FUDGE-5G

FUlly DisinteGrated private nEtworks
for 5G verticals

Deliverable 5.1

Technology Exploitation and Standardization Plan (interim version)

Version 1.0
Work Package 5

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Abstract

This document describes the innovation, exploitation, and standardization activities related to FUDGE-5G and identified in the initial 9 months of the project. We provide an initial analysis of the innovation potential of the project, together with the initial exploitation vision for each individual innovation. Finally, we list the standardization activities carried out so far.

Versioning and contributions

Versioning

#	Description	Contributors
0.1	Table of contents	THA, HWDU
0.2	First round of collection of the Individual Asset Exploitation (Section 3)	UPV, TNOR, ATH, CMC, FOKUS, O2M, UBI, ONE, 5CMM, IDE, HWDU, THA
0.3	Introduction (Section 1) and Project-wide exploitation and innovation (Section 2)	UPV, THA, ONE, 5CMM, FOKUS
0.4	Second round of collection of the Individual Asset Exploitation (Section 3)	UPV, TNOR, ATH, CMC, FOKUS, O2M, UBI, ONE, 5CMM, IDE, HWDU, THA
0.5	Licensing scheme (Section 3.2) and Standardization (Section 4)	HWDU, IDE, THA, UPV, O2M
0.6	Summary of Exploitation (Section 3.4)	THA
0.7	Executive Summary and Conclusion, document formatted for review	THA, HWDU
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1.0	Document Released	UPV

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Abbreviations

3GPP	3rd Generation Partnership Project
ETSI	European Telecommunications Standards Institute
GSMA	GSM Association
IETF	Internet Engineering Task Force
IoT	Internet of Things
IP	Intellectual Property
IPR	Intellectual Property Right
MNO	Mobile Network Operator
NPN	Non Public Network
OECD	Organisation for Economic Co-operation and Development
PLMN	Public Land Mobile Network
PNI-NPN	Public Network Integrated NPN
PPDR	Public Protection and Disaster Relief
PWS	Public Warning System
QoS/ QoE	Quality of Service / Quality of Experience
S-NPN	Standalone NPN
SBA	Service-based Architecture
SDO	Standards Developing Organization
SUCI	Subscription Concealed Identifier
SWOT	Strengths Weaknesses Opportunities Threats
TRL	Technology Readiness Level
TSN	Time Sensitive Network

Executive Summary

This Deliverable is the interim version of "D5.1 Technology Exploitation and Standardization Plan". It aims at providing an up to date view on the exploitation of the innovations proposed in the project. It also lists the standardization activities carried out so far.

The deliverable is composed of three main parts. The first part evaluates the **innovation potential of the project as a whole**. For this analysis, we have followed the framework of the Oslo Manual 2018 [1]. By following the Oslo Manual guidelines, we have extracted 17 business innovations across the FUDGE-5G use cases covering specific vertical markets. We have demonstrated that all verticals examined can benefit from innovative 5G use-cases.

The complexity of the 5G ecosystem and the multitude of stakeholders involved stress also the importance of acknowledging the parties involved in the value creation, by identifying their roles and existing relationship. We took inspiration from the value network approach in innovation and business management fields, and adapted it to each one of the FUDGE-5G use cases, in order to extract an analytic view of how an interconnected system is organized. This analysis represents also the foundation for realizing a business canvas and SWOT analysis that will be included in the next release of this deliverable.

The second part of the deliverable is concerned with the **exploitation of each individual innovation** developed in FUDGE-5G. For each of them, we provide their specific exploitation plans and a focused innovation analysis in tabular form. For each asset, we details its main characteristics, with a specific focus on its unique value proposition, the potential target market in which the innovation is, and the exploitation vision. As far as tangible outcomes are concerned, we specify when possible their time to market, the current TRL, and the associated licenses (identified by following a methodology for the open innovation [2]).

Finally, the third part of the deliverable deals with **standardization activities**. We first explain what technological innovations our standardization efforts focused to, summarizing in a table all contributions grouped by their target SDOs and the related working groups. More specifically, within 3GPP, we had contributions on various aspects of Non-public Networks (NPN), 5G LAN, broadcast and multicast, as well as Public Warning Systems (PWS), both in SA1 and SA2. In IETF and IRTF, we focused on service routing, while in NGMN cloud native platforms and service based architectures were in focus. Relevant aspects of network management were constitute our standardization contribution within NATO.

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1. Introduction

1.1. Objectives

According to a recent report from GSMA, Non-Public Networks (NPNs) are increasingly becoming the preferred approach to deliver wireless connectivity for critical communications, industrial IoT, enterprise and campus environments [3]. FUDGE-5G is the first 5G-PPP project that focuses on 5G NPNs. Its target is to devise, assess and demonstrate 5G architecture, solutions and systems for NPNs. On top of the development of novel technological innovations and their associated know how, one of the challenges is to **leverage on such technical developments to create or capture additional value and to bring in extra profits** for the members of the FUDGE-5G consortium and for the project's stakeholders in general. In this interim document we provide an initial analysis of the innovation, exploitation and standardization potential of the FUDGE-5G ideas and the related developments made by the members of the consortium.

This document, which is the result of the work performed in Task 5.1 "Exploitation and Standardisation" up to M9, concerns the achievement of the overall FUDGE-5G project objectives #6 and #7, namely:

- (To) demonstrate the value of the FUDGE-5G technology innovations to relevant vertical industry groups.
- (To) promote the FUDGE-5G technology innovations in relevant Standards Developing Organisations (SDOs) with at least 30 contributions.

More specifically, the deliverable D5.1 addresses the following sub-objectives:

- Maximize the business exploitation of the FUDGE-5G technology components by consortium members.
- Promote the project outcomes to targeted standardization bodies and industry fora that influence the development of standards, in order to facilitate the future exploitation of the innovations of the project beyond 5G Rel-16.
- Promote the project, its objectives, results and the developed concepts.
- Build awareness about the integration of the project verticals over private 5G networks.

1.2. Structure

After the current section that introduce the deliverable, Section 2 proposes the **innovation analysis, ecosystem identification, and value proposition** for the project. Here, the focus is on the innovations brought by the project as a whole, and specifically adapting the value proposition to the FUDGE-5G use cases, each one encompassing a different vertical sector.

On the other hand, Section 3 includes the **individual exploitation analysis,** with the specification of the different assets, in terms of the novel product or business process

offered, their potential target markets, the exploitation plans, as well as their time to market, the expected readiness levels at the end of the project, and the licenses.

Finally, Section 3.4 explains standardization status of relevant technologies and lists all standardization contributions of the project so far, grouped by the SDO and the working group within it.

1.3. Methodology employed

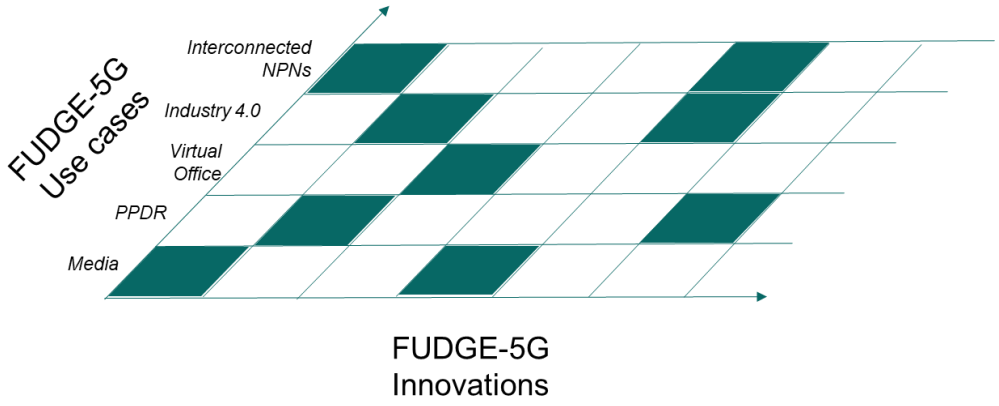

Figure 1: The two dimensions considered in FUDGE-5G exploitation and Innovation analysis

For exploitation and innovation, we have considered two main dimensions as depicted in Figure 1. The first dimension involves the **vertical markets** and the relevant stakeholders targeted by the project. In the analysis, the vertical ecosystem cannot be overlooked, and we should identify clearly the value brought by FUDGE-5G to their components. On the other hand, the second dimension maps directly with the **5G component innovations** developed by the individual participants in the consortium.

For the **use cases dimension**, we have adopted the Oslo Manual [1] framework from the OECD, to identify and categorize innovations into product or business process innovations. With this structure in mind, we try to extract the value of each innovation by providing the answers to the following three questions that represents the business objectives from innovations:

- How does a FUDGE-5G innovation makes prospective customers and stakeholders businesses more simple, productive, or convenient?
- How does a FUDGE-5G innovation reduces the risks (financial, physical, reputational) of prospective customers and stakeholders?
- How does a FUDGE-5G innovation delivers a leap in environmental friendliness, including social consciousness, that prospective customers and stakeholders value?

According to the proposed framework, we have extracted 17 business innovations across the FUDGE-5G use cases covering specific vertical markets. These innovations, mapped to the vertical ecosystem, provide the foundations for executing a SWOT and a Business Canvas analysis helping to extract potential strategies for creating market opportunities. The SWOT and Business Canvas will be provided in the revised and final version of this

document. Nevertheless, from our initial analysis it seems plausible that all vertical markets under analysis could benefit, in general, from the application of 5G to NPNs, and in particular, to the innovations brought by FUDGE-5G.

For the **individual exploitation dimension**, we have described the exploitation plans for the assets of each FUDGE-5G participant, with a specific description of the organization background and the general strategy of exploitation. The tables associated to each asset provide an in-depth description of the specific outcomes identified for each partner. For each outcome, we specify a high-level offering with a focus on the unique selling proposition, the potential target market in which the asset will have to compete, and the exploitation vision for the asset. When possible, we specify the expected time to market, the current TRL, and the associated licenses that are identified by following a framework for the intellectual property management strategies in open collaborative environments.

In Standardization, we relied on partners with well-established presence in most important SDOs, such as HWDU, IDE and O2M in 3GPP, HWDU and IDE in IETF/IRTF, IDE in NGMN and THA in NATO. The key technological innovations of the project, such as NPN, 5G-LAN, SBA and Cloud native platforms were brought to and discussed with the standardization teams of the said partners, then presented in relevant standardization meetings.

2. Innovation analysis, ecosystem, and value proposition

2.1. Innovation analysis

According to the Oslo Manual 2018 [1], there are two types of business innovations: **product innovations** (new or improved good or service) and **business process innovations** related to business functions. In order to be considered as innovations, both needs fulfilling two conditions:

- To be significantly new.
- To be the market/use by a firm.

FUDGE-5G as innovation project represents a crucial step to validate both conditions of the many potentially ground-breaking solutions brought by 5G and specifically designed for NPNs. It is thus important to categorize these innovations first, then to identify how they can bring value.

2.1.1. Product innovations

Product innovations must provide significant improvements to one or more product characteristics or performance specifications. Product innovations can involve two generic types of products:

- **Goods** that are tangible objects.
- **Services** that are intangible activities.

Relevant functional characteristics include quality, technical specifications, reliability, durability, economic efficiency, affordability, convenience, usability, and user friendliness.

2.1.2. Business process innovations

Business process innovations on the other hand cover the processes that govern the following:

- **Production of goods or services**: Activities that transform inputs into goods or services, including engineering and related technical testing, analysis and certification activities to support production.
- **Distribution and logistics**: including:
  - Transportation and service delivery
  - Warehousing
  - Order processing.
- **Marketing and sales**: including:
  - Marketing methods including advertising (product promotion and placement, packaging of products), direct marketing (telemarketing), exhibitions and fairs, market research and other activities to develop new markets.
  - Pricing strategies and methods.

- Sales and after-sales activities, including help desks other customer support and customer relationship activities.

- **Information and communication systems**: including:
  - Maintenance and provision of information and communication systems.
  - Hardware and software.
  - Data processing and database.
  - Maintenance and repair.
  - Web-hosting and other computer-related information activities.
- **Administration and management**: including:
  - Strategic and general business management (cross-functional decision-making), including organising work responsibilities.
  - Corporate governance (legal, planning and public relations)
  - Accounting, bookkeeping, auditing, payments and other financial or insurance activities.
  - Human resources management (training and education, staff recruitment, workplace organisation, provision of temporary personnel, payroll management, health and medical support).
  - Procurement.
  - Managing external relationships with suppliers, alliances, etc.
- **Product and business process development**: Activities to scope, identify, develop, or adapt products or a firm's business processes.

2.1.3. Objectives

Both types of innovation deals with the improvement of one or more business objectives that can be broadly categorised as follows:

- Improve the **market position**.
- Improve the **production efficiency and delivery**.
- Improve the **business organisations**.
- Improve the **economy, the society or the environment**.

In the following, we realize a qualitative analysis on the expected potential of the FUDGE-5G innovations, and the application of 5G NPNs to the different vertical activity sectors that are covered by the project (represented by the use cases described in [2]). The proposed approach is drafted in Figure 2. FUDGE-5G innovations allow and support the vertical stakeholders involved into the different activity sectors into creating innovative products and business processes.

Figure 2: Expected potential of FUDGE-5G innovations to several NPNs

2.1.4. Innovation potential

2.1.4.1. Media

The innovation potential in the **Media sector** resides in services and products that enable a unified and private infrastructure to handle diverse types of communications. Its business objective relates both with the improvement of the market position and the improved efficiency in the production and delivery of multimedia content.

Table 1: Innovation potential in the Media sector

#	Innovation	Type	Business function/ Functional characteristics	Expected benefits
M1	**Unified infrastructure management via 5G-based Private Networks**	Resource efficiency, reliability and resilience	Production of services	One infrastructure deployment using 5G technologies can handle diverse type of services and dynamically adapt to the owner needs. 5G coexists with other enterprise networking technologies, providing performance improvements
		Better use of infrastructure resources and maintenance	Information and Communication System	
M2	**Migration to all-IP networks for media production**	Flexibility	Production of goods and services	Existing components rely and communicate in proprietary interfaces. Moving into IP ecosystem enables a wider and more affordable market to build private networks
M3	**Wired to wireless transition for Media distribution**	Improved services	Production of Business Process Development	Reduced costs to deploy and impact to environment

2.1.4.2. PPDR

The innovation potential in the **PPDR sector** relates both with products and services and with the improvement of business process with the objective of improving the safety or security, and more generally the societal well-being and the environment.

Table 2: Innovation potential in the PPDR sector

#	Innovation	Type	Business function/ Functional characteristics	Expected benefits
P1	**Mission-critical broadband**	Increased observability	Production of goods or services	Increased service quality via multimedia communications (e.g., video streaming))
		Strategic decision-making	Administration and management	
P2	**Real-time monitoring of deployed agents**	Increased observability	Production of goods or services	Improved detection of vital threats, improved decision making, faster reaction time
		Strategic decision-making	Administration and management	
P3	**Seamless use of connectivity/compute available at different locations**	Improved service	Reliability, Economic efficiency, User friendliness and usability	Better processing power, reduced unavailability
P4	**Simplified collaboration between different agencies /coalitions**	Strategic decision-making	Administration and management	Improved decision making, faster reaction time, reduced costs leveraging deployed infrastructure
P5	**Coexistence on the same terminal of PPDR-specific and public services**	New service	Reliability, Economic efficiency, User friendliness and usability	Improved number of services available, reduced cost in providing publicly accessible services
P6	**Privacy-preserving communications**	Improved service	Quality, Technical specifications	Improved privacy by eliminating the risk of being tracked

2.1.4.3. eHealth

The innovation potential in the **eHealth sector** encompasses both services and products that enables improvements in work efficiency that will boost the eHealth business

organization, as well as the safety and security of the actors involved. It means that in the short term the societal well-being (improvement of the health service quality) and the environment (digitalization) will be positively impacted.

Table 3: Innovation potential in the Health sector

#	Innovation	Type of innovation	Business function/ Functional characteristics	Expected benefits
H1	**Patient's real-time remote monitoring** Wired to wireless transition 5G enabled monitoring equipment	Increased observability Improved Service	Production of goods and services	Improved detection of abnormal vital signs, faster reaction time
H2	**Unified all-ethernet access** Devices are agnostic to the connected access network (5G, Wi-Fi, fixed Ethernet)	New Service	Information and Communication System, User friendliness and usability	Transparent access to all network connected devices, improved number of services available
H3	**Privacy-preserving communications**	Improved Service	Quality, Technical specifications	Trustable communications without the risks of personal information leakage
H4	**Simplified collaboration between different categories of medical staff**	Strategic decision-making Increased observability	Administration and management	Improved quality of services (diagnosis, emergency response), reduced costs
H5	**Seamless use of connectivity/compute available at different locations** NF deployed dynamically on the edge to serve emergency response vehicles	Improved service	Reliability, Economic efficiency	Better processing power, increased availability, faster access times

2.1.4.4. Industry 4.0

The innovation potential in the **Industry 4.0 sector** resides in the business process for the production of goods and the distribution and logistics with the business objective of improving the production efficiency.

Table 4: Innovation potential in the Industry 4.0 sector

#	Innovation	Type	Business function/ Functional characteristics	Expected benefits
I1	**Wireless control of actuators**	Warehousing and order processing	Distribution and Logistic	Increase quality by increased productivity
		Increased control	Production of goods or services	
I2	**Remote monitoring of assets**	Fault diagnosis and predictive maintenance	Infrastructure provision and maintenance	Better detection of production faults, reduced accidents, faster maintenance and servicing
I3	**AR/VR for remote control**	Increased control	Production of goods or services	Improve efficiency of training and maintenance by providing contextual information in overlay

2.2. FUDGE-5G ecosystem and value proposition

In order to evaluate the overall value, we will base our analysis on the **Business Model Canvas** tool [5] from Osterwalder and Pigneur. We will use it as a visual representation to understand how FUDGE-5G can create, deliver, and capture value for its potential target customers. Indeed, value is a crucial element because unless somebody finds value in the set of services or products provided by FUDGE-5G, they will be worthless.

On top of that, and given the systemic nature of 5G, we highlight the concepts of **value networks** [6] and **business ecosystems** [7] that focus on the sheer number of involved parties and the embedding of vertical stakeholders key part of the value chain. Both approaches capture the complex relationships of value creation with a key difference in their scope. On the one hand, value networks focus on the technology tools and mediating business processes that allow interactions and transactions between different actors from a single industry, such as telecommunications, utilities, transportation, etc. On the other hand, ecosystems extend the value network approach, focusing on the composition of services created by different entities from different industries.

A SWOT analysis has to be carried out as well to identify the internal and external characteristics of each vertical use case addressed by FUDGE-5G. The internal analysis includes the strengths and weaknesses, while the external analysis contains the opportunities and threats that each vertical will have to deal with.

2.2.1. Concurrent Media Delivery

2.2.1.1. Description

The Multimedia communications ecosystem is composed of many different types of services, ranging from gathering the content at maximum quality possible (Contribution), processing and editing multiple synchronous video and audio streams (Production), then delivering the content to the audience in several formats and delivery method such as live content or on-demand (Distribution).

FUDGE-5G provides a framework for these services to coexist under the same infrastructure, easing the management and deployment costs, providing a reliable communication channel for 5G cameras via optimized uplink radio network, and enabling a cost-effective mechanism to deliver the produced content in a point-to-multipoint mode at the maximum quality available.

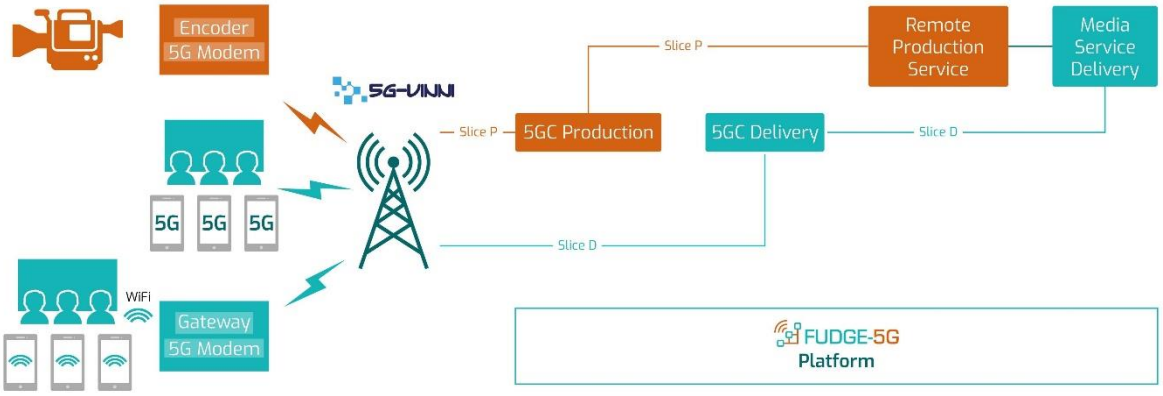

Figure 3: High-level vision of the concurrent media delivery use case.

2.2.1.2. Main Innovations

- **Interoperability for private networks.** The Remote Production part features components from SMEs 5G Core providers. The planned battery of tests will be carried featuring components distributed between public cloud and discrete functions deployed on premises. This innovation will prove the maturity of the 5G private network ecosystem where the interested parties and pick and deploy components from different vendors depending on their needs.
- **System Slicing**. Slices that serve different services that are being executed simultaneously, putting into stress different parts of the 5G Core: User Plane dedicated slice for Remote Production with uplink enhancement techniques; and innovative Control Plane slice featuring Opportunistic Multicast for Media Showroom.
- **Opportunistic Multicast** based on Name-based Routing to enable an efficient transport method of very high quality multimedia content to several devices, which can use either Wi-Fi or 5G access network.
- Uplink **enhancement techniques** and radio scheme parametrization to ensure the uplink QoS for the 5G Cameras in Remote Production. From D1.1, it is expected to each

camera to have stable 100 Mbps, Quasi Error Free robustness and less than 100 ms between the camera and the remote production studio.

2.2.1.3. Vertical Stakeholders

The Broadcasting & Media business verticals compose the stakeholder category for this UC. They include Studios, Broadcasters, Content providers, Satellite and cable providers, and Media service providers [6]. They currently face multiple challenges, such as the increased volume of data in both upload and download directions, and the on-demand delivery of media to a multitude of devices having heterogeneous characteristics.

2.2.1.4. Value networks & platform ecosystem

TBC in Year 2

2.2.1.5. Business Canvas

TBC in Year 2

2.2.1.6. SWOT

TBC in Year 2

2.2.2. PPDR

2.2.2.1. Description

Complex PPDR operations require the ability to coordinate multiple actors in harsh and risky environments. Exchanging a rich set of information in real-time and reliably in such complex theatres represents a decisive factor for first responders and deployed forces.

While legacy PPDR systems were limited to mission-critical voice in one-on-one fashion or within a group, new requirements enabling the delivery of effective PPDR services involve the high data rate multimedia services, such as video streaming, and the collection of data from massively deployed IoT sensors. FUDGE-5G leverages on the concept of 5G NPNs adapting to the required service levels of each communication type involved in PPDR. Network slicing plays a key role in managing and operating this heterogeneous set of requirements, extending the control end-to-end, from the access and core up to the cloud. Enabling real-time access to the information, via content-rich data exchange and remote processing, will lead to improved effectiveness for first responders and deployed forces coupled with reduced costs.

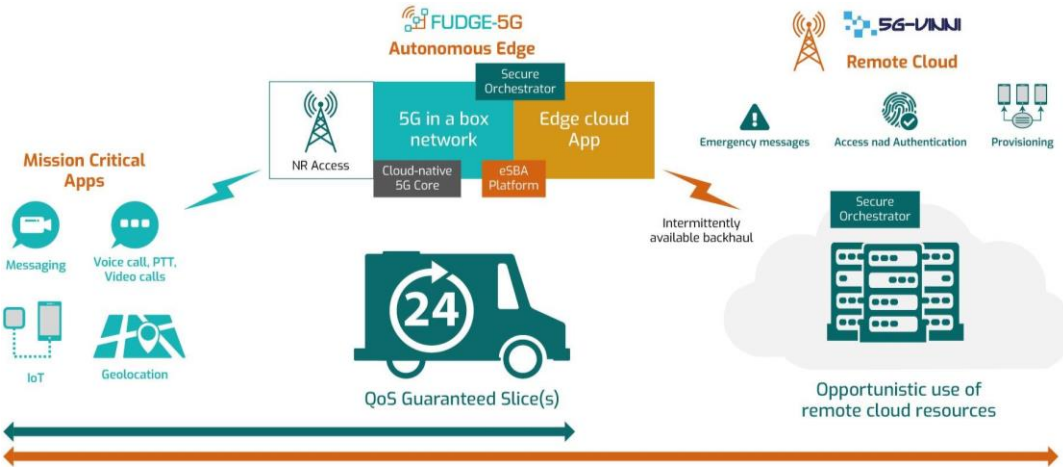

Figure 4: High-level vision of the PPDR use case.

As described in [2], the UC2 will demonstrate the FUDGE-5G platform capabilities of deploying NPNs for PPDR applications in three major scenarios:

- FUDGE-5G will enable the quick deployment of tactical bubbles (i.e. autonomous network) using S-NPNs.
- A tactical bubble will then be able to make opportunistic use of backhaul links to access a remote cloud.
- The tactical bubbles will also be able to coexist with public networks and use their resources.

2.2.2.2. Main Innovations

- **Mobile Autonomous 5G Edge.** All in one 5G solution embedded in a mobile platform (e.g., van, car, truck, etc...) providing local S-NPN connectivity and compute capabilities for PPDR scenarios. Capability to work in full isolation.
- **End-to-end orchestration.** Management and enforcement of PPDR services from the radio link up to the cloud, adapting to dynamics and topology change. Orchestration covers mainly the user-plane and application instances.
- **Enabling coalition/agencies work together.** Interconnection between a local 5G edge and a (public, private, or hybrid) remote cloud. Simplify collaboration between different agencies/ members of a coalition.
- **Coexistence of multiple public and non-public telecom services.** Simultaneous connections to a PPDR-specific NPN for specific PPDR services and to a PLMN for non-critical usage (e.g., web browsing, email).
  Use of SUCI. Protection against IMSI catching techniques via the 5G SUCI (Subscription Concealed Identifier). This allows improved privacy and disallow tracking end-users even during a first time connection to a visited network.

2.2.2.3. Vertical Stakeholders

The PPDR business verticals include any function of governments that ensures the protection of citizens, persons in their territory, organizations, and institutions against threats to their well-being and to the prosperity of their communities, such as the police,

the rescue and fire departments, border control, and the army [6]. Today, they typically face challenges related to the evolution of traditional mission-critical voice centric communications with new applications and smart devices, as well as how to benefit from wireless broadband services with significantly improved capacities and coverage in dense urban and remote areas.

2.2.2.4. Value networks & platform ecosystem

TBC in Year 2

2.2.2.5. Business Canvas

TBC in Year 2

2.2.2.6. SWOT

TBC in Year 2

2.2.3. 5G Virtual Office

2.2.3.1. Description

A 5G Virtual Office provides secure access to a specific set of corporate services without any restriction to the coverage range or proximity. This means that a 5G device can communicate with any other device that is member of the 5G Virtual Office, as long as there is 5G NPN coverage, both in a private and public setting.

This use case will demonstrate the FUDGE-5G platform capabilities of deploying "all-Ethernet" NPNs with 5GLAN support for eHealth applications of a 5G Virtual Office in three major scenarios: (i) Ward Remote Monitoring, (ii) Intra-Hospital Patient Monitoring and (iii) Ambulance Emergency Response.

The first scenario uses the NPN deployment to enable remote monitoring of ward patients using a set of biosensors, allowing smart processing and analysis to trigger alarms in case abnormal values are detected as well as doctor to patient remote interaction. The second scenario aims to ensure uninterrupted monitoring with quality when patients are transported inside the hospital, in contrast to what current technologies provide. Finally, the third scenario, extends the hospital network towards ambulances, emergency response using a 5G NPN deployed over a public 5G network, ensuring security, privacy, isolation, and connectivity at all times.

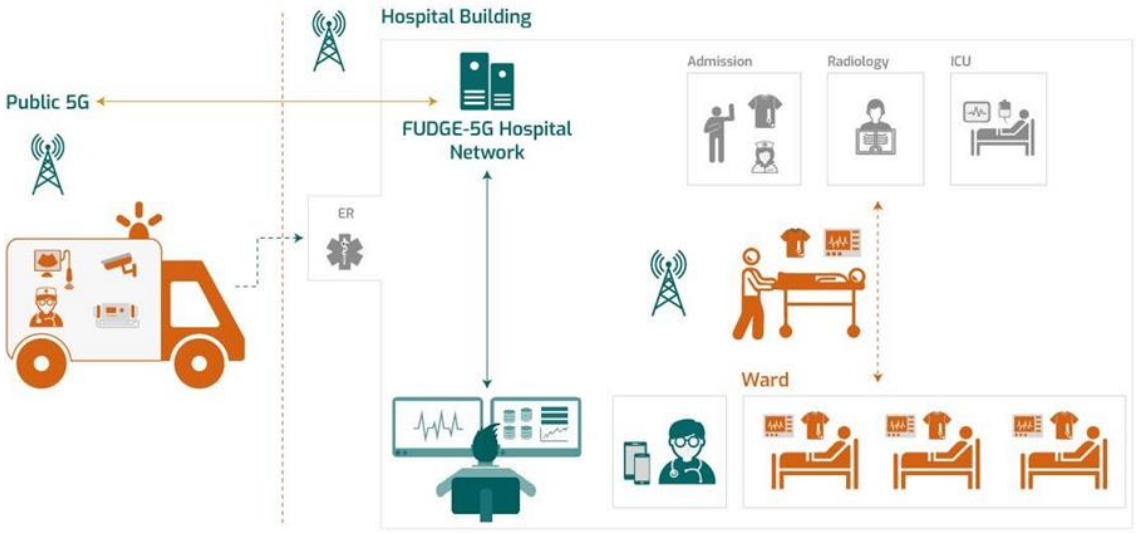

Figure 5: High-level vision of the 5G Virtual Office use case.

2.2.3.2. Main Innovations

E2E Secure Slicing Orchestration

An End-to-end secure slicing orchestrator fully compliant with the eSBA model in FUDGE-5G, to realize the full potential of network slicing and allow differentiated access to specific services. The objective is not only to deliver a complete end-to-end solution capable of providing unified slice management over the different orchestration domains (e.g., user entity, radio access, edge, core), but also to be able to showcase differentiated security levels for on-the-fly deployments (deployed as NF both on the user and the control plane). Due to the nature of the information processed in this use case, the isolation and security of the data is of paramount importance. Hence, the goal is to have separation of information per different slices, which will allow remote access to critical health data and services to be performed without reducing security or compromising required access restrictions. Examples of how the different slices instances will be used include:

- To perform remote operation of life support machines.
- To access the hospital electronic health records.
- The transmission of live video/sound from a patient room and from ambulances.
- The transmission of biosensor data from remotely monitored patients.

Vertical Applications Orchestration

Vertical Applications Orchestrator (VAO) performs deployment and runtime management of 5G-ready applications over application-aware network slices. The VAO on-boards the vertical application and evaluates a provided set of requirements (e.g. QoS/QoE constraints, computational requirements), handling the deployment and lifecycle management of higher-layer application components. With VAO, the following capabilities are explored:

- Strict QoS requirements for the 5G Virtual Office VA will be enforced end-to-end.

- Resource utilization of the 5G Virtual VA will be monitored and the correspondent scale-in and scale-out will be performed.
- When infrastructure is available, 5G Virtual Office VA components will be deployed closer to the UE location.

Multicast communications for 5G Virtual Office

The multicast functionality on the 5G Virtual Office VA will be used to:

- Roll out firmware updates to specific UE groups using the 5G Virtual Office VA.
- Send remote monitoring alerts to the subscriber UEs (Doctors, nurses or other staff UEs).
- Push notifications with updates on medical records to staff in charge of the specific patient.

5GLAN for the 5G Virtual Office

Enables seamless integration with fixed networks (e.g., Ethernet, Wi-Fi, etc.) moving towards an "all-Ethernet" abstraction in unified access. Enhancing 5GLAN allows for all-Ethernet VNs, seamlessly integrating devices served by different access networks and allowing direct Ethernet procedures between them.

Some of the 5GLAN-supported functionalities are:

- **Private Data Network Name (P-DNN) for 5GLAN Group Communication**. A Private DNN uniquely identifies a 5GLAN group and all the member UEs of the same group must establish a PDU Session towards the same Private DNN for 5GLAN group communication. In the 5G Virtual Office UC, P-DNNs will be used to define the UE group memberships. A group of sensors in a patient will be identified by a P-DNN. A set of different office equipment will be part of a P-DNN.
- **Communication between Ethernet type 5GLAN and Ethernet**, to support communication between Ethernet type 5GLAN and Ethernet network in a data network. The UEs at the control room are part of an Ethernet data network that will communicate with the 5G network.
- **One-to-many communications for 5GLAN service within a 5GLAN group.** This functionality will be used to provide the Multicast functionality to support several applications (see “Multicast communications for 5G Virtual Office”).

2.2.3.3. Vertical Stakeholders

The virtual Office UC is geared towards the Healthcare vertical stakeholder category that includes Regulators, Healthcare companies/Industry, Health providers, Emergency services, Users, and Smart Cities. The main challenges they face are to constantly improve the efficiency in all the healthcare-related processes and to access ubiquitously and share flexibly data among different providers and sources complying as well with the information accountability and the protection of data.

2.2.3.4. Value networks & platform ecosystem

TBC in Year 2

2.2.3.5. Business Canvas

TBC in Year 2

2.2.3.6. SWOT

TBC in Year 2

2.2.4. Industry 4.0

2.2.4.1. Description

An ongoing fourth industrial revolution is leading to the new Industry 4.0 where smart factories will leverage on concepts such as artificial intelligence, big data, IoT or cyber-physical systems to improve the resource and cost efficiency, the production quality and the production flexibility, among other factors. Industry 4.0 requires a massive interconnection of people, systems, machines, and devices in general based on communication systems with high security, low latency, and high reliability. 5G fulfils these needs also providing mobility and hence enabling a high degree of flexibility in the production.

The Industry 4.0 use case considers the application of 5G to communicate an industrial end-user (e.g., a robot) and an end-station of an industrial stakeholder (ABB). 5G communication is implemented through a 5G Non-Public network where the RAN part is provided by Telenor in the framework of VINNI and the core is provided by Cumucore while Interdigital contributes the orchestration support thanks to a SCP module added to the core. The 5G end-device that provides communication to the industrial end-user is a 5G-Modem from Fivecomm. In order to achieve a high synchronicity in the system, Cumucore will provide a TSN controller and the 5G-Modem will be updated accordingly.

In an intent of providing solutions in terms of high security, low latency and high reliability communications for the nowadays industrial revolution, FUDGE-5G project includes a use case related to Industry 4.0. Throughout this scenario, 5G Non-Public networks will be deployed taking in account a path from the end-user to the end-station (provided by the stakeholder ABB), connected by several devices that allow TSN communication such as TSN Controllers (Cumucore) and 5G-Modems (Fivecomm). Furthermore, these components will be able to get coverage using a 5G-RAN from 5G-VINNI provided by Telenor, in addition to get management and an SBA with support for TSN and time synchronization using a 5G-Core from Cumucore, that has been upgraded with orchestration support (by Interdigital).

All in all, this architecture will be tested in the framework of several applications in which latency, throughput, power consumption, reliability in addition to other key aspects will be evaluated in real scenarios with stressful and high requirements.

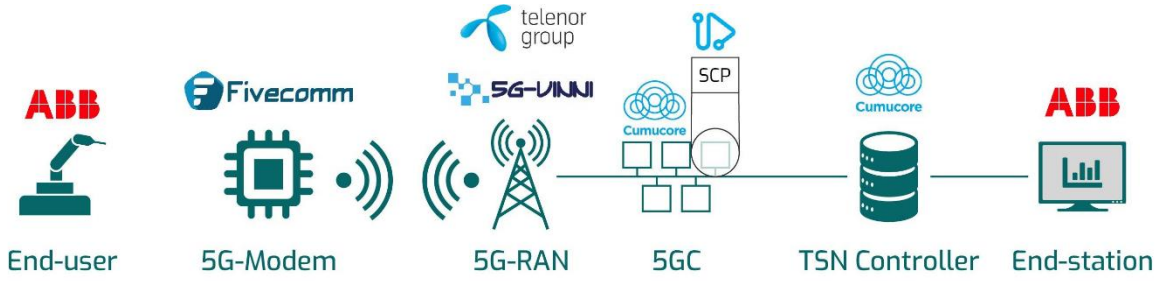

Figure 6: High-level vision of the Industry 4.0 use case.

2.2.4.2. Main Innovations

FUDGE-5G will incorporate two main technical innovations for the demonstration of the use case.

- 5G Time Sensitive Networking (5G-TSN) : Mobile networks currently use best effort IP networking in the backhaul that delivers a flat network for best effort traffic management between the radio access network and the UPF. FUDGE-5G will incorporate 5G-TSN to its platform, via pre-provisioning resources for URLLC, both for IP and non-IP transport. FUDGE-5G will prototype the required NFs for integrating 5G as part of an end-to-end TSN network, in addition to extend the 5G SBA for adding new TSN network modules and to utilize SDN for network slicing in the 5GC and ensure of accurately delivery time synchronization for TSN transport.
- 5G-LAN for Industry 4.0: Usage of NPNs in Industry 4.0 will allow to its stakeholders to get a network customized and focused on their activities, ensuring some aspects that are key points in industrial scenarios: High security, low latency, better coverage, high adaptability, and scalability. All these advantages will be obtained during the application of 5G-LAN which reproduces capabilities of LAN that are necessary for 5G networks applied in industry. Furthermore, 5G-LAN will provide integrability of 5G communications with fixed and wireless standards such as Wi-Fi. This innovation will be developed at core level adapting parts of the SBA, for example editing the UPF and SMF network functions to carry out a correct behaviour during PDU sessions.

2.2.4.3. Vertical Stakeholders

The Industry 4.0 business verticals include e.g. Manufacturers, IoT technology providers, Robotics, and Industry [6]. They face challenges such as to enable the time-critical process control, the automation of non time-critical factory processes, the remote control of robots, the intra/inter-enterprise communication and connected goods.

2.2.4.4. Value networks & platform ecosystem

TBC in Year 2

2.2.4.5. Business Canvas

TBC in Year 2

2.2.4.6. SWOT

TBC in Year 2

2.2.5. Interconnected NPNs

2.2.5.1. Description

With the increasing deployment of 5G NPNs, the telco environment is becoming massively multi- administrated with a wide range of full networks deployed close and covering only the use case area. 5G enables the deployment of small-size networks, located at the use case premise and locally administrated. These NPNs connect only a reduced number of devices and provide a customized service for the specific use case needs. The use case Interconnected NPNs showcase the scenario of Eduroam as an initial solution.

This use case will demonstrate the capabilities of deploying private campus networks and developing interconnection between separately administrated NPNs to provide secure and reliable communication among them. As part of this use case 5G Core network will be deployed in the premises of Fraunhofer FOKUS Germany, UPV Valencia, and Telenor Research Norway. There will be the support for authentication and authorization of users across the networks and secured exchange of data across an unreliable backhaul.

The use case will cover the scenario of roaming for the users within the coverage of these private networks. The users of the 3NPNs will get access to the network some local services, home services and local offload regardless of their location be it in the home network or within one of the visited networks. For both home subscribers and visited subscribers first the authentication should be done to authorize them for the local services. Subscribers when they are in the home network the authentication will be handled by the local network totally. For the roaming subscribers the authentication request will be send to the home network via the visited network.

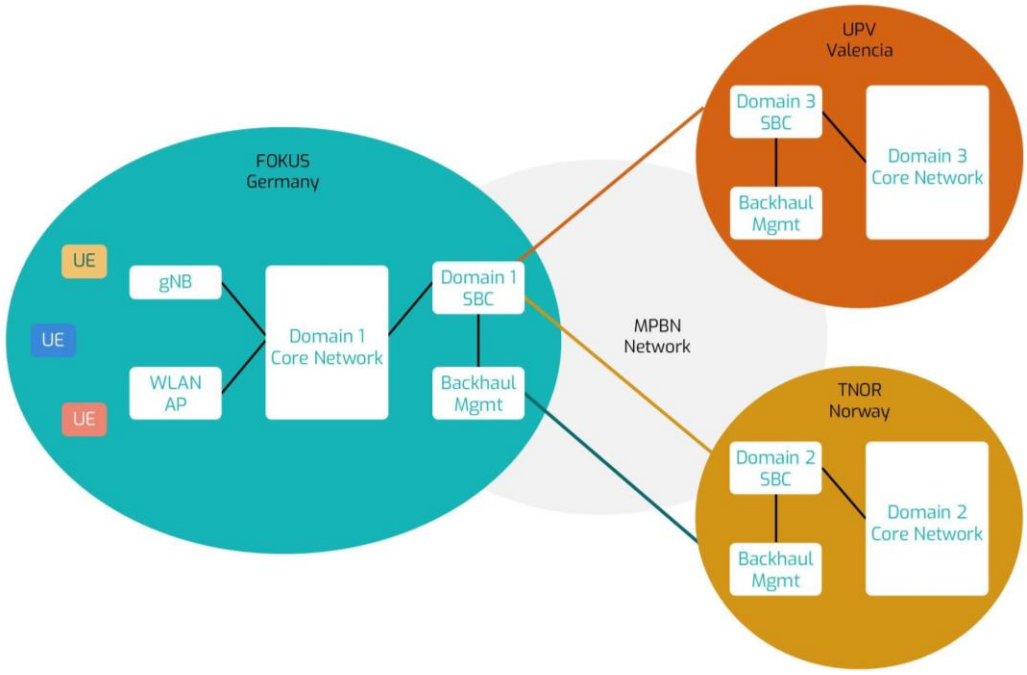

Figure 7: High-level vision of the Interconnected NPNs use case.

2.2.5.2. Main Innovations

This use case will demonstrate three main innovations within FUDGE 5G:

- **5G-LAN:** This use case will showcase seamless integration of multiple 5GLAN in a campus area. There will be NPNs deployed in three locations and these networks will provide services to set of subscribers based on their subscription profiles. These networks should provide secured, reliable communication with low latency to the subscribers. These NPNs for this use case will be deployed with the 3GPP 5GLAN concept.
- **Distributed Authentication Framework for Roaming**: This use case will allow the authentication and authorization of devices in home network and while roaming into other local networks. The roaming devices will be authorized to have access of the local services and the home network services in case of home routed roaming. To have the support of distributed authorization, one framework has been designed as part of FUDGE, which will go beyond the basic deployment and will have inter domain connectivity to forward messages from one domain to another.
- **Interconnection between NPNs**: This use case will deploy 3GPP 5G NPNs in three different locations and there will be seamless connectivity between the networks through transparent backhauls which should ensure guaranteed availability for the inter domain communications.

2.2.5.3. Vertical stakeholders

2.2.5.4. Value networks & platform ecosystem

TBC in Year 2

2.2.5.5. Business Canvas

TBC in Year 2

2.2.5.6. SWOT

TBC in Year 2

3. Individual innovation and exploitation analysis

3.1. Introduction

This Section describes the exploitation plans for the assets of each partner, with a specific description of the organization background and the general strategy of exploitation for the project. The associated tables provide an in-depth description of the specific assets identified by each partner. For each asset under analysis, we describe the innovation, the potential target market, and the exploitation vision. Those outcomes that are considered intangible or that do not have strong characteristics of business exploitation (e.g. results that are linked to scientific papers, study programs, other research activities and/or scientific dissemination), are described only from the point of view of the exploitation vision. As far as tangible outcomes are concerned, we specify when possible their expected time to market, the TRL, and the associated licenses (following the framework in [2]).

3.2. Intellectual Property, licenses, and innovation

The last couple of decades have witnessed the increase in extent and importance of open innovation fuelled by collaborative environments. Protection of the knowledge being generated and shared has then become an increasingly important yet challenging topic. The increasing importance of open innovation, as a means to use and recombine internal and external knowledge to develop, exploit, and commercialize valuable innovations, patents, and know-how [3], means that licensing and technology markets in general have become more important as a means to appropriate the benefits from innovation. Thus, the question of how to manage intellectual property (IP) is becoming increasingly important as more firms develop their open innovation strategies.

Knowledge can be partly considered similar to a public good with high fixed costs in production and low costs in distribution. However, in reality, it is possible to appropriate knowledge. Its protection, and in particular the protection of technical knowledge, is contingent on the embodiment of that knowledge, as this determines how it can be transferred and protected. In the context of open collaborative innovation, technical knowledge (i.e. technology) has specific properties such as codifiability, cumulativeness, combinatorial and patentability. These properties provide growth potential as well as transfer, spill over and trade possibilities. This implies a need from both buyer and seller side for long-term contractual governance on the technology market, resulting in license type of contracts, be they patent or know-how licenses.

IP may be considered as a form of property similar to a physical property, such as land or machinery. Yet, it can be distinguished due to its inherent intangibility. As such, it can be considered as a distinct form of intellectual capital. Real property has physical features making it a tangible good whereas the main characteristic of IP is its intangible nature. As any property, it can be bought, sold, given away, leased and exchanged. According to the World Intellectual Property Organization, IPRs refer to the legal rights, which result from intellectual activity in the industrial, scientific, literary and artistic fields [4].

Following the framework described in [2], understanding the main strategies to exploit IPs represents a key activity for the partners involved in FUDGE-5G. Once an organization has developed an IP, it needs to make some strategic choices.

First, it has to decide whether to allow others to use the IPR, via selling the right to use of via one of the possible licensing strategies. It is also possible for a company to disallow others to use an IP in order to enjoy a sort of monopoly on some specific patented technology. It is also possible to not implement at all the patent and use it to block the development of a rivalling technology of a competitor.

Licensing is a transfer of rights from a licensor (seller), typically the owner of an IPR, to a licensee (buyer). For the former, it is a means to exploit its IP while at the same time controlling its use or diffusion. For the latter, it is a way to use an IP without infringing the underlying IPR. The licensor can license out all or just some of the rights and will consider which restrictions to use.

Below some of the different considerations regarding licensing and some different licensing forms are discussed [5].

License type	Seller	Buyer
Self-license	Keep rights	No rights
Exclusive	No rights	Get rights (unique buyer)
Sole	Keep rights	Get rights (unique buyer)
Simple (non-exclusive)	Keep rights	Get rights (multiple buyers)
Sub-license (exclusive)	Keep rights	Get rights (can resell)
Grant-back	Keep rights (right to use any improvement of the originally licensed technology)	Gets rights
Block license	Keep rights	Get rights (on full package)
Blanket License	Keep rights	Get rights (also on future developments)
Bilateral cross-license	Share background and foreground Keep rights of the sideground and postground	Share background and foreground Keep rights of the sideground and postground
Multilateral patent pool (3+ parties)	Share background and foreground with all parties Keep rights of the sideground and postground	Share background and foreground with all parties Keep rights of the sideground and postground

3.3. Individual Asset Exploitation

3.3.1. UPV 5G Multicast solution

3.3.1.1. Proponent's background

Universitat Politècnica de València will exploit the results and experience gained from the project in further expanding their knowledge base in the field and staying competitive for future wireless research initiatives, in enhancing their teaching scope and quality by introducing new project findings and innovative technologies into the teaching and research syllabus at undergraduate, postgraduate teaching and research. UPV plays a central role in expanding the knowledge, teaching and training future engineers working in the fields of telecommunications. They also have the leading role in disseminating research results in major scientific venues. To remain competitive for future research project calls, universities need also to expand their circle of competence and deepen their understanding of future broadcast and multimedia challenges.

UPV will develop an extension of FOKUS Open5GCore in the form of 5G Multicast Functions. This functionality will be tested as part of the Interconnected NPNs use case, where the Valencia node will deliver content to several visiting UEs.

3.3.1.2. Innovation analysis

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
5G Multicast Functions	UPV	Software Prototype	18 Months (Q1 2022)	3→5	Self-license
Description					
The 5G Multicast Functions include the related 5G Core Network enhancements at Transport Layer to enable Multicast Broadcast services, as specified in TS 23.247 and TS 26.802. UPV implements the MB-SMF and MB-UPF, inside of Fraunhofer FOKUS Open5GCore Framework. The Multicast extension follows a self-license scheme. The MB-SMF is taken with the control and session management of the multicast and broadcast sessions, IP multicast groups and related tunnel management. The MB-UPF includes the creation of tunnels and decision to deliver broadcast eligible data in a unicast or multicast way.					
Potential Target Market					
No target market is foreseen, as this product cannot be resold. Nevertheless, the scientific and dissemination value of the 5G Multicast Functions will be pursued, such as partnerships, papers, conferences submissions or demonstrations in relevant conventions. The multicast enhanced 5G Core is an enabler for future studies for any vertical or stakeholder beyond traditional broadcasting or Use Case that can leverage from point-to-multipoint communications.					
Type of Exploitation Foreseen					
UPV plans to bring this asset to several research and broadcast related conventions and events to raise exposure and solidify the group as world leaders in 5G Broadcast research. UPV sees the 5G Multicast Functions as a constant iterative product that can produce many scientific publications, Ph.Ds/Master					

thesis, and knowledge for future standards such as 6G. Results obtained using the multicast enhanced 5G Core can be used as basis for pre-standardization work.

Planned/Desirable Actions to be Implemented					
	Planned	**Not Planned but desirable**	**Done**	**Not Required**	**Notes**
Set up a start-up or spin off				✓	-
Licensing to 3rd parties				✓	-
Partnerships		✓			UPV is open in partnerships to develop innovative trials involving 5G Multicast
Technology transfer				✓	-
Secure private investments				✓	-
Prototype validation in lab/testbed	✓				UPV is developing and validating the functions in their 5G laboratory
System validation in operation/real environment	✓				UPV will use the 5G Multicast as a service in the Interconnected NPNs use case
Market study / business plan				✓	-
Legal advice				✓	-
Patents, trademarks, IPR protection				✓	-
Standards	✓				The result and knowledge gained from the 5G Multicast implementation has potential to be submitted to 3GPP.

3.3.2. Athonet cloud platform

3.3.2.1. Proponent's background

Athonet (ATH) is an Italian SME that focuses on developing software for 4G/5G mobile networks, tailored to use cases and vertical deployment needs. With several 4G deployments worldwide for enterprises, ATH is notably a pioneer in the softwarization of mobile networks, with a number of world-first commercial products for public safety and private networks. ATH BubbleCloud is the mobile network solution for private networks developed for Amazon Web Services (AWS), and available as SaaS through the AWS marketplace. Currently available to Citizen Broadband Radio Service (CBRS) in the US, ATH BubbleCloud is meant to be spread worldwide in order to reach other markets too, and outside the AWS facilities. FUDGE-5G offers the ideal environment to integrate the 5G version of the product with other 5G equipment and industry-relevant applications. As a well-established solution provider for 4G private networks, ATH expects to benefit from FUDGE-5G to promote top-level 5G products, to accelerate the market growth and, to a broader extent, to increase the awareness and business opportunities of private cellular networks for different vertical segments.

3.3.2.2. Innovation analysis

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
Athonet cloud platform for private networks	ATH	Product (software), know-how/IP	Project lifetime (24 Months)	5→7	Simple (not-exclusive)

Description
Athonet's cloud core network for private networks is currently available for the US markets under AWS. This solution allows for an easy-to-use, centralized control dashboard on AWS for multiple instances of core networks deployed as close as possible to the location where user-plane traffic is generated. Indeed, the centrally managed edge nodes keep user-plane traffic at the edge, thus ensuring low-latency processing as well as preserving privacy.
Potential Target Market
Athonet's asset targets private network deployments for vertical industries including, e.g., smart factories, smart grids, public infrastructures, public safety. The competitors are Tier 1 vendors as well as other mobile core manufacturers.
Type of Exploitation Foreseen
We foresee the exploitation of the project results in world fairs (e.g. MWC, SDN/NFV world congress, Edge Computing Congress, AWS Reinvent), events for the general public and university career/open days.
Planned/Desirable Actions to be Implemented

	Planned	Not Planned but desirable	Done	Not Required	Notes
Set up a start-up or spin off				✓	-
Licensing to 3rd parties				✓	-
Partnerships			✓		-
Technology transfer				✓	-
Secure private investments				✓	-
Prototype validation in lab/testbed			✓		-
System validation in operation/real environment			✓		-
Market study / business plan	✓				Expand market presence of the company
Legal advice				✓	-
Patents, trademarks, IPR protection				✓	-
Standards	✓				Improve participation to SDOs

3.3.3. Cumucore Exploitable Asset Name

3.3.3.1. Proponent's background

Cumucore Oy is a Finnish SME company founded in 2015 by two networking entrepreneurs, with a proven track record of successful projects and patents developed in Nokia and several start-ups. Our mission is to disrupt mobile networks to provide flexible and affordable connectivity for big and small enterprises.

Our purpose is to bring to the market a disruptive one-stop solution that integrates Network Function Virtualization (NFV) and Software Defined Networking (SDN) to deliver flexible and affordable mobile services to truly connect the world. Cumucore is ultra-reliable and compact software-based mobile packet core for small private 4G/LTE and 5G/TSN industrial deployments.

Our aim is to provide a complete use case optimized communications solution for industrial applications to enable the creation of new business models in the transition to Industry 4.0.

3.3.3.2. Innovation analysis

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
5G SA Core	CMC	Product (software)	12-24 months	3→7	Self-license

Description
5GLAN makes it possible to connect cellular network to be part of industry existing infrastructure. Using TSN in the cellular network enables synchronization between end devices even they are using different access technology (radio and cable).

Potential Target Market
5G private networks are needed to make so called Industry 4.0 possible. Overall market size is estimated to be over 2 billion Euro by 2023. Cumucore is targeting to provide services for networks smaller than 10 base stations. These kinds of networks are found from factories having assembly lines, process control needs and warehouses. These companies can be sawmills, dairies, farms etc. Their annual sales are typically between 10 and 100 million and they can be part of bigger organization. In this segment, main competitors are Athonet, IPLOOK Networks, Quortus, UANGEL, Telcoware, Lemko, Polaris Networks, Benu Networks and Finzsoft Solutions.

Type of Exploitation Foreseen
FUDGE-5G will provide us a customer reference and target is that relationships during the project will lead to business relationship. In FUDGE-5G we are developing 5GLAN functionality with Time Sensitive Network feature (TSN). This will be productized and offered to customers. Required partners are end device manufacturers and mobile operators who own the used frequencies.

Planned/Desirable Actions to be Implemented					
	Planned	**Not Planned but desirable**	**Done**	**Not Required**	**Notes**

Set up a start-up or spin off				✓	Cumucore is a spin off itself
Licensing to 3rd parties	✓				Target is to license Cumucore technology to third parties in the future
Partnerships			✓		Form partnerships with mobile operators and end device manufacturers that will lead to common business.
Technology transfer				✓	-
Secure private investments	✓				-
Prototype validation in lab/testbed	✓				Validation work has been started in CMC laboratory and will be validated with ABB in Norway.
System validation in operation/real environment	✓				Validation will be done together with Telenor and ABB in ABB factory
Market study / business plan	✓				FUDGE-5G will provide us product/market fit reference that can be used to expand our presence on the market.
Legal advice				✓	-
Patents, trademarks, IPR protection	✓				Actively looking for topics to be protected
Standards	✓				Influence through FUDGE-5G partners to 3GPP standardization. Cumucore is 3GPP compliant solution.

3.3.4. FOKUS SBC for roaming support

3.3.4.1. Proponent's background

Fraunhofer FOKUS has a 15+ years of experience in providing testbed platforms for the R&D activities of the telecommunication industry. Fraunhofer FOKUS conducts research on digital transformation and its impact on economics, technology, and our society. Since 1988, FOKUS has been supporting commercial enterprises and public administrations in the shaping and implementation of digital transformation. For this purpose, Fraunhofer FOKUS offers research services ranging from requirements analysis to consulting, feasibility studies, technology development right up to prototypes and pilots in the business segments Digital Public Services, Future Applications and Media, Quality Engineering, Smart Mobility, Software-based Networks, Networked Security, Visual Computing und Analytics.

The department NGNI in Fraunhofer FOKUS provides a 3GPP standard-based core network that supports a standalone architecture and can be integrated with various front haul and backhaul networks, including Time Sensitive Networking (TSN) and satellite networks. The Open5GCore toolkit that is developed by NGNI prototypes 3GPP Release 15 and 16 core network functionalities, in a form suitable for R&D activities. Open5GCore is interoperable with 5G NR base stations and user equipment.

3.3.4.2. Innovation analysis

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
SBC for roaming support	FOKUS	Product (software), know-how/IP	18/24 months	3/6	TBD

Description
Extending Open5GCore with the SBC node, which has the functionalities of SCP and backhaul management for secured communications. This solution will ensure the connectivity between private networks and will provide the users' authorization to access the services of the local network irrespective of whether they are in the home network or roaming. Open5GCore with the SBC will have the capabilities to support roaming between 5G private networks.
Potential Target Market
This solution will target campus networks. It is expected that the communication of the NPNs would be strongly localized with all the devices staying within the coverage area of the network. This would be the case of factory robots that will not change the location.
Type of Exploitation Foreseen

As part of FUDGE-5G, FOKUS is developing SBC to support roaming between private networks. This solution integrated with Open5GCore will be available to customers with requirements to connect multiple private networks, like connecting campus networks or to interconnect multiple factory floors.

Planned/Desirable Actions to be Implemented					
	Planned	**Not Planned but desirable**	**Done**	**Not Required**	**Notes**
Set up a start-up or spin off				✓	-
Licensing to 3rd parties				✓	-
Partnerships				✓	-
Technology transfer				✓	-
Secure private investments				✓	-
Prototype validation in lab/testbed	✓				-
System validation in operation/real environment	✓				-
Market study / business plan	✓				-
Legal advice				✓	-
Patents, trademarks, IPR protection		✓			-
Standards	✓				-

3.3.5. One2many Cell Broadcast Centre Function

3.3.5.1. Proponent's background

One2many, an Everbridge company, is in the business of selling Public Warning Systems, based on Cell Broadcast technology, to Mobile Network Operators. Until today, the MNOs operate public networks for which (in most cases) regulatory requirements exist to provide a public warning service.

One2many's participation in the FUDGE-5G project is to explore if there is a market for Cell Broadcast technology in non-public networks and to explore how cloud-native deployments can provide high availability for the service.

There is a trend in 5G towards deployment of cloud-native Core Network Functions, also in MNOs that operate a public network. In the near future, it is expected that also the CBCF needs to be deployable as a cloud-native NF for which one2many needs to be ready in time.

PWS in the vertical market is expected to be of relevance when the non-public network has many individuals that use the service and regulatory requirements require PWS to be available for these individuals. Furthermore, Cell Broadcast technology may be useful when the recipients of such messages in non-public networks are not individuals but IoT devices.

3GPP WG SA1 has forgotten to include PWS as a requirement to be supported in non-public networks in Release-17. 3GPP TSG SA will rectify that either in Release-17 or in Release-18, depending on the outcome of SA#93 in March 2021. One2many supports the addition of PWS in Release-17.

3.3.5.2. Innovation analysis

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
CBCF	O2M	Product (software), know-how/IP	12 months after the end of the project	1→5	Self-license
Description					
The asset is a Cell Broadcast Centre Function (see 3GPP TS 23.041) that consists of cloud-native micro-services that can be deployed and managed by a service orchestrator. The innovation lies in that the CBCF needs to provide high availability and geo-redundancy to guarantee 99.999% availability of the public warning service.					
Potential Target Market					
The CBC is used today in public networks for to provide PWS. This CBC is a monolithic entity deployed on bare metal or on virtual machines. The cloud-native CBC is to be deployed in an environment that is not common in the telco world today. In addition, the vertical markets are still under development and one2many's participation in FUDGE-5G is party to explore if there is a market for CBCF in the world of verticals and to be ready when the telco world moves to cloud native deployments.					

Type of Exploitation Foreseen
The CBCF will continue to be sold to MNOs, and the CBCF that is being developed in the FUDGE-5G project should provide the opportunity to serve MNOs that require Network Functions to be cloud services. A new market for one2many is the vertical market and if vertical markets in 5G get more mature, opportunities for further exploitation may arise.

Planned/Desirable Actions to be Implemented					
	Planned	**Not Planned but desirable**	**Done**	**Not Required**	**Notes**
Set up a start-up or spin off				✓	-
Licensing to 3rd parties				✓	-
Partnerships				✓	-
Technology transfer				✓	-
Secure private investments				✓	-
Prototype validation in lab/testbed		✓			Current TRL for the cloud-native CBC:TRL=1
System validation in operation/real environment		✓			Current TRL for the cloud-native CBC: TRL=1
Market study / business plan		✓			-
Legal advice				✓	-
Patents, trademarks, IPR protection		✓			-
Standards			✓		Work in 3GPP ongoing, possibly also needed going forward

3.3.6. UBITECH MAESTRO

3.3.6.1. Proponent's background

UBITECH is a leading and highly innovative SME, serving as a software house for tailored system integration and technology solutions in various fields, including networks, analytics, cybersecurity and targeted services for verticals. One of the key focus areas in the field of networking is the development of orchestration solutions for cloud-native applications over 5G infrastructure. As we traverse the network softwarization era, UBITECH targets the development of holistic platform solutions in support of vertical stakeholders and NetApp developers seeking to smoothly deploy and manage applications in distributed 5G network environments.

UBITECH's MAESTRO will engulf FUDGE-5G vision for as a fully disintegrated 5G Architecture and will further enhance it by introducing an application orchestration layer that enables the design and development of cloud-native applications per vertical industry, as well as the dynamic on-the-fly deployment and adaptation of the cloud-native applications to its service requirements.

The goal with the exploitation of the above-mentioned item is to increase its competitiveness, targeting in both the public and private sectors and especially the industry. UBITECH identifies opportunities for technology transfer into the vertical industry sector (with priority in industry automation, telecommunication providers and the health sectors) offering customized solutions.

In the case of FUDGE-5G, UBITECH expects to benefit from the integration with the eSBA platform, providing a fully compatible and complementary solution to this innovative network orchestration paradigm. The exploitable outcomes are important as they complement the company's expertise in services solutions in the areas of service orchestration and automation, analytics and security, thus positioning the company at the edge of the next generation orchestration solutions and opening new market opportunities towards emerging vertical sectors.

3.3.6.2. Innovation analysis

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
MAESTRO	UBITECH	Product (software), know-how/IP	24 months after the end of the project	6→7	Closed Source UBITECH Licence
Description					
MAESTRO is an application orchestrator that enables the deployment and management of cloud-native applications per industry vertical. It also provides the dynamic reconfiguration of the cloud-native applications to its service requirements. This way, MAESTRO enables vertical stakeholders and NetApp					

developers to be able to smoothly deploy and manage applications in distributed 5G network environments.

Potential Target Market

UBITECH is targeting both the public and private sectors and especially the industry. It identifies opportunities for technology transfer into: a) various vertical sectors (with priority in solution for industry 4.0, health and automotive sectors), and b) telecommunication or/and integrated services providers and.

Type of Exploitation Foreseen

UBITECH will enrich its professional and consultancy services related primarily to digital transformation and IT service solutions. UBITECH will further exploit the innovative aspects of the developed technologies in new collaborative research projects and initiatives targeting specific vertical sector developments. Finally, UBITECH is open to the joint exploitation of the project solutions with other partners of the consortium and the offering of holistic solutions with higher benefit.

Planned/Desirable Actions to be Implemented

	Planned	Not Planned but desirable	Done	Not Required	Notes
Set up a start-up or spin off				✓	-
Licensing to 3rd parties				✓	-
Partnerships	✓				-
Technology transfer	✓				-
Secure private investments		✓			-
Prototype validation in lab/testbed			✓		-
System validation in operation/real environment	✓				-
Market study / business plan	✓				-
Legal advice				✓	-
Patents, trademarks,	✓				-

IPR protection					
Standards		✓			-

3.3.7. OneSource Mobitrust & disintegrated NEF

3.3.7.1. Proponent's background

OneSource is an IT company specialized in the fields of data communications, security, networking and systems management, including the consultancy, auditing, design, development and lifetime administration of specialized IT solutions for corporate networks, public-sector institutions, utilities and telecommunications operators.

OneSource has a large expertise integrating its Situational Awareness platform with other projects and platforms. Integration and development of its features were supported by projects Mobitrust (Eureka/CATRENE), Mobilizador 5G (national project) and 5GINFIRE (H2020).

With OneSource participation in FUDGE-5G, the SME aims to bring its Situational Awareness Platform closer to the potential customer needs not only on the PPDR sector but also to extend it to the eHealth vertical application market. The goal is to meet the stakeholder requirements and validate the Situational Awareness Platform capabilities in close to real scenarios provided by the FUDGE-5G trials.

From FUDGE-5G, OneSource expects to complement its expertise in the Situational Awareness services solutions combined with the 5th generation of mobile communications, specifically in the non-public networks field, bringing OneSource to the edge of the Situational Awareness services solutions and opening new market opportunities in that sector.

3.3.7.2. Innovation analysis

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
Mobitrust	ONE	Product (software, hardware)	24 months after project ending	6→7	Self-Licence
Description					
Mobitrust is a situational awareness platform that is already implemented as a VNF and delivers direct support for 5G SA, which goes beyond simple connectivity and includes the ability to request a given QoS from the 5GC via PCF (or indirectly via NEF). It is an end-to-end platform that includes all the required components to provide situational awareness, from the devices in the field to the Command and Control Centre. Mobitrust is a completely integrated all-in-one platform, and was repeatedly tested in a real-life environment with simulated scenarios, always delivering the expected outcomes and even surpassing the expectations. This situational awareness platform has a variety of devices that field operators wear/carry and enable monitoring of different aspects with a wide range of sensors and related equipment. These include GPS positioning, man-down detection (and body position) with accelerometers and gyroscopes, ECG and RR via wearable devices to control vital signs, environment sensors (e.g. gases, temperature, etc.) to quickly					

detect hazardous environments and conditions, and also a communication channel with on-demand video and audio in real-time.

Potential Target Market

Mobitrust Platform is designed to support PPDR initiatives/entities. It also adapted to support remote monitoring in health institutions (hospitals, clinics). Normally this type of activities are associated with local and national government institutions, but also with security/emergency entities like police, firefighters and military. The platform will be validated in real environments on the context of FUDGE-5G (Oslo Rikshospitalet and Rygge Airport, a Norwegian Defense airport). The goal is to align Mobitrust capabilities with the needs of the stakeholders involved.

Type of Exploitation Foreseen

During the FUDGE-5G project, Mobitrust will provide the platform that will enable the remote monitoring of patients not only on the partner (Oslo Rikshospitalet) premises but also on the emergency response vehicles deployed by the hospital. The hospital ecosystem will enable the exploitation of the Mobitrust monitoring software/hardware to improve the monitoring quality offered by the hospital. The Mobitrust platform, on the context of FUDGE-5G, will also be the situational awareness platform used by the Norwegian Defense Material Agency.

After the end of the project, OneSource aims to establish partnerships with security/emergency entities and with government institutions to improve their assets monitoring and situational awareness capabilities. On the other end, OneSource also has the goal to collaborate with communication operators not only in Portugal, but also across Europe to keep using the most advanced communication technologies.

Planned/Desirable Actions to be Implemented

	Planned	Not Planned but desirable	Done	Not Required	Notes
Set up a start-up or spin off				✓	-
Licensing to 3rd parties				✓	-
Partnerships	✓				OneSource has done multiple partnerships in the past, e.g. with Nokia. More partnerships are expected from the exploitation in FUDGE-5G.
Technology transfer				✓	-
Secure private investments				✓	-
Prototype validation in lab/testbed				✓	-

System validation in operation/real environment	✓				Mobitrust was already tested in limited operational environments. Due to the constant platform evolution, more complex operational environment tests are expected.
Market study / business plan				✓	-
Legal advice				✓	-
Patents, trademarks, IPR protection				✓	-
Standards				✓	-

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
Disintegrated NEF	ONE	Know-how/IP, Report, Prototype	24 months after project ending	5→7	Self-Licence

Description

The Network Exposure Function (NEF) uses APIs to expose services and resources within and outside the 5GC, enabling AFs to communicate with the 5G NFs in a secure way. OneSource is disintegrating NEF to use a micro-service architecture, on which each micro-service (MS) has a piece of business functionality with clear interfaces.

Potential Target Market

The disintegrated NEF is being designed to be part of a pure cloud native environment where each micro-service can be deployed, upgraded, scaled, and restarted independent of other services in the same application, typically as part of an automated system. In the context of FUDGE-5G, the disintegrated NEF will be deployed via the project cloud native orchestrator that will provide the NEF deployment as infrastructure-agnostic. Cloud-Native 5GC providers are the main potential customers.

Type of Exploitation Foreseen

In the FUDGE-5G context, OneSource expects to exploit the NEF cloud-native characteristics by contributing to a fully SW-based 5G core network. The disintegrated NEF can then be a part of an infrastructure-agnostic 5GC for non-public 5G networks.

After the end of FUDGE-5G, the disintegrated NEF is expected to be a part of OneSource's Mobitrust deployments, creating a safe endpoint for Mobitrust and other AFs to use a 5GC. The goal is to use the combined expertise to enable strategic partnerships to exploit the Mobitrust ecosystem.

Planned/Desirable Actions to be Implemented					
	Planned	**Not Planned but desirable**	**Done**	**Not Required**	**Notes**
Set up a start-up or spin off				✓	-
Licensing to 3rd parties				✓	-
Partnerships					-
Technology transfer				✓	-
Secure private investments				✓	-
Prototype validation in lab/testbed	✓				A few tests have been performed, but more complete tests are to be performed in lab during the FUDGE-5G project. The tests encompass both the service disintegration performance and the NEF integration on the FUDGE-5G platform.
System validation in operation/real environment	✓				Once the lab tests are successfully performed, the disintegrated NEF will be validated in operational environment scenarios provided by the project uses cases.
Market study / business plan				✓	-
Legal advice				✓	-
Patents, trademarks, IPR protection				✓	-
Standards			✓		-

3.3.8. FiveComm 5G Modem (F5GM)

3.3.8.1. Proponent's background

Fivecomm is a Spanish SME based in Valencia, focused on research and development activities of 5G solutions for industry verticals. It was founded by members of the academia that were involved from the beginning in the 5G development, with experience in digital transformation. The best of these two worlds joins together in Fivecomm with a single mission: to facilitate the adoption of 5G technologies by vertical industries. Fivecomm has the talent and contrasted experience in 5G international research projects. This permits us to be at the forefront in this technology and apply it to advanced solutions for the industry.

Fivecomm's mission is to facilitate the adoption of 5G technologies by vertical industries such as robotics, automotive, education, healthcare, energy, or the Industry 4.0. For this reason, and thanks to the FUDGE-5G project, Fivecomm aims to expand its portfolio in 5G and industrial applications with a clear business-to-business (B2B) perspective, helping end-users, stakeholders and customers on selecting the optimum solutions for their needs.

3.3.8.2. Innovation analysis

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
Fivecomm 5G Modem (F5GM)	5CMM	Know-how/IP, Product (software, hardware), Prototype	First stage: Q3 2021 Second stage: Q1 2022	3→8	Self-license, Sub-license

Description
Fivecomm aims at developing, under the FUDGE-5G umbrella, a 5G modem to be used on several use cases in the context of the project, that is, PPDR, Industry 4.0 and media showroom. The objective is to develop, integrate and technically validate a compact final solution that provides 5G wireless connectivity to end-users in an easy and flexible way. The product can be particularized for the connection link between the devices and the 5G network, depending on the specific needs and requirements of the media vertical. The aim is to provide time synchronization and implement the necessary aspects to support 5G-TSN.
Potential Target Market
Due to the large market of application in which 5G communications may be a key point, Fivecomm has several potential sectors of interest such as broadcasters, industrial agents or research institutions. During FUDGE-5G, Fivecomm will focus on the industrial sector, trying to use its product in applications of Industry 4.0 where there is a great number of potential clients and competitors such as Ursalink.
Type of Exploitation Foreseen

During the course of the project, the target is to maintain close links with other partners and stakeholders and position our product. This will lead to future business relationships after the project. It is also planned to bring our 5G modem to several conventions and main events such as the MWC to raise exposure and gain clients.

In a second phase, it is planned to sell licenses of commercialization of our product to several manufacturers, in order to save costs of production, basing the exploitation of the product on royalties.

Planned/Desirable Actions to be Implemented					
	Planned	**Not Planned but desirable**	**Done**	**Not Required**	**Notes**
Set up a start-up or spin off				✓	FCMM is a start-up itself.
Licensing to 3rd parties	✓				Planned for massive production and distribution
Partnerships	✓				Planned for massive production and distribution
Technology transfer	✓				Planned for massive production and distribution
Secure private investments				✓	-
Prototype validation in lab/testbed	✓				Ongoing activity
System validation in operation/real environment	✓				Planned to be conducted in Industry 4.0 Use Case
Market study / business plan	✓				To be developed on course of FUDGE
Legal advice		✓			-
Patents, trademarks, IPR protection	✓				Looking for topics to be protected
Standards				✓	Impact on standards is expected being part of FUDGE project

3.3.9. InterDigital Service Delivery Platform

3.3.9.1. Proponent's background

In 1992, InterDigital received its namesake by bringing the two main digital wireless technologies we pioneered into one company. Today, InterDigital is uniting the two main communication technologies – wireless communication and video communication – into one of the world's largest pure research, innovation and licensing companies.

On the wireless side, InterDigital has been a pioneer for four decades, with our engineers designing and developing a wide range of advanced technologies that are used in digital cellular and wireless products and networks, including 2G, 3G, 4G and IEEE 802-related products and networks. Today, we are a leader in 5G research and beyond, a thought leader in our industry and, over the course of the last two decades, the source of more than 5,000 contributions to key global standards.

Our track record of research & development is matched by our fair licensing practices, which are a model for the industry, and our willingness to partner with virtually anybody in developing new capabilities that will improve technology for consumers and businesses around the world.

InterDigital actively contributes to the technical development of standards pertaining to digital cellular and wireless communications and other technologies. These standards, among others, provide detailed specifications for wireless communications products and systems and are beneficial to the industry as they enable economies of scale and support interoperability. Moreover, the standardization process itself produces benefits to both implementers and consumers as it encourages the development of ideas and technical solutions that result in innovative standards.

As an innovator and a contributing participant in the wireless technology industry, InterDigital respects the important role that intellectual property policies serve within the standard-development environment. As such, InterDigital honours its commitments under applicable IPR policies of standards-development organizations of which it is a member.

3.3.9.2. Innovation Analysis

IDE have three distinct innovations brought into FUDGE which are analysed in separate tables, i.e., Service Communication Proxy (SCP), Service Function Virtualisation Orchestrator (SFVO), and Name-based Routing on the 5G user plane.

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
SCP	IDE	Product (software), Standard	24 Months	5→7	Simple
Description					

The Service Communication Proxy (SCP) enables the routing be tween Service-based Interface (SBI)-enabled 5G Core (5GC) Network Functions (NFs) and is an integral part of the FUDGE-5G platform. InterDigital's SCP is based on Name-based Routing (NbR) concepts partially standardised in IETF and protected through a rich portfolio. The SCP is one of the three official deployment options in 3GPP, TR23.501.

Potential Target Market

The target market for the SCP is two-fold and follows a demand-supply strategy: While vendors are the organisations that implement SCPs in order to sell it to operators in their 5G offering (supply chain), it is operators that create the demand for any supply. Hence, IDE follows a demand-centric strategy where a close relationship with operators is pursued in order to create the demand for the technology.

Type of Exploitation Foreseen

Following the demand-supply strategy for potential target markets, the exploitation goes hand in hand with the strategy to create demand. To support the standardisation work in 3GPP and IETF, IDE works closely with a range of operators through publicly funded projects or Memento-of-Understanding (MoU)-based collaborations where technological advances are being discussed and demonstrated at internal and external events. The highest appreciation for an InterDigital technology is the classification of a patent as standard-essential.

Planned/Desirable Actions to be Implemented

	Planned	Not Planned but desirable	Done	Not Required	Notes
Set up a start-up or spin off				✓	-
Licensing to 3rd parties	✓				-
Partnerships	✓				-
Technology transfer		✓			-
Secure private investments				✓	-
Prototype validation in lab/testbed			✓		The SCP was used in the FLAME platform which was deployed across four European cities and its service routing capabilities used in 30+ trials
System validation in operation/real environment			✓		The SCP was used in the FLAME platform which was deployed across four European cities and its service routing capabilities used in 30+ trials
Market study / business plan				✓	IDE have no plans to commercialise the software

Legal advice				✓	-
Patents, trademarks, IPR protection			✓		IDE have protected the technology already
Standards			✓		IDE's SCP is one of the three deployment options in 3GPP TR23.501

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
SFVO	IDE	Product (software), Standard	36 months	5→7	Simple

Description

The Service Function Virtualisation Orchestrator (SFVO) is a cloud native orchestrator for the telco world and key puzzle in the service-based architecture vision. While the SCP implements service routing, the SFVO seamlessly integrates with that vision allowing the orchestration of 5G services across multiple locations.

Potential Target Market

As SFV is seen as a complimentary technology to SCP, the potential target markets are very similar, i.e., 5G vendors and operators. However, SFV goes beyond cellular communication systems and is fully independent from 3GPP, allowing a broader applicability beyond traditional telco markets.

Type of Exploitation Foreseen

The SFV information model as well as the description definition is planned to be released under as an open standard, ideally in a group such as OASIS. Being able to utilise the SFV principles as part of a service delivery platform allows InterDigital to exploit the underlying service routing capabilities in standardisation bodies, e.g. 3GPP and IETF. Depending on the importance of a unified orchestration of 5GCs (potentially standardised in 3GPP SA5), SFV's principles partially defined in an open standard could provide a telco-owned alternative to Kubernetes and other emerging micro service-centric orchestration approaches for CNFs.

Planned/Desirable Actions to be Implemented

	Planned	Not Planned but desirable	Done	Not Required	Notes
Set up a start-up or spin off				✓	-
Licensing to 3rd parties		✓			-
Partnerships	✓				-
Technology transfer		✓			-

Secure private investments				✓	-
Prototype validation in lab/testbed			✓		-
System validation in operation/real environment			✓		-
Market study / business plan		✓			-
Legal advice	✓				-
Patents, trademarks, IPR protection	✓				-
Standards	✓				-

Exploitable Asset Name	**Asset Owner**	**Expected Output(s)**	**Expected Time to Market**	**TRL Current / Expected**	Licenses
NbR on the 5G user plane	IDE	Product (software)	36 months	5→7	Simple

Description
NbR on the 5G user plane utilises the same service routing capabilities as the SCP. However, when bringing NbR to the user plane a set of procedures and concepts must be revised, namely UPF and SMF capabilities. When even extending the service routing capabilities to the UE, the UE also must implement a set of new functionality.
Potential Target Market
The market here is threefold: while mobile operators are the customers of 5G vendors asking for a specific set of technologies, 5G vendors such as 5GC providers as well as UE and/or modem manufacturers would need to realise the additions.
Type of Exploitation Foreseen
Key for all components to find their way into products is a 3GPP and IETF-based standardisation roadmap with 3GPP SA2 and CT working groups as well as IETF ICNRG as the core target groups.
Planned/Desirable Actions to be Implemented

	Planned	**Not Planned but desirable**	**Done**	**Not Required**	**Notes**

Set up a start-up or spin off		✓			-
Licensing to 3rd parties	✓				-
Partnerships	✓				-
Technology transfer		✓			-
Secure private investments				✓	-
Prototype validation in lab/testbed	✓				-
System validation in operation/real environment	✓				-
Market study / business plan		✓			-
Legal advice				✓	-
Patents, trademarks, IPR protection			✓		-
Standards	✓				-

3.3.10. Huawei Resource Scheduler

3.3.10.1. Proponent's background

Huawei is a leading global information and communications technology (ICT) solutions provider. Its products and solutions are deployed in over 170 countries, supporting the communication needs of one-third of the world's population. Huawei offers the most complete telecom product portfolio in the industry to customers in Europe and worldwide. Huawei's 180,000 employees are committed to meeting the needs of telecom carriers, enterprises and consumers by providing competitive end-to-end ICT solutions and services. Founded in 1987, Huawei is a private company fully owned by its employees.

In Europe, Huawei currently has over 10000 staff, of whom over 1800 are working in R&D. Our European Research Institute (Huawei ERI) oversees the activities across our network of European R&D facilities: 20 R&D sites spanned across Europe (in countries such Belgium, Finland, France, Germany, Ireland, Italy, Sweden and the UK) covering wireless, fixed, optical, future network, standard and chipset design technologies. In addition, Huawei cooperates with more than 80 academic partners in Europe, investing over 75 Mio € p.a. in partnerships. Huawei's research facility in Munich, which belongs to Huawei Technologies Düsseldorf GmbH (HWDU), streamlines and manages Huawei's 5G effort at the European level.

4.11.1. The Munich research centre conducts research for telecommunication systems and enabling technologies, in particular leading the company's research efforts on converged CT and IT infrastructures. The Advanced Wireless Technology Laboratory (AWTL) was established at Huawei ERI with the mission of designing future network architectures including the evolution of mobile broadband networks (5G). Since its establishment, AWTL has been employing senior experts in the field of cloud computing, optimization, future networks architecture and mobile broadband networks. AWTL is connected to product lines responsible for the development and deployment of 5G systems.

3.3.10.2. Innovation analysis

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
Resource Scheduler	HWDU	Product (software, hardware), Standard, Report, Prototype	36 months	4→7	Simple
Description					
Pure resource scheduler (or resource controller) schedules request dynamically to network function instances as to balance the load and increase physical resource utilization. As a runtime functional entity,					

the HWDU resource scheduler brings in a considerable innovation in comparison with the state of the art solutions, which have a completely different, several orders of magnitude longer time scale.

Potential Target Market

Potential markets are ongoing 5G deployments. (This is what our current prototype targets and where we tested it. The core idea of service scheduling is however more general than 5G.) Competition is hard to assess, as all available solutions are prototypes proposed by academic institutions. In case these prototypes realize their promised potential, the competition can become all network infrastructure manufacturers, but also cloud providers. Potential customers are all 5G operators (or probably cloud providers which provide compute infrastructure for 5G deployments of those operators), whose main goal is to reduce the footprint of their deployments. The value of the potential market is high, at least in a eight digit dollar value.

Type of Exploitation Foreseen

In the course of the project, we plan to bring the resource scheduler software to the level at which it can offer convincing arguments for its adoption and deployment to the involved stakeholders (e.g. Telenor, as the operator). This should provide an advantage to enable a post-FUDGE5G success of the resource scheduler. There is strong IPR potential behind the scheduling as a concept and the concrete realizations we are implementing during the project. We plan to deliver at least one IPR (given that some background IP already exists) during the project. More inventions are also possible.

Planned/Desirable Actions to be Implemented

	Planned	Not Planned but desirable	Done	Not Required	Notes
Set up a start-up or spin off				✓	-
Licensing to 3rd parties		✓			-
Partnerships		✓			Operators, to provide realistic environment for testing and all pre-deployments preparations
Technology transfer		✓			-
Secure private investments				✓	-
Prototype validation in lab/testbed	✓				So far, only internal (HWDU) lab tests planned
System validation in operation/real environment		✓			-

Market study / business plan		✓			-
Legal advice		✓			-
Patents, trademarks, IPR protection	✓				Distributed aspects of scheduling
Standards	✓				Distributed aspects of scheduling, IETF (detnet, sfc) seems to be more appropriate than 3GPP.

3.3.11. Thales End-to-end slice orchestrator

3.3.11.1. Proponent's background

Thales is one of the world's leading providers of mission-critical systems for security, defense and aerospace. With over 81,000 employees in 50 countries, Thales annual revenue is over €16 billion with over 18% devoted to R&D and 25,000 researchers working on cutting-edge technologies. Leveraging a global presence and spanning the entire value chain, from prime contracting to equipment, Thales plays a pivotal role in making the world a safer place. As a key player in security markets, Thales role is to protect people, countries, critical infrastructure and data. To do that, Thales works closely with its customers — governments, cities, essential operators, companies and major national and international organizations — to address their specific concerns and develop solutions that meet the needs of their stakeholders.

Thales plans exploiting the work performed in FUDGE-5G, first by gaining insight in the setup, delivery and orchestration of critical communication services for PPDR, and non-public networks in general, over a fully cloud-native 5G platform.

5G networks are deemed to represent the cost-efficient architecture for any mission-critical system provided they are capable of guaranteeing extreme resiliency together with performance and simplicity of use(exactly as in the PPDR use case). For this reason, FUDGE-5G represents the ideal playground to develop, test and validate Thales' next-gen orchestration solutions.

The exploitation plan for integrating FUDGE-5G results into the critical communications solutions that Thales tailors to the needs of its customers (such as the PPDR customers) requires first a stage of technology transfer between Thales R&I teams to the involved Business Line (BL) that will deal with the industrialization and marketing of the solution. Specifically, the interaction between the R&I team and the BL will involve the planning of the PPDR pilots, the key technical review decisions for the development of asset(s), but also, and above all, the creation of commercial links with specific partners of the project and the creation of relationships with stakeholders. The results from the project will be employed to open the technology transfer phase (starting around TRL 6-7). This phase will last at least 3 months after the conclusion of the project. Such outcomes will be integrated into a prototype, in order to reach TRL 8. This phase will last approximately 6 months. Eventually, the last phase will envision test, validation, and bug fixing in order to reach the TRL 9. This will require at least 4 months, thus by the mid of 2024 the initial offer will be ready.

3.3.11.2. Innovation analysis

Exploitable Asset Name	Asset Owner	Expected Output(s)	Expected Time to Market	TRL Current / Expected	Licenses
End-to-end slice orchestrator	Thales	Product (software), Know-	Depending on market	4 → 7	Self-License, Simple

		how/IP, Prototype	conditions 1 to 3 years		(non-exclusive), Cross-licence

Description

End-to-end slice orchestrator capable of managing and configuring the components of a network slice. In order to guarantee the coherence of the slice, it encompasses the radio access, the edge, the core, and the cloud domains and for which the orchestration strategy can be automated, following the definition of service blueprints and their associated policies. The orchestrator architecture is built on top of a monitoring infrastructure and a standardized REST API layer for interacting with the various domain controllers.

Potential Target Market

Potential customers are the European and Global defense procurement agencies in search of an integrated solution for the end-to-end orchestration of deployable clouds, connectivity management, cloud applications and data hosting.

Today's orchestrator competitors on the market focus mostly on IT or Telecom domains only with various degrees of technology leadership. There is the market space to provide a solution capable of covering the whole value chain for orchestration, namely the cloud/IT, telecom, security and business services domains. In order to address this space, it is needed to leverage on the ability to be competitive in the area of security, and value added business services. Data sovereignty can be a key differentiator.

Main existing competitors include defense integrators strong in the same market spaces as Thales with a strong business knowledge, such as Airbus DS and Atos; Global IT players having strong civil IT technology leaders with worldwide footprint, including Microsoft, VMWare, AWS and IBM/RedHat; Major telecom equipment vendors with worldwide footprint, such as Cisco, Ericsson, Nokia. Moreover, small players with reputed experience in cloud orchestration domains, expert in open source, and with the ability to disrupt the market are Cloudsoft, and Cloudify.

Type of Exploitation Foreseen

Thales expects to participate in various events, demonstration, and trade fairs where to demonstrate the functionalities of the end-to-end slice orchestrator. It also plans to apply in the short term the knowledge, competences and expertise acquired to be provided internally to the business lines involved with 5G deployments.

In the post-project, Thales plans to use the expertise and the developments made for the end-to-end slice orchestrator component developed in FUDGE-5G by integrating it as one of the add-ons to extend its offer towards the use of 5G in military applications. This offer currently targets the European and Global markets for defense by providing an all-in-one solution for deployable cloud capabilities, end-to-end management and control of connectivity, cloud applications and data hosting.

As foreseen in the market analysis, the project will be mainly employed to increase the technical maturity of the orchestration solution and to test its integration and interoperation with various partners (including the participants in the stakeholder boards). The focus will be in evaluating and integrating with existing and future cloud- native IT and network orchestrators, edge cloud platforms, and providers of 5G components (including RAN, core, and NFs). Depending on the outcomes, it will also serve as the base for creating commercial partnerships with selected partners.

Due to the nature of the expected outcome and the target market, the licensing strategy will most likely follow a self-license approach, to be included into the Nexium product line, with the option of adopting cross-licensing arrangements in the case of joint offers with technical partners providing the cloud platform.

Planned/Desirable actions to be implemented					
	Planned	**Not Planned but desirable**	**Done**	**Not Required**	**Notes**
Set up a start-up or spin off		✓			Creation of an internal "virtual company" with start-up autonomy to develop disruptive products. Already experimented with Eiji.
Licencing to 3rd parties		✓			Simple (non-exclusive) licence, or cross-licence
Partnerships	✓				Partnership with selected virtualization platform providers and 5G-core provider
Technology transfer				✓	-
Secure private investments				✓	-
Prototype validation in lab/testbed	✓				Ongoing
System validation in operation/real environment	✓				PPDR UC pilot
Market study / business plan	✓				-
Legal advice		✓			-
Patents, trademarks, IPR protection	✓				Identification of patentable components ongoing
Standards	✓				Ongoing identification of possible standardization items ongoing in NATO STANAG

3.4. Summary of the exploitation strategies

The analysis of the different exploitation strategies performed on the FUDGE-5G assets is aggregated in Table 5. From there, it is possible to identify several key emerging trends.

Table 5: Summary of the exploitation strategies of the FUDGE-5G assets

	Planned	Not Planned but desirable	Done	Not Required
Set up a start-up or spin off	0	2	0	12
Licencing to 3rd parties	4	3	0	7
Partnerships	6	2	3	2
Technology transfer	2	4	0	8
Secure private investments	1	1	0	12
Prototype validation in lab/testbed	8	1	4	1
System validation in operation/real environment	9	2	3	0
Market study / business plan	6	4	0	3
Legal advice	1	3	0	9
Patents, trademarks, IPR protection	6	2	2	2
Standards	8	1	3	1

In general, the need to **setup a start-up or a spin-off** company is not perceived as an essential step to fully exploit the asset potential. Indeed, only in two cases it is considered as a not planned yet desirable option. This is motivated by the fact that most of the assets surveyed compose the core business of the FUDGE-5G participants, or that the participants are a start-up or spin-offs themselves.

Next, the strategy of **licencing the asset to 3rd parties** is more balanced, with around 50% of responses planning it or considering it as a desirable strategy. In this case, the portfolio of technologies developed in FUDGE-5G are expected to generate a profit through licensing agreements, joint ventures, and other arrangements. In this case, the selection of simple (non-exclusive) and cross-licensing strategies represents the two most favoured options. The remaining half of the assets are expected to use self-licenses as they represent key technological pillars of the firm offering, and thus they are not expected to be licensed. **Technological transfer** follows a similar trajectory having similar motivations. On the contrary, creating both **technological and commercial partnership** with 3rd parties

represents a common strategy to strengthen innovation, and it is either planned, considered desirable, or already done in the majority of cases. This resonates well with the complexity of the 5G ecosystem and the multitude of stakeholders involved.

In general, **prototyping and validation** activities, either realized in controlled or real environments, are seen as key exploitation activities in view of advancing the readiness level of the technology. FUDGE-5G and, more generally, research and innovation projects, represent relevant opportunities to test and validate such technologies in realistic environments.

In view of the commercial uptake of technologies, most of the assets plan or consider also beneficial to **realize a market study** and/or to **develop a business plan**. This is particularly relevant in case of innovative technologies such as those developed in FUDGE-5G as they require, before entering the market, a clear view on their potential value to the target customers. This represents as well one of the objectives of the analysis provided in this document.

On the contrary, seeking **legal assistance and advice** does not seems to represent a key exploitation objective, and it is considered a desirable activity when the exploitation involves specific regulatory requirements (e.g., spectrum and data protection to cite a few).

Finally, both pursuing **IPR protection** (in form of patents, trademarks, copyrights …) and influencing **standards** are considered key means to exploit and promote the technological advancements generated in the project. These two activities are strictly related in the 5G landscape, as standards facilitate communication between the different actors in the ecosystem, making it possible to create solutions at industrial scale. IPRs and patents represent a fundamental element of value creation from as they materialize the innovations to use them strategically to create and maintain value. This way of thinking is captured in the majority of assets that either plan to do, consider desirable to do, or have already done at least one of these two activities.

4. Standardization

4.1. Overview

Our standardization efforts are directed towards the following three SDOs: 3GPP, IETF and NATO Standardization Office (NSO). The FUDGE-5G topics for which standardization contributions are planned are 5GLAN, Non-Public Networks (NPN), Public Warning Systems (PWS), Service Routing (SR) as well as Slice Orchestration.

5G LAN type services is a feature introduced in 3GPP Release 16 to enable an emulation of LAN-like functionality into the 5G System. It is based on the concept of private 5G virtual network (5G VN). The set of devices attach into these 5G VN, which may be dynamically created by an operator or requested by Application Function via service exposure (NEF). The NEF might include the Group Management Function (GMF). This GMF will implement the functionality within the NEF for creating, modifying or removing a 5GLAN Group. Once the 5G VN is created, the UE will be accessing the 5G VN with a PDU session that is established for a specific 5G VN. Thus, the 5G LAN functionality would be provided by new features added to different network functions i.e. NEF, UDR, PCF, SMF and UPF that allow the creation, management and access to 5G Virtual Network.

The standardization work to introduce 5G LAN began in Release 15, inside the Study Items FS_5GLAN and FS_CAV; both led by SA1. This work derived into Technical Reports, which outlined the requirements of LAN-like services in 5G. Based on these reports, SA2 performed the normative work to introduce 5GLAN functionality into the 5G Core in Release 16, with an accompanying Study Item known as FS_Vertical_LAN to further explore topics and enhancements in this area. Finally, there was a proposal in Release 17, to keep studying topics left out in the Release 16 version, known as FS_5GLAN_enh, inside SA2; but was not accepted. These did include:

- Enhancement of 5G VN Group Management, including one to many mapping between DNNs and 5G VN groups; fast configuration support, how to enforce service area restriction of 5G LAN services; more efficient support over N19 tunnels, and how to improve reliability by supporting SMF redundancy in 5G VNs.
- Enhancement of 5G VN Group Communications, covering the support additional user plan efficiency; and potential improvements on packet routing and forwarding to support broadcast and multicast communications.

FUDGE-5G is integrating base 5G LAN functionality into its platform. Given the current status of 5G LAN standardization in 3GPP (basically frozen in Release 17) and depending on the concrete findings related to the said integration, concrete contributions on 5G LAN standardizations can be expected in Release 18.

NPN and its enhancements (eNPN), as well as **PWS** were addressed within 3GPP, while IETF is the most appropriate SDO to address **service routing** related standardization.

3GPP is currently formulating its release 17. **Non-public networks** are in the 3GPP standardization present through a number of work items under almost all stages. Among these work items the most important for the project are:

- WI #900015: Stage 2 for eNPN.
- WI # 850047 - TEI17: (Small) Technical Enhancements and Improvements for Rel-17.

As shown in the table below, FUDGE-5G standardization contributions on NPN fall within these two work items.

The 3GPP work on **broadcast and multicast** has been split into two separate work items:

- EnTV; Enhancement for TV service for Release-14.
- 5MBS: Architectural enhancements for 5G multicast-broadcast services in TS 23.247 for Rel-17.

EnTV is a service that fulfils the requirements for 5G, but uses E-UTRA (LTE radio). This service is intended for receive-only TV where no uplink exists. Hence, a valid subscription and USIM is not required for receive-only TV services. 5MBS specifies the stage 2 requirements for multicast and broadcast services. TS 23.247 is at the time of writing still under development and may or may not be finalized in the Release-17 time frame (freeze June 2021). The stage 3 protocol specifications will be developed under Release 18. From a formal perspective: no multicast/broadcast service for NR exists in 3GPP Release-17.

PWS for 5G is fully specified by 3GPP and is being deployed in 5G SA in some countries. Full service is expected in 2022.

The following specifications apply for PWS:

- Stage 1: TS 22.268, PWS Requirements.
- Stage 2: TS 23.041, CBS Service Specification.
- Stage 3: TS 29.518, AMF Service Specification and TS 38.413, NG-AP Specification.

Amongst others, due to the CU-DU split in the RAN node, there are additional specifications in the 38.4xx range.

In NATO Federated Mission Networking architecture, the Network Management & Cyber Defense (NMCD) is the entity in charge of the management and control of each network segment and cloud of a federation of networks. It provides near real-time control of network resources, as well as authentication and authorization of the network elements.

Thales participates in the IST-180 Network Management & Cyber Defense (NMCD) for Federated Mission Networking (FMN) activity in the definition of data models and exchange mechanisms to achieve end-to-end orchestration between different NMCD instances.

For service routing, FUDGE-5G focuses on IETF/IRTF. In IETF, **dyncast** drafts –HWDU contribution, no WG— are the most relevant. They propose an ingress architecture for service routing with an anycast addressing methodology for the service identifier. The selection of the suitable service instance (registered via its 'binding identifier') is constraint-based with those constraints being propagated as part of the service identifier advertisement. The use cases outlined are typical 5G use cases, therefore relevant to

FUDGE-5G, and the requirements and architecture outline the components of the ingress architecture. Those have a strong alignment with the SBA SCP architecture.

The COIN RG of IRTF has focus on micro-service based architecture. More generally, it explores existing research and fosters investigation of in-network computing and the resulting impacts of programmability in the data plane. The goal is to investigate how to harness and to benefit from this emerging disruption to the Internet architecture to improve network and application performance as well as user experience. HWDU co-authored drafts on use cases and micro-service centric datacenter architectures.

4.2. FUDGE-5G Standardization Contributions

The table below presents all FUDGE-5G standardization contributions in the concerned reporting period (September 2020 – May 2021).

WG	Title and document number or ID	Meeting Number, Date	Status	Comment
3GPP				
SA1	S1-204249 from Qualcomm: New WID: PWS support for NPN, co-signed by **one2many**	SA1#92, 10-19 Nov 2020	Not agreed	No agreement to do this work for Rel. 17
	S1-204078 from Nokia, Nokia Shanghai Bell, KPN, vivo, **one2many**, **Thales** Non public network support for PWS (CR to 22.268)	SA1#92, 10-19 Nov 2020	Noted	
	S1-210188 from Qualcomm: New WI on PWS for NPN (NPN_PWS), co-signed by **one2many**	SA1#93, 25 Feb – 5 Mar 2021	Not agreed	to be submitted for Rel-18
	S1-210189 from **one2many** Qualcomm Requirements for PWS over NPN (CR to 22.261), co-signed by **one2many**	SA1#93, 25 Feb – 5 Mar 2021	Noted	
SA2	S2-2008510 23.700-07 from **Huawei**, HiSilicon KI#2: Clarifications Sol#48: Solution for service continuity using application support	SA2 #142 (16 Nov– 20 Nov, 2020)	Approved as S2-2009146	

	S2-2008511 23.700-07 from **Huawei**, HiSilicon KI#2 Session continuity PLMN/SNPN	SA2 #142 (16 Nov– 20 Nov, 2020)	Noted	
	S2-2008985 23.700-07 from **Huawei**, HiSilicon KI#1, Evaluations and Conclusions regarding service discovery in external SP	SA2 #142 (16 Nov– 20 Nov, 2020)	Approved as S2-2009139 and S2-2009144	
	S2-2100505 CR 23.501 from **Huawei**, HiSilicon Service discovery between SNPN and separate entity hosting AUSF and UDM	SA2 #143 (24 Feb – 9 Mar, 2021)	Noted	
	S2-2100506 CR23.501 from **Huawei**, HiSilicon Discovery of UDM/AUSF in the separate entity and related reference architecture	SA2 #143 (24 Feb – 9 Mar, 2021)	Noted	
	S2-2100507 from **Huawei**, HiSilicon Service continuity for VIAPA	SA2 #143 (24 Feb – 9 Mar, 2021)	Approved as S2-2101069	
	S2-2102647 from **Huawei** Service discovery between SNPN and Credentials holder hosting AUSF and UDM	SA2 #144 (12 Apr -16 Apr, 2021)	Merged to S2-2102270 approved as S2-2102966	
IETF				
-	Dynamic-Anycast (Dyncast) Use Cases & Problem Statement [11]	Feb 15, 2021	I-D, active, expires Aug 15 2021	
	Dynamic-Anycast (Dyncast) Requirements: [12]	Feb 15, 2021	I-D, active, expires Aug 15 2021	
	Dynamic-Anycast Architecture: [13]	Feb 15, 2021	I-D, active, expires Aug 19 2021	
ICNRG	Internet Services over ICN in 5G LAN Environments [14]	Nov. 2020	Active	Updated draft with service-oriented

				principles in 5G User Plane
IRTF				
COIN RG	Use Cases for In-Network Computing [15]	Feb 17, 2021	I-D, active, expires Aug 21 2021	
	In-Network Computing for App-Centric Micro-Services [16]	Jan 26, 2021	I-D, active, expires Jul 26 2021	
NATO				
IST-180 (COM)	Network Management & Cyber Defense (NMCD) for Federated Mission Networking (FMN) [10]	TBA	Active (2020-2023)	
NGMN				
Service Based Architecture (Phase 3)	White Paper "5G Network Customization Based on Service Based Architecture" To appear	March 2021	Closed	
Future Networks Cloud Native Platform	D0 – "State of the art and gap analysis"	May 2021	Active	
	D1- "Cloud Native Enabling Future Telco Platforms v5.2" [17]	May 2021	Active	
	NGMN internal white paper – "Executive Summary on Cloud Native Enabling Future Telco Platforms" [18]	May 2021	Active	

5. Conclusion

- This document provided an initial report on the innovation, exploitation, and standardization activities carried out during the first nine months of the FUDGE-5G.
- We have set up the analysis of the innovation potential of the project with respect to the 5 targeted NPNs. We also provided the initial exploitation vision for each identified innovation, together with a report of the standardization items that have been contributed and/or are under active monitoring.
- This document will be updated during the project to reflect the advancements in terms of innovation, exploitation and standardization activities.

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