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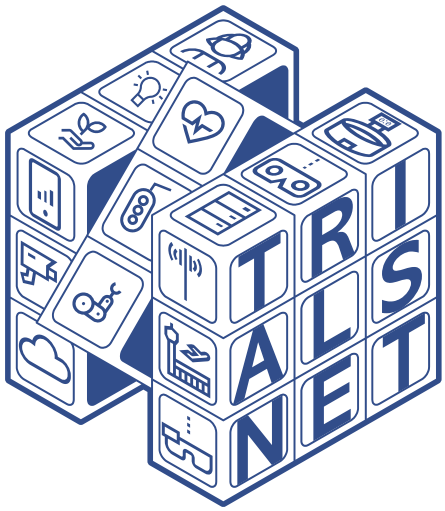

TrialsNet: TRials supported by Smart Networks beyond 5G

Deliverable D6.2

Second report on validation and dissemination activities

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Editor(s):	Hassan Osman, Julie Bradford (RW)
Author(s):	Hassan Osman, Julie Bradford (RW) Aruna Prem Bianzino, Marco Gramaglia (UC3M) Paolo Giaccone, Maurizio Munafò (CNIT) Miguel Angel Martinez, Mary Grace Burkett (YBVR) Andrea Basso, Claudia Chiavarino (CROSEU) Maurizio Cecchi, Barbara Ferraioli (PIIU) Andreas Georgakopoulos, Eleni (Nelly) Giannopoulou (WINGS), Nina Slamnik-Kriještorac (IMEC), Alessandro Trogolo (TIM), Gabriele Scivoletto (NXW)
Reviewer(s):	Andreas Georgakopoulos (WINGS) Chiara Benvenuti (CNR), Nina Slamnik-Kriještorac (IMEC)
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Table of Content

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-PPP	5G Infrastructure Public Private Partnership
6G	Sixth generation of mobile communications
6G-IA	6G Smart Networks and Services Industry Association
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
CSR	Corporate Social Responsibility
DAEM	Dimos Athinaion Epicheirisi Michanografisis
DT+	Design Thinking+
ETSI	European Telecommunications Standards Institute
EU	European Union
EuCNC	European Conference on Networks and Communications
GDPR	General Data Protection Regulation
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
NFV	Network Function Virtualization
ORO	Orange Romania SA
QBL	Quadruple Bottom Line
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
TAM	Technology Acceptance Model
TF	Task Force
TEI	Ericsson Telecomunicazioni S.p.A.
TIM	Telecom Italia S.p.A.
TMOG	Technology, Market, Organization and Governance
UC	Use Case
UC3M	Universidad Carlos III de Madrid
UN	United Nations
VR	Virtual Reality
WG	Working Group
WINGS	WINGS ICT Solutions
WP	Work Package
XR	Extended Reality
YBVR	Yerba Buena Virtual Reality

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Executive Summary

This deliverable D6.2 "Second report on validation and dissemination" of TrialsNet outlines the key activities, progress, and findings related to the tasks of Work Package (WP) 6 which covers the technical and business validation, and dissemination of the project. This is the second public deliverable of WP6 and provides updates on the tasks started in the first and second year of the project. In particular, this document outlines the evaluation methodologies established for assessing Use Case (UC) trials across the three domains identified by the project, including Key Performance Indicators (KPIs) as well as the definition of the process for the Key Value Indicators (KVIs) assessment. It also provides a comprehensive overview of dissemination and standardization outcomes achieved as of the document's release date. Additionally, the report provides a progress update related to the exploitation task.

The TrialsNet project leverages the concept of Smart Cities to drive positive change in the face of rapid urbanization and the push for sustainable development. Recognizing the strong connection between technological innovation and societal progress, TrialsNet envisions Beyond 5G mobile network (B5G) and Sixth Generation of mobile communications (6G) technologies as key to addressing social, economic, and environmental challenges. Focused on mobile technology, TrialsNet aligns with broader societal goals through large-scale trials of cutting-edge 6G applications that are designed to meet critical needs in key domains across European urban ecosystems.

Framed in this context, one of the core objectives in WP6 is the evaluation of KPIs of the TrialsNet UCs, which include also sustainability metrics. This includes revisiting the initially defined KPIs and ensuring they are well-suited for the diverse trials, covering areas like throughput, latency, reliability, and energy efficiency. These KPIs are central in benchmarking the performance of the TrialsNet network across various environments and conditions, guiding the project's technological improvements and optimizations. Furthermore, this deliverable analyzes the preliminary measurements performed across the UCs, discussing which KPIs have been validated, i.e., where measurements have met the required performance levels.

In parallel, WP6 also goes into the business aspects of TrialsNet by assessing the KVIs. These indicators evaluate the social, economic and environmental value generated by TrialsNet innovations, particularly in the context of emerging 6G technologies. By linking technological performance with broader societal goals such as sustainability, the project aligns its work with modern business models that prioritize environmental, social and economic impact. The core of the TrialsNet methodology involves the creation of Key Values (KVs) and KVIs, which will identify potential sources of sustainable value and serve as a guiding framework for aligning the project’s activities and goals. These elements will be reinforced by a rigorous application of KPIs, viewed through a comprehensive lens that goes beyond the technical aspects of B5G and 6G to include a wide array of social, economic, and environmental factors. Through the development of robust assessment frameworks that integrate both qualitative and quantitative metrics, TrialsNet aims to emphasize the multifaceted impact of its 6G solutions on society and promote the early adoption and widespread acceptance of these technologies and related applications to drive positive change and contribute to the greater good. By considering more than just financial outcomes, organizations can focus on achieving a Quadruple Bottom Line (QBL) of Profit, Planet, People, and Purpose, fostering a more equitable and brighter future for all. This deliverable provides a strategic roadmap for the TrialsNet project by integrating insights from social, economic, environmental, and business perspectives. By exploring KVs relevant to the project's UCs, it seeks to establish a framework that enhances communication and collaboration among partners, ensuring alignment and shared understanding. It also directs readers to more in-depth resources for further exploration if needed. The first trial with end users, conducted under UC5 “Control Room in Metaverse” in October 2024, has already been completed. This deliverable includes the initial outcomes of the KVI analysis derived from this trial. The assessment of KVIs for other UCs is also analyzed whereby these UCs are used as practical examples to illustrate the applicability of KVI assessment throughout the project’s activities.

This deliverable also provides an analysis of the KPIs and KVIs addressed by each one of the Open Call sub-projects based on the KPI terminology and the KVIs framework defined by TrialsNet in D6.1 [1]. Given the large number of sub-projects, i.e. 24, the adopted KPI/KVI terminology and definition needs to be harmonized. To coordinate such a process, the KPI and KVI information has been collected through the submission of a template elaborated by the project to guarantee that the same definition of KPIs/KVIs was adopted, hence avoiding possible misunderstanding due to incoherent definitions, conventions or naming of the related metrics.

The importance of integrating stakeholder feedback into the design of UCs to ensure that the solutions created address real-world needs effectively is also considered in TrialsNet and this deliverable. A summary of Design Thinking+ (DT+) activities is presented, including the methodological results and research conducted within UC1 “Smart Crowd Monitoring”, UC5 “Control Room in Metaverse”, UC10 “Immersive Fan Engagement”, UC12 “City Parks in Metaverse”, and UC13 “Extended XR Museum Experience”. The next steps for DT+ implementation are also reported.

Dissemination activities are another key focus of WP6 and the project in general and aim to maximize the project's impact by ensuring that results are shared widely with relevant stakeholders. These activities have included participation in conferences, publications, and social media outreach, as well as involvement in standardization efforts, particularly in the 3rd Generation Partnership Project (3GPP) standards. The project's dissemination efforts are on track, with KPIs for communication activities being met or even exceeded in some cases. This includes substantial engagement in social media, blog posts, videos, and presentations (including demos) at industry events, highlighting TrialsNet's efforts to raise awareness and engage the broader community. In addition, TrialsNet has participated in Working Groups (WGs), Task Forces (TFs), and joint activities with 6G Smart Networks and Services Industry Association (6G-IA) and Smart Networks and Services Joint Undertaking (SNS JU), which details are reported in this deliverable.

Additionally, this report discusses the exploitation strategies being updated by various project partners in response to evolving project developments. These strategies focus on ensuring that the innovations developed within the project lead to practical applications in the three different domains addressed by the project. For example, the development of AI (Artificial Intelligence) and Machine Learning (ML) applications in the TrialsNet UCs is seen as a key area of growth, with partners looking to leverage these technologies to enhance customer services and operational efficiency in their respective industries. In the second phase of the project lifetime, we will establish a joint exploitation plan to maximize the project's impact, support the commercialization of the proposed UCs, and foster ongoing collaboration among the involved partners.

Finally, this report outlines the ongoing work in the trials management, emphasizing the critical role of collaboration among key stakeholders (e.g., municipalities, end-users) and technical experts to ensure the success of the trials. Trials are technically demanding and involve the integration of complex technologies, related applications, platforms and network solution for showcasing the various UCs. The outcomes from these trials will provide valuable insights into how enhanced networks B5G (towards 6G) can support novel and demanding applications. To help capture these important outcomes, a proper process has been defined and reported in this deliverable addressing planning of the trials and including common templates for homogeneous collection of various information such as trial location, network infrastructure (e.g., commercial, private, experimental), network release (i.e. Rel-15, Rel-16, or Rel-17), coverage type (e.g., indoor or outdoor), coverage area, trial duration, and number of sessions-users-devices.

1 Introduction

This deliverable reports on the activities of the project performed in the context of WP6 "Validation and Dissemination" which is responsible for the validation and dissemination of the results coming from the trials' activities. This is the second WP6's deliverable, with the first one published in October 2023 [1].

WP6 is structured into five tasks, which interact with the other project's WPs as shown in Figure 1. This deliverable provides detailed progress of all these tasks that are part of WP6.

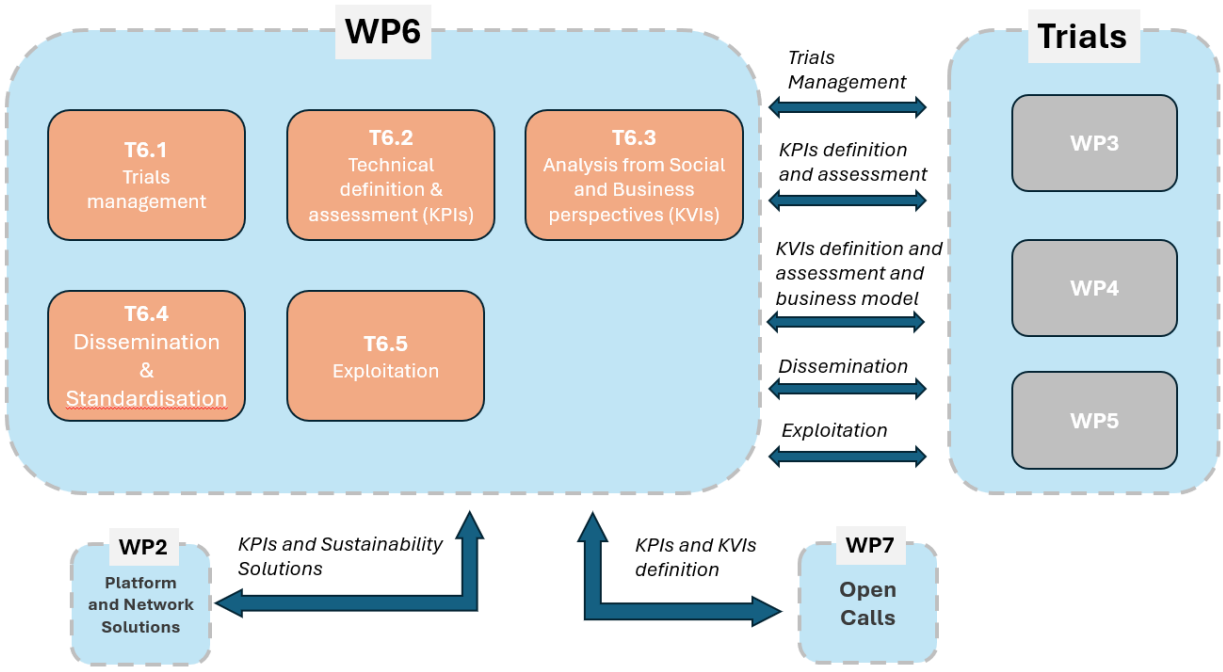


Figure 1. Interaction of WP6 task with WP3, WP4 and WP5.

As shown in Figure 1, there is a close interaction between each task in WP6 and the WPs in the project. The details of these interactions are as follows:

- **Task 6.1 (T6.1)**: Trials Management, addresses the trial execution phase for each UC, focusing on planning trial activities. This task interacts closely with WP3, WP4, and WP5 including the definition of the test and data acquisition protocols and the methodology for the evaluation of the results.
- **Task 6.2 (T6.2)**: Technical Definition and KPI Assessment Methods, focuses on the technical definition and assessment methods of the technical KPIs. It requires interaction with WP3, WP4, WP5, and WP7 for defining and assessing KPIs. Additionally, this task collaborates with WP2 to synchronize KPI definitions and sustainability considerations.
- **Task 6.3 (T6.3)**: Analysis from Social and Business Perspectives, involves analysing the trials from social and business perspectives to derive KVs and their corresponding KVIs. This task supports KVI assessment and interacts with WP3, WP4, WP5, and WP7 for defining KVs and assessing KVIs for the trials.
- **Task 6.4 (T6.4)**: Dissemination and Standardization Activities, is responsible for dissemination activities to promote the project's results and standardization plans for project solutions. The aim is to enhance the industrial, scientific, and standardization impact of TrialsNet. This task involves interaction with all project partners and WPs.
- **Task 6.5 (T6.5)**: Exploitation, focuses on defining and refining the exploitation plans as the project progresses. The task coordinates exploitation activities across all project partners and WPs.

In this document, Section 2 presents the progress related to the technical KPIs, including an analysis of the collected KPIs across all the UCs and a revision of the KPIs defined in D6.1 [1] to include energy-related KPIs.

Section 3 reports on the activities in T6.3 regarding the business models and the framework to define the KVs and the corresponding KVIs. Preliminary KVIs assessment of some UCs are described in the section and a summary of the KVI assessment process is presented at the end of the section.

Section 4 reports on the activities performed in T6.3 regarding the DT+ which is applied to different UCs of the project. The section provides a detailed explanation of the research activities conducted, the results obtained, and the next steps within the context of DT in UC1, UC10 (Immersive fan engagement) and UC11 (service Robots for Enhanced Passengers Experience).

In Section 5, the activities of T6.4 regarding dissemination, publications, and standardization activities by partners are presented. This section includes also the summary of the TrialsNet collaboration activities within SNS-JU (including its WGs and TF) and other projects.

Section 6 describes the trial management activity and section 7 includes the updated exploitation plan by each partner. Section 8 provides an analysis of the KPIs and KVIs addressed by the Open Call sub-projects.

Finally, the conclusions section provides the main outcomes of deliverable D6.2 and introduces the next steps related to WP6 activities.

2 Preliminary technical KPIs assessment

The technical KPI assessment has required a revision of the initial KPIs defined at the beginning of the TrialsNet project and has followed the workflow described in section 2.1. The analysis of the preliminary measurements during the test activities of the UCs are reported in section 2.2. Finally, a set of KPIs related to energy efficiency is introduced in section 2.3, tailored to the energy-sustainability innovations devised in WP2.

2.1 Consolidation of the KPIs

The process of the KPIs definition is based on the workflow depicted in Figure 2. The deliverables D3.1 [2], D4.1 [3], and D5.1 [4] provided an initial description of the KPIs identified for each of the UCs.

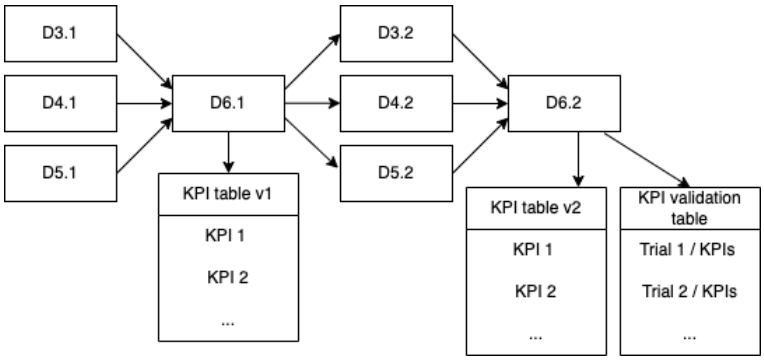


Figure 2. Workflow for the definition of KPIs.

Based on those, the subsequent deliverable D6.1 [1] provided a final KPIs table (denoted as the "v1" version) as the main output of the effort to harmonize the definition of the KPIs across all the different UCs. Such KPI table allowed to refer to the same naming convention and defined an individual index for each KPI, for a simpler reference. Deliverable D6.1 was shared with all the UCs, which were asked to adopt the naming and definitions there reported for the subsequent activities, such as the preliminary measurements activity reported in deliverable D3.2 [5], D4.2 [6], and D5.2 [7]. In the case a new KPI needed in a UC was not available in the KPIs table, the UCs would have reported it, for future inclusion in a new version of the KPIs table (denoted as "v2" version).

As the final step of harmonization, D3.2, D4.2, and D5.2 deliverables were reviewed to analyze any assessment on the suggested initial KPIs from the partners. A KPI validation table was used to collect all the measurements during the preliminary testing phases, and the required KPI values by which the KPI analysis has been performed. As a summary of such analysis, all UCs have shown to have adopted the harmonized KPIs of the KPIs table. No issue related to the need of additional KPIs was reported, mostly because the deliverables covered the preliminary tests and more in-depth measurements and KPIs are planned for the next stages. Furthermore, the KPI validation table provided a detailed insight on the KPIs that could be considered more "critical" to be validated in the current communication infrastructure.

2.2 KPIs validation of the test activities

This section reports the initial project's KPIs analysis and validation based on the preliminary measurements performed in the context of the testing activities of the various UCs, which results are reported in D3.2 [5], D4.2 [6], and D5.2 [7]. The final KPIs assessment will be reported in the last deliverable D6.3 and will be based on the results collected during the UCs' trials phase.

Table 1 shows the KPIs that were measured during the test activities in all the TrialsNet UCs. The most referred KPIs belong to the "Capacity" and "Latency" categories. This reflects the main performance metrics affecting the Quality of Service (QoS) experienced by the traffic flows. On the contrary, some other metrics have not been measured, such as "Coverage", "Location" and the ones belonging to "Availability and reliability" category, since they could not be evaluated in the laboratory settings adopted for the preliminary tests. Furthermore,

UC8 “Smart ambulance” did not report any measurements since no test were conducted at the moment of the submission of D4.2.

Table 1. Measured KPIs in the different UCs.

KPI name	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13
Downlink throughput per user (KPI#01)	X			X	X							X	X
Uplink throughput per user (KPI#02)	X			X	X							X	X
Downlink aggregate Throughput (KPI#03)	X						X			X		X	
Uplink aggregate Throughput (KPI#04)	X			X						X		X	
Downlink throughput per device (KPI#05)						X							
Uplink throughput per device (KPI#06)	X			X		X							
Coverage (KPI#07)													
Application round-trip latency (KPI#08)	X	X	X	X		X					X		X
Application one-way Latency (KPI#09)	X						X		X				X
Accuracy (KPI#10)													
Precision (KPI#11)		X				X					X		
Recall (KPI#12)		X				X					X		
F1 score (KPI#13)		X				X					X		
Communication Reliability (KPI#14)													
Service Reliability (KPI#15)		X									X		
Communication Availability (KPI#16)													
Service availability (KPI#17)		X									X		
Location accuracy (KPI#18)													

In the following paragraphs, the process of KPI validation is described, applied for the preliminary tests, but the same methodology will be adopted for all future measurements referring to the actual trials. Deliverables D3.2, D4.2, and D5.2 provided the measurements related to the preliminary test activities for which the KPIs have been “validated” according to the following definition. Given a particular UC and a value as requirement, a KPI is *validated* if the corresponding measurement satisfies the requirement. As an example, in the case of KPIs belonging to the “Capacity” category, the requirement is defined in terms of the minimum value that the measured KPI must satisfy. On the contrary, in the case of KPIs belonging to the “Latency” category, the requirement is defined in terms of the maximum value that the measured KPI must satisfy.

Based on D3.2, D4.2, and D5.2, a KPIs validation table has been created to highlight the KPIs that have been validated or not, for each specific UC and test setup. Table 2 provides a summary of the number of tests for which each KPI has been validated or not. To evaluate the probability of satisfying the KPI requirement, the metric called “validation ratio” is defined as:

$$Validation\ ratio\ (KPI) = \frac{Num.\ of\ validated\ tests}{Num.\ \ of\ \ tests}$$

A validation ratio close to 100% means that the KPI is almost always validated, thus the KPI is not critical to be satisfied. On the contrary, a validation close to 0% means that the KPI is almost never validated, suggesting that the KPI is very critical to be validated, due to very stringent requirements.

Table 2. KPIs validation in the different TrialsNet UCs and tests.

KPI name	Total tests with VALI-DATED KPI	Total tests with NOT VALI-DATED KPI	Validation ratio
Downlink throughput per user	4	2	67%
Uplink throughput per user	1	4	20%
Downlink aggregate throughput	9	12	43%
Uplink aggregate throughput	13	17	43%
Downlink throughput per device	1	0	100%
Uplink throughput per device	5	3	63%
Coverage	0	0	-
Application round-trip latency	14	5	74%
Application one-way latency	10	6	63%
Accuracy	0	0	-
Precision	4	0	100%
Recall	1	3	25%
F1 score	1	3	25%
Communication reliability	0	0	-
Service reliability	2	0	100%
Communication availability	0	0	-
Service availability	0	2	0%
Location accuracy	0	0	-

In the following, Table 3 shows the KPIs validation table with details of the most stringent requirements for all the tests, grouped according to the different UCs. When comparing different tests belonging to the same UC, the fact that a KPI is validated or not depends mainly on the specific settings of each test. This fact reflects the difficulty of evaluating the performance of a “best effort” communication network and advocates the need for strict QoS support in the Fifth Generation of mobile communications (5G) and B5G networks.
Regarding capacity related KPIs, the KPI validation table shows that both uplink and downlink capacity are critical ones since the validation ratio is always smaller than 100%. A similar reasoning holds for both latency KPIs, which appear critical for almost one-third of the tests.

Table 3. List of all the KPIs and their most stringent requirements.

KPI name	Validation ratio	Most stringent requirement	UC	Test case ID
Downlink throughput per user	67%	500 Mbps	UC1 – Smart Crowd Monitoring (Iasi) UC 4 - Smart Traffic Monitoring	1.4_Field01_01, 1.4_Field01_02 4.1_Field01_01
Uplink throughput per user	20%	150 Mbps	UC1 – Smart Crowd Monitoring (Iasi) UC 4 - Smart Traffic Monitoring	1.4_Field01_01, 1.4_Field01_02 4.1_Field01_01
Downlink aggregate throughput	43%	110 Mbps	UC1 – Smart Crowd Monitoring	4.1_Field01_04
Uplink aggregate throughput	43%	300 Mbps	UC10 - Immersive Fan Engagement	10.1_Lab01_04, 10.1_Lab01_05
Downlink throughput per device	100%	50 Mbps	UC6 - Mass Casualty Incident (MCI) and Emergency Rescue in Populated Area (Athens/Madrid)	6.2_Lab01_01
Uplink throughput per device	63%	110 Mbps	UC1 – Smart Crowd Monitoring (Iasi)	1.4_Field01_02.5
Application round-trip latency	74%	12 ms	UC13 – Extended Reality (XR) Museum Experience (Turin)	13.1_Lab01_01
Application one-way latency	63%	10 ms	UC9 - Adaptive Control of Hannes Prosthetic Device	9.1_Lab02_01, 9.1_Lab02_02
Precision	100%	0.8	UC 2 - Proactive Public Infrastructure Assets Management UC6 - MCI and Emergency Rescue in Populated Area (Athens/Madrid) UC11 - Service Robots for Enhanced Passengers' Experience	2.1_Lab01_01 6.1_Lab01_01 11.1_Lab01_01, 11.1_Lab01_02
Recall	25%	0.65	UC6 - MCI and Emergency Rescue in Populated Area (Athens/Madrid)	6.1_Lab01_01
F1 score	25%	0.7	UC6 - MCI and Emergency Rescue in Populated Area (Athens/Madrid)	6.1_Lab01_01
Service reliability	100%	0.9999	UC 2 - Proactive Public Infrastructure Assets Management UC11 - Service Robots for Enhanced Passengers' Experience	2.2_Lab02_02 11.1_Lab02_02
Service availability	0%	0.9999	UC 2 - Proactive Public Infrastructure Assets Management UC11 - Service Robots for Enhanced Passengers' Experience	2.2_Lab02_03 11.1_Lab02_03

Regarding the capacity-related KPIs, the most stringent requirement is in terms of downlink throughput per user. A throughput of 500 Mbps is required to support multiple surveillance video flows destined to the Command and the Monitoring room, in both UC1 and UC4 (Smart Traffic Monitoring) UCs. Furthermore, the uplink throughput is critical for UC10, due to the large number of video streams from the players' field.

In terms of latency KPIs, extremely low values are required (one way around 6-10ms) for UC13 "Extended Reality Museum Experience" in Turin and UC9 "Adaptive Control of Hannes Prosthetic Device", due to their intrinsic highly interactive nature. Indeed, for UC13 the video flow must be sent to the server to be processed

in real-time and then the output must be fed again to the user: the overall delay must be very small to be acceptable and avoid motion sickness. For robotic control in UC9, by classical control theory, it is well known that the positioning error is proportional to the overall control loop delay, thus high-precision robotic control poses high demanding requirements in terms of latency.

The KPIs related to the machine learning metrics are instead typical of the specific application and their criticality depends not only on the adopted model but also on the amount of training data available.

Finally, the UC2 “Proactive Public Infrastructure Assets Management” and UC11 “Service Robots for Enhanced Passengers' Experience” are the most demanding in terms of service reliability and availability, since related to public safety and public services.

To evaluate the level of validation of the KPIs across all the trials and Open Call sub-projects, a new accounting system will be established to track the performed KPI measurements and the corresponding expected target values. The results will be made available as open-data contributions of the project, whose impact may go beyond the scope of TrialsNet.

2.3 Energy-efficiency KPIs

To perform the evaluation of KPIs related to sustainability, a new category of KPIs is introduced in this deliverable to measure energy-efficiency metrics and accommodate the innovations related to sustainability solution introduced in the deliverable D2.2 [48] of WP2. The main reference documents regarding this category have been authored by 5G-PPP TMV WG, which leveraged the UCs in ICT-52 projects to analyse existing definitions in past standard documents and provided the reference KPIs for being standardized for 6G systems. Related to energy efficiency metrics, the following KPIs have been recommended by 5G-PPP:

- **Network Energy Efficiency**, measured in [Mbit/J]
- **Device Energy Efficiency**, measured in [Mbit/J]
- **Reduced Energy Consumption**, measured in [percentage %]
- **VNF Energy Consumption Reduction**, measured in [percentage %]

The actual definition of such KPIs is found in a past white paper by 5G-PPP TMV WG [8] [9], which inherits the definitions from International Telecommunication Union (ITU)-R M.2410-0 (11/2017). Notably, the network energy efficiency is defined as “the capability of a RIT/SRIT[1] to minimize the radio access network energy consumption in relation to the traffic capacity provided” and the device energy efficiency is defined as “the capability of the RIT/SRIT to minimize the power consumed by the device modem in relation to the traffic characteristics”. Notably, the first definition is tailored to the Radio Access Network (RAN) and must be extended in the context of any network segment relevant to the TrialsNet UCs. Furthermore, the second definition must be also extended to the different end-user devices adopted in the different UCs.

For what concerns the definition of Energy Efficiency in Network Function Virtualization (NFV), the adopted definition referred in [9] is from the European Telecommunications Standards Institute (ETSI) EN 303 471 V1.1.1 (01/2019) and from 3GPP TS 22.261 V16.4.0 (06-2018). Energy efficiency in NFV is calculated based on data transfer (KPIEE-transfer). The white paper [9] specifies two variants of KPIEE-transfer (KPIEE-bit_transfer and KPIEE-packet_transfer) which are measures of the data volume transferred to and from the NFVI per unit of energy consumed by the NFVI.

Additional KPIs are introduced in this deliverable to measure the energy efficiency in relation to the marginal cost in terms of energy required to achieve a target performance improvement at various layers (for instance, in terms of QoS and Quality of Experience - QoE). The Performance Improvement Energy Efficiency (PIEE) is defined as follows. Consider a benchmark reference scenario in which a given performance KPI (e.g., throughput, latency) x_b is achieved with energy E_b in a given time interval. Now consider a target scenario with an improved KPI x^* and corresponding energy E^*, typically higher than E_b. The KPI improvement is $|x^* - x_b|$. Note

[1] Radio Interface Technologies / Set of Radio Interface Technologies

that the absolute value is required to take into account cases in which the improved KPI is higher than the benchmark KPI (e.g., capacity-related KPIs) and cases in which it is smaller (e.g., latency-related KPIs). Now the PIEE is defined as the ratio of the KPI improvement by the corresponding energy increase:

$$\text{PIEE} = \frac{|x^* - x_b|}{(E^* - E_b)}$$

This KPI is generic and can be applied to any performance metric, given a reference benchmarking scenario. By construction, the unit of measurement depends on the considered improvement, e.g., s/J for latency-related KPIs and bit/s/J for capacity-related KPIs. Note that, given the same improvement, a higher efficiency is achieved for a smaller amount of additional required energy. As an example, consider a latency-related KPI in which the benchmark latency x_b is 60ms corresponding to an energy consumption E_b=600J and the target value x* is 20ms corresponding to an energy consumption E_b=800J, then the energy additional cost is 200J and PIEE is 200/40=5 ms/J.

Based on the above, the KPIs table v1 is revised into Table v2 and now comprises the additional energy-rated KPIs reported in Table 4. It has to be highlighted that further interaction with WP2 will be performed to further refine the proposed KPIs based on the actual experimentation of the sustainability solutions.

Table 4. Additional rows added to KPIs table v2.

KPI Name	KPI ID	KPI Definition	KPI Category
Energy Efficiency	19	Ratio of the total transferred data in a network system/segment/device during a given time period to the total consumed energy, measured in [bit/J].	Energy
Reduced Energy Consumption	20	This KPI is defined as: (E_s - E_b) / E_b, where E_s represents the energy consumption required to transmit a given data volume for a system that integrates energy saving oriented solutions at any layer (from the integration of more energy efficient hardware devices to resource management strategies to optimization approaches at the application layer...), whereas E_b represents the energy consumed in the baseline case that does not integrate the proposed solution. Normalized metric with no dimensions.	Energy
Performance Improvement Energy Efficiency (PIEE)	21	Ratio $\|x^*-x_b\|/(E^*-E_b)$ having defined for a given time period: - target KPI x^* with corresponding E* energy - reference KPI x_b with corresponding E_b energy The unit of measure may vary depending on the considered KPI (e.g., bit/s/J, s/J)	Energy

3 Progress on Business Models and KVIs

3.1 Business model and value

In today's rapidly evolving business landscape, the concept of value has transcended the traditional notion of shareholder primacy[2]. Businesses increasingly recognise the importance of considering a broader array of stakeholders and societal impacts in their value-creation processes. This section explores the intersection of technological innovation and sustainable value creation, with a focus on 6G and informing the direction of the TrialsNet project. It delves into the numerous dimensions of value, and the role of innovation in driving sustainable value. The initial business model framework was introduced in D6.1 [1], this model can establish which UCs have the potential for the greatest value creation. These concepts are viewed against the backdrop of the ongoing TrialsNet project, with the object of enhancing the project's potential to create and capture greater sustainable value through innovative 6G technologies and UCs.

3.1.1 Background

In an era characterised by rapid technological advancement, the TrialsNet project has embarked upon a transformative journey from 5G to 6G aimed at changing mobile technologies and reshaping the fabric of our interconnected world. At its core, TrialsNet seeks to harness innovation around mobile connectivity, focusing mainly on a series of technical, performance and productivity objectives. The project also seeks to generate societal benefits in several different industrial and geographical contexts, including a focus on sustainability, building towards a future defined by the well-balanced convergence of technology and collective well-being.

Amidst the backdrop of rapid urbanisation and the quest for sustainable development, the TrialsNet project draws inspiration from the concept of Smart Cities as engines of positive change. Recognising the intrinsic link between technological innovation and societal advancement, TrialsNet envisions a future where 6G technologies serve as catalysts for addressing social, economic, and environmental challenges. By harnessing the transformative potential of 5G mobile connectivity and beyond[3], TrialsNet aspires to cultivate resilient, inclusive communities characterised by sustainability, equity, and trust.

Mobile technology is the main focus of TrialsNet, which aims to align with broader social, economic, and environmental priorities through the deployment of large-scale trials of innovative 6G applications. These applications, spanning a diverse spectrum from Cobots to the Metaverse, from massive twinning to the Internet of Senses, are strategically tailored to address critical societal needs across three pivotal domains within European urban ecosystems:

- **Infrastructure, Transportation, and Security & Safety**: Enhancing the resilience and efficiency of urban infrastructure while safeguarding public safety and security.
- **eHealth and Emergency**: Revolutionizing healthcare delivery and emergency response mechanisms to ensure equitable access to quality care.

[2] Shareholder theory was championed in the 1960s and 70s by Milton Friedman and his colleagues at the Chicago School of Economics (Nelson, 2001). His doctrine asserts that, "an entity's greatest responsibility lies in the satisfaction of the shareholders" and that "the sole social responsibility of the firm is to increase its profits" (Friedman, 1970). Such ideas are said to have underpinned the rise of neoliberalism in the 1980s, which advocated for limited government intervention in the economy, promoting free-market capitalism, deregulation, and privatisation. It could be argued that such notions have accelerated climate change, inequality, and various forms of social, economic, and environmental decline by prioritising unrestricted market forces over sustainable development, exacerbating resource exploitation, widening wealth disparities, and undermining regulatory frameworks aimed at mitigating these issues (Monbiot, 2016). However, these arguments often quickly become political and polarising, so care is needed to ensure a free and open dialogue that embraces diverse perspectives and new ideas while avoiding narrow-minded or biased viewpoints.

[3] The scope of TrialsNet includes 5G, so-called Beyond 5G (B5G) technologies and 6G. For the purposes of brevity in this report we simply refer to these collectively as 6G.

- **Culture, Tourism, and Entertainment**: Enriching cultural experiences and promoting sustainable tourism through immersive technologies that foster community engagement and inclusivity.

Central to the TrialsNet methodology is the development of KVs and KVIs, which will highlight potential pools of sustainable value[4] and act as a focal point to align the project's activities and objectives. These will be supported by the rigorous application of KPIs through a holistic lens that aims to look beyond not only the technical merits of B5G and 6G but also encompass a broader range of social, economic, and environmental considerations. In developing robust assessment frameworks that integrate qualitative and quantitative measures, TrialsNet seeks to highlight the many-sided impacts of its 6G applications on society at large and to stimulate the early adoption and widespread acceptance of 6G technologies that will drive positive change and advance the common good.

In essence, TrialsNet aims to demonstrate the transformative power of technology when harnessed with a conscious commitment to a broader set of sustainable values. By considering more than just financial performance, organizations can focus on delivering against a QBL of Profit, Planet, People and Purpose, creating a brighter, more equitable future for all. In the following paragraph, there is an introduction to the context of value and how value definition has evolved over the years. This leads us to the reason why a wider context of value is considered in TrialsNet.

3.1.2 Scope of the analysis

The scope of the deliverable encompasses a comprehensive analysis of the social, environmental, and economic dimensions of value creation, emphasizing the significant role of technological innovation in driving sustainable outcomes. Drawing on a range of publicly available information and building upon the Technology, Market, Organization and Governance (TMOG) framework developed under 5G-TOURS, the report considers the alignment of business objectives with existing sustainability reporting standards and frameworks. Furthermore, it will examine the critical aspect of ensuring a good fit between innovations and the sustainability goals of stakeholder and end users, thereby improving the likelihood of capturing sustainable value.

By combining insights from various perspectives, including social, economic, environmental, and business, this report aims to provide a trajectory for the TrialsNet project. The exploration of KVs relevant to the project's UCs, it aspires to create a common language between stakeholders, which can enhance communication, improve collaboration, and ensure a shared understanding.

It has long been held that the primary measure of value for businesses revolves around maximising shareholder wealth. However, in recent years, there has been a paradigm shift towards stakeholder primacy, where businesses are expected to consider the interests of all stakeholders, including employees, customers, suppliers, and the broader society. This expanded notion of value recognises that businesses have social, environmental, and ethical responsibilities beyond financial returns. It emphasises the importance of creating value that is sustainable and inclusive, encompassing economic, social, and environmental dimensions.

3.1.2.1 The Meaning of Value

The word "value" finds its roots in Latin, stemming from the verb "valere," meaning "to be strong, be worth, be of value" [10]. This linguistic heritage hints at the intrinsic connection between value and strength, underlining the enduring importance placed on objects or concepts deemed worthy or significant.

Throughout history, value has been intertwined with notions of worth and significance. In ancient civilisations, bartering systems sought to maximise the mutual benefit of agreeing on a value for the exchange of goods and

[4] Sustainable value in the context of this report and the TrialsNet project refers to creating and delivering value in a manner that balances economic, environmental, and social equity both in the present and for the future. This concept integrates principles of sustainability into business strategies, technological innovation, product development, and operations to ensure that resources are used efficiently, environmental impacts are minimised, and social well-being is enhanced.

services. This subjective but collaborative appraisal of worth laid the foundation for early economic transactions and social relations.

In the realm of business, value assumes a quantifiable guise, often measured in terms of monetary worth. The advent of capitalism, spurred on by Friedman and his contemporaries [11], ushered in an era where, in some markets at least, profit maximisation became the primary metric of success for corporations[5]. In this context, value is equated with financial gain, and businesses strive to enhance shareholder value through efficient operations and revenue growth. Or as Mark Carney put it succinctly, "(the) concepts of value are rooted in philosophy and more recently – and narrowly – in economic and financial theory" [12].

However, the narrow focus on financial metrics neglects broader considerations of social and environmental impact. Critics argue that this myopic perspective fails to account for the true cost of production and consumption, leading to externalities such as pollution, exploitation, and inequality [13][14].

3.1.2.2 Significance of Expanding Notions of Value in Today's Business Landscape

In recent years, the notion of value creation in contemporary economics has undergone a significant transformation, reflecting shifts in economic priorities, technological advancements, and evolving societal values. While traditional economic theories have long emphasised shareholder primacy as the foremost measure of value, modern businesses are increasingly recognising the limitations of this narrow perspective. Instead, there is a growing consensus that value creation must be viewed through a multidimensional lens that encompasses not only financial returns but also social, environmental, cultural and ethical considerations. This paradigm shift towards a broader spectrum of values finds its origins in a historical trajectory marked by pivotal events, social movements, and evolving moral priorities.

One critical milestone in this transition was the emergence of the environmental movement in the mid-20th century. Influential works such as Rachel Carson's "Silent Spring" (1962) raised awareness about the detrimental effects of human activities on the environment, catalysing widespread activism and prompting businesses to consider their ecological footprint. Simultaneously, the civil rights movement and other social justice movements of the 1960s and 1970s challenged systemic inequalities and discrimination[6], prompting businesses to address issues of diversity, equity, and inclusion within their operations and supply chains [15]. In 1972 the Club of Rome, a global think tank, commissioned "The Limits to Growth" [16]. The report, based on a computer simulation, warned of the possible collapse of civilisation due to population, industrial growth, resource depletion, and environmental pollution. The report triggered a debate on the sustainability of economic growth and the need for alternative models that would balance environmental, social, and economic goals. The Club of Rome was one of the pioneers of ESG (environmental, social, and governance) criteria, which are now widely used by investors and companies to measure their impact on society.

At around the same time Friedman's assertion that, "the social responsibility of business is to increase its profits" [11] was becoming widely embraced by business leaders and politicians ushering in the era of neoliberalism. The main features of this era were widespread deregulation and increasingly globalised trade that led to spectacular growth but also to questionable moral governance, culminating some would argue, in the 2008 financial market failure [17], [18].

The late 20th century saw a series of corporate scandals, including Enron [19] and WorldCom [20], which eroded public trust and underscored the importance of ethical leadership and transparency in business practices. More recently the Deepwater Horizon oil spill in 2010 further eroded public confidence in the in the

[5] Mariana Mazzucato, a professor of economics at University College London highlights alternative capitalist models as seen in Germany, Scandinavia, and Japan. In those regions, companies are not encouraged to prioritise short-term profits. Instead, they offer lower executive remuneration and hold themselves accountable to a broader group of stakeholders, including employees (Mazzucato, 2018).

[6] In the US, landmark legislation such as the Civil Rights Act of 1964 and the Equal Employment Opportunity Act of 1972 mandated non-discrimination in hiring, promoting, and firing, compelling businesses to reevaluate their employment practices.

environmental responsibility of big corporations. These events and some others reported in [21], [22], [23], led to a growing demand for corporate accountability, responsible governance and environmental justice .

In response to these societal shifts and ethical priorities, the concept of Corporate Social Responsibility (CSR) has gained traction, emphasising the importance of businesses considering the interests of a broader set of stakeholders, including employees, communities, and the environment, alongside traditional financial objectives. Since the early 1990's the world's leading firms have been increasingly disclosing details of their impact and sustainability. Sustainability reporting is now so widespread that the few companies that have yet to adopt it will be at odds with emerging international standards, threatening their ability to succeed in the modern marketplace.

Building upon this foundation, the United Nations Sustainable Development Goals (UN SDGs) have emerged as a comprehensive framework for global action to address pressing environmental, social, and economic challenges [24]. Established in 2015, the SDGs represent a collective effort to eradicate poverty, promote equality, protect the planet, and ensure prosperity for all by 2030. This shift towards a more inclusive approach to value creation underscores the significance of aligning business strategies with the SDGs, as companies recognise the need to integrate sustainability into their core operations to meet the expectations of diverse stakeholders and contribute meaningfully to societal and planetary well-being.

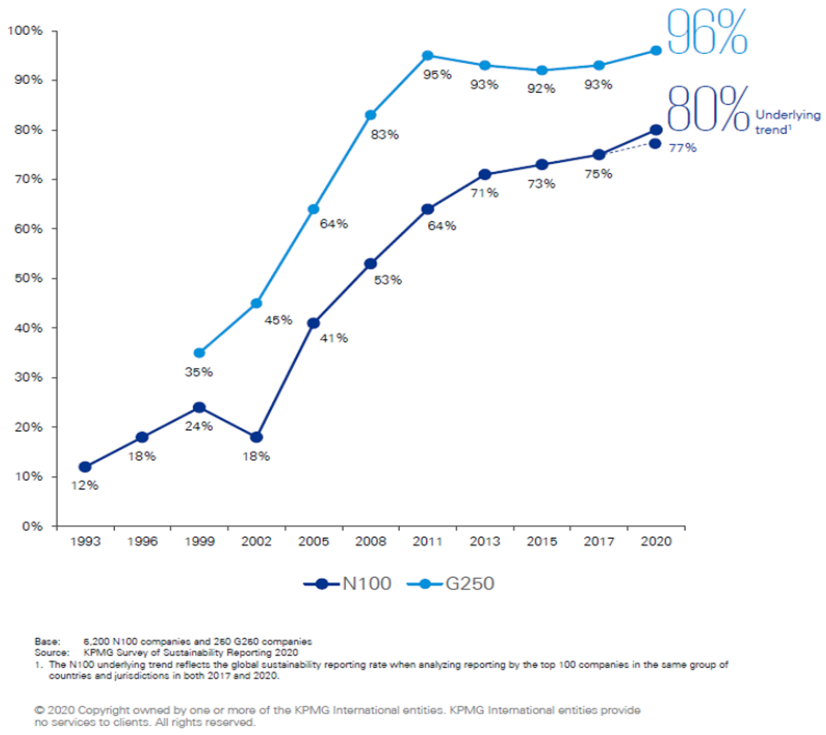


Figure 3. Growth in global sustainability reporting rates since 1993: N100 and G250[7] (KPMG, 2020).

The SDGs are designed to address global challenges and although ambitious in nature they are necessarily broad in scope. As shown in Figure 3, there is a growth in global sustainability reporting. To be practical and effective, therefore, means they need to be adapted and implemented at a number of different levels. It is essential therefore

[7] The N100 refers to a worldwide sample of 5,200 companies. It comprises the top 100 companies by revenue in each of the 52 countries and jurisdictions researched in this study. These N100 statistics provide a broad-based snapshot of sustainability reporting among large and mid-cap firms around the world. The G250 refers to the world's 250 largest companies by revenue as defined in the Fortune 500 ranking of 2019. Large global companies are typically leaders in sustainability reporting and their reporting activity often predicts trends that are subsequently adopted more widely.

that industries, corporations, organisations, and individuals interpret these goals in ways that align with their specific contexts and capacity to act. By customising strategies and objectives to fit more particular and/or localised needs and capabilities, these entities can contribute significantly to the overarching aims of the SDGs.

Today, businesses operate in an increasingly interconnected global economy, where stakeholders expect greater accountability and transparency, and society demands it due to a number of existential threats including climate change. The COVID-19 pandemic further highlighted the interdependence between businesses and society, emphasising the importance of corporate resilience, adaptability, and social responsibility [25], [26], [27], [28], [29], [30].

3.1.2.3 The Multidimensional Concept of Value in Contemporary Business Models

In the pursuit of wider sustainable value, it is important to recognise that businesses exist within complex ecosystems of diverse actors, including employees, customers, suppliers, local communities, and the wider society. The modern, broader concept of value is rooted in the philosophy of stakeholder primacy, which advocates that businesses should consider the interests of all stakeholders (not only shareholders) in their decision-making processes [31]. Each of these stakeholders contributes to and is affected by the activities of the business, shaping its operating environment and influencing its long-term success. Consequently, businesses are beginning to understand that their value proposition extends beyond merely generating profits for shareholders; it encompasses creating positive outcomes for all stakeholders involved.

Proponents of stakeholder primacy advocate that by prioritising the needs of employees, customers, communities, suppliers and partners, as well as shareholders, businesses can establish stronger relationships, build trust, and ultimately enhance their long-term sustainability and resilience. This approach argues that the key to enduring business success lies in recognising and addressing the broader spectrum of stakeholder interests. As companies begin to focus more on these aspects, they not only improve their reputations but also lay the foundation for sustainable operational practices that can withstand economic fluctuations and societal shifts.

A recent Aviva paper [32] has highlighted research, which indicates that diverse teams tend to be more innovative [33], and that employees who are happier are generally more productive [34]. It adds that companies that maintain close, trust-based relationships with their suppliers are better equipped to respond flexibly during a crisis, enhancing their resilience [35], [36].

From a practical standpoint, the concept of value creation can be understood across multiple dimensions:

- **Social Value**: Social value refers to the positive contributions that businesses make to society, including creating jobs, supporting local communities, promoting diversity and inclusion, and addressing social inequalities. Businesses that prioritise social value are often viewed more favourably by consumers, employees, and other stakeholders, leading to enhanced brand reputation and customer loyalty.
- **Environmental Value**: Environmental value pertains to the impact of business activities on the natural environment, including resource consumption, pollution, and greenhouse gas emissions. As concerns about climate change and environmental degradation continue to mount, businesses are under increasing pressure to minimise their environmental footprint and adopt sustainable practices throughout their operations.
- **Ethical Value**: Ethical value encompasses the ethical principles and values that guide business behaviour, including integrity, honesty, fairness, and transparency. Businesses that prioritise ethical value are more likely to earn the trust and respect of their stakeholders, leading to stronger relationships and greater long-term success.
- **Economic Value**: This dimension encompasses traditional measures of financial performance, such as revenue, profit margins, and return on investment. For the purposes of this discussion, we refer to these as indicators of commercial value. Whilst commercial value remains important, it is no longer viewed as the sole determinant of success. Instead, businesses are increasingly recognising the need to balance commercial interests with broader societal impacts. The notion of wider economic value encompasses factors such as education, job creation, economic growth, and innovation. Businesses that stimulate economic activity, foster innovation ecosystems, and create employment opportunities contribute significantly to overall societal prosperity. Therefore, a comprehensive understanding of value in contemporary business models requires the consideration of these broader economic impacts.

Furthermore, in once again considering the role of technology in realising sustainability goals it gives pause to reflect again that technology is a double-edged sword: it empowers us but can also lead to negative outcomes. It not only has the potential to do good, such as making clean water accessible to all humans but also enables us to do harmful things. It takes effort, vision and moral leadership to focus on using technology for good through the creation of sustainable value, therefore, we must be vigilant. As Anthony Kenny [37] noted, failing to act for good when we have the chance can be just as harmful as directly causing harm.

As discussed in this subsection, how the concept of "value" has evolved over the years within the business industry. Initially, "value" was primarily associated with financial gain or monetary worth. However, the modern interpretation of value has expanded to encompass broader dimensions such as social and environmental contributions. This introduction also explored the underlying reasons behind this shift, highlighting the factors driving the redefinition of value in today's business landscape.

In the following subsections, two examples of KVIs' assessment are provided. In particular, a couple of methodologies are proposed, the first one is about combining several KVIs into one KVI, while the second is based on KVI assessment through questionnaires.

3.2 KVIs assessment

In this section a couple of methodologies for KVIs assessment are presented. Hence, providing concrete examples that demonstrate how KVIs can be effectively applied to assess and measure value across various project activities. These UCs not only serve as practical illustrations but also highlight the versatility of KVIs in capturing a wide range of metrics, spanning social, economic, and environmental dimensions, relevant to the project's goals. By examining these real-world scenarios, readers can gain deeper insights into how KVIs function in diverse contexts, ensuring that value creation aligns with both the project's objectives and broader societal impacts.

These examples provide a blueprint for how KVIs can be used in some context as a decision-making tool to guide future developments, ensuring that the TrialsNet project remains agile, responsive, and aligned with its mission to generate inclusive, sustainable value across its ecosystem.

3.2.1 KVIs assessment of UC10

UC10 "Immersive Fan Engagement" explores 5G/B5G limits supporting immersive fan application (with a live basketball sports match) deployed by Yerba Buena Virtual Reality (YBVR) [7] using fixed network infrastructure with fiber connections linking cameras, production computers, and cloud-based streaming distribution platform. From a user's perspective, UC10 offers two scenarios to test the 5G network:

- **In-venue experience**: Users will utilize mobile smartphones allowing them to select different TV feeds in real-time.
- **At-home experience**: Users can access the sports match via Virtual Reality (VR) headsets to view the live sport match with cameras positioned in the courtside providing a seamless immersive viewing experience.

The following section details the method used to validate the KVIs, the conception process of the structural model used to link the KVIs, and the results and interpretation of results. The validation test was carried out in December 2023 and was detailed in the deliverable D5.2 [7].

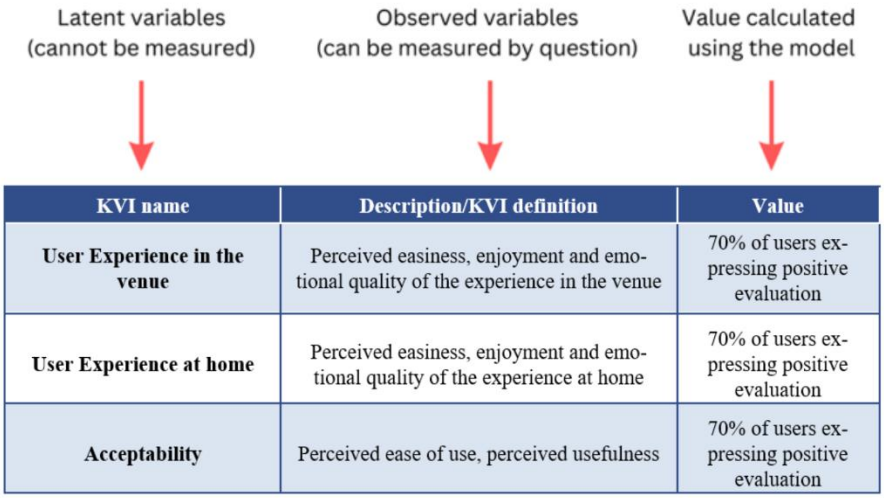
3.2.1.1 Methodology

The UC10 Immersive Fan Engagement has defined three main KVIs namely User experience in venue, User experience at home, and Technology Acceptance. Figure 4 provides the defined KVI and related descriptions.

Based on the above, it has to be highlighted that challenges arise when trying to quantify the KVIs as a single value without synthesizing the underlying components. For example, in the case of KVI for Technology Acceptance, which comprises multiple variables: perceived ease of use, and perceived usefulness, each variable is distinct and analysed independently. These observed variables differ from one another and cannot be directly combined to yield a comprehensive result. To overcome this, the Partial Least Squares Structural Equation

Model (PLS-SEM) method addresses this by converting these observed variables into a single latent variable. Practically, the PLS-SEM is a statistical method for structural equation modelling that allows estimation of complex cause-effect relationships in path models with latent variable and it has become a standard approach for analysing complex inter-relationships between observed and such latent variables as explained in [37] [38] [39]. This approach allows each component to be individually analysed to explain the latent variable and to collectively contribute to a more cohesive and accurate representation of the construct. Attempting to do so may result in a fragmented, general or incomplete measurement as each variable alone does not equate to the full construct.

In the case of UC10, Figure 4 shows the KVI name as latent variable, that comprises of the KVI descriptions as observed variables which can be measured through a series of questions, to be able to calculate the result. To investigate whether immersive fan engagement impacts users' experience, the first step is to examine the relationship between the UC (Technology Innovation) and the User Experience variable. If a significant relationship is found, the next step is to quantify the effect to determine the impact of the UC on User Experience. The same approach should be applied to evaluate the relationship and impact on Technology Acceptance.



KVI name	Description/KVI definition	Value
User Experience in the venue	Perceived easiness, enjoyment and emotional quality of the experience in the venue	70% of users expressing positive evaluation
User Experience at home	Perceived easiness, enjoyment and emotional quality of the experience at home	70% of users expressing positive evaluation
Acceptability	Perceived ease of use, perceived usefulness	70% of users expressing positive evaluation

Figure 4. UC10 KVI variables elaboration.

Starting July 2023, YBVR developed the structural model based on Telefonica's hypotheses that also included the KVI descriptions. These variables are then used to prepare the model and to investigate the existing relationships from previous studies.

Figure 5 show an overview of the structural equation model. Below are the variables included in the preliminary model:

- Innovation to Technology Acceptance Model (TAM) that consists of perceived ease of use and perceived usefulness) from Ngubelanga & Duffett (2010) [40]
- TAM to Perceived enjoyments from Li & Chen (2019) [41]
- Perceived enjoyment to Customer Experience from the study of McLean, *et al.* (2018) [42]
- Customer Experience to satisfaction relation was based on the study by Surjandy *et al.*, (2023) [43]
- Satisfaction´s relationship with consumer behaviour intentions (intention to interact and intention to recommend) was based on the paper written by Cronin *et al., (*2000) [44]

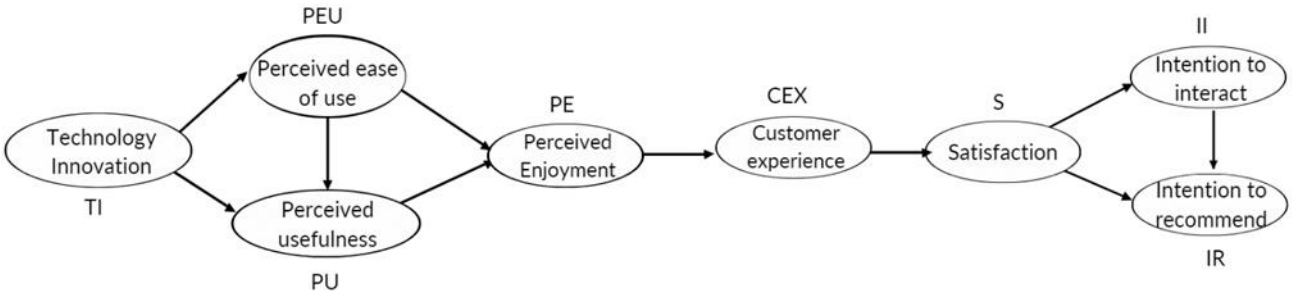


Figure 5. UC10 Structural Equation Model.

After the completion of the model, the questionnaires were drafted based on questions from previous scientific papers (reported in the Annex A).

On the 11-12th of December 2023, at the 5Tonic laboratory, YBVR and Ericsson carried out a pretest to test the existing production equipment with Ericsson's standard WIFI network. YBVR took the opportunity to conduct a trial with real users from Universidad Carlos III students and participants present in the laboratory to obtain preliminary results of the user experience. The technical detail of the pretrial was included in the deliverable 5.2 [7]. Due to a low number of participants, each user was requested to partake in both scenarios, to watch a snippet of the basketball match in their mobile phones (using YBVR's Euroleague VR application), then using the VR headset to watch the same match but in 360º view. Additionally, data for both scenarios were combined to calculate as only one user experience in general.

To focus only on the KVI results, the model has to be analysed twice due to the variable "perceived ease of use" being used twice (user experience and technology acceptance KVIs). UC10 is represented by Technology innovation variable, and the descriptions formed the user experience KVI, and the TAM KVI. Figure 6 depicts how UC10, represented by "Technology innovation", is connected to the latent variable User Experience, which includes the observed variables Perceived ease of use, Perceived Enjoyment, and Customer Experience.

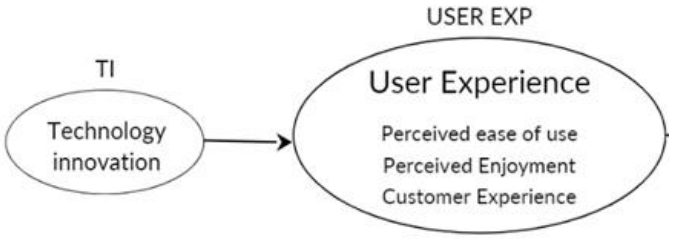


Figure 6. User Experience model.

Figure 7 shows how UC10 as a Technology Innovation is connected to Technology Acceptance as a dependent latent variable, that involves perceived ease of use and perceived usefulness.

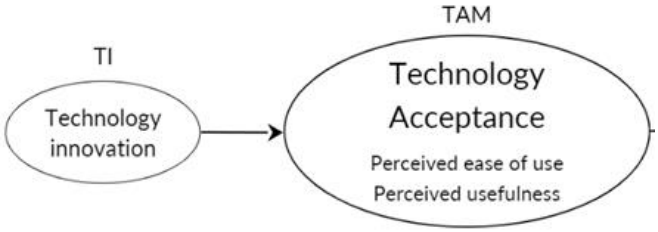


Figure 7. Technology Acceptance Model (TAM).

3.2.1.2 Results

After obtaining a total of 23 samples from the pretest, below is the graphical output of latent variables User Experience (Figure 8) and TAM (Figure 9).

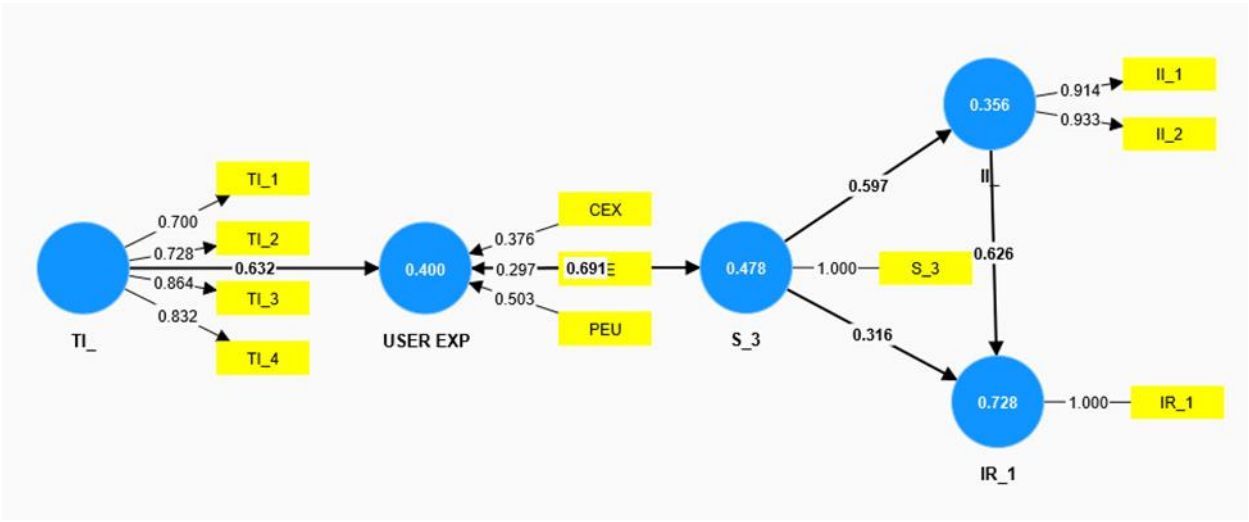


Figure 8. User Experience graphical output.

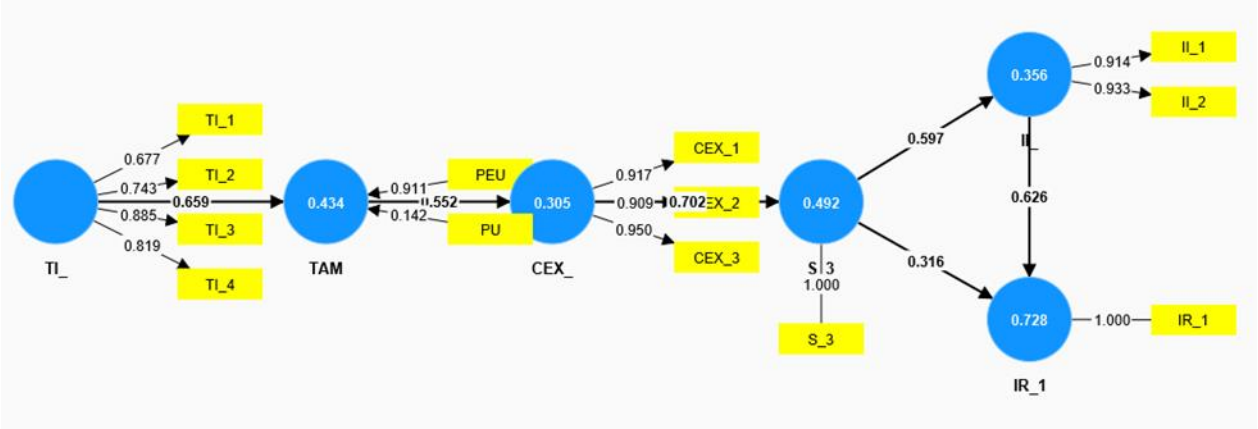


Figure 9. Technology Acceptance graphical output.

Path coefficients quantify the strength and direction of the relationships between exogenous variables, in this case UC10 represented by innovation technology (TI) and endogenous variables (User Experience and TAM) within a model. Essentially, these coefficients indicate how changes in an exogenous variable are expected to impact the endogenous variable, either positive or negatively. The higher the path coefficient suggests a stronger relationship, implying that the exogenous variable significantly influences the endogenous variable. T-statistic is used in the context of hypothesis testing. This method helps to compare the data if it did well than the other and determines whether the hypothesis is supported or rejected. The value of t-statistic that is considered to be supported should be >= 1.96. P-values help figure out if something is likely true or just by coincidence (luck). A variable is statistically significant if the value is <0.05.

Table 5. Measurement results.

Relationships	Coefficient	T-statistic	p-values	Research hypothesis
TI -> User Exp	0.632	4.827	0.000	H1 Supported
TI -> TAM	0.659	5.854	0.000	H2 Supported

*T-statistic >= 1.96; P-value should be < 0.05.

Correlation coefficients are used to measure the strength of the linear relationship between two variables. Since the coefficients in Table 5. Measurement results are evaluated as a measure of correlation, the range of correlation coefficient values proposed in the literature [45] [46] is adapted as shown in Table 6.

Table 6. Range of Correlation Coefficient Values and the Corresponding Levels of Correlations.

Range of Correlation Coefficient	Level of Correlation
0.80 to 1.00	Very strong positive
0.60 to 0.79	Strong positive
0.40 to 0.59	Moderate positive
0.20 to 0.39	Weak positive
0.00 to 0.19	Very weak positive
-1.00 to -0.80	Very strong negative
-0.79 to -0.60	Strong negative
-0.59 to -0.40	Moderate negative
-0.39 to -0.20	Weak negative
-0.19 to -0.01	Very weak negative

Table 7 displays the f-square of the latent variables “User Experience” and “TAM”. f-square determines how a dependent variable in a structural model may be affected/influenced by an independent variable. The F square measures the extent of the impact that the variables in the structural model or the exogenous latent variables have on the endogenous variables. This measure is determined by comparing the R square value achieved when variables are added or removed from the structural model. f-square effect size >=0.02 is small; 0.15 is medium; >= 0.35 is large (Cohen, 1988)[46].

Table 7. f-square matrix.

	User Exp	TAM
TI	0.666	0.767

Source: UC10 Own elaboration using SmartPLS software

3.2.1.3 Conclusions

Based on the data collected following the statistical analysis, results reveal statements summarized in Table 8.

Table 8. Summary of results.

Latent Variable (KVI)	Observable variables	Relationship	Value
User Experience	Perceived ease of use (PEU), Perceived enjoyment (PE), and Customer Experience (CEX)	TI -> User Exp	Analysis suggested a **strong positive relationship** between Technology Innovation and User Experience, with a substantial **effect** of 67%.

Technology Acceptance	Perceived ease of use (PEU) and Perceived usefulness (PU)	TI -> TAM	Analysis suggested **a strong positive relationship** between Technological Innovation and Technology acceptance (PEU and PU), with a substantial effect of 77%.

When preparing for the final trial in January 2025, issues may arise due to the capacity of the at-home scenario facility, and the probability of distributing the survey in the whole duration of the sports match. The partners decided to reduce the sample size to 80 users, granted that the size would not compromise the accuracy of the results. To make this possible, the model must reduce its variables, removing the coinciding questions in the survey form such as satisfaction, intention to recommend and intention to use.

Moreover, the questionnaire has been reviewed and improved to comply with General Data Protection Regulation (GDPR) regulations, and a global single item will be added to answer the question "What is your overall user experience". This will give a more detailed and informative result for the KVI user experience without disregarding the KVI descriptions (Perceived ease of use, Perceived enjoyment, customer experience). The final validation results will be detailed in the next deliverable D6.3.

3.2.2 KVIs assessment in the Turin Cluster

The Turin cluster involves three UCs, one in the Infrastructure, Transportation, and Security & Safety domain (i.e., UC5) and the other two in the Culture, Tourism, and Entertainment domain (i.e., UC12 and UC13).

UC5 focuses on enhancing the operational efficiency of security forces, including the Police, 112 emergency services, ambulances, and firefighters, within the municipality of Turin. This is achieved through the development of a collaborative "Metaverse Control Room," which can be accessed remotely via an access code. The scenario involves a public event (e.g., a concert or demonstration) where security teams have pre-coordinated an emergency action plan. During the trial, an accident is simulated within a restricted, traffic-free area created for the event, allowing security forces to test their coordinated response in a realistic setting [5].

UC12 centres around an engaging fantasy game set in Valentino Park, one of Italy's most iconic parks. Designed for teams of four players, including young adults, families, and friends, the game leads participants through various points of cultural interest within the park, incorporating augmented reality, virtual reality, and metaverse elements. Its adaptable design ensures playability, flexibility, and modularity, allowing it to be implemented in parks across different cities. This UC not only delivers an entertaining experience but also fosters cultural awareness by integrating advanced technology into a public recreational space [7].

UC13 seeks to enhance the appeal of four civic museums in Turin (i.e., Palazzo Madama, GAM, Museo Pietro Micca, and Museo del Risorgimento) through immersive experiences promoted via the city's main tourism portal. The trial includes evaluating the public 5G network's ability to support continuous, high-speed transmission of video, images, and sound data. The objectives are threefold: to increase museum visits using gamification strategies, making them more attractive, especially for younger audiences; to assess the effectiveness of augmented and virtual reality and metaverse technologies in creating a cohesive and engaging cultural experience across different museum contexts; and to determine whether the public 5G network infrastructure meets the demands of these advanced digital applications, particularly in terms of bit-rate and latency [7].

The following sub-sections outline the research design and methodology used to identify, validate, and assess the KVIs across these three UCs. Additionally, a preliminary description of the results from the application of this work to UC5 is provided, based on the trial conducted in October 2024.

3.2.2.1 Methodology

The methodology proposed for the evaluation of KVs within the context of UC12 and UC13 involves a comparative research design between an experimental group and a control group. The experimental group is exposed to and uses the new technologies developed and implemented as part of the TrialsNet project, while the control group continues to perform tasks and activities using standard methods, without the integration of new technologies. The advantages of this approach include:

- **Causal inference**: by comparing the experimental and control groups, the design allows for a clearer determination of the impact of the new technologies, whereby any significant difference in outcomes can more confidently be attributed to the technologies rather than other variables;
- **Control of confounding variables**: having the same participants taking part in both conditions or, when this is not possible, matching participants of the two groups helps control for confounding variables, ensuring that any observed difference is due to the experimented technology;
- **Benchmarking**: the control group provides a benchmark against which the performance and value added by the technologies can be measured, making it easier to assess their actual benefit;
- **Practical feedback**: insights gained from the experimental group can be used to refine and improve the technologies before broader implementation.

This approach is not applicable for UC5 because, for organizational and ethical reasons, it is not feasible to engage emergency vehicles and personnel for more than one trial condition. In this case, additional qualitative follow-up methodologies are used to allow for a comparison with standard operational situations and to evaluate the different potential applications of the metaverse technology.

Operationalization of KVs into KVIs

First, for each UC, relevant **KVs are identified and defined** based on observations from previous projects, current literature and the specifics of the project and of the UCs. Then, **each KV is operationalized**. Operationalizing a construct involves defining abstract concepts in measurable terms, by breaking them down into specific, observable, and quantifiable elements. In the context of KVs, for instance, the KV "Acceptance" can be operationalized by identifying specific KVIs that reflect how users perceive and engage with the technology. This might include measuring users' attitudes towards the technology, such as ease of use, usefulness and comfort of the experience. Questionnaire items (KVIs) for this KV could include statements like:

"It was easy to use the technology"
"The technology was useful to provide an appropriate service"
"The experience with the technology was comfortable"

These items are then rated on a Likert scale to quantify users' acceptance levels.

For each KV, **questionnaire items** (KVIs) are formulated according to the following **psychometric principles**:

- **Relevance to constructs**: items are directly related to the specific KV being measured, ensuring that the questionnaire accurately reflects the constructs of interest;
- **Clear and concise language**: items are written in clear and simple language to avoid any misunderstanding, and each item focuses on a single idea or concept;
- **Avoiding bias**: items are phrased neutrally and are free from leading or loaded language that might bias the respondent's answers;
- **Balanced scale options:** Likert scales are used to collect responses, with balanced response options which provide a full range of possible responses (from 1="strongly disagree" to 5="strongly agree");
- **Expert validation:** items are generated based on literature review, expert and stakeholder consultation, and relevant theoretical frameworks, and they are refined through iterative rounds of review;
- **User validation:** each questionnaire is examined with a small, representative sample from the target population during a DT+ session to identify any issues with item clarity, relevance, or interpretation.

Please note that, within each questionnaire, some items are common for the experimental and the control condition, while some items (specifically referring to the experience with the technologies) only apply to the experimental condition.

Two **general outcome items**, i.e., "intention to use" and "intention to buy", are added to each questionnaire directed at the experimental group.

Procedure and statistical analyses

For all UCs, at the end of each trial condition, users are administered the relative questionnaire, and asked to express their agreement to every statement on a Likert scale from 1="strongly disagree" to 5="strongly agree". Two types of evaluation are carried out:

- For the experimental condition, a mean score higher than 3 on the items relating to a specific KV is considered as a positive evaluation: the target is to achieve a **70% positive evaluation** for each KV;
- For UC12 and UC13 a comparison between the experimental and the control condition is carried out using a paired-samples t-test: the target is to obtain significantly **higher score in the experimental than in the control condition**.

In addition, for a more comprehensive assessment, some additional **KVIs based on factual measurements** (complementary to the subjective measurements derived from the questionnaires) are assessed for UC12 and UC13, to complement participants subjective views on the experience.

KPIs to KVIs mapping

Mapping KPIs to KVIs is essential for understanding how technical metrics (KPIs) affect subjective user experiences (KVIs). This process is particularly critical in contexts such as AR (Augmented Reality)/VR experiences, where network performance directly influences user satisfaction and perceived value.

KPIs to KVIs mapping is feasible only when an **adequate sample size** is available. In statistical terms, the reliability and validity of the mapping process depend on having a sufficiently large and diverse dataset. This ensures that the relationships between KPIs and KVIs are robust and generalizable across different user contexts and conditions. Moreover, a substantial sample size allows for more accurate statistical analyses, such as correlation studies or regression models, which are often used to establish the strength and direction of relationships between these metrics. Thus, for the UCs of the Turin cluster, this process can be applied only to UC12 and UC13.

In a **bottom-up approach**, it starts by identifying specific KVIs within an organization or system. These KVIs represent critical factors that directly impact business outcomes or value delivery. Rather than imposing predefined KVIs from the top down (e.g. derived from theories of technology acceptance), this approach allows KVIs to emerge organically based on data-driven insights (e.g. relevant dimensions emerge from the data and are not pre-defined). It recognizes that different contexts may require unique KVIs. By focusing on KVIs first, we ensure alignment with actual value creation and business goals. This approach avoids the pitfalls of selecting KPIs without considering their relevance to value delivery.

This approach involves a structured process to analyse KPIs and KVIs, enabling data-driven insights without relying on preconceived notions. The steps are as follows:

- **Step 1 - Identification of relevant indicators**: The process begins by identifying KPIs and KVIs that are critical to the specific project or UC. This step integrates multiple sources, including analysis of existing data and relevant literature, as well as detailed consideration of the project's goals and user characteristics. To ensure the selected indicators are both practical and meaningful, a DT session is conducted, during which user feedback validates the preliminary list of KPIs and KVIs. This collaborative approach bridges theoretical insights and real-world applicability, enhancing the overall relevance of the indicators.
- **Step 2 - Model creation**: Rather than preselecting specific KPIs and KVIs beforehand, this approach follows a bottom-up perspective, creating a model that includes all available KPIs and KVIs for the UC. Each KPI is treated as a predictor variable, which is then assessed for its contribution to understanding and predicting each KVI outcome. Depending on the complexity of the relationships, models can range from simple regressions to advanced statistical techniques such as Structural Equation Modeling (SEM). The goal is to uncover meaningful connections between KPIs and KVIs that may not be immediately apparent, ensuring a more comprehensive understanding of the data.
- **Step 3 - Emergent insights:** By allowing the data to guide the analysis, this approach reveals how KPIs influence KVIs and identifies the most significant predictors of user experience. It deliberately avoids relying on preconceived assumptions, allowing insights to surface organically. This method reveals patterns and relationships within the data, offering a deeper, evidence-based understanding of which KPIs are most relevant for measuring and enhancing user value.
- **Step 4 - Application to different UCs**: The methodology is designed to be highly adaptable, enabling its application across a variety of UCs. This adaptability facilitates comparative analyses, where insights from different contexts are contrasted to identify similarities and differences in KPI-KVI relationships.

By combining results from multiple UCs, the approach also highlights vertical-specific variations, offering broader, scalable insights that are applicable across industries.

- **Step 5** – **Example (using a regression model)**: A hierarchical regression model serves as an illustrative example of how this approach operates. In the initial step, vertical factors, such as the industry sector, are incorporated to account for contextual influences. Subsequently, all relevant KPIs for the specific UC are included as predictor variables, ensuring that the model captures a comprehensive set of inputs. The outcome variables represent either individual KVIs or groups of related KVIs.

This approach allows for a detailed exploration of how KPIs and contextual factors interact, offering a nuanced perspective on their combined impact on user value.

3.2.2.2 KVs investigation in UC5

In this section, a preliminary analysis of the trial data from UC5 is reported. The aim is to provide an example of the methodology applied and an initial understanding of the findings. All trial activities, including detailed results and final insights, will be documented in deliverable D5.3.

As previously reported, this UC aims to improve the operational efficiency of security forces by introducing a collaborative Metaverse Control Room, accessible remotely via a secure access code. The trial simulates an accident during a pre-planned public event, testing the coordinated emergency response of police, emergency services, and civil protection agents. The assumption is that an accident will occur during the event. The KVs identified for UC5 are as follows: Availability, Acceptance, Governance, Social Service, and Social Sustainability. First, each KV was defined based on observations gathered from previous projects, a review of current literature, as well as the specific characteristics of both the project and the UC [1]. Table 9 presents the definitions of the KVs for UC5.

Table 9. Definition of KVs for UC 5.

Name	Definition
Availability	Perceived easiness of access according to the users' needs
Acceptance	Perceived acceptability, ease of use, usefulness and comfort of the experience
Governance	Improvement of service efficiency due to stronger cooperation among organizations
Social service	Perceived usefulness in enhancing training experience and in improving the service provided to the public
Societal sustainability	Improved service effectiveness of the measures taken

Subsequently, each KV is assessed through measurable and quantifiable elements. To achieve this, questionnaire items (KVIs) were formulated following strict psychometric principles. These principles include, among others, relevance to theoretical constructs, the use of clear and concise language, and the avoidance of potential sources of bias.

Balanced response scales were employed to collect data: Likert scales were used, offering a full range of possible responses (from 1 = "strongly disagree" to 5 = "strongly agree"). This scale allows for the collection of quantitative data that can be used for accurate and comparable statistical analysis. The items were then refined through iterative rounds of review, which involved project partners, stakeholders, as well as experts in psychometrics. This process ensured a critical review of the items to enhance their quality and ability to accurately measure the identified KVs. Finally, the questionnaire was tested with a small, representative sample of the target population during a DT+ session. This phase aimed to identify and resolve any issues related to item clarity, relevance, or interpretation. The final version of the questionnaire is presented in Table 10.

Table 10. KVIs questionnaire for UC 5.

KV	Items
Availability	Av1 - It was easy to access the virtual reality experience
	Av2 - It was easy to communicate with the other operators involved *
	Av3 - I could quickly access the information I needed *
Acceptance	Ac1 - It was easy to use the functionalities of the control room
	Ac2 - We were able to exchange information promptly *
	Ac3 - The information received was adequate to understand the location and characteristics of the emergency *
	Ac4 - The information received was useful to provide an intervention appropriate for the situation *
	Ac5 - The experience in the control room was sufficiently comfortable (without nausea or other side effects)
	Ac6 - The control room in the metaverse is promising as a standard modality of intervention for the future
Governance	Go10 - The organization of the interventions facilitated effective cooperation among different operational units *
	Go11 - The organization of the interventions promoted operational effectiveness *
	Go12 - The possibility of receiving information during the journey to the emergency site facilitated operational effectiveness
Social service	Se13 - The control room is useful for improving operator training in emergency management
	Se14 - The control room is useful for enhancing the service provided to citizens during emergencies
Societal sustainability	So15 - The service was effective *
	So16 - The service was timely *
	So17 - The operational units cooperated effectively *

* For these items an additional evaluation on a 3-point Likert scale (1="less than in standard operating conditions"; 2="same as in standard operating conditions"; 3="more than in standard operating conditions") is required.

The trial for UC 5 was conducted on 15 October 2024 at Talent Garden (used as an operational headquarter) and Parco del Valentino (on the field) in Turin, involving the active participation of 18 emergency response personnel from various agencies, divided as follows:

- 2 participants from 112 emergency call center
- 5 participants from the Municipal Police
- 4 participants from the Fire Department
- 5 participants from the Ambulance services
- 2 participants from the Civil Protection agency

Upon completion of the trial, participants were asked to provide their personal feedback on the technological solution presented through the App, drawing from their professional field experience. The questionnaire presented in Table 10 was utilized as part of this evaluation process.

Out of the 18 participants, 17 provided valid responses. A preliminary analysis was carried out using descriptive statistics across the entire sample. As illustrated in Figure 10, overall responses were positive (mean scores > 3) in the KVs of Acceptability, Social Service, and Social Sustainability. A neutral evaluation was observed for the KV Governance, with a mean score of 3, while only one KV, Availability, received a mean score below 3, reflecting a negative evaluation.

Consistent with this, in the items relative to Social Sustainability, participants reported on average that the service provided using the Control Room in the Metaverse was more effective, more timely, and allowed more efficient cooperation than in standard operational conditions.

However, when examining the percentage of participants scoring above 3, the findings presented a slightly different picture. In this case, only the KV Service reached the target level, with over 70% of participants providing a score higher than 3.

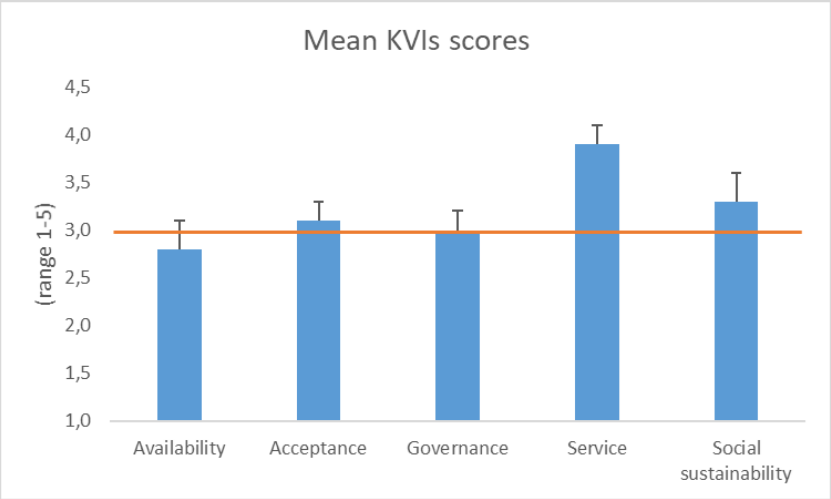


Figure 10. Mean scores for each KVI (mean scores above 3 are considered positive evaluations).

Based on the observation of participants' behavior in the "operational headquarter" and on the field during the trial, it was subsequently decided to conduct a second analysis. This analysis differentiated and compared the responses of those who, during the simulated emergency, were assigned to remain at the operational headquarters (n=6) and interact with the control room using a virtual reality headset, and those who operated in the field (n=11), managing the emergency on-site and connecting with the control room in the metaverse via tablets.

Independent sample t-tests showed that participants who remained at the operational headquarters (represented by green bars in Figure 11) provided a significantly more positive evaluation across all KVIs compared to those who operated in the field (represented by orange bars) (all $t>2.1$, all $p<0.054$). Despite this difference, all participants acknowledged the value of the Control Room in the Metaverse as a tool for enhancing training and improving performance during emergency situations, ultimately benefiting public safety (KV Social Service).

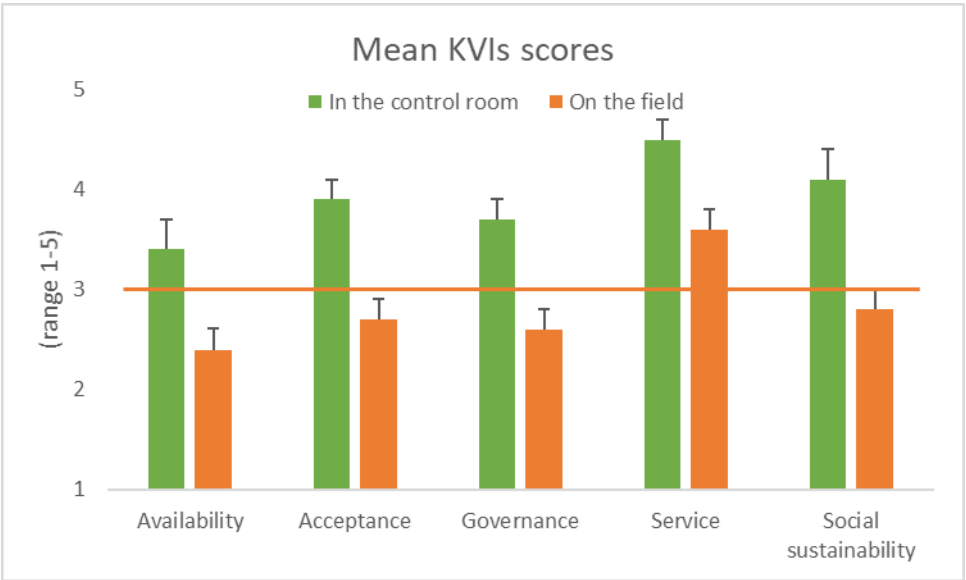


Figure 11. Mean scores for each KVI. Mean scores above 3 are considered positive evaluations.

In this case, more than 70% of the participants in the headquarters group scored above 3 in the KVs of Acceptance, Social Service, and Social Sustainability, while 67% of participants reached this threshold for the other two KVs, Availability and Governance.

An additional interesting finding from this initial set of analyses emerges from a multiple regression analysis, where the perceived value of the Metaverse Control Room over standard operational modalities was used as the independent variable, and the KVIs were the dependent variables. The model proved to be statistically significant ($F^{8}(5,11)=9.97$, $p=0.001$) and explained a total of 74% of the variance of the independent variable. The KV that contributed most to this evaluation was Acceptance (Beta=1.09, p=.013), indicating that the more an emergency operator perceives the technology as easy to use, useful, and comfortable, the more likely they are to view this new tool as superior to standard operational methods.

The next step will involve analyzing the qualitative feedback provided by the participants at the end of the session. This feedback will be used to develop an updated concept of the technology. A follow-up with the participants will then be conducted to assess their evaluation of the revised solution, both in terms of the KVIs and of their willingness to adopt the new technology. A comprehensive description of the assessment process and its results will be detailed in deliverable D6.3.

3.3 TrialsNet's process for KVIs assessment

Each UC includes one or more KVs, depending on the objective of the UC. The KVIs will be assessed in the second phase of the project based on the trials' results. To do so, TrialsNet has defined the process illustrated in Figure 12 below which consist of the following key steps:

- **Step 1 - Complete the KVs Table**: The initial step involves filling out the designated table with relevant preliminary information. This table includes the KVs, enablers, and related KPIs as outlined in D6.1.
- **Step 2 - Prepare Questionnaires for the Trial**: In this step, detailed questionnaires are designed and prepared to guide the trial process. These questionnaires must be comprehensive and tailored to capture all necessary information for KVI assessment. The questions should be clear, precise, and aligned with the trial objectives to ensure efficient data collection from end users.
- **Step 3 - Conduct Trials**: The trials are then carried out as planned, following predefined procedures and protocols to maintain consistency and reliability.
- **Step 4 - Share Raw Data**: Upon completion of the trials, the raw data collected via the questionnaires should be compiled and shared with WP6 partners. This ensures that all parties have access to the initial findings, which will serve as the basis for subsequent analysis.
- **Step 5 - Data Analysis and Post-Processing**: With the raw data in hand, data analysis and post-processing are performed. This involves cleaning the data, conducting statistical analysis, and applying any necessary processing techniques to extract meaningful insights.
- **Step 6 - Present Results and Visualizations**: Finally, the analyzed data is presented through comprehensive results and visualizations. This includes summarizing the findings and creating visual aids such as charts, graphs, and tables to effectively communicate the outcomes.

[8] Fisher's test.

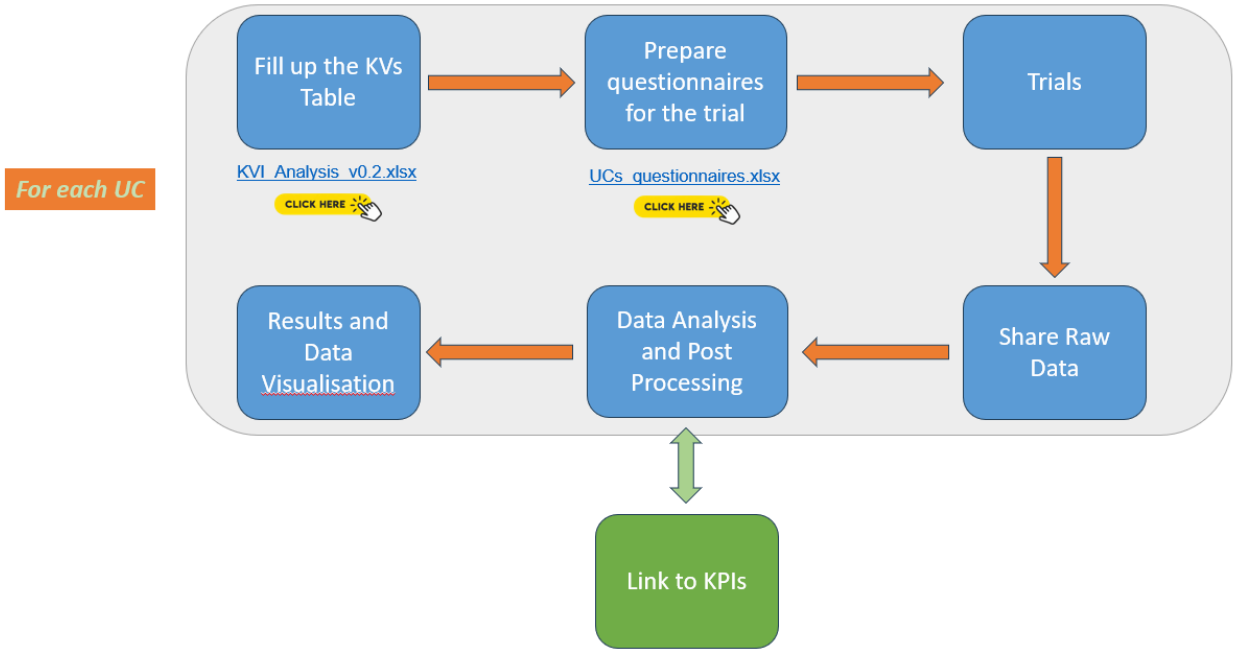


Figure 12. Process of KVI assessment in TrialsNet.

As depicted in Figure 12, further analysis can link KVI assessments to KPIs, offering deeper insights into how specific trial results align with broader performance metrics. This connection enables the identification of correlations, trends, and patterns, supporting data-driven decision-making by demonstrating the impact of technical metrics such as KPIs on the KVIs. The results of this process will be reported in the final deliverable D6.3.

4 Desing Thinking+ methodology results

As reported in D6.1 [1], different UCs of the project follow the DT+ methodology, which is widely used for designing products and services tailored to real user needs. DT is a problem-solving approach that focuses on understanding users, challenging assumptions, and redefining problems to create innovative solutions. It combines empathy, ideation, and experimentation in a non-linear, iterative process. Key stages include empathizing with users, defining the problem, ideating potential solutions, prototyping, and testing. This approach encourages collaboration, creativity, and a user-centred mindset, aiming to deliver practical and user-friendly outcomes. The process is well described in D6.1.

The following section provides a detailed explanation of the research activities conducted, the results obtained and the next steps UC1 (Madrid), UC5, UC10, UC11, UC12, and UC13 (Turin) which applied the DT + methodology in their processes. Each UC is at a different stage of development, determined by its activities completed and the resources available. Consequently, the phases described in this document may vary for each UC. This variation reflects the unique progress and priorities of each UC, ensuring a flexible and tailored approach that aligns with their specific needs and constraints.

4.1 UC1: Smart Crowd Monitoring (Madrid)

The “Smart Crowd Monitoring” UC is oriented to improve the protection of spectators at large sporting events by taking advantage of the benefits offered by 5G/6G technologies. The process was guided by a DT approach, and the following sections summarize the outcomes of each phase. The definition phase was included as a subphase and preparatory activity of the Ideate phase.

4.1.1 Empathise

The primary goal of the empathise phase is to conduct in-depth research aimed at understanding security personnel context and their expectations and requirements for future experiences. Semi-structured interviews were conducted to Prosegur personnel in charge of security at sporting events. Different profiles were interviewed: security guards (personnel in charge of controlling all spectators in the stands), security coordinator (personnel in charge of managing and coordinating the protocols and all security guards) and the Maximum Security Director of Real Madrid (Head of Prosegur for Real Madrid).

The interviews focused on obtaining information about their role and their functions as security personnel at sporting events and finding out what their perceptions are regarding procedures and protocols and how they think these processes could be improved.

As a result of the interviews, 13 main insights were obtained:

- There is a highly defined and hierarchical chain of command, in which the levels adapt depending on the complexity of the event.
- The official protocol for communicating roles or processes is not followed. Instead, instant messaging apps are used.
- Staff experience and familiarity with the environment are key points when selecting the personnel.
- Agents make decisions on the fly as events unfold, as there is not a fully defined action protocol in place.
- Security agents are not allowed to act without first having the order of their superior.
- Security agents communicate with each other via radio stations and use an app for incident recording.
- Spectators should have a direct communication channel with the club to report any incident occurring during the event.
- Prosegur lacks authorization to access camera images.
- Prosegur personnel is required to collaborate with other external companies hired by the club.
- Security companies are facing a rising workload attributed to both heightened levels of aggressiveness and the expanding number of spectators.
- Sustainability is not currently a prioritized concern within Prosegur security operations at sporting events.

- Security personnel struggle to envision how technological advances could enhance existing processes or devices.
- There is apprehension regarding the possible replacement of their jobs by machines.

4.1.2 Ideate

For the ideation phase, an ideation workshop was carried out. This workshop aimed at generating technological solutions that will help enhance intelligent monitoring at crowded events. The team worked in two directions: on one hand, identifying possible improvements and future evolutions of the prototype underdevelopment and, on the other hand, analyzing the different technologies and sensors proposed in the UC, with the aim of generating possible new applications.

The workshop brought together a diverse group of participants with varied backgrounds, perspectives, experiences and expertise. Among them were representatives from Prosegur (iSOC staff, a commercial manager and security personnel) and Telefónica. A total of 18 participants joined the session. They were divided into three teams to work on the three prototypes and to foster a greater diversity of ideas. The Telefónica team assumed the role of facilitating the session, guiding the discussions and activities throughout the workshop.

The workshop lasted for 1,5 hours and participants worked on different exercises in which they made an assessment of prototypes from different perspectives to identify positive aspects and pain points, and worked on an ideation exercise to generate ideas that will relieve the pain points identified.

As a result, 5 main insights were obtained and ideas for improving the prototypes were proposed.

- Robots can revolutionize security at large events, enhancing response times and supporting personnel.
- Robots enhance spectators' experience at large events by simplifying information management.
- The challenge of balancing personalization and human-like features must be faced.
- Robots face navigation challenges and vandalism risks at crowded events.
- Technical failures must be treated to reduce costs and ensure long-term profitability.

Two further research studies are planned: an ethnographic test with spectators and interviews with Prosegur personnel. The ethnographic test will allow understanding spectators' reactions with the security robots, while interviews to Prosegur employees who are not familiar with the robot will provide insights into their experience as they interact with this new professional tool. Finally, an ideation workshop that has the purpose of generating new innovative ideas, products and services around the UC will follow.

B5G technology is integrated into the user experience that will be analyzed throughout the research process. Therefore, the ethnographic tests with spectators and interviews with Prosegur staff will provide a detailed understanding of how B5G technology enhances the interaction between users and security robots, as well as how this impacts the overall perception of security at large events.

4.2 UC5: Control Room in the Metaverse

The UC "Control Room in the Metaverse" is focused on improving emergency management. This UC aims to allow remote handling of crisis situations while providing a real virtual environment for mission planning and live communication. The solution integrates B5G networks, the metaverse, IoT platforms, XR devices, and sensors to enhance safety and efficiency for first responders.
For UC5, the first three phases of DT+ (Empathise, Define, Ideate) have been completed. Below is a breakdown of each phase with the insights gained:

4.2.1 Empathise

The Empathise phase focuses on understanding the needs, challenges, and context of the end users, which in this case include emergency services such as firefighters, medical teams (118), and police forces. The team conducted interactive sessions to gather experiences and challenges from participants who provided valuable insights based on their respective roles:

- A park maintenance manager highlighted challenges related to setting up and maintaining event areas.

- A firefighter from the operations center emphasized the need for faster, more accurate information during emergencies.
- A first aid doctor involved in major emergencies pointed out outdated systems and confusion regarding protocols.
- A first aid coordinator recognized gaps in communication during high-pressure situations.
- A coordinator of emergency call responses for multiple provinces discussed the limitations of field experience and the importance of efficient communication.
- An emergency operator stressed the need for better real-time coordination between services.
- A police and civil protection officer focused on public safety, using drones and sensors to monitor crowds and prevent hazards.

During this phase, the participants shared their hands-on experience in managing emergencies, the use of existing technologies, and their familiarity with newer concepts like the metaverse. This led to the identification of specific needs, such as real-time data sharing, enhanced communication between emergency teams, and the requirement for accurate contextual information to ensure the safety of first responders.

At the end of this phase, the key challenges were summarized as follows:

- Emergency teams currently face communication issues due to outdated technologies and unclear protocols.
- A need for better tools to prevent and respond to crowd panics was identified, especially after the tragic events of June 2017 in Piazza San Carlo (https://it.wikipedia.org/wiki/Tragedia_di_piazza_San_Carlo, s.d.).
- There is an opportunity to leverage sensors and other advanced technologies to detect and manage crowd movements, even in areas beyond camera surveillance.

4.2.2 Define

In the Define phase, the key problems and patterns identified in the empathize phase are clearly articulated. The project team developed a shared understanding of the emergency management challenges, particularly focusing on situations that require coordinated efforts across multiple services (firefighters, medical teams, police).

The UC scenario focuses on a road accident near a large event, requiring external intervention from the 112 emergency services and the fire brigade. The intervention steps outlined during this phase include:

- **Police**: their role is to assess the nature of the event (e.g., terrorism vs. accidental incident) and notify the 112 control center, providing crucial information such as:
  - Incident location and access points;
  - Vehicle type and possible hazards (e.g., fuel leaks, explosive materials);
  - Medical status of the injured (if available from a caller on the scene).
- **112 Control Center**: their role is to activate the metaverse platform and invite all emergency services into a shared virtual room. The platform allows them to access and share static (security plan) and dynamic information (real-time sensor data).
- **Information Exchange**: All emergency forces communicate relevant information about the accident through avatars and audio/video links, exchanging dynamic, sensor-driven information that enriches their understanding of the ongoing situation. The shared dashboard allows for real-time updates and quick decision-making.

At the end of this phase, the key requirements of the solution were summarized as follows:

- Real-time access to accurate information (e.g., access points, traffic conditions) is critical for emergency teams to respond efficiently.
- Effective communication among police, fire brigade, and medical services is essential, particularly in scenarios where multiple agencies are involved.

- Implementing a metaverse-based shared platform can improve coordination and reduce response times, ultimately leading to more effective interventions.

4.2.3 Ideate

In the Ideate phase, the project team brainstormed solutions that could address the defined problems and meet user needs. Several key ideas emerged for improving the emergency response process using the metaverse and B5G technologies:

- **Metaverse Interaction**:
  - Emergency teams can enter a shared virtual environment, represented as color-coded avatars (e.g., different shirt colours for police, firefighters, and medical teams), facilitating quick identification of roles.
  - 3D maps of the incident site provide real-time information about the situation (e.g., injured person's location, vehicle details, traffic conditions) that are crucial for the intervention.
- **Devices**:
  - Emergency operators in the control centres use tablets and large shared screens to access and share information, while on-site teams may use XR devices to visualize the scenario in real-time.
  - The metaverse is accessible via 5G connectivity, ensuring that all teams, even in the field, have access to real-time updates without reliance on traditional communication channels, which can fail under pressure.
- **Improved Communication**:
  - The ability to communicate through avatars and live video streams ensures that all emergency forces are aligned in real-time.
  - Critical data such as traffic conditions, access points, and the health status of the injured are shared instantly, allowing for faster decision-making and intervention.
- **Training and Simulation**:
  - The metaverse can also be used to simulate emergency scenarios, allowing teams to test and refine their response protocols in a safe, virtual environment. This ensures that all protocols are regularly updated and optimized.

At the end of this phase, the conclusions reached were summarized as follows:

- The metaverse can significantly improve situational awareness by allowing emergency teams to visualize the incident scene in real-time and share live updates.
- The use of color-coded avatars and 3D maps helps streamline communication and ensure that all forces are on the same page.
- Integrating the metaverse into emergency response not only enhances real-time communication but also provides a platform for training and testing protocols.

4.3 UC10: Immersive Fan Engagement

The "Immersive Fan Engagement" UC explores the potential of 5G and beyond 5G networks to enhance fan engagement during sport events through immersive technologies. For UC10, an approach to the Empathise phase has been made.

4.3.1 Empathise

As part of the empathise phase, several research studies are planned. Given the constraints related to user availability, these research studies will be conducted on-site at the stadium during the trial period. This approach allows to observe and gather insights from users in the context where the technology will be used.

On the one hand, it is planned to carry out an ethnographic study with spectators, which will allow to analyze their behavior (frictions, reticence, misunderstandings…) when trying out this technology for the first time.

Additionally, an ethnography exercise with team members will be conducted. This will provide a broader perspective of the phenomenon.
On the other hand, it is planned to complement the observations with a focus group involving some of the users who will have participated in the "at-venue" tests organized by YBVR. This focus group will help us expand our understanding of user perception and identify possible areas for improvement. Finally, it is planned an ideation workshop that has the purpose of generating new innovative ideas, products and services around the UC. All the results obtained in these sessions will be presented in deliverable D6.3.

4.4 UC11: Service Robots for enhances passengers' Experience

The UC11 "Service Robots for enhances passengers' Experience" aims to develop a connected airport ecosystem leveraging the power of AI algorithms and data from diverse sources to optimize passenger flows and enhance their overall experience. The process was driven by a DT approach, and the results obtained in each phase are summarized in the sections below. Define phase was included as a subphase and preparatory activity of the Ideate phase.

4.4.1 Empathise

As part of the empathise phase, research with users was conducted. The research aimed at identifying passengers' experience at airports, focusing on their priorities and expectations in terms of services provided. It served as an initial approach to understand the context of the airport passenger's experience. In subsequent phases, this foundational understanding facilitates the proposal of 5G/B5G/6G technological solutions that have a greater impact on the KVIs.

Three questionnaires were conducted: two to consortium staff and the other one, to passengers who have an upcoming flight from or to Athens International Airport. Firstly, two online questionnaires to consortium staff were carried out with the aim of obtaining an estimation of passengers' satisfaction or dissatisfaction with the airport experience, perceptions of queue time in various processes, expectations in terms of services improvements and willingness to integrate technological advances in them. Consortium staff answered the questionnaires, who played the role of three different passenger profiles: "leisure passenger" (passengers whose reason for flying is leisure; families with children were included in this group), business passengers (passengers whose reason for flying is professional) and special needs passengers (passengers in wheelchairs or with impaired vision or hearing). Moreover, they were divided into "departing passengers" and "arriving passengers". The sample was composed of 9 users, 4 of them as "departing passengers" and 5 as "arriving passengers". The sample of 9 participants is both representative and valid for this project due to the strategic selection of respondents, who encompass a diverse range of key profiles within the user group. Although the sample size is small, it aligns with the qualitative objectives of this phase, enabling the identification of meaningful patterns and the extraction of valuable insights that will be fundamental for the subsequent stages of the project. Furthermore, logistical limitations in accessing users reinforce the validity of the responses obtained**.**

On the other hand, an online questionnaire to Athens International Airport passengers was carried out. This questionnaire focused on identifying passengers' satisfaction or dissatisfaction and unmet demands in the preflight and postflight events related to different services or functionalities offered by Athens International Airport.

The sample was composed of 40 Athens International Airport passengers, both "departing passengers" and "arriving passengers". With the questionnaire, different passenger profiles were reached: "leisure passengers", "business passengers" and "special needs passengers".

As a result, 11 main insights were obtained:

- Passengers generally rate airports experience positively, highlighting trustworthiness.
- The satisfaction of passengers at airports is largely determined by its logistics.
- The selection of an airport is a multifaceted decision, with location, transportation options, flight prices and efficiency of airport processes playing crucial roles.
- Passengers want to be informed throughout the entire trip, preferably through their personal electronic devices.
- Passengers seek better accessibility during their stay in the airport.

- The issue of losing luggage is a concern for air travelers.
- Passengers prioritize an enjoyable waiting experience at airports, emphasizing the need for both entertainment and comfort.
- Passengers urge streamlining airport processes for shorter queues and enhanced travel experience.
- Passengers desire automated processes, yet personal interaction remains crucial at various points in the journey.
- It is believed that XR could be used as a smooth airport guide.
- Diverging views in the willingness to receive personalized assistance from robots.

4.4.2 Ideate

Following the DT methodology, the team moved on to the ideation phase, where an ideation workshop was carried out. This workshop aimed at generating technological solutions that would help enhance passengers' experience at airports. Specifically, two objectives were pursued: on one hand, to consider how to expand the range of services that airport robots could provide and, on the other hand, to explore other services that could enhance passengers' comfort at airports.

The workshop brought together a diverse group of participants with varied backgrounds, perspectives, experiences and expertise. Among them were representatives from Athens International Airport, WINGS ICT Solutions (WINGS) and Telefónica. The Telefónica team assumed the role facilitating the session, guiding the discussions and activities throughout the workshop.

The workshop lasted for 2 hours and participants worked on different exercises in which they mapped the journey of the selected user profiles (focusing on reflecting pain points), brainstormed a range of solutions to alleviate these pain points and prioritized the most suitable one.

As a result, each group presented a technological solution aimed at enhancing passengers' experience at airports:

- **Solution 1**: a mobiles app tailored for families with children. The first group, who worked on the profile of the family with two children that goes on holiday, proposed a mobile app with various features aimed at providing passengers with information on optimal routes, waiting times, boarding gates, check-in counters, etc. Additionally, the app would send real-time notifications to keep passengers informed.
- **Solution 2**: a fast lane for passengers with reduced mobility complemented by an augmented reality app. The second group, who tackled the profile of a wheelchair user who travels for work, proposed to implement a fast lane for passengers with reduced mobility, complemented by an augmented reality application. This app would provide passengers with information about the busiest areas in the airport and guide them along the most suitable routes.

4.5 UC12: City Parks in Metaverse

The UC12 focuses on developing a virtual experience of the Borgo Medievale in the metaverse, offering an interactive layer for gaming and enabling visitors to explore the site using avatars during its closure for renovations (2024-2026). The goal is to create an engaging, hybrid experience for tourists and students. The process followed a DT approach, and the following outlines the results of each phase.

4.5.1 Empathise

The target users were 15 master's students, who were asked about their motivations for visiting a park offering a hybrid metaverse experience. The feedback revealed a generally negative attitude towards integrating technology into a physical park experience. The majority of students felt that parks serve as spaces for relaxation and connection with nature, and using technology, even for gaming, conflicted with this purpose. They were skeptical of using the metaverse, seeing it as a concept that emerged during the pandemic and not born out of real user demand.

At the end of this phase, the key challenges were summarized as follows:

- Students were not interested in the metaverse for park experiences, even with gaming elements.
- The natural setting of the park was valued for its disconnection from technology.

- The appeal of using virtual spaces might increase in specific contexts, such as historical reconstructions or fantasy experiences.

4.5.2 Define

The main challenge identified was a lack of enthusiasm for the hybrid metaverse experience in a park setting. The students expressed that while technology might be interesting in some cases (such as for fantasy scenarios or historical reconstructions), it felt unnecessary for their typical park visits. They saw the concept as forced rather than an authentic enhancement to their experiences.

At the end of this phase, the key requirements of the solution were summarized as follows:

- The students are not intrinsically motivated to visit parks for metaverse experiences unless there is a strong element of novelty or cultural value.
- They would prefer activities in the metaverse that offer something unique they cannot experience in reality, such as visiting inaccessible places or participating in fantasy scenarios.
- The integration of technology into natural environments, like traditional parks, feels like a contradiction and is perceived as unnecessary.

4.5.3 Ideate

Several ideas were proposed to make the metaverse experience more appealing to users:

- Fantasy role-playing games (RPGs): The students showed interest in fantasy-based activities in the park that could leverage AR and VR. Ideas like combining elements of RPGs with the physical space (e.g., treasure hunts or hybrid events) were proposed, but the usability (e.g., VR headsets, AR glasses) was identified as a significant challenge.
- Historical reenactments: The concept of virtually recreating historical events or locations was seen as more suitable for a park environment, particularly in areas like the Borgo Medievale. This approach could offer educational value and create a bridge between physical spaces and digital interactions.
- Virtual city exploration: Another idea was to offer an aerial view of the city through the metaverse, allowing users to virtually explore the city from above. However, this was seen as a one-time novelty that might lose its appeal after the first experience.

At the end of this phase, the conclusions reached were summarized as follows:

- The UC12 project seeks to combine physical park experiences with the metaverse in a way that enhances, rather than replaces, traditional activities. While the students showed initial reluctance, specific types of experiences—like fantasy RPGs and historical reenactments—proved more attractive. Success depends on creating complementary activities that add value and do not feel imposed.
- The integration of 5G/B5G (Beyond 5G) and emerging 6G technologies can make a profound impact on the user experience by bridging physical and virtual interactions seamlessly enabling a different level of gaming or interaction.

4.6 UC13: Extended XR Museum Experience (Turin)

The UC13 project aims at creating a virtual platform for visiting select museums in Turin (Palazzo Madama, Museo Pietro Micca, Galleria di Arte Moderna, Borgo Medievale), enabling users both in-person and remotely to interact with each other through portable devices. This platform seeks to enrich the cultural experience by using technology, offering augmented visits across multiple museums in the city. This innovation aims to promote Turin's cultural offering, attract more tourists and residents, and boost the city's overall appeal as a cultural destination. The project is being developed in collaboration with the City of Turin’s Department of Culture, utilizing content previously created during temporary museum experiences, like those at Palazzo Madama and Museo Pietro Micca. Each phase of the DT process is crucial for aligning the innovation with user expectations.

4.6.1 Empathise

The primary goal of this phase is to understand the needs and preferences of the target user group (i.e., university students, in this case) and identify where the developed solution should focus. The session involved interactions with various stakeholders, including museum representatives, cultural facilitators, and experts from the technology and gaming sectors.

At the end of this phase, the key challenges were summarized as follows:

- **Disconnection from museums**: Most students expressed that they prefer activities they find more interactive or fun, such as outdoor activities, socializing with friends, or going to the cinema. Some liked the idea of experiencing museum content from home but did not prioritize museum visits in their free time.
- **Interactivity and engagement**: Many showed a preference for experiences that involve interaction, such as video game exhibits, dynamic galleries, or events like DJ parties at museums (e.g., Museo dell'Automobile in Turin). These experiences, combining entertainment with art and culture, were much more appealing than traditional static exhibitions.
- **Technology aversion**: Interestingly, some participants expressed a desire to distance themselves from technology in their leisure time, preferring a break from digital devices. This contrasts with younger age groups, for whom technology might be more integrated into everyday life.
- **Past experiences**: Positive examples mentioned included guided tours of botanical gardens using apps, interactive experiences at Madame Tussauds Wax Museum, and the use of QR codes to engage with artwork or historical exhibits. The inclusion of gaming elements, such as retro gaming at video game exhibits, was particularly appealing.

These insights revealed the need to balance technology and interaction with user desires for authentic, immersive experiences without overwhelming them with digital components.

4.6.2 Define

This phase focuses on defining patterns and solutions based on user needs and preferences. The brainstorming session asked participants what kind of experiences they would like to see, feel, hear, taste, or do in a museum setting.

At the end of this phase, the key requirements of the solution were summarized as follows:

- **Cross-cultural experiences**: Participants suggested drawing connections between museum exhibits and current pop culture trends, such as video games, TV series, and music. This cross-pollination of cultural references could create more engaging and familiar experiences for younger audiences.
- **First-person historical experiences**: Museums could offer experiences where visitors feel like they are "living" history, with connections to food, music, and lifestyle from the historical periods on display.
- **Geolocated city tours**: Using apps to guide visitors around the city, providing cultural and historical information based on their location, could link outdoor explorations with museum visits.
- **Interactive storytelling**: Users wanted a more dynamic, narrative-based approach to museum information. Rather than dry historical facts, visitors should receive stories behind the artwork or artifacts, possibly using augmented reality or mobile apps to enhance understanding.
- **Informal atmospheres**: Participants proposed less formal environments, where museums could organize more "pop culture" events, such as evening shows, musical events, or even casual gatherings like parties.
- **Enhanced engagement with artwork**: The idea of interacting with art through augmented reality, where a visitor could see how a work was created or restored, was a popular suggestion. This would make the experience more engaging and informative.

Three key themes emerged from the feedback:

- **Physical space**: Many participants found traditional museums too formal and enclosed.
- Interactivity: There is a desire for more interactive exhibits, where users can engage actively with the content.

- **Emotional engagement**: Museums should aim to evoke feelings of fun, curiosity, and engagement rather than boredom.

4.6.3 Ideate

In this phase, participants were divided into three groups, each tasked with brainstorming solutions to address the pains and gains identified earlier. The focus was on developing immersive and interactive museum experiences.

Group Blue:

- **Virtualization of tours**: This group proposed turning museum tours into on-demand virtual experiences that could be personalized to fit users' interests. For example, visitors could experience a historical site as it appeared in the past using VR, or choose from a selection of thematic tours, such as artistic or cultural. This solution would work both in the museum and remotely from home.
- **Social aspect**: They suggested adding social interaction features, allowing visitors to leave comments or feedback, and creating virtual "graffiti" that could be shared with other users. These social interactions would help foster a community around the museum experience, connecting both remote and on-site users.
- **Personalization**: This concept involves allowing users to select different experiences, such as choosing which exhibits to explore more deeply or interacting with an artist avatar.

Group Orange:

- **3D portraits and AI guides**: This group proposed using augmented reality to bring historical portraits to life, where characters could "speak" to visitors and tell their stories. AI-driven personal guides could accompany visitors throughout the museum, offering a more customized and interactive experience. These AI guides could appear as avatars in the exhibits, allowing visitors to ask questions and explore exhibits in a non-linear fashion.
- **Reconstruction of spaces**: The group also suggested virtual reconstructions of historical environments, which could be explored by both physical visitors and those joining remotely.

Group Pink:

- **Immersive video game experiences**: Group Pink proposed a personalized, replayable video game experience within the museum, where visitors could play as a historical character or interact with the museum content in a gamified way. This could include augmented reality elements or personalized narratives that encourage visitors to return multiple times.
- **Cultural trends**: They also suggested using current pop culture trends, such as popular films, TV series, or video games, to theme certain temporary exhibits, making the museum experience more relevant and exciting for younger audiences. For example, a museum could create an exhibit based on a popular video game set in ancient Egypt.
- **3D printed souvenirs**: As an interactive feature, visitors could print personalized replicas of museum exhibits to take home as souvenirs. This could also cater to visually impaired visitors, making the museum experience more inclusive.

At the end of this phase, the conclusions reached were summarized as follows:

- The brainstorming phase resulted in creative ideas around virtual tours, gamification, AI guides, and augmented reality.
- Personalization was a recurring theme, with users wanting experiences tailored to their preferences, whether through social interaction, content selection, or immersive technologies.

5 Update on Dissemination and Standardisation

Dissemination plays a crucial role in TrialsNet, ensuring that research findings reach the relevant individuals and organizations promptly, thereby maximizing the impact and utility of the work. Effective dissemination and communication are essential for the research to have meaningful social, political, and economic effects. By raising awareness among stakeholders, dissemination enhances the visibility, understanding, and integration of the research outcomes. It serves as the first step toward translating knowledge into practice and fostering change. Sharing project results is an integral part of the initiative, benefiting researchers, professionals, and communities alike. In essence, dissemination is key to TrialsNet's success, increasing public engagement, drawing the attention of governments and stakeholders, and promoting the visibility, understanding, and implementation of the project's conclusions. As the project progresses and more results become available, the importance of dissemination continues to grow. In this context, Trialsnet identified the key target of communication and dissemination activities, on the basis of the specific project step and of the corresponding main target, e.g., webinars and media targeting startups approaching the Open Call, to inform potential applicants, DT workshops and participation in sector events to inform potential stakeholders to be involved in trials, or the organization and participation in specific workshops inside the project networks, like SNS JU, to compare solutions, share challenges and opportunities with other projects. Following this strategy, workshops have been organized, including 6GARCH: The 3rd Workshop on 6G Architecture at WCNC24, and Architectural Considerations Enabling the IMT 2030 Framework by European 6G R&D Activities at EuCNC & 6G Summit 2024, others have been contributed, as SNS Stream B/D Projects Workshop on KPIs and KVIs, and much more, as detailed in the remaining of this section.

Overall, Table 11 shows a summary of the KPIs measured to monitor the dissemination and communication activities of the project, including, for each KPI, the corresponding objective value, as defined in the project proposal, and the current measured value. In the light of the measured values, it can be concluded that TrialsNet is perfectly in line with the defined objectives for the dissemination, and communication activities, knowing how and where focus the effort during the second half of the project. In particular, it can be observed that, for some of the KPIs, the target value has already been reached, like for the Info videos produced. For some other KPIs, the target value has still to be reached, but, keeping into account that more than one third of the project activity is still ahead, including the part with the highest focus on dissemination activities and reaching of potential users, where the main results to be disseminated will be available (e.g., Trial results), the target values look perfectly in line. These KPIs include the social media followers (a new social media has been added, i.e., BlueSky), the video views (11 new videos have just been released explaining the different UCs, and new video are planned for the UCs corresponding to the different trials and most relevant demos), Newsletter recipients (Specific actions are planned to maximize the project impact, including the outreach maximization, showing the project results in events specific for the target potential users and directly to potential adopters), Presentation at conferences and technical publications (target relevant and top-level conferences and journals for the different sectors are currently under selection where to disseminate the trial results, which will be available in the next months), and open-source repositories (this item has been discussed among partners and attempts will be made to make real datasets available as open-source repositories, according with partners' company policies).

Table 11. Summary of dissemination and communication activities.

Communication activity	Target value	Current value
Social media - followers	1500	411
Social media – impressions	1500	2954
Info video	3	10
Video views	3000	1058
Blog posts	30	45
News	15	27

Newsletter recipients	2000	403
Interview target audience	100	64
Online/TV media talks	3	11
Presentations at conferences	25	9
Keynote speeches	10	4
Journal publications	40	7
Talks/panels/round tables	10	6
Demo at exhibitions	20	21
Attendance per demo (average)	50	74
Banner per event (average)	3	5
Technical publications	20	13
Open-Source repositories	2	1

5.1 Participation in dissemination events

The following section outlines all dissemination activities conducted by TrialsNet up to the release date of this deliverable. These activities aimed at sharing the most relevant results obtained so far by TrialsNet, including key architectural innovations detected at network level, challenges of large-scale trials, and KV and KVI definition, measurement, relevance and correlations. Events at which these results have been shared include, among others, two workshops also involving other EU projects working in parallel.

IEEE Future Networks Tutorial 5G/6G 2023. Telecom Italia S.p.A. (TIM) presented a tutorial at this event, in September 2023.

DT activity. WINGS, AIA (Athens International Airport SA) and TID collected responses from arriving passengers during October and November 2023, in the context of a DT activity to include users in the process, for the WP3 UCs. Statistics on the collected answers are available here.

11th Conference on Information and Communication Technologies (TICEC). IMEC presented a keynote speech, titled "Shaping a Connected Future: Understanding the current state of 6G technologies", in October 2023.

IEEE 9th World Forum on IoT (WFIoT2023**).** Universidad Carlos III de Madrid (UC3M) gave a talk titled "Cloudification of the mobile network stack: benefits and challenges", in Aveiro, Portugal, in October 2023.

3GPP UC WS – European Union (EU) Prep - Open Webinar. A private online event in which TIM participated. It was held in January 2024.

ACI World. AIA presented a webinar at this event on the potential of private wireless networks for airports, in March 2024.

6GARCH: The 3rd Workshop on 6G Architecture. UC3M organized this workshop at the IEEE WCNC, in Dubai, United Arab Emirates, in April 2024. Real Wireless (RW) was also involved as speaker in a panel of the workshop. The workshop aimed at discussing the key architectural innovations required for future 6G mobile telecommunications networks, including technology enablers and design recommendations.

6G-IA/6G-MAG Workshop on multimedia systems and services (6GAI). TID presented UC 10, 12 and 13, in this workshop, held online in May 2024.

Architectural Considerations Enabling the IMT 2030 Framework by European 6G R&D Activities. The workshop was organized by IMEC and UC3M. It was held in Antwerp, Belgium, in June 2024.

6G-IA Conference "5G Towards 6G for Citiverse". RW gave a speech about KV and KVIs. The event was held in Turin, in June 2024.

SNS Stream C & D projects Workshop. TIM and UC3M participated in the 6G-IA CT Discussions with SNS Stream C and D projects workshop. The event was private and held online, in June 2024.

6G-IA & PSCE Joint Workshop on PPDR. Comune di Torino (COTO) participated in this workshop, which was held online, in September 2024.

ERF 2024: European Robotics Forum. Fondazione Istituto Italiano Di Tecnologia (IIT) and ERC presented a poster on Adaptive Remote Control of Hannes Prosthesis at the ERF 2024 European Robotics Forum, in March 2023, in Rimini, Italy.

In the remaining period of the project, the main focus of the dissemination activity will be on the trial results, which will be transmitted to potential adopters of the trial solutions, as well as to other parallel projects and the scientific community. This objective will be achieved though the participation and organization of high-profile events in the specific verticals, which are currently under review by the partner of the different involved sector, as best experts on the subject.

5.2 Publications

The following lists all publications submitted and accepted by TrialsNet as of this deliverable's release. The results disseminated through these publications include, among others, key elements of the reference architecture, as the Zero-touch Service Management, as well as specific expertise acquired through the project development and related to crucial elements, such as preserving privacy, resource allocation in real-time applications, crowd monitoring, service orchestration, KVI analysis, and more.

Enhancing Crowd-Monitoring Through WiFi Fingerprint Analysis. Consorzio Nazionale Interuni-versitario per le Telecomunicazioni (CNIT) published a whitepaper on Zenodo, in October 2023, regarding the estimation of crowd counting by exploiting the probe requests in WiFi signaling protocol for all the smartphones carried by the people. The counting is approximate but enough accurate for some security and safety applications.

Privacy-Preserving People Flow Monitoring with Bloom Filters. CNIT published a whitepaper on Zenodo, in October 2023, which complements the previous paper, since it addresses specifically the problem of designing a scheme to store the WiFi fingerprints in different sensor nodes while preserving privacy. It is shown that the adoption of Bloom filter data structure allows to estimate, quite accurately, crowd flows across multiple sensor nodes.

Trials Supported By Smart Networks Beyond 5G: the TrialsNet Approach. The project partners submitted a paper at the IEEE Symposium on Vision and Facts on 6G and Future Networks in Europe, which was published in November 2023 and presented in Baltimore, USA. The paper is also available in Zenodo. This paper provides an overview of the core UCs of the project, the different contexts in which they will be trialed, the platform and network solutions that will be deployed by the project, and the advanced functionalities on which they are based.

ATHENA: Machine Learning and Reasoning for Radio Resources Scheduling in vRAN systems. UC3M had this paper published in the IEEE Journal on Selected Areas in Communications (JSAC), in November 2023. The article is also available in Zenodo. This paper presents an ML-based radio resource scheduler for virtualized Radio Access Network (RAN) systems. Its performance is then analized through a real-software implementation.

Large-scale trialing of the B5G technology for eHealth and Emergency domains. The project partners submitted this paper to IEEE Healthcom 23. The article was published and presented in December 2023. It is also available in Zenodo. The paper describes four UCs 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 (e.g., hospitals), bringing novel applications (e.g., Remote Proctoring and Smart Ambulance),, and bringing societal benefits in eHealth and Emergency areas through the development of innovative B5G/6G applications.

Zero-touch Service Management for 6G verticals: Smart Traffic Management Case Study. UC3M and IMEC submitted this paper to the IEEE Consumer Communications & Networking Conference (CCNC) 2024. The paper was published and presented in January 2024, in Las Vegas, USA. It is also available in Zenodo. The paper provides insights into the recent trends in defining and developing Zero-touch Network and Service Management (ZSM), the efforts towards standardization of its guidelines, coverage of existing solutions that apply the ZSM principles, as well as a proposal for its application in a vehicular UC of Smart Traffic Management (STM), where B5G/6G applications are enhanced by a robust ZSM capability of edge resources, to improve the effectiveness of STM.

MAP-MIND: An Offline Algorithm for Optimizing Game Engine Module Placement in Cloud Gaming. CNIT published this paper to the IEEE Access journal in March 2024. This work addresses the problem of distributing the internal modules of a game engine across multiple network nodes. The results are relevant for real-time interactive applications, as in the case of a metaverse-based application.

Privacy-preserving WiFi-based Crowd Monitoring. CNIT submitted this paper to the Transactions on Emerging Telecommunications Technologies (ETT) journal. The paper was accepted and published in March 2024, and is also available in Zenodo. The paper finalizes the results regarding the adoption of Bloom filters to preserve the privacy of crowd flow detection.

Bridging the Gap Between 6G Technologies and Societal Values: A Comprehensive Analysis of KVIs and Business Models. RW submitted this paper to the IEEE WCNC conference - WS-12: 6GARCH: THE 3RD WORKSHOP ON 6G ARCHITECTURE. The paper was accepted and it was published and presented in April 2024. This paper highlights the importance of independent KVIs in evaluating societal progress, including alignment with SDGs. It explores how technology influences business growth and societal development, categorizing values into economic, environmental, and societal dimensions. The paper is available in Zenodo.

Can I Add a VR Flow? On the Maximum Capacity of 5G to Support 360° Video. UC3M submitted this paper to the IEEE Communications Magazine. The paper was accepted and published in April 2024. It is also available in Zenodo. The paper describes a methodology to estimate the upper bound to the number of simultaneous video flows that can fit a 5G cell.

TrialsNet: TRials Supported By Smart Networks Beyond 5G. The project partners submitted this paper to the European Conference on Networks and Communications (EuCNC) & 6G Summit 2024. It was accepted and presented in May 2024 and is also available in Zenodo. The paper provides an overview of the project and of the large-scale trials that it will deploy, detailing the methodology and the technology advances it brings, as well as presenting some preliminary results obtained in the pre-testing phase of the different UCs.

Time-Based Coordination in Intent-Driven Management for Vehicular Service Orchestration. IMEC submitted this paper to the IEEE EuCNC & 6G Summit 2024 conference. It was accepted and published in June 2024, and it is available on Zenodo. This paper describes a realistic testbed setup at the Smart Highway (Belgian experimental facilities), aiming to demonstrate the benefits of ZSM and Intent-driven Management for vehicular edge computing and B5G/6G autonomous network management frameworks, designed and developed in TrialsNet.

Building Zero-touch Service Management Framework for Automotive Services Using the Smart Highway Testbed. IMEC submitted this paper to the IEEE BalkanCom 2024 conference. The paper was accepted and presented in Ljubljana, Slovenia, in June 2024. This paper presents a ZSM framework for automotive services using the Smart Highway testbed to improve the performance of vehicular services in a realistic environment. It also evaluates the performance of the advanced ZSM decision-making process based on a Deep Reinforcement Learning (DRL) model, showing that DRL can quickly adapt to the dynamic environment of a testbed and outperform the conventional rule-based approaches (decrease the E2E latency of vehicular services).

TrialsNet: TRials Supported By Smart Networks Beyond 5G. The project partners submitted this paper to the SNS JU Journal 2024. It was published in June 2024. The paper provides an overview of the project, of the methodologies it adopts, of the technologies it involves and the innovations it brings, of the UCs that the project includes, and of the preliminary results obtained by them in testing scenarios.

Network Intelligence Service for Smart Orchestration of Vehicular Applications. A master student supervised by IMEC representatives, working on topics related to the research and development IMEC performs

within TrialsNet, presented his thesis in June 2024. The work on the thesis included the design and development of the DRL-based decision-making for enhanced ZSM decision-making operations.

Privacy-Preserving WiFi Fingerprint-Based People Counting for Crowd Management. CNIT submitted this paper to the Elsevier Computer Communications journal. The paper has been accepted and is currently in press. It provides the details of the experimental testbed adopted for people counting and the actual measurements on the field.

Trialing solutions for Security & Safety, Infrastructure, and Transportation, Supported By Smart Networks Beyond 5G. TrialsNet's partners submitted this paper to the 2024 IEEE Future Networks World Forum (FNWF) - Symposium on Future Networks for Connected and Automated Mobility (CAM). The paper was presented in October 2024, in Dubai, UAE. The paper presents WP3 Ucs, detailing theis preliminary reults, reference architectures, main innovations, and next steps.

5G to 6G Evolution: Enhancing Trial Facilities with Vertical-Oriented Platforms – A Case Study Approach. IMEC, NXW and WINGS submitted this magazine paper to IEEE Communications Magazine in October 2024. The paper focuses on the in-depth analysis of enabling technologies for building network platforms that facilitate the integration of new vertical UCs into the 6G network ecosystem. The paper also highlights some of the platform components from the VITAL-5G project that are now being upgraded and exploited in the context of the TrialsNet project.

Advancing Vertical Services for 6G: Future Directions and Innovations. IMEC, NXW and WINGS submitted this magazine paper to IEEE Network, special issue "Deterministic, Reliable, Resilient and Programmable Networks for 6G". The paper studies the future of vertical services and network applications in the 6G era, focusing on network and location-awareness capabilities, application intelligence, energy efficiency and sustainable design of 6G applications.

As main results will be available during the remaining of the project, including Trial results and corresponding KPIs and KVIs, dissemination will represent a major task to bring these results in a meaningful way to potential users and adopters, stakeholders and the scientific community. As such, the aim is to present them in reference channels and events for each involved vertical, as well as reference events and channels for the target potential adopters and users. A specific analysis of such events and channels is currently ongoing by the specific partners of each involved vertical.

5.3 Communication activities

In the following, all the communication activities performed by TrialsNet at the time of the release of this deliverable are reported. These activities include the communication done to inform and attract applicants to the Open Call, as well as demos of the project's trials, aiming at informing stakeholders and potential adopters.

In order to promote the **Open Call**, different communication activities have been executed, including:

- Two webinars (TrialsNet first Open Call Webinar, November 2023, and TrialsNet second Open Call Webinar, December 2023) organized by PIIU and participated by all the partners. The webinars explained to potential applicants the details of the call, of the core UCs and the reference infrastructure, as well as how to integrate into them, and included Q&A sessions, very well participated. Each webinar was participated in by more than 100 possible applicants.
- Another webinar, organized by PIIU and participated also by Ericsson Telecomunicazioni S.p.A. (TEI), titled "Webinar From 5G To 6G Opportunities For European Start ups And SMEs" and directed to the European DIGITAL SME Alliance.
- Interviews and press releases by Orange Romania SA (ORO) and TUIASI members, to promote the Open Call among startups in Romania, in November and December 2023.

The project members created different videos to explain and promote the different UCs, and the reference infrastructure and facilities they use. These videos describe the different UCs to potential adopters and stakeholders, as well as show the development and testing activities carried out. The videos include:

- UC10 pre-test, by YBVR, released in January 2023.
- UC1 pre-test, by PROS, released in January 2023, and pre-trial, released in October 2024.

- UC 2 demo by AIA, released in May 2024, and pre-trial, released on November 2024..
- UC3 Autonomous APRON pre-trial, by AIA, released in November 2024.
- UC5 Trial, released in October 2024.
- UC6, by WINGS, released in June 2024, and pre-trial released in November 2024.
- UC7 released in November 2024.
- UC8 released in November 2024.
- UC9 released in November 2024.
- UC10 pre-test, by YBVR, released in January 2023, and pre-trial, released on November 2024..
- UC 13 (Athens) pre-test, released in June 2024, and pre-trial, released in November 2024.
- UC13 (Turin) pre-trial, released in November 2024.
- 5TONIC facilities used in the TrialsNet lab testing, by YBVR and ERC, released in March 2024.

Project members released the following press-releases related to the project and to their activity in it:

- Prosegur impulsa la adopción de tecnologías 6G en la seguridad y protección de eventos multitudinarios a través del proyecto europeo TrialsNet. It was released by PROS in May 2024.
- ORO presence to EuCNC & 6G Summit 2024, released by ORO in June 2024.

Demonstrations of TrialsNet's UCs have been performed at different events, including:

- 5G Conference Southeastern Europe, demonstration of UC2, UC6, and UC13 (Athens). The demonstrations were participated in by WINGS and held in September 2023. Each demo was attended by more than 50 attendees.
- Global event/webinar of Airports Council International for Private Wireless Networks at Airports, performed by AIA in March 2024.
- 6G-IA Conference "5G Towards 6G for Citiverse", demonstration of UC1 (Iasi), UC2, UC4, UC5, UC6, UC12, UC13 (Turin), and UC13 (Athens), participated in by all partners, and held in June 2024. Each demo was attended by more than 50 attendees.
- EuCNC & 6G Summit 2024, demonstrations of UC1 (Iasi), UC2, UC4, UC5, UC6, and UC13 (Athens), participated in by all the partners, and held in June 2024. Each demo was attended by more than 100 attendees.
- IEEE International Conference on High Performance Switching and Routing (HPSR2024). The demo was organized by NXW in July 2024, see Figure 13. It was attended by about 60 people.

Figure 13. Presence at IEEE International Conference on High Performance Switching and Routing.

EuCNC & 6G Summit 2024. During this event held in Antwerp, Belgium, in June 2024 (Figure 14), the project organized a Special session on Large-Scale trials and pilots with other Stream D Call 1 projects i.e., FIDAL, IMAGINE-B5G, TARGET-X. At the same time, TrialsNet's Project Coordinator presented at the WITAR convened session. At the same event, Also, IMEC presented a tutorial on Zero-touch Network and Service Management in 6G, during the conference's tutorial session. The content of this tutorial is also available on Zenodo. IMEC presented also a poster on Enabling efficient resource allocation for applications in vehicular systems using Zero-touch management for Smart Mobility, during the conference's poster session.

Figure 14. EuCNC & 6G Summit 2024 participation.

SITPolito. A student association of the Politecnico di Torino, Italy, organized an event, at which CNIT, TIM and CROSSMEDIA participated, presenting a session on The connectivyt in smart city and the role of Trialsnet. The event was held in April 2024, in Turin, Italy.

"Alexandru Ioan Cuza" University of Iasi - Spring School 2024. ORO participated in the Summer School, presenting a session on Orange developments towards 6G future architectures. The event was held in April 2024, in Iasi, Romania.

DAS conference 2024. ORO participated in the conference organized by the "Stefan cel Mare" University of Suceava. They presented a session about Orange developments towards 6G future architectures. The event was held in May 2024, in Suceava, Romania.

5G towards 6G for CitiVerse Conference & B2B. RW presented a keynote speech on "6G Positioning and Sensing Through the Lens of Sustainability, Inclusiveness, and Trustworthiness: which Key Value Indicators?". The event was held in June 2024, in Turin, Italy. The keynote speech discussed the future of 6G technology in smart cities and the social sustainability aspects. It was also shown how 6G can create more inclusive communities and reliable systems for urban living.

6G-IA and PSCE Europe WS on PPDR. COTO presented TrialsNet in this event targetting industry, practitioners, and researchers, presenting the project main results and next steps, UCs, challenges and opportunities. The event was held online, in September 2024.

European Night of Researchers. CNR presented the project, with a special focus on UC7, showing how, in case of diseases such as COPD, data collected during daily activities can also be important and useful in predicting and mitigating exacerbations, continuously assessing the individual patient's health status to reduce complications, improve patients' quality of life and mitigate healthcare costs.The event was held in Pisa, Italy, in September 2024 (Figure 15).

Figure 15. European Night of Researchers.

5G Techritory. TrialsNet has been invited to the co-creation event "From 5G to 6G: leveraging key trends and 5G evolution to shape 6G for vertical sectors", at the 5G Techritory conference held in October 2024, in Riga, Latvia (Figure 16). In particular TrialsNet presented an overview of the project, as one of the four Stream D projects of the Call 1. Starting from the project's scope and objectives, and depicting the adopted methodology, the presentation described the UCs addressed by the project in terms of developed applications and deployed infrastructures, as well as the KPIs and KVIs frameworks that are going to be used to validate the trials' results. An insight of the first trial hold in October was also provided. Additionally, TrialsNet took part also to the final Panel session as a good opportunity to exchange views and the challenges related to the trial implementation activities ad well as answer to the questions from the audience.

SNS ICE Podcast. During the 5G Techritory conference, TrialsNet also participated to the recording of a podcast organized by SNS ICE entitled "Lessons learned hosting vertical experiments from the perspective of 5G/6G experimental facilities" (Figure 16). The goal for this podcast was to gather 'hands-on' experts from each of the Phase 1 Stream D projects, to discuss their experience and insights and to participate in a panel with other experts, answering key questions om specific items such as the issues and obstacles in deploying vertical applications in 5G testbeds, the technological gaps between testbed providers and vertical developers that hinder deployment, the common services/tools to be provided to vertical experimenters for deployment and testing, and others.

Figure 16. SNS ICE Podcast recording session at 5G Techritory.

Beside these punctual communication activities, three continuous activities are performed to enhance the communication of the TrialsNet project and of its results: the management of project webpage and of its social media accounts, and the publication of a periodic project newsletter.

Webpage of the project https://trialsnet.eu/ - The webpage is constantly updated, and 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 17 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 10K different users, which interacted with the page through 142K events and produced 47K views. 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 17. Statistics about webpage access.

Social media accounts on LinkedIn https://www.linkedin.com/company/trialsnet/, X (previously Twitter) https://twitter.com/trialsnet, and YouTube https://www.youtube.com/@trialsnet/ are constantly updated to disseminate outcomes to the general public, including news, participation at events, demo videos, etc. Similarly 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 YouTube channel has a stable view rate, but with a growing view time. Some more statistics of the project social-media presence are reported in Figure 18, with data about LinkedIn reached members (and corresponding job functions), and YouTube reproductions (different colors refer to different videos).

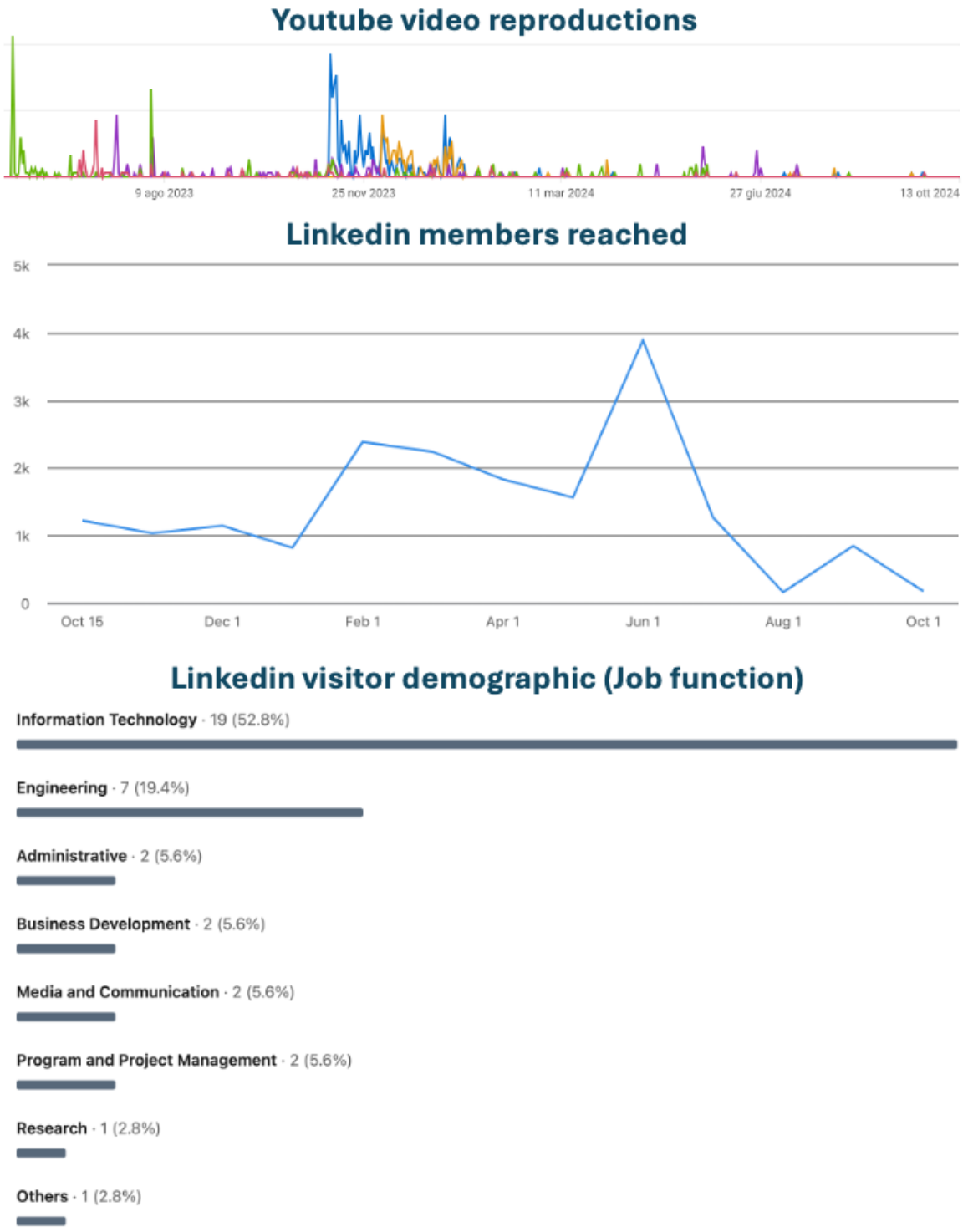


Figure 18. Statistics about social networks.

Newsletter - On a semestral basis, newsletters have 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 second issue has been published in January 2024 and summarizes the activity of the second semester of project execution, i.e., July-December 2023. The third issue has been published, instead, in July 2024 and summarizes the activities of the third semester of the project, i.e., January-June 2024. Both have been disseminated through project social media, partner contact lists and institutional portals. The three newsletter, sum up a total of 337 views and 209 downloads.

5.4 Standardization activities

In line with the project's objectives, a substantial impact in terms of influencing standards such as 3GPP has been achieved. In particular, TrialsNet partners have already contributed to different standards and fora almost reaching the target set at the beginning of the project. The main area of contribution has been 3GPP SA5 where different partners have a high engagement. Besides the specific technical contributions above, it has to be highlighted that TrialsNet also contributed to the definition of the EU position for the 3GPP Stage 1 Workshop on IMT2030 UCs held in Rotterdam the 8-10 of May 2024. In particular, TrialsNet contributed through the introduction of the UC5 “Control Room In Metaverse” as one of the representative UCs of the “Trusted Environments” UCs family, as well as the adoption of two requirements coming from two other UCs such as (i) the improvements of the human-robot interaction (from UC11 “Service Robots for Enhanced Passenger's Experience”) and (ii) the guaranteed QoS in mobility scenarios (from UC8 “Smart Ambulance”).

Additionally, TrialsNet also started a collaboration in the context of IEEE. In particular, as part of the development of IEEE P7003 standard, which outlines methodologies to help users certify their efforts in addressing and eliminating unwanted bias in algorithm creation, the TrialsNet UC1 “Smart Crowd Monitoring” of Madrid (lead by the partner PROSE) has been chosen as a part of a Proof of Concept (PoC) to validate the standard with a real-life example. Currently IEEE P7003 is working on the legal formulation of the PoC as the standard is not public yet. The activity will likely involve PROSE that will collaborate with a team from the WG.

In conclusion, the initial project objective related to standardization contribution was to participate in 20 of them. At the current phase (about half of the project execution), the objective has already been achieved (18 contribution to standardization bodies by TrialsNet have been tracked, detailed at the end of this subsection). Still, the project will continue relevant contributions towards standardization bodies as it was done in the first period.

The consortium is aware that, despite being the result of a project effort, the standardization contributions are mainly related to single partners. In the light of this, in the second half of the project, TrialsNet will elaborate a strategy in order to produce joint contributions as a project, over contributions as a single partner.

Table 12 outlines all standardization activities carried out by TrialsNet up to the release date of this deliverable.

Table 12. Summary of Standardization activities.

Title	Date	Partners	SDO	WG	Tdoc	Type	Status
pCR TR 28.912 Add conclusion and recommendations for issues related to collaboration with other SDOs	03/03/2023	Ericsson, TID	3GPP	SA5	S5-232790	Study Item Contribution	Approved
Add Stage 3 for data type AvailabilityStatus	26/05/2023	Ericsson, TID	3GPP	SA5	S5-233896	Correction	Approved
Rel-17 CR TS 28.312 Correct UC for delivering a service at the edge	21-25/08/2023	Ericsson, TID	3GPP	SA5	S5-236013	Mirror	Approved
Rel-18 CR TS 28.312 Correct UC for	21-25/08/2023	Ericsson, TID	3GPP	SA5	S5-236014	Correction	Approved

delivering a service at the edge							
Rel-17 CR TS 28.312 Add missing stage 3	21-25/08/2023	Ericsson, TID	3GPP	SA5	S5-236015	Mirror	Approved
Rel-18 CR TS 28.312 Add missing stage 3	21-25/08/2023	Ericsson, TID	3GPP	SA5	S5-236015	Correction	Approved
Discussion paper on GST version and Release	21-25/08/2023	Ericsson, TID	3GPP	SA5	S5-235664	Study Item Contribution	Approved
Rel-18 CR TS 28.554 Correct reference and fix void section	21-25/08/2023	TID	3GPP	SA5	S5-236048	Correction	Approved
Rel-17 CR TS 28.554 Correct reference and fix void section	21-25/08/2023	TID	3GPP	SA5	S5-236049	Mirror	Approved
Rel-16 CR TS 28.554 Correct reference and fix void section	21-25/08/2023	TID	3GPP	SA5	S5-236050	Mirror	Approved
DP on Service Management in SA5	13/10/2023	Ericsson, TI	3GPP	SA5	S5-237203	Study Item Contribution	Approved
New SID: Study on Management Data Analytics (MDA) – Phase 3	17/11/2023	TID, TIM	3GPP	SA5	S5-238351	Work/Study Item Creation	Approved
New WID on 5G performance measurements and KPIs phase 4	17/11/2023	Ericsson, TID	3GPP	SA5	S5-238202	Work/Study Item Creation	Approved
New WID on Support for Subscriber and Equipment Trace and QoE collection functionality in RAN and core network	17/11/2023	Ericsson, TID	3GPP	SA5	S5-238343	Work/Study Item Creation	Approved
New Rel-19 Study on Management of Network Sharing Phase 3	17/11/2023	Ericsson, TID	3GPP	SA5	S5-238209	Work/Study Item Creation	Approved
E2E Slicing user story support	04/11/2023	TID	GSMA	NG	Doc_018	Work/Study Item Creation	
The European view on 6G UCs	08-10/05/2024	6G-SNS (TrialsNet)	3GPP	SA1	SWS-240018	Information	N/A
Eliminating unwanted bias in algorithm creation	12/03/2024	PROS	IEEE	P7003 TM	N/A	Study Item Contribution	Approved

5.5 Patents

Patents are currently pursued by partners and due to confidentiality issues cannot be reported at this stage. As a result, no patents are included in this deliverable. Whatever information about patents is not confidential from companies' policies will be reported in the final report of WP6.

5.6 Collaboration activities within 6G-IA and SNS JU

5.6.1 6G-IA and SNS JU WGs/TFs and joint activities with other projects

Beyond the constant participation to the SB and the TB the projects' partners secure a wider stronger connection with SNS_JU activities by participating to the following WGs. The following activities (reported in Table 13) have been conducted with the 6G-IA and SNS-JU.

Table 13. Activities within SNS-JU WGs and 6G4Society project.

WG	Participant	Description	Project's involvement and achievements
6G-IA WGs			
Vision and Societal Challenges	RW	The 6G-IA VSC WG develops a comprehensive scientific, technological and socio-economic vision for the Smart Network and Services Joint Undertaking in general and for the upcoming next generation mobile system in particular.	TrialsNet participates in this group and monitors the groups current status for providing necessary contributions.
Trials	WINGS	The overall objectives of the Trials WG among others are to develop a 5G, 5G Advanced and 6G European Trial Roadmap and leverage the knowledge gained for upcoming trial roadmaps beyond 5G/6G systems to be addressed in the context of Smart Networks and Services partnership in Horizon Europe and to facilitate the involvement of verticals in the Trials roadmap.	TrialsNet actively contributes to the group and has already presented an overview of the UCs and the domains in which trials are conducted. Also, TrialsNet participates in WG calls and monitors the WG mailing lists for further collaboration with the WG and other related projects.
Pre-Standardization	TIM	The Per-Standardization WG mainly aims at developing a roadmap of relevant standardization and regulatory topics for 6G through the evaluation of existing roadmaps at the international level and to influence the pre-standardization on 6G and related R&D by potentially proposing where topics should be standardized.	The participation of TrialsNet to this WG is of relevant importance. In this context, TrialsNet contributed to the WG activities by participating to the input provision for the SNS JU projects standardization tracker, which aims at providing an overall overview of the SNS JU impacts on the standards (e.g., 3GPP, ETSI, etc.). In the next period further ways to contribute to the WG activities, including dissemination, will be considered.
SME	PIIU	The SME WG Meetings feature presentations aimed at fostering collaboration and innovation among European SMEs. Discussions also on upcoming events and initiatives designed to enhance networking and support for SMEs are held. Experts highlight efforts to strengthen the	TrialsNet follows the activities of the group and informs the SMEs about new activities. The group underscores the importance of ongoing collaboration and support for SMEs in driving technological and market innovation.

		global reach of the European ICT Ecosystem, emphasizing Open Calls and the importance of impact reporting.	
SNS JU WGs			
Architecture	UC3M	The goal of this WG is to serve as a common platform to facilitate the discussions between SNS JU projects developing architectural concepts and components as well as validating them, and to attain a consolidated European view on the overall 6G architecture.	The TrialsNet project representative in the Architecture WG had a prominent role in most of the WG activities since the creation of the group, in the last quarter of 2023. Besides presenting the project architecture, TrialsNet has been active in the three main dissemination activities performed by the group: The 3rd 6GArch workshop, co-located with IEEE WCNC 2024, on April 21st. Marco Gramaglia co-chaired the event on behalf of the project. The event featured 12 technical papers, a keynote, and a panel, organized by a committee that included Marco Gramaglia from TrialsNet. Hassan Osman presented a paper on the KVI framework proposed by the project, a subject that has been thoroughly addressed in this document. Additionally, Marco Gramaglia moderated a panel on Network Sustainability, which included Hassan Osman as one of the panelists. This topic is a core focus for TrialsNet and has been explored in detail in WP2 documents. The workshop attracted significant attendance and generated considerable interest, particularly in the discussions on Network Sustainability. The 4th 6GArch workshop, which will be co-located with IEEE Globecom 2024. The upcoming first white paper on 6G Architecture from the WG. Marco Gramaglia on behalf of TrialsNet project is co-editing the full white paper and the specific section on Stream C and Stream D project

Test, Measurement and Validation	WINGS	The Test Measurement and Validation WG (TMV WG) focuses on promoting commonalities across projects that have strong interest in Testing & Monitoring (T&M) methodologies. The TMV provides a forum to share the best practices in order to support 6G Trial UCs. Such efforts include the development of test and measurement methods, test cases, procedures as well as the KPI/KVI formalization and validation to the greatest possible extent.	TrialsNet has already contributed to the group by sending a detailed description of the KPIs definition and monitoring (through an Excel template circulated by TMV) as well as the description of the project's considered KVIs along with their definitions and the means of verification (through a second Excel template circulated by TMV). Moreover, TrialsNet contributes in the upcoming KPI white paper which is organized by the TMV leaders. Also, TrialsNet participates in TMV-related regular calls for presenting the project's status in terms of KPIs and KVIs.
SNS TFs			
SNS Open Call	PIIU	This is a TF which is responsible for promoting the Open Calls that various SNS projects implement.	SNS Management listed all information related to the Open Call that should be presented and TrialsNet follows the activities of the group in order to align with the procedures followed by other SNS projects and collect/present relevant material.
Sustainability	RW, UC3M	This is a TF which is responsible for promoting sustainability aspects among SNS projects.	Sustainability is an important aspect in TrialsNet and the project has contributed through the completion of relevant questionnaire which featured the activities of the project towards sustainability.
Other			
6G4Society	CROSSEU, RW	The 6G4Society project aims to ensure that societal and sustainable values are properly embedded into the development of 6G technology, bringing a sociological perspective to technological development.	TrialsNet is following 6G4Society and is discussing for co-organization of Workshop related to a transversal topic on KVIs definition. The co-organized Workshop will take place latest beginning of 2025 and all relevant project representatives from SNS community will be invited.

5.6.2 Main outcomes from Sustainability TF

As part of the project participation to the cross-project SNS-JU activities, TrialsNet joined the Sustainability TF promoted by the Technical Board. SNS-JU's feedback highlights the team's strong progress and identifies a core advantage of the project: the practical focus on real-world UCs. This hands-on approach allows the team to address tangible problems and apply solutions in a meaningful way. These advantages relate to both the network deployment (as discussed in the WP2 related deliverables D2.1 [47] and D2.2 [48]) and to the specific UCs deployment. The critical importance of adopting a standardized framework when tackling sustainability

challenges was also underscored. The team can establish clear metrics for sustainability related KVIs, such as reducing pollution by saving on travel time to physical venues. This can be achieved using immersive technologies like AR, XR, and the Metaverse, which allow virtual collaboration and experiences, thereby decreasing the need for physical travel and consequently reducing carbon emissions.

In addition to leveraging these technologies to minimize the environmental impact, it is advised to quantify the reduction in vehicle usage and corresponding CO2 emissions for specific UCs. By doing so, the team can demonstrate the measurable environmental benefits of adopting such solutions. Furthermore, SNS-JU stressed the importance of linking these sustainability KVIs directly to KPIs. This connection ensures that the project remains focused on achieving its sustainability goals while delivering real, quantifiable outcomes. Aligning KVIs with KPIs will help guide the team's efforts and provide a clear framework for evaluating success, making it a crucial component of the overall strategy.

5.6.3 Next steps

As reported above, TrialsNet is joining forces with the most important initiatives related to the KVI framework (especially on sustainability) promoted by the SNS boards. As next steps, the project partners will act in accordance with the recommendations provided by SNS-JU and will focus on establishing clear sustainability-related KVIs and make every effort to link them to KPIs wherever possible. This approach will help ensure measurable outcomes and allow us to track progress effectively toward achieving our sustainability goals. Further dissemination work activities and standards contribution will also continue. Progress and outcomes related to the various collaboration activities will be reported in final deliverable of WP6.

6 Trials management

The main goal of trials management is to maximize the effectiveness of the testing activities, anticipating issues and overcoming logistical bottlenecks through monitoring of status of different trials. Moreover, it will ensure the timely sharing of information among trials including information about planning and execution. The trials execution approach for each UC will be documented in a detailed report; this will include a plan for carrying out testing activities, test data acquisition protocols, and a common methodology for harmonized collection of measured KPIs and KVIs from each trial (including the trials from open call sub-projects).

Framed in this context, a methodology has been defined in TrialsNet in order to analyze the trials management approach as depicted in Table 14.

Table 14. Trials management approach.

Step	Description
1	**Define Objectives:** Clearly define the goals and objectives of the trial. These goals and objectives include among others the need of testing the speed, latency, reliability, coverage, energy efficiency, and scalability of the 5G network.
2	**Identify KPIs and KVIs:** Determine the KPIs/KVIs that align with the objectives of the trial.
3	**Design Test Scenarios:** Develop test scenarios and their plan that mimic real-world usage conditions.
4	**Data Collection:** Collect data using appropriate tools and methodologies. This may involve deploying test devices, sensors, and measurement equipment in the field.
5	**Performance Evaluation e.g.**
	Measure the maximum achievable throughput.
	Measure latency under different network loads and conditions.
	Assess reliability by monitoring packet loss and connection stability.
	Evaluate coverage by mapping signal strength and quality across the trial area.
	Other UC specific evaluations
6	**Experience Assessment:** Feedback from trial in terms of KPIs/KVIs
7	**Benchmarking:** Compare the results of the 5G trial against different releases towards B5G/6G and/or Wi-Fi networks or other benchmarks to assess the performance improvement offered.
8	**Analysis and Interpretation:** Analyze the collected data to draw insights and conclusions.
9	**Report Generation:** Compile the findings into a comprehensive report.

Moreover, for the effective management of trials a central trial management table has been created in order to check at every stage the status and information from every UC/trial as shown in Figure 19. This table collects important information such as trial location, network infrastructure (e.g., commercial, private, experimental), network release (i.e. Rel-15, Rel-16, or Rel-17), coverage type (e.g., indoor or outdoor), coverage area, trial duration, and number of sessions-users-devices from all trials in order to have an overall view and to compare them wherever possible.

			General information about trials															
WP	Use case	Related folder	Trial ID	Trial date	Trial location	Network infrastructure (e.g., commercial, private, experimental)	Network deployment			Coverage type (e.g., indoor or outdoor)	Coverage area (in square km)	Trial duration (in hours)	Number of sessions	Number of users (persons using the application)	Type of users (e.g., students, museum visitors, etc.)	People indirectly involved (e.g., UC1 and UC4 in Iasi)	Number of used devices (connected to the network)	Type of devices (e.g., tablets, VR glasses, etc.)
							Release (e.g., Rel-15, Rel-16, Rel-17)	Architecture (e.g., NSA or SA)	Band (e.g., 3.7 GHz or 26 GHz)									
WP3	UC1 (Madrid)	UC01-ES	T1.1	Feb-25	Wizink Center, Madrid													
			T1.2	Feb-25	Wizink Center, Madrid													
	UC1 (Iasi)	UC01-RO	T1.3	Dec-24	Bvd Stefan cel Mare, Piata Palat													
			T1.4	Dec-24	Bvd Stefan cel Mare, Piata Palat													
	UC2	UC02-GR	T2.1	Jan-25	City of Athens, streets around Technopolis,													
			T2.2	Jan-25	City of Athens, streets around Technopolis,													

Figure 19. Central trial management table (example): General information about trials.

Similarly, Figure 20 illustrates the KPIs mapped to the trials as shown in the central trial management table. Detailed results are collected in similar templates in a common format for all trials.

																		Add link to the KPIs measurments table
			Category	Capacity							Latency		Compute					
WP	Use case	Related folder	KPIs (mapping based on D6.1; to be checked)	Downlink throughput per user - KPI#01	Uplink throughput per user - KPI#02	Downlink aggregate Throughput - KPI#03	Uplink aggregate Throughput - KPI#04	Downlink throughput per device - KPI#05	Uplink throughput per device - KPI#06	Coverage - KPI#07	Application round-trip latency - KPI#08	Application one-way Latency - KPI#09	Accuracy - KPI#10	Precision - KPI#11	Recall - KPI#12	F1 score - KPI#13	Communication Reliability - KPI#14	
WP3	UC1 (Madrid)	UC01-ES		x	x					x	x		x	x	x	x		
				x	x					x	x		x	x	x	x		
	UC1 (Iasi)	UC01-RO									x	x						
											x	x						
	UC2	UC02-GR						x	x		x	x					x	
								x	x		x	x					x	

Figure 20. Central trial management table (example): KPIs mapped to trials.

Concerning the KVIs, the central trial management table also maps the KIVs to the trials as shown in Figure 21.

			KVIs_Evaluation_Process_v0.1.pptx																
WP	Use case	Related folder	KVIs (mapping based on UCs questionnaires)	Trust/Trustworthiness	Resilience	Security	Societal sustainability	Economical sustainability	Availability	Acceptance/ Acceptability	Service	Governance	User experience	Realistic telepresence	Affordable and stable communication up to high vehicle speeds	System success rate	Digital Inclusion	Edutainment	Cultural connection
WP3	UC1 (Madrid)	UC01-ES		X	X	X	X												
				X	X	X	X												
	UC1 (Iasi)	UC01-RO		X	X	X	X												
				X	X	X	X												
	UC2	UC02-GR		X	X	X	X												
				X	X	X	X												

Figure 21. Central trial management table (example): KVIs mapped to trials.

With the central trial management table, it is possible to have a quick overview of the status of the trials and the participants can upload also the related material to the dedicated folders which are created for each trial.

The paragraphs that follow below provide an elaboration of the methodology points that are introduced in Table 14:

- **1 - Define Objectives:** Clearly defining the objectives of each trial is the first and most crucial step in managing B5G/6G trials. These goals need to be specific, measurable, and aligned with the key innovations and capabilities that B5G/6G promises. Typical objectives include testing the speed and maximum throughput of the network, latency especially for time-sensitive applications like remote healthcare or autonomous robotic vehicles, and reliability in terms of consistent performance under varied conditions. Additionally, energy efficiency, especially for IoT devices and mobile applications, as well as scalability—how well the network handles an increasing number of connected devices—are critical. The well-defined objectives that are proposed by each trial in TrialsNet project serve as a guide for every subsequent step in the trial process
- **2 - Identify KPIs and KVIs:** After defining the objectives, it is necessary to determine the KPIs and KVIs that will help measure the success of the trial. KPIs focus on technical metrics such as data rates, latency, coverage, energy consumption, and device density, which provide an objective measure of the network's performance. On the other hand, KVIs are broader, considering the value provided to users and businesses, such as environmental, societal and economical. By aligning KPIs and KVIs with the trial's objectives, both technical and business outcomes can be effectively measured, ensuring the trial is evaluated from multiple dimensions.

- **3 - Design Test Scenarios:** The next step is to design test scenarios that show the benefits of each trial. These scenarios should cover a range of environments and conditions that users are likely to encounter, from urban to rural settings, and from high-density indoor areas to wide-open spaces (depending on the UC). Mobility scenarios, where the network's performance is tested as users move across cells or at high speeds, are also crucial. The project's UCs in the domains of Infrastructure, Transportation, and Security & Safety, eHealth and Emergency, and Culture, Tourism & Entertainment, have carefully considered such scenarios in order to properly show the benefits of each trial and discuss the main outcomes and potential replication.
- **4 - Data Collection:** Collecting accurate and comprehensive data is essential for assessing the performance of the network and the applications. This involves deploying various tools to capture performance metrics. Test devices, which could include consumer smartphones, IoT devices, or even drones and robots, are used. The data collection process is extensive, covering a wide range of locations according to the trial scenario and place, ensuring that the gathered information provides a holistic view of network performance across different environments.
- **5 - Performance Evaluation:** Once data is collected, the network performance is evaluated based on specific metrics. Speed tests are conducted to measure the maximum achievable throughput, while latency is assessed under various network loads to determine its suitability for low-latency applications like AR/VR or autonomous systems. Reliability is measured by monitoring packet loss, jitter, and connection stability over time. Coverage is also a key aspect. All the UCs in the project have already worked on defining the relevant KPIs and KVIs (including also the Open Call sub-projects). Templates (reference tables) are proposed for having a harmonized collection of KPIs and KVIs from each trial.
- **6 - Experience Assessment:** In addition to technical evaluations, it is essential to assess the end-user experience. Feedback from participants in the trial, including consumers and businesses, provides valuable insights into how the network performs in everyday usage. Experience-based metrics which are defined by KV/KVIs, are used to assess how the network and applications meets user expectations. The goal is to ensure that the network and applications not only performs well technically but also delivers a satisfying user experience.
- **7 - Benchmarking:** To understand how well the B5G network performs, benchmarking against existing networks like 4G and Wi-Fi can be provided. By comparing the trial results with these technologies, it is possible to quantify improvements in speed, latency, reliability, and energy efficiency wherever possible. This process provides context to the results, allowing stakeholders to understand how significant the advancements are over current technologies and what is the benefit brought by TrialsNet.
- **8 - Analysis and Interpretation:** With all the data collected, the next step is to analyze and interpret the results. Quantitative analysis involves processing the technical performance metrics, such as speed, latency, and coverage, while qualitative analysis focuses on user feedback and satisfaction levels. Cross-correlation between different data points—such as how performance changes with increased load or in different environments—helps provide deeper insights into the network's strengths and weaknesses. The aim is to transform raw data into actionable insights that can guide network improvements, optimizations, and recommendations.
- **9 - Report Generation:** Finally, the findings from the trials will be reported from the different UCs. This report should include a description that outlines the key findings and conclusions, as well as a detailed technical breakdown of the performance metrics. Graphs, tables, and charts should be used to visualize the data and provide a clear understanding of the performance.

In conclusion, the structured approach to manage the project's trials ensures a comprehensive evaluation of the related results. By defining clear objectives, aligning KPIs and KVIs, and designing trial scenarios, trials can effectively assess the performance across critical metrics such as speed, latency, reliability, and coverage. Accurate data collection, combined with thorough performance evaluation and experience assessment, ensures that both technical performance in terms of KPIs and the KVIs are measured. Through the trial management activities, it is possible to effectively monitor at every stage the status of the trials, collect in a harmonized way the results and proceed to potential synergies depending on the domain and the implemented solutions.

7 Exploitation plan

Starting from the exploitation plans reported in the project's proposal, this section provides an overview of how various partners project have updated or maintained their exploitation plans based on evolving project developments. Several partners have refined their plans to align more closely with real-world healthcare requirements and consumer innovation. Other partners have updated their plans with specific details and advancements in technologies such as 5G/B5G and AI. These updates include enhanced exploitation strategies focusing on innovative applications, academic integration, sustainability, and market-specific deployments. At the same time, some partners have maintained their original exploitation plans without significant changes.

The changes suggest that while the overall direction remains the same, many partners have tuned their scopes to accommodate revised strategies and that will be further elaborated in the context of T6.5 activities during the second phase of the project. Table 15 reports the updated version of the exploitation plan of each partner.

Furthermore, the project partners will collaborate on developing a joint exploitation plan, aiming to maximize the impact and benefits of the combined efforts. This plan will focus on leveraging each partner's strengths to ensure the efficient use of competencies and achieving the shared objectives. The outcome of this future work will be presented in D6.3.

Table 15. Partner contributions to exploitation.

Partner	Exploitation description
TEI	Leading actors from the healthcare sector within the consortium have provided practical, "real-world" requirements based on their specific UCs and applications. This input is crucial for the Ericsson Research (ER) team involved in the Pisa site deployment, enabling a more effective evaluation of the radio and transport architecture with a focus on mission-critical performance metrics such as availability, latency, and throughput. Understanding these demanding requirements is essential for identifying optimal orchestration strategies and pinpointing innovation gaps in the orchestration domain. This approach is necessary to support a wide range of services through the slicing mechanism in an end-to-end dimension, including the transport segment, which is an integral part of the trial experimentation. Furthermore, the innovations being tested enhance the automation and optimization of infrastructure resources. This is particularly beneficial when the infrastructure must support multiple services simultaneously across a geographical area and in nomadic scenarios. Ericsson Research collaborates with internal stakeholders responsible for innovating products through new features and capabilities. In this respect, future developments of Ericsson's solutions, related to the domains considered by the trial, may capture and give value to the insights gained from TrialsNet, in terms of both system concepts and components. It is part of the ongoing activity of the Ericsson team actively working on the TrialsNet project to evaluate opportunities for exploitation within the company.
TIM	Thanks to the activities performed in the context of TrialsNet, TIM aims to understand which are the potential limits of the current technology and, through the experimentation of innovative functionalities such as AI/ML and the analysis of the relevant KPIs/KVIs coming from the trials, to identify and define the new requirements on which consolidate the evolution towards the next generation of the mobile networks in terms of both architecture solutions and expected performance. Additionally, the implementation of the innovative project's UCs and the inclusion of the verticals, which both introduce new types of services with their specific requirements, are of crucial importance for TIM network and business development departments to understand the possible evolution of the telecommunications domain. Based on the above, the TrialsNet work will enable to build an ecosystem around transversal industry segments which would support to setup the basis for future business relationships and can serve as an example to other vertical industries. In relation to the technical activities performed in the context of the project, TIM is developing different VR applications based on an innovative technological solution. In particular, such applications will use the TIM XR

	streaming technology which moves the computational capacity to a high-performance server (with latest generation GPU) and which sends a video stream to the user. All the user's movements through the viewer and its controllers will be transmitted as quickly as possible to the server which will "redraw" the scene in real time. Thanks to the trials that will take place in the context of the TrialsNet, there will be the possibility of validating this experimental platform in a large scale and realistic scenario, collecting quantitative and qualitative statistics, thus accelerating its development towards an engineerable solution and, subsequently, marketable.
ORO	ORO is interested, in principle, in exploiting this project's outcome in the direction of prototyping new B2B, Public Sector and B2C products and services based on the technologies and knowledge gained from the Iasi deployed UCs. More exactly, ORO is planning the launch of a suit of video analytics servics for smart cities, based on the applications developed by TUIASI within the project for traffic and crowds monitoring. The main customers for these services will be public authorities and municipalities targeting the implementation of ML-based video surveillance systems for public spaces like roads, intersections, airports, and public transport vehicles. These services will be sold as an add-on to 5G-connected cameras and will be hosted on ORO's commercial 5G SA edge-computing facility.
NXW	In the scope of the TrialsNet project, NXW aims to consolidate company assets and know-how in MEC/NFV, 5G/6G and AI/ML technologies. In tems of horizontal innovations, NXW is continuously developing and improving a Network and Service Orchestrator; in the context of the TrialsNet project, this solution is enriched with closed-loop based mechanisms to implement the Zero-Touch Network and Service Management (ZSM) framework. This research work will allow NXW to employ this know-how for building 5G/B5G solutions for potential customers. NXW's involvement in design, implementation, and integration activities will enhance its expertise in service composition and chaining, extending from the fixed infrastructure (core/edge) to far edge resources. The knowledge and software assets developed in TrialsNet for the "Proactive Public Infrastructure Assets Management" and "Autonomous APRON" UCs are strategic for incorporating 6G-powered services into NXW's portfolio. NXW anticipates that TrialsNet will open new business opportunities across various verticals, including consultancy services, third-party software development, and advanced network and infrastructure monitoring services. Additionally, participation in the "Control Room in Metaverse" UC, where NXW provides the IoT Platform, will boost its expertise in managing smart environments, aiding the development of Symphony, NXW's building automation solution. The project also presents an opportunity to establish a 6G-enabled services ecosystem driven by SMEs, potentially creating new commercialization avenues for NXW's services and products.
WINGS	Through the participation in the project, WINGS enhances its product portfolio with new solutions and algorithms which are relevant to WP3 - UCc for Infrastructure, Environment, Security & Safety, WP4 - UCs for eHealth and Emergency and WP5 - UCs for Culture, Tourism & Entertainment. It also builds up synergies through other partners in the Greek cluster such as the Athens Airport and the City of Athens where field tests and trials are taking place in the context of the project. Furthermore, WINGS enhances its platforms namely WINGSPARK (for proactive infrastructure management and traffic monitoring), STARLIT (for proactive monitoring of vital signs of citizens in public venues) and also expands also its AR/VR and immersive 360 solutions in the cultural domain through the digitalization of new museums in Greece. Finally, WINGS continues pursuing valuable synergies with partners to set up a collaborative infrastructure that enables the delivery of the previously described advanced solutions.
UC3M	UC3M's exploitation strategy primarily focuses on using the knowledge generated by the project through academic programs, scientific excellence, and potential IPR generation.

	Being a project member provides UC3M with numerous opportunities, which will be leveraged along three main axes outlined in the following. Short-term Objectives: i) Incorporation of Advanced Knowledge into Academic Programs: TrialsNet will introduce state-of-the-art knowledge in mobile networking, artificial intelligence, and large-scale validation technologies into UC3M's academic offerings, enhancing the Telecommunication Engineering Bachelor's and Master's degrees and the Master in NFV and Software Defined Networking (SDN); ii) Development and Deployment of Training Materials: High-quality technical training materials will be created and released as Open Educational Resources (OER) under an open license, ensuring broad accessibility. These materials will cover the latest developments and best practices in 5G architecture and 6G design and their industrial applications. Medium/Long-term Objectives: i) Enhancing Technology Transfer and Consulting Capabilities: Utilizing knowledge from TrialsNet, UC3M aims to expand its consulting activities in next-generation technologies, impacting standardization bodies like IEEE to obtain essential IPR for future exploitation, as well as to support the creation of high-tech spin-offs and strengthen UC3M's role in the European technology transfer landscape; ii) Strengthening Scientific Leadership: Through collaboration within the TrialsNet consortium, UC3M will enhance its research quality, target top-tier publications, and reinforce its profile as a leading European institution in mobile network research; iii) Improving Teaching Quality with Interdisciplinary Focus: Insights from TrialsNet will enrich course materials and potentially lead to new degree programs that intersect various fields like AI and mobile networking. Cross-cutting Themes: i) Promoting Responsible Research and Innovation (RRI): By aligning technological innovation with broader social values, UC3M aims to enhance trust between technology and society; ii) Improving Accessibility and Inclusivity in Training: Ensuring training materials are accessible to non-specialist profiles, tailored to local languages, and support up/re-skilling across various digital capabilities; iii) Empowering Graduates for Industry Leadership: Offering research-oriented positions to graduates in forward-looking fields, reinforcing Europe's leadership in 6G technology.
IMEC	In the scope of the TrialsNet project, IMEC is actively working on the research and development of the Zero-touch Network and Service Management (ZSM) framework for the Beyond 5G system. This solution is associated with the WP2 Horizontal innovation, which can be applied to different UCs and vertical industries. In TrialsNet, we showcase the applicability of this solution on the Smart Traffic Management UC (UC4) as a mission-critical type of vertical service with stringent QoS requirements. This framework is being exploited internally in IMEC to support experimentally driven research by PhD researchers involved in the project. Beyond that, IMEC is progressing with the design and development of the ZSM framework in TrialsNet, which will be further used as IPR gained from TrialsNet to set up new projects on both international and national levels. Along with the progress of the TrialsNet project, IMEC is enhancing the capabilities of the in-house testbeds such as Smart Highway and Open5G (testbed based on O-RAN capabilities) with ZSM features, but also adding support for mmWave communication as a result of collaboration with Open Call participants. These testbed enhancements are critical for further exploitation of testbeds in new projects, and for creating means to conduct competitive research and development in the 6G era. Apart from ZSM, IMEC is actively working on the Beyond 5G application framework with application energy-awareness capabilities, which will be part of the IMEC's Edge Application (EdgeApp) Middleware solution, used for providing transparent and efficient communication between vertical services and 5G/6G network. Same as in the case of ZSM, this EdgeApp Middleware solution is planned for further exploitation, especially in the context of industry, to pursue potential prototyping and commercialization. Finally, as IMEC has a strong link with Flemish Universities (two research groups working in TrialsNet are associated with the University of Antwerp and Ghent University), the research and development conducted in TrialsNet is being exploited to support advanced engineering master courses

	and Ph.D. programs. In particular, one PhD student is full-time working on the topics of ZSM, with the help and support of one Master's student. This exploitation strategy will continue even after the end of the project, as all final solutions developed and tested in TrialsNet trial sites will be exploited to create high-quality and competitive Bachelor, Master, and PhD profiles and guide them during the thesis writing.
YBVR	YBVR already offers immersive fan engagement services, but with TrialsNet, YBVR aims to leverage 5G technology to enhance and expand their offerings. The introduction of 5G features will increase flexibility in camera placements and broaden audience reach, enabling the creation of unparalleled experiences for fans of sports and musical events. Once these new features become available in commercial communication networks, YBVR will integrate them into their service portfolio.
CNIT	CNIT is an academic consortium which exploitation strategy is based on the integration of TrialsNet-gained knowledge in the academic programs and on the exposure to advanced research topics and questions relevant for B5G/6G networks. The academic curriculum in the telecommunication fields at Master-of-Science (MSc) level has been integrated with the advanced technical competences gained through the participation to TrialsNet project. In particular, the main topics relevant for such integration have been and are the following: 5G/B5G/6G architectures, KPI/KVI monitoring and evaluation, edge computing, energy-aware network planning and control, Artificial Intelligence (AI), IoT and Wi-Fi sensing. Several MSc theses have been addressed some TrialsNet research topics in which CNIT was involved, thus creating a community of potential researchers who might contribute to the design and/or exploitation of next generation telecommunication networks and services in the whole EU. Furthermore, the student community at Politecnico di Torino have been exposed to TrialsNet events (DT+ sessions, focused seminars) increasing the interest for the related research topics and for the UC applications. This is expected to impact the number of students enrolled in MSc in the telecommunication fields and interested in focusing their study plan on TrialsNet technological pillars. We expect that most of them will be possible customers for the advanced services and applications similar to the one investigated in TrialsNet UCs. Finally, in terms of research activity, the possibility of validating the developed technologies and algorithms in large scale scenarios as provided by TrialsNet UCs provides a unique opportunity to impact the research community with convincing arguments.
TID	The NIV unit in TID will apply the experience gained in the project to enhance the network infrastructure supporting immersive services, including the network management and the integration of public and non-public infrastructures via capability exposure APIs, as those proposed by the Linux Foundation CAMARA initiative. The TID NIV unit will showcase the project features, with emphasis on how they can be used in supporting the automation and evolution of advanced network services, to provide the technology base and experience for the design and development of specific products and services for the commercial market. The Consumer Innovation unit in TID will consider the lessons learned from the user research and the evolution stage from technology along with the duration of the project to ideate new consumer-facing products and services around metaverse experiences, immersive communications (VR/AR), gaming, and entertainment, edutainment, and security, among others using DT+ methodologies.
ERC	ERC plays a role within the TrialsNet consortium as advanced 5G technology enabler provider, concentrating its focus of learning and innovation on i) 5G-Advanced Private Networks (delivering a PNI-NPN based mmWave SA system), and ii) assessing the fit of technology with application on the several domains served at different pilots. This type of contribution to the project facilitates that ERC involved staff gain direct insight on the evolution of 5G-Advanced technology and their foreseen novel applications, and towards 6G, and then spreading their knowledge and best practices developed through internal dissemination inside the company and influencing decision boards on strategy for capability development for

	this new market context. Therefore, the main expectation on exploitation of the learnings and results from ERC participation in the project fall in the category of identification of high value-added technology integration and optimization services related to 5G-Advanced, and -more specifically- Public Network integrated Non-Public Networks delivering 5G services over mmWave band.
IIT	IIT will exploit the knowledge generated through the project to boost internal research on autonomous and rehabilitation robotics. Patent protection will be sought, and all relevant IIT's foreground generated within the course of the project will be handled by a specialised technology transfer unit to license it to existing companies or spin-off from research. In addition, results will be used to establish or strengthen cooperation initiatives at the national and international levels through research agreements and joint labs. The foreground of the project could be exploited through the long-standing collaboration with INAIL, which represents the largest market for upper limb prostheses in Italy and one of the major stakeholders in Europe, or through the PNRR RAISE Innovation eco-system.
AIA	Athens International Airport (AIA) is committed to enhancing passenger safety, security, and experience through cutting-edge technological solutions. The TrialsNet project results will enable AIA to implement: (a) Advanced Infrastructure Management: Real-time digital twin representation of airport infrastructure Secure, high-bandwidth communication with staff via Private Wireless Networks (PWN) AI-driven predictive maintenance and security breach alerts (b) Autonomous APRON Operations: Deployment of robots and autonomous vehicles for apron tasks VR integration for remote monitoring and control Ultra-reliable, low-latency connectivity through dedicated PWN slices (c) Enhanced Passenger Services: AI-powered service robots for personalized assistance throughout the passenger journey Location-based services and real-time information delivery via PWN Seamless integration of passenger data and airport systems for improved efficiency These innovations, powered by 5G and beyond technologies, will position AIA as a leader in smart airport solutions, significantly improving operational efficiency, sustainability, and overall passenger experience.
SSSA	SSSA plans to leverage the results of the project to enhance its standing within the research community. The knowledge gained through the project's networking activities, especially in areas where SSSA had limited expertise will foster new research initiatives, especially considering scenarios with numerous users, with specific network needs and contrasting the traditional one-to-one teleoperation scenarios. In particular, the main topics for this integration include advanced technical competences in 4G/5G/6G architectures, IoT, and Wi-Fi sensing. Elements of this new knowledge is gradually being integrated into our academic programs, offering fresh content for courses, and as it is inspiring several MSc theses, it is stimulating the creation of potential new PhD and MSc programs.
PIIU	TrialsNet's results will be exploited by PIIU in the context of specific offers to Italian and other South-European Industries, especially SMEs, through which significant advantages are envisaged for the delivery of media services to end users. In addition, PIIU aims to expand turnover in terms of activities offered to innovative SMEs that already have a working solution, and which consider 5G as a market opportunity and are really interested in: 1) developing a competitive advantage on 5G technology applied to a specific vertical, 2) increasing market visibility in 5G field. Finally, PIIU aims at extending its current expertise in the areas of advanced media and gaming solutions, with respect to market dynamics, business models and value chains. To this end, PIIU will contribute to the protection of the industrial rights of its partners. The acquired knowledge will be used to setup advanced workshops and management courses that are part of PIIU's current activities.
COTO	COTO is deeply interested in showcasing the technical feasibility and economic sustainability of an innovative cultural offering that complements and expands traditional museum and recreational activities. The Municipality is also eager to explore metaverse solutions for

	various applications, such as cultural and recreational experiences, as well as the safety and security of these areas. Additionally, Turin aims to observe the results from other clusters and serve as a testbed for further UCs chosen through the "Open Call." The selected projects were presented during the plenary meeting in Turin in June (19th, 20th and 21st). This strategy is in line with the initiatives of the "Turin House of Emerging Technologies – CTE NEXT," a project financed by the Italian Ministry of Economic Development. The project supports the broad transfer of technology and the demonstration of urban innovative solutions powered by 5G and emerging technologies (IoT, AI, Blockchain) in key sectors for Turin: Smart Mobility (including Urban Air Mobility), Industry 4.0, and Smart City Services. Within this context, the Municipality provides specific facilities and a comprehensive "Urban Testing Programme" for start-ups and SMEs, which can be utilized for the "Open Call."
TUIASI	Through the implementation of TrialsNet, TUIASI aims to significantly enhance its expertise in the application of cutting-edge functionalities and technologies, particularly within the domains of connected mobility and AI/computer vision. These advancements will be applied in real-world urban environments, focusing on operations and events that are central to smart city initiatives. By engaging with these emerging technologies, TUIASI will not only broaden its understanding of their impact but also develop robust methods for assessing the broader implications of technology in urban contexts. To achieve these goals, TUIASI will utilize the pilot project developed together with the project partners, especially ORO, through TrialsNet as a strategic tool to strengthen its collaboration with city authorities, with leading technology companies. These partnerships will facilitate the integration of innovative technological solutions into the city's infrastructure, paving the way for more intelligent and responsive urban environments. Furthermore, TUIASI is committed to leveraging the outcomes of the TrialsNet project to enrich its educational and professional training programs. The knowledge developed through the project will be seamlessly integrated into the curriculum for post-graduate students, particularly in fields related to connected mobility, AI, and computer vision. This will ensure that students are equipped with the latest skills and insights required to lead in these innovative sectors. At the same time, TUIASI envisions that the expertise and innovations derived from TrialsNet will significantly enhance its role in technology transfer and consulting services. By utilizing the knowledge gained, the university aims to support the creation of high-tech spin-offs. Moreover, the project's outcomes will contribute to advancing research, with a focus on publishing in top-tier academic journals and participating in renowned conferences.
PROS	PROSE is interested on exploiting the capacities of B5G networks on its services of robotic fleets management from the iSOC. This services are oriented to complement the security sevices provided by security guards and to offer additional services of automated technical inspections based on the cameras an sensors in the robots. B5G/6G networks will enable the remote teleoperation from the iSOC which nowadays is not fully feasible due to the latency of the commercial networks. This innovation will position PROSE as the first company providing services of remote robotic security and inspection management which will represent a major differentiation of the portfolio of services provided from the iSOC. In addition to robotic services, the use of B5G networks will facilitate the use of other solutions oriented to improve the security services such as lidars and artificial intelligence. PROSE is already offering an interesting variety of AI models, however, most of them are installed in edge devices in order to avoid the latency due to video stream to the cloud. This type of communications networks will permit to run cloud-based algorithms and therefore to reduce the initial investment on hardware (servers) on site. Moreover, the reliability of B5G networks in crowded events will ensure the adequate transmission of images and alerts, helping to improve the quality of the offered service.

CROSEU	Crossmedia's achievements in cultural heritage, combined with its cutting-edge productions for immersive exhibitions, have opened doors to numerous international markets, including the United States, China, Argentina, Chile, Brazil, France, Peru, and various regions in the Far East. Looking ahead, Crossmedia will leverage the successes gained from TrialsNet to enhance its offerings with more advanced products that integrate AR, VR, AI, and gaming. Furthermore, in the field of security, Crossmedia will seek collaborations with industry leaders to promote the market adoption of these innovative solutions.
DAEM	Dimos Athinaion Epicheirisi Michanografisis (DAEM) maintains interest in the project results as a total as well as to sub-products envisioned to be delivered. TrialsNet verticals will leverage DAEM's services towards the City of Athens. The added value from DAEM's UCs implementation will be focused on the exploitation of services based on advanced network capabilities and the introduction of 6G vertical in the City of Athens. DAEM through its participation will exploit the solutions related to emergency incidents and infrastructure management for the Municipality. The expected impact relies on both the benefits that citizens can directly experience by exploiting network capacities for the improvement of city life, safety, and well-being.
CNR	The National Research Council (CNR) is keen to illustrate the transformative potential of new communication technologies as powerful and beneficial tools in the realm of medical innovation. CNR aims to showcase how these technologies can significantly impact and enhance the safety and efficacy of medical applications. Furthermore, CNR intends to leverage the outcomes of this project to bolster its international research presence in the domains of connected health and telemedicine. In addition, the CNR is also interested in developing expertise and scientific products about applications of extended reality (XAR) based technologies in the biomedical field. CNR is committed to disseminating the findings of this project to the broader research community. This will be achieved through the publication of results in prestigious international research journals and presentations at renowned international conferences. This approach ensures that the valuable insights gained from the project are shared widely, fostering further advancements in the field.
CERTH	CERTH is gaining a big experience with up-to-date processes related to the contracting of Open Call third parties, especially considering the large size of the TrialsNet OC framework. To facilitate the sub-project management, CERTH has adjusted and upgraded its internal platform which has worked to the benefit of the management with great efficiency. It aims to use this experience and the new infrastructure for future projects with similar demands. As part of the UC6, CERTH has developed new routing algorithms based on the Travelling Salesman Problem (TSP). These results will be considered for their potential academic application to wider mobility issues and will seek to leverage them through future research proposals.
RW	RW aims to enhance its consulting services and product offerings targeted at the Wireless Users market segment. TrialsNet will improve the analytic and performance frameworks used by RW Consultants to evaluate commercial and technical investment cases, specifically refining the previously used TMOG framework for innovation assessment. By evaluating a diverse range of UCs within TrialsNet, RW will refine its KPI and KVI translational frameworks, boosting business productivity and ensuring high-quality insights for vertical sector clients. Special focus will be given to enhancing our sustainability/NetZero toolset, addressing the growing concerns of the 5G/6G industry and its users. The KVI assessment frameworks developed during the project will be leveraged by RW to better serve their customers, particularly in the area of Environmental Sustainability.

8 KPIs and KVIs addressed by the Open Call sub-projects

The Open Call offered a relevant opportunity to apply the KPIs and KVI evaluation frameworks defined by TrialsNet. The most relevant fact has been the complete adoption of the terminology and methodology embraced by the external participants to the Sub-projects, which were not involved in TrialsNet.

A template for the KPIs and KVIs list was provided to the Sub-projects participants in order to report back the relevant KPIs and KVIs addressed by them, based on the KPIs terminology and KVIs framework defined in D6.1 [1] to avoid possible misunderstanding due to incoherent definition, convention or naming of the related metrics.

Thanks to the periodic reporting of the progress of each funded Sub-project, due the high variety of trials that have been funded through the Open Call, novel KPI and KVI might arise and become eligible to the included in the future versions of the KPI/KVI terminology adopted by TrialsNet.

Figure 22 and Figure 23 show the KPI and KVI addressed, respectively, in the Sub-projects as the number of sub-projects adopting them. Regarding the KPIs, all the recommended KPIs have been considered by at least one project. The most common KPIs are the latency and the throughput, since they mostly influence the QoE perceived by the final users. Some projects declared the use of other KPIs. By a preliminary analysis, it is clear that the some KPIs require to pass the harmonization process with the TrialsNet reference KPIs proposed in D6.1. Indeed, some “other KPIs” referred by the projects seem very similar to the reference KPIs and others must be reconsidered as KVIs.

The Interim Report prepared by the sub-projects details the activities carried out during the first half of their sub-projects and includes explicit indications on the KPIs and KVIs. It is important to highlight the activities undertaken by the consortium to disseminate information, collect data, and analyze results, with a particular focus on supporting KVI-related efforts. A final review will be conducted at the end of the sub-project to collect and analyze the results.

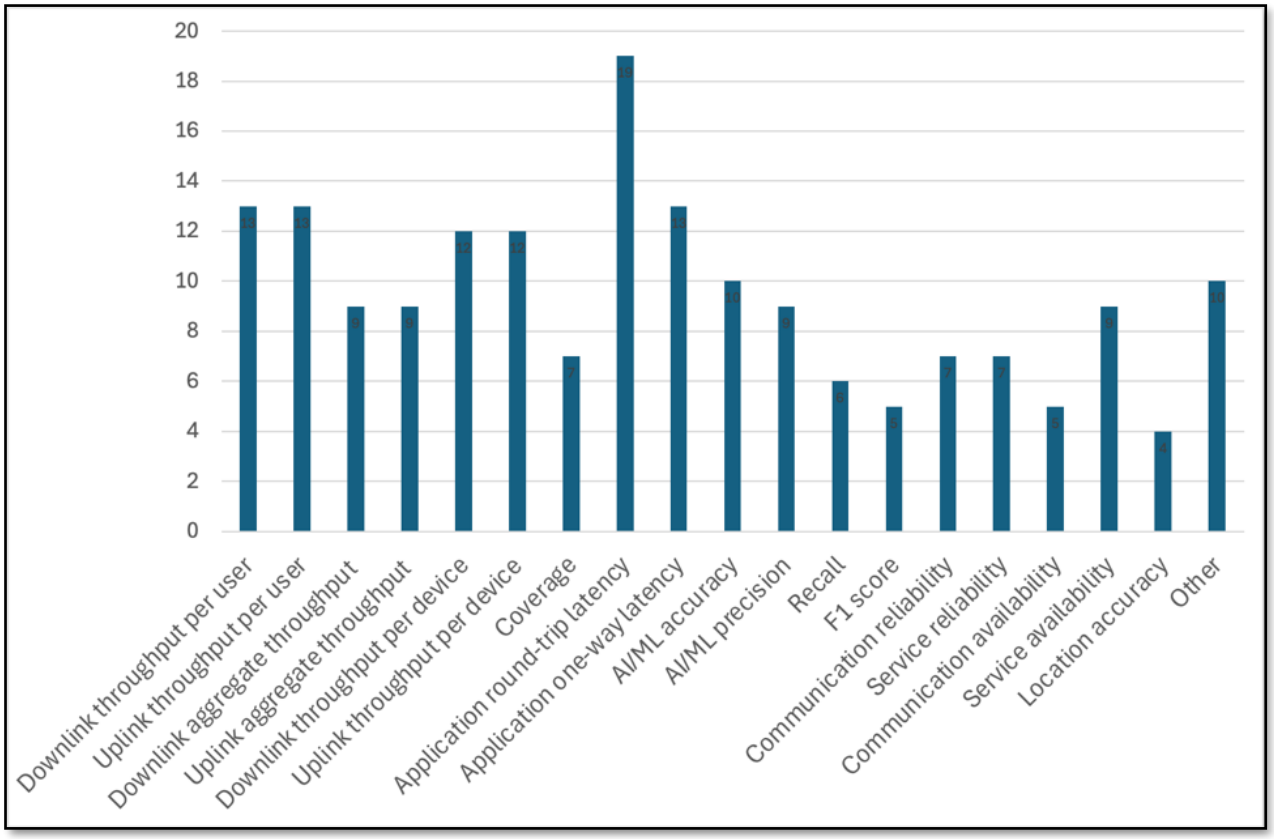


Figure 22. KPIs addressed in Open Call sub-projects.

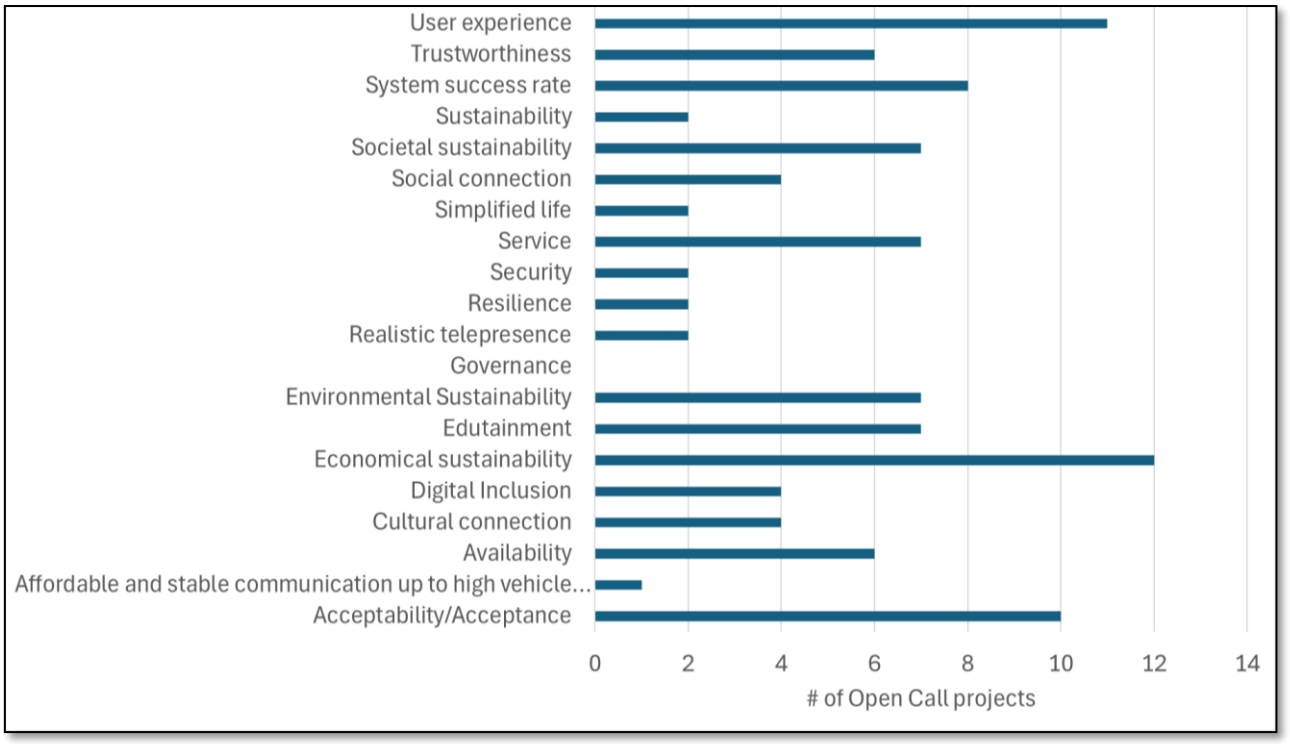


Figure 23. KVIs addressed in Open Call sub-projects.

9 Conclusions

The TrialsNet project has demonstrated significant progress in the validation of key technologies through the involvement of real end-users in the trials and dissemination of findings in strategic events. The work so far has highlighted the project's ability to set a framework for the analysis of critical challenges in B5G/6G networks in terms of business, social and environmental aspects, with a focus on efficiency and performance. Moreover, the comprehensive evaluation of KPIs and KVIs during the preliminary testing activity across different UCs provides robust insights into how these technologies can be applied effectively to real-world cases, enhancing both user experience and business value.

The integration of advanced technologies and solutions has enabled TrialsNet to showcase practical UCs and applications in various domains as elaborated in WP3, WP4 and WP5. The tests conducted so far have also facilitated the refinement of KPIs and KVIs, particularly by aligning technological advancements with sustainability.

The presented UCs illustrate the practical application and versatility of KVIs in assessing and measuring value across project activities, which includes the execution of one trial with real end-users. These examples demonstrate how KVIs capture social, economic, and environmental metrics, providing readers with valuable insights into their functionality in different contexts. Ultimately, these UCs offer a roadmap for utilizing KVIs in some cases as a tool for decision-making, ensuring that the TrialsNet project remains agile and aligned with its mission to create inclusive and sustainable values.

The project has also made notable contributions and demonstrations at various events. These efforts ensure that the outcomes of TrialsNet are not only impactful in the short term but also influential in shaping future networks and applications. Continued involvement in dissemination, exploitation, and standardization activities will be essential for the scalability and broader adoption of the technologies tested within the project's trials.

Overall, this deliverable has described the current status and achievements of the project in the context of KPIs/KVIs, including those of Open Call sub-projects. This includes a description of progress made by the industry on business and value, DT, trials management, dissemination, and exploitation aspects.

In the next and final deliverable of WP6 (D6.3), the focus will be on trial management, further assessment of KPIs and KVIs from the trials, as well as dissemination and exploitation activities. D6.3 will also cover the metrics concerning the trials management, and some of the activities done by the consortium itself and by sub-projects to maximize the impact of the project. The planned update on the exploitation task will also include a joint exploitation strategy across partners.

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References

[1] TrialsNet Deliverable D6.1, "First report on validation and dissemination activities", 31 October 2023
[2] TrialsNet Deliverable D3.1, "UCs definition for Infrastructure, Transportation and Security Safety (ITSS) domain", 30 April 2023
[3] TrialsNet Deliverable D4.1, "UCs definition for eHealth and Emergency (eHE) domain", 30 April 2023
[4] TrialsNet Deliverable D5.1, "UCs definition for Culture, Tourism, and Entertainment (CTE) domain", 30 April 2023
[5] TrialsNet Deliverable D3.2, "First results of UCs implementation for ITSS domain", 31 March 2024
[6] TrialsNet Deliverable D4.2, "First results of UCs implementation for eHE domain", 31 March 2024
[7] TrialsNet Deliverable D5.2, "First results of UCs implementation for CTE domain",31 March 2024
[8] 5G-PPP TMV Working Group white paper, "Beyond 5G/6G KPI Measurement, Version 1.0", June 2023, DOI: 10.5281/zenodo.7963247, URL: https://doi.org/10.5281/zenodo.7963247
[9] 5G-PPP TMV Working Group white paper, "Beyond 5G/6G KPIs and Target Values, Version 1.0", June 2022, https://5g-ppp.eu/wp-content/uploads/2022/06/white_paper_b5g-6g-kpis-camera-ready.pdf, DOI: 10.5281/zenodo.6577506
[10] Online Etymology Dictionary, https://www.etymonline.com/, 2024
[11] A. Friedman doctrine, "The Social Responsibility of Business Is to Increase Its Profits", New York Times, Sept. 1970
[12] Carney Mark, "Values: An Economist's Guide to Everything That Matters", William Collins London, 2021
[13] Wolf Martin, "Milton Friedman was wrong on the corporation", Financial Times, Dec. 2020
[14] Merrick Amy, "Is the Friedman Doctrine Still Relevant in the 21st Century", May 2021
[15] Kelly Erin and Dobbin Frank, "American Behavioral Scientist 41, How Affirmative Action Became Diversity Management: Employer Response to Antidiscrimination Law", 1961 to 1996, 1998
[16] Meadows Donella H., Meadows Dennis L., Randers Jørgen and Behrens William, "The limits to growth: a report for the Club of Rome's project on the predicament of mankind", Universe Books, New York, 1972
[17] Jaques Martin, "The death of neoliberalism and the crisis in western politics", The Observer, 2016
[18] Wolf Martin, "Milton Friedman was wrong on the corporation", Financial Times, 2020
[19] Curwen Lesley, "The collapse of Enron and the dark side of business", BBC, 2021
[20] George Betsy, "Fraudulent Accounting and the Downfall of WorldCom", 2021, https://sc.edu/about/offices_and_divisions/audit_and_advisory_services/about/news/2021/worldcom_scandal.php
[21] Osofsky Hari, M., Baxter-Kauf Kate M., Hammer Bradley, Mailander Ann, Mares Brett, Pikovsky Amy, Whitney Andrew, Wilson Laura, "Environmental Justice and the BP Deepwater Horizon Oil Spill", NYU Environmental Law Journal, 2011
[22] Financial Times, "iPhones: slow burn", Aug. 2021
[23] Singleton Tom, Rahman-Jones Imran, "Tech firms told to hide 'toxic' content from children", BBC, May 2024, https://www.bbc.co.uk/news/articles/czrx13jj9p3o
[24] Sustainable Development Goals, UNDP, 2024, https://www.undp.org/sustainable-development-goals
[25] Yahya Habeeb, "The role of ESG performance in firms' resilience during the COVID-19 pandemic: Evidence from Nordic firms", Global Finance Journal, Nov. 2023
[26] Digital technologies to achieve the UN SDGs, https://www.itu.int/en/mediacentre/backgrounders/Pages/icts-to-achieve-the-united-nations-sustainable-development-goals.aspx
[27] Griffiths Sarah, "Smart guide to climate change: Why your internet habits are not as clean as you think", March 2020, https://www.bbc.com/future/article/20200305-why-your-internet-habits-are-not-as-clean-as-you-think
[28] Yang Lin-Lin, Guo Chen, Li Geng-Yin, Gan Kai-Peng, Luo Jin-Huan, "Mobile phone addiction and mental health: the roles of sleep quality and perceived social support", Frontiers in Psychology, Sept. 2023
[29] Kolkowska Natalia, "Employee Engagement in Sustainable Business", May 2023, https://sustainablereview.com/employee-engagement-in-sustainable-business/
[30] Brundtland G.H., "Our Common Future: Report of the World Commission on Environment and Development", UN-Dokument A/42/427 Geneva Switzerland, 1987
[31] Evan W.M., Freeman, R.E., Englewood Cliffs, "A Stakeholder Theory of the Modern Corporation: Kantian Capitalism", Prentice Hall New Jersey, 1988

[32] Baig Mirza, “Is 'purpose' the new green? - Pandemic exposes leaders and laggards in stakeholder capitalism”, March 2021, https://www.avivainvestors.com/en-gb/views/aiq-investment-thinking/2021/03/covid19-stakeholder-capitalism/
[33] Lorenzo Rocío, Voit Nicole, Tsusaka Miki; Krentz, Matt, Abouzahr Katie, “How Diverse Leadership Teams Boost Innovation”, January 2018, https://www.bcg.com/publications/2018/how-diverse-leadership-teams-boost-innovation
[34] Oxford Saïd research “Happy workers 13% more productive”, Oct. 2019, https://www.sbs.ox.ac.uk/news/happy-workers-13-more-productive-finds-oxford-said-research
[35] Balch Oliver, “For sustainable, read resilient as companies strengthen relationships with suppliers”, Oct. 2020, https://www.reutersevents.com/sustainability/sustainable-read-resilient-companies-strengthen-relationships-suppliers
[36] Henisz Witold, Koller Tim, Nuttall Robin, “Five ways that ESG creates value”, McKinsey Quarterly, Nov. 2019
[37] Kenny Anthony, “What I Believe”, Continuum 2006
[38] Hair, J.F., Hult, G.T.M., Ringle, C.M., Sarstedt, M., “A Primer on Partial Least Squares Structural Equation Modelling (PLS-SEM)”, Second Edition, 2017, Sage. ISBN 9781483377445.
[39] Hair, J.F., Hult, G.T.M., Ringle, C.M., Sarstedt, M., Danks, N.P., Ray, S., “Partial Least Squares Structural Equation Modelling (PLS-SEM) Using R. Springer Nature”, 2021, ISBN 97883030805197, https://doi.org/10.1007/978-3-030-80519-7
[40] Ngubelanga, A. & Duffett, R., “Modeling Mobile Commerce Applications´ Antecedents of Customer Satisfaction among Millenials: An Extended TAM Perspective. Sustainability”, 2021, 13(11), 5973. https://doi.org/10.3390/su13115973
[41] Li, T. & Chen, Y., “Will virtual reality be a double-edge sword? Exploring the moderation effects of the expected enjoyment of a destination on travel intention”, Journal of Destination Marketing & Management, 12, pp. 15-26, 2021 https://doi.org/10.1016/j.jdmm.2019.02.003
[42] McLean, G., Al-Nabhani, K. & Wilson, A., “Developing a Mobile Applications Customer Experience Model (MACE) - Implications for Retailers”, Journal of Business Research. 85, pp. 325-336, 2018 https://doi.org/10.1016/j.jbusres.2018.01.018
[43] Surjandy, S., Azra, A.B., Fernando, N., Brillian, B., “The Effect of Short Video Advertising on Online Shopping Using Pay-Later Based on Online Customer Experience”, 2023 10th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI) proceedings, https://doi.org/10.1109/EECSI59885.2023.10295890
[44] Cronin, J.J., Brady, M. & Hult, G.T., “Assessing the effects of quality, value, and customer satisfaction on consumer behavioural intentions in service environments”, Journal of Retailing, 76(2), PP. 193-218, 2000, https://doi.org/10.1016/S0022-4359(00)00028-2
[45] Evans, J.D., “Straightforward Statistics for the Behavioural Sciences”, (1st Ed.) Brooks Cole Publishing Company, 1995
[46] Cohen, J., “Statistical power analysis for the behavioural sciences”, (2nd ed.) Lawrence Erlbaum, 1988, ISBN 0-12-179060-6. https://doi.org/10.4324/9780203771587 1
[47] TrialsNet Deliverable D2.1, “Preliminary design aspects for Platforms and Networks solutions”, 30 June 2023
[48] TrialsNet Deliverable D2.2, “Intermediate design of Platforms and Networks solutions”, 07 July 2024

Annex A

In this annex, the questionnaires related to the KVI assessment of UC10 (Section 3.2.1) are shown.

UC10 Survey items

Privacy policy

This questionnaire gathers your socio-demographic information and your input on the VR experience. You shall have the right to withdraw your consent at any time. Please read the following disclaimer to understand how your data will be handled.

Introduction

You are invited to participate in a research conducted by Telefonica and YBVR, about virtual reality experience using beyond 5G/6G technology. This is part of the quantitative study for UC 10 of Trialsnet, a project financed by EU's Horizon-JU-SNS-2022 Research and Innovation Programme. Your participation in this study is entirely voluntary and the result will be anonymous. You shall have the right to withdraw your consent at any time. You should read the information below and ask questions about anything you do not understand, before deciding whether or not to participate. If you have any doubts or questions, kindly contact privacy@ybvr.com. The result of this survey shall be analysed using Partial Least Squares Structural Equation Model.

Data Protection

Neutrality and impartiality are guaranteed in the management and production of statistics, as well as confidentiality in the collection and treatment of the individual data provided. The answers will NOT be, in any case, analyzed individually, but by AGGREGATE STATISTICAL TREATMENT, in which the INDIVIDUAL IDENTIFICATION of the participants is NOT possible. NO PERSONAL DATA will be stored in compliance with current data protection regulations. All information -without restrictions- will be treated confidentially and in accordance with the GDPR (EU) 2016/679 and the Council of April 27, 2016 on the protection of personal data.

Questions	Scale
Sex	a. Male b. Female c. I prefer not to say
Age	a. Below 20 b. 20-29 c. 30-39 d. 40-49 e. 50-59 f. I prefer not to say
TECHNOLOGICAL INNOVATION	
This innovative immersive VR experience incorporates state of the art technology	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
This innovative immersive VR experience involve major technological changes on an existing product	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
The technology of innovative immersive VR experience is quite new to our industry	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree

The technology incorporated in the innovative immersive VR experience always offers dramatic improvements than that in existing product features (TV viewing).	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
PERCEIVED USEFULNESS	
Using VR with beyond 5G/6G technology helps me watch sport event at home	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
I believe using VR with beyond 5G/6G network would help me be more productive	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
I believe using VR with beyond 5G/6G network would be useful in my sports viewing experience	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
I believe using VR with beyond 5G/6G network would improve my life	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
PERCEIVED EASE OF USE	
This VR headset/device using beyond 5G/6G network is easy to use	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
Learning to use this VR headset/device using beyond 5G/6G network is easy	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
Instructions to navigate this VR headset/device using beyond 5G/6G network are clear and understandable	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
I find VR with beyond 5G/6G network flexible to interact with	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree f. I completely agree
PERCEIVED ENJOYMENT	
I know watching sports game through VR headset using beyond 5G/6G network to be enjoyable	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
Watching sports match through VR headset using beyond 5G/6G network makes me feel good	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree

	e. I completely agree
Watching sports match through VR headset using beyond 5G/6G network is fun	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
Watching sports match through VR headset using beyond 5G/6G network is engaging	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
CUSTOMER EXPERIENCE	
During the VR sports match, I was fully engaged	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
During the VR sports match, I was fully involved	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree
During the VR sports match, I had full concentration	a. I completely disagree b. I somewhat disagree c. Neither agree nor disagree d. I somewhat agree e. I completely agree

**Socio-demographic items were adapted from Sanchez-Cañizares et al. (2021)*
**Innovation items were adapted from Ding & Ding (2022)*
**Perceived ease of use items were adapted from Heetae et al. (2018)*
**Perceived usefulness items were adapted from Heetae et al. (2018)*
**Perceived enjoyment items were adapted from Mclean et al. (2018)*
**Customer experience items were adapted from Bilgihan et al.(2013)*