D2.1

Development and deployment plan

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Meaning
3GPP	3rd Generation Partnership Project
AI	Artificial Intelligence
AMF	Access and Mobility Management Function
ATP	Automated Truck Platooning
CAM	Connected and Automated Mobility
CN	Core Network
CNF	Containerized Network Function
COTS	Commercial off-the-shelf
C-ITS	Cooperative Intelligent Transportation System
eMBB	Enhanced Mobile Broadband
eNB	Evolved Node B
FDD	Frequency Division Duplex
FTED	Floating Truck Emission Data
FW	Firewall
GHG	GreenHouse Gas
GLOSA	Green Light Optimal Speed Advisory
gNB	Next generation NodeB
GNSS	Global Navigation Satellite System
HCV	Heavy commercial vehicles
HMI	Human-Machine Interfaces
HSS	Home Subscriber Server
I2V	Infrastructure to Vehicle
IaaS	Infrastructure as a Service
IDS/IPS	Intrusion Detection System/Intrusion Prevention System
IoT	Internet of Things
ITS	Intelligent Transportation System
LCMM	Low Carbon Mobility Management
LCV	Light commercial vehicles
LIDAR	Laser Imaging Detection and Ranging
LL	Living Lab
LTE	Long Term Evolution (4th generation mobile network technology)

MANO	Management and Network Orchestration
MAP	Map Data
MIMO	Multiple Input, Multiple Output
MEC	Multi-access Edge Computing
MME	Mobility Management Entity
mMTC	massive Machine Type Communications
NPM	Nationale Platform Mobilität (National Platform Future of Mobility) (https://www.plattform-zukunft-mobilitaet.de/en/)
ML	Machine Learning
mMTC	Massive Machine-Type Communications
MNO	Mobile Network Operator
Nb-IoT	Narrow-band Internet of Things
NFV	Network Function Virtualization
ng-eNB	Next Generation evolved Node B
NR	New Radio
NSA	Non-Stand Alone
OBU	Onboard Unit
ORDP	Open Research Data Pilot
OSM	Open Source MANO (Management and Network Orchestration)
PNF	Physical Network Function
PGW	Packet Data Network Gateway
RAN	Radio Access Network
SA	Stand Alone
SGW	Serving Gateway
SLA/SLS	Service Level Agreement, Service Level Specification
SMF	Session Management Function
SPAT	Signal Phase and Timing
STS	Ship to Shore
TAVF	Testfeld autonomes- und vernetztes Fahren
TEU	Twenty-foot Equivalent Unit
TDD	Time Division Duplex
TLF	Traffic Light Forecast
TMS	Traffic Management System

UC	Use Case
UDM	Unified Data Management
UE	User Equipment
UHD	Ultra-High Definition (video)
UPF	User Plane Function
UTRA	Universal Terrestrial Radio Access
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
VNF	Virtual Network Function
vTMC	Virtual Traffic Management Center
WiFi	Wireless networks technology based on IEEE 802.11 family standards

Table 1: List of Abbreviations

EXECUTIVE SUMMARY

This deliverable aims to provide a common timeline and guidance for the alignment of development and deployment activities across all the three 5G-LOGINNOV Living Labs, i.e., Athens, Hamburg and Koper. It details the methodology and tools used for closely monitoring the rollout activities of each LL, including the identification of potential synergies across LLs and to prevent both time and scope deviations from the original plans set out in this document, ensuring readiness for WP3 trials.

This document is focused on several aspects, namely to:

- Ensure compliance with WP1 specifications, i.e., use case specifications.
- Provide a detailed timeline for all relevant development and deployment tasks of all use cases that will be deployed in each LL.
- List the foreseen equipment (trucks, 5G-IoT devices/GWs, cranes, cameras, MEC, etc.) that will shape and participate in the LL trials (described in D3.1).
- Draft the process for the preparation, execution, and feedback cycles to be followed by all LLs to ensure coherent progress and development and to facilitate cross-Living Lab knowledge sharing, monitoring and checks, including the description of the data collection activities required to assess 5G-enabled use case benefits.
- Describe the monitoring tools used to ensure the efficient and timely integration of the 5G and logistics technologies\innovations at the LLs.
- Ensure readiness to carry out WP3 trials.

In this context, each LL will present their detailed rollout plan following a phasing approach that describes (i) the "*development and deployment strategy"* that will be followed by each pilot side, (ii) the actual "*development and deployment in the LLs"* which breaks down and implements each use case relevant development and deployment subtasks (iii) "*Testing and Verification, Report readiness for Living Lab Trials"* where all use case components and solutions are tested, verifying intended use case operation and that data can be collected for the 5G-LOGINNOV evaluation phase, and finally (iv) "*Maintenance and Support for Trials Execution*".

It is crucial to highlight that the focus of this deliverable is to sketch the high-level planning and methodology for the development and deployment activities at each LL, and it serves as a guideline for the actual development tasks that take place in the subsequent parts of WP2, i.e., T2.2 (Tools for data collection and evaluation), T2.3 (Development and deployment LL Athens), T2.4 (Development and deployment LL Hamburg) and T2.5 (Development and deployment LL Koper).

The rollout plans and roadmaps presented in this document reflect the 5G-LOGINNOV partners best estimate for the completion of the deployment, development and rollout phases at each LL by the end of M20 (April 2022), whereas WP2 is finalized in M22 (June 2022).

1 INTRODUCTION

1.1 Project intro

5G-LOGINNOV will focus on seven 5G-PPP Thematics and support to the emergence of a European offer for new 5G core technologies in 11 families of use cases.

5G-LOGINNOV's main aim is to design an innovative framework addressing integration and validation of Connected Automated Driving/Mobility (CAD/CAM) technologies related to the industry 4.0 and ports domains by creating new opportunities for LOGistics value chain INNOVation.

5G-LOGINNOV is supported by 5G technological blocks, including new generation of 5G terminals notably for future Connected and Automated Mobility, new types of Industrial Internet of Things 5G devices, data analytics, next generation traffic management and emerging 5G network architectures, for city ports to handle upcoming and future capacity, traffic, efficiency and environmental challenges.

5G-LOGINNOV will deploy and trail 11 families of Use cases targeting beyond TRL7 including a GREEN TRUCK INITIATIVE using CAD/CAM & automatic trucks platooning based on 5G technological blocks.

Thanks to the new advanced capabilities of 5G relating to wireless connectivity and Core Network agility, 5G-LOGINNOV ports will not only significantly optimize their operations but also minimize their environmental footprint to the city and the disturbance to the local population.

5G-LOGINNOV will be a catalyst for market opportunities build on 5G Core Technologies in the Logistics and Port operations domains, thus being a pillar of economic development and business innovation and promoting local innovative high-tech SMEs and Start-Ups. 5G-LOGINNOV will open SMEs' and Start-Ups' door to these new markets using its three Living Labs as facilitators and ambassadors for innovation in future European ports.

5G-LOGINNOV's promising innovations are key for the major deep-sea European ports in view of the mega-vessel era (Hamburg, Athens), and are also relevant for medium sized ports with limited investment funds (Koper) for 5G.

1.2 Purpose of the deliverable

The purpose of this public document is to record the first results of T2.1 being realizing a consortium-wide agreed approach to develop and deploy the 5G-LOGINNOV systems in the Living Labs. With this agreed approach, the deliverable serves to ensure a timely development and deployment of the innovations with high quality, across all Living Lab sites.

This purpose is served by:

- Recording how to interpret the different subjects within development and deployment.
- Describing the approach including phases, milestones, development, integration, testing and associated meetings and synchronization moments.
- Providing relevant tools for tracking the agreed approach.
- Recording the lessons learnt when drafting this approach.

Attainment of the objectives and explanation of deviations

The objectives related to this deliverable have been achieved in full and as scheduled.

1.3 Intended audience

This deliverable is PUBLIC intended for the following audiences:

- 5G-LOGINNOV partners must use the deliverable as recorded agreement, reference and guideline throughout development and deployment of the innovations.

- The European Commission, Agency and related reviewers can use the deliverable to gain insight in how the development and deployment work result in the delivery of the 5G-LOGINNOV innovations.
- Any reader can use the deliverable to gain insight in how these kinds of innovations are tracked and realized in 5G-LOGINNOV.

1.4 Structure of the deliverable and relationship with other work packages/deliverables

This deliverable is structured in the following manner:

- **Chapter 1:** Introduction, provides a brief overview of the project and the purpose and audience the deliverable is intended for.
- **Chapter 2**: 5G, innovations, architectures and designs, provides a brief overview of the living labs, trial sites and innovations that will be developed. The requirements of these innovations are available in the requirements deliverables D1.1 to D1.5.
- **Chapter 3**: Approach, provides the approach that 5G-LOGINNOV uses to develop, deploy and test the innovations and use cases of the project.
- **Chapter 4:** Tracking sheet, describes the tool we use for tracking the progress of WP2 tasks and how we use them to ensure timely delivery of 5G-LOGINNOV innovations in high quality.
- **Chapter 5:** Conclusion, concludes the overall planning and methodologies that will be used in the LLs.

2 5G, INNOVATIONS, ARCHITECTURES AND DESIGNS

5G-LOGINNOV's family of use cases will be tested and validated in three Living Labs connected to TEN-T European ports in Athens (Greece), Hamburg (Germany) and Koper (Slovenia). An overview of each Living Lab is presented here, while more detailed information about the 5G-LOGINNOV ports and 5G enabled use cases to be developed can be found in Deliverable D1.1 [1]. In D1.2 [2] the 5G architecture tailored to each Living Lab use cases has been described, whereas D1.3 [3] aimed to specify the Living Lab infrastructure requirements of the equipment to be provided for the three pilot sites. Finally, the list of KPIs selected from each Living Lab for the evaluation and impact of the project can be found in D1.4 [4].

2.1 Generic View of the Innovations in Port Operations with Focus on 5G Aspects

The Athens Living Lab at Piraeus port will develop a set of use cases and platforms that communicate over the deployed 5G NSA network (Non-Stand Alone) with different types of end devices. 5G technologies will enable the use case innovations exploiting the eMBB service (Enhanced Mobile Broadband), low latency transmissions and enhanced localization services of the cellular infrastructure at the port premises, including MANO-based services and orchestration (Opensource MANO [8], Openstack [10]), pioneering far-edge computing solutions, computer vision and AI/ML video analytics. Figure 1 shows a high-level overview of Athens Living Lab use case layout including various 5G end devices (5G-IoT device, 5G connected yard/external trucks), portraying the main components of the envisioned services and thus the trials that will take place in WP3 (described in detail in D3.1 [7]). Several MANO (Management and Network Orchestration) service components will be connected to different modules for surveillance (Streaming management), managing the inference of video analytics from the deployed 5G-IoT devices and alert generation (Inference management), and the module that aggregates data from the fleet of 5G connected yard/external trucks (Telemetry management).

For the support of all use cases, the Greek pilot MNO (Vodafone) will establish 5G communications within the port premises, enabling real-time tracking and operations optimization of the fleet of 5G connected trucks. Currently 170-yard trucks operate at the port, a subset of which will be equipped with 5G technology and participate in the 5G-LOGINNOV trials, targeting port operations optimization for the horizontal movement of containers between stacking areas and loading/unloading areas for vessels and rail, exploiting the low latency transmissions of the 5G network and enhanced localization, as well as predictive maintenance services from various on-truck sensors. The envisioned scenarios will have a direct effect on the efficiency of operations at Piraeus Container Terminal (PCT), as well as the environmental footprint in the surrounding area. Additionally, live (near real-time) tracking of external trucks in-bound to the port will further enable the end-to-end view in the supply chain of the logistics sector, further coordinating port operations. Furthermore, NFV-MANO-enabled video analytics services, following the far-edge computing paradigm based on distributed 5G-IoT devices at difference port areas, will target safety/security applications (human presence detection) as well as logistics applications (container seal detection) exploiting the enhanced mobile broadband capabilities of 5G coupled with low latency transmission from the inference of the analytics tasks, shaping the trials and innovations tailored to 5G and the Athens LL use cases. Finally, real-time UHD (Ultra-High Definition) video surveillance transmitted by the distributed 5G-IoT devices will further enable the supervision of port operations. Such uplink-data-intensive applications call for enhanced capacity that cannot be served with legacy LTE networks. Hence, 5G-NSA cellular communications exploiting the eMBB service of 5G technology will be adopted in the envisioned use case operation.

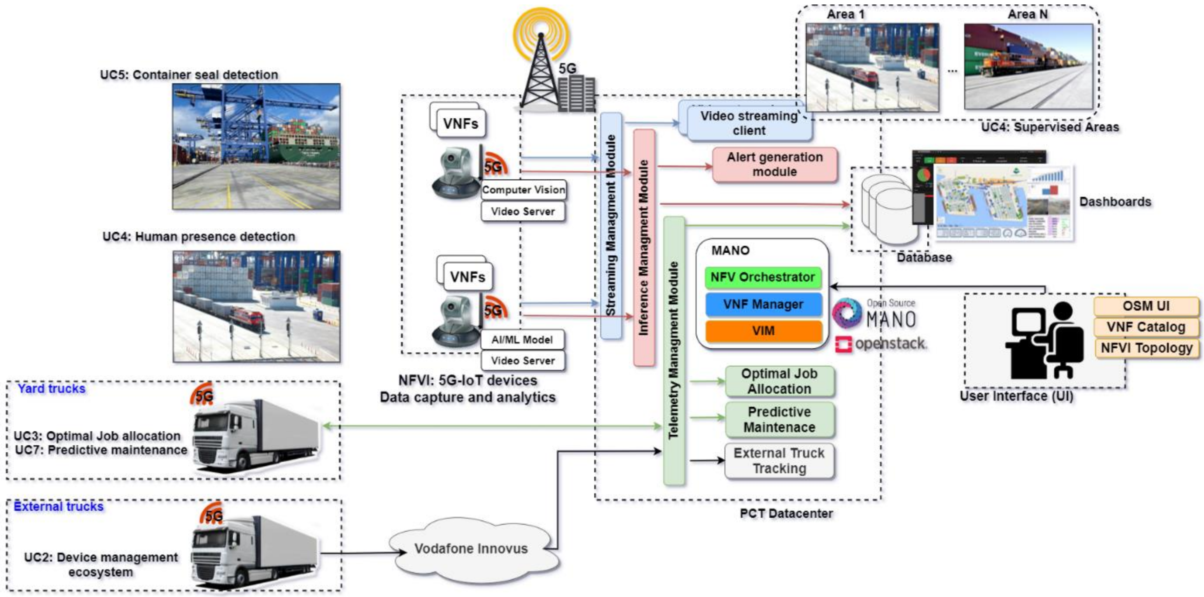

Figure 1: Athens LL view for use case trials execution

In the case of Hamburg Living Lab, two pilot site scenarios increasing efficiency from urban hinterland to Hamburg's port terminals are planned to be implemented. Figure 2 depicts the location of the targeted test fields. The red rectangle shows the inner-urban Testfield for Connected and Automated Driving (TAVF), a round trip inside the City Centre of Hamburg in where all traffic lights are transmitting Traffic Light Forecast via 5G Mobile Edge to APP users for Green Light Optimal Speed Advisory (GLOSA). The governmentally backed test field includes intersections where 5G-LOGINNOV Hamburg partners (Swarco, Continental and T-Systems) enable ultra-low latency collision alert warnings in the range <50 ms. The messages are part of the GLOSA-enabled vehicle platoon use case (UC10) and have the objective to avoid accidents of the platoon with crossing vehicles or Vulnerable Road Users.

It must be mentioned that the environmental impact in carbon savings achievable by vehicle platooning will be studied not exclusively in use case 10. Additionally, there will be Floating Cars collecting speed profiles and carbon footprint in both rectangles illustrated in Figure 2 (red and blue) as described in use cases 8 and 9. The purpose of evaluating Floating Car data is to quantify the baseline without 5G-enabled GLOSA and to compare it to the improvement of baseline when using 5G-enabled GLOSA. In UC8 and UC9 this measurement will take place with vehicles driving in single mode, whereas in UC10 the impact of vehicles platooning with regards to speed and energy profiles will take place. Use cases 8 and 9 will cover the mission of collecting data in free, dense, and congested traffic states, which will lead to an overview of emissions depending on traffic volume time series during the day. Therefore, these use cases are summarized under the category of Floating Truck Emission Data (FTED). As all FTED is valuable emission map data to feed the virtual traffic management centre of SWARCO for setting up use case 11 (Dynamic Control Loop for Environment Sensitive Traffic Management Actions - DCET), accuracy and scalability of data collection has to be ensured, meaning that only the 5G-related functionalities of network slicing and Mobile Edge can guarantee the required Hamburg wide Quality of Service.

For all the described 5G functionalities of Network Slicing and Mobile Edge, some horizontal requirements hold true when it comes to quality of service linked to all use cases mentioned. Pre-tests revealed that the slope contribution to the energy demand of a vehicle in motion heavily relies on the accuracy of the height information. The same is true for the accuracy and reliability of the collision warning service needed for GLOSA enabled vehicle platooning, where precise positioning is of same importance given the trajectories anticipating a potential collision. Therefore, the Living Lab Hamburg partners will work on correcting the available GNSS signal by the 5G based Precise Positioning service offered by Deutsche Telekom and Skylark. The service is available in 4G/LTE, but not scalable given the size of Hamburg; it will be deployed during the 5G-LOGINNOV trial in Hamburg using 5G-R15 NSA in the indicated test fields; nevertheless, higher releases of 5G will pave the way for viable commercial service deployment and go-to-market scenarios built on the expected positive results after the trial phase in 2022.

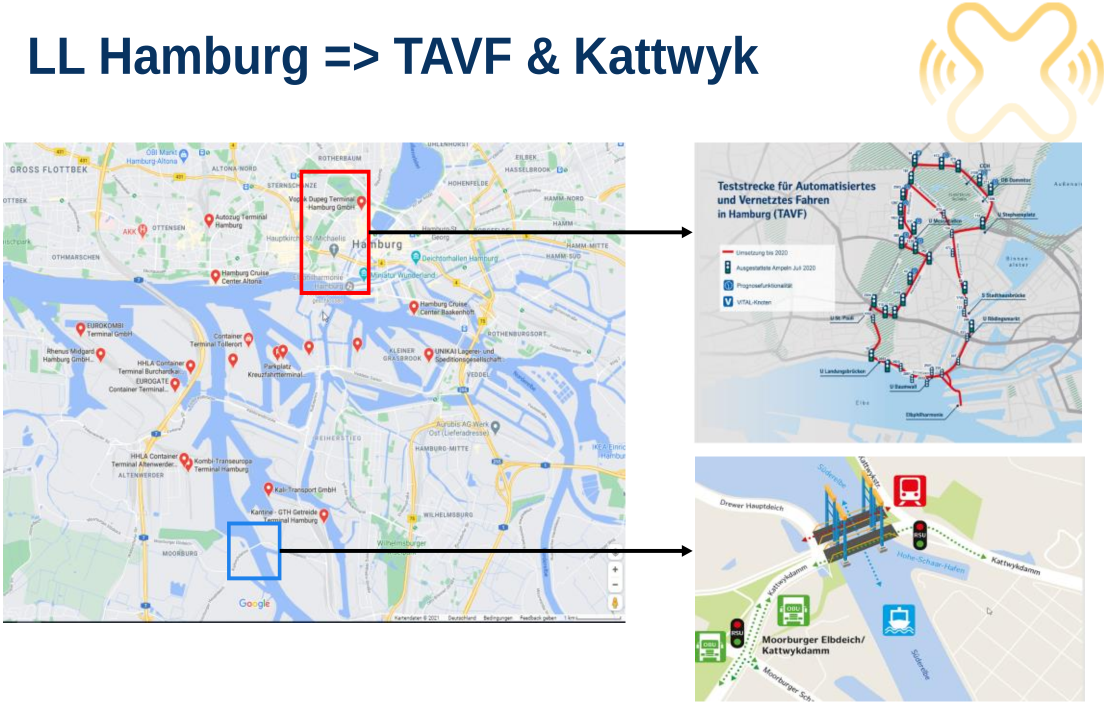

Figure 2: Hamburg LL view for use case trials execution

Figure 3 shows the existing 5G design already used in the Hamburg TAVF test field. 5G-LOGINNOV is using the same C-ITS (Cooperative Intelligent Transportation System) and 5G infrastructure for all Hamburg use cases planned. The technical components are ready to use, the Mobile Edge will be shared with TAVF projects, the same holds true for the collision alert warning planned for UC10. Additional to the solution architecture shown in Figure 3, precise positioning will be deployed and linked to all Hamburg use cases for impact assessment and KPI verification.

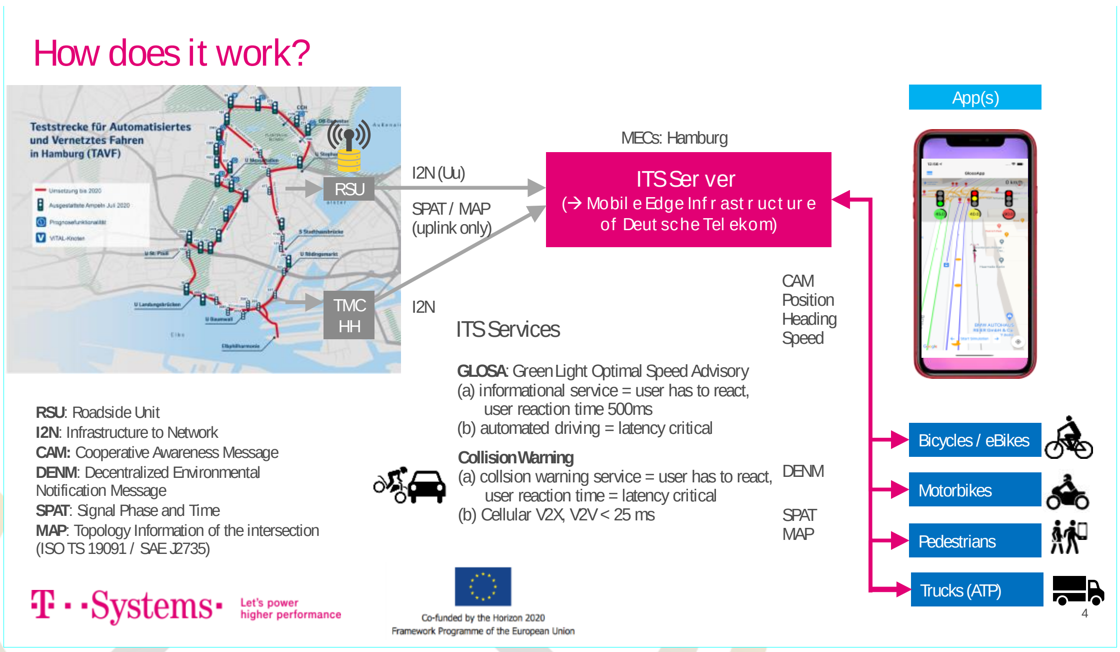

Figure 3: Solution Design already in action in Hamburg

Trials in Living Lab Koper will first focus on providing a stable 5G mobile network (UC1) in order to support following two use cases/trials related to port's specific operations (UC5 and UC6). The overall network will be deployed by orchestrating two 5G networks - public 5G network (5G NSA at the beginning and then evolved to 5G SA within the project duration) and private 5G SA network. 5G technology plays important role due to certain capabilities that cannot be realized such efficiently or cannot be realized at all using other technology, or could be realized using several other technologies which would add to the complexity of the system impacting overall efficiency. Network architecture will enable on-demand and automatic deployment of VNF-based network (Virtual Network Function) and services components, high availability and resilience of services deployed, including mission critical communication services, and IoT-5G devices support. To trial the complete system, a few components will need to be first configured, tested and integrated: network infrastructure, 5G network and application enablers, 5G network slice enablers, and application enablers. The system will be trialled against multiple KPIs; some of the most important are: deployment time, time to scale, components onboarding, configuration and reconfiguration, traffic capacity, latency, availability, connection density, bandwidth, etc.

The following two use cases, i.e., UC5 and UC6, will mainly focus on efficient solutions for collecting/transmitting data (relying mainly to eMBB and mMTC prepared in UC1) and analysing these data (edge computing). Since these two use cases will be user oriented, i.e., focused to port/logistics operations, 5G KPIs described previously will be trialled under conditions of real traffic load and will be examined in scope of providing adequate environment for the end users applications. However, end users experience will be also evaluated by trialling several KPIs:

- Related to video analytics: model accuracy and reliability, model inference time.
- Related to telematics: data on trucks acceleration, speed, fuel consumption, stand still time, parked time.

Figure 4 illustrates LL Koper high-level 5G network architecture and place of the use cases trials specific technology within it.

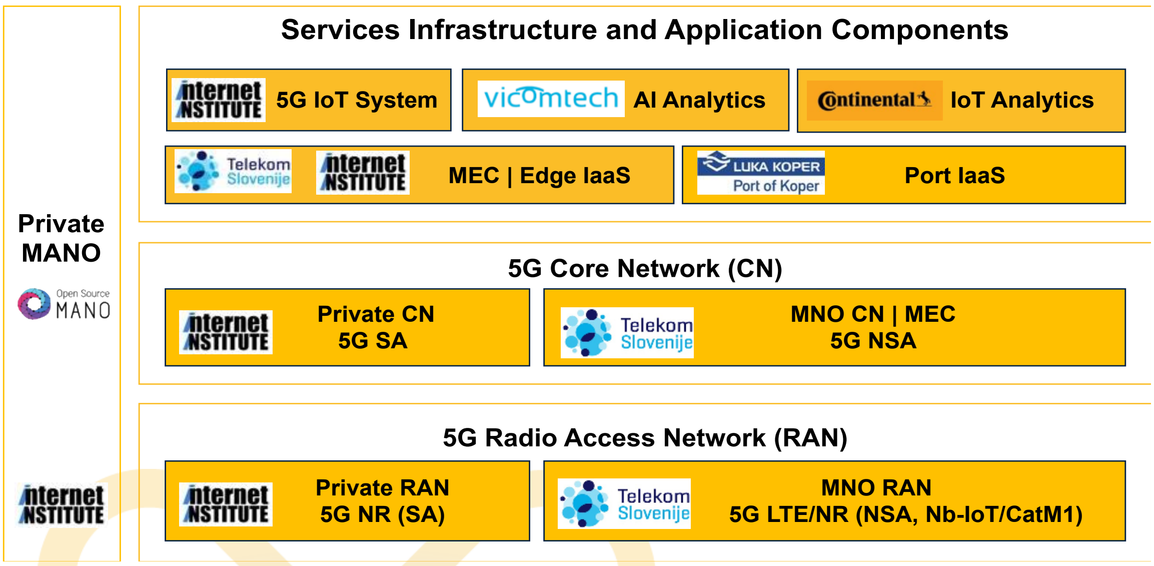

Figure 4: LL Koper view for use case trials execution

2.2 Evaluation and data collection tools

2.2.1 High level data collection architecture

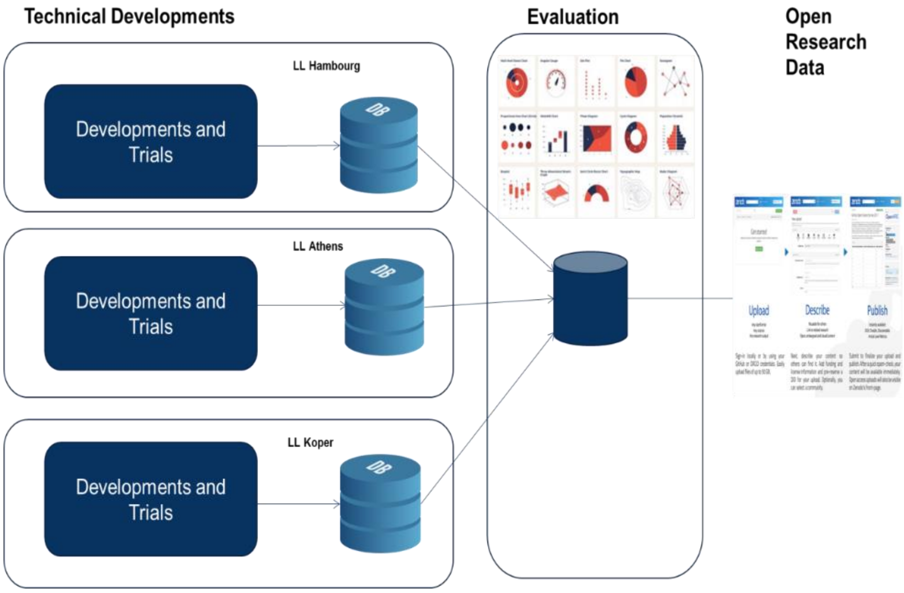

Figure 5: Data collection architecture overview

The project's Data Management Plan (D6.4) has provided an initial high-level architecture for data management as illustrated on Figure 5, which shows that each of the three Living Labs generates data during the use case operations and trials. The data may be raw or processed (in case of KPIs for example). Some of the generated data are collected to a central data collection tool for evaluation purposes. It is up to the Living Labs to decide what data they are willing to provide. To support the evaluation tasks, the central data collection will interface with each of the Living Labs to collect evaluation data. As such, it makes project-wide evaluation data available to the evaluation team. Additionally, the central data collection tool will help in publishing selected data under the frame of ORDP (Open Research Data Pilot).

The deliverable D1.4 provides input for data collection by providing a list of KPIs and the data necessary to calculate them. It provides also common requirements regarding evaluation data that will be considered.

The data collection process will take into account the data handling requirements and cybersecurity policies described in the deliverable D1.5 - Data and cyber protection policies.

2.2.2 Development and deployment of the data collection tools

Data collection tools will be thoroughly discussed in the deliverable D2.2. Figure 6 illustrates the technical choices made in the task T2.2 for the data collection in this project. These choices are for:

- The central data server: Fluentd, Elasticsearch and Kibana.
- The living labs: Fluentd.
- The authentication and authorization: Oauth2.0/OpenID Connect.

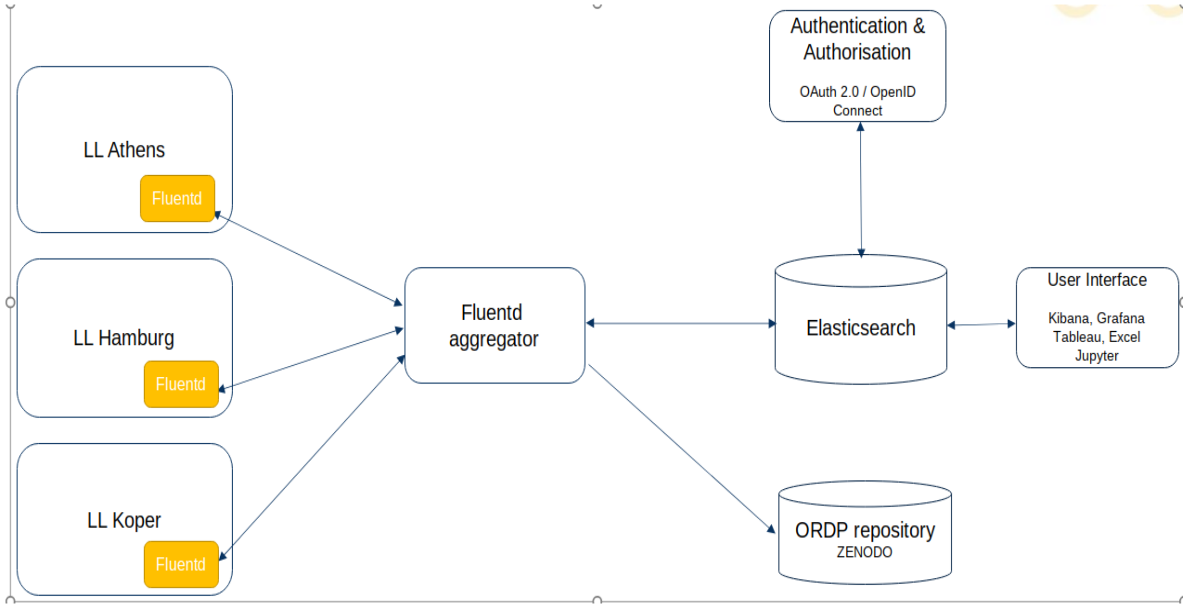

Figure 6: Data collection aggregation tools overview

The central data collection tools are based on open-source tools which are Fluentd for the log processing, Elasticsearch for data storage and indexing and Kibana for data visualisation, evaluation computation and management of Elasticsearch. However, other visualisation tools with statistical modelling such as Grafana, Jupyter and Microsoft Excel may be used.

The data collection process using the tools described above will intervene after the data production occurred. Therefore, each living lab will use another set of tools different from the ones used for the data collections and evaluation purposes. Thus, each living lab will configure internally its Fluentd server to connect to its internal data sources and pre-process them for the needs of 5G-LOGINNOV evaluation that will be done in WP3.

An Authentication and Authorisation server will be used based on OAuth 2.0 to secure the access to the evaluation data. Finally, at the completion of the project, the central Fluentd server will read the content of the central server and send the Open Research Data sets to Zenodo.

2.3 Living Lab Athens

Table 2 provides a brief overview of the Athens Living Lab 5G-enabled use cases and their contribution to the operations of the port of Piraeus. For more details, please refer to D1.1 [1] document. Furthermore, this chapter also provides the intended target timeline for all development and deployment phases of each use case (development, deployment, testing, integration and validation), including also technologies that will be developed in the ICCS lab environment (i.e., MANO platform, AI/ML solution) and integrated to PCT premises at a later stage. Finally, the foreseen installed equipment (5G-IoT devices, UHD cameras, 5G UEs/modems, telematics devices, etc.) as described in detail in D1.3 [3] is listed in Table 4, including also the number of port assets (e.g., yard/external trucks, STS Cranes) that will be equipped with 5G-LOGINNOV devices and participate at the pilot side trials and evaluation at Piraeus port. The timeline for the development of each use case is given in sub-section 2.3.2.

2.3.1 Use case contribution to the Living Labs

Use case	Contribution
UC2: Device Management Platform	**“5G connected external-truck in port operations”** This use case is two-fold aimed. The first aim is an informative task and the goal

Ecosystem	is to leverage the position of external trucks in order to estimate anticipated traffic towards the port. This information, visible on the truck drivers' mobile phone, will offer an insight of expected conditions at the port entrance. The second aim is informing (map based) all truck positions to other truck drivers in real time. This information is important for truck drivers when manoeuvring close to other trucks and during platooning
UC3: Optimal Yard Truck selection	**"5G connected yard-truck in port operations"** This use case aims at optimizing the horizontal movement of containers between stacking (and storage) areas and loading/unloading areas for vessels and rail by utilizing enhanced localization services and low latency transmissions of 5G technology, to coordinate the operation of the fleet of 5G connected trucks, in (near) real-time. A 5G modem/router will be installed on yard trucks and connected to the on-board telematics device with access to CAN-Bus data, container presence sensor data, and localization. The selection of the optimal yard truck from the fleet of 5G connected trucks will be a factor of many variables (based on the truck telemetry data aggregated at PCT's management platform): the distance between the live (precise) location of each available truck and the container job location, e.g., the unloading vessel (in order to minimize truck travel distance); a truck's moving direction and speed (in order to avoid potential manoeuvres and additional delays due to caused traffic jams within the port premises, as well as unnecessary braking which further burden the life cycle of tires); and finally the current load, i.e., number of containers already carried by each truck. Based on live tracking of 5G trucks and the above-mentioned criteria, UC3 will validate the improved efficiency of container job allocation by optimizing port operations and reducing the environmental footprint (i.e., reducing fuel consumption and CO_2 emissions) around the port area.
UC4: Optimal surveillance cameras and video analytics	**"Far-edge computing NFV-MANO enabled video analytics for human presence detection"** Frequent incidents involving boom collisions, gantry collisions or stack collisions, along with the presence of stevedoring personnel in port areas, make the risk for serious bodily injuries considerable. This use case aims at the design, development and deployment of a novel 5G-IoT device that will be distributed to selected locations (risk areas, e.g., areas with increased traffic or increased crane operation) at PCT premises. The IoT device will be equipped with a UHD camera (serving as input video streams for the AI/ML solution for detecting human presence), and a 5G interface to establish cellular communication with the backend system at PCT. NFV-MANO support will enable the instantiation (and deactivation) of the service at the IoT device, including all relevant AI/ML components, monitoring and life cycle management of the service. The transmission of 4K resolution streams is not possible over current WiFi and LTE installations especially when the presence of multiple cameras is required in the area of coverage. eMBB service of 5G NSA network deployed at Piraeus port will be exploited to handle the massive uplink data traffic of UHD streams from multiple locations (and potentially multiple IoT devices), whereas low latency transmissions will be utilized for transmitting the inference of the analytics from the 5G-IoT device to the port's management platform (i.e., human presence detected at risk area), triggering immediate alerts and further actions to security patrols.
UC5: Automation for ports: port control, logistics and remote automation	**"Far-edge computing NFV-MANO enabled video analytics for container seal detection"** This use case will exploit the 5G infrastructure at Piraeus port and advanced computer vision techniques to detect the presence (or absence) of container seals during the loading (and unloading) process of vessels at the STS cranes. An STS crane will be equipped with the 5G-LOGINNOV 5G-IoT device that is

	composed of UHD camera(s), a compute node that will host the VNFs carrying all relevant modules for the computer vision algorithm (service instantiation, termination and life cycle management), and a 5G interface for cellular communication with PCT's management platform. The NFV-MANO platform will control and monitor all deployed devices (and services), also including the transmission of the analytics inference (i.e., seal present/absent). The IoT device will also exploit the broadband 5G network at PCT premises delivering voluminous video streams (uplink UHD video data) for further surveillance and monitoring for the STS crane operation.
UC7: Predictive Maintenance	**"Predictive Maintenance"** Predictive maintenance is a significant contributor to increasing operational efficiency and reducing unplanned downtime of expensive equipment by identifying and solving problems before they occur. A key concern at Athens LL is storing and managing bulky assets (such as spare/repair parts) that occupy significant space of the port, especially at PCT operating close to maximum annual capacity. This use case will equip yard trucks with 5G access points connected to truck's data sources (CAN-Bus and other custom on-truck sensors) that will be transmitted via the 5G network to PCT operations management platform. The accumulated telemetry data will be exploited by the predictive maintenance tool (based on insights from the COREALIS (768994/MG-7.3-2017) project) to potentially predict possible breakdowns, reduce downtime for repairs and optimise stock of spare parts, increase the service life of yard vehicles and optimise operational efficiency through minimisation of breakdowns. The proposed tool will capture historical and recent status data for the assets in question, utilized by the ML algorithm and driving a per yard-vehicle data driven approach (schedule of purchases, storage of parts, proactive maintenance), by taking advantage of 5G technology that provides a flexible, reliable and predictable environment to remotely keep track of the connected assets on a real time basis.

Table 2: Use Case Overview, Athens Living Lab

2.3.2 Timeline planning of development and deployment

5G-NSA (Rel. 15): The development and deployment of each use case is dependent on the deployment of the private 5G network at PCT premises, involving all radio access and core cellular network components (software and hardware related). The detailed 5G architecture requirements tailored to each Living Lab use cases have been explained in D1.2 [2]. At Piraeus port the deployment of the private 5G network started on M07 (March 2021) and is due by M14 (October 2021), managed by the MNO of the Greek pilot, Vodafone, following the 5G-NSA option of Release 15. Additionally, a 5G UE/modem (at least CAT-13) will be provided by the MNO and will be installed on all pilot participating end-devices (i.e., yard and external trucks, IoT devices) to establish cellular communication with the port's management platform, addressing the needs of all use cases. The expected arrival date for the 5G modem is due by the end of M14. The development of the use cases, as described in the following, progresses in parallel. Table 3 depicts the timeline planning for the development of all use cases.

UC2: The development of the mobile application and UC2 solution depends on the existing Fleet Management Platform of Vodafone Innovus, which is a web-based platform, globally accessible hosted at Vodafone infrastructure. The back-end system is operational at production level with thousands of live vehicles. For this use case the mobile application requirements are defined, and preliminary development has commenced, the final version is scheduled for M15. The application will run on 5G-enabled Android mobile phones. Testing will take place under 4G and then 5G network, leading to be ready for trial during M20.

UC3: The optimal selection of yard trucks algorithm has been developed based on insights from the INTE-TRANSIT project (5187/2C-MED12-05) and is already operational at PCT premises; however, telemetry data are currently transmitted from yard trucks over either a 4G or WiFi interface, whereas localization technology is based on legacy GNSS system. Upon establishment of the 5G network at Piraeus port, also including the delivery of the 5G UE/modem on M14 (October 2021), M15 (November 2021) will be dedicated to integration and testing with the in-place system, utilizing the 5G cellular link and enhanced localization service. Next, starting on M16 (December 2021) the preparation for the data collection tools and methodology following the specifications of D2.2 [6] will begin, and finally reporting readiness for trials on M18.

UC4 & UC5: UC4 and UC5 are based on NFV-MANO support for the deployment and life cycle management of the service. To this end, the NFV-MANO setup available at the ICCS 5G testbed is utilized for the preparation of the use cases, before the deployment at the port of Piraeus. D1.3 [3] details the relevant software and hardware components with respect to NFV-MANO architecture and 5G-IoT device. The specifications for the hardware components of the IoT device have been finalized at M07 (March 2021). At the time of submitting this document, the equipment for the IoT devices is located at the ICCS lab, particularly 2X compute nodes (Jetson AGX Xavier) and 2X UHD cameras (Dahua IPC-HFW3841T-ZAS). The development of the VNF descriptors for both computer vision models (human presence detection on UC4 and container seal detection on UC5) are developed in parallel, and are expected to be finalized by the end of M14. For UC4 open datasets are used to train the machine learning model for detecting human presence, whereas for UC5 a test dataset was obtained in M06 (February 2021) from PCT's database (about 60K images depicting cargo-container door, both sealed and unsealed cases). The in-lab ICCS development is expected to be finalized in M15 (Nov. 2021). Migration of the MANO platform at the port's datacenter will start on M16 (December 2021) including all preparations regarding database management and also the preparation of data collection tools for the use case evaluation. The installation of UHD cameras and compute node at the STS crane is the most challenging aspect for UC5, started on M12 for the STS crane, at Pier III of the Piraeus port, and will be available for video data collection by M13. Some adjustments to the computer vision approach are expected, given that the cameras will feed the algorithm with new image sources (different view angles, etc.) compared to the initial dataset used from training. The MANO platform at PCT premises is foreseen for M19, whereas readiness for trials is due by M20.

UC7: The predictive maintenance algorithm for PCT's yard trucks is based on insights from the COREALIS project (768994/MG-7.3-2017). This use case follows a similar development plan and timeline as UC3, since they are dependent in the same components, i.e., private 5G network readiness (M14) and 5G/UE modem installation and interconnection with the in-place systems at PCT (M15). Starting on M16 the focus will be on the implementation of the data collection tools as described in D2.2 [6], and testing that data can be collected as intended. By M18 preparation for trials should be completed.

UC/ Time -plan	2021												2022					
	Phase 1			Phase 2								Phase 3				Phase 4		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	M 05	M 06	M 07	M 08	M 09	M 10	M 11	M 12	M 13	M 14	M 15	M 16	M 17	M 18	M 19	M 20	M 21	M 22
UC2			S								Dv				Dp	R		
UC3		S								Dv			Dp	R				
UC4			S								Dv				Dp	R		
UC5			S								Dv				Dp	R		
UC7		S								Dv			Dp	R				
S: Specifications				**Dv: Development**						**Dp: Deployment**					**R: Ready for Trials**			

Table 3: Timeline planning of use case development and deployment, Athens Living Lab.

2.3.3 Foreseen Equipment Deployment

Table 4 summarizes the hardware components including the number of 5G-IoT devices that will be deployed at the port premises including the number of STS cranes as well as external and yard trucks that will be involved at the trials for the evaluation of the use cases and 5G-LOGINNOV objectives for the Athens Living Lab.

Equipment Description	Addressed Use cases	Amount
5G modem (for IoT devices and yard trucks)	UC3, UC4, UC5, UC7	10
UHD cameras	UC4, UC5	4
Compute Node (edge processing node)	UC4, UC5	2
STS Cranes	UC5	1
Yard trucks	UC3, UC7	8
External trucks	UC2	8
5G UEs	UC2	8

Table 4: Foreseen Equipment installations, Athens Living Lab

2.4 Living Lab Hamburg

Hamburg Living Lab will demonstrate the potential of leveraging positive environmental impact by using 5G in data exchange for traffic management, in particular outside the port and the hinterland. Due to special situation as a city port, the living lab Hamburg will operate in public urban areas in particular within the TAVF (Testfeld Autonomes und Vernetztes Fahren, Testfield for connected and automated driving) where the NSA 5G Network of Deutsche Telekom is already available. Therefore, the living lab will rely on existing 5G infrastructure and no private 5G network must be deployed. For more details, please refer to the documents D1.1 [1] and D1.2 [2].

Table 5 provides an overview of the Living lab Hamburg uses cases, their overall research questions and the intended approach to improve the efficiency of logistic operations within the city limits and reduce the environmental impact by using 5G technologies. The foreseen devices already described in document D1.3 [3] in detail will be listed in Table 7, with the expected number of installations and addressed use case.

Furthermore, the intended timeline for the development and deployment as well as integration, testing and validation is provided.

2.4.1 Use case contribution to the Living Labs

Use case	Contribution
UC8/9: Floating Truck & Emission Data (FTED)	**"Evaluation and communication of driving manoeuvres (forced by infrastructure, traffic volume, etc…) of 5G connected vehicles"** For use cases 8 and 9, emission data from floating vehicles/trucks will be made available in a cloud-based centre to enable situation monitoring on emissions. Both use cases have the objective to analyze vehicles in motion with regards to their driving behavior, including energy demand in specific

	road and traffic conditions. For traffic management operators, the emission and vehicle data are displayed in the virtual traffic management centre. The input can also be used for fleet and traffic managers for route optimization. 5G-enabled Precise Positioning improves the accuracy of ISO-23795 calculation for GHG (Greenhouse Gas) monitoring, especially the height-component. Future 5G deployment will allow to roll this out all over Hamburg. Taxi-fleets are planned to achieve trip coverage, then the new DTAG service for precise positioning will enable Hamburg wide coverage to guarantee highest accuracy possible.
UC10: 5G GLOSA & Automated Truck Platooning (ATP)-under 5G-LOGINNOV Green initiative	**"5G enabled speed advice for automated truck platoons"** For this use case, the current and predicted traffic light signalling will be made available. In case of intersections in the TAVF testbed, signal states and predictions are provided by the local traffic light controllers and routed via the virtual Traffic Management Center (vTMC), whereas for all other intersections the signalling data is made accessible by the urban data platform of the city of Hamburg and a prediction is performed on the vTMC. Based on these signal states and state predictions, a Green Light Optimal Speed Advice (GLOSA) is calculated and communicated towards each vehicle, to allow an optimised trajectory planning for automated vehicle manoeuvring across intersections, saving energy and emissions. The prediction use case 10 has the objective to showcase how Automated Vehicle Platooning can be deployed by GLOSA and V2V communication. Collision warning messages will be transferred relying on Precise Positioning, ultra-Reliable Low Latency (<50ms) and MEC-X infrastructure. 5G NSA is an option for setting the solution up, but not to roll it out to a wider area of the City, as planned in the ITS policy framework of Hamburg's policy makers. It is planned to equip a mini-platoon of 2 vehicles with 4K-Video cameras and LIDAR (Laser Imaging Detection and Ranging), making use of the eMBB of the 5G network, starting with 5G NSA and roll it out after project end commercially based on 5G-R15 or higher. The purpose of using this equipment is to monitor the vehicles' behavior and the external interference to enable the safe operation of the use case.
UC 11: Dynamic Control Loop for Environment Sensitive Traffic Management Actions (DCET)	**"5G enabled environmental sensitive traffic management"** For use case 11, the vehicle-based emission data received in UC8/9 will be used to trigger traffic management measures (strategies) in traffic control (e.g. adjust the traffic signal plan or provide information to vehicles through variable message signs). In general, existing sources for emission data could be used additionally, but the virtual traffic management center is not linked to the city of Hamburg traffic management network. Nonetheless, the objective is to showcase the usefulness of vehicle-based emission data to initiate holistic traffic management actions for pollution control. As use case 11 is dependent on reliable positioning data generated in UC8/9, 5G enabled Precise Positioning is of same importance as in FTED use case.

Table 5: Use Case Overview, Hamburg Living Lab

2.4.2 Timeline planning of development and deployment

As the Living Lab Hamburg will use the public and already available 5G-NSA network operated by the Deutsche Telekom (currently Release 15), the development and deployment of the Living Lab Hamburg use cases do not depend on the deployment of the private 5G networks (please refer to document D1.2 for more details). However, the development depends partly on the availability of 5G enabled hardware which will be available mostly by end of M14 (October 2021). Until then, the development and testing of the data backend, the analytical infrastructure und the evaluation of the approach is ongoing.

UC8/9: The automatic detection, evaluation and live classification of driving manoeuvres and their resulting effect on emissions is based on calculations of the Low Carbon Mobility Management application (LCMM) by T-Systems, calibrated by the telematics and telemetry system Entruck, developed, and operated by tec4U. For the common data collection and data exchange with additional parties as the Continental 5G IoT and the traffic management system, the development of common data structure on a MEC (Multi-access Edge Computing) is ongoing since M10 (June 2021) to be finalized by end of M16 (December 2021). For the planning of the vTMC, see UC11 below. Additionally, the analysis of the infrastructure started in M8 (April 2021) with test drives within the TAVF (Testfield autonomous and connected driving) and the access to the container terminals in the southern part of the river Elbe. The test drives have been performed with 5G-enabled mobile phones and vehicles equipped with Entruck onboard units. However, the latter ones communicate by 4G networks and use legacy GNSS as Galileo for localization. Both will be replaced by 5G-enabled hardware as soon as available, but latest on M16 (December 2021). At this stage, selected vehicles will be equipped with 5G mobile phones running LCMM, 5G enabled Entruck onboard units and Continental IoT devices and the trials are ready to be executed.

UC10: For achieving an Automated Truck Platoon, a constant flow of information is needed. The trucks not only have to be aware of each other, but also about their environment. By using the Green Light Optimized Speed Advisory (GLOSA) App, the platoon is made aware of upcoming obstacles, enabling it to act timely and to optimize its driving behaviour regarding environmental aspect and maintaining the traffic flow. For UC10 the first step represents recording a baseline. Starting with M7 (March 2021) first platoon tests on the TAVF have been conducted. The first round of baseline collection thereby was executed without the help of any assistance from the GLOSA App and only environmental relevant driving parameters have been collected. In the second round of baseline collection, starting with M10 (June 2021), the GLOSA App has been integrated as a simple information system about the signal phase, without any derived intelligence fostering driving in a platoon.

The data collected during these two phases shall be used the specify the platooning GLOSA component until M14 (October 2021). The GLOSA Platoon component will afterwards be integrated into the MEC environment of Living Lab Hamburg, which is planned to be available as alpha version in M16 (December 2021). For the planning of the vTMC, see UC11 below. Using the alpha platform further field trials shall be conducted, to optimize MEC latency and the further enhance the accuracy using 5G precise positioning. After all components have been integrated and cross reference between the use case have been established, a fully functional beta version of UC10 is planned to be available in M18 (February 2022). Using the beta version, another round of field tests and bug fixing shall lead to the completion of the deployment of UC10 and the whole Living Lab Hamburg in M20 (April 2022).

UC11: The requirements for the vTMC are to receive and display the FTED online, constantly evaluating these data to decide on predefined traffic strategies, receive the traffic sign states, calculate a traffic sign state prognosis, disseminate the prognosis and route locally produced traffic sign state and prognosis towards the GLOSA server continuously. The implementation of the vTMC will be based on the SWARCO MyCity platform, which has been launched in M11 (July 2021). 5G-LOGINNOV specific extensions require a private cloud instalment on dedicated hardware, which is deployed from M11 to M14 (July-October 2021). Starting M14 (October 2021), the implementation of the interfaces to the LCMM server (i.e. receiving FTED data), to the urban data platform (i.e. traffic sign state via SensorThingAPI), to the GLOSA server (i.e. traffic sign state and prediction data in ETSI SPaT and MAP format), as well as the central Traffic Light Forecast (TLF), FTED visualization and strategy manager, will be ongoing until M18 (February 2022).

Especially for the TLF functionality, it is crucial that data received by the urban data platform are reliable and delivered with constant low latency and the processing time is constant and low too.

The activation threshold for the strategy manager, with regard of measured emissions, needs to be fine-tuned based on the LCMM data, which will probably exceed the implementation phase and be taken care of in the trial phase.

The routing of the locally generated traffic sign state data and their prediction is done via a server of the TAVF project, where they will be accessible from M13 (September 2021) onwards. UC11 trial is planned to be ready for execution M20.

UC/ Time -plan	2021												2022					
	Phase 1			Phase 2								Phase 3				Phase 4		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	M 05	M 06	M 07	M 08	M 09	M 10	M 11	M 12	M 13	M 14	M 15	M 16	M 17	M 18	M 19	M 20	M 21	M 22
UC-8/9	S				Dv							DP		R				
UC-10			S								Dv			Dp		R		
UC-11				S								Dv		Dp		R		
S: specifications				**Dv: Development**			**Dp: Deployment**					**R: Ready for Trials**						

Table 6: Timeline planning of use case development and deployment, Hamburg Living Lab.

2.4.3 Foreseen Equipment Deployment

Table 7 summarizes the hardware components including the number of 5G-related devices that will be deployed on heavy commercial vehicles, light commercial vehicles and roadside units that will be involved at the trials for the evaluation of the use cases and 5G-LOGINNOV objectives for the Living Lab Hamburg.

Equipment Description	Addressed Use cases	Amount
Precise Positioning (Skylark+Telematics)	UC8/9/10/11	1
5G Smartphones U	UC8/9/10	>=10
tec4u CarPC	UC8/9/10	>= 5
Conti-IOT Box	UC8/9/10	>= 5
Flowradar (HPA)	UC8/9/10	>= 5
Mobileum 5G-KPI measurement	5G NSA coverage and network features (horizontal)	>= 1
4K-Video	UC10	>= 2
MEC	UC8/9/10/11	1
VTMC (SWARCO MyCity)	UC9/10/11	1

Table 7: Foreseen equipment installations, Hamburg Living Lab

2.5 Living Lab Koper

The Living Lab Koper targets implementation of novel 5G technologies (MANO-based services and network orchestration, Industrial IoT, AI/ML based video analytics, drone-based security monitoring etc.) and cutting-edge prototypes tailored to be operated in port environment.

Since the targeted implementation represents not only operational but also development challenge, the deployment of the 5G mobile network in the Port of Koper will rely on the availability of commercial 5G products, especially those related to the support of eMBB and mMTC features. The deployment plan already takes this into consideration, and the use of products and components that are either already commercially available or announced is planned. However, in case of delays in the commercial rollout on the part of 5G vendors and consequently unavailability of some components/ features, these will be replaced with the most suitable prototypes and open-source implementations already available in the 5G ecosystem.

The Port of Koper, even though located in the territory of the Republic of Slovenia, carries a status of an autonomous security zone, for which some specific security and regulatory constraints apply (e.g., use of drones and video streaming cameras). The partners involved in the activities linked to and taking place in the Port of Koper will take these constraints into consideration and will work closely together and under guidance of the Port of Koper representatives to ensure compliance and execution of any required formal procedures within the context of the project timeline.

Table 8 provides a brief overview of the Living Lab Koper use cases and their contribution to the operations of the Port of Koper (Luka Koper). For more details, please refer to D1.1 (5G-enabled logistics use cases) [1]. Further, this chapter provides the intended target timeline for all development and deployment phases of each use case (development, deployment, testing, integration and validation), including technologies that will be developed in the ININ (Internet Institute) and TSLO (Telekom Slovenije) lab environment and migrated to LK (Luka Koper) premises at a later stage, more details on technology used can be found in D1.2 (5G architecture and technologies for logistics use cases) [2]. Finally, the foreseen installed equipment, as described in detail in D1.3 (5G-enabled Living Labs infrastructure) [3], is listed in Table 10, including the number of port assets (e.g., yard/external trucks, STS Cranes, etc.) that will be equipped with 5G-LOGINNOV devices and participate at the pilot side trials and evaluation at Luka Koper.

2.5.1 Use case contribution to the Living Labs

Use case	Contribution
UC1: 5G-LOGINNOV Management and Network Orchestration platform (MANO)	**Deploying and orchestrating two 5G mobile networks in order to fulfil port's operational requirements** The proposed 5G-LOGINNOV network architecture will enable on-demand and automatic deployment of VNF-based network and services components, high availability and resilience of operations of the most demanding logistics services, IoT-5G devices and mission critical communication services for ports operations. Considering these benefits, i.e., high availability and flexibility in the first place, 5G network will replace existing WiFi network and certain parts of optical infrastructure which are both is in place to support port operation and logistics services for the time being. UC-related work will focus on research and development of best practices/solutions in terms of components onboarding and configuration, deployment time, time to scale, service availability, slice reconfiguration, area traffic capacity, availability, bandwidth, connection density, coverage area probability, end-to-end latency, reliability, etc.
UC5: The 5G-LOGINNOV automation for ports: port control, logistics and remote automation	**Using 5G infrastructure for collecting and analysing data with a goal of automating business processes in the port** A family of use cases related to port control, logistics and remote automation will be implemented (logistics sector and Industry 4.0). More specifically, a logistics support use case scenario will be implemented where operating port machinery (such as lifts, forklifts, terminal tractors, etc.) will be equipped with industrial cameras for capturing and transfer of UHD images to the CNS system for identification of container markers

	and detection of structured damage to containers using image processing techniques. Next to this, telemetry data will be collected from some of the vehicles (e.g. terminal tractors) that operate within LL Koper. This data will be further transmitted via the 5G network, to the backend to be further processed/analysed. Within the UC, work will be focused on tailoring 5G mobile services to the needs of port operation, enhancing functionalities of the 5G IoT GW, MANO orchestration, capturing vertical and horizontal network and services KPIs, as well developing proprietary computer vision SDK, developing multiplatform to rapid prototyping in a large variety of sectors (including Advanced Driver Assistance System, security, inspection and HMI), developing annotation model to describe content of image sequences, enhancing equipment monitoring through the collection of telemetry data from vehicles involved in port operations, etc.
UC6: The 5G-LOGINNOV 5G mission critical communications in ports	**Enhancing security using 5G infrastructure** A family of two use cases are planned to support the port security operations. A real-time video surveillance use case will be implemented, using body-worn cameras carried by security personnel to support their regular and mission critical operations and provide additional personnel security; portable video surveillance cameras with night vision capabilities will be used to monitor specific port areas, and automated and coordinated drone-based surveillance will be implemented for extended ad-hoc video-surveillance support. The second part of the use case will constitute private security operations management and support, featuring multiple services to support security operations, including personnel/team status monitoring, positioning and triage operations support with dedicated mobile applications. As within UC5, work will be focused on enhancing mobile services and introducing novel surveillance technologies and mechanisms (drone-based, wearable cameras, AI/ML based video analytics), e.g., there is no video analytics available at the time being. In particular, the reliability and resilience of the multi-faceted real-time video surveillance in scope of mission-critical needs using public and stand-alone 5G networks will be investigated.

Table 8: Use Case overview, Living Lab Koper

2.5.2 Timeline planning of development and deployment

In Koper LL, two 5G networks will be established. National MNO's (Telekom Slovenije, TSLO) 5G NSA network is already operational (see below for further details). Next to this, additional NR NSA antennas are expected to be added and tested by M15. Previously, it has been planned an additional gNB base station location (or more of them) to be established to sufficiently cover the area of interest; however, according to the results of radio signal measurements performed in M11, additional gNBs base stations are not required. Next to this, TSLO will establish additional edge computing capabilities due to the security reasons related to the data processing of Luka Koper specific data. The second network will be private 5G SA network provided by ININ. The network is not operational yet.

Hardware, required for private 5G RAN has been delivered in M9, which is the same as when global deployment strategy has been completed, while detailed deployment plan has been completed in M11. Frequency licenses for the trial site have been approved in M5. Deployment of private 5G RAN subsystems components has been finished in M11, while testing is to be completed by M13. Finally, all private 5G RAN level laboratory tests will be finished by M14.

On the core network end, hardware for the private 5G core network has been delivered in M9. Deployment of private 5G SA system is expected in M14, followed by final integration and testing in the laboratory to be completed by M15.

Components for the public NSA system (RAN + core network) have been deployed in M11, while final tests are expected to be completed in M15 (as already described above). Public 5G SA RAN and core network deployment and test strategy will be completely defined by M13, while deployment, integration and test tasks related to public 5G SA will be completed by M22 – only in case equipment is commercially available by M20. Network slicing, if commercially available as well, will be available after M22, MEC deployment will be completed in M15 and NFV-MANO will also be completed in M15.

UC1: use case 1 will address 5G-LOGINNOV MANO architecture (ETSI Management and Network Orchestration) and its cloud extensions that will be used for demonstration of automated deployment and life cycle management of a network and applications operated in a 5G-enabled port environment targeting on Industrial IoT applications. In scope of achieving this goal, industrial IoT system design and specification have been already completed (M8). 5G network hardware components have been specified and ordered; it is expected that all hardware is delivered by M14. Required software components are being prepared, most of them are already in the phase of containerization which is expected to be completed by M13. Similar situation is with OSM-MANO, which deployment is expected to be completed by M15. Within UC1, lab testing of hardware and software components has started in M7 and is ongoing. Final lab tests are expected to be completed by M15, followed by migration to LL premises, which is expected to start in M13 and be completed in M17. Finally, Living Lab setup, testing and validation is about to start in M16 and should be finished by M22.

UC5: 5G network, cloud and Industrial IoT infrastructure deployed in UC1 will be used as the baseline communication system in UC5. UC5 will primarily target Industry 4.0 related port operation. The logistics and port operation support scenario will be implemented where operating port machinery (STS crane) will be equipped with industrial cameras for capturing and transfer of 4K UHD streams in real-time over the 5G network to the video analytics system. Logistics support system design and specification has started in M7 and is ongoing at the moment, expected to be completed by M14. Required UHD cameras have been specified and are in the phase of ordering, expected to be delivered by M15. Integration of industrial 5G IoT GW, integration of cameras and initial AI/ML system deployment work will start in M14 and is expected to be completed by M18. Lab testing of components will start in M15. Final lab tests are expected to be completed in M20, followed by migration to LL premises, which is expected to start in M18 and finish in M16. Living Lab setup, testing and validation is about to start in M20 and should be finished by M22.

In the second part of UC5, remote telemetry and port equipment monitoring (supported by the 5G mMTC) will be performed for operating machines (e.g., terminal tractors). This will be achieved by means of capturing and transferring key information (e.g., consumption, position and other related telemetry information) to the port operation support system. In scope of this, telemetry 5G-IoT device design has started in M7 and is expected to be completed by M15. In M15, telemetry 5G-IoT device configuration and setup will start, expected to be completed in M17. Next task within the UC5 is system setup for fleet telemetry operation, which will start in M16 and is expected to be completed in M18. Installation of 5G-IoT device to trucks will start in M17 and is expected to be completed in M19. Visualization of telemetry data will start in M18 and should be completed by M20. Finally, Living Lab testing and validation will start in M19 and will be finished in M22.

UC6: 5G network, cloud and Industrial IoT infrastructure deployed in UC1 will be also used as the baseline communication system in UC6. On top of the UC1 infrastructure, several services/activities related to the port security operation will be introduced within UC6, which is split into 2 sub-UCs. System design and specification for portable surveillance has started in M8 and will be completed by M14. Scenario requires UHD cameras, which have been specified and are in phase of ordering; delivery is therefore expected by M15. Next, cameras need to be integrated with industrial 5G IoT GW and AI/ML system needs to be deployed. These tasks will start in M15 and are expected to be completed by M17. Lab testing of the mentioned components will start in M16 and should be finished by M17, followed by migration to LL premises between M18 and M20, and finally, LL setup, testing and validating will take place during M20 – M22.

For the second sub-UC, mobile surveillance system design and specification is in place, expected to be finished by M14 (it has started in M8). Wearable cameras and terminals required for this task have been specified and are expected to be delivered by M15. In M15, integration efforts and system deploy will start and are expected to be completed by M18. In M17, lab testing will start and will last until M19, followed by migration from lab environment to the LL premises between M18 and M20. Finally, LL setup, testing and validation will start in M20 and will end in M22.

UC/ Time-plan	2021												2022					
	Phase 1			Phase 2								Phase 3				Phase 4		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	M 05	M 06	M 07	M 08	M 09	M 10	M 11	M 12	M 13	M 14	M 15	M 16	M 17	M 18	M 19	M 20	M 21	M 22
UC1	S		Dv						Dp			R						
UC5			S								Dv			Dp		R		
UC6				S								Dv		Dp		R		
S: Specifications				**Dv: Development**					**Dp: Deployment**					**R: Ready for Trials**				

Table 9: Timeline planning of use case development and deployment, Living Lab Koper.

2.5.3 Foreseen Equipment Deployment

Table 10 summarizes the hardware components including the number of 5G-IoT devices (e.g., cameras, 5G UEs) that will be deployed at the port premises, including the number of STS cranes as well as external and yard trucks that will be involved at the trials for the evaluation of the use cases and 5G-LOGINNOV objectives for the Living Lab Koper.

Equipement Description	Addressed Use cases	Amount
UHD cameras, wearable cameras	UC5, UC6	14
Drones	UC6	2
5G UE (phones, tablets)	UC5, UC6	8
Cranes equipped	UC5	1
Yard trucks equipped	UC5	5
5G IoT GWs	UC1, UC5, UC6	12
gNb (NSA)	UC1, UC5, UC6	2
5G enabled EPC	UC1, UC5, UC6	1
MEC/IaaS	UC1, UC5, UC6	1
Port IaaS	UC1, UC5, UC6	1
Portable 5G SA mobile system (gNb & 5G CN)	UC1	1
Telemetry 5G-IoT device	UC5	5

Table 10: Foreseen equipment installations, Living Lab Koper

2.6 Open Call Contribution to Living Labs

At the time of writing of this document, the application process for participation in the 5G-LOGINNOV Open Call is completed. A total of 15 applications were received, distributed across the LLs, among which a total of 5 applicants will be selected. The proposed innovations vary, and are tailored to the description of innovations as explained in the Open Call tender conditions, whereas additional details can be found in D1.1 [1] and D1.3 [3]. The call for innovations was designed to ensure that the development, deployment and rollout activities of the participants can be fully supported by the LLs, by providing specific areas of interest described by each LL, addressing direct needs of the ports. Hence, each Living Lab will offer space for development and piloting of innovative cutting-edge 5G technologies and the know-how to enable SME participants to further develop and enhance their 5G portfolios within the 5G-LOGINNOV project. On M13 (September 2021), where the winners of the Open Call will be selected, the respective LLs will finalize the SMEs development plan with emphasis on the required time period, which was already included in their respective application forms at submission. Internal meetings for the alignment of the SMEs contributions (design, development, testing, and demonstration) and ensuring the timely delivery of the innovations to the port will be the responsibility of each LL.

2.7 Overall Living Lab Architecture (Commonalities and Differences)

Figure 7 gives an overview of the project deployment concepts in the three Living Labs, their specific infrastructure and their innovation focus in hinterland (Hamburg) and port areas (Athens and Koper). In the EU there are more than 300 different trans-European network (TEN-T) maritime ports, and they represent nodes from where the multimodal logistic flows of the TEN-T corridors are organised, using short sea shipping, rail and inland waterways links [11]. Due to the fact that 74% of goods imported and exported and 37% of exchanges within the Union transit through seaports, they present one of the most essential (critical) infrastructures in the EU that needs to be continuously modernized with the new innovative technologies such as 5G.

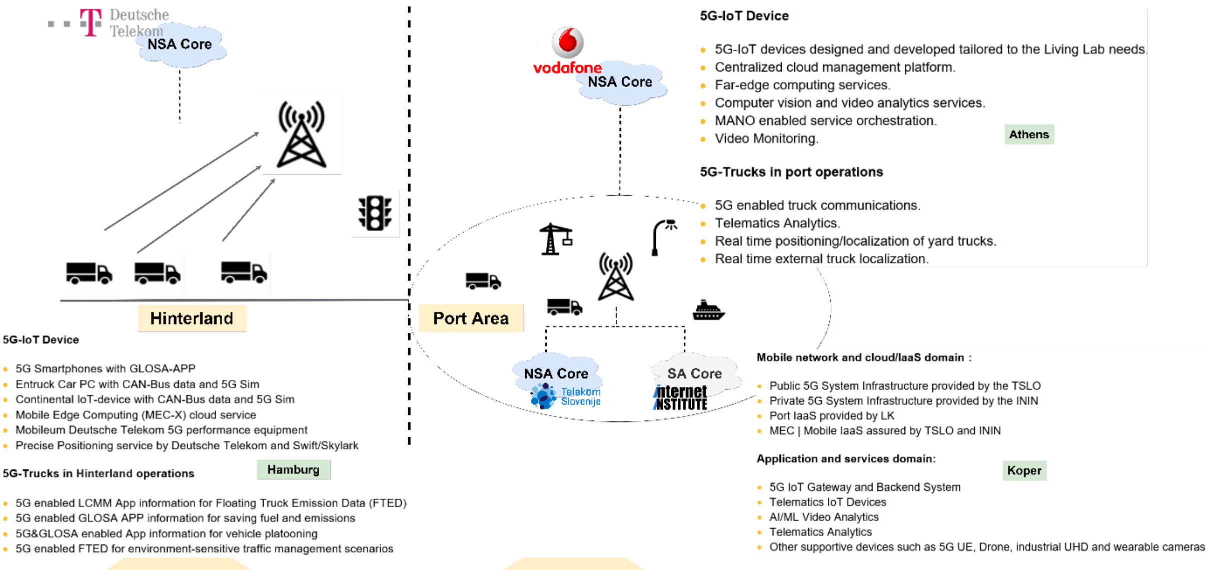

Figure 7 Overview of Use Case areas targeted in 5G-Loginnov

As such, 5G-LOGINNOV will showcase the impact of 5G technology in heterogeneous port environments, of different dimensions and geographic locations (Adriatic, Mediterranean and Northern Sea), also including the unique case of Hamburg (due to its physical position) which focuses on the interconnection of the port area to the hinterland's road network. The project will have the opportunity to showcase various innovations with different architectures and deployment options of 5G; for instance, in Hamburg LL and Athens LL the 5G NSA core is located outside the port area, whereas in the case of Koper LL both the NSA and SA 5G core will reside inside the port premises. The project will thus investigate several aspects of 5G technologies, focusing on the respective needs of the LLs, addressing biggest EU ports such as Piraeus and Hamburg that are able to serve respectively about 6 and 10Million TEUs annually, and also small to medium sized EU port, such as Port of Koper, currently handling approximately 1M TEU.

The Athens Living Lab at Piraeus port will develop a set of use cases and platforms that communicate over the deployed 5G NSA network with different types of end devices. It includes communication with external trucks around the port (UC2: Device Management Platform Ecosystem), yard trucks dedicated to port operations (UC3: Optimal selection of yard trucks, UC7: Predictive Maintenance) including NFV-MANO based services and orchestration, pioneering far-edge computing solutions, computer vision and AI/ML video analytics tailored to safety and logistics applications (UC4 & UC5). An overview classification for the use cases that will be developed in Athens LL tailored to the deployed end device is as follows:

5G-IoT Device
- 5G-IoT devices designed and developed tailored to the Living Lab needs.
- Centralized cloud management platform.
- Far-edge computing services.
- Computer vision and video analytics services.
- MANO enabled service orchestration.
- Video monitoring and surveillance.

5G-Trucks in port operations
- 5G enabled truck communications.
- Telematics Analytics.
- Real time positioning/localization of yard trucks.
- Real time external truck localization.

In Hamburg, Green Light Optimal Speed Advisory is complemented by collision warnings making use of the ultra-low latency feature of the 5G mobile network within the inner-urban test field (TAVF). Additionally, 5G-LOGINNOV activities rely on positioning not only within the TAVF, but also in the surrounding areas and the port road network. All use cases will be studied with and without precise positioning functionalities of the 5G network to showcase the improvement linked to the accuracy of the 5G corrected positioning signal in the different sectors of the urban and port road network.

5G IoT Devices
- 5G Smartphones with GLOSA-APP
- Entruck Car PC with CAN-Bus data and 5G Sim
- Continental IoT-device with CAN-Bus data and 5G Sim
- Mobile Edge Computing (MEC-X) cloud service
- Mobileum 5G NSA network measurement equipment for Deutsche Telekom
- Precise Positioning service by Deutsche Telekom and Swift/Skylark

5G-Trucks in Hinterland operation
- 5G enabled LCMM App information for Floating Truck Emission Data (FTED)
- 5G enabled GLOSA APP information for saving fuel and emissions
- 5G&GLOSA enabled App information for vehicle platooning
- 5G enabled FTED for environment-sensitive traffic management scenarios

The Koper Living Lab will explore different 5G system deployment options and business models, where private mobile services can be assured across public or private communications infrastructure, which is extended with cloud principles and MEC functionalities. To evaluate the 5G technology reediness and 5G system performance, three distinctive use cases will be built, deployed and verified in real port environment and under realistic conditions: UC1: 5G-LOGINNOV Management and Network Orchestration platform (MANO), UC5: 5G-LOGINNOV automation for ports: port control, logistics and remote automation and UC6: 5G-LOGINNOV 5G mission critical communications in ports. To support use case activities the following 5G devices and services will be assured in the LL.

5G-IoT Devices
- 5G-IoT devices and back-end system designed and deployed by the cloud native principles
- Private 5G system operating in 5G SA mode deployed by the cloud native principles
- OSM/MANO assured orchestration and deployment of 5G SA and 5G IoT system
- MEC services supporting 5G NSA operation in the port
- AI/ML based video analytics supporting logistic process and security services

- UHD video monitoring assisted with drone-based video streaming and wearable-cameras

5G-Trucks in port operations

- mMTC (Nb-IoT) based port fleet monitoring
- Remote telemetry assurance

As also indicated above, and explained throughout the projects story so far (following the submitted deliverables), the LLs share both different and common points in their research agendas for the 5G-LOGINNOV project. On the one hand, hinterland connections are investigated only in the Hamburg pilot. Although Koper and Athens focus on operations inside the port area, both port operators showed increasing interest in the hinterland pilot that will be investigated in Germany, in terms of business opportunities and innovations as well as the technologies exploited, and their overall contribution to the Hamburg port. On the other hand, several use cases that are to be developed in Athens and Koper, related e.g., to the video analytics services, edge computing, mission critical applications etc., are of direct interest to the Hamburg LL and as such they are applicable also to other EU smart ports.

Additionally, in Athens and Koper pilots NFV-MANO enabled applications and services will be investigated and exploited within the respective heterogenous port areas, in terms of both 5G technologies involved, but also taking into consideration each port's daily operations and needs. In both pilots, the envisioned services employ (among other services) open source solution and industry proven technologies such as open source MANO, Openstack and Kubernetes, creating fertile ground for cross-Living Lab knowledge sharing (lessons learned, obstacles faced, etc.) as well as providing generic solutions to facilitate interoperability across heterogeneous port facilities, potentially including 3rd parties interested outside the 5G-LOGINNOV consortium.

Therefore, through the meetings involved and explained in the following sections for the 5G-LOGINNOV partners, we aim not only at sharing the lessons learned from each LL development and deployment activities, but also to identify potential synergies and business cases across LLs.

Finally, with the proposed project and LL approach, exploring different 5G deployment models and various innovative use cases in biggest and medium sized EU ports, the project is directly addressing the Commission future agenda where *the availability of adequate port infrastructure, good performance of port services and a level playing field are vital if the Union is to remain competitive in the global markets, improve its growth potential and create a more sustainable and inclusive EU transport system.*

3 APPROACH

The approach defines from multiple cross-sections how the developments and deployments will be performed. Together, these cross-sections provide the full view of how 5G-LOGINNOV ensures the timely delivery of the innovations with high quality. The different cross-sections can be found below. The final section (management) provides the overview of how all parts come together. Figure 8 illustrates the dependency to WP1 tasks. Each LL begins by carefully analysing their user stories, specifications and requirements in T1.1, whereas T1.2 extracts the 5G requirements to facilitate the LL innovations/use-cases. T1.3 describes the enhanced infrastructure and the components or devices in the Living Labs, whereas the KPIs & evaluation data specifications are created in T1.4. Finally, T1.5 provides data handling requirements with consideration of personal data and cybersecurity policies to ensure an appropriate level of cyber protection for safe operations. The outcome of the development and deployment phase for the 5G-LOGINNOV project in WP2 will be the input for WP3, where trials and the evaluation of the use cases will take place in all LLs.

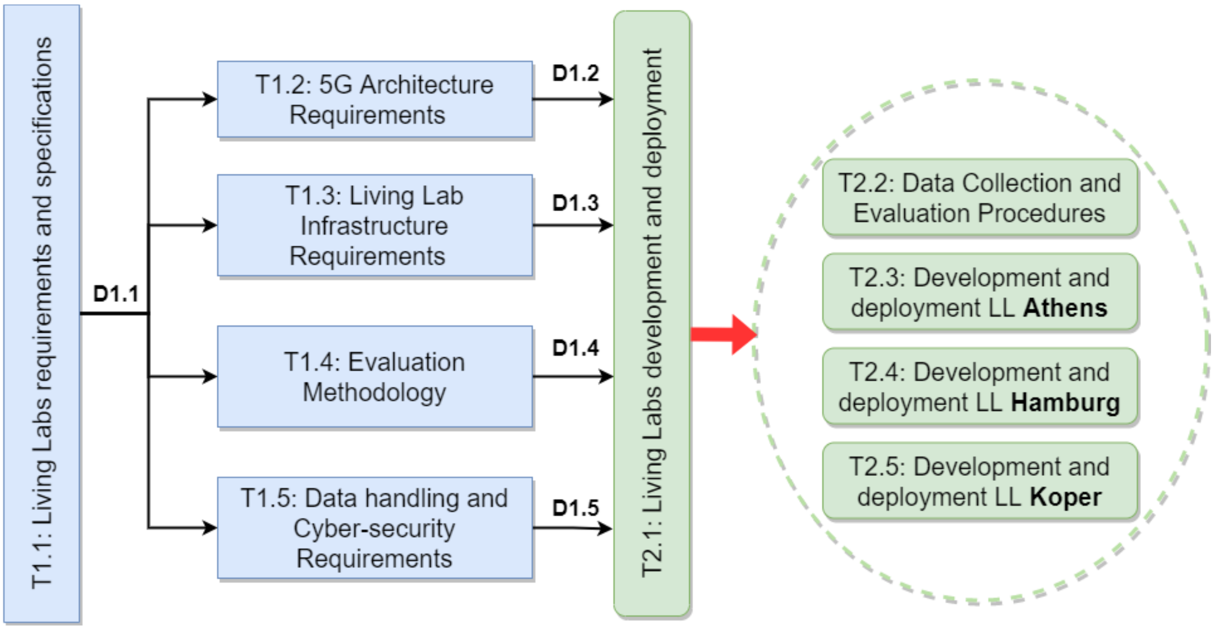

Figure 8: Development and deployment plan dependencies

3.1 Phasing

Phasing is necessary to provide the first basics of tracking progress. Because there are multiple innovations and deployments, phases will overlap. On top of that, partners use iterations and subsequent updated versions throughout the project. This indicates the need for clarity on what (individual) phases involve and how they bind to each other. Below the different phases are explained, together with the reasons why each phase is relevant and the method of verification of moving to the next one.

3.1.1 Phase 1 – Development and Deployment Strategy

Phase 1 of 5G-LOGINNOV aims at devising an appropriate strategy (roll-out methodology) for the development and deployment plan, based on a practical timeline, which is coherent across all pilot sites, taking also into consideration the peculiarities and unique characteristics of the different LLs. In particular, Athens and Hamburg LLs will employ the 5G-NSA network provided by the MNOs (i.e., Vodafone and Deutsche Telekom, respectively), while Koper, in addition to the 5G-NSA network provided by Telekom Slovenije, will deploy a private 5G SA network, provided by ININ. Furthermore, different stakeholders and authorities are involved in the pilot sites, e.g., port authorities are engaged for Athens and Koper LLs, whereas road/transport authorities need to be addressed in the Hamburg pilot.

This phase is focused in the definition of the specifications for the required hardware (e.g., 5G RAN/CORE, 5G-IoT devices, 5G telematics devices, etc.) and software assets (NFV-MANO, AI/ML, GLOSSA-APP, FTED, etc.) that will facilitate the LL innovations (for more details please refer to D1.2 [2], which details the characteristics for the 5G network deployments in the three LLs, and D1.3 [3], which lists the infrastructure/device and software enhancements tailored to the use cases), also including the envisioned schedule/timeline for the respective deployments. This phase started on M05 (January 2021), after the use case specifications were finalized through D1.1 [1], and includes the initial provision planning of required hardware and software assets. Creating a global deployment strategy for the RAN and core networks (e.g., radio planning, eNB/gNB deployments sites, etc.), as well as finalizing the road trip execution plan and vehicle acquisition for the Hamburg pilot, are also completed within this period.

While this phase mainly focuses on rollout methodology, planning, and hardware/software acquisition, early deployment of some hardware and software components also started (e.g., the in-lab equipment of ICCS and ININ 5G testbeds, the GLOSA-APP and FTED), in order to increase the readiness for the development of the 5G-LOGINNOV use cases that will be the main focus of Phase 2. Phase 1 was concluded in M07.

3.1.2 Phase 2 – Development and Deployment in Living Labs

Phase 2 is ongoing and covers all development and integration activities to ensure the timely preparation for the kick-off and report readiness for the LL trials by the end of M20. It started on M07 (March 2021) and is due by the end of M20 (April 2022). The main tasks of this phase include development and deployment activities for the use cases in all LLs. The deployment activities include: the deployment of all relevant components of the 5G network (CORE and RAN) for both NSA and SA cases; the deployment of the envisioned 5G-IoT nodes at the LL premises; vehicle/truck acquisition/selection and installation of on-board telematics devices, precise positioning, including also additional installation of sensors on vehicles. The development tasks include: the development of the computer vision techniques that will optimize port operations; the development of the MANO platform, preparation of respective VNFs/CNFs, components, and NFV services; MEC related service/components; interconnection of new software/solution to existing applications/platforms (e.g., GLOSA-APP, FTED); the development of the data collection tools (definition of evaluation data format and creating the tools and applications for data collection) that will facilitate the evaluation of the three LLs. Additionally, this phase also includes the integration of tested software/solutions/algorithms from in-lab tested applications to the LL premises.

All LLs, as part of Phase 1, have already described in detail each use case in multiple subtasks (in terms of hardware, software, development, integration, testing, etc.) that need to be completed for the realization and evaluation of the use cases. Each of these sub-tasks have been documented in an Excel sheet (explained in Section 4) maintained at the project repository as a living document, containing the details of the separate activities, the start and due dates, the responsible partner and contact point of the respective organizations, and the progress achieved so far, in order to have at any time a detailed view of each LLs progress and identify potential issues as early as possible.

3.1.3 Phase 3 – Testing and Verification, Report Readiness for Living Lab Trials

The main tasks of this phase focus on testing and verification of the LL activities, i.e., the roll-out of the use cases. In coordination with deployment tasks in Phase 2, this activity will verify the correct and intended operation of all equipment (network equipment and connectivity, traffic light system, IoT devices, sensors, MEC, etc.) including all sub-systems, service components, solutions developed and integrated in WP2. Testing and ensuring the data acquisition process to facilitate the LL evaluation (as described by the defined KPIs in D1.4 [4] and will be performed in *Task 3.5: Evaluation of operation optimization*) is also one of the main activities of this phase. In short, the main outcome of this activity is to verify and report on M20 the finalisation of development and deployment at the Living Labs and confirm the readiness for trials in WP3.

3.1.4 Phase 4 – Maintenance and Support for Trials Execution

This final phase is focused on maintaining the LL user stories (site infrastructure, services, sub-systems, components, etc.) for the execution of trials in WP3. This includes integrating changes and verifying end-to-end operation as described in Phase 3, especially in cases where the use cases are dependent on commercial 5G networks, that experience continuous integrations/additions/modifications towards the full potential of a 5G ecosystem.

Based on the result of the 5G-LOGINNOV trials, Task 3.6 will assess the 5G-LOGINNOV technologies tested within the LL use cases, by identifying the factors that are influenced by the projects core innovation technologies and analyzing their impacts with both qualitative (e.g., surveys, interviews, etc.) and quantitative tools (sensors and traffic monitoring systems), focusing on the environment, the society and the economy.

3.2 Requirements and white spot assessment

The setup of 5G-LOGINNOV is such that the requirements on the Living Labs and innovations are written by the same persons as those who will use the requirements. Therefore, there are no white spots expected in the requirements that need to be resolved upfront. Throughout development, some unclarities may arise, which is perfectly normal in innovative projects.

3.3 Development and Deployment of Pilot sites

3.3.1 Living Lab Athens

Figure 9 depicts the foreseen services and components at Piraeus port, in Athens Living Lab, at the end of the 5G-LOGINNOV project. All services are built on top of the private 5G network that will be provided by the local MNO, Vodafone. NFV-MANO platform will be provided by ICCS, including all relevant components and services for the video analytics tasks that will be hosted at distributed 5G-IoT devices. Subsequent sections will discuss the detailed development and deployment plan, where all relevant components (software and hardware) are broken down in sub-tasks to facilitate a global view for deployment, development, testing and migration tasks of each sub-service/component, and deliver all foreseen services, i.e., use cases.

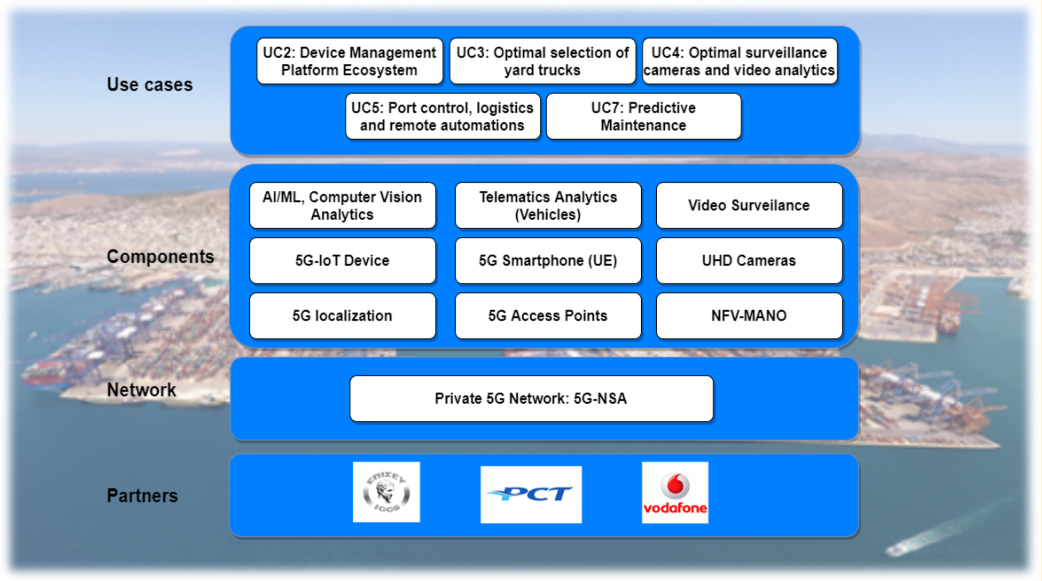

Figure 9: Living Lab Athens overview.

5G NSA System, Design and Deployment

Initially, the deployment of the 5G NSA network in Athens Living Lab will follow the specifications of 3GPP Release 15, and is one of the main activities of WP2. The radio access network will consist of two base station units (a primary gNB to support the discussed services and a secondary base station in case of failure), upgrading the in-place 4G cellular infrastructure at the port premises to support the 5G-LOGINNOV use cases and innovations.

For the deployment of the RAN, the preparation of the radio sites is currently ongoing, started on M07 and is due by M14. This task includes the selection and preparation of the sites that will host the gNB functionality, the specification and acquisition of the required software and hardware components, configuration and interconnection with the master 4G base station(s) for the NSA setup, testing, and finally the optimization at the RAN level. To this end, Vodafone has extensive operational experience at the port premises and access to all historical data parameters relevant for facilitating the optimal deployment of the access network at Piraeus.

Following NSA Option x3, the gNB is supplemented by the LTE eNB that carries control plane information (signalling) while the data plane operations (i.e., application data) are routed to and transmitted by the gNB. For the LTE network, control operations take place in band 7 (@2.6 Ghz, FDD) whereas for the NR communication, frequency range 1 band n78 TDD, is exploited. Particularly, in the initial deployment the 5G active antenna unit will operate at 3.7 GHz with 100 MHz channel bandwidth, supporting up to 64x64 MIMO. Figure 10 shows the location of the first gNB deployed at Pier III in PCT. At the time of writing of this document, measurements and testing are performed at RAN level with temporary UE equipment. The first measurements which started at the end of M11, depict high RSSI values of about -60dbm whereas average latency is between 20-25ms. The final UEs that will interconnect the respective end-devices (5G-IoT devices, yard/external trucks) to PCT's 5G network and participating in WP3 trials will be at least CAT-13, connected via an ethernet connection to the respective end-device, and are expected to be delivered on M14.

Figure 10: Athens Living Lab, primary 5G base station location.

The backhaul connection of the cellular network is established over wired networks leading to Vodafone's CORE network that resides outside the port of Piraeus, in the city of Athens. Gradual upgrades are ongoing following the specifications of 3GPP Rel-15 of NSA architecture. Currently, Vodafone supports a full CUPS (Control and User Plane Separation) EPC core, and partially virtualized NSA core as indicated in Figure 11. To support failure occasions of network core elements without interruption of service, Vodafone supports multiple core deployments, e.g., 3x EPC H/W specific and 2x EPC virtual, all following the respective upgrades for the 5G NSA core, and potentially move to full 5G core architecture at a later stage. For more details, please refer to D1.2 [2]. Initial interconnection and testing of the 5G base station at PCT with Vodafone's NSA core was completed in M11.

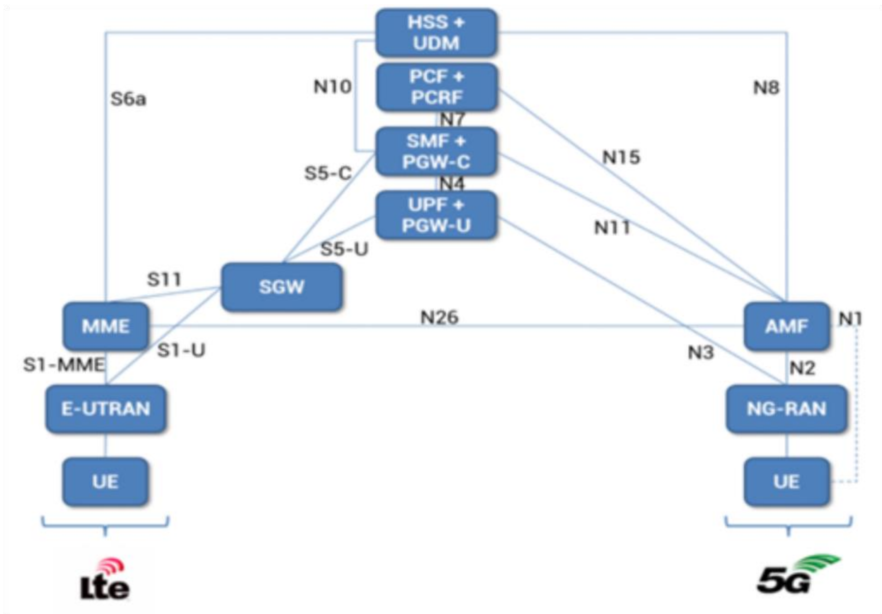

Figure 11: 5G NSA core elements, Athens Living Lab

Figure 12 gives a high-level overview of the phasing approach described in Section 3.1 for all relevant deployment task (specifications, design, deployment, integration, testing, ready for trials, maintenance) for the 5G NSA network at Piraeus port, which will be addressed by Vodafone. Overall, a fully operational 5G NSA network is foreseen by the end of M14 (October 2021).

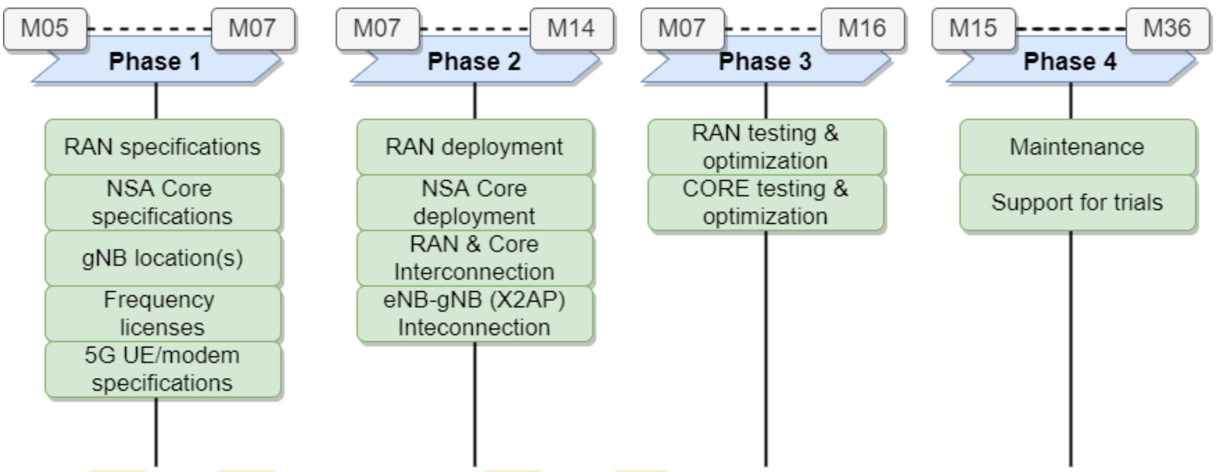

Figure 12: Phasing of 5G network deployment, Athens Living Lab.

5G Technologies and Innovations

NFV-MANO Enabled Video Analytics

To support the envisioned use cases, in addition to the 5G NSA network deployed at PCT premises, a set of technological tools will be employed, composing the 5G ecosystem that will be delivered by 5G-LOGINNOV project. Particularly, a NFV-MANO platform will be developed by ICCS, tailored to the needs of specific use cases, that is UC4 (Optimal surveillance cameras and video analytics) and UC5

(Automation for ports: port control, logistics and remote automation). In more detail, Open Source Mano (OSM) [8] will be used to facilitate the composition, orchestration and deployment of VNFs to distributed 5G-IoT devices at the port area, tailored to security and safety applications (human presence detection, UC4), or logistics operations automation applications (container seal detection, UC5). A subset of Openstack [10] services will be utilized (composing the VIM - Virtual Infrastructure Management tool) to deliver the envisioned services, controlling pools of compute, storage, and networking resources of the deployed 5G IoT devices, i.e., the NFVIs, as orchestrated by OSM tool (please refer to D1.3 for additional information).

UC4 and UC5 will be fully tested at the ICCS 5G testbed before deployment to PCT premises. Particularly, the ICCS testbed operation includes the OSM tool of Release 9 (potentially to be upgraded to Release 10 or above before/at deployment in PCT), as well as a subset of Openstack services based on Victoria and Wallaby Releases. Furthermore, the OpenAirInterface platform [9] is used for the in-lab experimentation of the 5G stack, enabling an end-to-end testing of the envisioned use cases, before integration at PCT premises. As described in D1.3 [3], the 5G-IoT devices will be composed of a UHD camera that will provide the video input for the analytics tasks, a COTS 5G UE/modem that that will facilitate 5G connectivity at the port premises, and a compute node (Jetson AGX Xavier) that will host the VNFs and perform locally the video analytics services. Test equipment for two 5G-IoT devices have been delivered at ICCS on M10 and currently configuration and testing of the respective use cases are performed at the ICCS lab.

The preparation of the respective VNFs, i.e., software applications that deliver network and service functions (including all related components for the computer vision and machine learning tasks), is ongoing and due by the end of M14 for UC4 and UC5. For UC4, open available datasets are used for training the machine learning model for human presence detection, which will be packaged as VNFs for deployment at the respective 5G-IoT devices tailored to security/safety applications. Deployment location options for UC4 IoT devices include areas close to STS cranes or close to PCT's railway and will be decided on M14. With respect to UC5, an initial dataset obtained from PCT databases was used to train the first version of the computer vision approach for detecting container seals. The training of the initial model was finished on M10, showing an accuracy of about 93%. In M12 the first STS crane will be equipped with camera(s) at Pier III, as depicted in Figure 13 (D1.3 [3] details all illustrated components).

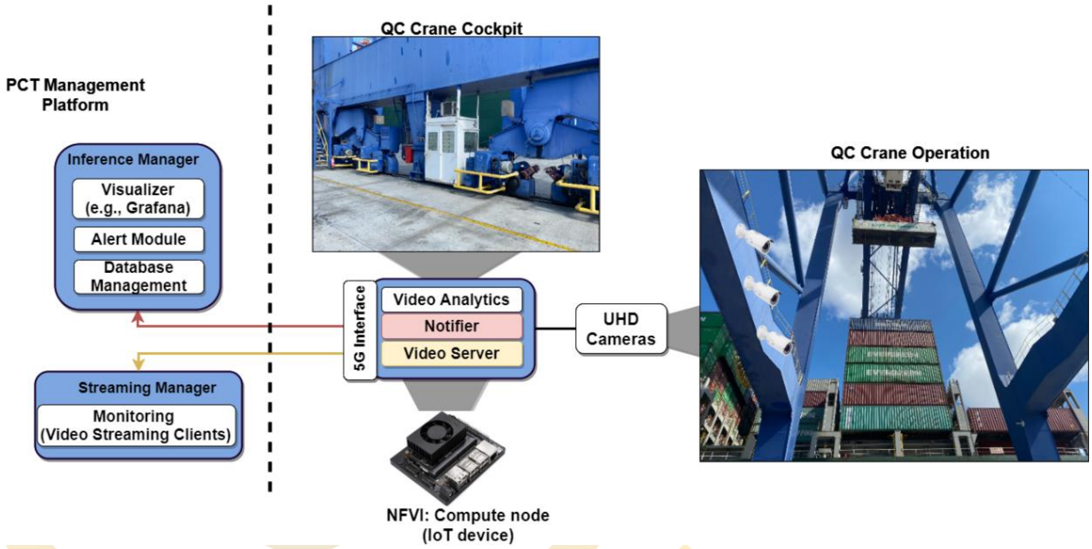

Figure 13: Athens LL, UC5 architecture

As the initial dataset was obtained from a different camera, at a different and less challenging location (i.e., at a stop-house, namely OCR Portal, were the yard truck remains still), several challenges are expected to arise in this dynamic environment, where the crane moves to pick up (or drop) the container from (to) yard trucks, and the camera will get the view of the container door for only a few seconds, from different angles, etc. The new dataset is expected by ICCS on M13, where the computer vision approach (and the tailored VNFs) will be customized to meet the requirements of the new dataset/environment.

Deployment of the MANO platform at PCT premises is expected to start on M16 (December 2021). Dedicated virtual machines (VMs) will be provided by PCT, over the existing infrastructure at the port of Piraeus, to facilitate both the OSM and Openstack controllers including all complementary sub-services/components. The specification of the VMs (memory, storage, CPU, etc.) will be at least equal to those deployed and verified at the ICCS 5G testbed. Additionally, the video service modules that enable live video surveillance service from the distributed 5G-IoT will be completed in this phase, including the inference triggered alert system based the analytics services that occur at the IoT devices, e.g., human presence detected at a risk area, or container seal missing. Finally, this phase also includes the interconnection of the MANO platform with the data collection tool that will be described in D2.2 [6], to enable the evaluation of the 5G-LOGINNOV innovations.

The overall envisioned MANO enabled service platform (due by M20) will exploit 5G technologies and enable computer vision analytics at the UE side, i.e., at novel 5G-IoT devices deployed at several key port areas, as far-edge computing services targeting safety/security applications (UC4) and port operations automation (UC5). The requirements of these services, including the live UHD surveillance of the port operations, are mostly focused on uplink traffic. Such uplink-data-intensive applications call for enhanced capacity than cannot be served with legacy LTE networks. Hence, 5G-NSA cellular communications exploiting the eMBB service of 5G technology are needed to ensure the successful operation of the envisioned use cases. Additionally, the video analytics service for security/safety applications (UC4) will exploit the low latency communication link at PCT premises from transmission of the inference result (i.e., person detected) from the 5G-IoT device(s) to the port's management platform, triggering immediate alerts and further actions to security patrols.

Figure 14 illustrates an overview of the phasing approach (as discussed above) for UC4 and UC5, which are based on the MANO platform initially developed at ICCS and later integrated at the LL premises. The decision for the MANO components, the design of the 5G-IoT device and all relevant modules for controlling the operation of the end-to-end NFV-service for detecting human presence in risk/private areas (UC4) and for detecting container seals at the loading/unloading of vessels (UC5) are considered (more details in D1.3 [3]), given the timeline of the 5G-LOGINNOV project.

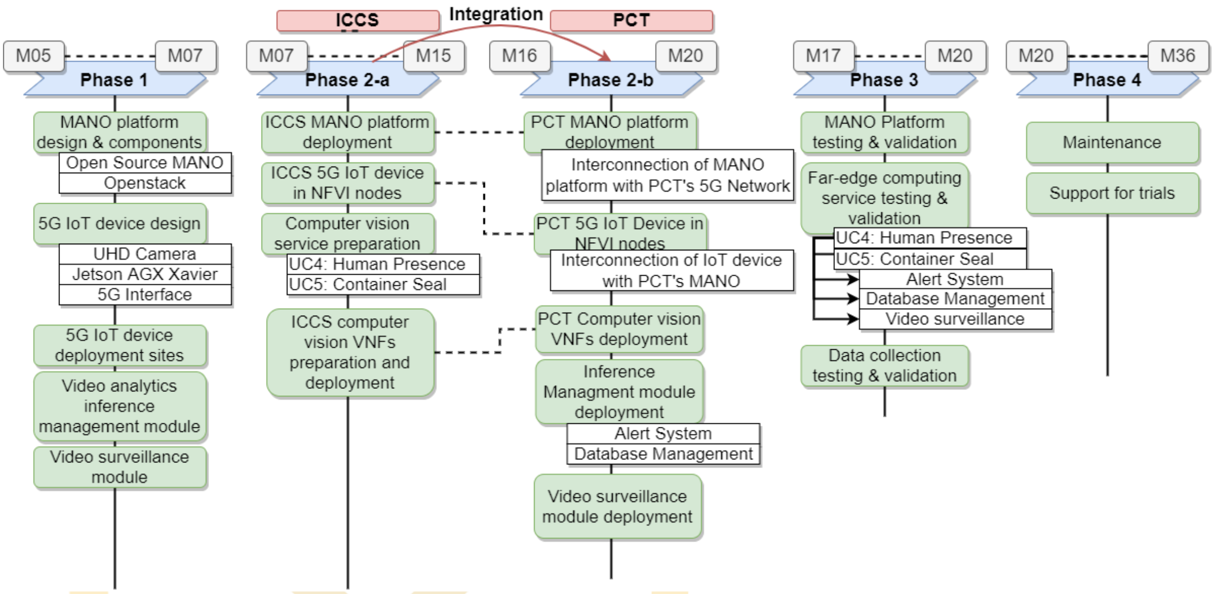

Figure 14: Phasing of UC4 & UC5, Athens Living Lab

5G Connected Yard/External Truck in Port Operations

For the use cases that employ 5G connected (external/yard)-trucks (UC2, UC3 and UC7), the main targets are the low latency transmissions and, in some cases, the enhanced localization services of 5G technology. At PCT, about 170 yard trucks are operational within the port area of about 2 square kilometres. In addition to this fleet of yard trucks, external truck visits rise up to about 1100 trucks in a daily basis, adding up to increased traffic within the port premises. Efficient management and coordination of port operations is thus of paramount importance, as delays on truck operations will pose delays also in several work chains (i.e., dependent operations) at the port of Piraeus.

For UC2 the process is straightforward, since this is based on existing infrastructure. The Vodafone Innovus infrastructure is hosted on Vodafone datacenter in Athens with needed security in place by design. The mobile application will use the public internet interface (via 4G and then 5G network) for data exchange between the platform and each mobile smartphone.

Initially the interface of the application is defined. The application is to be used by truck drivers during driving, so it is imperative that the UI is minimal and to follow the existing trends in map based in car applications. The following screenshot of the mobile application depicts that, but during testing/trials it will be enhanced from the feedback that we will get.

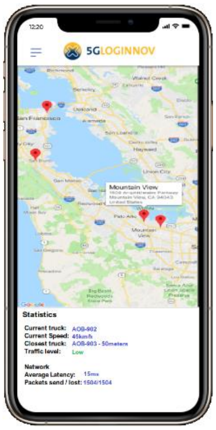

Figure 15: UC2 Mobile application UI

The needed data interaction between the platform and the mobile app(s) are identified including any meta-data needed for the data collection tools and the evaluation methods. This information is not visible to the truck driver, so it will not overwhelm the application with meta data. During Phase 1 the requirements were identified, and the design of the application started. During Phase 2 the application is developed, tested in emulation mode, and tested in real mobile applications. During Phase 3 the trials commence with the application running on 4G/5G enabled smartphones. The backend system can send data to the data collector for further analysis. In the final phase the mobile application will be used by the truck drivers in the real environment.

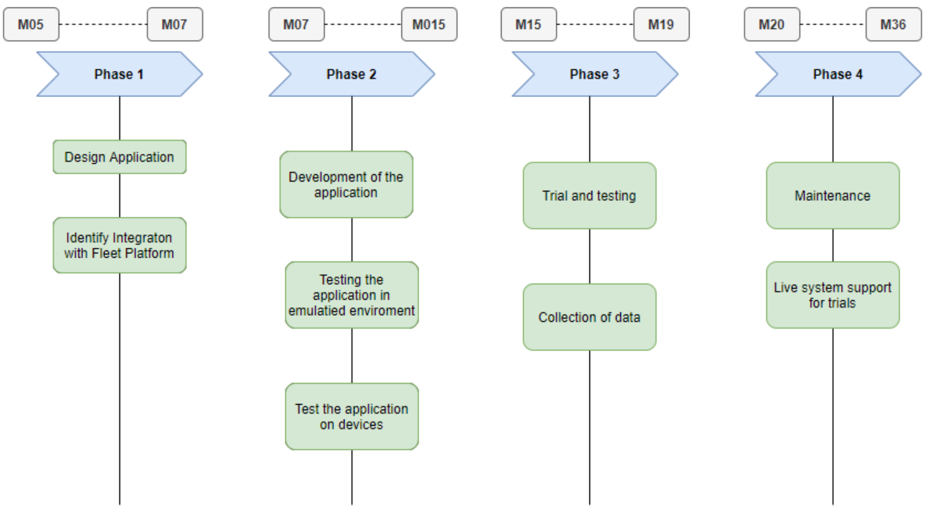

Figure 16: Phasing of UC2, Athens Living Lab.

UC3 (Optimal Selection of Yard Trucks) has been developed following insights from the INTE-TRANSIT project (5187/2C-MED12-05). The mechanism/algorithm for the selection of optimal yard trucks is already in place at PCT; however, the transmission of the required telemetry data (CAN-Bus, container presence sensors, localization, moving direction, speed, etc.) is based on either WiFi or 4G communications and legacy GNSS data. Similarly, UC7 (Predictive Maintenance) is based on insights from the COREALIS project (768994/MG-7.3-2017), where historical and recent status data (CAN-Bus and other sensor data) for the assets in question (i.e., yard trucks), utilized by the ML algorithm, will drive a per yard-vehicle data driven approach (schedule of purchases, storage of parts, proactive maintenance) taking advantage of 5G technology that provides a flexible, reliable and predictable environment to remotely keep track of the connected assets on a real time basis. UC3 and UC7 follow a similar development plan and timeline, since they depend on the same components, i.e., private 5G network readiness and 5G/UE modem delivery on M14. Installation of 5G UEs on trucks, interconnection with the in-place systems (databases, algorithms, APIs, controllers, etc.) and testing will start in M15. The interconnection with the data collection tool (described in D2.2 [6]) will occur after all subservices and components have been tested to verify that evaluation data (as described in D1.4 [4]) can be collected appropriately, reporting ready for trials on M18.

3.3.2 Living Lab Hamburg

The development in the LL Hamburg is mainly driven by three prerequisites: the already existing 5G NSA network provided by the Deutsche Telekom, the TAVF Hamburg (Testfeld autonomes und vernetztes Fahren, i.e., testfield for autonomous and connected driving) and an assigned test route for ITS applications at Kattwyk Bridge, within the area of the Hamburg Port Authority. These three prerequisites have to be considered and brought inline with the four uses cases of the LL Hamburg described in document D1.1 [1].

Figure 17 gives an overview of the different components planned for the living lab Hamburg pilot site in 5G-LOGINNOV. Use cases addressed are 8, 9, 10 and 11. They have different elements which are described in detail within deliverable D1.1 [1], D1.2 [2] and D1.3 [3].

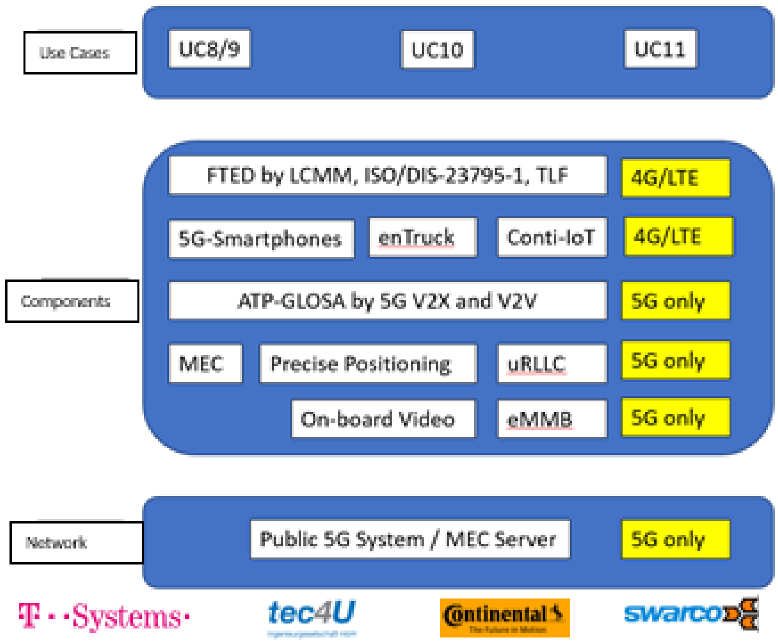

Figure 17 Overview of use cases, services and components in Living Lab Hamburg

It is worth noting that the existing telematic devices of Entruck and Continental, which are currently running on 4G LTE, can still be used to a certain extent, whereas the vehicle-to-infrastructure and vehicle-to-vehicle components linked to the automated vehicle platooning and traffic light forecast targeted for GLOSA are exclusively running properly using 5G, especially with regards to stability and scalability. However, with ongoing development, current 4G LTE functionalities will be replaced and transferred into 5G only to avoid any communications gaps. This transformation is not linked to hardware only, but also to applications and data analytics communications structures.

Other important elements shown are the mobile edge as well as precise positioning and the usage of video data. These services are latency-critical and consume a lot of bandwidth, requirements that are part of the 5G infrastructure and can ensure to make the planned services scalable. The network planned to be used in Hamburg LL is the public network of Deutsche Telekom; the support for technical activities will be requested by the 100% Telekom daughter company T-Systems, project partner of 5G-LOGINNOV. With regards to the urban coverage, the deployment will have a focus on the test field autonomous driving in the city center of Hamburg, an area where the coverage of 5G and the deployment of 5G services go together with the deployment strategies of Deutsche Telekom. It must be mentioned that all telematic devices have 5G technology available in their IoT device and are therefore prepared for further 5G roll-out activities.

5G NSA System, Design and Deployment

The overall 5G-enabled service design is shown for use case 8 and 9 (FTED - Floating Truck Emission Data) in Figure 18. The core communication concerns the transmission of telematics and vehicle data via 5G to the service center exchanging data with the virtual traffic management center. The signal phase and time (SPAT) is used for the traffic light forecast which is transmitted via 5G to the GLOSA App. Additional to the collection of floating truck emission data, the virtual traffic management center also uses the vehicle trajectories for traffic control and strategic measures, as well as other environmental data as shown as in Figure 18.

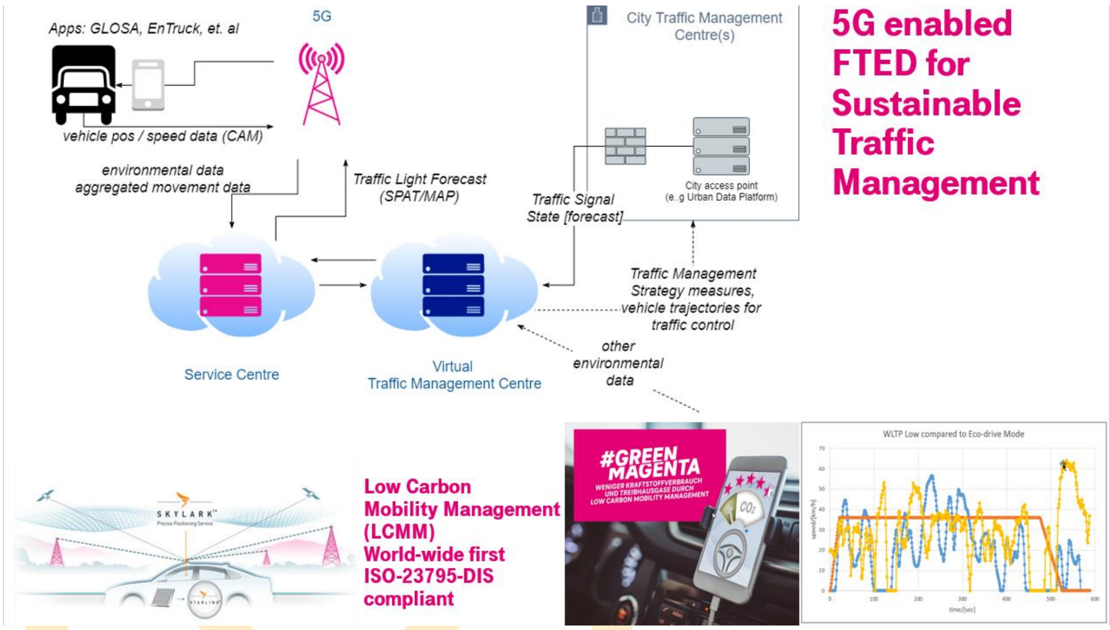

Figure 18: 5G, Design and Deployment

The exchange of real-time data with strategic traffic management measures for environmental protection is part of use case 11. One important element of the 5G network here is the ability to increase precise positioning from 3 to 10m up to 10 cm, which allows a much higher accuracy to the energy calculation used from the three different telematic devices inside the vehicle fleet. The overall design also uses the mobile edge computing feature of the 5G network, making sure that low latency communication takes place for the use case 10 the truck platooning design. Especially for collision warning, this is highly relevant and safety-critical for the planned pilot activities in the test field of the city of Hamburg.

Figure 19 depicts how the mobile edge infrastructure of Deutsche Telekom is planned to be used in use case 10, automated truck platooning. As can be seen the GLOSA service for automated driving is latency-critical, because the vehicles have to exchange information with time restrictions less than 15ms due to reaction time, especially in the case of collision warning. For the automated driving function, the latency-critical aspect comes with the teleoperation and remote driving control. In Hamburg LL, the intersections and roadside units shown in Figure 19figure 19, use the CAM protocol to exchange calculated traffic light forecast from the mobile edge to the different users driving in the geographical circle close to the intersection. Assuming the alarm can be sent to all vulnerable road users in the surroundings, the collision warning is dependent on precise positioning but also on low latency. It should be mentioned that the map information of the intersection is using an ISO standard to ensure transferability. In the case of the automated truck platoon, the lead vehicle needs to communicate with the follow vehicles ensuring stable distance in the long run remote driving whereas collision warning refers to road users as pedestrians, bikes and bicycles that are approaching the intersection. The collision warning service is already implemented by Continental and T-Systems by the ongoing project NPM and will be deployed and developed for logistics corridor services and vehicle platooning inside the test field for autonomous driving. Roadside Units and traffic management centre are already ensuring traffic light forecast for the uplink to the ITS server and the GLOSA App.

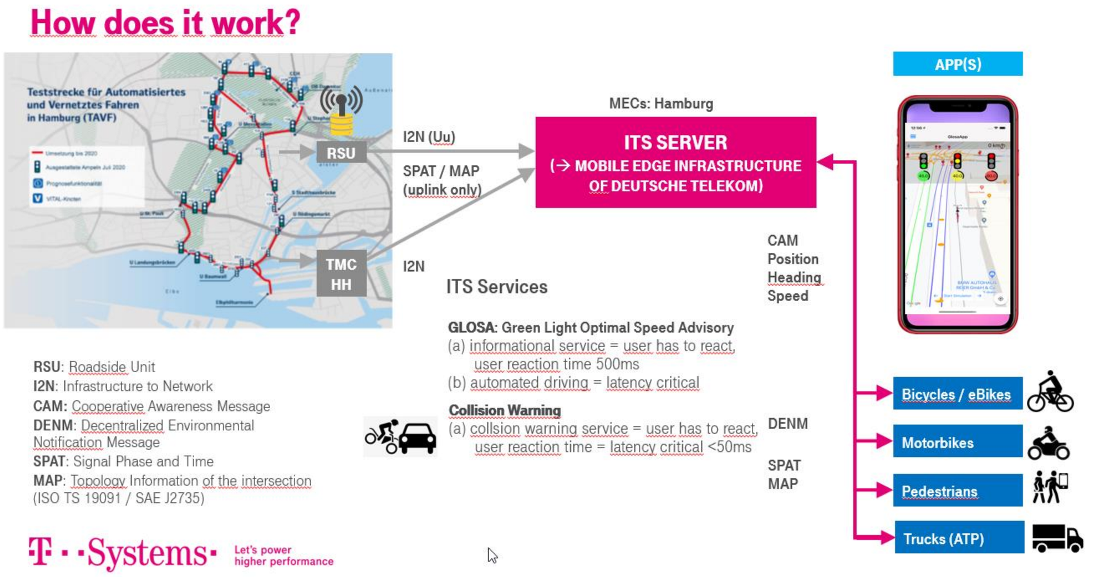

Figure 19: Using the MEC-X 5G functionalities for Hamburg Use Case 10

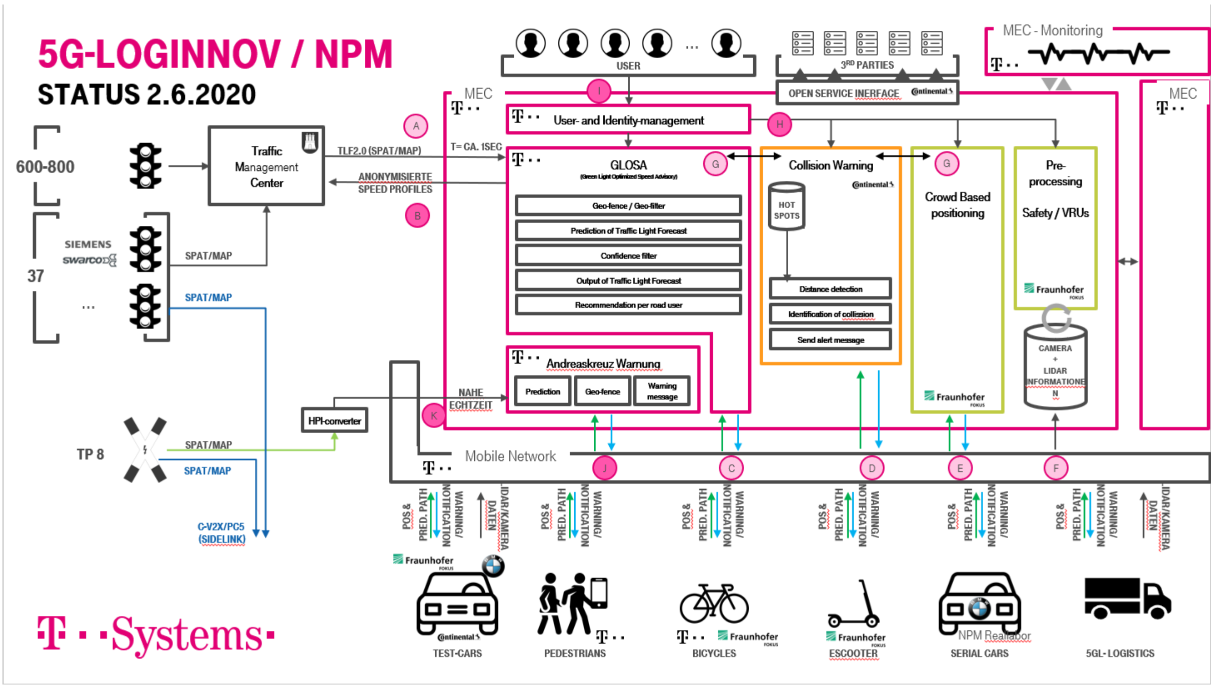

Figure 20 shows the overall 5G architecture using mobile edge and the monitoring features as well as communication layer of the mobile network of Deutsche Telekom. As one can see, the different traffic lights connected to the traffic management centre ensure that the traffic light forecast sends anonymized speed profiles and links it together with a signal phase and time information, to hand it over to the green light optimum speed advise. On one hand, the different participants in traffic handover

Figure 20: Service overview

information via the mobile network to the speed GLOSA information, ensuring that the information leads towards the recommendation for the road user. On the other hand, the collision warning module of Continental generates hotspots out of this information and sends alert messages back to the road user. The architecture was set up in the partner project NPM, which includes all road users with a smartphone. The 5G-LOGINNOV project uses the same infrastructure shown in the right part of the figure, and exchanges data also with the same collision warning by Continental and GLOSA as well as traffic light forecast module the speed profiles in a way to make it available for services. The elements of the mobile network and the 5G architecture are in this architecture vertical and horizontal at the same time. In 5G-LOGINNOV it is planned to distribute the information to the different use cases and to include precise positioning with regards to the four use cases described earlier.

To ensure this, the development of the LL Hamburg uses cases is defined in three steps with a continuous tracking of each step and regular reviews of accompanied activities in weekly meetings.

1. Step one: – Analysis, segmentation and definition of test area

The two test areas TAVF and Kattwyk Bridge will be analyzed against their specifications, e.g. route profile, traffic volume based on day time, elevation, traffic lights, relevant POIs, manoeuvres forced by infrastructure and transferred into digital maps that can be used as a blue print for the upcoming trials in WP3.

This analysis of the infrastructure started in M8 (April 2021) with test drives within the testfield autonomous and connected driving (TAVF) and the access to the container terminals in the southern part of the river Elbe. The test drives have been performed with 5G-enabled mobile phones running LCMM and vehicles equipped with Entruck onboard units. However, the latter ones communicate by 4G LTE networks and use legacy GNSS as Galileo for localization. Both will be replaced by 5G-enabled hardware as soon as available, but latest on M14 (October 2021). Until then, all data analytics and data communication processes are evaluated regarding timing, bandwidth, data input/processing ratio and latency of the backend server infrastructure. This process, started in M7 (March 2021) and scheduled to be finished in M13 (September 2021), will enable the identification of system-related data bottlenecks that might prevent exploiting the full available capacities of the 5G network.

For the test drives conducted since M8 (April 2021), the LCMM and Entruck hardware was deployed on several vehicle classes, i.e. passenger cars, LCV and HCV. Additionally, T-Systems is contributing tracking data collected by a Taxi fleet in Hamburg and transferred by LCMM into traffic and infrastructure information. Starting with M7 (March 2021), first platoon tests on the TAVF have been conducted. The first round of baseline collection thereby was executed without the help of any assistance from the GLOSA App and only environmental relevant driving parameters have been collected. In the second round of baseline collection, starting with M10 (June 2021), the GLOSA App has been integrated but at this point as a simple information system about the signal phase, without any derived intelligence fostering driving in a platoon.

Secondly, in M7 (September 2021), a detailed evaluation of the performance and coverage of the public 5G NSA network operated by Deutsche Telekom will be conducted, to identify the best routes and corridors for the defined LL Hamburg uses cases. Finally, and by latest end of M14 (October 2021), the results of all activities will be linked to define the most suitable routes for the planned LL Hamburg trials, considering inter alia routes and route segments for testing and trials, start and end points for logistic corridors, entry and leaving points for these logistic corridors, vehicles, and vehicle classes.

2. Step two: – MEC and alignment of data structure and communication protocols

Based on the results of step one, the common data structure and the communication protocols between the mobile devices, i.e. IoT boxes, OBUs and mobile phones, will be defined and applied to the MEC. This includes the setup of the MEC at a strategic position for the intended trials in, the common database and database structure for the specific uses cases and the interfaces to enable V2V, V2I, I2V communication. Additionally, the virtual TMS will deployed to establish the link between traffic and infrastructure.

The data collected during the analytics performed in step one shall be used to specify the platooning GLOSA component until M14 (October 2021). The GLOSA Platoon component will afterwards be integrated into the MEC environment of Living Lab Hamburg, which is planned to be available as alpha version in M16 (December 2021). For the planning of the vTMC, see UC11 below. Using the alpha platform, further field trials shall be conducted to optimize MEC latency and the further enhance the accuracy using 5G precise positioning.

The implementation of the vTMC will be based on the SWARCO MyCity platform, which has been launched in M11 (July 2021). 5G-LOGINNOV specific extensions require a private cloud instalment on dedicated hardware, which is deployed from M11 to M14 (July-October 2021). Starting M14 (October 2021) the implementation of the interfaces to the LCMM server (i.e. receiving FTED data), to the urban data platform (i.e. traffic sign state via SensorThingAPI), to the GLOSA server (i.e. traffic sign state and prediction data in ETSI SPaT and MAP format), as well as the central Traffic Light Forecast (TLF), FTED visualization and strategy manager, will be ongoing until M18 (February 2022).

3. Step three: – testing and preparation of trials.

The last step will combine the activities of the first two steps and set the framework for the trials. Each use case will get a storyboard including an operation chart and methodology to evaluate to application of the use case itself and the intended results. This step is accompanied by additional test drives as a pre-qualification of the uses case trials and setups.

After all components have been integrated and cross reference between the use case have been established, a fully functional beta version of UC10 is planned to be available in M18 (February 2022). Using the beta version, another round of field tests and bug fixing shall lead to the completion of the deployment of UC10 and the whole Living Lab Hamburg in M20 (April 2022).

Especially for the TLF functionality, it is crucial that data received by the urban data platform are reliable and delivered with constant low latency and the processing time is constant and low too. The activation threshold for the strategy manager, with regard of measured emissions, needs to be fine-tuned based on the LCMM-data, which will probably exceed the implementation phase and be taken care of in the trial phase.

3.3.3 Living Lab Koper

Figure 21 depicts the foreseen use cases, components, networks and partners collaborating in Living Lab Koper.

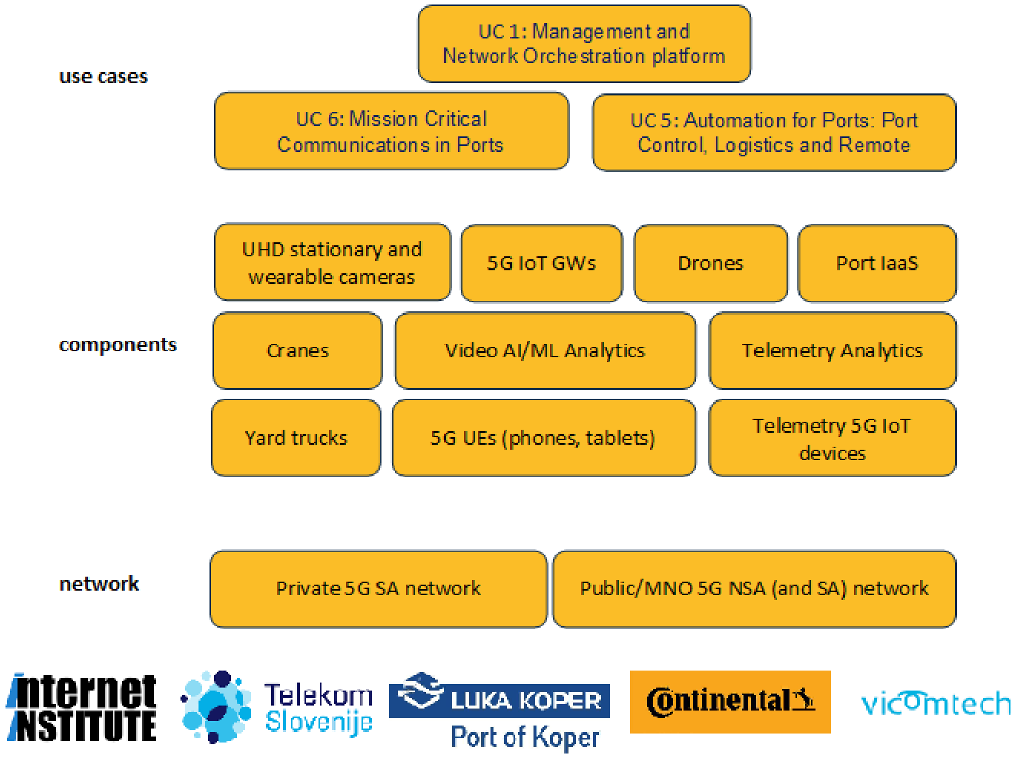

Figure 21: Living Lab Koper Architecture and Components

Applications and services deployed within use cases UC1, UC5 and UC6 will rely on two 5G networks provided by TSLO (Telekom Slovenije) and ININ (Internet Institute), IaaS provided by LK (Luka Koper) and MEC/Mobile IaaS assured by TSLO and ININ. This infrastructure will enable proper operating of both public and private 5G networks and running application/services related to port daily operations (e.g., video analytics, telematics analytics). Figure 22 depicts high level network architecture of LL Koper, including application components used in port operations (UC5 and UC6).

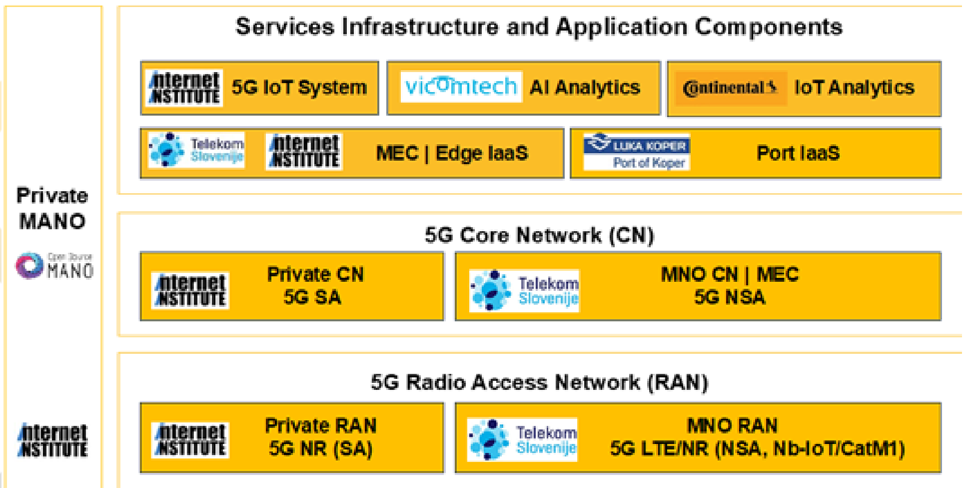

Figure 22: Living Lab Koper Network Architecture

As explained with more details in the following sub-sections, each component comprises a few sub-components (both SW and HW), essential for the complete system to work as expected. Development and deployment plan includes monitoring the overall progress and also monitoring the progress of certain sub-components. Thus, it will be possible to detect potential troubles in early phases, and searching for viable solutions can start immediately, in order to avoid or at least minimize delays. However, as mentioned multiple times, certain expectations for UCs are related to commercial availability of specific components, which is out of the project's control. For specifics on certain technical details, D1.2 [2] would be suggested.

Public 5G NSA System Infrastructure

Public 5G NSA system infrastructure will be provided by TSLO using its production core network and dedicated 5G base stations at the LL Koper premises. An overlay 5G EPC core network connected to LTE and 5G NR radio enables 5G Non-standalone (NSA) Option 3X. The core network deployment/integration and testing has been finished within M11. 5G core will be physically installed in the Living Lab and the infrastructure will also be further extended with Multi-access Edge Computing (MEC)/Mobile IaaS capabilities to assure smart routing of the port-related network services and applications traffic directly to the operations support systems of the LL Koper.

5G NSA Option 3x provides both NR and LTE radio access (as per 3GPP Release 15) - the New Radio (NR) base stations (gNB) are connected via the 4G network, while the LTE anchor (ng-eNB) is required for control plane communication and mobility management. The initial 5G radio access network at LL Koper is being deployed on NR 4x4 MIMO 20MHz at 2600 MHz FDD mode (n7), with an LTE anchor layer 2x2 MIMO 10 MHz in B20 at 800 MHz and 2x2 MIMO 20 MHz in B3 at 1800 MHz. LTE carrier is 4x4 MIMO 15 MHz in B7 at 2700 MHz. The LL Koper area is also covered by the NB-IoT network, which is based on the existing LTE technology (E-UTRA operating bands 8 and 20). Component deployment has been finished in M11, while final RAN testings are expected to be completed in M15. Additional antennas NR NSA in band n78 (3500MHz) with 100MHz bandwidth and LTE anchor B3 are planned in M15. Figure 23 represent actual radio coverage in LL Koper, i.e., with 4G eNBs in function only. Although there has been a plan to establish additional base station locations in case of insufficient radio coverage, radio signal measurements results performed in M11 show there is no such need.

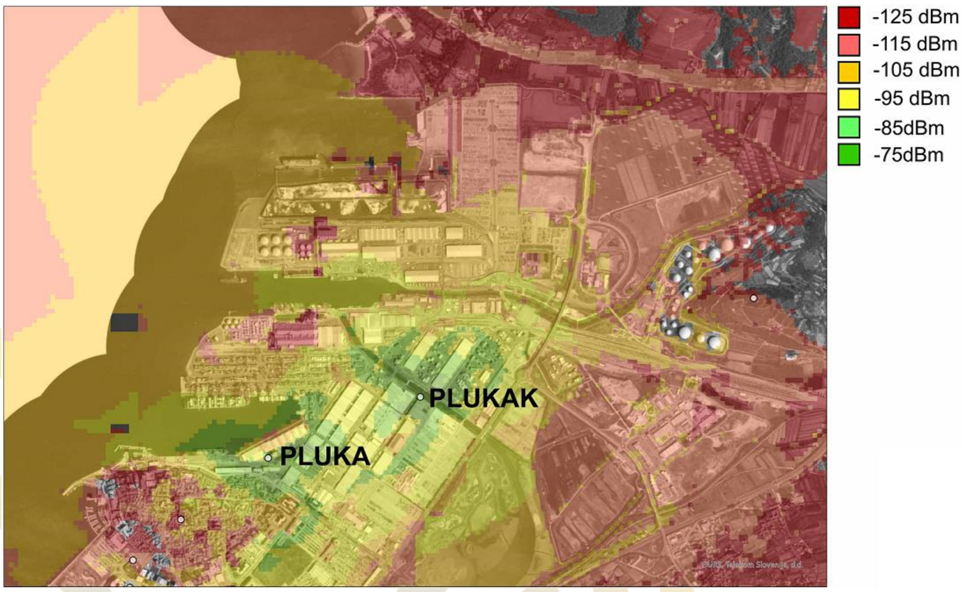

Figure 23: Public 5G NSA network radio coverage in LL Koper (NR FDD 2600 MHz).

An incremental upgrade of the commercial/public 5G NSA network with the 5G SA option 2 is planned during the project in case commercial equipment is available on time, i.e., at least by M20 which would give us enough time to deploy, integrate and test 5G SA by M22. This also includes network slicing, which will be assured in case commercial technology is available and 5G SA Option 2 is deployed in LL Koper, i.e., expected in M22 if commercially available. Upgrade to 5G SA will require additional Mobile IaaS capabilities, also provided by TSLO for the public 5G SA network scenario (extending Mobile IaaS capabilities has the same timeline as other tasks related to 5G SA).

Private 5G SA System Infrastructure

Private 5G SA System Infrastructure is being provided by the ININ; Figure 24 represents its architecture. The network deployment will operate in 5G SA mode and will be prepared as a compact solution deployed over the portable Mobile IaaS infrastructure provided by ININ (this IaaS is physically other infrastructure than IaaS provided by Luka Koper and described in the following section). 5G NR in SA mode will be deployed as part of a private 5G system which will be prepared in a compact form and will enable simple reallocation of the gNb site inside the LL Koper.

Private 5G SA components are to be deployed in the laboratory environment by M15 and fully integrated into the LL Koper network and tested end-to-end by M17.

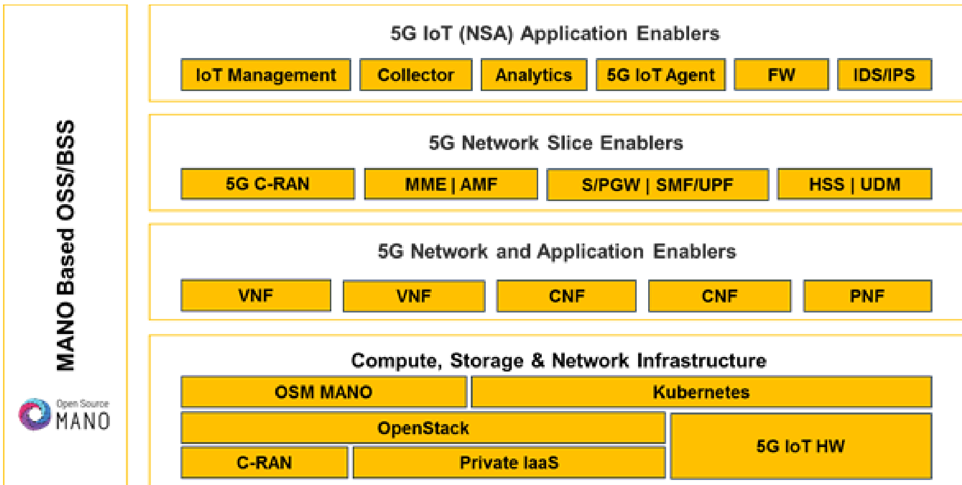

Figure 24: Private 5G deployment architecture.

Figure 25 presents high level phasing for 5G network development, deployment, testing and maintenance/support throughout the project.

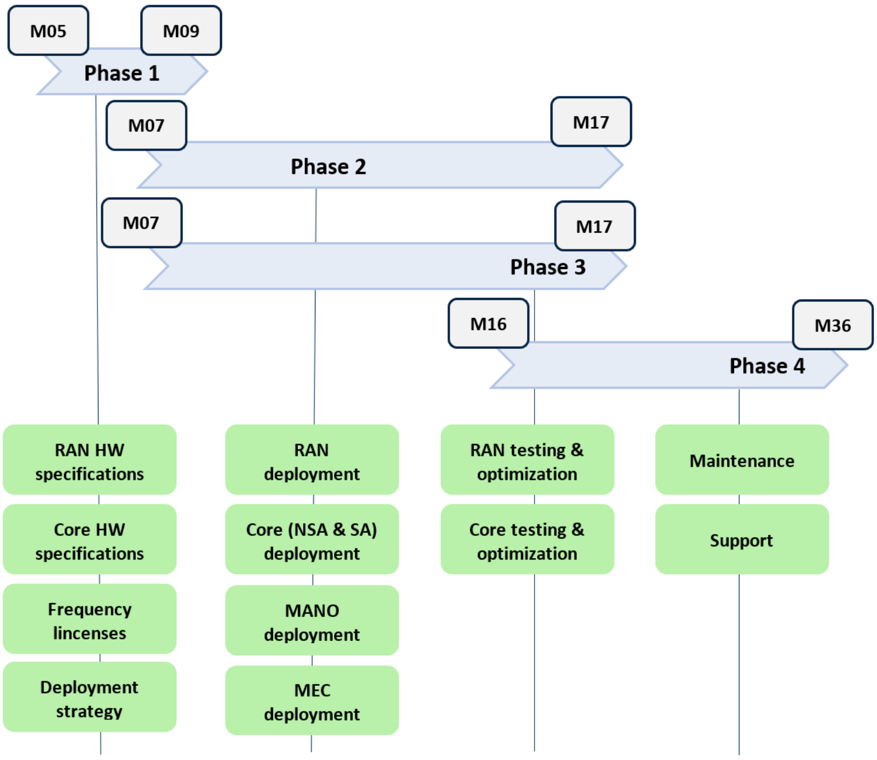

Figure 25: 5G network in LL KP phasing.

5G Technologies and Innovations

Port IaaS

To support specific port operations related services, LK will deploy its own, so-called Port IaaS capabilities. This IaaS is physically not the same as Mobile IaaS/MEC deployed by ININ and TSLO to support 5G network operations (see above - 5G Network deployment). The Port IaaS requirements will be covered by placing dedicated physical servers at the data centre at the LL Koper location that will serve as a private IaaS (Infrastructure-as-a-Service) in terms of NFV-based terminology. Applications/services running on the Port IaaS are video analytics, telematics analytics and SLA/SLS monitoring. Adding IaaS infrastructure into data centre requires room space, free rack enclosures, power and optical infrastructure capabilities. IaaS infrastructure will be fully operational by M17.

Mobile IaaS

Mobile IaaS will serve providing key management and orchestration technologies, i.e., MANO, as well as backend for IoT platform, including monitoring network parameters. Since the deployment will be provisioned using NVF-based deployment and will include VNFs/CNFs on the core network side and PNF for gNb, OpenSource MANO (OSM) orchestrator will be used to efficiently deploy and manage the virtualized/containerized applications (VNFs/CNFs), while also allowing a certain degree of management for physical devices (PNFs). For testing and monitoring purposes, the qMON monitoring tool will be deployed and will allow continuous end-to-end 5G network service monitoring as already mentioned. On the application layer, the private 5G deployment will support hosting additional and 3rd party applications, such as deep packet inspection, IPD/IDS or some use case application. Within this architecture, the only requirements for such applications are the application is containerized and its descriptors for VNF (CNF) and NS do fully support OSM orchestration.

Timeline for tasks related to Mobile IaaS coincides with general timeline for 5G NSA and SA network deployment, integration and testing as described in the above sub-section 5G Network deployment.

User devices

Several IoT and other types of devices are necessary to fulfil UCs scenarios: IoT GWs, Continental telematics IoT devices, UHD cameras, drones and industrial 5G UE handheld terminals (devices are expected to be delivered by M15). These devices will be mounted/installed on some existing infrastructure: cranes, yard trucks and prefabricated columns, which require additional optical infrastructure to be provided. According to the previous experiences, availability of the devices relies on the availability of commercial 5G components and products, especially those related to the support of 5G eMBB features (e.g., 5G support on industrial UE and drones), i.e., terminal device vendors usually roll out devices only after network is ready, which allows them to perform tests. In case of delays in the commercial rollout on the part of 5G vendors (especially industrial editions), and consequently unavailability of some elements/functionalities, these will be replaced with the most suitable prototypes and open-source implementations already available in the 5G ecosystem. Timeline to provide equipment are bound with the timeline of certain UCs, as defined in Chapter 2.5.2 (for detailed UCs definition see D1.1 [1] and D1.3 [3]).

Analytics systems

Data of port-related daily operations collected by IoT and other kinds of devices will feed Telematics Analytics and AI/ML-based Video Analytics installed on Port IaaS infrastructure. Vicomtech AI/ML-based Video Analytics platform is used for the detection of several events both in logistics and risk-management scenarios, with the objective of performance and security improvement, respectively, while the Telematic Analytics provided by Continental serves for remote telemetry monitoring of the operating machines in the port (some of the terminal tractors will be equipped with telematics IoT devices provided by the Continental). As with devices, also Vicomtech and Continental analytics tools timelines are tightened to the timeline of certain UCs, as defined in Chapter 2.5.2 (for detailed UCs definition see D1.1 [1] and D1.3 [3]).

Testing, migration to the final premises, maintenance and support

There are certain expectations of how each of the components should behave before it is ready for the integration to the Living Lab premises. Internal lab tests of the components/equipment/devices already available are on-going, i.e., in relation to UC1 scenarios in the first place, started in M7 and to be finished in M15. Each component is therefore tested first for its functionalities and then, when integrated with other components, for the functionalities of the complete system. These (initial) tests of the particular components are not being defined within the project since the partners bringing them into the project have sufficient expertise in knowing it; therefore, it is the partner's responsibility to configure the component in a way to be able to provide expected results when integrated into the complete system supporting certain UC.

It is expected that the transition of the components form internal labs to the Living Lab environment will be a challenge; similarly, it is also not expected that migration/integration task will address all the potential issues that may appear during the trial phase. Therefore, support and maintenance will be available all the time until trials are completed. While the LL leader is responsible for the coordination of the support and maintenance during the trial, each partner is responsible for all the components/equipment brought into the project. As one of the functions delivered within LL Koper is continuous monitoring, potential issues will be detected as early as possible, thus keeping LL infrastructure outages to a minimum.

3.4 Methodology and Technical Quality Assurance

3.4.1 Integration

Ensuring correct integration of the innovations is performed at several levels and moments. Integration starts with having agreements on how to integrate, in which all partners have the flexibility to operate as they are used to. These agreements start before development starts and ends with the final acceptance tests. This means integration is an active cross-pilot task throughout the development and deployment of the innovations.

- **Architecture and design**: this phase is where integration starts, at the very beginning with an overview on how the different components interlink. Throughout the discussions on architecture and design, multiple topics have been discussed and covered, ensuring the chosen architecture ideally supports integration at the end of development.
- **Proof-of-Concepts**: throughout the development of WP2, several cross-partner Proof-of-Concepts (PoCs) will be held to show early results and to ensure integration is actually being performed early on. When developing systems, it is possible to choose either to begin with the internals and end with the externals, or vice-versa. Very often, the first option is chosen, whereas the risk lies within the second option. In 5G-LOGINNOV, the chosen pattern is the early integration; the PoCs are performed in the Living Lab environment and will mark a successful completion of the development and deployment.

3.4.2 Testing

Testing is performed to ensure a fit-for-purpose system. The nature of the project (Innovation Action) is to collect evaluation data for the innovations in the project. This means a lighter and more flexible testing approach, aimed at assuring the operational workings of the innovations and collection of evaluation data is sufficient. To this end, testing is carried out in the following manner:

- **Internal Testing** is performed according to each partners own testing approach. For WP2, partners ensure that these internal tests have no remaining major or blocking issues before the components/equipment are transferred to the Living Lab.

- **Proof-of-Concepts** will be executed throughout development on subsystem and system level. Within these PoCs, the partial and incremental integration of the Living Labs' systems are assessed in relation to the final trial plan of WP3. By doing this from early on, potential interfacing issues are anticipated at the start of the development phase, to ensure they do not occur during integration. The outcome of these PoCs will be discussed in the regular meetings as a means to share success and learnings, and keep track of development.

  When a PoC has proven successfully that (part of) the trials in the final trial plan can be executed, the tested functionality is marked ready and operational.

The PoCs will be part of deliverable D2.6.

3.4.3 Trial support

During the validation, and throughout the trial period, WP2 is available for maintenance, support, fixes and potential upgrades, to ensure WP3 will receive as much valid trial data as possible.

3.5 Management, Activity Planning and Progress Monitoring

3.5.1 Planning

The overall planning of WP2 is presented in Figure 26. The orange-bordered column marks the first interim review completed on the 20th of May.

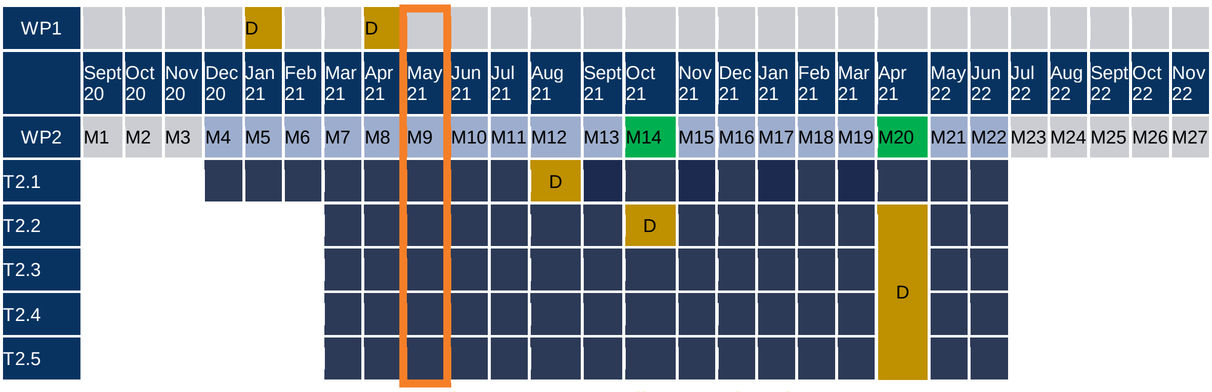

Figure 26: Overall WP2 planning

The planning of WP2 has the following incoming dependencies:

- The initial use case descriptions delivered in M05 as part of D1.1 [1].
- The finalized requirements that have been made available in M08 (D1.2-D1.5) [2]-[5].

The planning of WP2 has the following outgoing external dependencies:

- The trials in WP3 with the initial plan available in D3.1 [7] at the same time of the availability/delivery of D2.1.
- The start-ups from WP4 whose operation is dependent on the service availability at the LLs.
- Task 5.3: Exploitation and T5.4 Standardisation and Spectrum from WP5, which will contain the realized exploitable results starting M16.

WP2 has the following milestones:

- MS6: Evaluation data management tools ready (M14).
- MS7: Living Labs' deployment completed (M20).

3.5.2 Monitoring

To monitor progress and to coordinate the efficient and timely integration of the 5G and logistics technologies at the LLs, a comprehensive Excel sheet has been developed. In this sheet, the development and deployment activities have been listed. Per activity and living lab, milestones are recorded and periodically checked. The monitoring period initially is bi-weekly. When developments have taken up, a lower frequency may be adopted.

The Excel sheet will be explained in Section 4.

Next to milestone tracking, tasks are monitored in the same periodical meetings.

Part of the 5G-LOGINNOV approach is a monthly consortium meeting assessing progress. In these meetings, a status report for the developments is given completing the total monitoring cycle for WP2.

3.5.3 Meetings

For WP2, periodical virtual meetings have been organized so far. Ideally these meetings are physical once in a while. If the COVID-19 pandemic permits, WP2 meetings will shift occasionally to live mode instead of virtual mode.

To get a clear and detailed overview of progress and to share success, the aforementioned PoCs may be planned alongside the regular WP2 meetings, if the COVID-19 pandemic allows for physical meetings.

The initial period of the WP2 meetings is bi-weekly. When the developments permit this frequency will be lowered.

In case during development specific topics are identified, specific meetings may be organized.

Each Living Lab will have its own internal meetings to solve potential issues that may occur an ensure the timely delivery of their respective innovations.

4 TRACKING SHEET

To coordinate the efficient and timely integration of the 5G and logistics technologies at the LLs, and to ensure well-aligned development and deployment of trials and data collection activities required to assess 5G-enabled use case benefits, each living lab analysed and partitioned its respective use cases is several components. An indicative illustration (snapshot) of the living document for all LLs is depicted in Figure 27. This document is in compliance with the phasing approach described in Section 3.1, taking care of the activities of software and hardware selection and procurement (RAN, Core, 5G-IoT devices, etc.), the development of in-lab services and components/subsystems and their integration at the LL premises and trial sites including software designed solutions (MANO, AI/ML, GLOSSA-APP etc.), testing and verification of the data collection mechanism, and finally the report of readiness for trials.

The purpose of this live document is to facilitate the discussions among the partners in the bi-weekly meetings of WP2, also including the consortium meetings that occur on a monthly basis. This tracking sheet will enable the timely identification of potential issues and risks of the development for each LL, in all identified phases (planning and strategy, development and deployment, testing and verification, maintenance and support for trials), in order to provide immediate solutions and remedies and ensure the successful kick-off of the LL trials in WP3.

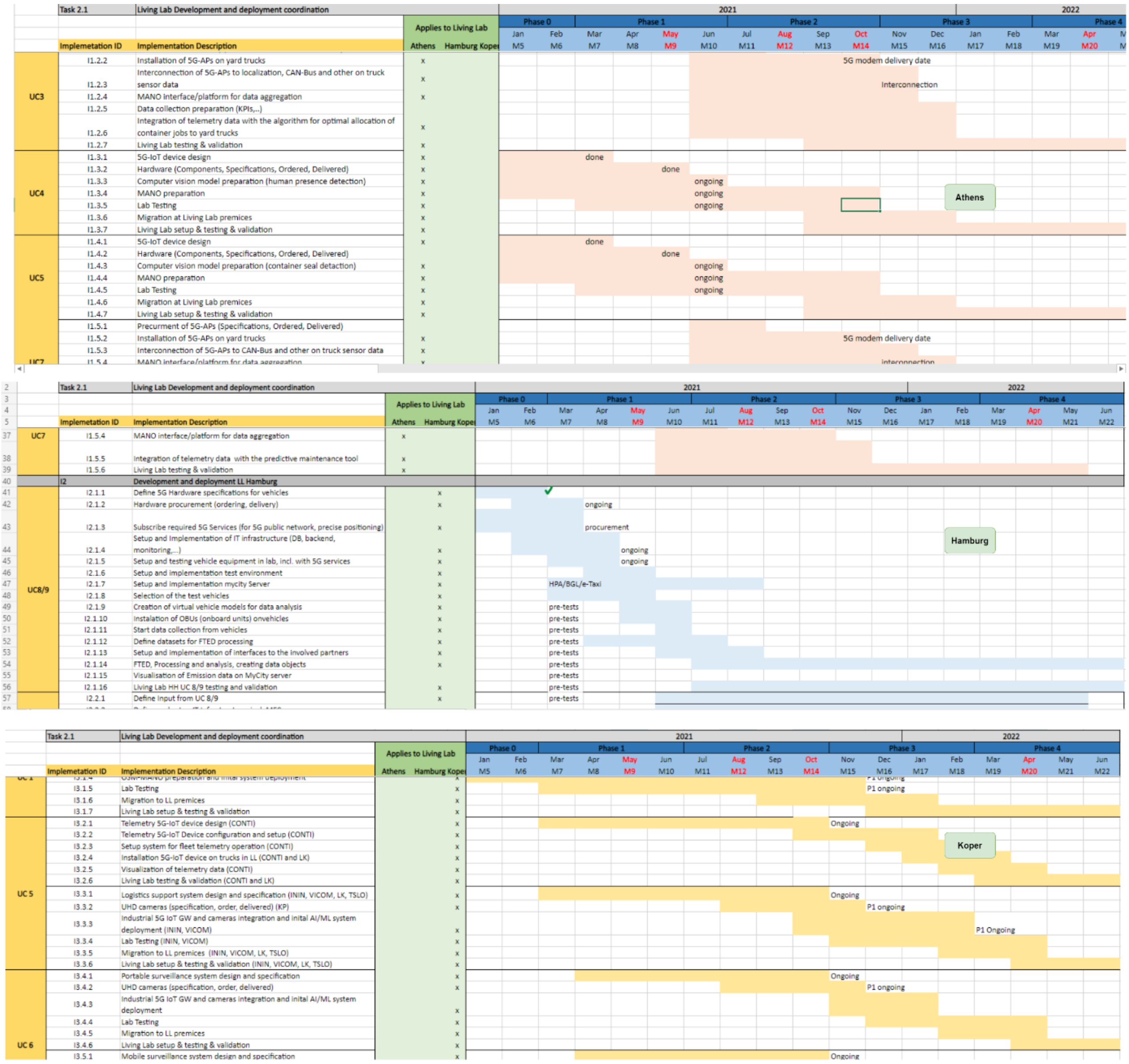

Figure 27: Tracking the development and deployment progress for all LLs.

5 CONCLUSION

The aim of this deliverable is to provide a detailed methodology and strategy, describing the development and deployment activities of the 5G-LOGINNOV project, to draft the process for the preparation, execution, and feedback cycles to be followed by all Living Labs and ensure coherent and timely delivery of the 5G and logistics technologies and innovations at the three Living Labs of Athens, Hamburg and Koper. After providing a brief description of the pilot sites, their respective focus area (inside the port area or hinterland), use cases, and a brief description of the envisioned trials, the document focused on the timeline of WP2 tasks that will be followed by each LL, followed by the envisioned equipment that will be deployed in each pilot site such as the number of 5G-IoT devices (e.g., cameras, 5G UEs), number of STS cranes as well as the number of yard and external vehicles/trucks that will be involved at the trials for the evaluation of the use cases and the 5G-LOGINNOV objectives. In the sequence, the commonalities and differences across the different pilot sites have been discussed.

A detailed phasing approach was described in Section 3.1, providing the basics of a tracking progress, where each LL detailed the different phases and relevant aspects for the successful roll-out of the activities of each individual use case, and thus the overall development of the LL innovations. The methodology for technical quality assurance has been discussed, and further monitoring of activities facilitated though regular meetings at consortium/partner/LL level, including additional meetings if/when issues arise, considered and agreed by all partners.

The purpose of this document is thus the circumventing or minimizing potential risks due to delays or deviations from the original plans set out in this draft, by providing a feasible and carefully studied plan of the LL activities. It is therefore the aim of this deliverable to serve as a guideline for the actual development that takes place in the main body, i.e., development tasks, of WP2.

As a final remark, the rollout plans and roadmaps presented in this document reflect the 5G-LOGINNOV partners best estimate for completion of the deployment, development and rollout phases at each LL by the end of M20 (April 2022), whereas WP2 is finalized in M22 (June 2022).

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