget.
- **Improved collaboration**: By mapping resources, designers can also identify opportunities for collaboration and teamwork. For example, they may find that they need to work with other departments or stakeholders to access certain resources, such as technology or data. Having a clear understanding of the resources available can help facilitate more effective collaboration and teamwork.
- **Increased efficiency**: An initial map of resources can also help designers identify opportunities for optimization and improvement. By understanding the resources they have at their disposal, designers can find ways to use them more effectively and avoid wasting time and resources on solutions that are not feasible.
- **Better resource allocation**: An initial map of resources can also help designers allocate their resources more effectively. This may involve making trade-offs between different aspects of the DT process, such as user research or prototyping, in order to maximize the impact of their resources.

This initial map of resources can help designers make more informed decisions, prioritize their work more effectively, and work more efficiently to achieve their goals. By having a clear understanding of the resources available, designers can ensure that their DT process is optimized for success, and that they are able to deliver impactful solutions that meet the needs of their users.

The process of MAP includes collection and analysis of material from related projects and identifying business constraints, user constraints, technology constraints, and KV constraints for the current project. It involves the following steps:

- **Business constraints**: Identify any constraints or limitations that are imposed by the business context in which the use case is being defined. These could include factors such as budgetary constraints, time limitations, or legal or regulatory requirements.
- **User constraints**: Identify any constraints or limitations that are imposed by the users of the system. These could include factors such as physical or cognitive limitations, language or cultural barriers, or user preferences or expectations.
- **Technology constraints**: Identify any constraints or limitations that are imposed by the technology being used to implement the system. These could include factors such as compatibility with existing systems or platforms, limitations in processing power or memory, or limitations in available network bandwidth or connectivity.
- **KV constraints**: Identify any constraints or limitations that are imposed by a selection of a given set of KVs. These could include factors such as inclusion, sustainability, acceptance, or edutainment.

By identifying and documenting these constraints, the use case definition can be tailored to better fit the specific business, user, and technical contexts in which the system will be used. This can help to ensure that the use case accurately reflects the needs and requirements of all stakeholders, and that the resulting system will be effective, efficient, and reliable.

In addition, the MAP phase serves as the foundation for the entire process, as it consists of analyzing the starting point of the use case. The aim is to thoroughly understand the broader context in which the

problem exists. This involves exploring the current state of art, identifying main trends and exploring stakeholders that are involved in the use case. All this helps to identify opportunities that define the use case and extract hypotheses to be tested in the research.

4.5.2 Application to the TrialsNet use cases

The DT+ methodology is being applied to different use cases of the project (UC1, UC5, UC10, UC11, UC12 and UC13) with the aim to tackle complex problems that are ill-defined or unknown in a user centric way. Among other benefits DT+ has proven as a valid methodology to improve the understanding of users, enhance the usability and increase the product acceptance, some variables that are very relevant in use cases with a strong focus on the interaction with the end user like in UC10, UC11, UC12 and UC13. In the case of UC1 there is a special interest on understanding the acceptance and the engagement of the end user with robots in large scale events.

It is important to note that all use cases are following this methodology voluntarily and the reason why DT is not applied to other uses cases is either because the technology is more transparent to the end user or because it would be too complex to apply. In UC5, UC12 and UC13, the involvement of the users is key to ensure the attractiveness and usefulness of the UCs and their prospects for economic sustainability. For UC5, Control Room in the Metaverse, safety and security agents will have to agree on a common control room which as much as possible caters for their individual needs and existing protocols. In UC12, City Park in the Metaverse, and UC13, Extended XR Museum Experience, the DT is focusing on youngsters between 18-25 years old, to better understand which feature they would most appreciate and would like to include in the UC.
The results of the initial DT+ sessions will be provided in the next deliverable D6.2.

4.5.3 Ethics implications

DT+ has several ethical implications that have to be taken into account when applying the methodology in the use case design when involving the users:

- **Empathy and Inclusivity**: DT encourages empathy for end-users. Ethically, this is positive as it promotes the creation of products and services that cater to a wider range of people.
- **Bias and Stereotyping**: DT should avoid perpetuating biases or stereotypes in the solutions it generates.
- **Sustainability**: DT can account for sustainability by reducing waste, energy use, and considering long-term ecological consequences.
- **Business Interests vs. User Interests**: DT can sometimes clash with a company's financial interests. Ethical issues can arise when companies prioritize profit over user well-being or mislead users with design choices.
- **Accessibility**: Ensuring that designs are accessible to all, including people with disabilities, is an ethical imperative. Failing to do so can lead to exclusion and discrimination.
- **Impact on Society**: Ethical concerns may also arise concerning the broader impact of design solutions on society. If a product or service unintentionally causes harm or disrupts social norms, ethical considerations become essential.
- **Iterative Learning**: Ethical DT often entails a willingness to iterate and learn from mistakes. This openness to improvement can be seen as a positive ethical aspect, as long as designers take responsibility for addressing shortcomings.
- **Cultural Sensitivity**: Globalized design efforts should consider and respect different cultural norms and values.

These aspects will be considered in the relevant ethics procedures as described in TrialsNet deliverables D1.2 [31] and D8.1 [32].

5 Dissemination and standardization

Dissemination is a key aspect of TrialsNet because it ensures that the research findings are delivered to the individuals and entities who can utilize them as soon as possible, in order to maximize the usefulness of the research. Effective dissemination and communication are vital to ensure that the conducted research has a social, political, and economic impact. They draw attention of stakeholders to research results and findings, enhancing their visibility, comprehension, and integration. Dissemination of results is an important first step on the path toward knowledge translation and practice change. Dissemination of project findings is an important part of the project itself, passing on the benefits to other researchers, professional and the communities. In summary, dissemination is key in TrialsNet, as it helps to increase the visibility of outputs, public engagement, and it draws attention of governments and stakeholders to the project results and conclusions, enhancing their visibility, comprehension, and implementation. In this context, the following sections report the relevant activities that have been carried out.

5.1 Participation in dissemination events

In the following, all the dissemination activities performed by TrialsNet at the time of the release of this deliverable are reported.

2023 European Conference on Networks and Communications (EuCNC23) & 6G Summit in Gothenburg. At this event held in June 2023, TrialsNet participated, among others, holding a stand, as shown in Figure 19, where the project advances have been presented, including six posters, a video and three use case demos:

- The video prepared by ORO for the EuCNC23 TrialsNet booth addresses the implementation details regarding the two use cases that will be developed in Romania, Iasi, for Smart Crowd Monitoring and Smart Traffic Management. The video is published under ORO's official YouTube channel and can be accessed via the following link: TrialsNet Research project – Romanian testbed and use-cases - YouTube. The video is recorded in Romanian and has English subtitles.
- The poster prepared by ORO for the EuCNC23 TrialsNet booth showcases the WP3 use cases that will be developed in the scope of the project in Romania, Italy, Spain and Greece, highlighting their core functionalities and main beneficiaries. The poster is available in pdf format at this link.
- ORO's presence to EuCNC 2023 was highlighted on the company LinkedIn page, as can be seen at the following link: Post | LinkedIn, reaching about 5000 persons and getting 49 impressions.
- WINGS showcased initial implementations of UC2 (Proactive Public Infrastructure Assets Management) and UC6 (Mass Casualty Incident (MCI) and Emergency Rescue in Populated Area). Regarding UC2, it is implemented in two areas within the Greek Cluster: the Athens International Airport and public infrastructure provided by DAEM in the Municipality of Athens. The solution utilizes data from various sources, such as municipal vehicles, weather information, security cameras drones and robots, to assess the structural health of buildings, pavements, and roads. The data collected will allow for more efficient and effective proactive management of public infrastructure assets, leading to cost savings and improved operations and services. Demonstration of preliminary front-end and concepts of UC2 were showcased during EuCNC 2023. Regarding UC6, it aims to provide more efficient and digitally traceable triage procedures and pre-hospital treatment by first responders in case of MCI, as well as showcase the feasibility of a coordinated response in a densely crowded location during which the collected data will be utilized to derive insights on for emergency crews to provide an optimal

evacuation plan. This plan will include, with priority, optimal routes to the intervention targets (victims of the disasters), considering any obstacles or inaccessible sections that have been previously identified. Demonstration of preliminary front-end and concepts of UC6 were also showcased during EuCNC 2023.

- YBVR carried out an immersive virtual reality demo in EuCNC using Virtual Reality (VR) headsets. During the demo, the EuroLeague Basketball Final Four game was showcased, aired using state-of-the-art 360º cameras, allowing users to experience the match in breathtaking high definition from any angle. As the official virtual reality media outlet of EuroLeague Basketball, YBVR continues to revolutionize sports entertainment by bringing fans closer to the action than ever before.

Figure 19. TrialsNet presence in EUCNC 2023.

UAIC 2023 Spring school. During April 2023 the UAIC university from Iasi organized a spring school for its own students, that was also opened to participants from other cities and countries. The average number of attendees was about 50/day. ORO was invited at this event to talk about Mobile Networks, IoT, Cybersecurity and Entrepreneurship. The detailed agenda of the event is available online [33]. During the "Virtualization. 5G lab architecture. Edge Compute Facility, Object detection use-case" presentation, depicted in Figure 20 there were presented the objectives of the TrialsNet pro-

Figure 20. ORO presence to UAIC Spring School 2023.

ject and the 5G and edge-compute technical details related to the implementation of the project use cases that will be piloted in Romania, Iasi.

Cluj Innovation Days 2023. In May 2023 the Cluj IT Cluster organized the Cluj Innovation Days event that lasted for 3 days. This was a major Romanian event dedicated to encouraging innovation and entrepreneurship and to forging cross-industry and cross-sector collaborations for the emergence of new business models with societal impact, that gathered about 300 attendees from the public authorities' side as well as from start-ups and important tech business from Romanian and abroad. Relevant information about the event, including the detailed agenda can be found online [34]. ORO was invited to speak about its projects within the NetZeroCities Advanced Solutions for Climate Neutrality (RO) workshop, where, as can be seen in Figure 21, it presented the Orange 5G Labs connected infrastructure that hosts important use cases for the future of smart cities, including the ones developed in the context of the TrialsNet project.

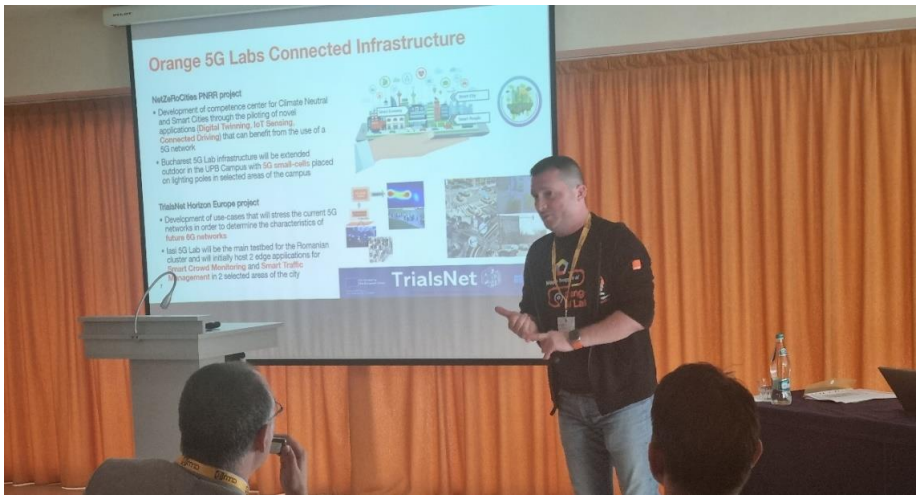

Figure 21. ORO presence to Cluj Innovation Days 2023.

ECAI 2023 IEEE Conference. In June 2023 the Faculty of Electronics and Telecommunications from University Politehnica of Bucharest organized the 2023 edition of the International Conference on Electronics, Computers and Artificial Intelligence (ECAI 2023). The detailed agenda of the conference can be accessed online [35]. During the conference there were almost 200 participants and ORO had one slot dedicated to the presentation of its 5G Labs ecosystem developed in the context of research and innovation projects. As can be seen in Figure 22, TrialsNet was one of the highlighted projects that is closely connected with ORO's Iasi 5G Lab, using its infrastructure to host the use cases that are developed in the city.

Figure 22. ORO presence to ECAI 2023 conference.

Orange 5G, AR and Drones event. In July 2023 ORO, in partnership with a local drones company, has organized a corporate event regarding the emergence of 5G, AR and Drones in the industrial landscape with 40 participants from the public sector and large enterprises side, all customers of ORO. During the event, as its highlighted in Figure 23. ORO presence to Orange 5G, AR and Drones event., the Development & Innovation team showcased what are the future use cases of 5G that are currently being developed in the 5G Labs, including the ones piloted in the context of the TrialsNet project.

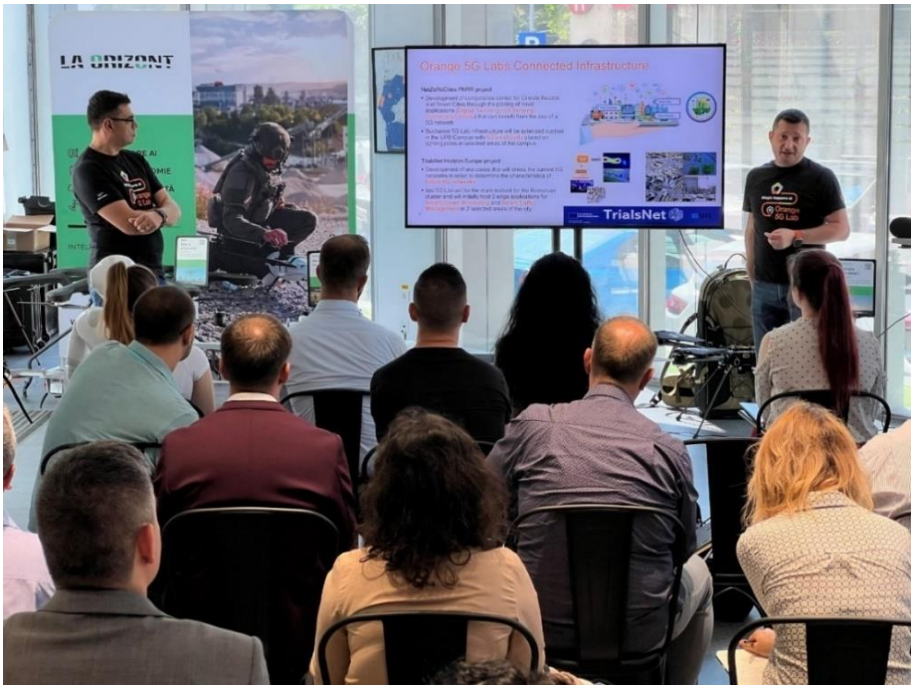

Figure 23. ORO presence to Orange 5G, AR and Drones event.

ISSCS 2023 IEEE Conference. In July 2023 the "Gheorghe Asachi" Technical University of Iasi organized the 2023 edition of the International Symposium on Signals, Circuits & Systems (ISSCS 2023). The conference had around 250 guests from both Romania and foreign countries, including India and USA. Detailed information about the conference and its agenda can be found online [36]. During the conference ORO had one slot dedicated to its presentation regarding Cloud-native 5G ecosystems, highlighting the Iasi 5G Lab virtualized setup for both infrastructure and compute that hosts the applications developed in the context of the TrialsNet research project, as it is showcased in Figure 24.

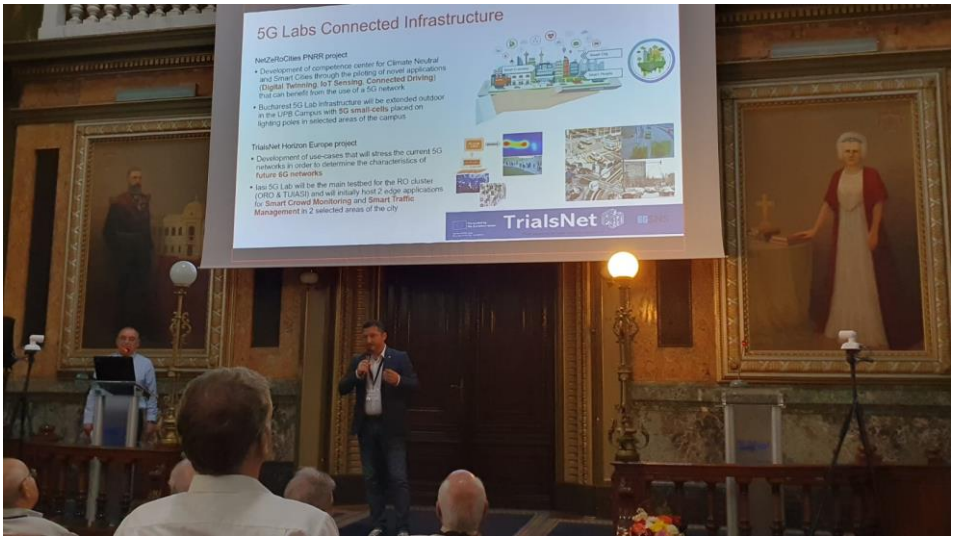

Figure 24. ORO presence to ISSCS 2023 conference.

ISPDC 2023 IEEE Conference. In July 2023 the Faculty of Automatic Control and Computer Science from University Politehnica of Bucharest organized the 2023 edition of the International Symposium on Parallel and Distributed Computing (ISPDC 2023). Detailed information about the conference, as well as the full agenda, can be found online [37]. During the conference ORO had the chance to present its 5G Lab Cloud-native 5G ecosystem in front of almost 200 international guests, as highlighted in Figure 25, leveraging on the important advancements that are brought to its research focused infrastructure in the scope of the TrialsNet project.

Figure 25. ORO presence to ISPDC 2023 conference.

Orange 5G Labs Seminar. In April 2023 Orange France organized a cross-dissemination event for all of its affiliates that are implementing the Orange 5G Lab concept. During this event, the representatives from different country branches presented their 5G Lab infrastructure status as well as the use cases and projects that are currently piloted within the labs. ORO, with its two 5G Labs in Bucharest and Iasi had an important contribution to this presentation, showcasing, as can be seen in Figure 26, its flagship research infrastructure as well as the pilots that are developed in the context of its research activities. TrialsNet was one of the highlighted projects, with its extended use of the Iasi 5G Lab Infrastructure that will host the use cases developed in Iasi.

Figure 26. ORO presence to Orange 5G Labs Seminar event.

Passenger Terminal Expo and Conference 2023. In March 2023, AIA and RW participated in the Passenger Terminal Conference 2023 that lasted 3 days. The title of their presentation was "5G deployment models and beyond 5G-future developments", explaining the concept of TrialsNet Project and its ambitions. This was a significant presentation dedicated to 5G Mobile Networks Deployment Models for Airports and a glimpse from the future for Beyond 5G (B5G) and 6G use cases for Airports. This event was held at RAI exhibition centre, Amsterdam, The Netherlands, as part of Passenger Terminal Conference and co-presenters were Nikos Papagiannopoulos from AIA, GR, and Julie Bradford from RW, UK (Figure 27). The Passenger Terminal Conference constitutes the most significant opportunity for airports and airlines to debate current issues and form business relationships on a global scale. It has firmly established itself as the most highly regarded airport design and operations conference in the world. It is an exceptional opportunity for industry leaders to share their innovations, knowledge and insight through a comprehensive and diverse range of conferences and panel discussions. The presentation of the TrialsNet project information in such an important industry event is considered a major achievement for the project.

Figure 27. AIA and RW at PTE conference 2023

Iasi Municipality Public Transport Company presentation. In April 2023 ORO, together with the "Gheorghe Asachi" Technical University from Iasi organized a meeting in the 5G Lab with representatives from the Iasi Municipality Public Transport Company (CTP). During the meeting, the 5G Lab infrastructure as well as the on-top developed projects, including the TrialsNet applications, were presented to CTP. They were interested to further develop the partnership with ORO by piloting similar Crowd Monitoring solutions to the ones developed in the context of the project in their smart busses and trams leveraging on the 5G Lab connectivity and infrastructure.

Press release from COTO about TrialsNet. In February 2023, COTO promoted its participation in the TrialsNet project, in cooperation with Fondazione Torino Musei and Fondazione Piemonte Innova. The project was presented in the Torino City Lab platform, where the three use cases involving COTO are detailed. The article (in Italian) can be accessed online [38].

Press release from ORO about TrialsNet. In April 2023, ORO's work towards 6G networks through research and development projects was showcased in a press release on a popular tech-blog from Romania. TrialsNet was one of the projects mentioned in the post, details about the future use cases piloted in the Iasi city being discussed as possible enablers for smart tracking of vehicles and people in the cities of the future. The article (in Romanian) can be accessed online [39].

Press release from TEI about TrialsNet. In June 2023, TEI presented the TrialsNet project and its participation in it, explaining the impact it will have in the real world, and how it will contribute in improving out life. The project contribution in the different vertical sectors are explained, together with the expected benefits. The project was presented in a report from a national news broadcast (Sky Tg24), and can be accessed online (in Italian), both as text and as video [40].

Press release from UC3M about TrialsNet. In September 2023, UC3M detailed its participation in the TrialsNet project, explaining how the project will make different technologies interact with each other and how the project will challenge the technology, looking for its limitations, paving the way to future steps. The release note details the project consortium and introduces the open call. The note has been released on the university webpage (in Spanish), and can be accessed online [41].

Interview and press release about TrialsNet. In July 2023 another important tech and economy online publication from Romania, start-up.ro, decided to look into what ORO does with their 5G Labs and what projects do they implement in this research dedicated spaces and invited ORO's Development & Innovation Manager, Cristian Patachia, to an interview about those topics. During the interview TrialsNet was mentioned in the context of the Iasi 5G Lab that will host the project applications and the collaboration with the Technical University of Iasi that will develop the use cases related to crowd monitoring and traffic management. The interview was published on YouTube [42] and parts of it were also transcribed into a blog post [43].

Tutorial at IEEE Future Networks. TIM presented a tutorial (1 hour duration) at IEEE Future Networks Tutorial 5G/6G 2023, titled "5G and beyond for eHealth". The IEEE Future Networks Tutorial Series is a set of one or multi-day tutorials designed to demystify 5G and beyond technologies and train technology and industry teams with the knowledge of 5G and beyond 5G upcoming future networks.

Innovation radar by Digital Health Uptake. TIM participated in the population of innovation radar promoted by Digital Health Uptake (DHU). The European DHU Radar collects digital health resources, henceforth called practices, with a particular focus on digital health solutions. The Radar serves as a one-stop-shop catalogue of digital health solutions and services, but also strategies and policies, supporting tools, and other types of resources on the uptake of digital health practices in Europe. In particular, TrialsNet added 4 new "practices": "MCI and rescue", "Smart proctoring", "Smart ambulance", and "Prosthetic arm", corresponding to the eHealth use cases studied in WP4.

Webinar. In February 2023, TrialsNet participated in a webinar organized by SNS-JU, where the project coordinator presented an overview of the project, including the consortium composition, the project vision, objectives, methodology, structure and use cases. The webinar video and slideshow can be accessed online [44].

5G Conference Southeastern Europe. Various TrialsNet partners participated to the conference in Athens, in September 2023 (Figure 28). Among them, WINGS promoted the project by actively presenting the use cases, with their criticalities and specificities, while other partners participated in comparing to other solutions and monitoring the 5G development and deployment status in Greece and SE Europe. The conference program is accessible online [45].

Figure 28. TrialsNet presence to the 5G Conference Southeastern Europe

5.2 Publications

In the following, all the publications submitted and accepted by TrialsNet at the time of the release of this deliverable are reported.

Submission and publication of a 6G State-of-the-Art paper. ORO submitted a paper, related to the TrialsNet project, regarding the current 6G State-of-the-Art in terms of software networks for the 2023 edition of the International Conference on Electronics, Computers and Artificial Intelligence (ECAI 2023) that was organized by the University Politehnica of Bucharest (UPB). The paper [46] depicts the current trends related to the usage of cloud and orchestration tools within mobile networks, future networks programmability and the network implementation of Zero Touch Management frameworks, all related to 5G advancements that are planned for ORO's testbed within research projects like TrialsNet. The paper also highlights which are the network KPIs that should be achieved with 6G networks, starting from the findings obtained through a controlled stress testing of the current 5G networks. The paper was accepted, presented and published on the IEEE Explore website as well as on Zenodo.

Submission of a positioning paper on WP4. TIM submitted a paper at the IEEE International Conference on E-health Networking, Application & Services (IEEE Healthcom 23). The paper describes four use cases to demonstrate the large-scale trialing of the B5G technology specifically devoted to eHealth and Emergency domains, by supporting the B5G applications in large-scale environments and bringing novel applications, and on societal benefits in eHealth and Emergency areas through the development of innovative B5G/6G applications.

Submission of a positioning paper on UCs. UC3M submitted a paper at the 2023 IEEE Future Networks World Forum. The paper describes the three domains defined in the project, the different UCs that will be implemented in the context of each domain, the project iterative methodology, the organization of the different clusters, as well as the different technologies available at each one of them, and the KPIs and KVIs used in the project.

Submission and publication of a research paper. CNIT submitted a paper at the International Conference on Information and Communication Technologies for Disaster Management (ICT-DM 2023). The paper describes two contributions. The first one is a privacy-aware crowd monitoring scheme that has been designed for effective crisis management, i.e., tailored for UC5 about Control Room in Metaverse in Turin cluster. Furthermore, the paper presents a WiFi traffic emulation scheme to test derandomization algorithms, required for crowd monitoring schemes. In addition to UC5, the contributions of the paper are useful for the people counting schemes that may be adopted in UC12 and UC13. The paper was accepted, presented and published on the IEEE Explore website as well as on Zenodo [47].

5.3 Communication activities

In the following, all the TrialsNet related communication activities at the time of the release of this deliverable are reported.

Webpage of the project https://trialsnet.eu/ has been setup and is constantly updated. The webpage represents the main interface of the project towards the general public. It offers a contact point, and the main information about the project and its vision, objective, consortium composition, and activities. The webpage collects also public deliverables, publications, news, and videos, together with all the relevant information for the Open Call participations (i.e., overview, details and instructions, contact point, deliverables including the architecture description, etc.). In order to assess the efficiency of the webpage as a communication channel, visit statistics are collected through Google Analytics. In particular, Figure 29 reports some statistics about user count (top), user geographical origin (center), views

per page (bottom left), and session source (bottom right). The webpage accounts up to now for 916 different users, which interacted with the page through 15K events. This information will be used to focus and optimize the project communication efforts in the future. In particular, the webpage visibility is expected to improve through the project social-media presence and through the partner contacts and direct diffusion. The user engagement is expected to increase, by constantly improving the webpage structure and interface, and by producing better text for the news and updates, by having them written by the different partners directly involved in the event, and by not centralizing their production.

Figure 29. Webpage access statistics.

Social media accounts have been created on LinkedIn https://www.linkedin.com/company/trialsnet/, Twitter https://twitter.com/trialsnet, and YouTube https://www.youtube.com/@trialsnet/ being constantly updated to disseminate outcomes to the general public, including news, participation at events, demo videos, etc. Similar to what done for the webpage, also for the project social-media presence statistics are gathered to help focus and optimize the communication effort. The project Twitter account is earning on average 3 impressions per day with an engagement rate of 5.3%. The project YouTube channel has a growing view rate, currently at about 4 per day, with users viewing about half

the video on average. Some more statistics of the project social-media presence are reported in Figure 30, with data about LinkedIn visits (including job titles), and YouTube reproductions (different colors refer to different videos).

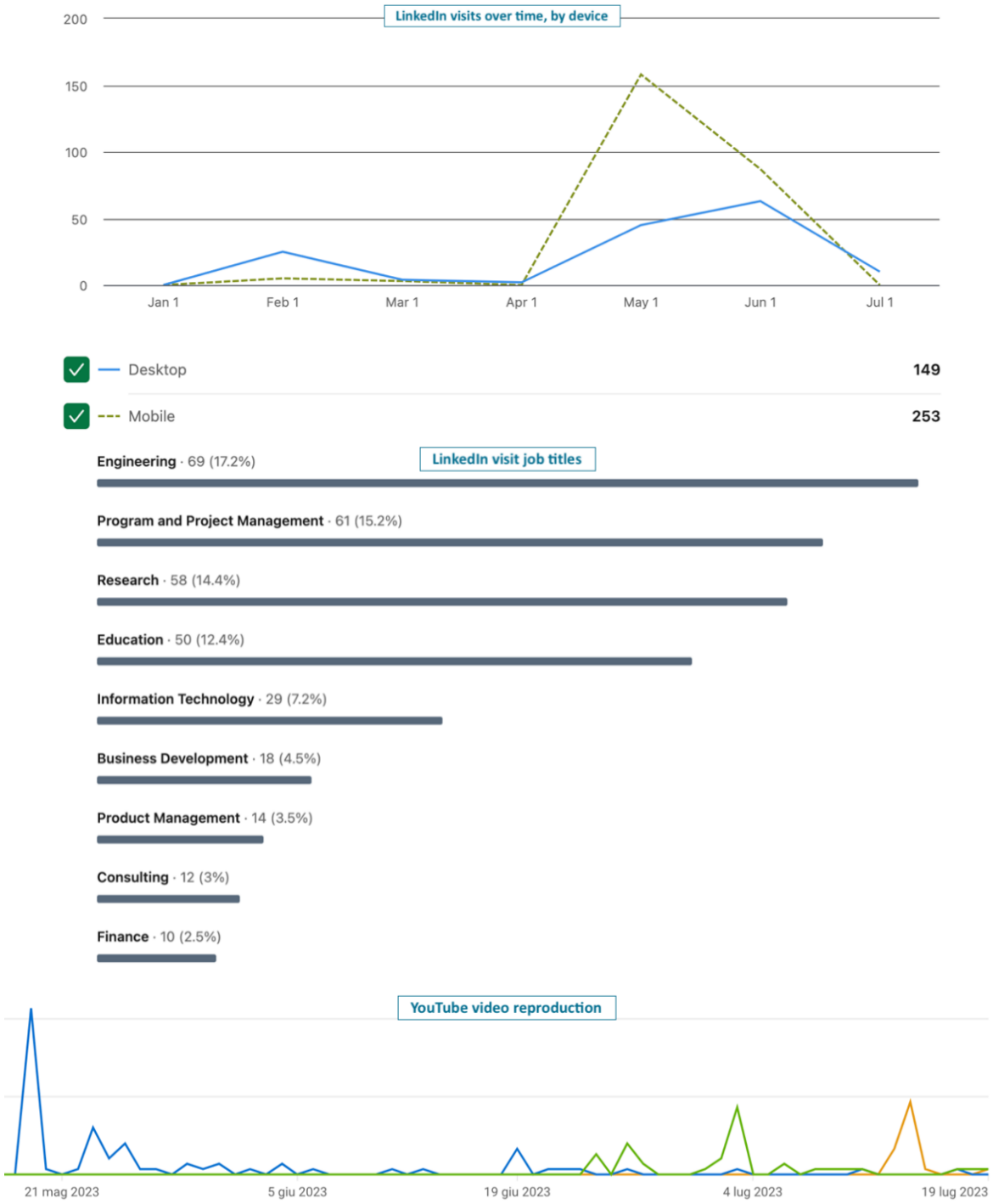

Figure 30. Statistics about social-media presence of the project.

Newsletter on semestral basis(https://zenodo.org/record/8155325) has been created to collect the main achievements of the project, present them to the general public, and advertise project events and other initiatives (e.g., the Open Call). The first issue has been published in July 2023 and summarizes the activity of the first semester of project execution, i.e., January-June 2023, and is being disseminated through project social media, partner contact lists and institutional portals. A generic template has been developed and will be reused for the following issues of the project newsletter.

5.4 Standardization activities

A timeline has been defined for the standardization activities, as shown in Figure 31, taking into account both the expected release of relevant standards (e.g., releases Rel-18 and Rel-19), and the project development plan. Partner sensibilization and involvement is a key element for obtaining a meaningful standardization activity inside the project. To this extent, all project partners have been invited to designate responsible to interface with the different relevant standardization bodies.

The organization of pre-standardization workshops is now considered, to gather requirements from the different verticals, before and after the trials. This could be done internally to the project, and also involving other projects. Previous similar experiences and the corresponding results have been analyzed (e.g., 5G-SOLUTIONS).

In line with the project focus on contributing to the advancement of the next generation of standards, while the primary objective is not to directly impact the standardization of 3GPP components, the insights and developments from TrialsNet project have significant implications for the evolution of future standards. TrialsNet main goal lies in providing valuable input that can shape the trajectory of forthcoming standards, particularly in areas concerning the efficient and sustainable management of networks and the seamless integration of end-user experiences.

As part of the work towards these objectives, the project remains actively involved in initiatives such as the GSMA Open Gateway, which seeks to enhance the interoperability of mobile networks, as well as the Linux Foundation CAMARA, focusing on strengthening network management capabilities through open-source collaboration. Additionally, TrialsNet participation in SA WG5 underlines the commitment of promoting secure and efficient network operations that include the seamless integration of network services.

Furthermore, the involvement in AI-related standardization initiatives reflects TrialsNet dedication to leveraging cutting-edge technologies for the enhancement of network performance and user experiences. Members of TrialsNet team are active within key groups such as IEEE P3301, which works on AI ethics, IEEE P7003, which addresses algorithmic bias, and IEEE P7018, which focuses on the standardization of AI model interoperability. Additionally, TrialsNet members contribute to MPAI – AIF which fosters the development of ethical and responsible AI frameworks.

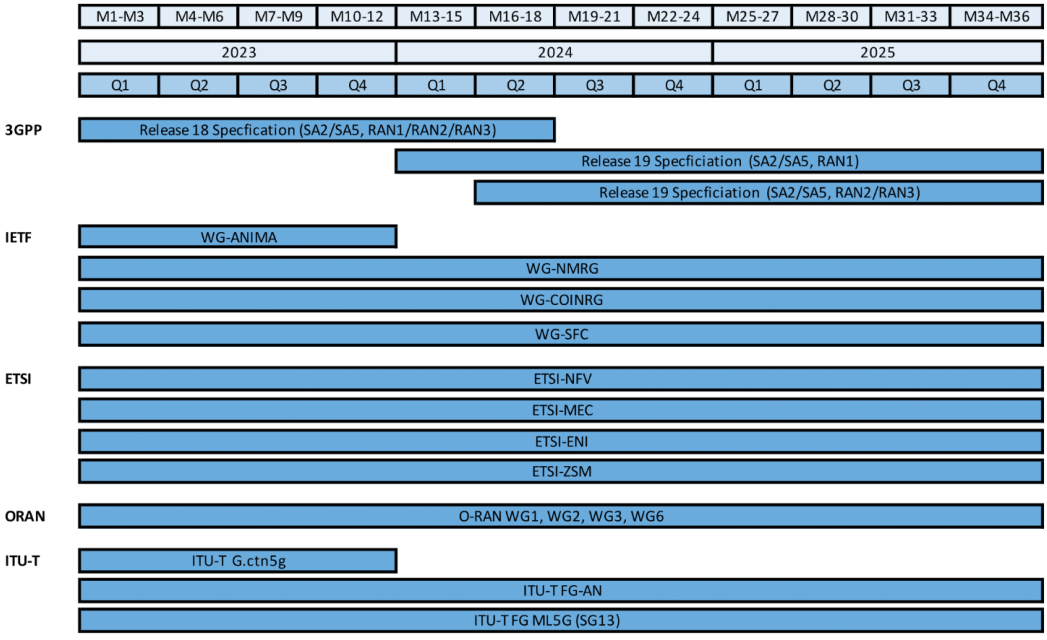

Figure 31. Timeline for the standardization activities.

6 Conclusions

The current deliverable reported on the progress of the validation and dissemination activities related to the WP6 of TrialsNet, achieved through the synergic contributions of all the partners involved in the related activities as well as in the other WPs.

The document posed an important ground for the validation of the use cases, since it provides a first set of 18 recommended reference KPIs harmonized across all the use cases. All the use cases will refer to these set of harmonized KPIs in the following phases and will be reported in deliverable D3.2, D4.2 and D5.2. It should be noted that the list if harmonized KPIs should not be considered as finalized and that further updates will be possible according to the progress of the use cases implementation, testing activities and trials execution phases. From this perspective, KPIs from the network perspective defined in the context of WP2 could be also included.

This deliverable also provided a common framework to define and analyze the KVIs, required to identify a coherent validation approach in the whole project, taking into account the link between business, value and technology, and highlighting the relation with economical, societal and environmental values. The framework will be adopted by each use case to define KVs, the corresponding KVIs, and related (technological) enablers which outcomes will be included in the next deliverable D6.2.

Furthermore this deliverable introduced and described the DT+ methodology and its practical application to a subset of meaningful use cases. This will allow to define properly the target and the ambitions of the involved use cases, including the KVIs, and will be adopted in most of the use cases of TrialsNet. The next deliverable D6.2 will document the outcome of DT+ process on the identified use cases.

Finally, the deliverable collected the dissemination, publication and standardization activities occurred in this first period of the project up to the release of this document. In particular, 19 dissemination events have been described and 4 publications have been produced. The web page of the project, together with all the other communication means (e.g., newsletter, social networks, etc.), has been created and now provides a multimodal communication approach optimizing the visibility of the TrialsNet project across the public and the possible future stakeholders, interesting in joining the Open Call.

Acknowledgment

TrialsNet project has received funding from the European Union's Horizon-JU-SNS-2022 Research and Innovation Programme under Grant Agreement No. 101095871.

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