5G INDUCE

Deliverable D7.4

Dissemination, communication and standardization activities - Version b

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Glossary of terms and abbreviations used

Abbreviation / Term	Description
3GPP	3rd Generation Partnership Project
5G PPP	5G Infrastructure Public Private Partnership
5G-ACIA	5G Alliance for Connected Industries and Automation
AGV	Automated Guided Vehicles
AI	Artificial Intelligence
B	Business
C	Customer
CPE	Customer Premise(s) Equipment
CSP	Communications Services Provider
D	Deliverable
EC	European Commission
ECP	Edge/Cloud Provider
ETSI	European Telecommunications Standards Institute
EU	European Union
ExFas	Experimentation Facilities
GSMA	Global System for Mobile Communications Association
I4.0	Industry 4.0
ICT	Information and Communications Technology
IPR	Intellectual Property Right
ITS	Intelligent Transport Systems
ITU	International Telecommunication Union
KPI	Key Performance Indicator
MaaS	Metal-as-a-Service
MEC	Multi-Access Edge Computing
ML	Machine Learning
NaaS	Network-as-a-Service
NaaS	Network-as-a-Service
NAO	Network-App Orchestrator
Network-App	Network Application
Network-AppaaS	Network-App-as-a-Service
OSC	Open-Source Community
OSS	Operating Support System
PaaS	Platform-as-a-Service
QoS	Quality of Service

Abbreviation / Term	Description
SaaS	Software-as-a-Service
SB	Steering Board
SDO	Standards Development Organization
SME	Small Medium Enterprise
SWOT	Strengths, Weaknesses, Opportunities, and Threats
T	Task
TB	Technical Board
TBD	To Be Decided
TR	Technical Requirements
TS	Technical Specifications
UAV	Unmanned Aerial Vehicle
V	Vendor
WG	Working Group
WP	Work Package
X	Any

Executive Summary

This Deliverable D7.4 discusses the key actions undertaken by the 5G-NDUCE consortium during the second year of the project, building upon the corresponding efforts contacted in the first year, relating with the major pathways to impacts, i.e., Dissemination / Communication, Standardization, and Innovation Management / Exploitation activities implemented collectively by the partners contributing to Tasks T7.1 / T7.3, T7.2 and T7.4 / T7.5, respectively. D7.4 focusses primarily on the Dissemination/Communication, and Standardization activities, while there are other dedicated deliverables focusing on the Innovation Management Activities (i.e., D7.6) and the Exploitable Market Potentials / Business Models (i.e., D7.7). All five WP7 tasks constitute the project work towards the realization of the project Outcomes at the end of the project, as well as the achievement of wider-scope and longer-term Impacts, while the associated Deliverables provide detailed account of the specific actions that the consortium partners contacted during the reporting period.

As illustrated in the Figure, WP7 partners, followed closely the work that was contacted within the other Technical WPs (WP2-WP3-WP4-WP5-WP6) with the goal to identify the key innovative Results of the project (e.g. the NAO, the OSS, …) and promote them within the community of researchers working at the individual consortium partners (i.e. internal dissemination), across other related projects working on Network-Apps (i.e. external dissemination) and event beyond to the wider community working on 5G networks and their applications in various vertical sectors of the economy with a particular focus on Industry 4.0 players. Besides the technical Objectives that the project realized as part of WP2 to WP6 activities, the work of WP7 is of equal importance as it ensures the realization of Objectives relating with the Standardization and Exploitation of the project innovations by the wider Network-Apps community and eventually by the whole 5G networks ecosystem, towards the establishment of EU as a key player in the broadband networks and services telecoms, as well as in the targeted end-users community of I4.0 industries.

1   Introduction

1.1   Scope

The key objective of this document is to present the communication and exploitation activities that took place in the second year of the project (M12-M24, 2022), aiming to the maximization of the impact that will lead to the exploitation of the produced results. It constitutes the written summary of the conducted work that was carried out in the framework of Work Package 7 (WP7), as it tracks the results that were committed by the tasks T7.1, T7.2, T7.3, T7.4 and T7.5 until the time of writing. Finally, it highlights the participation of 5G-NDUCE in 5G PPP activities and the liaisons with other sister projects.

The pathway to economical, societal, environmental, and other impacts is strongly connected to the exploitation of the innovations that will arise from the consortium's activity and it is dependent on achieving the strategic outcomes that concern:

- Testing and validation of Network-App solutions on top of a 5G virtualized experimental environment with different implemented functions and vertical-specific configurations.
- Secure interoperability beyond vendor-specific implementation across multiple domains and availability of related standards or reference implementations.
- Open-source repository of Network-Apps that can be further leveraged by other developers.
- Creation of 3rd party markets for start-ups and SMEs. 50% of SMEs are targeted for this action.
- Relevant 5G PPP KPIs; among others, Service Creation Time in minutes.
- Generation of results that may be appropriate for transfer towards an incubator or a start-up, either within the project or outside of the projects in follow-up actions.
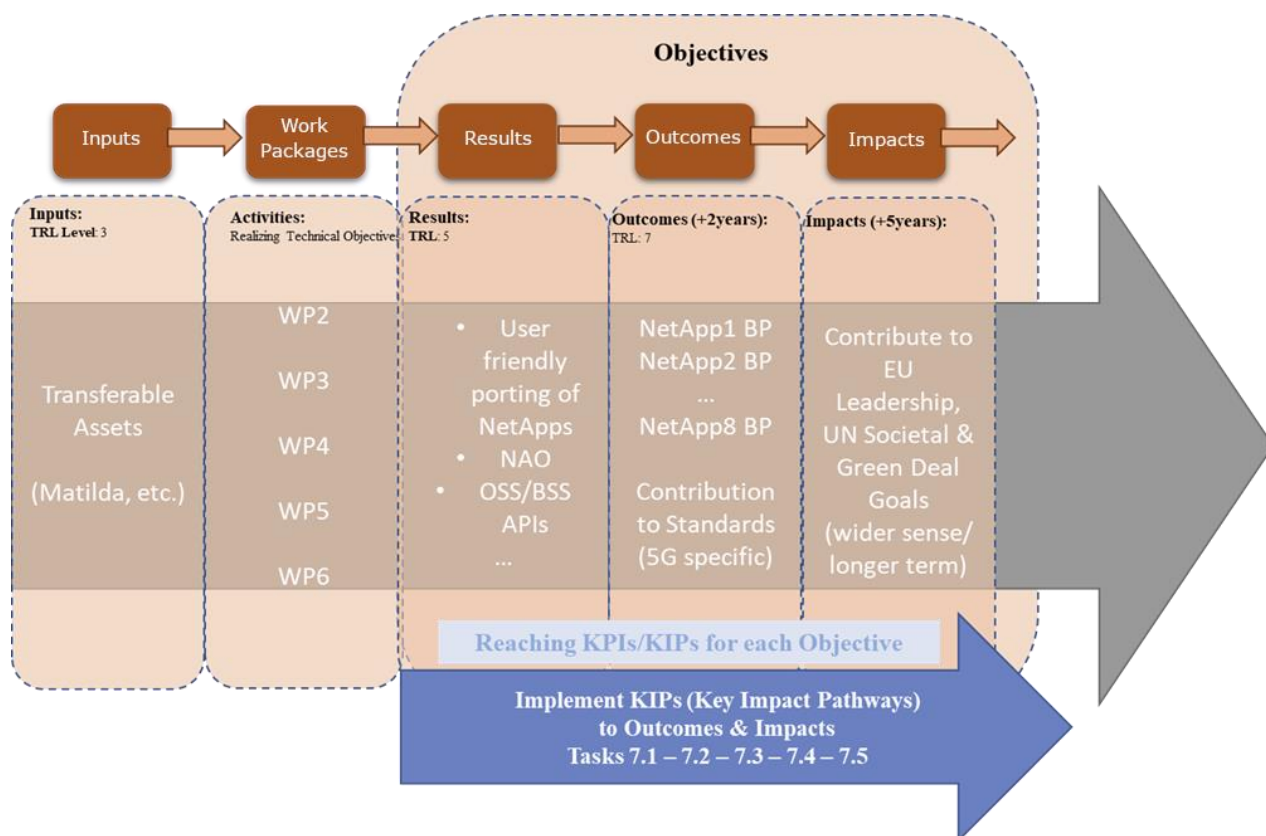
Figure 1: 5G-NDUCE strategy towards the implementation of KPIs that will realize the targeted project Outcomes and Impacts.

5G-NDUCE partners have the commitment to proceed for maximizing the popularity of the project, set up the proper communication links to attract and interact with a wide audience, including public and private stakeholders, and take care of spreading the project results in several different activities and actions. For attaining that goal, the consortium's members, either as Network-App developers or end users, have created messages in order to inform the interested third parties regarding the target groups, the use cases and expected impact of each Network-App individually.

It is understood by all partners that the diffusion of the aforementioned messages is instrumental to effectively promote the exploitation activities. In this framework, the measures to maximize 5G-NDUCE impact include publications in the individual communication channels through a number of collaborations, participation in industry and corporate events, organization of academic lectures and workshops. The dissemination and communication activities are expected to propagate the scientific and technological knowledge generated in the context of the project, aiming to ensure both mid- and long-term impact.

1.2   Structure

Following this introduction in Section 1, the remainder of this document has been structured as follows:

- Section 2 presents the impact pathway by analyzing the meaning of strategic outcomes and how these will be achieved considering potential obstacles.
- Section 3 presents the actions made to communicate and disseminate the project's early results.
- Section 4 describes the effort dedicated to standardization activities.
- Section 5 presents the work done towards the maximization of impact of the project, by exploiting its tangible results.
- Section 6 presents the liaisons with other EU and international projects, as well as the clustering activities with industry associations (e.g., 5G ACIA), 5G PPP workgroups and collaborations (e.g., ICT-41 projects).
- Section 7 presents the KPIs for the evaluation of the progress of the implementation of the communication activities, as they were defined in the communication plan.
- Section 8 provides the document conclusions.

1.3   Timeline

The following chart effectively sums up the timetable for this deliverable.

The initial discussions regarding the content of this begun after the summer holidays, in order to incorporate it with the rest of the activities that went on during the second semester of the year. After the review meeting and some crucial activities (e.g., presentations on MeditCom and SB Meeting) the Table of Contents was presented, and the first round of inputs started. After all the contents were in place, the document went through internal and external review mid-December, before getting submitted during the Christmas holidays.
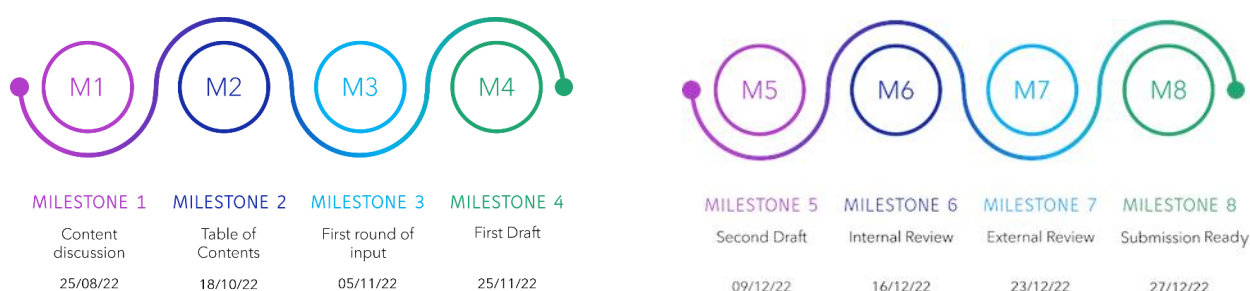
Figure 2: Deliverable's timeline.

2 Communication and Dissemination Actions

In terms of Dissemination Activities, there have been 33 representations of 5G-NDUCE in form of workshops and webinars in major events hosted across Europe, while 12 paper presentations and publications in prestigious journals also took place. Some of the most important of those actions are the participation in Workshop at EuCNC/6G Summit 2021 and 2022, the joint participation at the MeditCom Conference with the other ICT41 projects, while for the publications some of the most important ones are "Flow Assignment and Processing on a Distributed Edge Computing Platform" on IEEE Transactions on Vehicular Technology and "Optimized Joint Allocation of Radio, Optical, and MEC Resources for the 5G and Beyond" on IEEE Transactions on Network and Service Management. All of the dissemination actions and the publications can be found at the private area of the project's website under the corresponding tabs.

2.1 Communication and Dissemination Channels

2.1.1 Social Networks

The 5G-NDUCE project is active in three social networks LinkedIn, YouTube and Twitter. All the partners' activities and participation in events are posted on LinkedIn and get twitted / re-twitted in Twitter, in order to maximize the outreach of the project.

In addition, as the project reaches almost two thirds of its lifetime, the YouTube Channel was created in order to showcase and deliver to the public audience the early results of the project. The videos that will be uploaded will present what the project is about, which 5G use cases are explored, how the ExFas construct an Industry 4.0 testbed and how the 5G-NDUCE platform will be used to bring all these together.

Figure 3: Twitter post.
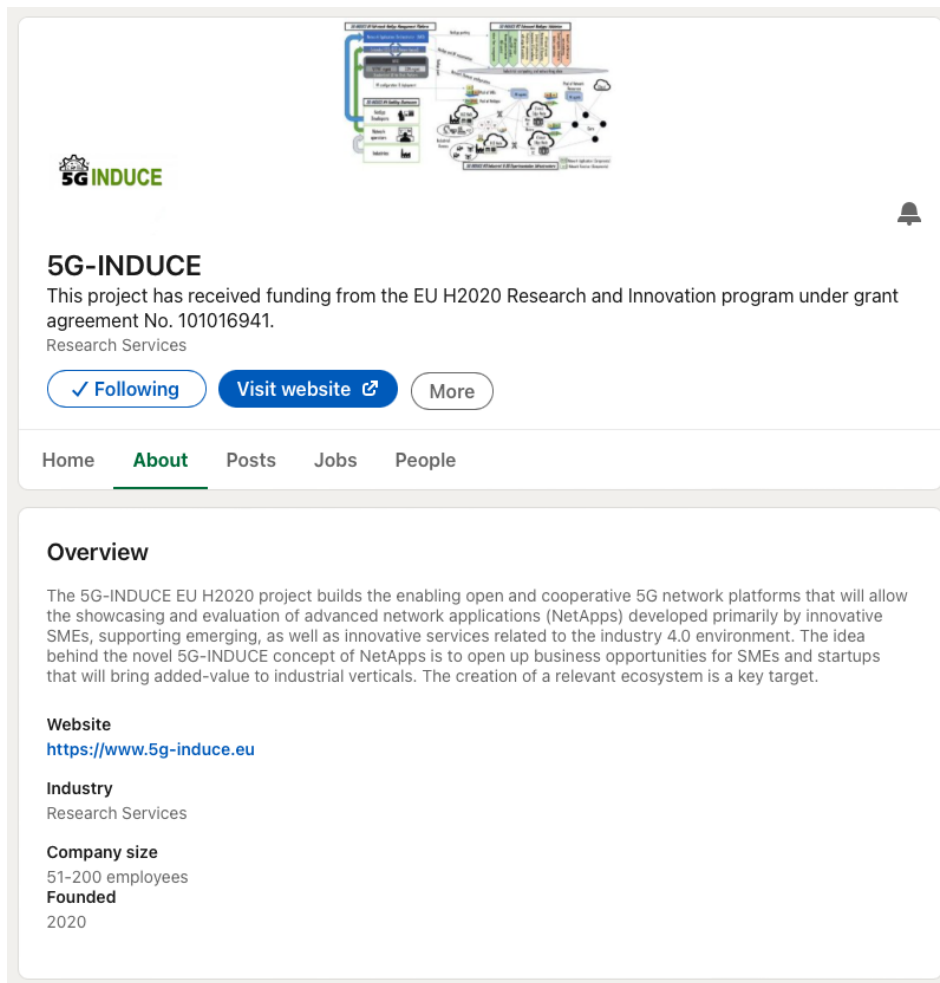
Figure 4: LinkedIn page.
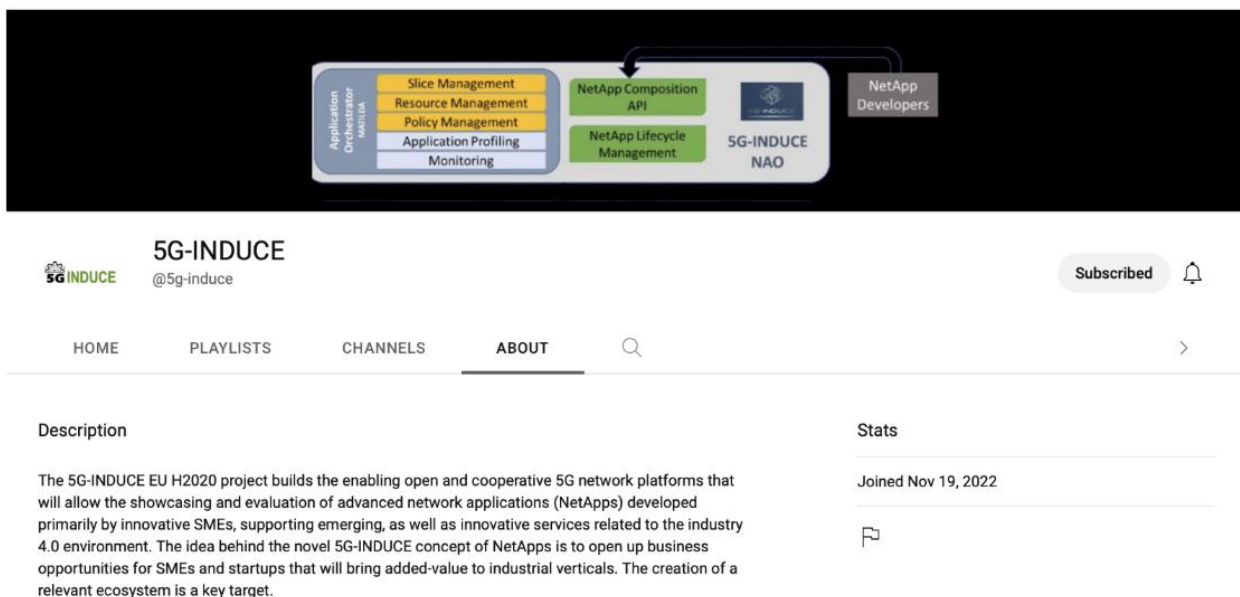
Figure 5: YouTube Channel.

Eventually, it will be a complete description of the project's environment with a clear view on every aspect of it. Especially, demos of Network-App development and deployment in top of the platform would be a great asset for the project, as they could be used as training for 3rd party experimenters even after the project ends, extending that way its overall impact.

It is estimated that by M30 the Channel will have more than ten explanatory videos either vertical and business oriented, or more technical deep diving in the actual developments.
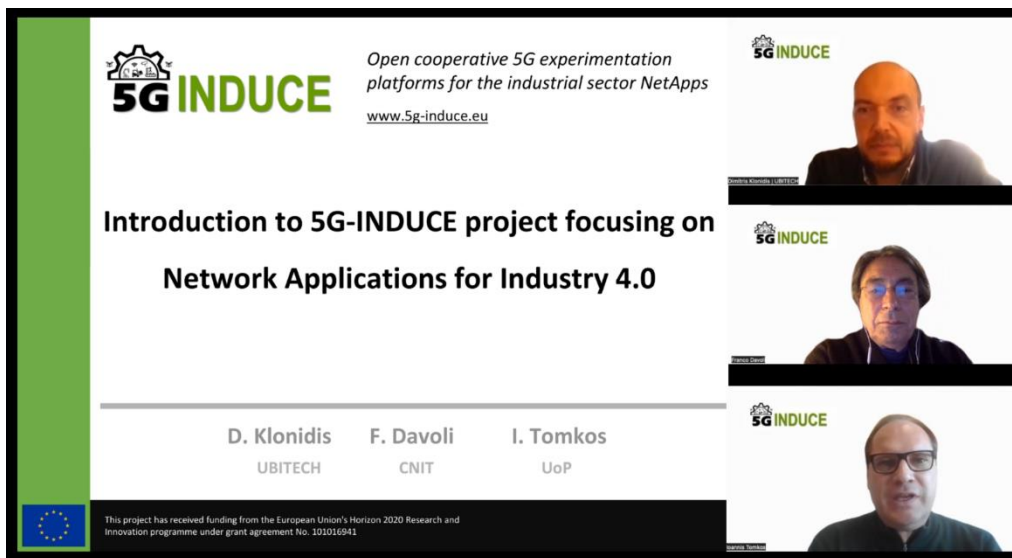
Figure 6: Screenshot from "Introduction to 5G-NDUCE" video.

2.1.2 Conferences and Workshops

The project partners actively participated at and organized conferences and workshops to:

- encourage the dissemination of 5G-NDUCE projects results,
- empower bidirectional communication with 5G-NDUCE industry stakeholders to validate current results,
- synchronize with other research projects in the field of Network-App development to build a common understanding and derive standards.

The project partners were actively engaged in major upcoming events during 2022, since they had received relevant invitations to act as co-organizers or participate as speakers. The following table shows an overview of all conferences in which 5G-NDUCE research partners participated (Table 1) and will participate (Table 2).

Table 1: Participation in major events.

	Partner	Conference (Session)	Title	Audience	Date and Venue
1.	OCULAVIS	**EuCNC & 6G Summit** (Special Session 10: Network-Apps for Verticals Smart Factories and Industry 4.0)	AR-based Remote Maintenance and Repair as an Example of a 5G-NDUCE I4.0 Network-App Orchestration	Telecommunication research institutes and industry	21/06/22 online / Grenoble, FR
3.	ININ	**25th Seminar on Radio Communications**	Testing and optimizing 5G for industrial verticals	Industry (utilities, telecommunication vendors, ISPs, etc.), researchers in telecommunications	02-04/02/22 Ljubljana, SL
2.	UOP	**MeditCom**	Open cooperative 5G experimentation platforms for the industrial sector Network-Apps	ICT-41 partners	05-08/09/22 Athens, GR
4.	ININ	**31st International Electrotechnical and Computer Science Conference**	Collecting mobile network radio parameters using consumer CPE modem	IT and electrical engineering researchers/scientists, students, developers	19-20/09/22 Portorož, SL
5.	UWS	**SoftCOM**	Network-Apps Approach for Accelerating Vertical Adoption of 5G Networks: A UAV Case	Industry, Researchers	22-24/09/22
6.	OCULAVIS	**All About Remote** (Innovation and Research Booth)	Visual Assistance towards 5G – Showcasing and discussing 5G network benefits and deployment considerations for the Industry 4.0	Machine and plant engineering industry and Industry 4.0 stakeholders	08/12/22 Aachen, DE

Table 2: Planned participation in major events.

	Partner	Conference (Session)	Date and Venue
1.	CNIT	IEEE International Conference on Communications (ICC)	28/05– 01/06/2023 Rome, IT
2.	CNIT (organizer)	2nd Int. Workshop on Green and Sustainable Networking (GreenNet 2023) – in conjunction with IEEE ICC	28/05-01/06/2023 Rome, IT
3.	CNIT	EuCNC	06-09/06/2023 Gothenburg, SE
4.	UWS	EuCNC	06-09/06/2023 Gothenburg, SE
6.	UOP	MeditCom	To be announced

2.1.3 Demos & Training

The partners of the project also participated in a variety of demonstrations and trainings to showcase the early results of the project. In Table 3 the organized demos can be found, while in Table 4 the organized trainings. In the paved path of this year, in Table 5 can be found the planned activities of this subsection. All these tables are sorted by UC.

Table 3: Organized Demos.

	Partner	Demo	Title	Description	Audience	Date and Venue
UC2	5COMM	5G live demo for Telefonica	5G Rel-16 network slicing demo in 5TONIC (phase-1)	End-to-end demonstration of gesture recognition software deployed in the Rel-16 5TONIC network	Visitors from Telefonica, Spain	21/06/2022 Madrid, ES
UC2	5COMM	5G live demo for Telefonica	5G Rel-16 demo in 5TONIC (phase-2) 5G Rel-16 network slicing demo in 5TONIC (phase-2)	Enhanced end-to-end demonstration of gesture recognition software deployed in the Rel-16 5TONIC network	Visitors from Telefonica, Spain	04/10/2022 Madrid, ES

	Partner	Demo	Title	Description	Audience	Date and Venue
UC3	**YBVR**	Demo organized to Telefonica	5G advanced network slicing demo in 5TONIC	Video VR monitoring of AGV with data overlay, using 5G comms in different network congestion scenarios	Visitors from Telefonica: Spain, Germany and Latam (on-line)	15/06/2022 27/09/2022 Madrid, ES
UC4	**S5**	AI Engine for Manufacturing Environments	Data Ingestion, AI Engine and Pipeline creation demonstration	Showcasing the operation of the Network-App in an end-to-end scenario using energy data harvested from a data source till the design and execution of complex AI pipelines and the visualisation of the results	Potential Industry customer/ contacts from existing projects	16/09/2022 Online
UC5	**UWS**	Lab tour to introduce AI research at UWS including 5G INDUCE demos	AI Research in UWS Beyond5GHub	Showcasing different research in the team related to 5G-induce such as, intruder and corrosion detector, 5G network, and other research, including face recognition, autonomous driving capabilities	Visitors from Turku University of Applied Sciences, Finland Visitors from University of Strathclyde, UK Visitors from Hamburg University of Applied Sciences	28/10/2022, 10/10/2022, 18/7/2022 Paisley, UK
UC7	**ILINK**	Internal Assets' Tracking	Presentation of internal asset tracking capabilities related to safety and performance optimizations	ITS (Intelligent Transport Systems) Hellas	ITS audience, Ministry of Transportation and Key Stakeholder of the ITS Hellas community	08/12/2022 Athens, GR

Table 4: Organised Trainings.

	Partner	Trainings	Title	Description	Audience	Date and Venue
UC5	UWS	Machine Learning for AI	Lecture and lab to introduce machine learning for object detection etc. with reference to 5G-NDUCE Network-Apps	An introductory lecture regarding AI, machine learning techniques including traditional and deep learning methods and technologies for object detection, installation of testbed suitable for running AI-based models. Show casing some results from 5G-induce project for intruder detections.	Master Students	02/11/2022 Paisley, UK
UC5	UWS	Cloud computing with MaaS in 5G network	Workshop to introduce how to deploy a datacenter with Maas using JuJu with reference to 5G-NDUCE Network-Apps	Introductory talk regarding MAAS (metal-as-a-service,) to provide automation to physical servers through Juju, an open-source application modelling tool which supports MAAS and setup and installation.	Researchers esp. new PhD students	28/01/2022 Paisley, UK
UC7	ILINK	Internal Assets Tracking	Using the Location container to locate assets position inside internal infrastructures	An introductory talk to potential software engineers that would like to benefit from internal assets tracking for providing relevant industrial applications	Software Engineers	20/09/2022 ILink HQs Athens, GR

	Partner	Trainings	Title	Description	Audience	Date and Venue
UC7	ILINK	Safety Application Training	Using the application from forklift drivers & workers in order to avoid collisions in WH	A validation check of the application at Whirlpool's refrigerator line. Training was related to the user-based scenario of acquiring a UWB tag and tracking the entity's location inside the factory while moving around for daily operations.	Industry partner - Whirlpool	19/11/2022 Cassinetta, IT
UC8	ININ	Internal workshop	qMON Training	Using qMON in public network environment	Industry partners	Online 13/01/2022
UC8	ININ	Internal workshop	qMON Training	Using qMON for R&D activities	Academia, R&D and industry partners	Online 26/10/2022

Table 5: Planned Demos & Trainings.

	Partner	Demo / Training	Title	Description	Audience	Date and Venue
UC5	UWS	Dockerization	Workshop to introduce dockerization with reference to UWS 5G-NDUCE Network-Apps	Workshop for researchers on how to containerise VNFs	Researchers esp. new PhD students	January 2023 Paisley, UK
UC5	UWS	Drone Regulations	Lecture to Drones and related regulations with reference to 5G-NDUCE	Lecture how to fly drones safely and legally	Researchers esp. new PhD students	January 2023 Paisley, UK

	Partner	Demo / Training	Title	Description	Audience	Date and Venue
UC4	**Suite5**	AI Engine Training	Using the AI Engine in the 5G-NDUCE demonstrators	Webinar for partners PPC and WHRL to present the Network-App operation in their ExFas and their business scenarios	Industry partners PPC and WHRL	March 2023 online
UC7	**ILINK**	Workshop	Warehouse Optimization & Safety Techniques	Presentation of internal asset tracking capabilities related to safety and performance optimizations	Potential Industry customer	Q1 2023 Athens, GR
UC8	**ININ**	Internal workshop	Demos on qMON testing and monitoring tool	Lab tour and presentation of qMON tool features	Potential industry partners	To be scheduled in 2023 Ljubljana, SI

2.2   Communication Material

2.2.1 Conferences Project's Logo

The project's logo has not been changed, in order for the external audience to have a coherent and unified view of the project for the whole timespan of the project.

2.2.2 Poster

In terms of the poster, it is still the same but there is a plan to be updated during the last year of the project in order to include the actual progress and tangible results. A more technical aspect will be adopted to gain the attention from directly related 3rd stakeholders and developers.

2.2.3 Videos

A very tangible and efficient way to showcase the results and the progress of the project is to present them through videos. Their direct way of providing the information is more than suitable to engage the people watching them. Towards that direction 5G-NDUCE partners decided to collect all available videos from demonstrations or create some new ones to effectively showcase their developments. Hence in the next table those videos can be found.

Table 6: Available Videos.

Partner	Video Title	Short Description	Date
ERC, 5COMM	Gesture recognition demo video	During both phase-1 and phase-2 demos performed in 5TONIC and specified in Table 3, both Ericsson and Fivecomm recorded a video where the gesture recognition SW is used to control an indoor AGV.	26/10/22
ININ	Spatial UC8 video Demo	Video shows the qMON offline advanced analytics tools displaying how does the monitoring agent, while on a drive test, switching among base stations and radio technologies (5G, LTE) and showing all relevant radio KPIs as well.	28/10/22
UWS	Intruder detection Network-App UC5 video demo	The video showcases AI-based intruder detection to identify undesired presence of intruders using UAVs.	14/11/22
YBVR	AGV from the headset, and a 360 from camera UC3 video demos	First video includes the user experience from a VR headset. Second one is a 360 video as captured by the camera on the AGV	02/11/22
S5	Predictive Maintenance Analytics UC4 video demo	The video, used as a teaser for the Network-App, provides a quick overview of the main Network-App functionalities, showing screens briefly screens of the data ingestion functionalities, the Analytics designer and of the visualisation engine	02/10/22
ILINK	Forklifts & Workers Safety in Internal Infrastructures video - iLink Demo at Whirlpool ExFa	The need for a factory to provide safe working conditions, the appropriate Network-App by iLink through 5G-NDUCE, and the implementation of indoor positioning in other cases.	15/11/22
UOP, UBITECH, CNIT	5G-NDUCE: Introduction to the project	This video was created as a panel discussion (Q&A) with panellists being Franco Davoli (PC), Dimitris Klonidis (TM) and Ioannis Tomkos (WP7 Leader). It covered topics like the main development goals of 5G-NDUCE project, description on the ExFas where the Use-Cases are demonstrated and some overview information about the Use Cases	06/12/22

2.2.4 Handbook

The proposed "Handbook of Deployment – 5G-NDUCE" will be a short description of the steps needed for a Network-App to be executed on top of the 5G-NDUCE Platform. This handbook will address partners of the project, or any 3rd party and it will guide them among the several components and stages of onboarding and deployment. The handbook constitutes an initial piece of documentation, very useful for a developer or an integrator to have a first overview of the platform and experiment through a tested and safe path.

The proposed table of contents of the handbook includes:

- Introduction to 5G-NDUCE Platform
  This section will provide the core information regarding the architecture and the topology of the platform, in order for the user to have a complete overview of the underlying infrastructure
- Composition of a Network-App
  This section will provide the needed guidelines and tools for the conversion of a simple application into a Network-App format before the onboarding process.
- Entering the Web Platform
  This section will provide an overview of the user interface of the platform and the different features granted by the role-based access control.
- Registration of Individual Network-App Components
  This section will present the process of registering the Network-App components. During this procedure, several key parameters are provided to the platform such as the docker image of the application, the needed resources and the global variables.
- Composition of Network-App Graph
  This section will provide the instructions on how to connect the different Network-App components registered in the previous step in order to compose the Network-App. In addition, at this point restrictions and constraints regarding the runtime of the Network-App are declared. After the composition of the Network-App Graph, the Network-App is ready to be deployed.
- Runtime Monitoring of Network-App
  This section will describe the use of the monitoring and logging tools provided by the platform to inspect the runtime operation of the Network-App.
- Runtime Policies
  This section will describe the way to enforce rules on the operation of the Network-App, by taking advantage of live data obtained by the actual infrastructure. Such rules and policies may implement actions of scaling, security and traffic management.

The handbook will be mainly based on D4.1: "First release of NetApp developments and onboarding methodology and requirements" of 5G-NDUCE, but it will be regularly updated in order to follow any advancements and add-ons adopted by the platform. Its creation is anticipated by the end of February 2023.

Regarding its exploitation, the handbook could be used as the main dissemination material of the project. Due to its compact size and dense information, it will be much easier to disseminate than the deliverables of the project. In addition, its table of content could be easily included in flyers or posters of the project in booths or presentations of major events. Finally, its content could pave the way for workshops and videos dedicated to the Network-App onboarding process.

2.3 Dissemination Material

2.3.1 Scientific Publications

A core activity of the project is the provision of high-quality papers, showcasing the procedures followed through the specifications definition, the architecture creation, the actual development, the testing and validation of the solutions adopted and finally the description of the results. Those publications follow the open-access principles and peer-review processes of the scientific community, so as to maximize their validity and impact. Seven papers were created during this second year, and they were published in some well-established journals and conferences.

Table 7: Scientific Papers.

Authors	Paper title	Journal / Conference
	Paper Description	
F. Davoli, M. Marchese, F. Patrone	Flow Assignment and Processing on a Distributed Edge Computing Platform	IEEE Transactions on Vehicular Technology
	The paper addresses the case of distributed streaming platforms with multiple message brokers to develop an optimization model for the real-time assignment and load balancing of event streaming generated data traffic among Edge Computing facilities. The performance indicator function to be optimized is derived by adopting queuing models with different granularity (packet- and flow-level) that are suitably combined. A specific use case concerning a logistics application is considered and numerical results are provided to show the effectiveness of the optimization procedure, also in comparison to a "static" assignment proportional to the processing speed of the brokers.	
R. Bolla, R. Bruschi, C. Lombardo, F. Davoli, J. F. Pajo	Multi-site resource allocation in a QoS-aware 5G infrastructure	IEEE Transactions on Network and Service Management
	The paper presents the Resource Selection Optimizer (RSO) – a software service in the Operations Support System (OSS), whose main goal is to select the most appropriate network and computing resources (according to some criterion) among a list of options provided by the Wide-area Infrastructure Manager (WIM). It consists of three submodules that respectively handle: (i) the aggregation of vApp components based on affinities, (ii) the forecasting of (micro-) datacentre resources utilization, (iii) and the multi-site placement of the (aggregated) vApp micro-service components. The RSO's performance is mainly evaluated in terms of the execution times of its submodules while varying their respective input parameters, and additionally, three selection policies are also compared	
R. Ušaj, R. Sušnik, L.Koršič, J. Sterle	Collecting mobile network radio parameters using consumer CPE modem	ERK 2022
	The paper describes a generic approach for collecting radio network parameters values measured by general UE devices which do not implement dedicated interface/API to access these values but have rather implemented web interface only for displaying measured radio parameters values. The generic approach elaborated in the paper is implemented by an API aimed at fetching and parsing data from UE's web interface and forwarding them into network monitoring tool. The paper demonstrates usability of the API by describing its implementation to a consumer CPE modem facilitating Fixed Wireless Access service.	
G. Golcarenarenji, I. Martinez-Alpiste, Q. Wang, J. M. Alcaraz Calero	Illumination-aware image fusion for around-the-clock human detection in adverse environments from Unmanned Aerial Vehicle	Expert Systems with Applications

Authors	Paper title	Journal / Conference
	Paper Description	
	This study proposes a novel illumination-aware image fusion technique and a Convolutional Neural Network (CNN) called BlendNet to significantly enhance the robustness and real-time performance of small human objects detection from Unmanned Aerial Vehicles (UAVs) in harsh and adverse operation environments. The proposed solution is particular useful for mission-critical public safety applications such as search and rescue operations in rural areas.	
R. Bolla, R. Bruschi, A. Carrega, F. Davoli, C. Lombardo	Trading off Power Consumption and Delay in the Execution of Network Functions by Dynamic Activation of Processing Units	1st International Workshop on Network Energy Efficiency in the Softwarization Era, in conjunction with IEEE NetSoft 2022
	The paper addresses a "smart sleeping" control problem, where computing resources in multi-core processors executing network functions are modelled as multi-server queues, and the number of active processing units (either physical or virtual) can be dynamically adjusted by parametric control over a time scale compatible with the long-term dynamics of the traffic flows that require processing. It is shown that, on average, up to 25% of processing capacity of a network node can be turned off in the presence of bursty traffic with low load without significantly affecting packet latency.	
A. Mohammadpour, C. Lombardo, R. Bolla, R. Bruschi, F. Davoli, L. Ivaldi	A Zero-Touch as-a-Service Active Monitoring Framework for Virtualized Network Environments	4th International Workshop on Performance Evaluation of Next Generation Virtualized Environments and Software-Defined Networks, in conjunction with IEEE NetSoft 2022
	The paper presents a software traffic generator, based on TRex and executed in a VNF, which leverages on an automation framework to provide zero-touch as-a-Service active monitoring. Results show that the impact of this solution on the measured performance is negligible in terms of deployment time, as well as required input lines.	
S. Giannakidou, P. Radoglou-Grammatikis, S. Koussouris, M. Pertselakis, N. Kanakaris, A. Lekidis, K. Kaltakis, M. Koidou, C. Metallidou, K. Psannis, S. Goudos, P. Sarigiannidis	5G-Enabled Network-App for Predictive Maintenance in Critical Infrastructures	WSCE 2022
	In this paper, a Network-Application (Network-App) for predictive maintenance in power plants was presented taking full advantage of containerisation, 5G and Artificial Intelligence (AI). In particular, the proposed Network-App adopts an autoencoder in order to recognise timely potential anomalies/outliers with respect to the functionality of industrial devices, paying special attention to electricity generators. For this purpose, operational data of the electricity generators are used. This kind of data is received through Programmable Logic Controllers (PLCs). Next, the autoencoder receives this kind of data and is responsible for the detection of anomalies.	

2.3.2 White Papers

The purpose of the white papers is to promote 5G-NDUCE concepts, platforms, and solutions, as well as to demonstrate how these solutions may handle various difficulties in key application cases, with an emphasis on commercial exploitation. Up to now, 5G-NDUCE has participated in two major White Papers both in cooperation with 5G-PPP, as well as other European projects.

The first one, "Network-Applications: Opening Up 5G and Beyond Networks – 5G-PPP Projects Analysis" [1] was produced in cooperation with other projects organized under the umbrella of the 5G-PPP Software Network Working Group. It explains the concept of Network-Applications and presents the various implementations and categorized approaches in ICT-41 projects to address the challenge of facilitating verticals to deploy their Network-Applications over 5G and beyond networks.

The second one, "Delivery of 5G Services Indoors – the Wireless Wire Challenge and Solutions" [2] was also delivered in cooperation with other projects organized by the 5G-PPP Technology Board. It addresses the requirements and presents emerging solutions of verticals' deployment of their applications in 5G indoor environments for various use cases such as the industry 4.0, with first KPI achievements in such solutions provided.

5G-NDUCE project is also leading the elaboration of the next 5G-PPP whitepaper on "New I4.0 Trends enabled by 5G and its evolution" for tentative publication in Q1-2023. This whitepaper is oriented to provide both an update and a forecast on the key cases, initiatives, challenges and expected technology evolution of applications of I4.0 leveraging 5G and beyond networks. The research work carried out in 2022 for enabling this whitepaper has included, among other activities, conducting a comprehensive survey distributed to and answered by more than ten key vertical stakeholders of the European I4.0 ecosystem, followed by a quantitative and qualitative analysis of the collected responses, being a sample of such analysis, restricted to the scope of 5G-NDUCE project, already documented in 5G-NDUCE deliverable D2.3 [3].

Apart from these efforts, 5G-NDUCE aims to participate in more White Paper especially focusing on the standardization part of the Network-App deployment platforms, such as NAO. This path will be followed along with the other ICT-41 projects, in order to maximize the Papers' effect towards the community.

2.3.3 Project's Deliverables

Aside from being a duty and a method of project evaluation, the deliverables are a highly useful instrument for any interested party to have a full understanding of the project's operation and outcomes. The knowledge presented is broad and diverse, ranging from management and specification definition through architecture and development. Up to the time of writing this D7.4 the openly available deliverables on project's website are the ones included in the following table.

Table 8: Publicly available deliverables.

Deliverable number	Deliverable Title
D2.1	5G platform design and requirements in support of Industrial sector Network-Apps
D2.2	Targeted use cases and Network-App related requirements
D2.3	5G technology and strategic investment sectors in Industry 4.0
D7.2	Data Management Plan
D7.3	Dissemination, communication and standardization activities - Version a

3 Standardization

3.1 Approach

First of all, 5G-NDUCE project set its initial focus and scope of Standardization action on Standardization Bodies (3GPP, ETSI, IRTF, IEEE, ITU-T) and Key European Associations & Clusters (5G-PPP & IERC), while remaining open to watch and explore other organizations and associations that could be relevant for the achievement of standardization impact from the project.

Then, as outlined in 5G-NDUCE D7.3, the general context for Standardization activities along the project builds upon two additional key considerations, summarized here:

a) An Innovation Action project like 5G-NDUCE project may rely on, adopt, and even evaluate existing standards in the real-world, end-to-end scenarios targeted by the project. So, 5G-NDUCE may open opportunities to leverage and impact varied standards, in two alternative ways:
  - Assessing the level of support and/or potential gaps of specific adopted standards to the targeted use cases and needs of the platform solutions created in the project,
  - Spotting whitespaces in between the respective scope and coverage of several Standards adopted by 5G-NDUCE.

b) A multi-disciplinary, end-to-end, and ecosystem-based project like 5G-NDUCE assumes and promotes a broader understanding of the "Standards" reality beyond SDOs, naturally extending its scope of technology watch and impact to
  - Open-Source Communities (OSCs), proving an excellent way for rapid adoption, evolution and diffusion of new technological solutions, especially when a critical mass of contributors is reached.
  - Knowledge and Practice Communities, that even if not devoted to creating new standards or norms, are instrumental for identifying common challenges and homogeneous solutions for multiple projects. This is certainly the case for 5G-PPP in the broad field of 5G research and innovation.
  - Industry forums. Especially in the case of 5G-NDUCE, with a variety of industry applications in the scope of action, the role of Industry fora, as both concentrators and disseminators of outstanding challenges and industry advancements, is also a source of inputs and a powerful lever for maximizing impact into new Standards related to specific industries.

Next, for the actual identification, follow-up, promotion and fulfilment of concrete standardization activities, 5G-NDUCE project is leveraging two major assets:

a) Experience-based findings and proposals from the respective WPs of 5G-NDUCE project, with involvement of many partners (beyond the team of Task 7.2), which provides a bottom-up flow of insights related to standards suitability, performance, and potential improvements. Moreover, being these insights of general applicability to other ongoing 5G-PPP projects (mainly ICT-41 family of projects) they are regularly shared with the 5G-PPP community through the varied WGs and Committees in order to promote syndication of efforts to specify and address collective challenges and promote joint action towards Standards impacts.

b) Balanced team of Task 7.4 partners (when it comes to complementary roles and geographical footprint, as can be seen on Table 9) for securing the overall follow-up and coordinated support of Standardization-related activities at project level.

Table 9: Partners involved in Task 7.2.

Type of Partners	Greece	Italy	Spain
I4.0 Partners	PPC	WHR/WHMAN	FORD
ICT/Telco Partners	OTE	WIND3	ERC
Academic/Research Partners	UOP	CNIT	(UPV)

This diversity of partners translates into a major potential for reaching out to collecting feedback and promoting action on the respective specific Industrial sectors, on the ICT/telco domain, and on the Academic/research clusters.

Finally, the materialization of concrete activities and achievements (impacts) in standards is expected to be always driven by either:

a) Contributions to Standards by concrete 5G-NDUCE partners with active delegates in the related Standardization bodies,
b) Initiatives promoted, on 5G-NDUCE behalf, for generating general awar4eness and early influence in relevant stakeholders of Standards

3.2   Ongoing initiatives: Achievements and Expected Results

In this section a situation update on the Standards context and the rationale for associated actions triggered by 5G-NDUCE project is provided, followed by a summary of the concrete achievements fulfilled and the launched activities for pursuing further impact.

Taking the above introduced framework for the approach to Standardization related activities at 5G-NDUCE project into consideration the learnings, conclusions and type of actions initiated shall be now discussed.

From the initial set of SDOs considered for impact by 5G-NDUCE, there is two outstanding ones (ETSI, 3GPP and ITU-T) concentrating our major attention and action, especially for the aspects related to, respectively: the formal validation of B5G-enabled apps and energy-efficiency challenges (ETSI); the advanced features for NPN scenarios and smart app-network interaction via Exposure of Network Analytics (3GPP); evolving edge applications for verticals using private 5G (ITU-T). As a result, several contributions from 5G-NDUCE partners have materialized into TR's and TS's either already approved or close to being approved by these Standardization Bodies.

Then, although not considered initially in the targeted SDOs, GSMA is consolidation as a reference to our project in several aspects related to Orchestration of Network Slices.

With regards to European innovation clusters, the orientation to 5G-PPP is clearly prevailing, due to the generation of high consensus of 5G-NDUCE with other ICT-41 projects on concrete common challenges posed by Network-Apps' deployment, validation, business model and lifecycle management in general. Impact in Standards in this field is expected to be relevant, at the cost of taking some more time to translate into the creation of concrete Work Items and contributions to new TR's and TS's.

From the direct experience of 5G-NDUCE project in the hands-on adoption and evaluation of Standards, along their varied Work Packages, several conclusions can be drawn.

From WP2, the analysis for strategic investments of the industrial sector on 5G, as per 5G-NDUCE vertical stakeholders' needs depicts a scenario of adoption of 3GPP Rel15 and Rel16 standards fulfilling those needs (standards closed before the start of 5G-NDUCE). That said the interest in leveraging flexible NPN models and

the envisaged trend for smarter interaction of orchestration systems, apps and networks, especially as more and more services (apps) are deployed in 5G NPN environments calls for close watch of Rel17 and Rel18 standards and concrete and timely influence and contributions by 5G-NDUCE partners involved in 3GPP. Additionally, from WP2 research work documented at D2.3 a broader initiative towards for the next "5G-PPP whitepaper on I4.0 trends enabled by 5G and its evolution" was launched under the coordination of 5G-NDUCE, collecting inputs from several 5G-PPP backed projects on I4.0 evolution aspects, and including insights related to relevant standards of major influence to I4.0.

From WP3, the pursuit for advanced intent-based models of orchestration for Network Slicing has led to the adoption of GSMA NG.116 recommendations, and the consolidation of invaluable hands-on feedback (to be shared with GSMA) and the identification of evolution aspects to improve the adopted recommendations. This constitutes a new line of action going forward, for the final months of the project, as more and more usage of the 5G-NDUCE NAO delivers more learnings to be shared with GSMA.

From WP4, the adoption of OpenSource solutions by all Network-Apps being developed is, without a major surprise, generalized and even pervasive. The learnings on the suitability and limitation of the OpenSource solutions adopted is subject for sharing with the ecosystem of Network-App developers, and eventually for reaching out to some of the communities delivering them. A project like 5G-NDUCE does not have the critical mass of SMEs to, other than for that influence, to create a major impact in these OSCs via direct participation of partners in them. That said remarkable efforts and achievements at ITU-T have been achieved starting from the analysis of the logic and challenges of concrete use cases to be integrated in 5G Private/Edge environments, i.e., at the intersection of WP4, WP3 and WP5 relative scopes, via contributions to the ITU standard "Use cases for autonomous networks" [6] have been made and become approved. This Supplement 71 to ITU-T Y-series Recommendations analyses representative use cases for autonomous networks. 5G-NDUCE partner UWS contributed with a use case entitled "Evolving edge applications for verticals using private 5G". The use case is based on Use Case 5 regarding ML-assisted inspection and surveillance services for critical infrastructures in 5G networks for industries. The details of this use case are described in Clause 7.20 in this standard, and the 5G-NDUCE approach for managing Network-Applications is highlighted in a note: "This aligns with the concept of Network-Apps and the Network-Application orchestrator (NAO) [b-FGAN-O-013-R1], decoupling the network operations logic from service provider logic and providing clear business roles."

From WP5, the day-to-day is characterized by the adoption and integration of standards of varied sources and communities into an overall and orchestrated working solution for Network-Apps delivering their service over 5G networks. 5G-NDUCE platform interprets and integrates several standards for acting as the glue securing the end-to-end red thread from intent to actual deployment. At the ExFas their adherence to standards (such as 3GPP Rel15 and Rel16) secures adequate compatibility and interoperability between networks, systems and UE devices, and for hosting orchestrated Network-Apps at the Edge of the Network. Even so, securing the conformance of Network-Apps over 5G environments is not a straightforward process at all, falling somewhat in between chairs of several standards, and therefore impacting the lead times for application readiness and exploitation. Potential improvements to adjacent Standards are expected to be collected and shared with 5G-PPP and, tentatively with ETSI, given their focus on helping simplifying app deployment and validation over 5G and beyond networks.

From WP6, finally, 5G-NDUCE heavily leverages the science and recommendations on 5G-enabled apps' testing and validation approved by ETSI in 2022, By putting them in practice, extensively, in 2023 it is expected to build new experience and learnings for the case of complex Network-Apps scenarios and feedback about that to ETSI, eventually promoting new Work Items for introducing improvements to existing TR's and TS's.

At WP7 all these learnings are collated and processed, and consequently initiatives are discussed, pushed, on behalf of the project, in the selected research clusters and industry associations, and overall progress is followed up. Taking into consideration the general timeline of the project with its focus shifting from architecture and integration to validation and showcasing, for year 2023, clearly more and better insight on standards adoption experience by 5G-NDUCE and identified lines for their evolution shall call for open dissemination activities, to be delivered by the project. More concretely workshops on Standardization aspects with 5G-PPP WGs, ETSI, ITU-T, GSMA, and 5G-ACIA shall be held, and 5G-NDUCE webinars to be delivered in 2023 shall incorporate specific sections covering Standards adoption and proposed evolution by 5G-NDUCE. By doing so further influence on Standards and Research Clusters direction is expected to crystalize along 2023, with both new impacts and new lines of action most likely extending beyond 5G-NDUCE project end.

The achievements in Standardization by 5G-NDUCE project, at the moment of reaching the first 24 months of the project, along with the enumeration of ongoing prioritized initiatives towards further impact in Standards in the final year of the project, and beyond, are captured in Table 10.

Table 10: Summary of Standardization related ongoing activities, achievements and expected results.

SDO/ Research Cluster/ Community	Initiative • **Expected Result / Achievement**	Timeline	Main Driver
3GPP (Rel17)	Contributions to late Rel17 specs on Edge Connectivity • Achievement: Rel17 TS 23.548 [4]	Approved: 2021-Aug	ERC
3GPP (Rel18)	Contributions to early Rel18 TR on 5G Automation • Expected Result: Rel18 TR 23.700-81 [5] to be approved	2022-Q4	ERC
ITU-T	Contribution to ITU-T Focus Group on Autonomous Networks • Achievement: TS "Use cases for autonomous networks" approved [6]. Further background at [1]	Approved: 2021-Oct	UWS
ETSI (ETSI INT TC)	Leading Work Item on "E2E T&V of Vertical apps over B5G networks" • Achievement: ETSI INT TR 103 761 [7]	Approved: 2022-May	ERC

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[1] The contribution is developed from the previous contributions made by UWS in the Focus Group on Autonomous Networks (FG-AN, https://www.itu.int/en/ITU-T/focusgroups/an/Pages/default.aspx):

- ITU FG-AN AN-I-065, "Autonomous Network Management for 5G and Beyond Services and Vertical Applications: Case Studies", 13-16 April 2021. (UWS as proposer)
- ITU FG-AN AN-I-088-R1, "Proposed updated draft of use cases for Autonomous Networks", 15-17 June 2021. (UWS as contributor)
- ITU FG-AN AN-I-156, "Intelligent Network-Applications (Network-Apps) over 5G and Beyond Networks", 3-5 November 2021. (UWS as proposer)
- ITU FG-AN deliverable FGAN-O-013-R1, "Use cases for Autonomous Networks", 1-3 Sept 2021. (UWS as contributor)

SDO/ Research Cluster/ Community	Initiative • Expected Result / Achievement	Timeline	Main Driver
GSMA	Feedback Workshop on 5G-NDUCE adoption of GSMA NG.116 recommendations [8] • Expected Result: Motivation for new Work Items /Evolved Recommendations	2022-Q1	CNIT
ETSI	Feedback Workshop on 5G-NDUCE adoption of ETSI INT TR 103 761 recommendations • Expected Result: Motivation for new Work Items /Evolved Recommendations	2022-Q1	ERC+ UOP
5G-ACIA	I4.0 evolution workshop with 5G-ACIA • Expected Result: Discuss directions on high-prio standards evolution aspects for safer I4.0 over 5G take off, for further publication/dissemination	2022-Q2	ERC+ UOP
5G-PPP	Lead 5G-PPP whitepaper on "I4.0 Trends enabled by 5G and its evolution" • Expected Result: Publication	2022-Q2	ERC
5G-PPP	5G-NDUCE Webinars, including Standardization insights and proposed evolution aspects • Expected Result: Dissemination and Coalition with other projects and with new SDO partners	2022-Q4	ERC+ ExFa drivers

UOP follows the activities on ETSI ZSM, ETSI NFV and ETSI F5G WGs as well as TM FORUM. However, there are no specific activities therein focusing on Network-Apps to contribute part of our work. To this path, UOP/5G-NDUCE will attend the ETSI Research Conference 2023 during Feb'23 and the particular sessions focusing on 6G networks.

As can be seen in Table 10, there are ongoing and identified planned activities aiming at relevant impact in Standards, being assigned to specific drivers until the end of the 5G-NDUCE project. Structured in just three categories, for simplicity, the course of action and strategy of 5G-NDUCE for year 2023 can be summarized as:

- Adoption and Evaluation of Standards and Technologies by 5G-NDUCE project.
  The intent is to turning results and insight from direct experience with adopted Standards into broad sharing of results in relevant events, fora, and associations, seeking feedback and support of partner firms' Standardization/Technology Strategy, and searching for partners for jointly addressing the opportunities for contributing to and impacting standards.
- Driving ecosystem activities with 5GPPP in I4.0-5G field and with Industry associations, and pushing for alignment and action on Network-Apps field at the 5G-PPP community and into Standardization bodies.
- Continue standardization actions at individual firm/institution level for anchoring strategic standardization intent of 5G-NDUCE.

4 Exploitation and Impact Creation

4.1 IPR Analysis

The Intellectual Property Rights (IPR) management incorporates all actions involved in managing innovations and all background and foreground IPR in the framework of 5G-NDUCE. IPs will be continuously updating for the whole duration of the project, in order to fully identify the innovations and to ensure adequate exploitation of the project's outcomes.

The main exploitable results as identified and updated by the consortium, with the corresponding ER number and a short description, are presented in Table 11. The IPR table will be continuously updated through the whole duration of the project. As Network-Apps are in implementation and onboarding phase, more individual or combinations of exploitable assets will be included in the 5G-NDUCE platform and use cases. The identification of these exploitable assets will be carried out throughout the duration of the project.

Table 11: Main Exploitable results.

ER Number	Exploitable Result (ER)	Short Description	Main Partner(s)
ER1	5G-NDUCE Platform	The complete 5G-NDUCE platform	5G-NDUCE Consortium
ER2	NAO	Undertake the deployment, real-time management, and graceful un-deployment of Industry 4.0 Network-Apps, while inherently providing elasticity and compliance with certain high-level Network-App policies.	5G-NDUCE Consortium
ER3	OSS	Provides the interface that translates Application requests into Network connectivity and resource allocation requirements.	5G-NDUCE Consortium
ER4	UC1 Network-Apps	Autonomous indoor fleet management	ASTI, 5COMM
ER5	UC2 Network-Apps	Smart operation based on human gesture recognition	YBVR, ASTI, 5COMM
ER6	UC3 Network-Apps	VR Immersion and AGV Control	ASTI, YBVR, 5COMM
ER7	UC4 Network-Apps	ML-Supported Edge Analytics for Predictive Maintenance	S5
ER8	UC5 Network-Apps	Inspection and surveillance services for critical infrastructures	UWS
ER9	UC6 Network-Apps	Remote Service Platform for Inspection, Maintenance and Repair	OCULAVIS
ER10	UC7 Network-Apps	Crossroad control for safety	ILINK
ER11	UC8 Network-Apps	Drone assisted network performance and coverage monitoring for industrial infrastructures	ININ

4.2 SWOT Analysis

The SWOT (Strength, Weakness, Opportunities, Threats) analysis is a business tool that helps the formulation of a business strategy. The main goal of the SWOT analysis is the identification of the internal and external factors that can affect an organization or a project. The internal factors are the **S**trengths, which are describing all the positive tangible on intangible assets, and the **W**eaknesses where are all the disadvantages a project has compared to similar approaches. On the other hand, the external factors are the **O**pportunities which represent the external environmental factors that can lead to improvements and potential growth, and the **T**hreads that represents the risks that can lead a project to a potential failure. In general, the Strengths and the Opportunities are the positive characteristics for a project, where the same time, the Weaknesses and the Threats are the negatives. Finally, it is easy noticed that the Strengths and Weaknesses are the same but directionally opposite and the same applies to Opportunities and threads respectively. Usually, the SWOT analysis is represented by a 4 square template as shown in Figure 7.

Figure 7: SWOT Analysis representation.

In the deliverable D7.6 "SWOT analysis on Operator, Industry 4.0 and NetApp provider markets", a complete SWOT analysis is performed in the key components of the 5G-Platform, which are the NAO and the OSS. Additionally, the SWOT analysis is performed also to all the eight distinguished use cases, in order to be used as an input on the deliverable D7.7 to facilitate the identification of new business models and market potentials.

Although still in development, the 5G-NDUCE platform already demonstrates its capabilities and cutting-edge technology with the aim of leading the industry. As the project approaches its last year of implementation, the use cases will be thoroughly evaluated and refined to make the most of the 5G network and the platform's essential elements, while keeping an eye out for any dangers or disadvantages from internal and external factors that can affect the project's results.

4.3 Business Models

Concerning the possible commercialization opportunities and exploitable business potentials of the project, an effort has been initiated to identify the key outcomes of the project as a whole and of each one of the partners individually. The relevant work is performed under Tasks 7.4 and 7.5. Task 7.4 focuses primarily on the individual exploitation plans of each of the partners on the basis of a SWOT analysis (see D7.4 for more details) and the expected benefits that each of the developed Network-Apps will bring to end-users of the

I4.0 vertical (as those were detailed at D7.3a). Task 7.5 focused initially on the definition of possible business models to be evaluated subsequently towards the submission of D7.5 at M36.

Following an analysis of the business players in the 5G ecosystem and a comparison of traditional and emerging business models, it is anticipated that the primary players in the Network-Apps ecosystem would be the operators that will eventually offer the end-to-end services over their deployed 5G network infrastructure. Of course, the Network-Apps developers will be essential for the development of the ecosystem as they will contribute to the development of the Network-Apps marketplace. However, our analysis so far, foresees the need for the emergence of new actors in the ecosystem: Network-Apps Integrators who will own or Operate the Network-Apps Orchestrator Platform that will be interfacing with the Network-Apps marketplace and the enhanced OSS of the Operators. Clearly, the NAO & associated OSS that are developed by the 5G-NDUCE project are essential innovations that could be adopted by the new player (i.e., the Network-Apps Integrator -> "NAO Provider"). It should be mentioned that it is foreseen that the 5G-NDUCE NAO could be also exploited directly by the Network Operator or the Communications Services Provider (CSP) in a Public 5G Network, or even by an Equipment Vendor (V) or an Edge/Cloud Provider (ECP) or even the Vertical end-user (Vertical) in case of Private or Hybrid 5G Network deployments. The Figure 8 below illustrates the 5G Network-Apps ecosystem players, including the NAO provider.
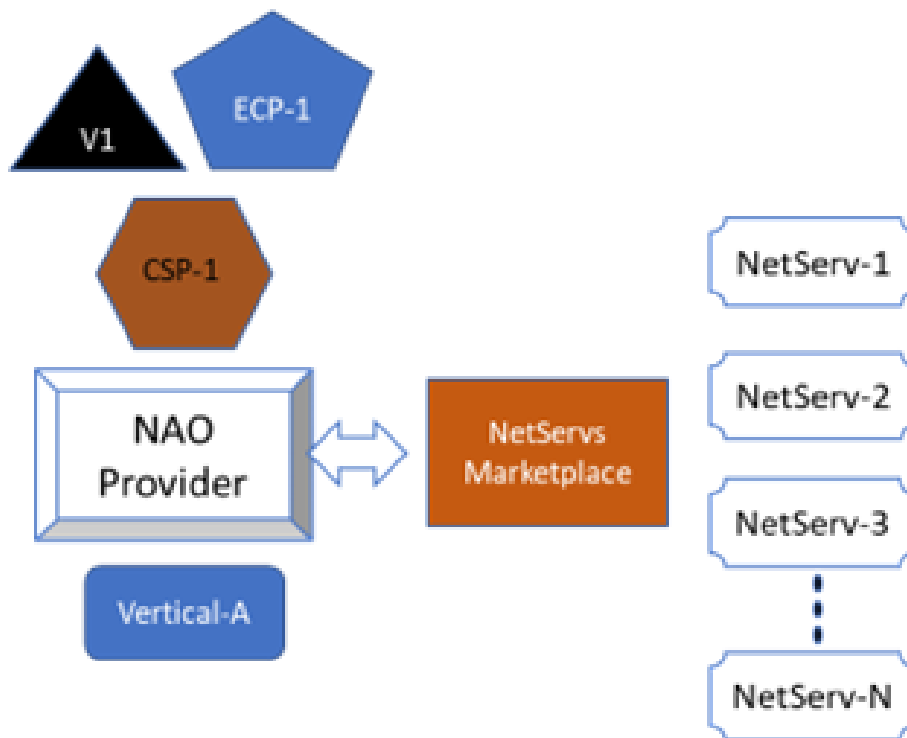

Figure 8: 5G Network-Apps ecosystem players.

In the new era of 5G and especially as the industry advances towards 6G networks, the traditional Network Operators/Communications Services Providers have to transform their current business models if they wish to compete effectively in the new emerging reality. They must move beyond just network platform deployments and providing horizontal network services offerings, to provide tailored platforms and software capabilities to specific vertical industries (alone or with partners), as shown in the Figure 9 below.
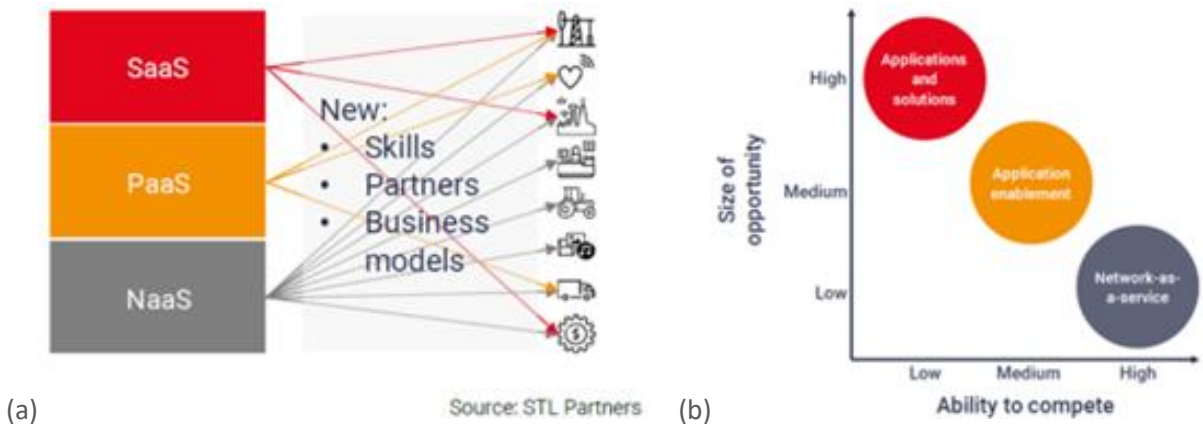
Figure 9: Network/Platform/Software as a Service (SaaS/PaaS/NaaS) offerings by 5G CSPs is a must as the move on to become Network-Application Enablers first or possibly Network-Applications Providers next.

In the core of this transformation would be the evolution of the business models that they adopt, from the conventional B2B and B2C models used so far to the emerging business to business to any (B2B2X) model Figure 10.

Figure 10: B2B2X Business model enabled by the new capabilities of 5G to offer a multitude of new end-to-end services (Network-Apps) to all Vertical end-users.

This B2B2X business model will not be based only a single specific Network-App, as many of them will be produced independently with a distinct owner and target customer, but rather the NAO platform and the Network-Apps Marketplace which are the common grounds for all ICT-41 projects.

The necessity of the NAO and the new market player (or new business unit of existing players) that will own/operate it, is becoming apparent if we consider that the multitude of the use cases that are enabled by the 5G networks, will require expertise beyond the traditional strengths/knowhow of network operators/service providers (CSPs). To address these new opportunities, CSPs will need to develop new

expertise or greatly expand their use of partners (including the Network-Apps Developers). They need to co-develop partner ecosystems and attempt to achieve monetization in a collaborative way (therefore defining innovative business models). Partners can play an important role in B2B2X scenarios, providing/selling end-solutions that will be incorporated in offerings from the service provider towards the many possible end-users from the many Verticals (i.e., where the service provider takes the lead to sell solutions that include components from partners). Eventually CSPs can utilize the developments by 5G-NDUCE to become B2B2X enablers with ability for efficient onboarding and offerings of customer-tailored innovative value-added applications for any targeted vertical partner.

The NAO/Network-Apps Integrator/Provider, in partnership with the CSPs and the Network-App developers, will eventually offer specialized end-to-end Network Services over the 5G network (Network-App or Network-Apps) to Verticals end-users, which will be formed as a series of linked Virtual Functions (Application Functions or/and Network Functions or/and Physical Functions) that collectively are able to provide an end-to-end service over the CSPs 5G network infrastructure. As discussed in the WP2 deliverables, a Network-App/Network-App can be composed of just one Function, if this can offer an end-to-end service, or multiple-standalone Network-Apps that can be linked together to form another Network-App (as a more complete type of service), see Figure 11. The Functions can be interlinked over a Network-Apps/Servs Platform that will be offered by the new NAO Provider company/business unit.
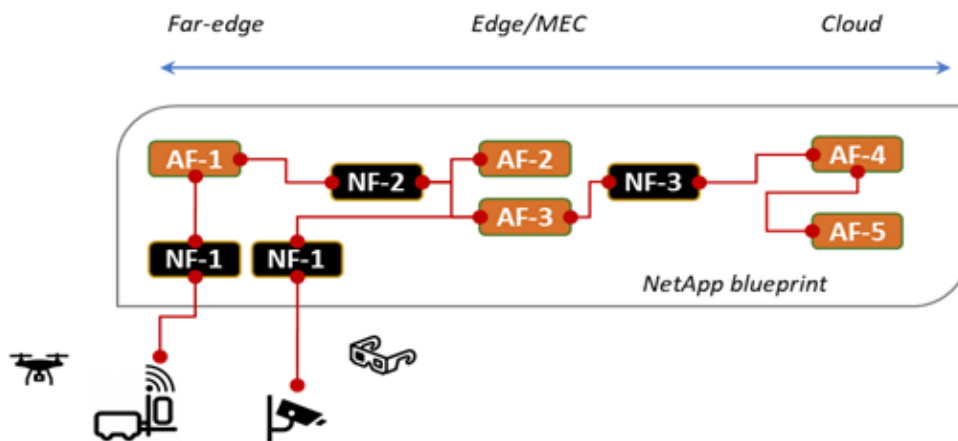

Figure 11: Composition of end-to-end services by the NAO provider as envisioned by 5G-NDUCE.

The 5G-NDUCE model is part of one of the three possible Network-Apps Deployment models that are considered by all ICT-41 projects, as summarized in the relevant white article issued in Sep'22 by the 5G PPP Software Networks Working Group. According to this article, Network-Applications (Network-Apps) deployments require the development of a separate middleware layer to simplify the implementation and orchestrate the deployment of Network-Apps on a large scale (i.e., a Network-Apps Orchestrator). Different implementations have been conducted by the different ICT-41 projects considering different API types and different levels of trust between the verticals and the owner of the 5G platforms. As a result, three main options of interaction between the verticals and the 5G platform owner seem to prevail (Figure 12):

1. Network-AppaaS Model: it is the model where the vertical application consumes the Network-App as a service. The Network-Application is deployed in the vertical service provider domain. It connects with the 3GPP network systems (EPS, 5GS) in one or more operator domains. This is the Model that 5G-NDUCE follows.

2. Hybrid: it is the model where the vertical instantiates a part of its Vertical App in the operator domain like the EDGE. The other part remains in the vertical domain. A similar approach has been followed in TS 23.286 related to the deployment of V2X server.

3. Coupled/Delegated: it is the model where the vertical delegates its app to the operator. The Network-App will be composed and managed by the operator.
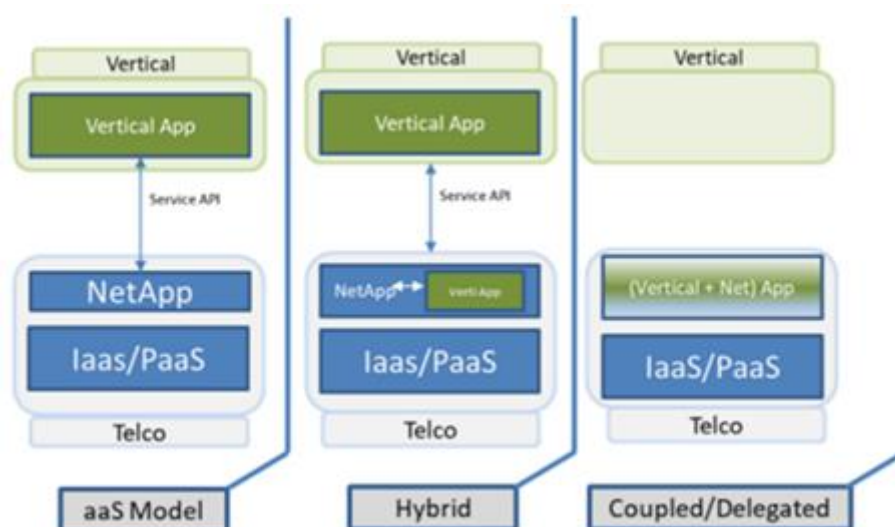

Figure 12: Classification of Network-Apps deployment models considered by ICT-41 projects.

Based on the possible Network-Apps deployment model, different business models can emerge for adoption by the Network-Apps/NAO provider or CSP business plan. In the forthcoming period towards the end of the project duration the Network-Apps deployment models and the associated business models that can emerge will be examined by the 5G-NDUCE project partners in collaboration with other ICT-41 projects and the entire related ecosystem.

4.4 Targeted Market Players

In order to specify the targeted audience of the solutions developed in 5G-NDUCE, an effort was dedicated to identifying developers that actively participate in the concept of Network-Apps. Those 3rd parties will be the main beneficiaries of the developed platform. This activity is ongoing, and it will take place in cooperation with other projects such as the ones of ICT-41 call.

Table 12: Network-App Developers and Network-Apps.

#	Company Name	Network-App Developed	Sector	ICT Project (Optional)	Small description
1.	University of the West of Scotland (UWS)	Intruder Surveillance for Critical Industry Infrastructure	Industry 4.0	5G-INDUCE	This Intruder Surveillance Network-App performs automatic UAV-based, AI-empowered surveillance monitoring to detect intruders to the industrial premises and provide real-time warning accordingly.

#	Company Name	Network-App Developed	Sector	ICT Project (Optional)	Small description
2.	University of the West of Scotland (UWS)	Corrosion Detection Services for Critical Industrial Infrastructures	Industry 4.0	5G-INDUCE	This Corrosion Detection Network-App performs automatic UAV-based, AI-empowered tank and pipeline inspection to detect corrosion on the surface in the industrial premises and provide real-time warning accordingly.
3.	Suite5 Data Intelligence Solutions Limited (S5)	Edge Analytics for Predictive Maintenance	Industry 4.0	5G-INDUCE	This Network-App offers a set of tools to be used at the factory and shop floor levels for running analytics, exploiting the power of 5G networks in terms of bandwidth and flexible resource allocation for facilitating the needs of the analytics algorithms to be deployed.
4.	SIDROCCO	Automatic Power Distribution Grid Fault Detection	Energy	Smart5Grid	It aims to increase the availability of automatic selection function (ASF) of distribution network failures. The ASF discriminates between several possible types of gird faults. The performance of the ASF depends on the timely communication between the protection and fault detection devices on real power distribution infrastructures.
5.	SIDROCCO	Remote Inspection of Automatically Delimited Working Areas at Distribution Level	Energy	Smart5Grid	It aims to enhance the safety procedures for maintenance workers in High Voltage primary power substations making use of real-time information collected from advanced tracking cameras and wearable sensors.
6.	Software Company	Retrieving data. Wait a few seconds and try to cut or copy again.	Energy	Smart5Grid	The scope is to monitor, in real-time with millisecond-level precision multiple parameters of distributed energy resources' using 5G connectivity.
7.	Software Company	Real-time Wide Area Monitoring	Energy	Smart5Grid	The scope of the Network-App is the real-time monitoring of a geographical wide area where cross-border power exchanges take place. A virtual Phasor Data Concentrator will be developed for the data gathering process from the Phasor Measurement Units mounted on the energy grids of Greece and Bulgaria.

4.5   Innovation Radar

A major achievement of the project that validates the orientation towards the platform exploitation and impact creation, is the selection of the 5G-NDUCE Orchestration Platform by EU's Innovation Radar. This selection also validated the quality of the developed

The Innovation Radar aims to make information about EU-funded innovations from high-quality projects visible and accessible to the public via the EU's Innovation Radar platform. This will show citizens the many excellent technological and scientific advances being delivered by researchers and innovators around Europe, funded on their behalf by the European Commission.

Details of this innovation, and how it was categorised by the analysis, are as follows:

- **Innovation Title:** The complete 5G-NDUCE orchestration platform.
- **Market Maturity of the Innovation:** Tech Ready.
- **Market Creation Potential of the innovation:** Noteworthy.

5 5G PPP Interactions and Activities

Since the last 5G PPP projects share almost the same objectives in terms of adoption of the Network-App concept and its dissemination and standardization, a significant effort has been made to lead and coordinate a cooperative activity among the Network-App oriented European projects. The goal of this endeavour is to collaboratively attract third parties and SMEs to experiment on the projects' platforms. This initiative applies to projects from the ICT-41 call, projects from the Industry 4.0 vertical, and other projects that express interest or in which the 5G-NDUCE partners participate. The approaching strategy is primarily through direct contact with the project's dissemination, exploitation, and impact creation leaders, but also through the 5G-PPP Working Groups, Task Board, and Steering Board.

Regarding the ICT-41 projects, 5G-NDUCE leads the unofficial coordination action, bringing all the projects together in a monthly conference call to discuss and decide in common actions and activities. In addition, a mailing list has been created to gather all the interested parties together, having the domain name ict41-cooperation@5g-induce.eu. In order to maximize the impact of this initiative, it was collectively decided to choose a more formal way of action. Thus, the Project Coordinators and the Technical Coordinators of each project were invited to join the dedicated coordination calls, in order to be informed about the available options, vote for the one that they support and nominate, if they want, candidates for Chairman and Vice-Chairman. After a thorough investigation and contact with 5GPPP, the possible options of formalization are the following:

- Option-1: Under Vision & Software Networks WGs
- Option-2: Separate WG composed by ICT-41 Cluster & chairs from WGs
- Option-3: Subgroup under Technical Board
- Option-4: Do not participate at all

Before voting, some of the projects' representatives asked for a description of work of this "task force", in order to be able to clearly identify its objectives and outcomes. Having that in mind, 5G-NDUCE created the following proposal aiming option-3, as it seems the most eminent one.

Proposal to formalize ICT-41 Projects' Cooperation under 5G-PPP TB

Background

ICT-41 project consortia are eager to maximize the expected outcomes and longer-term impacts of their R&I activities. To achieve this target their Technical Managers and Project Coordinators were engaged in discussions on the possible ways that they can collaborate more effectively towards:

1. Creation of a Network-Apps ecosystem,
2. Setting-up joint dissemination/communication activities,
3. Defining common targets for standardization, and
4. Evaluating business models, relevant to the commercialization of key projects/cluster outcomes.

The possible options considered to formalize the ICT-41 Cooperation, were the following:

1. Option-1: Incorporate activity under either the existing Software or Vision Networks WGs for specific aspects of project outcomes (e.g. definition of Network-Apps definition).

2. Option-2: Create separate WG composed by ICT-41 projects cluster & Chairs from WGs

3. Option-3: Create a horizontal ICT-41 related subgroup under TB

The ICT-41 projects decided, after internal (project-specific and cluster-wide) formal discussions to propose Option-3 formally to the 5G-PPP TB as the vehicle that will ensure in the best possible way the sustainability of the cluster activities after the end of the projects' duration and will enable a smooth transition to the forthcoming 6G-PPP associated Cluster.

<u>Objectives, Deliverables, Organization & Timeline</u>

This "ICT-41 Cooperation Group" will work towards the realization of the following objectives/deliverables:

1. Objective A: Creation of an *ICT-41 web-site/portal* wherein major cluster related ecosystem players, events and outcomes (organized individually or jointly by the projects) will be collected/promoted to the wider community.

   - Deliverable A: The developed *site/portal* should be somehow maintained in a long run.

2. Objective B: Identification of a couple of *Network-Apps related processes and methods that can be standardized* by selected Standardization Bodies or/and Industry Associations.

   - Deliverable B: The selected ones will be proposed to the Standardization WG *based on a relevant document* and will be then presented to the targeted Bodies/Associations for subsequent discussions on their standardization.

3. Objective C: Defining business opportunities and associated business models that can be the basis for effective commercialization of projects'/cluster's innovations.

   - Deliverable C: A relevant *White article on the monetization of Network-Apps* can summarize these business opportunities/models.

This new "ICT-41 Cooperation Group" is proposed to be coordinated by a Chair and a Vice Chair, and the associated Deliverables should be handled by deliverable owners.

The Deliverables should be completed by the end of 2023 and their progress should be checked by the TB at an intermediate Milestone (i.e., a TB meeting scheduled in Sep. 2023.

Figure 13: ICT-41 Formalization Proposal.

Following our Proposal presentation to the TB, it was proposed to discuss in more detail the implementation of the workplan for reaching the 3 Objectives with the members of the 5GPPP "Software Networks" WG. As a result of this meeting, it was decided that all 3 Objectives that are vital for the sustainability of the ICT-41 projects efforts towards the realization of their targeted impacts should be coordinated under the leadership of the "Software Networks" WG. For each Objective, a responsible Project/person is to be appointed in order to lead the respective efforts. 5G-NDUCE/Ioannis Tomkos was proposed to orchestrate the work on defining business opportunities and associated business models for effective commercialization of projects'/cluster's innovations with an end-goal to edit a relevant White article.

6 Evaluation and Reporting

In order to evaluate the impact of the project's dissemination and communication activities, the Consortium has set specific metrics per dissemination and communication activity, in order to effectively monitor its achievements. The effectiveness of the dissemination, as well as of the communication, activities will be assessed during the life of the project and the results of these assessments will be presented in each reporting period. For the second reporting period those results are showcased in Table 13.

Table 13: First & Second Reporting Period Achievements.

#	Activities	1st Reporting Period	2nd Reporting Period
1.	**Number of workshops**	2	6
2.	**Number of demos**	3	7
3.	**Number of trainings**	-	10
4.	**Number of conference papers**	2	4
5.	**Number of journal papers**	2	6
6.	**Number of synergies with projects**	7	15
7.	**Number of joint activities**	-	5
8.	**Number of social media posts/month**	3	~6
9.	**Number of accumulative followers**	147	>250
10.	**Number of posts**	36	~80
11.	**Number of videos**	-	7

According to this table, the KPIs for both dissemination and communication activities are increasing. This is a result of the fact that the first project outcomes were revealed during the second year of the project. This tendency is likely to continue in the project's final year, completing KPIs that are now lagging behind (e.g., publications).

7   Conclusions

In this deliverable, we summarized the main activities undertaken towards the implementation of the five Key Pathways to Impact (KIPs); i.e., dissemination/communication, standardization, and innovation management/exploitation activities.

It was shown how the technical project work that led to important innovative results, has been disseminated/communicated to i) the Network-Apps community specifically as well as the wider 5G networks, and also to ii) I4.0 industrial partners (that have been identified and are gradually updated via the ongoing efforts of project partners), via the established dissemination/communications channels, the organization of events, the publication/presentation of articles at international fora, the preparation of informative videos, etc.

Initial efforts on the preparation of a Handbook and associated training videos on how to Network-App Developers, the Network Operators and System/Software Integrators can use the 5G-NDUCE platform for offering end-to-end services over 5G network infrastructures have been presented.

Furthermore, the initiative of 5G-NDUCE project alongside other ICT-41 projects, as a collective Clustering effort, has been presented and the foundations that have been established towards the sustainability of all ICT-41 projects after the end of their lifetime have been defined in the form of three collaborative objectives and associated deliverables that would be realized under the umbrella of the Software Networks WG and the 5G-PPP Technical Board.

Finally, the key thoughts on the Network-Apps related topics that can be brought forward towards Standardization, as well as commercial Exploitation of the project innovations and the way that the various business actors across the value chain can interact together forming different business models that will assist in the enlargement of the monetary and societal value for their activities, have been outlined.

On all aforementioned topics, the included summarized plans on how the consortium will proceed with the related WP7 activities during the remaining of the project duration, but even afterwards, with the goal to ensure the realization of the targeted outcomes and impacts.

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