H2020 5GASP Project

Grant No. 101016448

D7.3 Market Research Report

Abstract. This document is a report of Market Research Activities performed by the Consortium Members within the scope of WP7. Specifically, we treat market research as a key component of the 5GASP business plan to be delivered at M24 of the project. The objective of of this document –which will be a living document, regularly being updated from monitoring the markets of interest - outlines the determination of market size, major competitors, service offerings, and market segmentation for two groups of NetApps addressing the Automotive and PPDR Segments. Evidently, the market analysis outcomes in this document show a market opportunity and potential for both the forementioned market segments and beyond. The document discussses thekey findings and and presents the directions of future work in terms of the parallel WP6 / Community Engagement and WP7 / Exploitation and Dissemination actitities that the project actively pursues towards grasping the momentum and deriving viable business models. Finally, this document includes, for all NetApps of the SMEs of the Consortium, an initial analysis of the business elements of each NetApp in terms of Value Proposition pertinent to its target market segment, a list of existing and potential customers, identification of competitors, a discussion of the NetApp's intended licensing / pricing schemes as well as a first version of SWOT analysis of the NetApp.

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Disclaimer

Executive Summary

5GASP aims at shortening the idea-to-market process through the creation of a European testbed for Small and Mid-size Enterprises (SMEs) that is fully automated and self-serviced, in order to foster rapid development and testing of new and innovative Network Applications (NetApps) built using the 5G Network Functions Virtualization (NFV)-based reference architecture. Building on top of existing state of the art experimental 5G infrastructures, 5GASP intends to focus on innovations related to the operation of experiments and tests across several domains, providing software support tools for Continuous Integration and Continuous Deployment (CI/CD) of VNFs/CNFs in a secure and trusted environment for European SMEs capitalising in the 5G market.

The Market Research Report document will summarize the research performed by the project via discussing and analyzing current Market Trends, Market Players and Market Value for each of the selected, namely the Automotive and PPDR Applications Verticals, which are primarily addressed by in the 5GASP project.

This document provides an account for:

- An analysis of the Cloud-Native 5G Context for enabling scalable, efficient and secure deployments of NetApps.
- An initial analysis of the PPDR 5G Apps Market, including its overall Value, the trends in this Market, notable players, opportunities and challenges in developing NetApps and the Market Evolution.
- An initial analysis of the Automotive 5G Market Value, trends, challenges and opportunities and to identify notable players and Market Evolution potential.
- An assessement of the overall 5G Apps Market Value Chain,
- A presentati of key finding and directions for future work within the scope of WP7 as defined in the project’s Description of Work and its associated timeplan.
- An initial analysis of the business elements of each NetApp in terms of Value Proposition pertinent to its target market segment, a list of existing and potential customers, identification of competitors, a discussion of the NetApp’s intended licensing / pricing schemes as well as a first version of SWOT analysis of the NetApp.

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3GPP	3rd Generation Partnership Project
5G IOPS	5G Isolated Operation for Public Safety
5G PPP	5G Infrastructure Public Private Partnership
5GAA	5G Automotive Association
5GASP	5G Application & Services experimentation and certification Platform
5GC	5G Core
5QI	5G QoS Identifier
ADAS	Advanced Driver Assistance Systems
AF	Assured Forwarding
AI	Artificial Intelligence
AMazING	Advanced Mobile wireless Network playground
AMF	Access and Mobility Management Function
AOEP	Automotive Open Experimental Platform
API	Application Programming Interface
APN	Access Point Name
APCO-P25	A suite of standards for interoperable digital two-way radio products
AUSF	Session Management Function

BBU	Baseband Unit
BSS	Business Support Systems
BW	bandwidth
C2C-CC	Car2Car Communication Consortium
CaaS	Container as a Service
CAM	Cooperative Awareness Messages
CAGR	Compound annual growth rate
CCAM	Cooperative, Connected and Automated Mobility
CEN	European Committee for Standardization
CI/CD	Continuous Integration and Continuous Deployment
CISM	Container Infrastructure Service Management
C-ITS	Cooperative Intelligent Transport Systems
CNF	Cloud-native Network Function
COP	Common Operational Picture
COTS	off-the-shelf
CP	Control Plane
CPE	Customer-Premises Equipment
CPM	Collective Perception Message
CPRI	Common Public Radio Interface
CPU	Central Processing Unit
CRUD	Create, Read, Update, and Delete
CS	Customer Service
CSI	Communication Service Instance
CSMF	Communications Service Management Function
CU	Centralized Unit
CWDM	Coarse Wavelength Division Multiplexing
DEMN	Decentralized Environmental
DevOps	Development and Operations
DN	Data Network
DNS	Domain Name System
DPDK	Data Plane Development Kit
DRT	Demand Responsive Transportation
DU	Distributed Unit
E2E	End-to-End
EDGE	Enhanced Data GSM Environment
ELK stack	Elasticsearch, Logstash, and Kibana

eMBB	Enhanced Mobile Broadband
eNB	evolved Node B
ENDC	E-UTRAN New Radio – Dual Connectivity
EPC	Evolved Packet Core
ESN	Emergency Services Network(s)
ETSI	European Telecommunications Standards Institute
EVE	Evolution and Ecosystem
FEC	Forward-Error-Correction
ExVe	Extended Vehicle
FIDEGAD	Fire detection and ground assistance using drones
GDPR	General Data Protection Regulation
gNB	gNodeB
GPS	Global Positioning System
GPU	Graphics Processing Unit
GSMA	Global System for Mobile Communications Association
GST	General Slice Template
GUIs	Graphical User Interfaces
H2020	Horizon 2020
HO	Handover
HSS	Home Subscriber Server
IaaS	Infrastructure as a Service
ICT	Information and Communication Technologies
IOC	Information Object Class
IoT	Internet of Things
IP	Internet Protocol
IPsec	Internet Protocol Security
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
ITU	International Telecommunication Union
KNFs	Kubernetes-based Network Functions
KPI	Key Performance Indicator
L2	Layer 2
L3	Layer 3
LIDAR	Light Detection and Ranging
LoRa	Long range, low power wireless platform

LTE	Long-Term Evolution
LTR	Local Test Repository
M	Month
MAC	Medium Access Control
MAE	Mobile Automation Engine
MANO	Management and Orchestration
MAP	Map Data
MC	Mission-Critical
MCData	Mission-Critical Data
MCPTT	Mission-Critical Push To-Talk
MEC	Multi-Access Edge Computing
MEPM	MEC platform manager
MIGRATE	Mobile Device Virtualization through State Transfer
MIMO	multiple input, multiple output
ML	Machine Learning
mMTC	massive Machine-Type Communication
MNO	Mobile Network Operator
MPLS	Multiprotocol Label Switching
MShed	MShed Museum
MSq	Millennium Square
NaaS	Network as a Service
NBI	North Bound Interface
NER	Named Entity Recognition
NEST	Network Slice Template
NetApps	Network Applications
NetOr	Cross Domain Network Orchestrator
NFs	Network Functions
NFV	Network Functions Virtualization
NFV ISG	NFV Industry Specification Group
NFVI	NFV Infrastructure
NFVO	NFV Orchestrator
NG-RAN	New Generation - Radio Access Network
NICs	Network Interface Cards
NMS	Network Management System
NODS	NetApp Onboarding and Deployment Services
NR	New Radio
NRF	Network Repository Function
nRT-RIC	near Real Time RAN Intelligent Controller

NS	Network Service
NSA	Non-Standalone Architecture
NSD	Network Service Descriptor
NSMF	Network Slice Management Function
NSSAI	Network Slice Selection Assistance Information
NSSF	Network Slicing Selection Function
NSSI	Network Slice Subnet Instance
NSSMF	Network Slice Subnet Management Function
NWDAF	Network Data Analytics Function
OAM	Operations, Administration and Maintenance
OBU	On-Board Unit
ODA	Open Digital Architecture
ONAP	Open Network Automation Platform
ONE	Outdoor and iNdoor 5G Experiments
O-RAN	Open RAN
OSI	Open Systems Interconnection
OSM	OpenSourceMANO
OSS	Operations Support Systems
PaaS	Platform as a Service
PCI	Physical Cell ID
PDCP	Packet Data Convergence Protocol
PHY	physical
PII	Personal Identifiable Information
PKI	Public Key Infrastructure
PMR	Private Mobile Radio
P-NESTs	Private NESTs
PNF	Physical Network Function
PoP	Point of Presence
PPDR	Public Protection and Disaster Relief
qMON	Quality Monitoring System
QoE	Quality of Experience
QoS	Quality of Services
RAN	Radio Access Network
RESTful	Representational State Transfer
R-ITS-S	Roadside ITS Stations
RSRP	Reference Signal Received Power
RSUs	Road Side Units

RT	Real-Time
RU	Radio Unit
SA	Standalone Architecture
SAM	Service Announcement
SDN	Software-Defined Networking
SDOs	Standard Development Organizations
SLA	Service Level Agreement
SLS	Service Level Specification
SM	Slice Manager
SMEs	Small and Mid-size Enterprises
SW	software
T&L	Transport & Logistics
TETRA	Terrestrial Trunked Radio
TETRAPOL	Digital professional mobile radio standard, as defined by the Tetrapol Publicly Available Specification (PAS), in use by professional user groups, such as public safety, military, industry and transportation organisations throughout the world
TBD	To Be Determined
TRL	Technology Readiness Levels
UDM	Unified Data Manager
UE	User Equipment
UI	User Interface
UML	Unified Modeling Language
UPF	5G User Plane Function
UPF	User Plane Function
URLLC	Ultra-Reliable Low Latency Communications
V2C R2C	Vehicle-to-Cloud Real-Time Communication
V2C/C2V	Vehicle-to-Cloud / Cloud-to-Vehicle
V2X	Localised communications between the vehicle and its surrounding environment
VAL	Vertical Application Layer
vApps	vertical and cross-vertical NetApps
VDUs	Virtualized Distributed Units
VIM	Virtualized Infrastructure Manager
VM	Virtual Machine
VNFM	VNF Manager
VNFs	Virtual Network Functions
vOBU	Virtual On-Board Unit

VPN	Virtual Private Network
VRP	Vehicle Route Problem

1. Introduction

1.1. Objectives of this document

This initial market study report gathers information about the commercial challenges and opportunities arising from the development of a Innovative NetApps for the PPDR and Automotive verticals, primarily addressed by the project.

Specifically, for each vertical, this documents presents an nitial analysis of the corresponding to the vertical Market, including its overall Value, the trends in this Market, notable players, opportunities and challenges in developing NetApps and the Market Evolution.

The information provided herein is to support the development of the 5GASP business models pertinent to the addressedmarket verticals and will provide an objective overview of opportunities and challenges towards developing a viable ecosystem of services/products/technologies with commercialision potential.

[1]Finally, this document includes, for all NetApps of the SMEs of the Consortium, an initial analysis of the business elements of each NetApp in terms of Value Proposition pertinent to its target market segment, a list of existing and potential customers, identification of competitors, a discussion of the NetApp's intended licensing / pricing schemes as well as a first version of SWOT analysis of the NetApp.

5G requires dynamic allocation of computing and storage resources, flexible deployment of functions in distributed cloud infrastructures wherever needed, and at the transport level, to embed the required end-to-end control and data plane connectivity between software peer entities and devices/terminals, as well as across physical network elements in order to meet end-to-end demands.

This, in turn, paves the way towards a common, agile and open network substrate driven by advanced intelligent network orchestration, while it opens up the market for innovation, wide adoption and new products to more players of different technical backgrounds and business domains.

The NetApps Market is not yet clearly defined and cannot be precisely evaluated at this moment. Therefore, to understand the context, we will be looking at existing market studies, evolution and trends for related markets and attempt to position the target NetApps around them.
A key innovation of 5GASP[1] is creating a marketplace portal that aggregates NetApps from several SME's or any other NetApp developer in a single location curated by the NetApps

Community. The portal will include information of tests/validations which NetApps has successfully passed as well as testbeds and Network Operators that have successfully deployed the NetApp. The purpose of this portal is to promote the SME's and their respective NetApps as well as the platforms and operators that support them. Furthermore, this portal can be marketed in a way similar to stores for mobile apps, such as Apple's App Store[2] and Alphabet's Google Play[3].

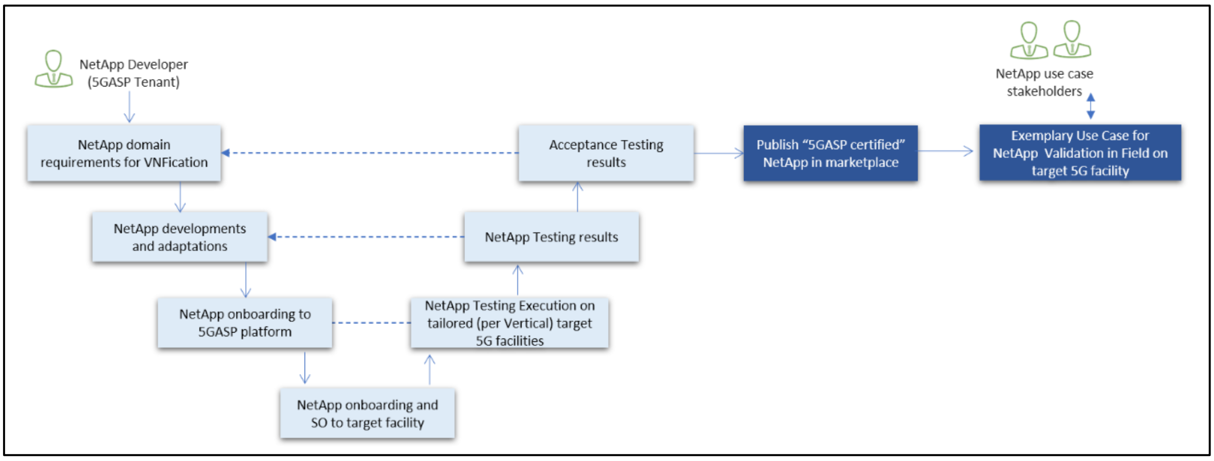


Figure 1- 5GASP Methodology Diagram

The business model based on a NetApp Store assumes that SMEs and start-ups developing NetApps can offer their tested and certified products, which can be deployed in minutes, to service providers and other users and developers who will leverage by employing these reusable network applications in their business. Business models will be developed and validated aiming at the sustainability of the 5GASP business solution.

The business planning process shall cover the entire value chain identifying the stakeholders for each step of the chain. This involves:

- the identification of points of exploitation in the system,
- the definition of different billing/costing (revenue streams) models to the end-users
- reimbursement models to the NetApp creators and/or experimental infrastructure providers.

The project aims to exploit the implementation of the open 5GASP platform and its associated NetApp Store repository[1], where initially a number of NetApps shall be deposited, along with documentation on best practices on how to build NetApps.
The engagement of third parties to the 5GASP open platform is the real Impact of 5GASP. It can generate significant revenues to SMEs innovating in 5G, since the demand of the innovative NetApps is of great demand from 5G stakeholders worldwide, such as telco hardware manufacturers, 5G operators, SMEs capitalising in 5G and finally 5G end-users who shall obtain lower-prices when accessing 5G services and products implemented as software NetApps.

Along these lines, the 5GASP Project is clearly a business-oriented project that aims to make an actual impact in the creation of innovative NetApps by European SMEs and assist in the growth and sustainability of involved SMEs. The project treats the business modelling and planning tasks as catalyst activities that will steer the technical activities and address the needs of third parties working on different 5G verticals.
An analysis of strengths, weaknesses, opportunities, and threats for each application has been done by the members of the ConsortiumConsortium with the most valuable expertise in each topic.

1.2. Related Projects

The list of the related projects is quite long, as the focus of this deliverable will be shifted towards Automotive and Public Protection and Disaster Relief (PPDR) projects, from which some ideas, or results could be referenced herein.

Automotive Projects

5G-IANA
5G-IANA started on June 1st, 2021. 5G-IANA aims at providing an open 5G experimentation platform, on top of which third party experimenters (i.e., SMEs) in the Automotive-related 5G-PPP vertical will have the opportunity to develop, deploy and test their services. An Automotive Open Experimental Platform (AOEP) will be specified, as the whole set of hardware and software resources that provides the compute and communication/ transport infrastructure as well as the management and orchestration components, coupled with an enhanced NetApp Toolkit tailored to the Automotive sector. 5G-IANA will expose to experimenters secured and standardised APIs for facilitating all the different steps towards the production stage of a new service. 5G-IANA will target different virtualisation technologies integrating different MANO frameworks for enabling the deployment of the E2E network services across different domains (vehicles, road infrastructure, Multi-Access Edge Computing (MEC) nodes and cloud resources). 5G-IANA NetApp toolkit will be linked with a new Automotive VNFs Repository including an extended list of ready to use open accessible Automotive-related VNFs and NetApp templates, that will form a repository for SMEs to use and develop new applications. Finally, 5G-IANA will develop a distributed Artificial Intelligence (AI) / Machine Learning (ML) framework, that will provide functionalities for simplified management and orchestration of collections of AI/ML service components and will allow ML-based applications to penetrate the Automotive world, due to its inherent privacy-preserving nature. 5G-IANA will be demonstrated through 7 Automotive-related use cases in 2 5G SA testbeds. Moving beyond technological challenges, and exploiting input from the demonstration activities, 5G-IANA will perform a multi-stakeholder cost-benefit analysis that will identify and validate market conditions for innovative, yet sustainable business models supporting a long-term roadmap towards the pan-European deployment of 5G as key advanced Automotive services enabler.

5G-MOBIX
This ongoing H2020 project aims at executing Cooperative, Connected and Automated Mobility (CCAM) trials along x-border and urban corridors using 5G core technological innovations to qualify the 5G infrastructure and evaluate its benefits in the CCAM context as well as defining deployment scenarios and identifying and responding to standardisation and spectrum gaps. Those trials will allow running evaluation and impact assessments and defining also business impacts and cost/benefit analysis. As a result of these evaluations and also international consultations with the public and industry stakeholders, 5G-MOBIX will propose views for new business opportunities for the 5G enabled CCAM and recommendations and options for the deployment. ITAv takes part in 5G-MOBIX.
SECREDAS
SECREDAS (Security for Cross-Domain Reliable Dependable Automated Systems) is a project (2018-2022) developing secure technologies (hardware, software) to collect and transmit data, mostly for the automotive industry, but also for railways and healthcare verticals. Early on, the ConsortiumConsortium decided to develop the technologies related to the automotive sector in compliance with Cooperative Intelligent Transport Systems (C-ITS) standards. While not a strong focus of SECREDAS, 5G is also considered as the novel technology to connect vehicles to the cloud. YoGoKo is participating to SECREDAS and is leading WP5 “connectivity”. 5GASP will thus benefit from the expertise developed by YoGoKo and from technologies developed to secure access to vehicle data in conformance with C-ITS standards.
5GinFIRE
The automotive environment in 5GinFIRE, provided by ITAv, has consisted of on-Board Units (OBUs) in the vehicles, roadside units (RSUs) and datacenter. The vehicles were connected among each other via standard IEEE 802.11p/WAVE links and to the RSUs and the Internet through IEEE 802.11p/WAVE, IEEE 802.11g/WiFi or 4G/LTE C-RAN. The datacenter included, among other components, the Virtualized Infrastructure Manager (VIM), directly connected to the multi-site orchestration managed by OSM MANO deployed in 5TONIC (another 5GINFIRE facility), and the Network Function Virtualization Infrastructure (NFVI). Experimenters have had access to real OBUs, RSUs, In-Car Node Processors, and so forth, also having the possibility to create and deploy their own VNFs within the Automotive testbed. Possibilities of evaluating/validating automotive VNFs services included V2X communication performance and metrics (e.g., latency vs overhead, throughput vs packet loss, and so forth), as well, testing automotive VNFs within the car with its diversity of contextual-aware information gathered from extra sensors (traffic signals) and from OBUs internal sensors available (accelerometers, heading, speed, link quality connection, GPS, compass, RSSI, car neighbour’s density, and so forth).

PPDR Projects

5G-EPICENTRE
5G-EPICENTRE just started in January 2021 and will deliver an open end-to-end experimentation 5G platform focusing on software solutions that serve the needs of PPDR. The envisioned platform will enable SMEs and developers to acquire knowledge with regard to the latest 5G applications and approaches for first responders and crisis management, as well as to build up and experiment with their solutions. The engaged SMEs and organisations that will participate into the realisation of the use cases constitute active players in the public security and disaster management, thus acting as key enablers for the assessment of 5G-EPICENTRE with regard to the real needs that should be addressed. Best ideas and practices can be reused in 5GASP for the PPDR use cases.
5GinFIRE
5GINFIRE focused on developing Experimental Facilities for PPDR use cases which have evolved into the ININ PPDRone product also used and further developed for advanced use cases within 5GASP. 5GINFIRES's PPDRone facility provided 5G-ready network, orchestration and management components, performance monitoring, NFV environment, and many more. It was connected through a secure VPN connection with the 5TONIC core site, i.e., another 5GINFIRE facility. Next to this, PPDRone has also provided PPDRone Node, a portable 5G-ready mobile radio, Core and Cloud node to be deployed in the field. The goal of possibilities provided (indoor experimentation site, outdoor experimentation site, portable mobile system) was primarily intended to PPDR network provider related experiments and PPDR end-user and service provider related experiments, e.g., PPDR network resilience and high availability architecture verification, radio experiments from functional and performance aspects, end-to-end performance testing of network architecture, IaaS nodes and network services, deployment and testing PPDR mobile applications in real-world settings, performance verification of deployed services, and so forth.
PPDR-TC
The PPDR-Transformation Centre (PPDR-TC) (GA: 313015) project concentrated to provide a harmonised frequency allocation in order to enhance cross-border coordination, increase the potential for interoperability and international cooperation and improve spectrum management and planning for PPDR operations. The main outcome has been the recommendations for a PPDR roadmap in a form of a white paper for next generation PPDR systems. This was addressed to network operators and system integrators. 5GASP considers the recommendations of PPDR-TC for 3G/Long-Term Evolution (LTE) and places them in the context of 5G. Moreover, the NetApps derived from ININ’s and Lamda Network’s PPDR use cases shall provide validated proof of compliance with the PPDR-TC’s recommendations and they shall also unleash the interoperability dimension of the value proposition of 5GASP, towards catering for PPDR solutions which: • are not bound to the hardware requirements of telecom operators; • enable cross-border PPDR operations to work seamlessly among collaborating albeit country-specific telecom operator substrates.

1.3. The Context of Cloud-Native 5G

Cloud-Native 5G best describes the architectures, technologies and processes able to support reliable, scalable and secure, cloud-oriented business models. Key models and components of Cloud-Native deployments consist of practices such as continuous deployments, microservices-based architectures, the use of containers and the achievement of elastic scaling capabilities with readiness to introduce new functionality with increased automation.

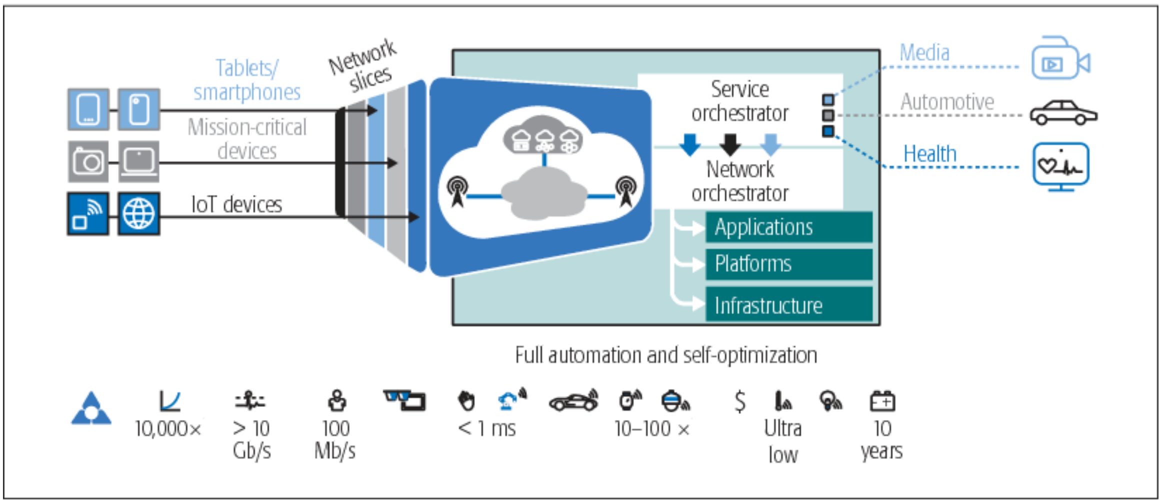


Figure 2 - Cloud-Native 5G Architecture

The 5GCore[4] (5GC) standard of 3GPP introduces a new service-based architecture (SBA), which is designed for cloud-native deployment as a set of interconnected Network Functions that deliver control plane functionality and common data repositories of a 5G network. By deploying cloud-native SBA, new requirements arise for control, coordination and orchestration of Network Functions distributed across the network. These Network Functions present as containerised microservices that can support the 5G Core, vRAN and LANs.

Cloud-Native Applications - are applications characterised by scalability and efficiency, able to decompose software into smaller, manageable pieces through the usage of microservices. This design convention reaches to structure an application as a collection of loosely coupled stateless services supported by stateful backing services. By implementing these mechanisms, a Cloud-Native application will have the capability to be deployed, scaled and upgraded through a granular process.

The principal benefits and opportunities of Cloud-Native are

- operational efficiency,
- shorter time to market for new services,
- improved security and improved automation through CI/CD,
- Improved life cycle management,
- improved resource utilization,
- native ability to scale,
- migration from a vertical to a horizontal stack implementation.

In this context, the success of service providers in the 5G era and ecosystem will be based on their ability to deliver Network and related Services to their customers in a flexible, cost-efficient, and cloud-native fashion. As the cloud-native software development and deployment accelerates the creation of new services at a lower cost, providers will have to enable their infrastructure sites to support the cloud-native stack of technologies (often, based on the Kubernetes ecosystem). Conversely, software application creators, who are using a cloud-native approach, need to be able to access the 5G services and (when necessary) the underlying infrastructure in a seamless, transparent, and API-driven way using compatible tools that traditional cloud provider platforms provide. For example, Kubernetes, which is an internal Google stack and toolchain, released into the open-source domain circa 2014, is a containerisation platform that is majorly supported by both cloud providers and software developers and sees a meteoritic rate of adoption. Just as telco service providers have previously rallied around efforts such as Infrastructure-as-a-Service OpenStack, the community now pivots towards support in this Cloud-Native Computing Foundation (CNCF)-based technologies in a network environment.

1.4. Document structure

This document is composed of five chapters, the first Chapter as an introductory title, presenting the objectives of this document, the context of Cloud-Native 5G including concepts and benefits and the approach and methodologies used in 5GASP, pertinent to the 5G Applications Markets.

Chapters 2 and 3 presents, in distinct sections, the two major markets of interest: PPDR and Automotive, with each section containing information related to Market Value, Market Evolution, trends, identification of most important players, opportunities and challenges to the Apps ecosystems. These two chapters refer to the two business verticals for which 5G Applications will be demonstrated in 5GASP, with contributions from SMEs in their roles as developers.

Chapter 4 discusses the Market Value Chain across business verticals, as the fifth Chapter provides conclusions and directions for future work.

The Appendix presents an initial discussion, on the business aspects of the Automotive and PPDR NetApps in 5GASP

2. PPDR Market Overview

Communications in Public Protection and Disaster Relief sector have for a long time relied on narrowband networks, which is still today a case in many countries. Narrowband PPDR communication systems are mainly utilising mission-critical voice and, in certain cases, low-speed data services. Although there are still analogue systems in use, PPDR communications have over the years adopted digital technologies in order to improve voice quality, provide end-to-end encryption and some other advanced functionalities enabled by digital technology. In Europe, TETRA and TETRAPOL are most commonly used. APCO P25 technology

(Association of Public-Safety Communications Officials Project 25) is also used[6], although the latter is otherwise predominantly used in North America. PPDR communication systems, including those already mentioned, have in the past lagged several technological generations behind the commercial sector and even the aforementioned, digital communication systems are still unable to support up-to-date services already available in commercial networks, e.g., broadband services (massive) IoT devices support[5] [6], etc. Therefore, International Telecommunication Union considers 5G and LTE-Advanced systems as a mission-critical PPDR technology able to address the needs of mission-critical intelligence by supporting mission-critical voice, data and video services[7]. Also, the EU funded Broadmap project has in its deliverable D4.1 defined a solution for the next generation of radio systems for PPDR, which are, at the radio network level, based on the 3GPP Release 15 mission-critical standards[8].

So far, many nation-level BB PPDR deployments hosted on the 4G and/or 5G-ready networks are already operational or are in the process of being deployed, e.g., FirstNet in the US, Emergency Service Network (ESN) in the UK, SafeNet in South Korea, and those expected to recently come to light: the Royal Thai Police's 4G network (already operational in the greater Bangkok region), Finland's VIRVE 2.0, France's PCSTORM, Russia's secure 450 MHz 4G network for police forces, emergency services and the national guard[5] [9]. As we can see, there is a kind of common vision worldwide to improve the technological base of PPDR communications, while it is not obvious whether systems deployed in different countries would be interoperable one with each other, which might make sense as in certain point it comes to the national security and related aspects. However, at least in EU, there are initiatives like projects Broadmap and Broadway which strive to make EU member states' mobile broadband networks for Public Safety interoperable, while at the same time preserving the independence of each national Network and EU agencies operating in the field of PPDR[10] (e.g., Frontex, Europol).

Since 3GPP has lately standardised a few features for 5G (and previously for 4G as well) addressing the PPDR sector, the PPDR vertical can benefit substantially on 5G when it is properly matured, e.g: search and rescue support using emergency robots and unmanned aerial vehicles (UAVs), sensing of the affected areas using high definition (real-time) video streaming and massive Internet of Things (IoT), multimedia messaging, mobile office/field data applications, location services and mapping, situational awareness and other broadband capabilities, as well as mission-critical voice services provided by traditional system[5] [9]. To support envisioned services, there are numerous requirements requested to be met by the PPDR network, such as extremely high availability and reliability, mission-critical services support, direct device-to-device operation, ad-hoc coverage augmentation, isolated operation and network resilience during disaster scenarios, and quality guarantees and priority access in both day-to-day operations as well as under disaster circumstances[5].

Therefore, when it comes to certain specific technologies like 5G Apps for PPDR operations support (as one of the 5GASP Project objectives), the future of the Market is yet unclear since the infrastructure needs to be provided first and, as will be discussed later, will take quite some time. However, once the infrastructure is ready, opportunities are expected both on a national and a cross-country level. The architecture proposed in the aforementioned Broadmap and Broadway projects (i.e., SpiceNet reference architecture[6] [8]) would require similar solutions as the ones being developed and tested within the 5GASP project's PPDR use case.

2.1. Market Value

As we can conclude from the above text, the 5G PPDR Network and Services Market is not yet established. Therefore, Market Value estimations can be made on the current situation and expected impact of gradually introducing 5G technologies into the PPDR sector. As in commercial networks, we may expect the evolution of 4G/LTE PPDR systems towards 5G systems, hybrid networks to be in use at a certain point (e.g., Belgium is for the time being using the broadband commercial network for non-mission-critical PPDR services), and also direct migration from TETRA/TETRAPOL to 5G[7] [9] [11]. It is also necessary to consider PPDR networks will not all follow the same model in terms of sharing or not sharing capabilities with commercial customers - different strategies are expected to be employed, e.g., dedicated RAN and core, shared RAN and dedicated core, dedicated RAN and shared Network, or shared both RAN and core. Trends and evolution of PPDR networks from narrowband to broadband is further discussed in Chapter 2.2. Market Trends and 2.4 Market Evolution.

According to SNS Telecom & IT research[9], annual investments in future PPDR infrastructure will be predominantly driven by new buildouts and the expansion of existing dedicated and hybrid commercial-private networks in a variety of licensed bands, in addition, to secure MVNO networks for critical communications. The Market is expected to further grow at a CAGR of approximately 10% between 2020 and 2023, eventually accounting for more than $ 3 billion by the end of 2023. Market Research Future's research[7] predicts a market size of $ 3,25 billion by 2025; the research highlights that Europe had been dominating the public safety (LTE/5G) market. On the other side, Global Industry Analysts research[12] projects a global public safety (LTE/5G) market size of $ 12.8 billion by 2025, growing at a CAGR of 18% over the period 2020 - 2025. Services, as one of the segments contributing to total Market Value, are projected to record a 21% CAGR and reach $ 6 billion by 2025.

2.2. Market Trends

Although there is a clear turn towards broadband networks for future PPDR operations, as described at the beginning of Chapter 2, there are still many countries or regions that are expected to stay with narrowband solutions (TETRA, TETRAPOL) for the next decades or so. Some characteristic examples include Germany (upgrading its TETRA network from TDM to IP[13] at the time being[14]) as well as the Netherlands, and Switzerland[15]. Based on this, the evolution of the Market will most likely be much slower compared to what is expected in the commercial Market.

However, countries that keep narrowband solutions for PPDR services in operation express positive trends toward shifting to a broadband solution. Many of them already plan broadband trials in the years to come[15]. A possible business opportunity for the 5G PPDR verticals and, especially, SMEs would lie in leveraging (independent) test/trial environments, including 5G Apps ecosystems, 5G-related knowledge and consultations.

Shifting to broadband PPDR networks has started by combining mission-critical narrowband networks for mission-critical services and broadband networks for non-critical services, e.g., Belgium, whose Blue Light Mobile service introduced in 2017 is still a limited data solution as it does not meet mission-critical requirements[15]. Such an approach of transition could also be expected with countries that plan to use narrowband networks in the mid-term. It might be worth mentioning France's approach here that is working on deploying a broadband network that will serve all PPDR services and provide interoperability between the different services and agencies. The deployment of the Network will occur over the next couple of years, and the French Ministry of Interior expects to begin migrating users over in 2023. The first departments and agencies to make the transition to the new service will be those supporting the 2023 Rugby World Cup. In addition, agencies and departments in Paris and its inner suburbs will also make the transition during that year in preparation for the 2024 Olympic games. In 2024, France plans to start the transition of another 90.000 users to the Network and finish the transition to the new Network by 2025. The new Network will move from TETRAPOL standards to 3GPP standards and will purchase services from two mobile network operators (MNOs) rather than via a dedicated network. The new Network will have a dedicated core that connects to the MNOs, and the plan is to connect to the first MNO in 2022[15].
As previously stated, the 5G PPDR Market will grow gradually in terms of both infrastructure and services, while it is unlikely for the majority of PPDR networks to become completely broadband earlier than in 10 years in the future.

2.2.1. Opportunities for the Evolution of 5G Apps Ecosystems

As stated by our partner ININ, an expert SME in the PPDR area, the vertical of PPDR is well behind the innovations brought upon the evolution of communication networks. TETRA is used in many cases whilst many EU countries still have not adopted 4G for their PPDR services yet. 5G is not currently supported for PPDR - at least at a country level within the EU - with only some research efforts taking place in Europe, such as the effort of ININ for the country of Slovenia.

The above statements are supported by the survey of the 5G-EPICENTER H2020 project, which is working on NetApps for the PPDR vertical. According to 5G-EPICENTER's questionnaire in their deliverable D1.3,[16] *"The majority of the participants (58% entered 4 or 5) believe that the PPDR services are limited by current networks".*

Given the limitations of commercial 4G networks to cater to the requirements of PPDR stakeholders, mainly public authorities, there is a considerable market opportunity in transferring 5G innovations within the PPDR vertical. Specifically, 5G networks are able to provide URLLC services via dedicated slices to PPRD service providers. However, having access to URLLC services is not the only requirement of PPDR stakeholders. For example, PPDR services must comply with security and privacy standards and regulations. Thus, the message is that 5G is not enough to cater to PPDR as a network communication technology. It is the NetApp concept that leverages the 5G communication services as one key promising approach towards building user-driven PPDR services in the form of interconnected Network Functions. Such user-driven PPDR services shall be the ones that shall satisfy all the requirements of PPDR stakeholders, and these PPDR services shall succeed in the PPDR market, a highly competitive market but still critical to address Market for the safety of citizens at the international level.
To that end, Europe's advances and investment on 5G NetApps can strongly lead to innovations by EU SMEs and/or large industries to grasp the market momentum and innovate and capitalise within the PPDR market.

5GASP shall demonstrate - in its WP4 PPDR use case - the technical feasibility to implement and validate NetApps that can consist of (i) Network Functions (NFs) dedicated to specific PPDR service requests (these NFs will be developed by ININ) and (ii) NFs that are involved in the staging phase of a real PPDR service deployment, specifically NFs that shall detect potential privacy leaks of the network messages involved in the network communications between First Responders and between First Responders and their responsible Control Command. Via detection of privacy leaks during staging, PPDR service developers shall refine their implementation in order to eliminate privacy leaks and ensure that once that they deploy their implementation in the operational environment no such leaks will be possible to occur. This second line of work in analysing the privacy vulnerabilities of PPDR communications is the goal of Lamda Networks' PrivacyAnalyzer NetApp. Summarising the above, 5GASP shall demonstrate how two different NetApps (one by ININ and one by Lamda Networks) can inter-work over a 5G substrate towards providing a privacy-aware 5G-enabled PPDR service, which shall be demonstrated in the University of Patras testbed. Therefore, 5GASP - via its NetApp community and NetApp store free offerings - can provide substantial help to PPDR innovators across Europe. For example, a cyber security SME can provide their solution as a NetApp that shall be a core element of a novel PPDR service which constitutes of inter-working specialised NetApps.

As discussed previously, the Market for 5G in the PPDR sector is not established yet as not much 5G infrastructure for PPDR is in service. Due to 5G PPDR trials and related expectations, the opportunity on short-term could be in establishing, operating, and supporting testing/trial environments for both operators and PPDR practitioners considering the ability to test and validate the behaviour and performance under realistic circumstances is key importance and a prerequisite for a commercial rollout and successful adoption of new technologies and solutions. We may note that a test/trial environment consists of both infrastructure elements and (5G) Apps. As these environments can be highly flexible, it could be expected that infrastructure vendors will have an interest in participating. A review of the available literature shows an underrepresentation of 5G facilities supporting PPDR-centric experimentation and trials, and there continues to be a scarcity of available performance studies of broadband 5G networks for PPDR that needs to be conducted in real-world experimental deployments[5]. E.g., in cases where PPDR services would share the same 5G commercial infrastructure with other users, a test/trial environment would be extremely beneficial since the transition to and the adopting of 5G for PPDR implies a challenge regarding resources, aspect of designing physical and virtual architectures (in terms of ownership and sharing models), migration strategies and backward compatibility, and functional architecture designs capable of meeting stringent PPDR performance characteristics.

There are already several potential issues identified that can be addressed for different stakeholders through such experimentation environments:

- vendors, commercial mobile operators, PPDR operators, PPDR network and services integrators, application developers, PPDR practitioners: unavailability of 5G infrastructures for test and verification for PPDR needs; limited locations where test/verification can take place,
- vendors, commercial mobile operators, PPDR operators, PPDR network and services integrators, application developers, PPDR practitioners: unavailability of specific PPDR features (e.g., 5G IOPS) and components for 5G experimentation; unavailability of test/verification tools that are already integrated and easy to use; available 5G implementations typically don't support configuration flexibility,
- PPDR practitioners: outdated ICT systems (e.g., TETRA and DMR), lack of technical knowledge.

Through the tests and trials, not only can several potential issues be addressed and solved, but also new or missing solutions can be developed, causing all involved stakeholders to be more confident to provide their solutions for production. Pure experimentation can be therefore extended to other services as well:

- dedicated/custom support and consulting,
- test/verification support, benchmarking,
- education and training,
- co-design and business development support,
- solution/product co-design, technical development.

According to the current state-of-the-art of 5G for PPDR, we believe customers are willing to pay for the following services:

- vendors, mobile operators, PPDR practitioners, developers: access to one-of-a-kind test/verification facility,
- vendors, mobile operators, PPDR practitioners: custom support and consulting services (by recognised experts), business development support (includes in-depth knowledge of their needs),
- mobile operators, PPDR practitioners: vendor/supplier tests and tendering support PPDR practitioners: implementation support and consulting, training,
- on-site training and workshops,
- possibility for R&D funding.

As it can be envisioned for 5G in general, on a long-term, also 5G Apps Ecosystem should improve and evolve through being included in tests, trials and in general into experimentation environments. Relevance of (open) 5G Apps Ecosystem will be on a long-term based on the policy each country/entity will implement for PPDR.

2.2.2. Threats to the 5G Apps Ecosystem

First of all, a threat to the adoption of 5G NetApps by the PPDR market is the fact that the PPDR vertical, being a mission-critical vertical with uppermost societal impact, must comply with specific regulations. Currently, established regulations are a mixture of European and country-specific regulations. Therefore, to speed up the adoption of 5G in the PPDR European arena, it is important that a common strategy is followed among member states so that the relevant PPDR software and hardware vendors produce products that comply with an EU-wide regulation and, of course, offer the necessary extensibility options so that they can also comply with any country-specific regulation. Such a common strategy shall aid Europe to take advantage of the NetApp opportunities for the PPDR vertical, as discussed in the previous section of this deliverable.

Second, still, the PPDR market is still dominated by large industrial players who have many years of market presence and have established networks with the end-users. As a starting point, large industrial players must understand the benefits of the 5G technology for producing new products that shall overcome the limitations of the existing products (latency problems, lack of support for video streaming / Augmented Reality, cross-border limitations, etc.). Given the lack of global 5G presence across all EU countries, it is more difficult (and a threat) to demonstrate 5G and convince the PPDR players to invest in augmenting their existing products with 5G hardware and software solutions.

On the other hand, PPDR vendors (possibly in collaborative funding schemes with end-users) need to make investments in 5G technologies. This is not an easy task to accomplish. Specifically, as stated in the whitepaper produced by the FP7 project PPDR-TC, "*Any decision-*

makers should realise that acquisition of PPDR networks will be never profitable whether it is based on CAPEX or OPEX. The objective is to ensure public safety for the protection of citizens as well as continuous and sustainable development of the economy. For these needs to be met, efficient wireless communication networks of sufficient capacity and good quality of services have to be provided. They should also guarantee interoperability with other communication networks that are vital for crisis management". However, a 5G-enabled PPDR solution must deploy and operate new 5G-enabled Control Command Centres, supply PPDR personnel with 5G UEs and other terminal equipment (which are not yet commercially available), provision for 5G radio and MEC for a new line of Mobile Control Command Centres, etc.

5GASP encompasses a PPDR use case and its related demonstrations. The goal is to act as the first adopter of a fully NetApp-based 5G service offering and use our NetApp marketplace and Community Portal (as well as other communication channels and dissemination activities, demos to PPDR vendors, etc.) to help PPDR stakeholders to understand the opportunities for adopting the NetApp approach in building the new generation of PPDR solutions, this way providing evidence that shall lessen the impact of the threats discussed in this section.

2.3. Players in the Market

The concept of a 5G ecosystem and a vision for PPDR communication systems that may become less closed or isolated as is today, seems interesting enough to attract various players. However, new players may experience some barriers, perhaps one of the most common would be a lack of domain knowledge.
Recent market researches show there is an increasing interest in developing and providing 5G services for the PPDR vertical[9] [17] [18] [7].

We can already see major 5G vendors:

- Cisco,
- Ericsson,
- Huawei,
- Nokia,
- Samsung,

vendors specialised in the security domain, e.g:

- Airbus,
- Frequentis,
- Leonardo,
- Motorola,
- Thales,

mobile/ISP operators, e.g:

- AT&T,
- Nordic Telecom,

- Telefonica,
- Verizon,
- Vodafone,

and European SMEs as well, e.g:

- Athonet,
- Internet Institute,
- Nemergent.

2.4. Market Evolution

As described in the “Market Trends” sub-chapter, there is a clear turn towards broadband PPDR networks, although the transition will last for a decade or so. During this time, there will exist narrowband networks, broadband networks and hybrid networks utilising a combination of narrow- and broadband services. Although it would be in favour of safety for first responders to have the ability of cross-border communication, it is expected that (at least EU member) states will remain independent in choosing their PPDR networks strategy, technology and legislation related to it.

However, Broadmap and Broadway projects are a great example of an approach to bring multiple PPDR networks closer to one another, and make them interoperable. The Broadmap in its SpiceNet architecture also addresses a possible way of PPDR networks evolution which has similarities to an approach 5GASP PPDR use cases are following. The latter might not be seen as a surprise since they all, i.e., the SpiceNet architecture and 5GASP PPDR use case, rely on 3GPP standards.

The Broadmap/Broadway projects state the “Pan-European broadband for public safety will rely on each member state and associated country to invest in new infrastructure to bring broadband to their public safety services in each country. Investment in innovation is also key to ensure that public safety is never left behind again with 20-year-old technologies”[10]. BroadWay further envisions the global 3GPP Mission-Critical standards will continue to provide suitable capabilities and longevity as mobile standards develop. The project also addresses new capabilities to cooperate in cross border and cross-agency situations, which will bring the need to study and standardise new ways of cooperating and to further refine pan-European standards with regard to co-operational procedures[10]. At this point, we can conclude 5G Apps will play a crucial role in building such a system. The latter can be further supported by the aforementioned SpiceNet Architecture Reference (the Standardised PPDR Interoperable Communication Service for Europe) proposing a reference architecture for harmonised pan-European PPDR mission-critical broadband services. Among others, it includes functionalities and elements that can be only realised and customised by (Net)Apps.

As long as broadband PPDR services are based on 3GPP standards, the 5G Apps Ecosystem should be expected to play an important role within these networks, being related to building national-level networks or solutions for interoperability among networks operated by different entities.

3. Automotive Market Overview

This section gives an overview of the current 5G Apps Market, at European and country Level, for the Automotive business verticals, expanding on the Market Value, Market Trends, Players in the Market and also highlights the opportunities and challenges to the 5G Ecosystem.

3.1. Market Value

According[19] to the US Department of Transportation, autonomous vehicles could potentially eliminate up to 94% of traffic fatalities. Research[20] conducted at the University of Ohio estimates that a 60% reduction in harmful emissions can be achieved with autonomous vehicles (AV). KPMG estimates[21] that AVs could reduce travel time by 40%, saving US workers 80 billion hours of commute time and $ 1.3 trillion dollars a year. AVs are a fundamental component of a paradigm shift the automotive industry is undergoing – the move towards Connected Autonomous, Shared and Electric (CASE, or ACES[22]).

There seems to be little doubt that Autonomous Vehicles deployed within a wide range of use cases – including robo-taxis[23], trucks[24], delivery robots[25], agriculture, yard and port automation, to name a few – will become a reality in the coming years. Autonomous vehicles technologies have made great leaps forward. Examples of hours of uninterrupted AV driving have been released by Mobileye[26], Voyage[27], Waymo[28], Cruise[29] and others. Yet there are, and always will be, cases where the AI "driving" the autonomous vehicle does not 'know' what to do, or its level of confidence in selecting the appropriate action is too low – such as an unprotected left turn – instances in which the AV requires human assistance for mission accomplishment.

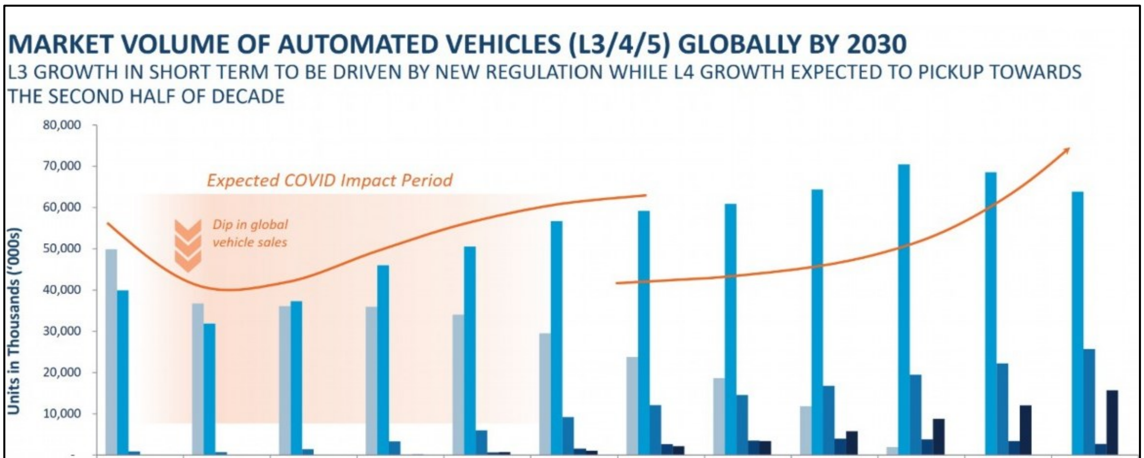
In light of the above, and as has been widely acknowledged by industry leaders[30] and government entities such as NIST[31] (US National Institute of Standards and Technology), AV teleoperations is needed. Teleoperation is the technical term for the operation of an unmanned machine, system or robot from a distance. Teleoperation is needed in order to ensure AVs are able to complete their mission under any circumstances. Some even see teleoperations as the stop-gap between driven and driverless vehicles.

In teleoperations, remote operators residing in a command & control centre are ready to be called on by an AV in need, prepared to guide the AV on how to overcome a specific obstacle or take over the entire driving operation until the challenge is dealt with.

3.2. Market Trends

Some of the key questions addressed regarding the forces influencing the Market in the near future and the opportunities are related to Market evolution in the following years, by vertical and service categories.

We perceive this field as a large and fast-growing market, reaching over € 3 billion by 2025. This can be deployed for current and future market opportunities, segments, and challenges; for selective autonomy (Level 3), such as NCAP 2020 in EU, for Highly Automated Driving (Level 4 and 5), for aftermarket solutions as well as for sidewalk delivery robots. The Total Addressable Market is comprised of the relevant segments of the Market, as described above. According to FIOR Market Research 2019, the Global Automotive Teleoperations Market will be valued at € 60 billion in 2030, with a CAGR of 44% from 2020 to 2030. According to another research firm, HTF, the Teleoperations market size for AV will be € 38 billion in 2025 (Global Teleoperations Service Industry Market Research Report, Oct 2018).
The global autonomous vehicle market is projected to reach a market size of $ 888.40 billion by 2028 at a rapid and steady CAGR[32]. Teleoperation is a mandatory requirement for large scale deployment of AVs; considering the numbers of the AV units forecasted to be shipped over the next nine years, generally grouped into passenger AVs, autonomous trucks and autonomous delivery robots, the offering SAM will become $ 1.1 billion in 2025, and grow to just under $ 5 billion by 2030.



	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Level 0	49,885,000	36,745,000	36,076,000	35,976,000	34,054,000	29,517,000	23,808,000	18,664,000	11,884,000	1,984,000	-	-
Level 1	39,904,000	31,885,000	37,315,000	46,008,000	50,544,000	56,729,000	59,223,000	60,905,000	64,373,000	70,448,000	68,577,000	63,833,000
Level 2	907,000	693,000	1,413,000	3,331,000	6,017,000	9,207,000	12,116,000	14,561,000	16,771,000	19,479,000	22,240,000	25,743,000
Level 3*	3,000	3,000	28,000	129,000	656,000	1,559,000	2,649,000	3,519,000	3,962,000	3,814,000	3,399,000	2,714,000
Level 4	1,000	3,000	29,000	215,000	699,000	1,114,000	2,182,000	3,392,000	5,794,000	8,802,000	12,055,000	15,724,000
Level 5	-	-	-	-	-	-	-	-	-	-	-	-

Figure 3- Market Volume of Automated Vehicles

5G in the automotive and transport sector will generate revenue to € 300.5 billion in total GDP across European Union member states and the United Kingdom. Road and rail vehicles are fundamental to a vast number of public and private sectors, including delivery and logistics, agriculture, construction, emergency services, tourism, public transit, consumers and commuters. Over the next five years, the effects of 5G will boost European automotive and transport revenues by up to € 220.5 billion, and up to € 89.5 billion in direct GDP impacts[33].

The indirect economic impact of these supply chains could generate up to € 85.9 billion in additional GDP. Furthermore, governments and operators will invest in constructing 5G-supported road and rail infrastructures, which could create up to 8.0 million jobs, generating approximately € 95.6 billion in labour income[34]. Due to the increasing digitalisation of the vertical, the more demanded jobs will be for software developers, device designers and equipment engineers.

Over the course of the next decade, 5G networks and their associated enabling technologies will transform the automotive sector. Using the massive 5G capacity of handling devices, all private vehicles, enterprise road fleets, road infrastructure will be directly connected to the Internet. Besides, thanks to the enhanced throughputs supported by 5G networks, the video data analysis from the vehicles and roads will be enabled.

3.2.1. Opportunities for the Evolution of 5G Apps Ecosystems

5G plays a key role in one of the most promising wireless standards for CAMs, Cellular Vehicle-to-everything (C-V2X). 5G-V2X offer both short-range and long-range capabilities, allowing vehicles to communicate with devices in the immediate and distant surrounding. This standard allows the vehicles to predict in real-time how hidden vehicles will react to road events. Also, 5G's simultaneous two-way communications for a massive number of devices will help to enhance road safety by reducing the low reaction times needed in these environments[35]. Enabled by 5G, cellular vehicle-to-everything (C-V2X) connectivity underpins a variety of new use cases being currently advanced by the major technology trends in this vertical.

In this way, 5G technology can completely transform traffic management systems and road infrastructures. These infrastructures and systems can facilitate new vehicle safety solutions, autonomous driving, advanced weather analysis, enhanced public transit or smart parking management. As more vehicles adopt these technologies, 5G networks will provide the QoS capabilities to give preferential allocations of safety-critical messages, such as emergency services.

The automotive industry and, more largely, the ground transportation industry is currently investigating the integration of 5G into services for improving road safety, traffic efficiency and other value-added services. For the automotive industry, 5G is perceived as the technology that will enable the development of innovative value-added services, which are highly demanding services in terms of latency and bandwidth.

To this end, the automotive industry is envisioning a digital twin of the vehicle based on a set of standards (ExVe - Extended Vehicle) under development within ISO's Technical Committee

22 (”road vehicle”). Parallel to that, the transportation industry is currently developing Cooperative ITS (C-ITS) services that enable the vehicle to share information with other vehicles, its surrounding environment (other vehicles, other road users, the roadside infrastructure, the urban infrastructure) and remote stakeholders (service providers, traffic authorities, fleet management platforms, etc.). This exchange of information is made possible through a standardised data management and communication architecture (“ITS station architecture”) developed by CEN (Technical Committee 278 on “Intelligent TransportTransport Systems”), ISO (Technical Committee 204 “Intelligent Transport Systems”), and ETSI (Technical Committee ITS “Intelligent Transport Systems”). Numerous standards have been developed around this ITS station architecture, including standards on a variant of WIFI (IEEE P1609 / ETSI ITS-G5) targeted to V2X communications (communications between a vehicle and its surrounding environment). These standards are under deployment across Europe under the C-Roads flagship. Furthermore, the integration of 5G as one of the technologies needed to transfer data is currently under discussion in standardisation organisations (ISO, CEN, ETSI) and industry fora, mainly the Car-2-Car Communication Consortium (C2C-CC) and the 5G Automotive Association (5GAA).

3.3. Players in the Market

Although the Automotive NetApp Market is nascent, it attracts interest from a broader number of companies and institutions compared to the PPDR NetApp Market. A key element could be the expanded technological surface for the Automotive domain overall and the increased drive towards connected mobility. This Market could prove to be diverse in use-cases, attracting players’ interest and resources towards technologies such as Human Assistance Systems, Intelligent and Connected Infotainment systems or Autonomous Driving.

Most developers of autonomous vehicles have adopted or have announced plans to adopt Human Interaction to assist the vehicles in Edge Cases. Some prominent examples of such companies include:

- Amazon/Zoox
- Aptiv
- BMW
- Bosch
- Caterpillar
- Daimler
- Denso
- DoorDash
- EasyRide
- Einride
- Ford
- GM-Cruise

- Hitachi
- Kodiak
- Lyft
- Mobileye
- Navya
- Nio
- Nissan-Renault-Mitsubishi Alliance
- Nuro
- Postmates
- Uber
- Valeo
- Volvo
- Voyage
- VW
- Waymo

These developers state that for the foreseeable future, remote human intervention will be needed.

3.4. Market Evolution

New investments in intelligent transportation systems will lay the foundations for improved vehicle automation and expanded telematics offerings. These systems are likely to drive only 5% of the total economic benefit from 5G in the sector (primarily from improved smart parking utilisation and connected toll-road demand and collections, among others). However, it is imperative to research and develop these systems to create an ecosystem of benefits that are related to these technologies, such as faster commutes and enhanced passenger and pedestrian safety[36].

4. Market Value Chain

Ever since 2012, the Telco industry has embarked on a transformation from purpose-built appliances, often in physical boxes, to virtualised, and later, containerised software applications that deliver Network Functionality. This has, of course, been in line with the still ongoing trend of software transformation in many industries, including the telecom and service-provider related sectors. Considering that the value chain for any given consumer market is divided into three parts: suppliers, distributors, and consumers/users, the best way to make significant profits in any of these markets are to either gain horizontal control in one of the three parts or to integrate two of the parts such that you have a competitive advantage in delivering a vertical solution. Before software-defined network applications, a lot depended on controlling distribution. With this change now ongoing, there is a considerable shift in market-value chains to the left: function producers, who traditionally have had a limited role in later stages of the Market with vendors, channels, distributors, ISVs, and operators bridging the gap towards the end-users, are now empowered to be able to directly provide their appliances/application services to end-users and the way to realize that would be through enabling platforms.

Presently, users can pick their virtualised or container infrastructure manager of choice, decide on their servers of choice, and most importantly, pick from a massive ecosystem of Network Functions from vendors; still, marketplaces are nascent in this area, and 5GASP fills in an important role as an easy-available open certification system and program.

Many industry players (including Consortium partners, such as VMware) run their own proprietary certification programs for partner readiness and have had a positive experience building momentum in their ecosystems and realise benefits for their platform, app developers, and customers with a minimum of overhead in the value chain.

Learnings include the fact that self-certification gives partners yet a choice: the option to pursue is at the NetApp developer's disposal to verify that their Network Functions work with a particular site; self-certification also helps prepare relevant workloads for easy deployment with and makes their Value transferable across certification-participating sites in Europe. Such a cloud-based self-certification path gives emerging partners more flexibility to define their own timelines, helps them certify more workloads, and reduces dependencies on building an on-premises lab for preparations.

The benefits of self-certification are an important step in re-defining telco service platforms in the value chain. The self-certification option advances our customers' transformation to software in four ways:

- **Choice**: Partners who develop network applications are in different phases of their journey. They operate different versions of our platform and different versions of their virtual Network Functions. By offering a self-certification extension, we help vendors verify that any version of their software is ready to quickly be deployed in any version of our partners' infrastructure sites.
- **Agility**: The first few migration projects take a while and are a learning phase for an organisation: Processes get tuned, operational aspects are ironed out, and sometimes even the procurement process changes. We then see a clear hockey-stick effect in VNF deployment. Because self-certification is cheaper, easier and quicker than using a process based on setting up an on-premise testing environment, we expect to see the hockey-stick effect appear earlier in the deployment process.
- **Efficiency**: The 5GASP program focuses on educating and strengthening the community and defining our platform capabilities. We can propose that developers would want hands-on experience with our platform to follow our test plan and evaluate their readiness. By giving our partners a virtual lab that mirrors our reference architecture, we help them prepare without needing a large hardware installation.
- **Focus**: Creating a strong community on the certification-platform side with resources and guidance will allow specialised services vendors or industries to step in when unique problems arise, and network application developers need specific consulting

to adapt their work to a particular use case. The self-certification program frees resources to help partners with their unique and hard questions by automating the rest of the access and verification of functionality.

5GASP tries to grasp the momentum to enter the NetApp market, which shall consist of vendor/CSP/co-created microservices according to the study for 5G cloud-native software solutions. The momentum is evident according to the phases depicted in Mason's study[37] in the following figure:

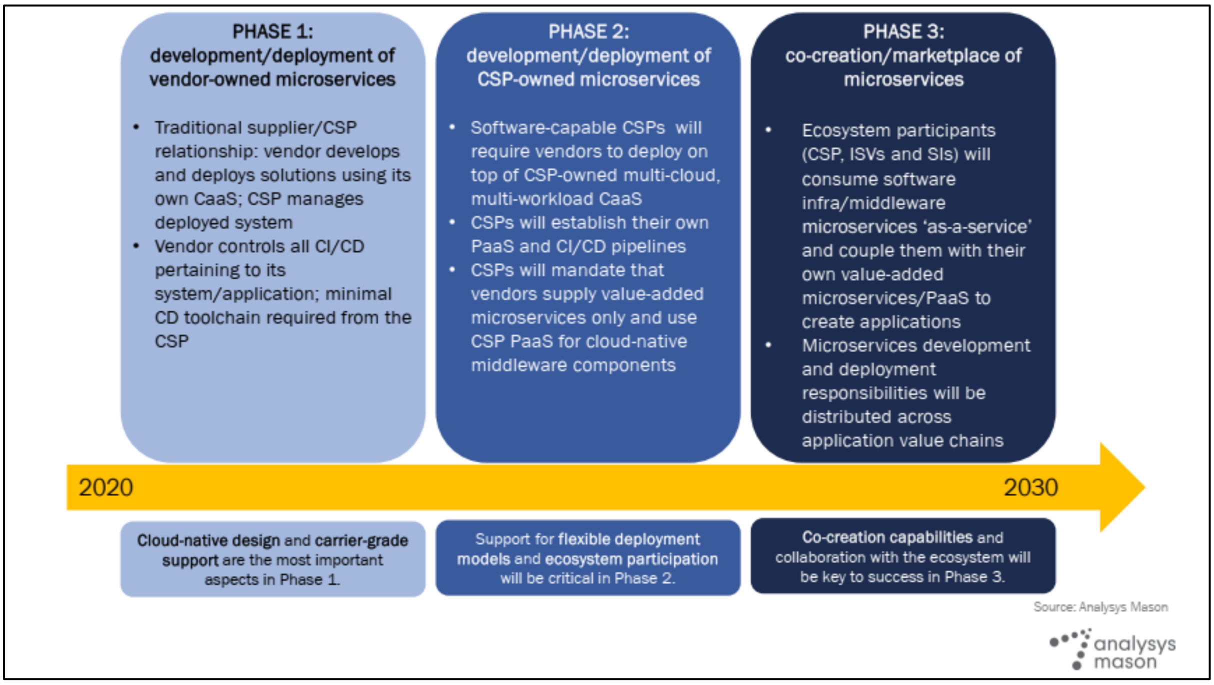


Figure 4 - Mason Analysis, Study for 5G Cloud-Native Software Solutions

In the current phase, labelled as "Phase 1" in the above figure, vendors like VMWare – a key partner of 5GASP – are competing in order to adopt the cloud approach for building customised 5G solutions by reducing the associated development costs and also importantly the time to market a new 5G solution that might be in great interest of the end-customer. It is in this current phase where vendors try to leverage the cloud-native software engineering approach to offer carrier-grade SLAs to Network Functions that follow the cloud-native approach, whose concept is depicted in the following figure.

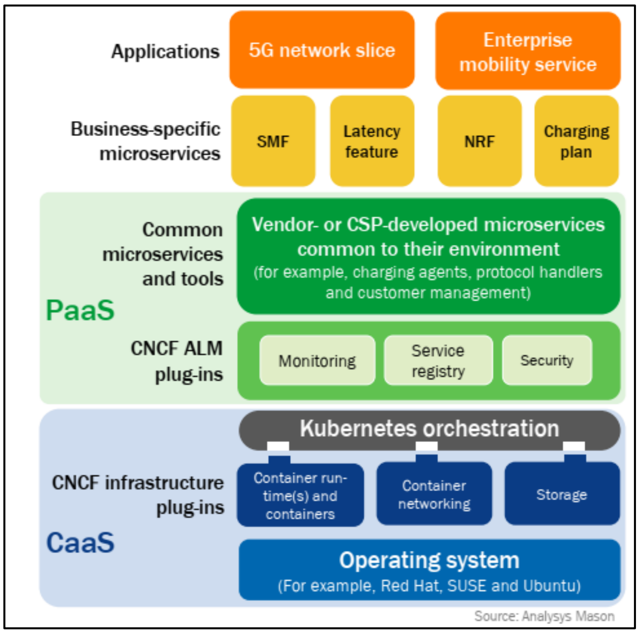


Figure 5 - Cloud Native Approach Concept

In this evolving 5G landscape, many players all try to capitalise their innovations, each player according to their specific business goals. The following figure from the analysis provides an overview of the goals of various players' categories (technology providers / VNF vendors / OSS-BSS vendors) as well as their strengths, opportunities and threats.

Vendor	Category	Strengths	Weaknesses	Opportunities
Canonical CloudBees Cloud Foundry Rancher Red Hat Solo.io VMware	**Technology component providers[2]** Companies that sell K8s distributions, CaaS, PaaS and/or individual plug-ins or combinations of plug-ins and 'operators' (K8s automation).	▪ Cloud-native software credentials ▪ Ecosystem presence ▪ Ability to run across any public cloud provider stack ▪ Speed of innovation	▪ New cloud-native start-ups are not traditionally geared up for carrier-grade support	▪ Opportunity to influence cloud-native software market evolution ▪ Opportunity to help CSPs to build vendor-agnostic cloud-native software environments ▪ Opportunity to provide self-managing automation (for example, through the CNCF Operator Framework)
Affirmed Ericsson HP Enterprise Huawei Metaswitch Nokia	**VNF vendors** Companies that are developing cloud-native network functions (CNFs) for the 5G market.	▪ Able to provide carrier-grade support ▪ Well-established CSP customer base	▪ NEPs are lacking strong cloud-native software skill sets ▪ NEPs must support legacy systems ▪ NEPs' cloud-native software credentials are only just emerging ▪ NEPs are used to delivering full stack solutions ▪ VNF ISVs have new solutions that are untested in the market	▪ Opportunity to use their support to create new partnerships ▪ Opportunity to invest in PoCs and memberships in organisations that influence the cloud-native industry in a CSP-friendly direction ▪ Well-placed to move along the value chain and provide both infrastructure and software solutions
Amdocs Netcracker	**OSS/BSS vendors** Companies providing OSS/BSS solutions.	▪ Robust portfolio of offerings that addresses BSS/OSS functionality ▪ Customers include multiple Tier-1 CSPs and large enterprises	▪ Not traditionally oriented towards vendor-agnostic solutions	▪ Opportunity to sell consultancy services around cloud-native software development

Figure 6 - SWOT Analysis of Various Players in the Market

5. Key Findings, Conclusions and Future Work

In both priority verticals addressed by 5GASP, NetApps are generally viewed as a nascent technology, one for which the Market is not yet clearly defined, and whose adoption depends on a multitude of factors, with the most important ones being:

- National and European regulations and other legal barriers, lack of standardisation.
- The timing of 5G deployments, as well as cross-country interoperability.
- The technological evolution and openness to leverage disruptive 5G NetApp-based solutions of the targeted verticals (PPDR, Automotive).

However, despite the potential risks related to the above in terms of NetApps being adopted by PPDR and Automotive stakeholders, there is a high potential that NetApps can be soon adopted by the aforementioned stakeholders, with the main reasons being:

- The very fast development of the 5G market ecosystem and its proven business benefits in the verticals of telecoms,
- The interest of major players to get involved in the early phases and playing a role in the definition of 5G cloud application development,
- The need of all stakeholders to test new NetApps on mature 5G testbeds to advance their technology, even before it is market-ready,
- Foreseen involvement of European and national authorities in both topics, with the interest of increasing resiliency, efficiency, and public safety,
- The need for competency and already marketable services around the NetApps themselves include dedicated support and consulting, test support, benchmarking, training, co-design, business development, validation over 5G testing facilities, support for R&D funding, etc.

One of the business goals of 5GASP is to take advantage of and support the vertical market opportunity for SMEs and related developers that exists as per our current market research activity. It is important to note here that this deliverable, D7.3 at Month 9 of the project, presents the first output of our market research activity. We treat market research as an ongoing activity throughout the lifetime of the project since the market is quickly evolving and thus we strive to ensure alignment with the market at all times of the project, so that our Value Proposition will bring value to the addressed market segments, namely the PPDR and Automotive segments which this project mainly addresses. Concluding, we shall treat internally this document as a living document which we shall be internally updating and use for our business model activities within the scope of WP7 Task 7.2. The outcome of our busines model activities shall be documented to the EC via the deliverable "5GASP Business Model" in M24.

In terms of next steps in our work in WP7 of paramount importance is that 5GASP organizes vertical-specific industrial workshops inviting vertical-specific players through our active contacts and through our wider dissemination activities within the scope of Task 7.1 (Twitter, LinkedIn, participation to industrial fora and associations). The goal of these vertical-oriented workshops is to present to business users what are the benefits that 5GASP can bring in their specific business so that these busines users would engage with 5GASP in order to leverage our innovations mainly centered around the creation of an ecosystem of NetApps that may inter-work with vendor-specific solutions, allowing vendors to leap forward and overcome the competition via our innovations. The PPDR and Automotive industries, as discussed in this document, undoubtedly have a great business potential should they adopt innovative NetApps which shall augment their existing service offerings. Here we must also state that the PPDR and Automotive SMEs of the 5GASP Consortium shall act as the evangelists of 5GASP's innovations to their respective verticals. Specifically, partner ININ in collaboration with partner Lamda Networks, through the implementation and demonstration of the PPDR use case within the scope of WP4, do have the potential to show to PPDR stakeholders how 5GASP's innovations can help them to meet their mission critical requirements towards next-generation PPDR services across Europe and beyond. The same is intended to be achieved by our Automotive SMEs which shall work closely with Universities and other SMEs (Bristol, Patras, ItAv, OdinS, Lamda Networks, etc) in order to showcase how 5GASP's Automotive use cases of WP4 can help the Automotive stakeholders towards leaping forward and providing advanced network-based automotive services and applications which shall well operate in mobility scenarios, leveraging the advances of the project in such scenarios, e.g. the OdinS innovations in their Virtual OBU product and the remaining automotive innovations that shall be developed and demonstrated within WP4.

As discussed earlier, the goal of the ongoing market research activities is to assist us in establishing viable business models that consider the entire market value chain. As discussed in the proposal, the project considers that both a Free and a Freemium business model are possible. The 5GASP Consortium - during the first 9 months of the project - has been based upon Open Source technologies to build the 5GASP DevOps toolset and the testing and validation tools. Therefore, it seems attractive to the Consortium to follow a Free business model. Of course, to achieve sustainability and profits with a Free model, it still remains a big challenge of the Consortium on how it shall be possible: i) to generate revenues to sustain the 5GASP platform and its associated fabrics and resources to support such a complex infrastructure and tools; and, ii) how to gain revenues and achieve profitability.

We have discussed with Consortium partners part of WP7 that the SMEs of the 5GASP Consortium can become the early adopters and the critical mass from the viewpoint of SMEs that provide innovations to end-users namely PPDR and Automotive stakeholders. That is, we could try that our NetApps shall be offered to other SMEs working for the aforementioned stakeholders or to the stakeholders themselves for a fee and/or a licensing scheme with possibilities to have revenues from installation, maintenance and support costs. Furthermore, as per our use cases, we are investigating (and this is under our IP management activities) on how to combine the functionalities of NetApps to produce an innovative services.. As an example, Bristol and Lamda Networks are jointly working on enabling PrivacyAnalyzer (Lamda Networks' NetApp) to leverage Bristol's NetApp intelligent MEC offloading capabilities in a way that PrivacyAnalyzer can work in a MEC environment and be capitalized in verticals such as the automotive vertical, an option would was not considered during the writing up of the proposal. Similar business opportunities are expected through multi-party collaborations between partners, forming small hubs of innovation within the project where each hub aims to sell an innovative service to a segment either of the PPDR or the automotive vertical.

We are also considering the option for a Freemium model where some services shall be provided by 5GGASP platform for free and some other services at a premium rate. Currently, we see that like other European experimental facilities, 5GASP could act as a European facility for testing and validation of NetApps to European SMEs and that this could be provided for free to European SMEs towards achieving impact in the EU. This is particular of interest to the Consortium since if this succeeds, 5GASP can be a paradigm to become a leading EU platform that shall gain the interest of many industrial players who do not have the necessary fabrics to deploy and validate next generation telco-based services to their clients. Furthermore, support and consulting services for building and developing a NetApp could be provided as part of the business model to both SMEs and industrial organizations. The success of this model of course lies on the size of the user community and the quality of the premium service. To achieve a community with an adequate size, we have seen that we need to strengthen our dissemination and user engagement activities. This is a primary goal for the next moths of the project. For the aspect of the quality of the premium service, we are more confident since we have already three NetApps that soon shall be onboarded on the 5GASP platform: one NetApp belonging to the PPDR vertical, one belonging to the Automotive vertical and one being a cross vertical NetApp. These NetApps shall provide a form of consulting to the other SMEs of the Consortium and after an iterative process and including the feedback of SMEs, we aim to build a strong consultancy competence within the Consortium.

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Appendix

[I] ***NetApp "5G Isolated Operation for Public Safety ", by partner ININ: Initial discussion of business aspects***

1. Please describe the Value Proposition of your NetApp (product / service / concept / ongoing development)[1]

Background: 5G Isolated Operation for Public Safety (5G IOPS) NetApp aims at maintaining a level of communication between PPDR (Public Protection and Disaster Relief) users, offering them local mission-critical services even when the gNB backhaul connectivity to the 5G core network is not fully functional or is disrupted. This operation mode is typically needed in PPDR disaster situations when commercial mobile infrastructure is damaged or destroyed, and in the out of coverage, emergency cases operated in the rural areas. The main components of the 5G IOPS NetApp are:

- 5G IOPS enabled gNB and
- local 5G CN integrating all the essential components to operate 5G IOPS network (NetApp) independently (AMF, SMF, UPF and AUSF).

5G IOPS NetApp will be designed, implemented, verified and showcased on the Public Protection and Disaster Relief facility for Outdoor and Indoor 5G Experiments (PPDR ONE) in Ljubljana. PPDR ONE is an environment supporting experimentation with 5G network architectures and services for the PPDR and Critical-Communications verticals. The facility comprises an SDR- and CPRI-based radio and mobile core system (4G and 5G) with flexible configuration options powered by NFV, cloud backend infrastructure, a set of reference PPDR services and apps, a PPDR IoT kit, industrial and ruggedised end-user devices as well as a test and validation toolkit.

Value: Enable an all-in-one PPDR-grade development, testing and verification environment for 5G IOPS network architectures and services.

Problems we help solve:

- Vendors, commercial mobile operators, PPDR operators, PPDR network and services integrators: 5G IOPS system implementations are not available.

[1] Note: that we use as interchangeably in this template the words NetApp, product or service or concept or ongoing development. This means that at day 0 of the 5GASP project, there is no NetApp from partners, but existing products or services or concepts/ongoing developments. At the end of the 5GASP project, a NetApp shall be made out of the product or the service or the concept or the ongoing development

- Vendors, commercial mobile operators, PPDR operators, PPDR network and services integrators, application developers, PPDR practitioners: Unavailability of 5G infrastructures for test and verification for PPDR needs; limited locations where test/verification can take place.
- Vendors, commercial mobile operators, PPDR operators, PPDR network and services integrators, application developers, PPDR practitioners: Unavailability of specific PPDR features (e.g.5G IOPS) and components for 5G experimentation; unavailability of test/verification tools that are already integrated and easy to use; available 5G implementations typically don't support configuration flexibility.
- PPDR practitioners: Outdated ICT systems (e.g. TETRA and DMR), lack of technical knowledge.

Products and services offered:

- Operational 5G IOPS system infrastructure for experimentation, testing and verification in Ljubljana (Slovenia).
- Lease of resources; configuration and test/verification support services 5G IOPS portable infrastructure anywhere in EU.
- Lease of the 5G IOPS portable implementation, shipping within EU; configuration and test/verification support services.
- Co-design, technology development and deployment consulting.

Addressed customer needs:

- Test and verify 5G IOPS and PPDR solutions in the pre-commercial stage without the need to invest in own 5G PPDR-grade infrastructure, specific test/verification tools.
- Custom test and verification services for 5G IOPS, deployment optimisation support.
- Education.
- Help with product/service design.
- Development and deployment support.

2. Please list your existing and potential customers:

For the time being, the 5G PPDR Network and Services Market in the EU is not yet established. Leading EU countries (e.g. Belgium) are using commercial mobile networks (UMTS/3G and LTE/4G based) to provide non-mission-critical services for the PPDR stakeholders (police, firefighters, medical services). Based on the state of the Market, we foresee the following niche market customers / multi-sided markets:

- 5G equipment vendors.
    - Needs: test and verification of 5G IOPS and PPDR features, standards & regulatory compliance .

    - Challenges: Unavailability of 5G IOPS and PPDR environments, lack of understanding of practitioners's needs, 5G PPDR regulation.
    - Risks: Features are not adopted by practitioners, telcos cut investments/competition.
- 5G PPDR application developers and service providers.
    - Needs: Test and verification of PPDR apps for 5G, promote the app in 5G PPDR, understand 5G technologies for PPDR.
    - Challenges: No access to 5G PPDR environments, limited access to 5G PPDR domain partners.
    - Risks: Poor adoption by PPDR practitioners.
- Mobile operators with 5G PPDR offerings.
    - Needs: Test and verification of 5G equipment against PPDR features, QoS/QoE/SLA measurements, deployment/config support.
    - Challenges: Unavailability of 5G PPDR environments, lack of tools for in-depth QoS/QoE/SLA monitoring.
    - Risks: features are not adopted by PPDR practitioners, compliance issues of 5G equipment.
- PPDR customers (public safety agencies)
    - Needs: Test and verification of PPDR services/capabilities in a 5G environment, better understanding of benefits of 5G for PPDR, technological modernisation, regulatory compliance, business development (owned, shared, hosted etc.).
    - Challenges: Lack of technical knowledge and skills, no access to telco-grade 5G PPDR demos, compliance of offers with established procedures/practices, need to train personnel for new services/tech.
    - Risks: Features are not suited to or adopted by practitioners, compliance issues of provided services against established procedures.

3. Please discuss how you plan to license and set the commercial price of your NetApp and provide a roadmap on how you will have revenues from the sales of your NetApp:

Due to the low maturity level of the 5G PPDR market in the EU, the following general revenue streams are planned:

- Dedicated/custom support and consulting
- Test/verification support, benchmarking
- Education and training
- Co-design and business development support
- Solution/product co-design, technical development

Revenue streams - transaction-based, on a periodic (yearly) basis

- Dynamic pricing.

        - Lease or usage fee for 5G IOPS system resources (feature dependent, volume dependent); the baseline is a fixed list price plan – cheap/moderate price per unit, free extras.
        - Consulting services – expensive per unit, hourly rates or bundles.
        - Offer includes the complete package, bargaining based, possibility of volume/continuity discounts.
    - R&D funding for portfolio development
        - Programme-specific funding models
        - Includes piloting, testing/verification, R&D of new components, joint trials with vendors, mobile operators, PPDR practitioners etc.

Value customers are willing to pay for:

- Vendors, mobile operators, PPDR practitioners, developers: Access to one-of-a-kind test/verification facility.
    - Vendors, mobile operators, PPDR practitioners: Custom support and consulting services (by recognised experts), business development support (includes in-depth knowledge of their needs).
    - Mobile operators, PPDR practitioners: Vendor/supplier tests and tendering support.
    - PPDR Practitioners: Implementation support and consulting, training.
    - On-site training sessions and workshops.
    - Possibility for R&D funding.

4. Please discuss competitors related to the business problem that is tackled by your NetApp:

No known ones.

5. Please fill the following SWOT analysis table for your NetApp.:

Strengths	Weaknesses
• Low instantiation and reconfiguration time. • Improved operability of the Public Safety unit out of its trritory. • A novel approach with new services available. • No significant changes of user experience for existing services.	• Public safety users may not be yet ready or willing to adopt new technologies. • Public safety operational plans and doctrine may require additional time to adapt to new approaches available with 5G technology. • Considerable infrastructure investments for 5G.

• New, enhanced possibilities for customer applications developers. • Interoperability (due to the common 5G global standards). • Digital Innovation. • Scalability.	• 5G UEs and other terminal equipment with supported PPDR functionalities are not yet commercially available.
Opportunities	**Threats**
• Expanding business globally due to common 5G standards. • Expanding business to other segments. • Expand business to the development of customer applications. • Strengthen the company brand as a pioneer of high-tech in lifesaving operations. • Strategical alliances with established but less innovative public safety services providers.	• Public safety users may not be yet ready or willing to adopt new technologies. • Public safety operational plans and doctrine may require additional time to adapt to new approaches available with 5G technology. • Considerable infrastructure investments for 5G.

Table 1- SWOT analysis table for the "5G Isolated Operation for Public Safety " NetApp

[II] *NetApp "Remote Human Driving NetApp - Teleoperation for assisting vehicles in complex situations ", by partner DriveU: Initial discussion of business aspects*

1. **Please describe the Value Proposition of your NetApp (product / service / concept / ongoing development) :**

   DriveU solves the communication reliability, latency, and video quality issues of the remote assistance operation. Using cellular bonding to aggregate multiple cellular modems into one virtual link tightly coupled with dynamic video encoding. The tight coupling enables minimising latency while maximising video by adapting to the changing network conditions seamlessly.

2. **Please list your existing and potential customers:**

DriveU segmented the Market into three main groups; automotive retrofit, autonomous vehicles and delivery robots - each with different needs and for each a relevant value proposition.

Segment: Automotive Retrofit;
Users/Users Groups: Aftermarket for Mining, Agriculture, Logistics, Defense, Security;
Sample Users: WENCO Mining, Volvo Trucks;

Segment: Self driving vehicles;
Users/Users Groups: Company developing full stack Autonomous Driving solution;
Sample Users: BMW, Aurora, Voyage, EasyMile

Segment: Self driving vehicles;
Users/Users Groups: Tier-1 Suppliers developing connectivity ;
Sample Users: ZF, Continental, Denso, Valeo

Segment: Delivery robots;
Users/Users Groups: Service providers that provide sidewalk and campus delivery;
Sample Users: Postmates, Starship, Doordash, Teraki, Telerob.

3. **Please discuss how you plan to license and set the commercial price of your NetApp and provide a roadmap on how you will have revenues from the sales of your NetApp:**

Product	Market price for small quantities (per vehicle)	Market Price for mass market license (per vehicle)	Explanation at how this price is derived
Vehicle HW	€4000	€200	Based on alternative Multi-WAN Routers available in the Market and the price of cellular modems.
Vehicle SW Licensing	€1000	€50	Based on the current Value of SW components to the vehicle and compared to current HW solutions. This Value has been validated as reasonable by two Auto OEMs
Teleoperations monthly licensing	€100/month	€8/month	Based on current Value of video transmissions solutions in other markets as well as typical services for connected-car services

Table 2- Plan of licensing and commercial pricing for NetApp

4. **Please discuss competitors related to the business problem that is tackled by your NetApp:**

Since this NetApp is a public contribution and academic research in 5G community, hence we do not see any competitors.

5. **Please fill the following SWOT analysis table for your NetApp:**

Strengths	**Weaknesses**
• DriveU's technology is based on LiveU's years of experience and market recognition as a leader in video transmission. • DriveU technology has better video quality, lower latency and more reliable link than alternatives. • DriveU was already recognised in several competitions for its highly commercial potential in both POCs and initial design wins.	• Public safety users may not be yet ready or willing to adopt new technologies. • Public safety operational plans and doctrine may require additional time to adapt to new approaches available with 5G technology. • Considerable infrastructure investments for 5G. • 5G UEs and other terminal equipment with supported PPDR functionalities are not yet commercially available.
Opportunities	**Threats**
• New and innovative product to disrupt the Market. • Market opportunity: Additional markets, such as rail, maritime, security and others.	• Future Competition: DriveU has already the advantage of being first in the Market for a SW-based approach. Also, currently filed patents may serve to block competitors from using the same technologies. • Regulation: DriveU is very well familiar with the current and evolving regulation and plans on being in full compliance.

Table 3- SWOT analysis table for the "Remote Human Driving " NetApp

[III] *NetApp "Virtual RSU", by partner YoGoKo: Initial discussion of business aspects*

1. Please describe the Value Proposition of your NetApp (product / service / concept / ongoing development)

RoadSide Units (RSU) are devices installed on the side of the road to detect hazardous situations and inform vehicles. They can be stand-alone equipment or integrated in traffic lights, toll gates, variable message signboards (VMS), etc. They can be connected to traffic control centres by many means, including cellular, LoRA, and optic fibber. They could also integrate localized communications to communicate with passing by vehicles, using for instance ITS-G5 as in the pilot deployment of C-ITS services. RSUs deployed for C-ITS services are referred to as roadside ITS station (R-ITSS), as these services are developed in conformance with the ITS station architecture [ISO-21217] [ETSI-EN-302-665].

Depending on vehicle density, decision choices of each region, cellular coverage and particularly on the use cases, it is in some situations required to install physical units at specific locations of the road (e.g. black ice detectors, contextual speed limits, traffic lights providing time and phase information, etc.). However, such deployments cannot be envisioned on all roads. Moreover, not all services would be feasible to be deploys as this would be too expensive, particularly in areas with scarce density of vehicles and already covered by cellular networks. In such situations, virtual roadside ITS stations deployed in the cloud would allow the collection and transmission of data alike physical ITS stations along the road.

This is actually what has been implemented by YoGoKo in Nordic Way, the Scandinavian pilot deployment of C-ITS services. Virtual roadside ITS stations allow the transmission of C-ITS services to vehicle using LTE-based networked communications as much as it would be transmitted by roadside ITS stations to vehicles using ITS-G5 localized communications.

Further extending this idea, 5GASP will develop a virtual RSU NetApp acting as a roadside ITS station implementing C-ITS services such as CAM, DENM, SPaT, MAP, amongst others.

2. Please list your existing and potential customers.

- Traffic control centers providers and road operators
- Autonomous vehicle manufacturers (e.g. Navya) and operators (e.g. Transdev)
- Tier-1 providers to the automotive industry (Valeo, Bosch, Continental, Renesas, …)

3. **Please discuss how you plan to license and set the commercial price of your NetApp and provide a roadmap on how you will have revenues from the sales of your NetApp.**

We intend to sell licenses of our software stack that is designed to provide standard-compliant data transmission services to companies selling or integrating hardware telecommunication unit in vehicles or in roadside equipment, or to companies selling services that require pre-collection and pre-treatment of data from vehicles and roadside equipment.

4. **Please discuss competitors related to the business problem that is tackled by your NetApp.**

Competitors are stakeholders involved in the deployment of Cooperative ITS services across Europe, and mainly road equipment vendors (RSU): LaCroix (FR), Commsignia (HU), Ynex Traffic (= Siemens) (DE), QFree (NO)

5. **Please fill the following SWOT analysis table for your NetApp.**

Strengths	**Weaknesses**
YoGoKo is one of the leaders in the deployment of C-ITS services in Europe Extend the availability of C-ITS services • reduce accidents and casualties / in case of accident accelerate public emergencies (eCall) • new services made possible (more potential value-added services compared to ITS-G5) • Reduce C-ITS services deployment cost	• Requires adoption by an entire ecosystem (road operators, vehicle manufacturers); different stakeholders must be synchronized and competitive business models must emerge • Require 5G-NR to be standardized at 3GPP and equipment available for purchase • Lack of qualified 5G resources in the company
Opportunities	**Threats**
• The European Commission is preparing a new Action Plan on Intelligent Transport Systems and new regulation on access to vehicle data. • Alignment with the European Commission initiative on CCAM (connected & cooperative autonomous mobility)	• Risk that the technology doesn't meet the performance requirements • Risk that agreement on the radio technology takes time at 3GPP • Risk that the 3GPP standards are not adopted by the C-ITS community (including vehicle manufacturers) • Risk that no radio band gets allocated for time critical road safety services

• YoGoKo is leading several C-ITS related standardization activities where 5GASP results could be pushed ahead of time ○ Very innovative topic subject to attract VC funding, qualified engineers and to facilitate the development of new, innovative and disruptive services	• Pending Venture Capital investments necessary to grow the company may be delayed

Table 4 - SWOT analysis table for the "Virtual RSU " NetApp

[IV] *NetApp "Virtual OBU", by partner OdinS: Initial discussion of business aspects*

1. Please describe the Value Proposition of your NetApp (product / service / concept / ongoing development).

OdinS has experience in smart scenarios, including urban mobility, and it is in a perfect frame to move vOBU advances to the product market. We are planning at the moment the integration of vOBU results to offload computing from final mobile devices that are subject to energy and processing constraints.

2. Please list your existing and potential customers.

Service providers, road operators, local or national public authorities, car manufacturers, telecom operators, vehicle OEM providers, companies with fleet management requirements.

3. Please discuss how you plan to license and set the commercial price of your NetApp and provide a roadmap on how you will have revenues from the sales of your NetApp.

To be Developed

4. Please discuss competitors related to the business problem that is tackled by your NetApp.

To be Developed

5. Please fill the following SWOT analysis table for your NetApp.

Strengths	**Weaknesses**
• Digital Innovation • Reduction of energy impact of OBUs	• Implementation of the platform • Maintenance of the solution • Hosting services for edge resources

• Reduction of hardware needs in new-generation vehicles	
Opportunities	**Threats**
• New services for power-constrained vehicles	• Competitive responses

Table 5 - SWOT analysis for the "Virtual OBU" NetApp

[V] *NetApp "Privacy Analyser", by partner Lamda Network: Initial discussion of business aspects*

1. Please describe the Value Proposition of your NetApp (product / service / concept / ongoing development).

Lamda Network's commercial product is the Qiqbus messaging and analytics platform. The platform has been designed to operate on a cloud environment. It implements a share-nothing architecture that allows it to scale to a very large number of users, devices and traffic rate. It is geographically distributed, with each geographic zone operating in complete isolation from the other zones. The platform is fully multitenant with each tenant managing her own set of users, devices, processing topologies and alerts. Qiqbus follows a SaaS approach, where customers integrate with the service solely through a REST API and by specifying the cloud provider and geographic region of preference. Thus, the service is local to their infrastructure avoiding high latencies. Qiqbus integrates to customer services through the concept of input and output endpoints for streaming data. In between input and output endpoints, there exists a graph of stream processors and a complex event processing (CEP) engine that can generate new events when certain conditions are met.
PrivacyAnalyzer is a flavour of Qiqbus with stream processors implementing novel privacy detection algorithms. Its unique selling points are i) the accuracy of the privacy detection methods ii) PrivacyAnalyzer' easy integration due to the versatile set of endpoints and its support for in-memory computations that render it suitable for real-time applications, such as for applications pertinent to the PPDR and Automotive Verticals.

2. Please list your existing and potential customers.

We have customers (one in Greece and one in US) using Qiqbus.
PrivacyAnalyzer (a specific flavour of Qiqbus) is not currently being used by any customer. One of the main reasons that drived us to join 5GASP was the potential to transfer PrivacyAnalyzer either in the PPDR or in the Automotive market.

3. Please discuss how you plan to license and set the commercial price of your NetApp and provide a roadmap on how you will have revenues from the sales of your NetApp.

PrivacyAnalyzer shall follow the licensing and commercial concepts of Qiqbus. Similarly to Qiqbus, PrivacyAnalyer shall be offered as a Software as a Service platform. The revenue streams shall derive from the monthly subscription fees of customers. Specifically, each customer shall pay Lamda Networks according to a volume-based subscription pricing model. Currently two (2) service packages are planned for PrivacyAnalyzer: (A) the Professional and (B) the Enterprise edition. Each package shall be offered at a different price. Professional users are envisaged to be clients requiring PrivacyAnalyzer for their low-volume non-mission critical application. A non-customizable UI shall be offered to the Professional package.

Our Enterprise offering will include advanced features such as purely in-memory computations for very fast responses of our privacy analysis stream processors, suitable for real-time and mission critical applications. Customizable UIs shall be offered to Enterprise Users.

The pricing scheme for both service packages shall be volume based with monthly volume subscriptions starting from €7 per 520,000 messages per device per month with discounts for higher volume packages.

Lamda Networks is also exploring a second revenue stream through a parallel business model based on a technology licensing scheme, which has strong success record and it is likely to lead to substantial revenue growth. For this purpose, the components of PrivacyAnalyzer that have a high value from an Intellectual Property endpoint (notably our privacy analysis algorithms) will be re-engineered for standalone integration with 3rd parties according to their privacy requirements.

4. Please discuss competitors related to the business problem that is tackled by your NetApp.

Currently there is no commercial software able to provide real-time privacy analysis capabilities in IoT and 5G UEs. Only research prototypes exist, and these are only simulators. No patent exists with a solution similar to PrivacyAnalyzer. We have the competitive advantage, but we still wait a patent to be granted for PrivacyAnalyzer, this is under pursue and expected to be completed in 2022 through a patent to EPO.

5. Please fill the following SWOT analysis table for your NetApp.

Strengths	**Weaknesses**
• PrivacyAnalyzer incarnates novel methods for privacy analysis of network messages to identify Personal Identifiable Information (PII) leaks. • The software is a flavour of Qiqbus product thus leverages its high performance and in-memory	• Device manufactures and/or system integrators are typically following in-house policies for security assessment. They are reluctant to adopt new technologies for privacy assessment, since privacy assessment is a new topic not often implemented as a business process.

technologies for near real-time of messages.	• 5G UEs, sensors and other terminal equipment must expose APIs that shall allow inter-working with PrivacyAnalyzer, posing some extra implementation efforts to the equipment vendors.
Opportunities	**Threats**
• European Commission emphasizes on privacy-aware network communications to protect citizens and organisations for PII leaks. • System integrators need privacy analysis software to access the privacy properties of the network messages stemming from hardware from different vendors (e.g. sensor manufacturers, mobile equipment vendors). • No product or patent exists with the capabilities of PrivacyAnalyzer which provides potential to attract VC funding without a hefty sacrifice.	• Pending patent. • Entrance of new competitors. • Brain drain due to economy of the state.

Table 6 - SWOT Analysis for the "Privacy Analyser" NetApp