5GLOGINNOV

# D3.1

## Trial methodology, planning and coordination

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| | |
|---|---|
| **Work Package** | WP3 Trials and Evaluation |
| **Task 3.1** | Specify a framework for the operation of LL trials and evaluation |
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## List of abbreviations and acronyms

| Abbreviation | Meaning |
| --- | --- |
| 3G | Third Generation Wireless System |
| 3GPP | 3G Infrastructure Partnership Project |
| 4G/5G | 4th/5th Generation (of cellular networks) |
| 5G | 5th Generation Wireless System |
| 5G MOBIX | 5G for cooperative & connected automated MOBIlity on X-border corridors |
| 5G-PPP | 5G Infrastructure Public Private Partnership |
| ADAS | Advanced Driver Assistance System |
| AEOLIX | Architecture for EurOpean Logistics Information eXchange |
| AI | Artificial Intelligence |
| API | Application Programming Interface |
| ATP | Automated Truck Platooning |
| CAD | Connected and Automated Driving |
| CAM | Connected and Automated Mobility |
| CAN | Controller Area Network |
| CCAM | Cooperative, Connected and Automated Mobility |
| CEN | European Committee for Standardization |
| CENELEC | European Committee for Electrotechnical Standardization |
| CNF | Cloud Native Functions |
| CONTI | CONTINENTAL AUTOMOTIVE ROMANIA SRL |
| COREALIS | Capacity with a pOsitive enviRonmEntal and societAL footprInt: portS in the future era |
| CSF | Critical Success Factor |
| DoA | Description of the Action |
| E2E | End-to-End |
| EC | European Commission |
| eMBB | Enhanced Mobile BroadBand |
| EPI | Energy Performance Index |
| EU | European Union |
| EAMS | Enterprise Asset Management System |
| FTED | Floating Truck & Emission Data |

| | |
|---|---|
| GLOSA | Green Light Optimal Speed Advisory |
| GNSS | Global Navigation Satellite System |
| HMI | Human-Machine Interface |
| IoT | Internet of Things |
| IT | Information Technology |
| ITS | Intelligent Transport Systems |
| KPI | Key Performance Indicator |
| LCMM | Low Carbon Mobility Management |
| LL | Living Lab |
| MANO | MAnagement and Network Orchestration |
| MCA | Multi Criteria Analysis |
| MEC | Mobile Edge Computing |
| ML | Machine Learning |
| MNO | Mobile Network Operator |
| NFV | Network Functions Virtualization |
| NSA | Non-Standalone (5G network operation) |
| OEM | Original Equipment Manufacturer |
| ORDP | Open Research Data Project |
| ORDP | Open Research Data Pilot |
| PCT | Piraeus Container Terminal |
| SA | Standalone (5G network operation) |
| SDK | Software Development Kit |
| SME | Small and Medium Enterprises |
| STS | Ship to Shore |
| TEC4U | tec4U Ingenieurgesellschaft mbH |
| TEU | Twenty-foot Equivalent Unit |
| TOS | Terminal Operating System |
| TSYS | T-SYSTEMS INTERNATIONAL GMBH |
| TMS | Truck Monitoring System |
| UC | Use Case |
| UHD | Ultra-High Definition |

| | |
|---|---|
| VNF | Virtual Network Function |
| WLTP | Worldwide-harmonized Light vehicles Test Procedure |
| WP | Work Package |

# 1 EXECUTIVE SUMMARY

The deliverable D3.1 'Trial methodology, planning and coordination' is result of task 3.1 within the work package 3 (WP3) of the 5G-LOGINNOV project. It defines the framework of the tasks T3.2, T3.3 and T3.4 within WP3.

| Task # | Task description |
|---|---|
| **T3.1** | Specify a framework for the operation of LL trials and evaluation |
| **T3.2** | Specify LL test scenarios and test cases for the LL Athens and process test cases |
| **T3.3** | Specify LL test scenarios and test cases for the LL Hamburg and process test cases |
| **T3.4** | Specify LL test scenarios and test cases for the LL Koper and process test cases |
| **T3.5** | Evaluate and assess the LL trial data for operation optimization |
| **T3.6** | Evaluate and assess the social and economic impacts |

*Table 1: Tasks of WP3: Overview*

Task T3.1 will set up the trial methodology and planning and due operation of the LL trails by specifying and presenting a common trial methodology for each (LL of 5G-LOGINNOV, the related planning LL, the submission of the data for evaluation and the overall coordination to monitor the trials demonstrated in the context of 5G-LOGINNOV.

To standardize the aspects the following approaches have been chosen:

1. The common trial methodology per each LL base on storyboards to detail and describe the demonstration and all relevant information to setup and perform the LL UCs.
2. For the LL planning the 'LL trial plans' have been initiated by setting up a common template for the related aspects of planning and monitoring.

This approach covers the task objectives of T3.1 referring to a framework for the operation of the trials and the evaluation with respect on the defined evaluation methodology, specified D1.4 'Initial specification of evaluation and KPI's' and deliverable D2.2 'Data collection and evaluation procedures'.

The deliverable D3.1 is finally the base for deliverable D3.2 'Living Labs trials preparation report' (M22) with reflection to deliverable D3.5 'Evaluation of operation optimization' (M32) and deliverable D3.6 'Evaluation of social, economic and environmental impacts' (M32).

The following chapters of D3.1 are structured with an introduction (Chapter 2) to the 5G-LOGINNOV project, the objectives of the deliverable and the intended audience. Chapter 3 focuses on the methodology approach itself and the related aspects of the deliverables D1.4 and D2.2. Within Chapter 4 all storyboards from the LL are defined and presented for the LL trials. The LL planning is summarized in Chapter 5 by the initial LL plans in relation to the overall workplan of the project. Within the Annex the initial planning sheet is added.

# 2 INTRODUCTIONS

## 2.1 PROJECT INTRODUCTION

5G-LOGINNOV's main aim is to design an innovative framework addressing integration and validation of CAD/CAM technologies related to the Industry 4.0 and ports domains by creating new opportunities for LOGistics value chain INNOVation. 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 clusters of Use cases.

5G-LOGINNOV is supported by 5G technological blocks, including new generation of 5G terminals notably for future Connected and Automated Mobility, new types of Internet of Things 5G devices, data analytics, next generation traffic management and emerging 5G networks, for city ports to handle upcoming and future capacity, traffic, efficiency and environmental challenges. 5G-LOGINNOV will deploy and trail 11 clusters of Use cases beyond TRL7 including a GREEN TRUCK INNITIAVE using CAD/CAM and 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 domains, thus being a pillar of economic development and business innovation and promoting local innovative high-tech SME 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 on ports. 5G-LOGINNOV 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.

## 2.2 PURPOSE OF THE DELIVERABLE

The purpose of the present deliverable D3.1 is to present the framework for the operation of LL trials and evaluation. This framework is divided (A) to the overall trial methodology and (B) to the trial plans by the LL to collect the data with relation to defined KPIs for the evaluation.

Specific scenarios (Storyboards) are defined for each LL and for the addressed Use Cases. A detailed initial planning with dates and commitments is also specified, following a common agreed template throughout all LL.

This provides an easy way to monitor the planning and the performance of the LL during the trial period for each site, keeping the activities in time and according to schedule and preventing deviations from the plans that could cause subsequent delays in the project work.

Moreover, detailed scenarios and plans for the pilots are also effective tools for assessment activities, to optimally plan and perform the foreseen evaluations.

With respect to the defined evaluation approach and the central data collection a summary of the relevant deliverable D1.4 'Initial specification of evaluation and KPI's' and an outlook on the future deliverable D2.2 'Data collection and evaluation procedures' will also be summarized.

## 2.3 INTENDED AUDIENCE

The dissemination level of D3.1 is a ‘public’ (PU) deliverable and available to members of the consortium, the Commission Services and those external to the project. It is specifically aimed at providing the 5G-LOGINNOV consortium members with an extensive set of guidelines and tools that contribute to the project’s promotion and diffusion.

# 3 METHODOLOGY

The methodology to specify and to describe the overall trial operations, processed in the tasks T3.2, T3.3 and T3.4 by the LL, covers aspects of ‘Storyboards’, ‘LL trial planning’ and a ‘Progress matrix’ for the execution. The following sub chapters 3.1 and 3.2 define these aspects in detail. In addition, summaries of the related deliverables D1.4 ‘Initial specification of evaluation and KPI’s’ and an outlook on the future deliverable D2.2 ‘Data collection and evaluation procedures’ are given within chapter 3.3.

## 3.1 ‘STORYBOARDS’

In order to have a very clear view on the course of the demonstrations deployed in each LL, the LL leaders will define storyboards. The objective of the storyboards is to detail and describe all relevant information to setup and perform a single UC.

The storyboards describe in simple words what is needed to perform the UC deployed by the LL and how it will be processed. It starts e.g. when the user arrives at the location of the demonstration, describes the whole process he/she is following and ends with the last action completing. Pictures/cartoons have been added to illustrate the story. Most of the LL have several storyboards, usually one for each UC and related KPIs because the experience for each UC is different.

The exercise of detailing step by step is very helpful for the related tasks T3.2, T.3.3 and T3.4 in the LL. It is helpful in the sense that it allows highlighting all actions needed for a smooth execution of the demonstration. The storyboards also aim at integrating the rather technical demonstrations into a comprehensive, user and business-oriented context.

To increase transparency and comparability the template for the storyboards covers the following aspects:

| Object | Description |
|---|---|
| **Storyboard ID** | Numeric identifier for each Living Lab for the storyboard |
| **Title** | Name of the storyboard |
| **UC** | List of relevant use cases for the storyboard |
| **KPI** | List of the relevant KPIs for the storyboard |
| **Baseline Data** | Description of the approach to collect baseline data (Level KPI) |
| **Operational data** | Description of the approach to collect operational data (Level KPI) |
| **Evaluation Data** | Description of the approach to provide data for evaluation (Level KPI) |
| **Action/sub UC / step …** | All needed information on:<br>• The organizational ‘setup’: e.g. Vehicles, infrastructure, participants etc.<br>• The technical setup to process the storyboard with regards to WP2 architecture and the overall technical bracket related to 5G technologies<br>• Optional information about ‘story’ and ‘setup’ e.g. diagrams, maps, pictures etc. |

*Table 2: Tasks of WP3: Overview*

Based on this structure of the storyboards the initial storyboards per LL are defined in chapter 4.

Within this deliverable the LL will provide their initial specification of each LL storyboard which will be used for the tasks T3.2, T.3.3 and T3.4 and updated in deliverable D3.2 'Report on the Living Labs preparation and readiness of the trials'.

## 3.2 'TRIAL PLANS'

The 5G-LOGINNOV LL trial plans are defined by each LL per storyboard and related KPIs. The template for the 'LL trial plan' has been initiated by setting up a common template for the related aspects. Aspects are defined by items like:

| Object | Description |
|---|---|
| **Name of the LL** | Name of the LL |
| **Date** | Date of the version edited |
| **Version** | Version of the planning |
| **Storyboard Number** | ID of the storyboard defined for the storyboard |
| **KPI and name of KPI** | ID and name of the related KPI |
| **Number of iterations** | Number of planned iterations |
| **Baseline Data collected** | Date to confirm baseline data for the Storyboard/KPI are collected |
| **Baseline KPI calculated** | Date to confirm baseline data are finally calculated |
| **Baseline data pushed for evaluation** | Data to confirm baseline data are transferred to central data storage |
| **Status UC deployment** | Date to confirm deployment has been finalized for the storyboard |
| **Test setup ready** | Date to confirm test/trial setup has been finalized for the storyboard |
| **Operational data collected** | Date to confirm operational data for the Storyboard/KPI are collected |
| **Operational KPI calculated** | Date to confirm operational data are finally calculated |
| **Operational data pushed for evaluation** | Data to confirm operational data are transferred to central data storage |

*Table 3: LL trial planning objects: Overview*

Within an iterative process all objects of the planning are the result of the contributions by the LL. The template therefore has been agreed by all LL leaders and will be initially setup for each LL within this deliverable (see Annex). The trial planning sheet covers the status overview on trial preparation per storyboard and the execution. Within deliverable D3.1 there is one initial LL trial plan per LL and this initial trial plan is added as annex to this deliverable.

| Date of planning | Version | | | | | | | M | M13 | | | | | M14 | | | | M15 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| yyyy/mm/dd | V0.1 | | | | | | | MONTH | September | | | | | October | | | | November | | | |
| | | | | | | | | WEEK | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
| Athens | UC Name / storybook | #KPI & KPI Name | Baseline data collected and calculated | Status deployment | Test setup ready (SW, HW, Services) | #KPI data collected - operational data | Data assessed | #Iterations | | | | | | | | | | | | | |
| #UC ID | x | A | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | #1 | #1 | | | #2 | | |
| | | B | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | C | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | D | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | #1 | | | | | |
| | | E | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | F | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | G | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | H | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | I | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| #UC ID | y | A | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | B | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | C | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | D | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | E | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | F | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | G | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | H | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | I | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| #UC ID | z | A | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | B | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | C | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | D | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | E | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | F | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | G | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | H | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |
| | | I | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | yyyy/mm/dd | | | | | | | | | | | | | | |

| | |
|---|---|
| #1 | #Test Iteration planned |
| #1 | #Test Iteration excecuted (sucessful) |
| | planned |
| | under construction |
| | done |

*Figure 1: WP3 illustration LL trial plan*

During the performance of the trails in the LL the planning will also feed the deliverable D3.2 'Report on the Living Labs preparation and readiness of the trials'. In this sense the matrix is foreseen as monitoring basis for the readiness and the execution of the trials. The structure and the related items are also based on contributions by the LL. For the structure and the frame of monitoring see also Table 3: LL trial planning objects: Overview

During the processing of the tasks 3.2, 3.3 and 3.4 this 'LL trial plan' will be updated by needs of the task progress. To discuss the plans with the LL frequently bi-weekly calls with the LL leaders will be organized to update the 'LL trial plan' if replanning is needed and to monitor the progress concerning performance and data collection. The final outcome of the updated 'LL trial plans' will be reported in deliverable D3.2 by each LL. To assess the execution, the progress and the collection of data for the KPIs, finally to monitor and to assess the success of stories defined by the LL the 'LL trial plans' will offer the overview of the operation by each LL during processing the tasks 3.2, 3.3 and 3.4.

The outcome of the assessment will also be documented in deliverable D3.2. During processing the tasks 3.2, 3.3 and 3.4 the 'Progress matrix' will be analyzed by the WP3 core trial team (LL leaders and WP3 task leader) on necessary refinements for the execution of the trials.

# 3.3 EVALUATION AND CENTRAL DATA COLLECTION

The evaluation aims to assess the impact of 5G-LOGINNOV on port operations (T3.5) and on the society, economy, and environment (T3.6), based on the data collected by the tools developed in the context of the project (T2.2). In the end, 5G-LOGINNOV will demonstrate a set of use cases (UC) within the three Living Labs (LLs) and the evaluation will assess the impact.

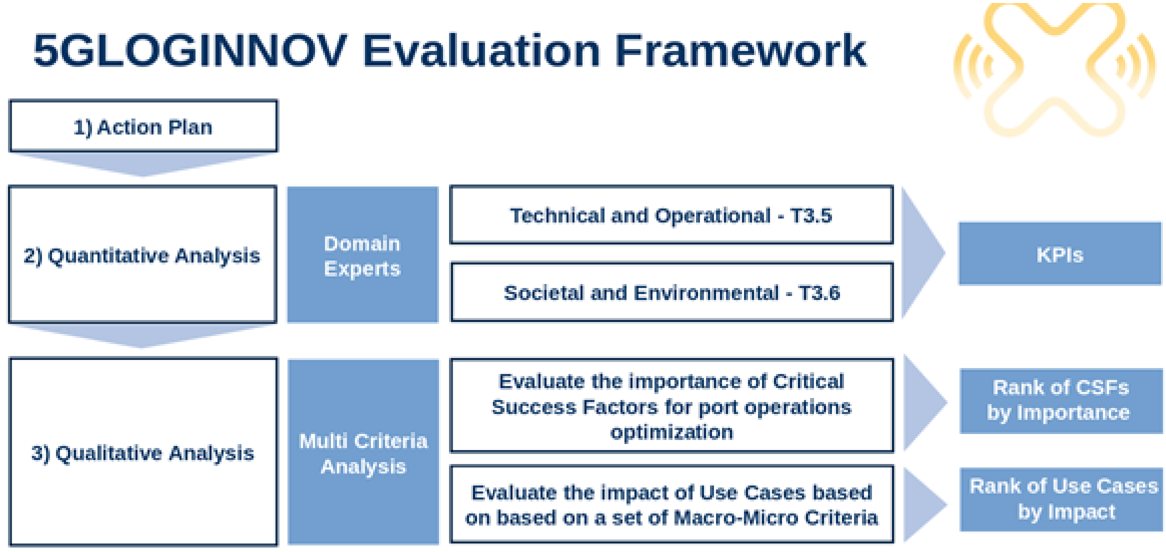



*Figure 2 5G LOGINNOV evaluation framework, authors' elaboration*

In general, the evaluation methodology of 5G-LOGINNOV consists of the following components:

1. An Action Plan to assist step by step the LL leaders and the project partners in the evaluation process.
2. A quantitative analysis, which consists of a set of KPIs that are measured based on data collected during the UCs demonstration. The objective of the indicators is to measure the impact of the UCs on:
    - Technical and operational aspects (T3.5).
    - Societal and environmental aspects (T3.6).
3. A qualitative analysis that aims to:
    - Evaluate the most important Critical Success Factors (CSF) for port operations optimization (T1.4).
    - Evaluate the impact of 5G-LOGINNOV UC according to a set of Macro and Micro-Criteria (T1.4).

The KPIs selected and specified in D1.4 by each LL rely on the capability of measuring the impact of each UC and the possibility to calculate them.
Within the storyboards the relation to the relevant KPIs and the data to be collected during the performance for the evaluation is described.
With reference to the data collection, the requirements of the tool for the data collection had to be defined. It was agreed that some data needs to be collected prior to the implementation of the 5G-LOGINNOV UC to assess the baseline scenario and to quantify the "before" situation.
The data collection process is based on the data management for 5G-LOGINNOV.

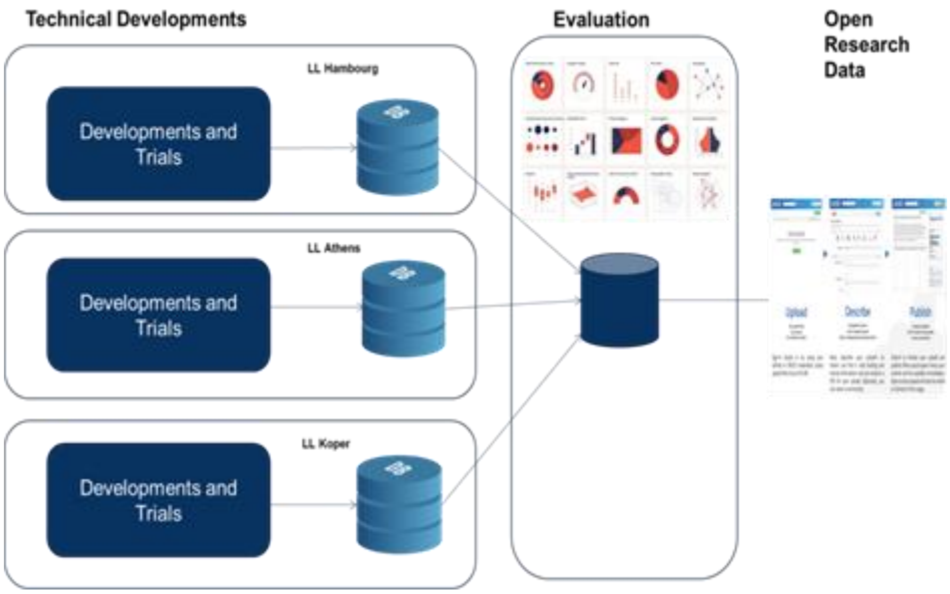



*Figure 3 5G LOGINNOV data management process*

The overall approach of D2.2 ‘Data collection and evaluation procedures’ is still under development during the time of writing the present deliverable, but the data collection principles are already defined. These principles focus on:

1. The LL are responsible for collecting KPI relevant data.
2. The LL will decide whether a preliminary calculation of data by the LL is needed.
3. The LL will provide all relevant data to the central data collection tool.
4. The LL will add meta data within agreed data schemes to the collected/calculated LL data (Figure 4).
5. All data are foreseen for the evaluation processes within 5G-LOGINNOV and ORDP.

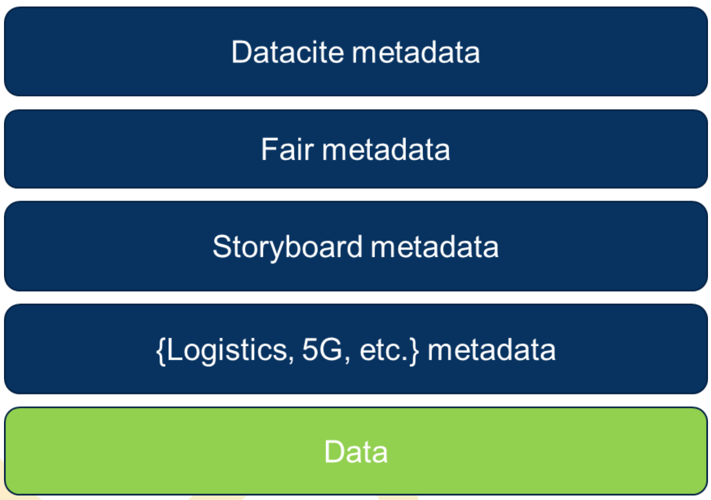



*Figure 4 5G LOGINNOV common evaluation data model*

Below the most relevant scenario on data provisioning is visualised.

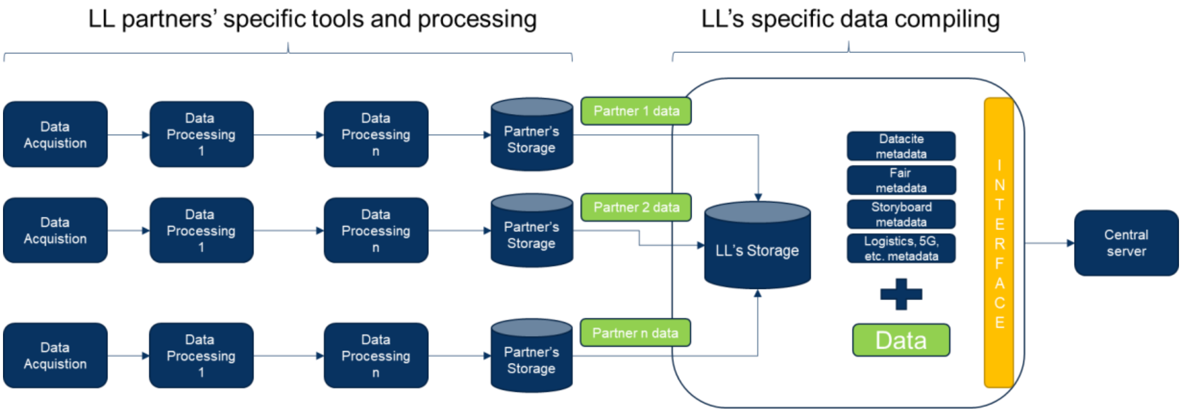



*Figure 5 5G LOGINNOV data provisioning process to the central data collection tool*

The central data collection tools or central server will primarily make the collected evaluation data available to the 5G-LOGINNOV tasks that will conduct the evaluation (T3.5 and T3.6). Additionally, the tool will help in publishing some of the collected datasets under the frame of ORDP1 in which 5G-LOGINNOV is participating.

[1] https://data.europa.eu/data/datasets/open-research-data-the-uptake-of-the-pilot-in-the-first-calls-of-horizon-2020?locale=en

# 4 LL TRIAL STORYBOARDS

In the following sub-chapters, the storyboards are detailed per LL and UC, according to the plans of each LL. Deployment, testing and execution of the demonstrations is taking place in the LL according to their specific planning.
As the procedures and the involved stakeholders vary significantly between the different LL, there is no fully standardized template for the storyboard description, but some requested information for each story is mandatory. Consequently, the LL are free to describe the procedures in the way that they deemed more appropriate according to the specificities of their LL.

Due the above-mentioned aspects for the template a storyboard is defined as such:

| | | |
|---|---|---|
| **Storyboard ID** | Numeric identifier for each LL for the storyboard: e.g. LL_Athens_Story_#1 | |
| **Title** | Name of the storyboard | |
| **UC** | List of relevant UC for the storyboard | |
| **KPIs** | List of the related KPI(s) for the storyboard<br>e.g., A-KPI-7 … | |
| **Baseline data** | Describe the approach to collect baseline data (Level KPI), make a clear distinction to direct or indirect related KPIs, refer to literature where applicable, e.g. since the size (number of devices) used for evaluation will not be demonstrated | |
| **Operational data** | Describe the approach to collect operational data (Level KPI) | |
| **Evaluation data** | Describe the approach to provide data for evaluation (Level KPI) | |
| **Action/sub UC / step** | **Description** | **Illustration** |
| **Step 1: install/download/prepare…** | All needed information on:<br>• The organizational 'setup': e.g., Vehicles, infrastructure, participants etc.<br>• The technical setup to process the storyboard with regards to WP2 architecture and the overall technical bracket related to 5G technologies<br>• Optional information about 'story' and 'setup' e.g. diagrams, maps, pictures etc.<br>• e.g. the user will activate, will start, will download, store, etc.<br><br>The description should cover<br>• the 'story' and the description of the needed 'setup': e.g., vehicles, infrastructure, other participants etc.<br>• the expected results to be achieved with a 'story' | Screenshots, diagrams etc. |

*Table 4: Storyboards objects: Grid Template*

# 4.1 ATHENS
# LL_ATHENS_STORYBOARD_#1

| | |
|---|---|
| **Storyboard ID** | LL_Athens_Story_#1 |
| **Title** | 5G-LOGINNOV 5G-NSA network (Release 15) at Piraeus Container Terminal (PCT) # UC2, UC3, UC4, UC5, UC7 |
| **KPIs** | A-KPI11: User experienced data rate<br>A-KPI21: Area traffic capacity<br>A-KPI22: Bandwidth<br>A-KPI23: Connection density<br>A-KPI24: Reliability<br>A-KPI25: end-to-end latency<br>A-KPI26: one-way latency |
| **Operational data** | The operational data of the 5G NSA network (Release 15) that will be deployed in Athens LL will be measured at the deployment phase and tested to validate the operation of the 5G system for all 5G related KPIs. It is intended to identify the limitations and capabilities of the deployed network, that will support the rollout of all use cases that will be explained in detail in the following sections and storyboards. No baseline data are foreseen prior to the establishment of the 5G network at Piraeus port. Vodafone MNO will provide the tools for aggregating all relevant operational data, among all participating devices at the Greek pilot trials to illustrate the performance of the 5G network based on the selected KPIs. |
| **Evaluation data** | The evaluation will come from multiple sources including 5G base station related metrics for A-KPI21 [*Area traffic capacity*], A-KPI22 [*Bandwidth*], A-KPI23 [*Connection density*], A-KPI24 [*Reliability*], as well as from the end-device (5G-UEs, 5G-IoT devices, 5G telematics device on trucks) experienced measurements related to A-KPI11 [*User experienced data rate*], A-KPI25 [*end-to-end latency*], A-KPI26 [one-way latency]. The obtained operational measurements will be handed over to the data collection tool described in D2.2. |
| **Action/sub UC / step** | **Description** |
| **5G end devices for data collection** | Figure 6 illustrates a summary of the 5G end device terminals that will be used for data collection and evaluating the 5G KPIs, including the 5G IoT devices that will be distributed to several areas within the port premises to support the operation of UC4 and UC5 (c.f. Table 9 and Table 10), 5G telematics devices installed on trucks for support in yard truck operations as well as 5G UEs/modems from external trucks in-coming to the port of Piraeus. |

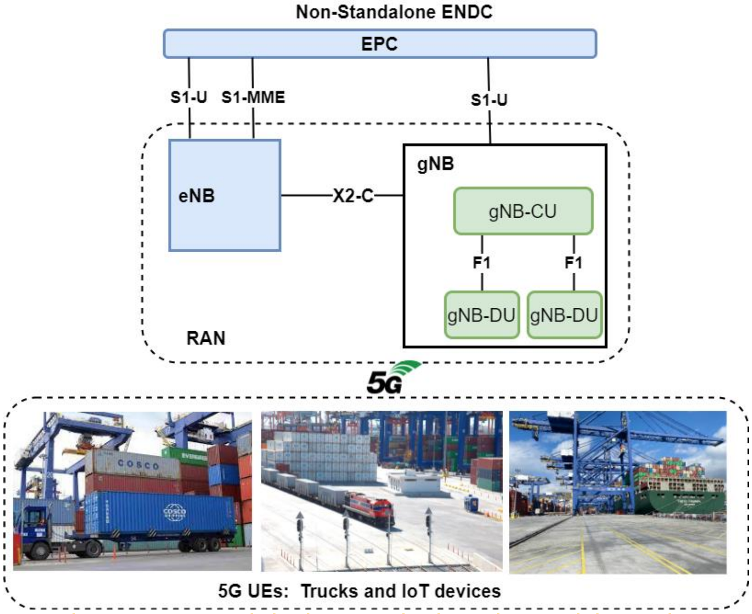
<table>
<tr><td></td><td colspan="2">

Figure 6: 5G end device terminals, Athens Living Lab.</td></tr>
<tr><td>5G technology summary</td><td>Figure 7 provides a summary of the 5G technologies to be deployed in the Athens LL as described in D1.2.</td><td>
<table>
<tr><td>Radio Access Network</td><td>LTE and NR</td></tr>
<tr><td>Number of cell sites</td><td>2- Cell Sites</td></tr>
<tr><td>Frequencies used</td><td>3.6 GHz</td></tr>
<tr><td>Frequency Bandwidth</td><td>3,6 GHz 140 MHz</td></tr>
<tr><td>Mobile Core</td><td>3GPP Rel.15</td></tr>
<tr><td>Virtualised infrastructure</td><td>Yes, CUPS</td></tr>
<tr><td>MEC</td><td>On roadmap 2023</td></tr>
<tr><td>NFV</td><td>OpenSource MANO</td></tr>
<tr><td>eMBB</td><td>Yes, Rel.15</td></tr>
<tr><td>Network Slicing</td><td>On roadmap 2023</td></tr>
<tr><td>mMTC</td><td>NB-IoT Rel.13</td></tr>
</table>
Figure 7: 5G technology summary, Athens Living Lab.</td></tr>
</table>

Table 5: LL_Athens_Storyboard_#1

# LL_ATHENS_STORYBOARD_#2

| | |
|---|---|
| **Storyboard ID** | LL_Athens_Story_#2 |
| **Title** | 5G-LOGINNOV Device Management Platform Ecosystem<br># UC2 |
| **KPIs** | A-KPI5:  Percent of Empty Containers Runs<br>A-KPI6:  Mean time of container job<br>A-KPI7: Time needed the device to open a network connection<br>A-KPI25:  End-to-end Latency<br>A-KPI1: CO2 Emissions<br>A-KPI2: Fuel Consumption<br>A-KPI26: One-Way Latency |
| **Baseline data** | This UC leverages existing live infrastructure with thousands of live vehicles. The data will be filtered to cover the area of the port and selected routes (through anonymization) will be selected as the baseline data. Data regarding traffic will be provided by Vodafone Innovus Fleet Management data sources. The data reside in the platform and are available, after authorization, for use. On top of that, the qMon system provided by ININ will be used to collect network related data in the port area. This information will be used in the KPIs but also as baseline during operational usage. |
| **Operational data** | Several trucks operating in and outside the port will be given 5G (and 4G) enabled smartphones. The application is custom built to meet the use case requirements and data collection needs. The Fleet Management Platform offers a management UI that manages devices and configuration, displays a live map, routes, traffic and all received information. During operational phase the driver will login to the application and data collection will begin automatically. During configurable intervals the application will record the current location and will post it to the Fleet Management Platform. The platform will log all relative information and broadcast truck locations to all trucks participating to the process. |
| **Evaluation data** | Data generated by the devices stored at the platform will be prepared / curated and sent to the evaluation tool. The KPIs will be explored with collected data including baseline and operational data. |
| **Action/sub UC / step** | **Description** |

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<td>Actions</td>
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This UC is relatively straight forward as it is based on an existing platform with mature flows and processes.<br>
Once the application is developed and tested the following procedure is followed so that the related users will use the application. The steps needed are as follows:
<ul>
<li>A PCT manager will be given an account that can create users. The users of the application are the truck drivers. This task is performed at the web UI.</li>
</ul>

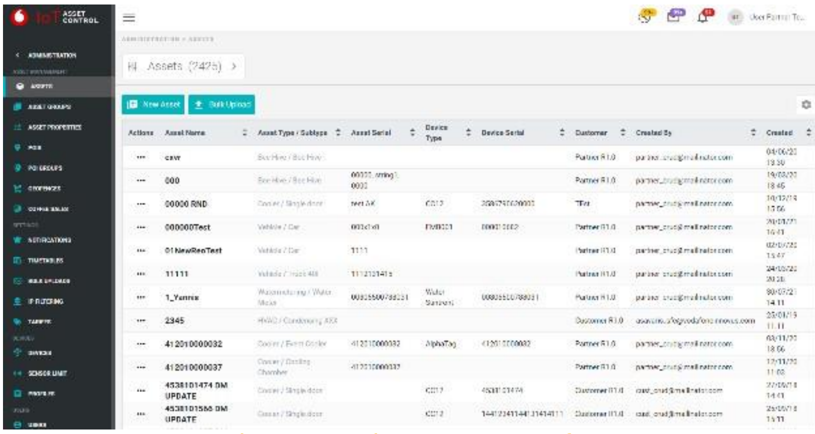


Figure 8: Main management form

<ul>
<li>Once the account is created the users can download the application and login with the provided credentials.</li>
<li>The application consists of a main map that depicts the current user location (truck) and the location of the other trucks. The map is refreshed every 1 second.</li>
</ul>

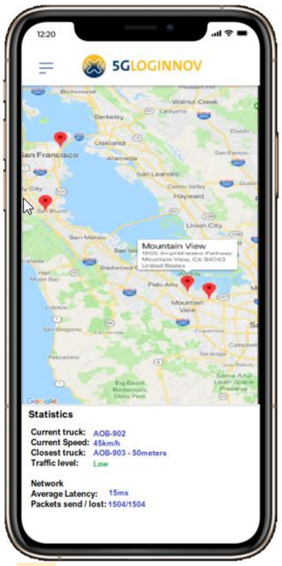


Figure 9: Truck driver GUI

<ul>
<li>All collected data are available at the platform at any given moment. The manager can use the UI to gain insights.</li>
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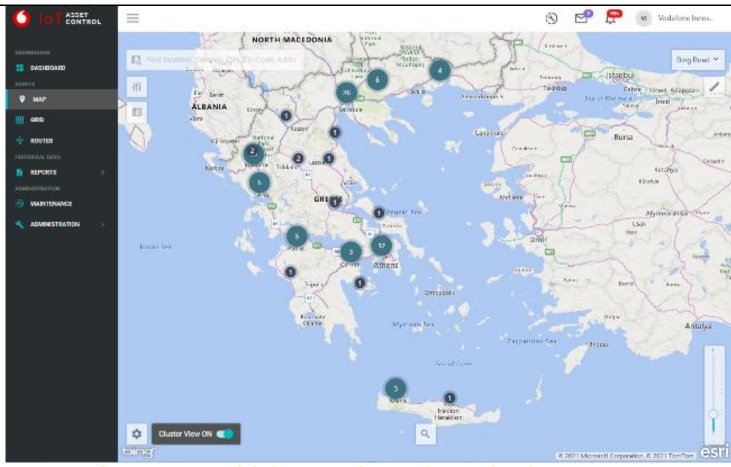


Figure 10 Vehicle map based monitoring

- Via the UI the users can view location data and network related data (as captured by the mobile application).

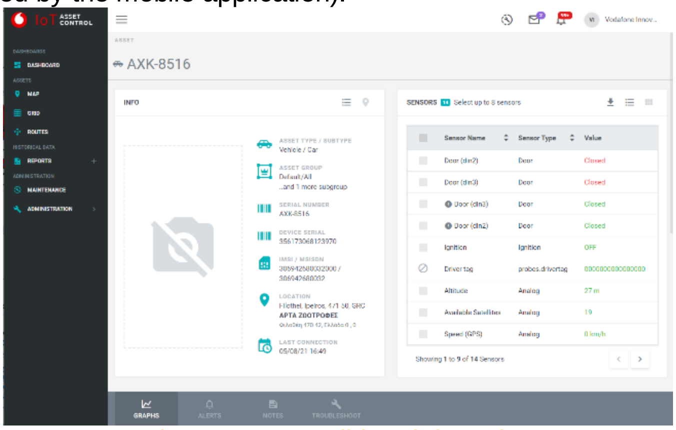


Figure 11 Consolidated data view

- All vehicle routes are displayed and the most relevant to the KPIs will be statistically selected. The platform offers a UI for visual confirmation.

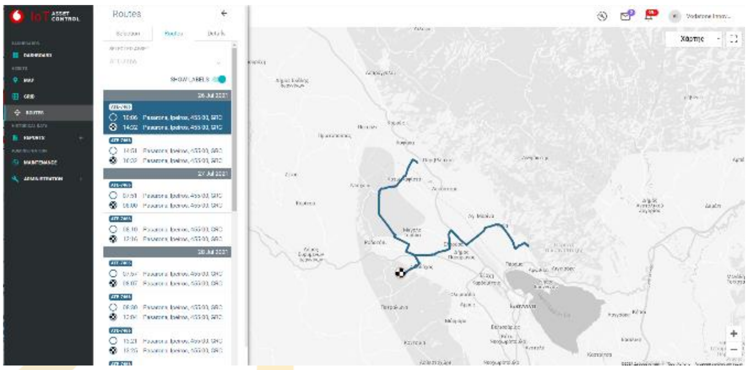


Figure 12 Vehicle routes view

Data are stored and structured along with the needs of the project for KPI assessment purposes. The data can be extracted in CSV format, human readable aggregated reports and custom export for the project needs.

Table 6: LL_Athens_Storyboard_#2

# LL_ATHENS_STORYBOARD_#3

| | |
|---|---|
| **Storyboard ID** | LL_Athens_Story_#3 |
| **Title** | 5G-LOGINNOV Optimal selection of yard trucks<br># UC3 |
| **KPIs** | A-KPI1: $CO_2$ emissions<br>A-KPI2: Fuel consumption<br>A-KPI3: Truck travel distance<br>A-KPI4: Assets Idling<br>A-KPI25: end-to-end latency<br>A-KPI26: one-way-latency |
| **Baseline data** | In Athens LL each yard truck (about 170-yard trucks in total) is equipped with a telematics device. Particularly, the device is connected to various on-truck data sensors e.g., CAN-Bus, localization, container presence (and other custom) sensors. Currently, the telematics device on each truck is connected via a 4G modem to PCT's backend system (i.e., connected to PCT's real-time Truck Monitoring System, TMS), where telemetry data are collected from the truck fleet for storage, monitoring, further processing and business planning. The telemetry data aggregated by the fleet of current 4G connected yard trucks will be used as baseline data and KPI evaluation, particularly for A-KPI1 [*$CO_2$ Emissions*], A-KPI2 [*Fuel Consumption*] and A-KPI3 [*Truck Travel Distance*]. A-KPI2 and A-KPI3 data are directly accessible from CAN-Bus, whereas A-KPI1 ($CO_2$ emissions) will be calculated based on travel distance and fuel consumption (available through the CAN-Bus data) of each truck. Statistics (average) values from the fleet of 4G connected trucks operation (i.e., prior to 5G-LOGINNOV) will be calculated at TMS and used as baseline data.<br>The data necessary for the calculation of A-KPI4 [*Assets Idling*] incude timestamped localization data obtained from the GPS receiver of the telematics device and container presence sensor data indicating whether the truck is loaded (or not) with a container. The data will indicate whether the subject yard truck is active (participating in port operations), or idle (not in use). Baseline data will be collected from the current 4G truck fleet operations. |
| **Operational data** | The procedure for collecting the operational/trial data will be identical to the collection/calculation of the baseline data (i.e., through the telematics devices and PCT's TMS), where the trucks equipped with 5G technology will participate to the 5G-LOGINNOV trials compared to the 4G trucks, in typical daily port operations, i.e., assignment of container jobs for the horizontal movement of cargo containers within the port area, in the time period of WP3 trials. Enhanced localization services and 5G low latency communications will enable the live tacking of 5G trucks, where the accumulated telemetry data from the fleet of 5G-LOGINNOV vehicles (in daily loading/unloading operations of vessels) will be exploited to optimize the efficiency of the operation and to collect the operational data. |
| **Evaluation data** | It is intended to hand-over the deviation of operational and baseline data for A-KPI1, A-KPI2, A-KPI3, and A-KPI4 to the evaluation tool. For the latency measurements of the 5G telematics device on yard trucks detailed logs from Vodafone (Greek pilot's MNO) will be provided (A-KPI25, A-KPI26). |
| **Action/sub UC / step** | **Description** |
| **TMS dashboard system at PCT** | Figure 13 shows part of the visualization tool of the Truck Monitoring System (TMS) at PCT, where the current vessels are illustrated at Piers II and III, along with the movement/operation of 4G connected yard trucks. Different coloured pins represent different speeds of yard tucks (slow, normal, fast), where also the arrow shape of the truck pin indicates its moving direction. Finally, black dots on the yard truck pin indicate that the truck is carrying one container (one black dot) two containers (two black dots) or no containers, derived from container presence sensors installed on each truck. A similar dashboard will be illustrated at the trial phase of UC3 in WP3, |

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where the pilot trucks will be equipped with 5G modems connected to the on-board telematics device and sensors, utilizing the 5G NSA network at PCT premises and enhanced localization services. Real time telemetry data aggregated over the low latency 5G network from the fleet of 5G connected yard trucks (i.e., location, moving direction, speed and number of containers carried) will be exploited by the job allocation algorithm, to optimally assign container jobs to yard trucks and optimize yard truck traffic at PCT premises for the horizontal movement of containers between stacking areas and loading/unloading areas for vessels and rail.


*Figure 13 : PCT's real-time Truck Monitoring System (TMS) dashboard, Athens LL*

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**Optimal container job allocation to 5G connected yard trucks**

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In each yard truck there is a Terminal Operating System (TOS) relaying information to yard truck drivers regarding the QC crane jobs as assigned by the job allocation algorithm that resides at PCT's backend system, indicating also the current freight carried by the truck as well as a subset of CAN-Bus data. Figure 14 is a snapshot of an operation as it appears to a driver's TOS (data regarding the ID of the yard truck and driver are blurred).

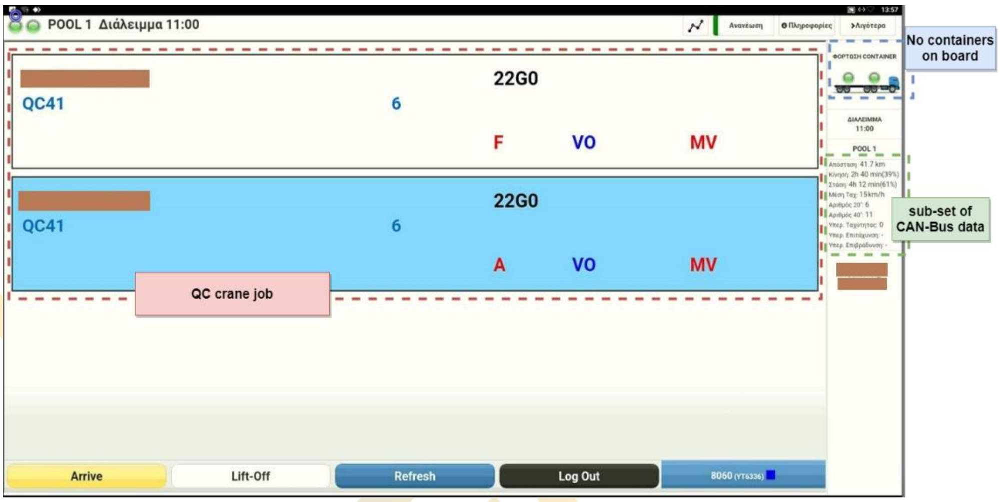


*Figure 14 : Terminal Operating System (TOS) on yard trucks, Athens Living Lab*

Figure 15 (left) shows the TOS installed in the cabin of trucks which illustrates the data explained in Figure 14, as well as an indicative fleet of yard trucks, subset of which will be used for the trials (right), exploiting the 5G NSA network and enhanced localization services in daily port operations to coordinate and allocate open jobs to yard trucks in real time, for the horizontal movement of containers within the port premises.

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| | |
|---|---|
| |  <br>Figure 15 : PCT yard trucks pool and TOS terminal, Athens Living Lab. |
| **Data Collection** | Telemetry data from the fleet of 5G connected yard trucks in daily port operations for UC3 in the timespan of WP3 trials will be aggregated at PCT's management platform, where the data collection tool (D2.2) will be interconnected and receive a subset of those data to proceed in the evaluation of the UC and the discussed KPIs. |

Table 7: LL_Athens_Storyboard_#3

# LL_ATHENS_STORYBOARD_#4

An NFV-MANO platform will be developed at PCT premises, targeting service orchestration and life-cycle management to distributed 5G-IoT devices, employing computer vision techniques (composed as VNF functions) for detecting human presence in risk/prohibited areas of UC4, and for the detection of cargo container seals at the loading/unloading phase of vessels in UC5. The envisioned service will enable far edge computing services in port operations, tailored to the aforementioned UC needs, where the envisioned 5G-IoT devices will compose the pool of NFVI compute nodes of the orchestrator.

| **Storyboard ID** | LL_Athens_Story_#4 |
|---|---|
| **Title** | 5G-LOGINNOV NFV-MANO enabled video analytics platform.<br># UC4, UC5 |
| **KPIs** | A-KPI12: Deployment time (addressed to UC4 and UC5 for the VNF service instantiation). |
| **Operational data** | The discussed service follows the NFV-MANO paradigm for VNF service orchestration to distributed 5G-IoT devices and implements the management platform for UC4 and UC5 (instantiation, monitoring, logging, termination, etc.). Hence, for both UC the deployment time of the VNF service will be measured, i.e., elapsed time from the moment the deployment is started via the MANO orchestrator until the system/service is ready to use, A-KPI12 [*Deployment Time*], which will potentially be compared against similar approaches based on the available literature. Thus, the operational data for this story will be obtained through the MANO platform deployed at the LL premises where the VNF deployment time will be measured and logged by the orchestrator. |
| **Evaluation data** | It is intended to hand-over the logged data for the service deployment time at the evaluation tool (D2.2). |
| **Action/sub UC / step** | **Description** |
| **MANO platform components overview** | To facilitate the 5G-LOGINNOV MANO platform a set of services and tools will be deployed at PCT premises to enable the orchestration of the analytics services and VNFs (software applications that deliver network and service functions) at the distributed 5G-IoT devices. Particularly, the MANO platform will be based on open-source solutions and industry proven technologies ensuring ease of transferability to other ports/facilities and their operations. The proposed solution will be based on OpenSource MANO (OSM) and Openstack controllers, deployed as two interconnected virtual machines at Piraeus port datacentre. The IoT devices, i.e., the NFVI pool that will participate in the trials for UC4 and UC5, will be interconnected to the Virtual Infrastructure Manager (VIM), which will be composed of a subset of services of Openstack (e.g., NOVA, NEUTRON, KEYSTONE, PLACEMENT, HORIZON, etc.). Appointed PCT personnel will be able to interface with the OSM UI, select from the network service (NS) catalogue the VNFs (prepared and tested at the ICCS 5G testbed) and 5G-IoT devices, targeting use case UC4 or UC5 (Figure 16). |

| | |
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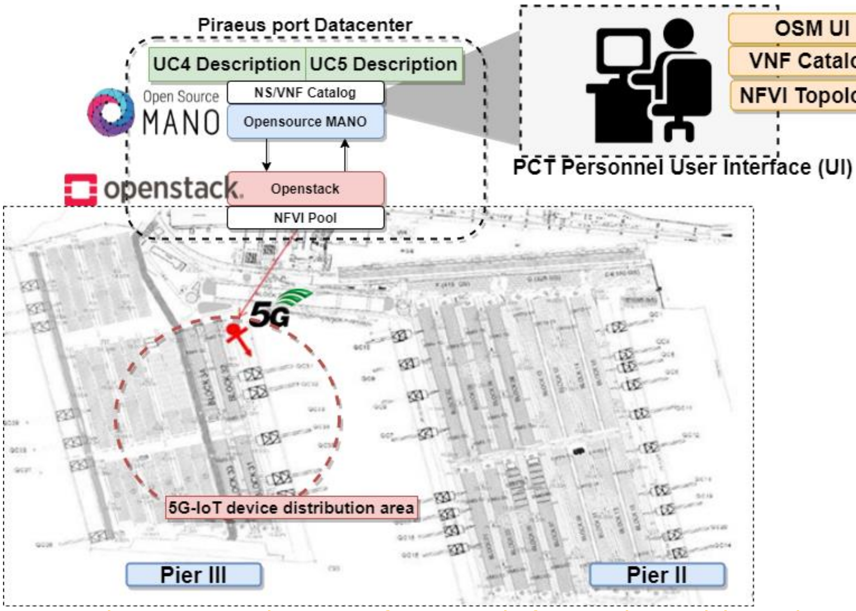
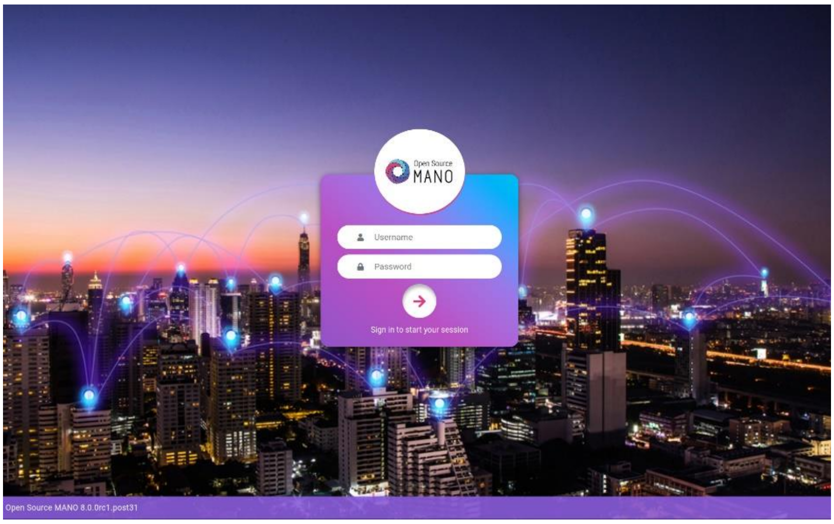
| | <br><br>*Figure 16: Deployment of MANO Platform, Athens Living Lab.* |
| **MANO UI Access (OSM & Openstack)** | Appointed PCT personnel will interface with the OSM UI to gain access to the NS and VNF catalogue, and manage the orchestration for UC4 and UC5, where the default OSM UI access will be used (Figure 17).<br><br><br>*Figure 17: OSM log in UI, Athens Living Lab.*<br>After successful login the appointed personnel will be able to select the NS for the respective UC that in turn have the configuration from the ICCS prepared VNFs to support all relevant components for UC4 and UC5 video analytics services. Figure 18 shows the dashboard that will be available, illustrating the relevant parts for network service packages, VNF packages, VIM accounts (the Openstack will be used), as well as an overview of the active services and the total packages available at the MANO platform of 5G-LOGINNOV. |

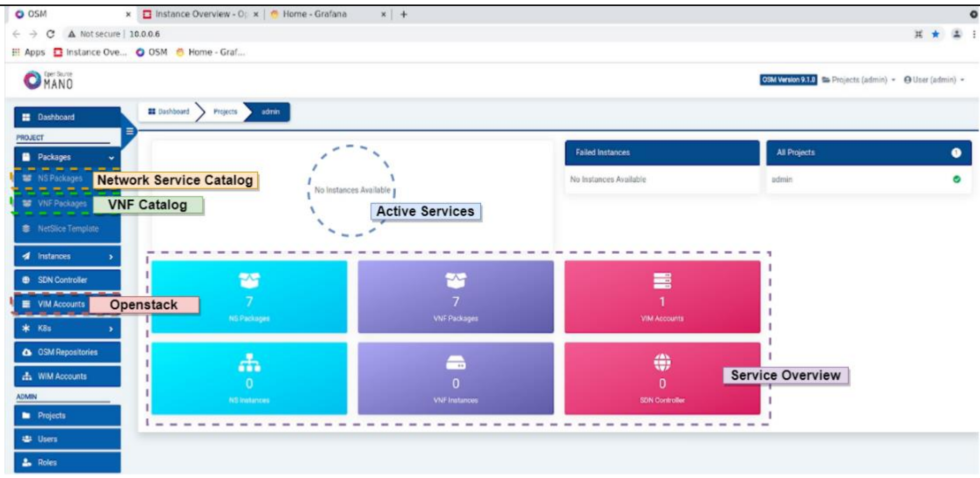



Figure 18: MANO (OSM) dashboard, Athens Living Lab.

Additionally, to OSM UI, the Openstack HORIZON service (dashboard) will be available for information regarding the NFVI nodes (statistics on compute, networking, storage, traffic, etc.) and their utilization in UC4 and UC5. Similar to OSM UI, the Horizon UI is illustrated in Figure 19 where an overview of the active VNFs and their utilized resources will be displayed (e.g., VCPUs, RAM, IPs, etc.), as well as the network topology for the control interface towards the NFVI devices.

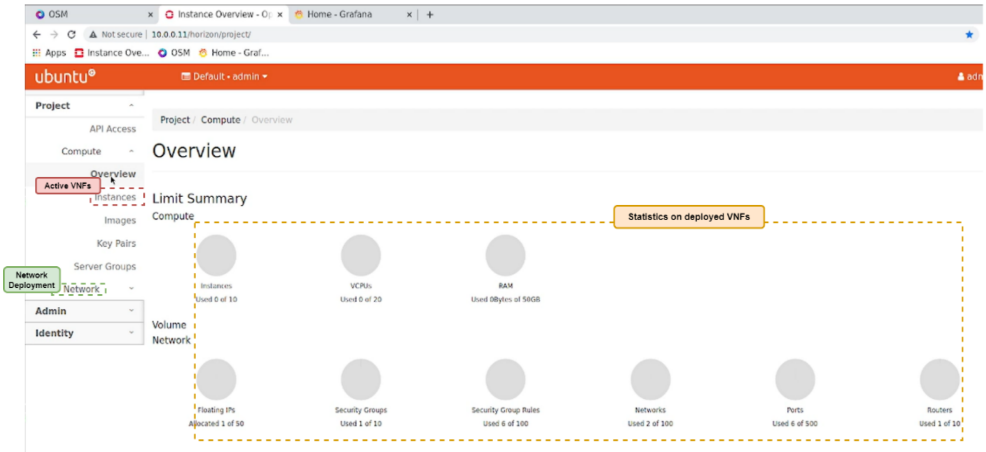



Figure 19: Openstack UI, Athens Living Lab.

Overall, an overview of the architecture layout for the 5G NFV-MANO video analytics services in both cases (UC4, UC5) is depicted in Figure 20 (for more details please see deliverable D1.3), and will be further explained in the following storyboards, respectively.

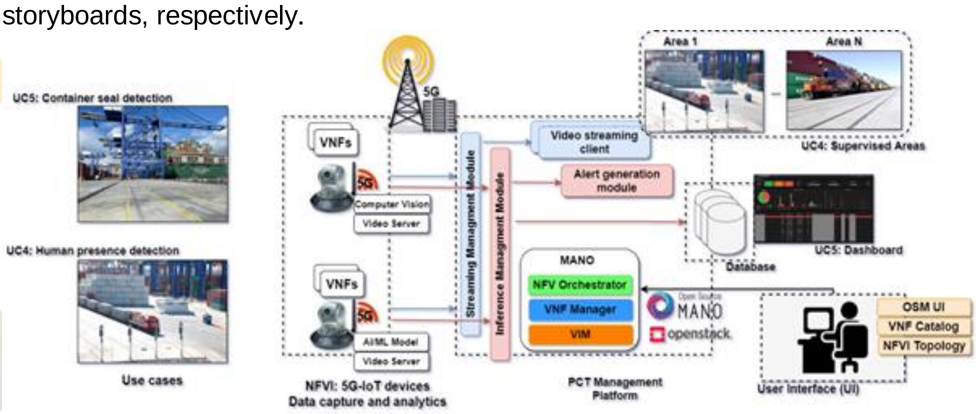



Figure 20: NFV-MANO enabled video analytics services, Athens Living Lab.

| | |
|---|---|
| **Data Collection** | The data collection procedure for A-KPI12 [Deployment Time] will be recorded at the virtual machine hosting the OSM controller and delivered to the data collection tool that will be detailed in D2.2, as mentioned in the following section. The envisioned file will refer to the elapsed time from the moment the deployment is started via the MANO orchestrator until the system/service is ready to use for both UC4 and UC5. |

*Table 8: LL_Athens_Storyboard_#4*

# LL_ATHENS_STORYBOARD_#5

| Storyboard ID | LL_Athens_Story_#5 |
| --- | --- |
| **Title** | 5G-LOGINNIOV optimal surveillance cameras and video analytics (human presence detection)<br># UC4 |
| **KPIs** | A-KPI8: Human resource optimization (person-hours)<br>A-KPI9: Model inference time<br>A-KPI10: Model accuracy/reliability<br>A-KPI11: User experienced data rate<br>A-KPI12: Deployment time (NFV-MANO required time for service activation)<br>A-KPI26: one-way latency |
| **Baseline data** | The baseline data for this UC will come from multiple sources. Particularly, to evaluate A-KPI8 [Human resource optimization] the baseline data will be acquired from PCT's personnel management plan. Currently appointed safety/security patrols are distributed to various areas, at specified intervals/shifts, to prevent the risk for serious bodily injuries, which for this KPI will be interpreted as person hours allocated for this service. Additionally, this UC will introduce machine learning techniques for automatically detecting human presence in such areas, hence baseline data with respect to A-KPI9 [Model inference time] and A-KPI10 [Model Accuracy/Reliability] need to be collected for performance evaluation. To this end, a literature review of current state-of-the-art machine learning algorithms for detecting human presence will derive the base line data for both; the time required to process the input of video stream(s) and infer the presence/absence of people (A-KPI9), and the achieved accuracy/reliability of the model with respect to established state-of-the-art approaches for this task (A-KPI10).<br>Voluminous video streams will be transmitted to PCT's backend system from the distributed 5G-IoT devices for further inspection and security. 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 are needed to ensure the successful operation of the envisioned UC which will be measured by the 5G-IoT device,A-KPI11 [User experienced data rate]. In case of positive inference, i.e., person detected, the IoT device will exploit the low latency transmissions of PCT's 5G network to trigger alerts to PCT's management platform and facilitate the necessary actions to prevent any incident, A-KPI25 [End-to-End Latency] and A-KPI26 [One-way Latency]. Finally, as the discussed service follows the NFV-MANO paradigm, the deployment time of the service, i.e., elapsed time from the moment the deployment is started via the MANO orchestrator until the system is ready to use, needs to be investigated A-KPI12 [Deployment Time], as explained in Table 8. |
| **Operational data** | The operational data for this UC will be derived from PCT's updated personnel management plan showing the difference in the involvement of safety/security patrols considering the duration/frequency of the patrol shifts (in terms of person-hours spent), after the service is available at the LL premises. The remaining technical and 5G KPIs will be collected directly from the participating 5G-IoT devices, with respect to the uplink traffic volumes transmitted, and latency measurements. Similarly, the inference time will be logged and transmitted to PCT's backend system, for each positive inference event (i.e., human presence detected). For the achieved accuracy of the AI/ML solution, annotated snapshots will be stored (indicating true/false positives/negatives), enabling the (manual) evaluation of the algorithm's accuracy. Finally, through the MANO platform deployed at the LL premises, the VNF deployment time will be measured and logged by the service orchestrator. |
| **Evaluation data** | It is intended to hand-over the deviation of operational and baseline data (A-KPI8) to the evaluation tool. For the technical and 5G KPIs, the log files recorded by the 5G-IoT device(s) and MANO platform will be sent to the data collection tool, potentially with some processing to reduce the volume of transferred data. |

| Action/sub UC / step | Description |
|---|---|
| **Selection of 5G-IoT device and deployment locations** | A prototype of the 5G-LOGINNOV IoT device is illustrated in Figure 21. Please note that the components shown in the figure are the in-lab testing equipment that are used at the ICCS 5G testbed. The camera and radio access modules will be replaced at the trials with the 5G-LOGINNOV cameras and radio interface that are described below.<br><br>*Figure 21: 5G-IoT device components, Athens Living Lab.*<br><br>The three main components of the 5G-IoT device are:<br>• A UHD camera (Dahua IPC-HFW3841T-ZAS) for the input video streams that will be processed at the IoT device locally, enabling far-edge computing services in port operations.<br>• A compute node (Jetson AGX Xavier) connected to the camera via a Gigabit Ethernet connection, that will process the video stream, host the VNFs and the AI/ML logic for human presence detection.<br>• A 5G modem (at least CAT-13) provided by the Greek pilot MNO, Vodafone, also connected to the compute node via a Gigabit Ethernet link, to enable 5G communication of the IoT device at the LL premises, transmitting the inference of the ML model to PCT's backend system as well as voluminous uplink UHD streams for further monitoring and security services.<br>The locations for the deployment of the IoT devices have been selected based on identified risk areas by PCT's personnel, and the deployment site (and thus coverage) of the 5G base station at the LL premises, at Pier III, as indicated in Figure 22. |

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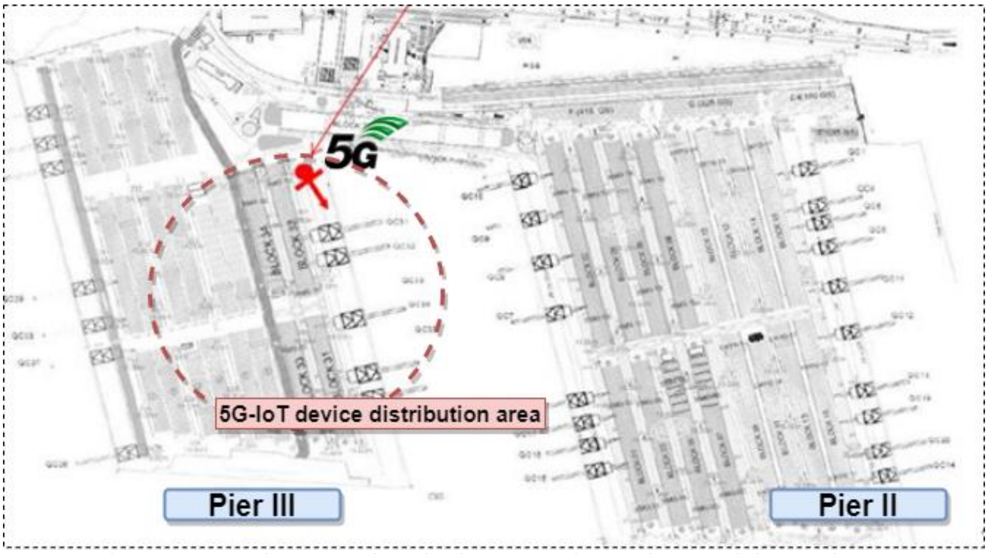
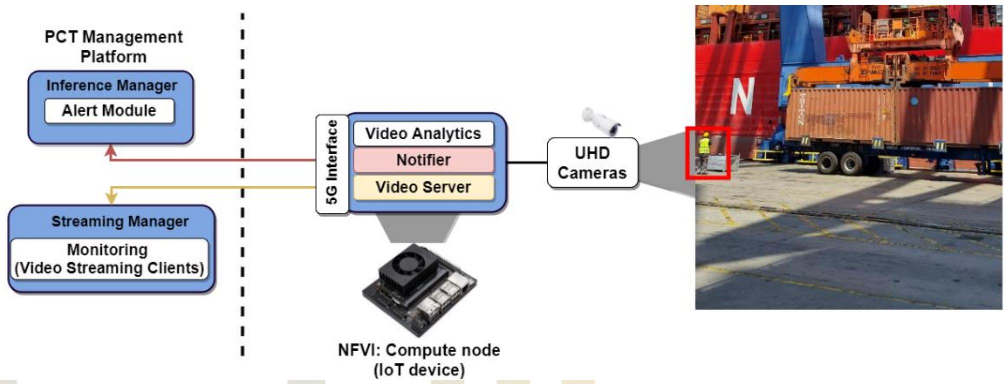
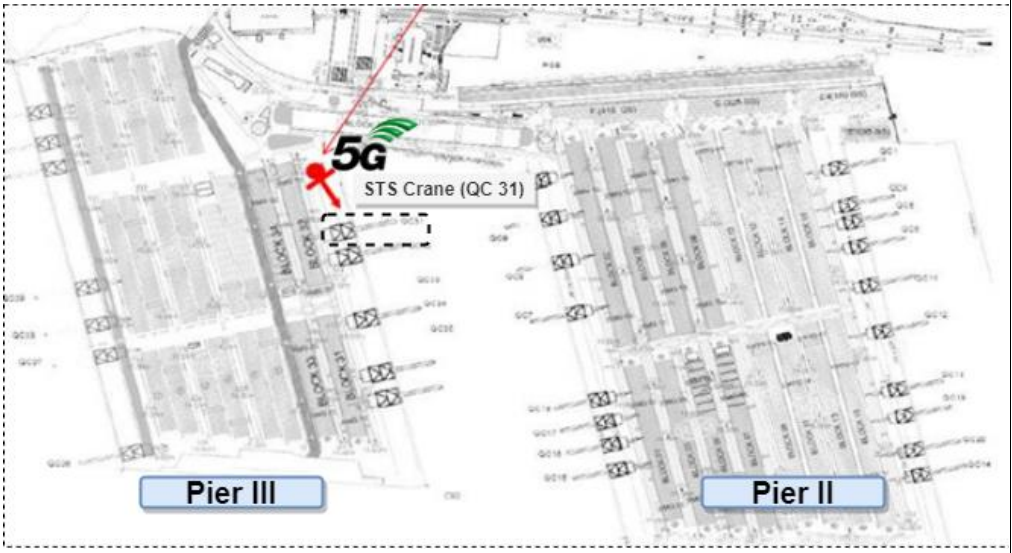
| |   Figure 22: 5G base station deployment site and potential area for UC4. |
| **NFV-MANO enabled far-edge computing service operation for human presence detection.** | UC4 depends on the MANO platform that was explained in Table 8. The envisioned service will enable far-edge computing AI/ML processing at the 5G-IoT device, controlled by the Virtual Infrastructure manager (VIM), i.e., Openstack, for human presence detection in specified risk/private areas. Appointed personnel by PCT will access the OSM UI, and instantiate the service. The user selects the NS Packages list item, where the specific Network Service Description (NSD) for the deployment of UC4 is listed. The NSD file is linked to the appropriate VNFs that describe the resources (e.g. compute, storage, networking), software packages, etc., that need to be enabled at the IoT device for the realization of the UC, and are located at the VNF Packages list item. Both NSD and VNF files will be prepared and tested at the ICCS lab. The aforementioned descriptor files will also include to which 5G-IoT device(s) the service should be instantiated. The procedure is depicted in Figure 18 of Table 8.<br>An illustration of the service including the relevant components is depicted in Figure 23. After the service is instantiated over the MANO platform, the 5G-IoT device will receive the input video stream over the UHD camera for the video analytics tasks of human presence detection. In case of positive event, e.g., person detected, the inference of the ML model is transmitted with low latency to the inference manager at PCT's backend system, generating respective alerts to security shifts at PCT. Additionally, the appointed person will have live access to UHD streams of all 5G-IoT devices by exploiting the uplink capacity of the eMBB service, i.e., a direct video feed of the event(s) transmitted over the 5G network to the video streaming client(s) at PCT streaming manager system.<br>  Figure 23: UC4 service layout, Athens Living Lab. |

| | |
|---|---|
| **Data Collection** | For A-KPI8 [*Human resource optimization*], the deviation between the hours spent for security/surveillance before and after the activation of the service will be handed to the data collection tool. The 5G-IoT devices will also record the inference time, A-KPI9 [*Model inference time*] (i.e., the required time to infer the presence of a person from the input video stream), at each successful event. Both the baseline data (acquired from literature review) and the operational data of the UC will be sent do the tool for evaluation. Similar policy will be followed for A-KPI10 [*Model Accuracy/Reliability*] where annotated images/snapshots will be sent from the 5G-IoT device to PCT's management platform to detect true/false positives/negatives from the acquired operational data, similar to the one depicted in Figure 23. The resulting accuracy will be sent to the data collection tool along with literature/baseline data for performance evaluation. For the 5G KPIs, data can be collected any time by the IoT devices, either through traditional tools, e.g., ping, to log latency measurements (A-KPI25 and A-KPI26), and e.g., iperf to record the user experienced data rate (A-KPI11) over a particular timespan along the UC operation. |

*Table 9: LL_Athens_Storyboard_#5*

# LL_ATHENS_STORYBOARD_#6

| | |
|---|---|
| **Storyboard ID** | LL_Athens_Story_#6 |
| **Title** | 5G-LOGINNOV Automation for Ports: Port Control, Logistics and Remote Automation (Container Seal Detection)<br># UC5 |
| **KPIs** | A-KPI8: Human resource optimization (person-hours)<br>A-KPI11: User experienced data rate<br>A-KPI12: Deployment time (NFV-MANO required time for service activation)<br>A-KPI13: Vessel operation completion time<br>A-KPI14: Model inference time<br>A-KPI15: Model accuracy/reliability |
| **Baseline data** | The baseline data for this use case will come from multiple sources. Particularly, to evaluate A-KPI8 [*Human resource optimization*] the baseline data will be acquired from PCT's personnel management plan. Currently, an appointed employee manually checks for the presence/absence of container seals after the container has been unloaded from the vessel and loaded to a yard truck. The baseline data for this KPI will be interpreted as person hours assigned for the manual container seal check service, prior to the activation of the 5G-LOGINNOV UC that automates this task. In addition, this UC also aims to reduce the vessel stay at the port premises A-KPI13 [*Vessel Operation Completion Time*]. Currently, the assigned employee for the manual seal check requires about 30 seconds per container, i.e., checking for the presence/absence of seals and triggering the next container for unloading from the STS crane, adding a significant amount of wait time for the next container, and thus increasing the vessel stay at Piraeus port. Baseline data will be obtained from PCT's database records of manual seal check operations (and vessel operations completion time) and compared against the automated approach that will be developed (also removing the need for human personnel at an area with high safety risks).<br>Additionally, UC5's detection of container seals solution will be based on computer vision methodologies to infer the presence/absence of seals, hence, similar to LL_Athens_Storyboard_#5, A-KPI14 [*Model inference time*] and A-KPI15 [*Model Accuracy/Reliability*] will be measured. However, unlike the ML approach described in Table 9, for the subject UC, there is no available literature, and thus no baseline data, for this particular computer vision task. Hence, the performance of the algorithm will be measured focusing on the time required to process the input of video stream(s) and infer the presence/absence of cargo container seals (A-KPI14) as well as the inference accuracy (A-KPI15) of the developed model.<br>For further inspection and monitoring of the loading/unloading phase of vessels, authenticated users will be able to activate live video stream(s) from the distributed 5G-IoT device(s), deployed at the respective STS crane, exploiting the eMBB service of 5G to deliver massive uplink video data traffic from the live operation to PCT management platform, A-KPI11 [User experienced data rate]. Finally, as the discussed service follows the NFV-MANO paradigm, the deployment time of the service, i.e., elapsed time from the moment the deployment is started via the MANO orchestrator until the system is ready to use, needs to be investigated A-KPI12 [Deployment Time]. |
| **Operational data** | The operational data for this UC will be derived from PCT's updated personnel management plan, i.e., reduction of hours spent for the container seal check service, as well as records of the updated vessel operation completion time (i.e., time taken for the vessel to be unloaded) after the 5G-LOGINNOV UC is finalized and operational. Additionally, the inference time will be logged and transmitted to PCT's backend system for each inference event (i.e., container seal present/absent). For the achieved accuracy of the computer vision solution, annotated snapshots will be stored (indicating true/false positives/negatives), enabling the (manual) evaluation of the algorithm's accuracy. The remaining |

| | |
|---|---|
| | technical and 5G KPIs will be collected directly from the participating 5G-IoT devices, with respect to the live uplink traffic volumes transmitted, and through the MANO platform deployed at the LL premises, the VNF deployment time will be measured and logged by the service orchestrator. |
| **Evaluation data** | It is intended to hand-over the deviation of operational and baseline data for A-KPI8 and A-KPI13 to the evaluation tool. For the technical and 5G KPIs, the log files recorded by the 5G-IoT device(s) and MANO platform will be sent to the data collection tool, potentially with some processing to reduce the volume of transferred data. |
| **Action/sub UC / step** | **Description** |
| **Selection of 5G-IoT device and deployment locations** | The 5G-IoT device components for UC5 are the same with the IoT device described in Table 9. Briefly, it is composed of a UHD camera (Dahua IPC-HFW3841T-ZAS) for capturing video streams to be processed at the IoT device locally, enabling far-edge computing services in port operations; a compute node (Jetson AGX Xavier) that will process the video stream, host the VNFs, the computer vision components for the container seal detection algorithm and other software packages; a 5G modem (at least CAT-13) provided by the Greek pilot MNO, Vodafone, also connected to the compute node (via a Gigabit ethernet link), to enable 5G communication of the IoT device for transmitting the inference of the computer vision model to PCT's backend system, as well as live UHD streams for further monitoring of the loading/unloading operation of vessels, and security. The quay side crane (QC) 31 will be used for deploying the 5G-IoT device and for the execution of trials, located at Pier III as highlighted in Figure 24.<br><br><br>*Figure 24: STS crane employed for 5G-IoT device deployment and trials execution of UC5.*<br><br>Figure 25 (left) shows an STS crane at Piraeus port, as well as the cockpit terminal at the bottom of the crane (right). |

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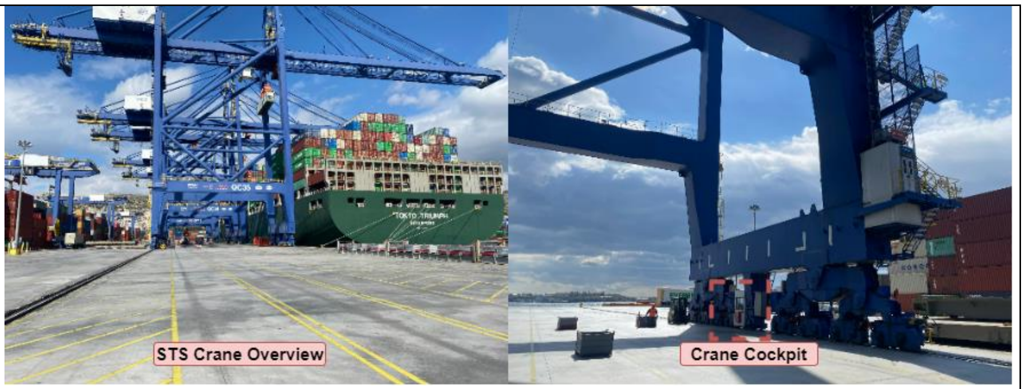
<td>

Figure 25: Overview of STS cranes, Athens Living Lab</td>
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<td>5G-IoT device placement on STS crane; NFV-MANO enabled far-edge computing service operation for container seal detection</td>
<td>All components of the 5G-IoT device will be deployed on the crane. Particularly, camera(s) will be positioned on the horizontal axis of the crane, indicated as camera area in Figure 26. Based on the needs of the UC (i.e., based on the performance of the computer vision algorithm) multiple cameras may be deployed to access video streams from multiple view points and angles. The cameras are powered over ethernet (PoE) and are interconnected via an ethernet Gigabit link to a switch that is placed inside the crane cockpit. The compute node that will process the video streams(s) (Jetson AGX Xavier) will also be inside the cockpit and connected to the switch, ready to receive the video stream(s) from the cameras. Finally, the 5G modem will be attached to the same switch to enable access to massive uplink video streams for service monitoring, and facilitate cellular communication of the IoT device with PCT's Management platform. Yard trucks following the storyboard of Table 7 arrive at the STS crane from two possible lanes, and wait for the unloading of containers from vessels.<br>


Figure 26: Deployment topology of 5G-IoT device on STS crane, UC5, Athens Living Lab.<br><br>
An illustration of the service including the relevant components is depicted in Figure 27. After the service is instantiated through the MANO controller (LL_Athens_Story_#4), the 5G-IoT device will receive the input video stream from the UHD camera for the video analytics task of container seal detection. The inference of the computer vision algorithm (seal present/absent) will be transmitted over the 5G network to PCT's management platform, and interface with existing</td>
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<td>services, e.g., for storage and visualization. Additionally, appointed personnel will have live access to UHD streams the 5G-IoT device by exploiting the 5G mobile broadband connection and receiving a live video feed of loading/unloading operation from potentially multiple cameras.

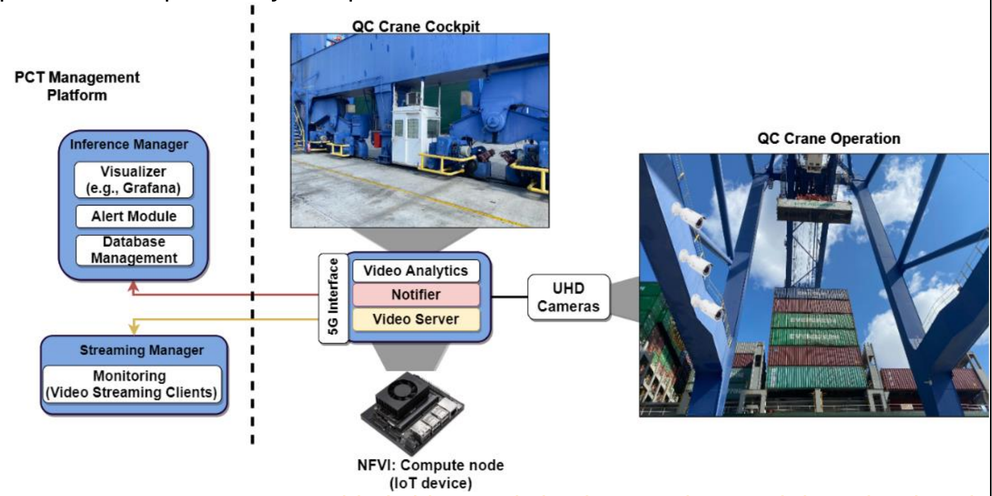


Figure 27: 5G NFV-MANO enabled video analytics for container seal detection (UC5), Athens Living Lab.</td>
</tr>
<tr>
<td>Data Collection</td>
<td>For A-KPI8 [Human resource optimization], the deviation between the hours spent for manual seal check before and after the activation of the service will be handed to the data collection tool. Similarly, the deviation (before and after) of the vessel completion operation time A-KPI13 [Vessel Operation Completion Time] will be sent to the tool. The 5G-IoT devices will also record the inference time, A-KPI14 [Model inference time] (i.e., the required time to infer the presence/absence of container seal from the input video stream), for each container unloaded. Similar to the storyboard of Table 9, for A-KPI15 [Model Accuracy/Reliability], annotated snapshots will be sent from the 5G-IoT device to PCT management platform to (manually) detect true/false positives/negatives from the acquired operational data, similar to the ones depicted in Figure 28. The resulted accuracy will be sent to the data collection tool.


Figure 28: Detected sealed and unsealed container snapshots, Athens Living lab

For the technical (A-KPI12) and 5G KPIs (A-KPI11), data can be collected any time by the MANO platform for the NFV service deployment time and from the logs of the IoT devices through traditional tools, e.g., iperf to record the user experienced data rate over a particular timespan along the use case operation.</td>
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Table 10: LL_Athens_Storyboard_#6

# LL_ATHENS_STORYBOARD_#7

| | |
|---|---|
| **Storyboard ID** | LL_Athens_Story_#7 |
| **Title** | 5G-LOGINNOV Predictive Maintenance<br># UC7 |
| **KPIs** | A-KPI4: Assets idling<br>A-KPI16: Parts in stock<br>A-KPI17: Vehicle breakdowns<br>A-KPI18: Vehicles under maintenance<br>A-KPI19: Vehicles unexpected breakdown<br>A-KPI20: Maintenance costs of vehicles |
| **Baseline data** | Similar to the storyboard of Table 7 the data exploited by the predictive maintenance tool are obtained from the truck CAN-BUS and sent by the telematics device (installed on yard trucks) to the telemetry system of PCT. Maintenance and breakdown data are stored in terms of work orders at PCT's Enterprise Asset Management System (EAMS), and include the description of the breakdown, the part of the truck that was affected and the spare parts used for the repair. The telematics device is directly connected to CAN-Bus data, which are transmitted over 4G and used by the predictive maintenance algorithm at PCT's backend system. The predictive maintenance tool is based on the innovations of the COREALIS project (768994/MG-7.3-2017), and will be evaluated in 5G-LOGINNOV by using 5G technology, over the fleet of 5G connected yard trucks. Historical maintenance and breakdown data including logs of relative spare parts required for maintenance, vehicle (unexpected) breakdowns, vehicles under maintenance and maintenance costs for a period of at least two years will be extracted from PCT's databases and used to define the baseline data for all KPIs targeted by UC7, based on yard trucks operation not equipped with 5G-LOGINNOV technology. |
| **Operational data** | The acquisition of the data (CAN-Bus) that will be used by the predictive maintenance tool will be transmitted by the telematics device installed on yard trucks over 5G to PCT's telemetry system and exploited by the predictive maintenance tool. The proposed tool will capture historical and recent status/operational data for the assets in question, i.e., yard trucks, 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. Hence the operational data of this use case will be based on the prediction accuracy of the AI tool, which will have a direct impact on the KPIs that are selected for this storyboard. Along with telemetry data, maintenance and breakdown data will be extracted on a monthly basis from the EAMS and used to retrain the predictive algorithm. |
| **Evaluation data** | It is expected to hand over the deviation of baseline and operational data to the data collection tool for A-KPI4, A-KPI16, A-KPI17, A-KPI18, A-KPI19, A-KPI20 for the evaluation of UC7. |
| **Action/sub UC / step** | **Description** |
| **Predictive maintenance tool.** | In PCT the AI-based predictive maintenance tool has been implemented for the prediction of possible breakdowns of yard trucks, and to provide a data driven approach for purchasing spare-repair parts. The tool interfaces with the telemetry system TMS and EAMS, exploiting CAN-Bus data and historical maintenance data. Figure 29 depicts the web interface for the predictor tool. The user will be able to select the time period of data that the prediction will be based on as well as the period and the specific spare parts for which the predictions need to be made. Its purpose is to train the developed algorithm based on historical maintenance and breakdown data in order to predict future breakdowns of yard trucks as well as the parts that will be affected and relative spare parts required for the maintenance. |

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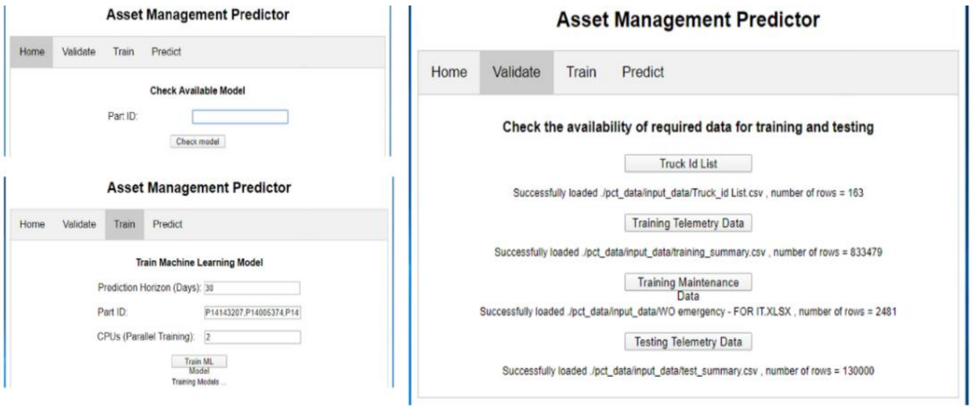
<tr><td></td><td>

*Figure 29: Predictive maintenance tool web interface*</td></tr>
<tr><td>Test scenarios of the prediction tool in 5G-LOGINNOV</td><td>For the WP3 trials of 5G-LOGINNOV that will showcase the predictive maintenance tool, PCT will focus in two main scenarios. The first scenario is dedicated to deciding the maintenance schedule of the yard trucks, whereas the second case will be focused on determining the quantity of the spare parts required for maintenance. The potential input data of the AI algorithm that are expected to be utilized include historical telemetry data, maintenance and breakdown data of the yard trucks fleet as well as telemetry data accumulated from the 5G yard trucks for the period of WP3 trials. The expected outcome of the UC will be a list of potential (predicted) dates of vehicles malfunction, i.e., break down, as well as the spare part requirements to repair/fix the foreseen problem. Predictions will be made for the one month and at the end of the month, the maintenance/breakdown work orders will be extracted from EAMS. The success criteria of the trial will be based on the accuracy of the prediction date and truck part that failed for the first scenario while the type and quantity of spare parts will be used to determine the success rate of the second scenario, addressing all KPIs of the UC7.</td></tr>
<tr><td>Data collection</td><td>Data collected from the operation of the 5G yard trucks will be sent at TMS and EAMS system. It is expected to hand over the deviation of baseline and operational data to the data collection tool for evaluation, conducted at the time period of the trials. The data may be presented in the following format:
<table>
<tr><th>Part ID</th><th>Parts needed to fix break down (Qty)</th><th>Parts predicted to be needed to fix break down (Qty)</th><th>Savings</th></tr>
</table>
Based on the accuracy of the prediction, data driven purchases and schedules will have a direct impact on the relevant parts in stock, maintenance cost of vehicles, and in the schedules of vehicle maintenance.</td></tr>
</table>

Table 11: LL_Athens_Storyboard_#7

# 4.2 HAMBURG
# LL_HAMBURG_STORYBOARD_#1

| | | |
|---|---|---|
| **Storyboard ID** | LL_Hamburg_Storyboard_#1 | |
| **UC** | Related UC 8/9: 5G-LOGINNOV Floating Truck & Emission Data (FTED) | |
| **KPIs** | H-KPI1; H-KPI2; H-KPI3<br>Increase average truck speed, reduce acceleration and standstill in single vehicle mode with equipped vehicles (vehicles for LL Hamburg will be equipped with devices of Entruck, Continental IoT and LCMM). | |
| **Baseline data** | Statistically representative trips of the city road network and in an exemplary manner in the port will be collected and speed profile evaluated. Three categories of traffic and daily profile will be used: A) dense traffic; B) medium traffic; C) free traffic. Planned for data collection are taxi and rental cars driving individually in single vehicle mode. Time series will be used as baseline reference, especially the classification of traffic data by the corresponding traffic volume of city roads and Hamburg port roads. The reference speed profiles, and Level-of-Service definitions will be used based on the Hamburg definitions per traffic state and road characteristics, see https://geoportal-hamburg.de/verkehrsportal/. Acceleration and standstill in single vehicle mode will be measured separately by Floating Cars of the project partners. GPS NMEA standard includes speed and change of speed per second which is according to Newtonian Physics Acceleration including speed zero per second defined as standstill. Baseline determination will take place by massive GPS data collection in the two road networks of interest (inner-urban and port roads). Baseline data collection will include usage of Precise Positioning technology based on 5G-R15 NSA available in the public mobile network of Deutsche Telekom. Equipment to compare GPS and Precise Positioning will be used in the single mode vehicles to evaluate the 3D signal quality relative to GPS. This will be done only in the baseline reference phase to evaluate the quality of the height signal. | |
| **Operational data** | Statistically representative trips in the port and city road network will be collected on a regular basis by taxis and on an exemplary manner by rental cars. The baseline data collection will be an orientation for the operational data collection phase. The selected vehicles will be equipped with GLOSA information and drivers shall measure via LCMM and Entruck the deviation relative to the baseline reference. | |
| **Evaluation data** | It is intended to hand-over the deviation of operational data (H-KPI-1-3) to the evaluation tool. All KPIs will be studied with collected trip data without GLOSA (baseline) and with GLOSA (operational phase). 3D signals and their reliability will be measured only once in the baseline phase. | |
| **Action/sub UC / step** | **Description** | **Illustration** |

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<td>Selection of FTED fleet vehicle</td>
<td>Different types of vehicles will be evaluated in different types of road network categories (e.g. city, port). Fleets will drive according to their work schedule or according to a special demand for statistically representative trip selections. Objective is to have a minimum of ten trips per time series and road class. In a second step taxis will be evaluated and compared to the selected fleet. Result is a valid average speed profile per time series of traffic volume and vehicle category.</td>
<td><br>TAXI AD DIGITAL<br>Figure 30: Vehicle fleet LL Hamburg</td>
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<tr>
<td>Urban and Port Road network</td>
<td colspan="2">The urban test area is located in the city centre of Hamburg. With an estimated speed of 25km/h this area is suited to have improvements outside rush hour and especially during weekends. The speed is also collected by taxis, to generate adequate statistics. The port road network is close to the southern part of the city and the river “Elbe”. The road network around that area is still to be chosen.<br><br><br>Figure 31: Trial area LL Hamburg<br><br>The second test area has critical infrastructure in the port area. It is planned to collect trip data for all three phases “baseline, operational, special events” by taxis and rental cars according to the twin series of traffic volume. In 2021, the data collection took place according to the “Green 4 transport” project of the Hamburg Port Authority (HPA) with a special green light platoon extension for the bridge shown in the following figure.</td>
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Figure 32: Green 4 for TransPort<br>LL Hamburg</td>
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<td>Preparation of the FTED equipment</td>
<td>Rental cars equipped with LCMM, Entruck and Conti-IOT via CAN and electric power supply.<br>The platoon is equipped with smartphones and a GLOSA application as shown on the figure on the top right, as well as additional equipment linked via CAN bus to the vehicle data infrastructure.<br>Additionally, the Continental IoT box will be installed inside the vehicle, so that it can send data to the Continental data base. All equipment can easily be added to the given infrastructure of the vehicle via “plug ‘n’ play”. The three data collection bases will then be able to collect the data and the drivers will receive a schedule for data collection based on the evaluation scheme (baseline, operational, special events).</td>
<td><br>Figure 33: GLOSA UI<br>LL Hamburg<br><br>Figure 34: Onboard Device<br>LL Hamburg<br><br>Figure 35 Continental IoT device<br>

Figure 36: Tec4u onboard device</td>
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<td>Start of the FTED</td>
<td>Before drivers can start the LCMM application, they should have password and credentials to Log-In. Once the LCMM-App is running, drivers should control that GPS and GSM are working properly. Whenever this is the case the LCMM-APP shows GPS/GSM availability in Green. Usually, this takes 3-5 Minutes needed to warm up before driving.<br>For collecting data with tec4u Entruck, there is no direct signal indicating whether the device is running or not. Entruck is an open Telemetry- and telematics system that starts data collection automatically when the ignition of a vehicle is switched on. The correct function will be supervised either automatically or by a person authorized to do so by the Entruck backend and Entruck online. The Log-In window is presented for both devices to the right.<br>The initial, one-time configuration of the Continental IoT device will be performed prior to its installation in the monitored vehicle. Once powered on, the device will automatically start the collection and transmission of data to the backend. No interaction with the device is required.</td>
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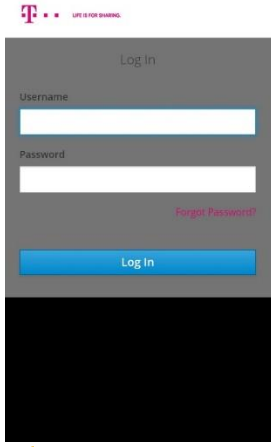


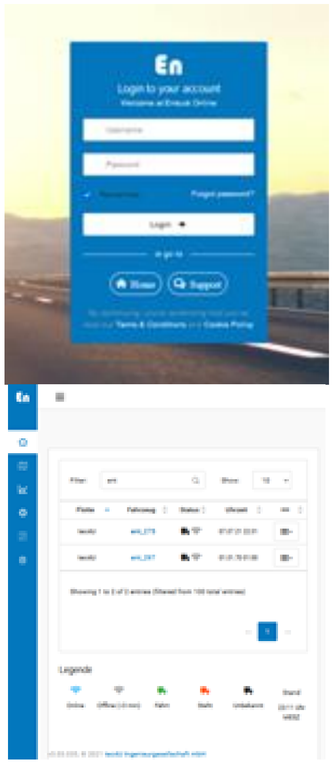
Figure 37: LCMM UI LL Hamburg


Figure 38: Entruck UI LL Hamburg
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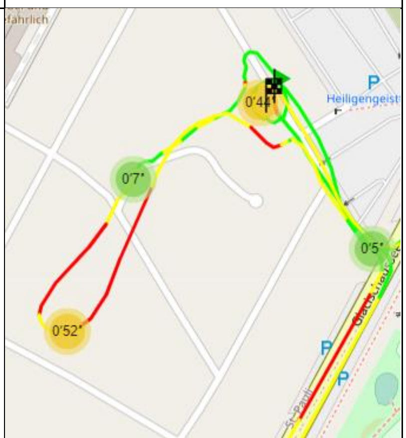
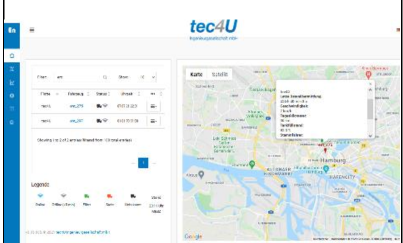
| **FTED Vehicle on-trip data collection** | Once the equipment for data collection is installed, it will be used in a similar way as shown in the figure on the right. The transmission device is exchanging messages with an external ITS G5 modem. The low carbon mobility management hardware is shown as smartphone given to the driver and attached to the windshield. For data collection purposes it is not very important that drivers see fuel consumption or other information but to regularly control if the device is still running.<br><br>The Entruck onboard unit records the data parallel to the other installed devices and transfers the data live to the IT infrastructure. Additionally, the data will be saved to the Entruck onboard unit.<br><br>The Continental IoT device records data collected from the vehicle, as well as internally generated (e.g. GNSS information) and transfers the data live to the IT infrastructure. | <br>Figure 39: Test trip LL Hamburg<br><br><br><br>Figure 40: Entruck unit LL Hamburg |
| **Arrival at the destination** | After arrival, drivers simply must turn off the device and make sure the mobile phone will be re-charged to be used next day. Drivers can access their trip collection on the LCMM data front-end and check their trip with regards to the here described KPIs Average Speed, Acceleration and Standstill. Available is an Open Street Map presentation of the trip flagged Green as Start and flagged Black as Stop.<br><br>Entruck finishes the recording of driving data for the current ride according to fixed criteria and starts the recording of data for the following ride automatically. Entruck online provides the data in differing depictions for authorized users/ applications as FTED live data and as on evaluated data on route section level. | <br><br>Figure 41: LCMM map LL Hamburg<br><br><br><br>Figure 42: Entruck map LL Hamburg |

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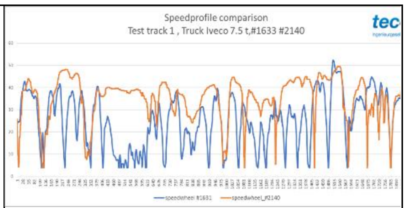
<td>

Figure 43: Entruck speed profile LL Hamburg</td>
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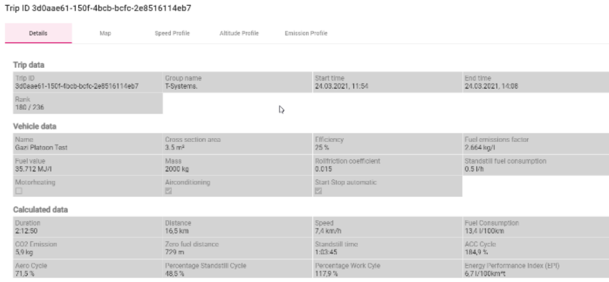
<td>Data collection</td>
<td>All LCMM data of FTED is available in the LCMM portal of the MS-Azure cloud. It can be accessed via Internet and evaluated according to the ISO-23795 evaluation scheme. For speed, the figures to the right show how the GUI is presenting this to users being connected to the LCMM cloud system. All data can be monitored online by authorized users. The data has a microscopic level with GPS speed profiles per second as well as an aggregated level per trip. For impact and KPI assessment purposes, data can be stored and evaluated according to the timeline of the project duration.


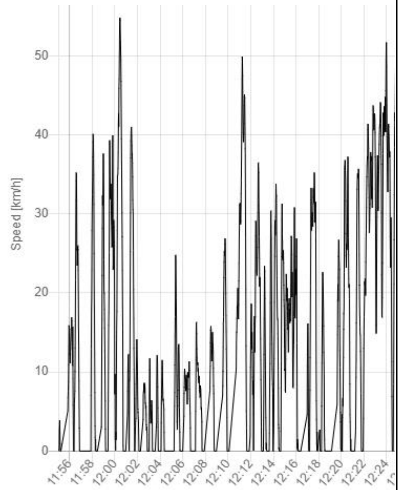
All data is structured in Entruck for the individual UC and are retrievable via Internet. That applies to the live data set for the FTED applications as well as the evaluated and matched drive, fuel consumption and traffic management profile matched to each route section.<br>
Data collected by the Continental IoT device is sent to the Conti backend installed in the MEC and is stored in a structured manner, to be used for the individual UC.</td>
<td>

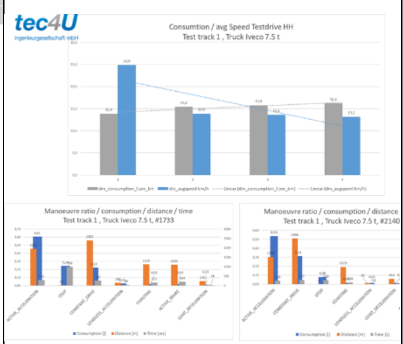
Figure 44: LCMM speed diagram LL Hamburg


Figure 45: Entruck speed diagram<br>LL Hamburg</td>
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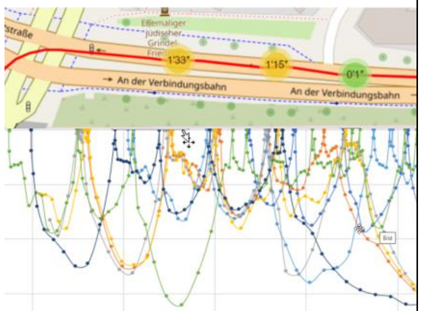
Table 12: LL_Hamburg_Storyboard_#1

# LL_HAMBURG_STORYBOARD_#2

| | | |
|---|---|---|
| **Storyboard ID** | LL_Hamburg_Story_#2 | |
| **UC** | Related UC 10: 5G-LOGINNOV 5G GLOSA & Automated Truck Platooning (GTP)-under 5G-LOGINNOV green initiative | |
| **KPIs** | H-KPI4; H-KPI5; H-KPI6<br>Increase average truck speed and reduce acceleration and standstill in platooning vehicle mode with equipped vehicles (platoon vehicles for LL Hamburg will be equipped with devices of Entruck, Conti IoT and LCMM). | |
| **Baseline data** | Statistically representative trips of the city road network and in an exemplary manner in the port will be collected and speed profiles evaluated. Three categories of traffic and daily profiles will be used: A) dense traffic; B) medium traffic; C) free traffic. Planned for data collection are taxi and rental cars platooning with a minimum platoon size of two vehicles. For the baseline measurement, there will be no GLOSA-APP actively indicating speed advice. Drivers will choose their speed ranges spontaneously by individual perception of the external traffic conditions. To better understand the manoeuvres of drivers, traffic volume time series will be used complementary as baseline reference, especially the classification of traffic data by the corresponding traffic volume of city roads and Hamburg port roads. As reference speed profiles and Level-of-Service thresholds, Hamburg definitions per traffic state and road characteristics will be applied, see https://geoportal-hamburg.de/verkehrsportal/. Acceleration and standstill in platooning vehicle mode will be measured separately by platooning Floating Cars of the project partners as already described in Storyboard #1. GPS NMEA standard includes speed and change of speed per second, including speed zero per second defined as standstill. Special attention will also be given to the technical infrastructure of the 5G-R15-NSA mobile network, the MEC-X latency data transfer and other 5G related performance KPIs. As the truck platooning vehicles need to transmit collision warning messages in ultra-low latency timeframes the reliability of the mobile network will be studied in the baseline period. | |
| **Operational data** | Statistically representative trips in the city road network will be collected on a regular basis by taxis and on an exemplary manner by rental cars. The baseline data collection with platooning Floating Cars will be an orientation for the operational data collection phase. The drivers of the selected platooning vehicles will receive GLOSA information during their trips which will influence their choice of speed. Acceleration and standstill will be recorded with the Android Smartphone LCMM-APP and tec4u Entruck device being connected to the CAN-Bus. Deviations will be recorded, and data quality analysed based on measurements executed in the baseline phase. | |
| **Evaluation data** | It is intended to hand-over the deviation of operational data (H-KPI4-6) to the evaluation tool. | |
| **Action/sub UC / step** | **Description** | **Illustration** |

| | | |
|---|---|---|
| **Selection of ATP fleet vehicle** | Platoons show special characteristic with regards to the vehicle type and driving behaviour in complex urban road networks. The main reason for this lies in the irregular and unstable driving caused by the traffic situation outside of the platoon. Therefore, the selection of the automated vehicle types is closely linked to the purpose of the platooning tests relative to the external traffic situation. This gives an overview about the traffic conditions needed to operate any types of platoon stable and without safety concerns. Especially when driving and approaching traffic light-controlled intersections, the platoon must manage several stop-go events linked to the given traffic flow. An example is shown to the right. Based on pre-pilot evaluations, the plot shows the number and time of stops the platoon had on the road and how the vehicles crossed the intersection. As there is little experience how truck platooning can take place in urban road networks and during rush hours, the stop & go behaviour needs to be studied in detailed test cases considering the statistical relevance of the probe data along the test field. As shown in the example to the right, any platoon will have difficulties turning left as traffic light phases for left turns usually have very little green time. This means that the platoon risks to get separated due to irregular and asynchronous stop&go speed profiles, which will make future operation of automated platoons totally impossible. Also, GLOSA information needed for V2V data exchange will be heavily influenced by the traffic light forecast and the phases of traffic light status. Given the sum of constraints listed and after evaluation of the pre-test in Hamburg City, it was decided to select Light Commercial Vehicles for the inner-urban test field and to focus on low-speed operation to keep the platoon as stable as possible. In the port area, only feasibility tests will be executed using rental passenger cars for platooning speed profile studies, given the fact that no GLOSA traffic light forecast is available on port roads. |  TAXI AD DIGITAL<br>*Figure 46: Vehicle fleet LL Hamburg*<br><br>*Figure 47: Platoon diagram LL Hamburg* |

<table>
<tr>
<td>Urban and Port Road network</td>
<td>

The urban test area lies in the city centre of Hamburg. With an estimated speed of 25km/h this area is suited to have improvements outside rush hour and especially during weekends. The speed is also collected by taxis, to generate adequate statistics. The port road network is close to the southern part of the city and the river “Elbe”. Road network around that area is still to be chosen. The Roadside Units shown in the map below include 68 traffic light intersections with traffic light forecast features needed to implement GLOSA. Speed advice shown to the driver will be the key message to keep the platoon stable and allowing the platoon to cross intersections smoothly, an especially without any interruption. The speed advices are transmitted to all vehicles of the platoon. By the help of 5G low latency, intersections will send Collision Warning messages from passengers or vehicles close to the platoon depending on its trajectory, thus ensuring that all vehicles are warned, so that collisions can be avoided in case of any risk detected by the sensors.


Figure 48: Trial area<br>LL Hamburg

The second test area has critical infrastructure in the port area. In 2021, the consortium collected data with Hamburg Port Authority (HPA) making use of the “Green 4 transport” V2X project of (HPA) with a special green light extension along the bridge shown in the Figure below. As GLOSA information is not available in this area, only some basic feasibility tests took place in 2021 and will be examined jointly with HPA during the field trial period in 2022.


Figure 49: Green 4 for TransPort LL Hamburg

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</table>

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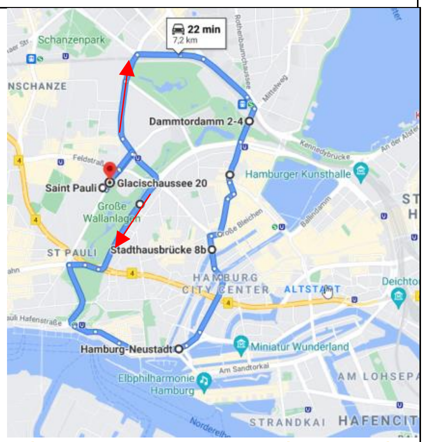
|---|---|---|
| **Preparation of the GLOSA ATP equipment** | The platoon is equipped with smartphones running LCMM and GLOSA application as shown on the figure on the top right, as well as additional equipment linked via CAN bus to the vehicle data infrastructure.<br>Additionally, the Continental IoT box will be installed inside the vehicle, so that it can send data to the Continental data base. All equipment can easily be mounted into the vehicle via “plug ‘n’ play”. The three data collection bases will then be able to collect the data and the drivers will receive a schedule for data collection based on the evaluation scheme. The data collection will be defined and agreed upon the requirements of KPIs, also including recommendations from the traffic authorities in Hamburg. | <br>*Figure 50: GLOSA UI LL Hamburg*<br><br>*Figure 51: Onboard Device LL Hamburg* |
| **Start of the GLOSA ATP in the vehicle platoon** | Drivers must switch on the LCMM-App and make sure that GPS and GSM are working properly. The LCMM-APP indicates the GPS/GSM availability in Green (3-5 Minutes before driving). Entruck is an open Telemetry- and telematics system that starts data collection automatically when the ignition of a vehicle is switched on. The correct function will be supervised either automatically or by an authorized person online via the Entruck backend.<br>From the starting area Heiligengeistfeld, the GLOSA enabled platoon has two possible directions after leaving the Glacischaussee – driving north- or southwards of the RSU equipped test field TAVF. Equipped vehicles form a platoon in the red circle area in the parking zone shown to the right. After ensuring all mobile devices to work properly, the vehicles start their first platooning manoeuvres inside the parking zone before leaving towards the exit, see red arrow. | <br>*Figure 52: Test area urban roads LL Hamburg*<br><br>*Figure 53: Platoon parking area LL Hamburg* |

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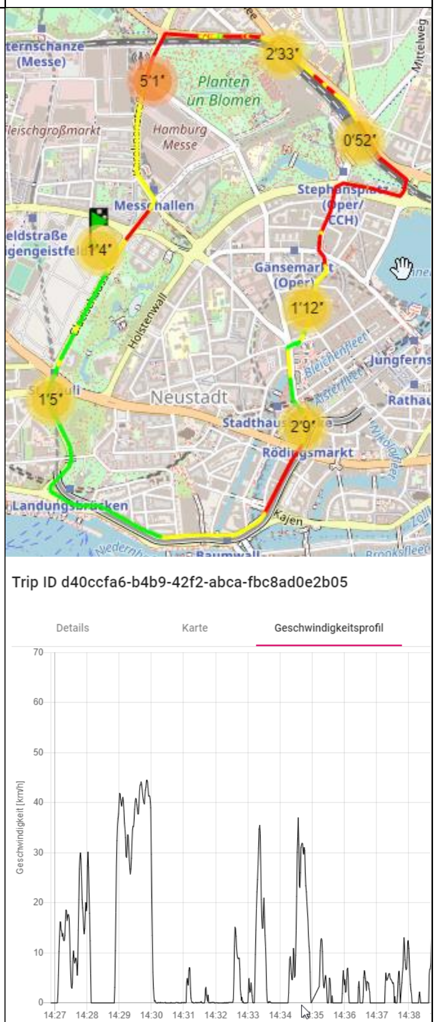
| **GLOSA ATP platoon -trip data collection** | Once all equipment for data collection is installed and the platoon started its trip on the test field, drivers will use the GLOSA-APP and the speed advice recommendations as illustrated in the figure to the right. The transmission device is exchanging messages with an external V2X modem. The low carbon mobility management (LCMM) application is installed on a smartphone attached to the windshield. For data collection purposes it is not very important that drivers see fuel consumption or other information, but it enables the driver to supervise the functionality of the device.<br>The Entruck onboard unit records the data parallel to the other installed devices and transfers the data live to the IT infrastructure. Additionally, the data will be saved to the Entruck onboard unit. | <br>*Figure 54: GLOSA -APP LL Hamburg* |
| **Arrival at the destination** | On arrival, drivers must simply turn off the device and make sure the mobile phone will be re-charged to be used next day. The figure to the right shows the post-trip evaluation by the LCMM system. In an exemplary manner, the Open Street Map plot to the right recorded during rush hour traffic conditions illustrates how the platoon test will be presented directly after the trip was done. The speed profile is shown below. The x-y-plot has typical stop times at intersections and during left turns. Post trip analysis should include a fast plausibility check considering these typical urban conditions as well as a verification that 5G and mobile edge ensure stable platoon operation with regards to speed, acceleration, and distance, keeping in mind collision warning aspects in safety critical platoon situations. Speed and acceleration profiles will be compared depending on the position of the vehicle in the platoon (lead vehicle and sequence of followers) with the objective to define safe operation modus for the platoon, needed to determine further SAE levels.<br>Entruck finishes the recording of driving data for the current ride according to fixed criteria and starts the recording of data for the following ride automatically. Entruck online provides the data in different depictions for authorized users/ applications on platoon and on route section level. | <br>*Figure 55: LCMM UI LL Hamburg* |

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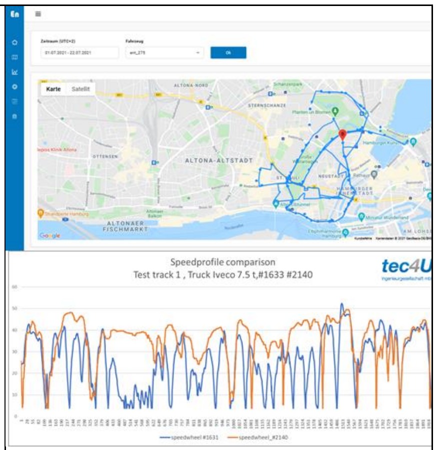
| | | <br>*Figure 56: Entruck UI LL Hamburg* |
| **Data collection** | All LCMM data of FTED is available via the LCMM portal as part of the T-Systems' MS-Azure cloud, where it is evaluated according to the ISO-23795 evaluation scheme. It can be accessed via Internet. As shown in the step "Arrival at destination", the LCMM GUI presents speed data and location-based trips to users. tec4u and Continental provide access to their Entruck and Conti-IOT device database on a different IT-platform. Data of their platforms will be merged based on an agreed format and protocol with the LCMM one. | |

*Table 13: LL_Hamburg_Storyboard_#2*

# LL_HAMBURG_STORYBOARD_#3

| **Storyboard ID** | LL_Hamburg_Story_#3 | |
|---|---|---|
| **UC** | Related UC 8/9, 10, 11:<br>5G-LOGINNOV Floating Truck & Emission Data (FTED)<br>5G-LOGINNOV 5G GLOSA & Automated Truck Platooning (GTP)-under 5G-LOGINNOV green initiative<br>5G-LOGINNOV dynamic control loop for environment sensitive traffic management actions (DCET) | |
| **KPIs** | H-KPI7; H-KPI8, H-KPI9; H-KPI10<br>Reduction of fuel consumption and $CO_2$ emissions in single mode (vehicles for LL Hamburg will be equipped with devices for Entruck, Conti IoT and LCMM) up to 10%<br>Reduction of fuel consumption and $CO_2$ emissions in platoon mode (vehicles for LL Hamburg will be equipped with devices for Entruck, Conti IoT and LCMM) up to 20% | |
| **Baseline data** | Statistically representative trips in the port and city road network will be collected on a regular basis by taxis and on an exemplary manner by rental cars. The baseline data collection will be an orientation for the operational data collection phase. The selected vehicles will be equipped with GLOSA information and drivers shall measure via LCMM and Entruck the deviation relative to the baseline reference. | |
| **Operational data** | A significant number of rides will be conducted through the city road network of Hamburg and around the docks which will be recorded and evaluated. The evaluation takes place on the base of real vehicle sensor data in combination with the digital route network that is to be drawn up as digital map and on the base of live data regarding traffic situation, traffic volume and location of the traffic infrastructure such as traffic lights. The data relevant to emissions and fuel consumption in relation to the type of vehicle, vehicle dynamics and driver interaction will be recorded in high resolution and matched to the relevant route section. The recorded data provide, next to precise positioning based on 5G-R15 NSA, the speed profile and all consumption relevant engine parameters as RPM, torque, and current real fuel consumption in a resolution of at least 2 HZ. Additionally, Entruck records driver interactions such as accelerator pedal position, brake- and clutch confirmation and use of kickdowns. The evaluation represents the determined driving manoeuvres for the current driving conditions of the vehicle, the driving resistance distribution and resulting real consumption for the individual categories of manoeuvres such as acceleration, constant drive, active deceleration or standstill) matched to the sections and in relation to the current traffic conditions. Through the evaluation of the manoeuvre execution (intensity and acceptance of traffic restrictions) the driver characteristics and driving influence will be determined. Resulting out of this, the consumption-optimized traffic management and driving profiles can be determined for each route section. | |
| **Evaluation data** | It is intended to hand-over the deviation of operational data (H-KPI8-10) to the evaluation tool. All KPIs will be studied with collected trip data without GLOSA (baseline) and with GLOSA (operational phase) | |
| **Action/sub UC / step** | **Description** | **Illustration** |

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| **Selection of fleet vehicle** | Different types of vehicles will be evaluated in different types of road network categories (e.g. city, port). Fleets will drive according to their work schedule or according to a special demand for statistically representative trip selection. Objective is to have a minimum of ten trips per time series and road class. | <br>*Figure 57: GLOSA-APP & Urban road network LL Hamburg* |
| **Urban and Port Road network** | The urban test area is located in the city centre of Hamburg. With an estimated speed of 25km/h this area is suited to have improvements outside rush hour and especially during weekends. The speed is also collected by taxis, to generate adequate statistics. The port road network is close to the southern part of the city and the river “Elbe”. Road network around that area is still to be chosen.<br><br><br>*Figure 58: test area urban road network LL Hamburg*<br><br>The second test area has critical infrastructure in the port area. It is planned to collect trip data for all three phases “baseline, operational, special events” by taxis and rental cars according to the twin series of traffic volume. In 2021, the data collection took place according to the “Green 4 transport” project of the Hamburg Port Authority (HPA) with a special green light platoon extension for the bridge shown in the following figure. | |

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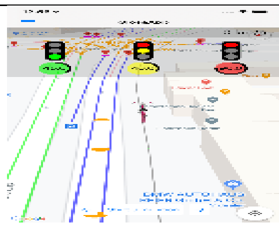
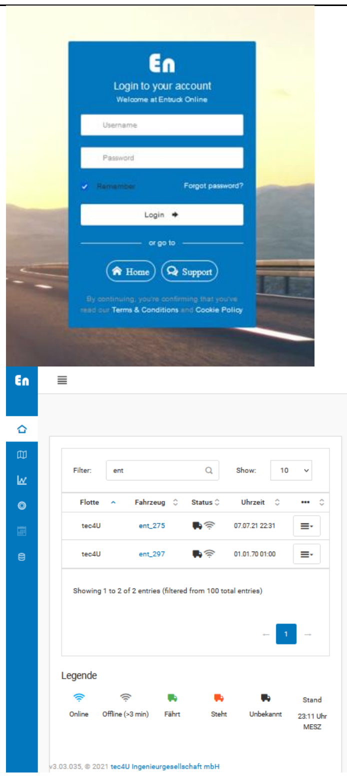
| |  #<br>Figure 59: Green4TransPort LL Hamburg | |
| **Preparation of the FTED equipment** | The platoon is equipped with smartphones and a GLOSA application as shown on the figure on the right, as well as additional equipment linked via CAN bus to the vehicle data infrastructure.<br>Additionally, the Entruck and the Continental IoT box will be installed inside the vehicle, so that it can send data to each database of their telematics platform. All equipment can easily be added to the given infrastructure of the vehicle via "plug 'n' play". The three data collection systems will then be able to collect the data and the drivers will receive a schedule for data collection based on the evaluation scheme (baseline, operational, special events). | <br>Figure 60: GLOSA-APP LL Hamburg |
| **Start of the Data Collection** | Entruck is an open Telemetry and telematics system that starts data collection automatically when the ignition of a vehicle is switched on. The correct function will be supervised either automatically or by a person authorized to do so by the Entruck backend and Entruck online.<br>The initial, one-time configuration of the Continental IoT device will be performed prior to its installation in the monitored vehicle. Once powered on the device will automatically start the collection and transmission of data to the backend. No interaction with the device is required. | <br>Figure 61: Entruck App LL Hamburg |

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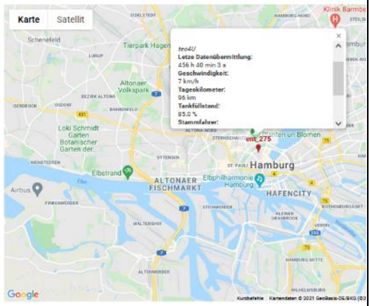
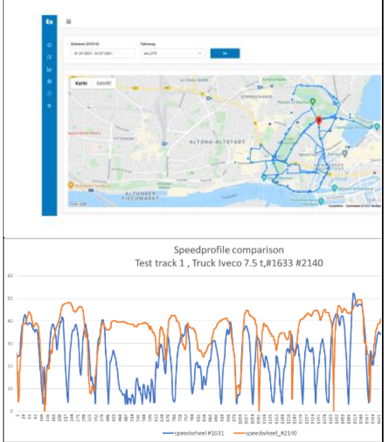
|---|---|---|
| | |   *Figure 62: Map Hamburg Source Google: LL Hamburg* |
| **Vehicle on-trip data collection** | The Entruck onboard unit records the data parallel to the other installed devices and transfers the data live to the IT infrastructure. Additionally, the data will be saved to the Entruck onboard unit.<br><br>The Continental IoT device records data collected from the vehicle, as well as internally generated (e.g. GNSS information) and transfers the data live to the IT infrastructure. |  *Figure 63: Entruck onboard unit LL Hamburg* |
| **Arrival at the destination** | Entruck finishes the recording of driving data for the current ride according to fixed criteria and starts the recording of data for the following ride automatically. Entruck online provides the data in differing depictions for authorized users/applications as FTED live data and as evaluated data on route section level. |   *Figure 64: Entruck UI LL Hamburg* |

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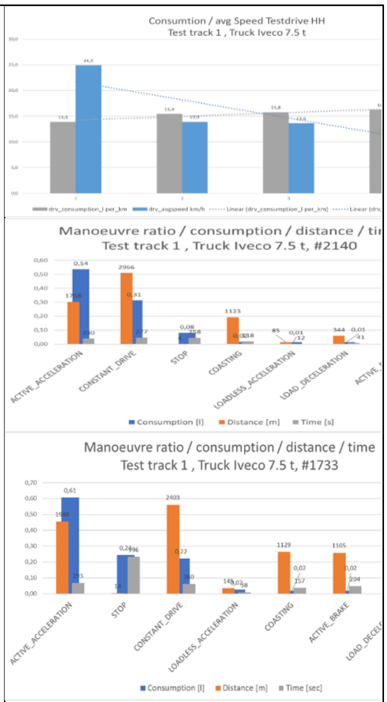
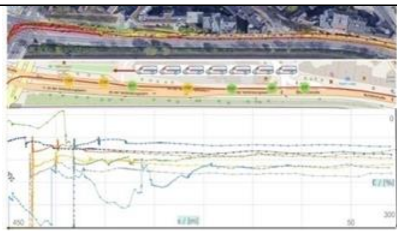
| **Data collection** | All data are structured in Entruck for the individual UC and are retrievable via Internet. That applies to the live data set for the FTED applications as well as the evaluated and matched drive, fuel consumption and traffic management profile matched to each route section.<br><br>For impact and KPI assessment purposes, data can be stored and evaluated according to the timeline of the project duration. | <br>*Figure 65: Entruck onboard unit LL Hamburg* |

*Table 14: LL_Hamburg_Storyboard_#3*

# LL_HAMBURG_STORYBOARD_#4

| **Storyboard ID** | LL_Hamburg_Story_#4 | |
|---|---|---|
| **UC** | Related UC 10:<br>5G-LOGINNOV 5G GLOSA & Automated Truck Platooning (GTP)-under 5G-LOGINNOV green initiative | |
| **KPIs** | H-KPI-11 and H-KPI-12<br>H-KPI-11: Optimize Energy Performance Index ‘EPI - cl per ton and km’ (platoon vehicles for LL Hamburg will be equipped with devices for LCMM)<br>H-KPI-12: Optimize Acceleration Performance Index ‘API - KWh per ton and km’ (vehicles for LL Hamburg will be equipped with devices for LCMM)<br>Target: Increase value of ‘EPI - cl per ton and km’ and ‘API – kWh per ton and km’ up to 10% for vehicle trips | |
| **Baseline data** | The basis of the energy performance index is the LCMM calculation based on ISO/DIS-23795. This procedure compares speed profiles of vehicles in motion from a real trip perspective to the speed profile of the WLTP reference cycle. The procedure is based on the floating car data principle described in Hamburg storyboards 1 and 2. With regards to both KPIs ‘energy demand and acceleration’, it is mainly necessary to collect speed profiles in the statistically relevant time series of daily traffic. As the GNSS signal includes speed per second, acceleration and braking behaviour can be calculated and becomes measurable in unit of [%] relative to WLTP. For Hamburg, this includes analysis of time series and status references of free, dense, and congested traffic in both targeted geographical areas, the urban and the port road network. The baseline will be measured without any green light optimized speed advice and will also make use of the publicly available speed profile index used by the city of Hamburg. It is foreseen to collect numerous EPI and API data sets allowing the determination of carbon footprint inside the city and along the port roads while driving without and with GLOSA, in single as well as in platoon mode.<br><br>Based on measurements in units of [%]-deviation to the WLTP-cycle calculated results quantify units of Mega-Joule per ton weight and kilometres [MJ/tkm] and will be transferred to kilogram $CO_2$ per ton-km for baseline determination. | |
| **Operational data** | During the field trial operation, operational data will be collected based on the same trips and day times on which baseline trip data was collected. Recorded during comparable time series during the week and with numbers of trips which are statistically relevant for both periods, the operational phase will focus on the complex interaction of 5G network features and logistics service relevance. The operational data collection will focus on improvements achievable by using green light optimum speed advices (GLOSA) while driving and how to use Traffic Light Forecast for further automation of vehicle platooning. Drivers will not drive according to the traffic situation alone but also make use of the GLOSA speed advice influencing their behaviour towards best practise manoeuvres. Especially by analysing the energy and acceleration performance, this will lead to business case assumptions for the related use cases UC8, 9, 10 and 11. | |
| **Evaluation data** | The evaluation data will make use of the aggregated energy and acceleration performance per trip, giving evidence how specific road conditions and individual manoeuvres influence these UC. The KPI pre-processing takes place in the T-Systems, tec4u and Continental databases whereas the overall project evaluation will be executed in the AKKA evaluation tool with related KPIs from the evaluation team. | |
| **Action/sub UC / step** | **Description** | **Illustration** |

<table>
<tr>
<td>Selection of Floating Cars for EPI data collection</td>
<td>For 5G-LOGINNOV LL Hamburg, the selection of floating cars for EPI & API analysis is closely linked to the road conditions of the inner-urban road network TAVF as GLOSA App information is available only for TAVF road segments. Therefore, taxis and selected rental cars will be equipped and according to the statistical measurement principles representative trips will be recorded. A detailed time schedule for data collection will be planned to maximize the statistical assumptions. Based on the pre-testing phase, taking place in 2021 before the ITS congress, it is planned to have a special focus on total energy values with and without GLOSA, braking and acceleration behaviour with and without GLOSA as well as impact of traffic flow, standstill and stop&go due to congestion. Road characteristics including left turns, curves and slope impact for EPI and API will be detected and included into the overall KPI analysis. Some typical trip data presentation taking place during the pre-test period is shown to the right.</td>
<td><br>Figure 66: Platoon data diagram LL Hamburg<br><br><br>Figure 67: Prelimary platoon fleet LL Hamburg</td>
</tr>
<tr>
<td>Urban and TAVF road network</td>
<td colspan="2">
<br>Figure 68: Urban roads test area LL Hamburg<br><br>The test field for autonomous driving shown above is the key test area for GLOSA as GLOSA relevant information can only be received within this test field. Therefore, all KPI measurements will take place in this test field and in the surrounding inner urban road network in the city centre of Hamburg. As can be seen in the TAVF road segments, the road network has different road categories causing different emissions and resistances increasing stop&go and energy demand. Most of the roads in the TAVF and the nearer area of urban roads with category 3 and 4 leading to higher energy resistance. Therefore, it is assumed that the energy performance index used will have an additional resistance factor of 1.8 to quantify the emissions. This will be used in the test field.</td>
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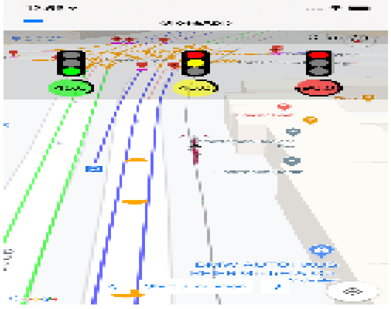
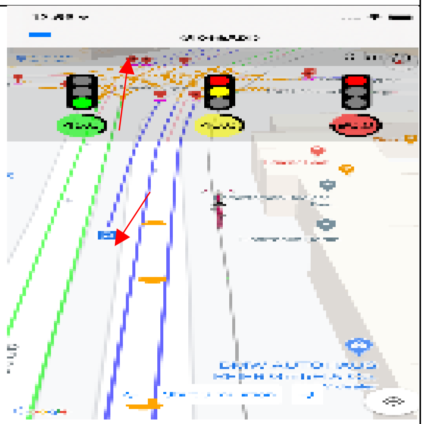
| **Preparation of the GLOSA ATP equipment and test trip collection for EPI-measurements** | The platoon is equipped with smartphones and a GLOSA application as shown on the figure on the top right, as well as additional equipment linked via CAN bus to the vehicle data infrastructure.<br>Additionally, the Continental IoT box will be installed inside the vehicle, so that it can send data to the Continental data base. All equipment can easily be added to the given infrastructure of the vehicle via “plug ‘n’ play”. The three data collection bases will then be able to collect the data and the drivers will receive a schedule for data collection based on the evaluation scheme (baseline, operational, special events). | <br>*Figure 69: GOLSA scenario LL Hamburg* |
| **Start of the GLOSA ATP in the vehicle platoon** | Drivers must turn on the LCMM-App and make sure that GPS and GSM are working properly and the LCMM-APP does give the GPS/GSM availability in Green (3-5 Minutes before driving, GPS). Entruck is an open Telemetry and telematics system that starts data collection automatically when the ignition of a vehicle is switched on. The correct function will be supervised either automatically or by a person authorized to do so by the Entruck backend and Entruck online.<br>One can see to the right that the GLOSA enabled platoon has two possible directions after leaving the Galcichaussee – driving north or southwards of the test field TAVF. Equipped vehicles form a platoon in the red circle area in the parking zone shown to the right where an aerial image of the platoon starting point Heiligengeistfeld is shown. After making sure all mobile devices work properly, the vehicles start their first platooning manoeuvres inside the parking zone and drive towards the exit, see red arrow. Galcichaussee is part of the test field with RSUs. | <br>*Figure 70: Test area urban roads LL Hamburg*<br><br>*Figure 71: Platoon parking area LL Hamburg* |

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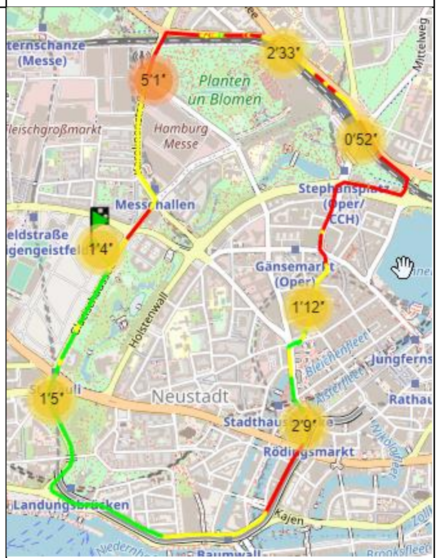
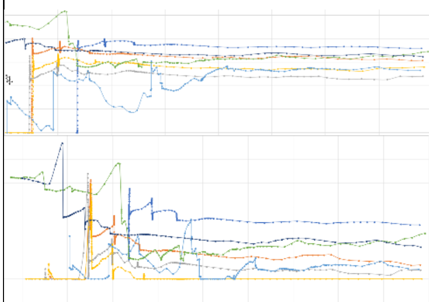
|---|---|---|
| **GLOSA ATP platoon -trip data collection** | Once all equipment for data collection is installed and the platoon started its trip on the test field, drivers will use the GLOSA-APP and the speed advice recommendations in a similar way as shown in the figure to the right. The transmission device is exchanging messages with an external V2X modem. The low carbon mobility management hardware is shown as smartphone given to the driver and attached to the windshield. For data collection purposes it is not very important that drivers see fuel consumption or other information but to regularly control if the device is turned on.<br>The Entruck onboard unit records the data parallel to the other installed devices and transfers the data live to the IT infrastructure. Additionally, the data will be saved to the Entruck onboard unit. | <br>Figure 72: Platoon parking area LL Hamburg |
| **Arrival at the destination** | After arrival, drivers simply must turn off the device and make sure the mobile phone will be re-charged to be used next day. The figure to the right shows how trips will be evaluated post-trip with the LCMM system. In an exemplary manner, the Open Street Map Plot shown to the right which was recorded during rush hour traffic conditions shows how the platoon test will be presented directly after the trip was done. The speed profile is shown below. The x-y-plot has typical stop times. Intersections and left turns are regular taking place during the test phase causing delay. Post trip analysis should include a fast plausibility check considering these typical urban conditions. Post trip analysis will also include the examination of how 5G and mobile edge can ensure stable platoons within urban traffic conditions (TAVF).<br>Entruck finishes the recording of driving data for the current ride according to fixed criteria and starts the recording of data for the following ride automatically. Entruck online provides the data in differing depictions for authorized users/ applications as Platoon and as on evaluated data on route section level. | <br>Figure 73: Test area LL Hamburg<br><br>Figure 74: Platoon data diagram LL Hamburg |

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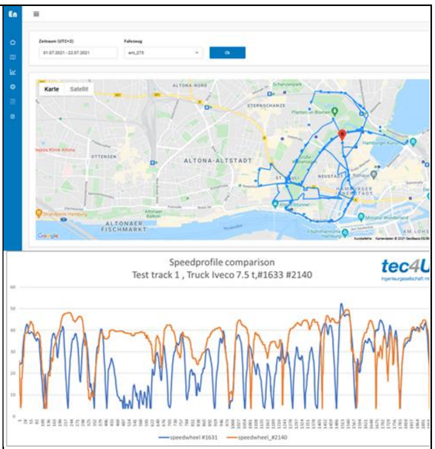
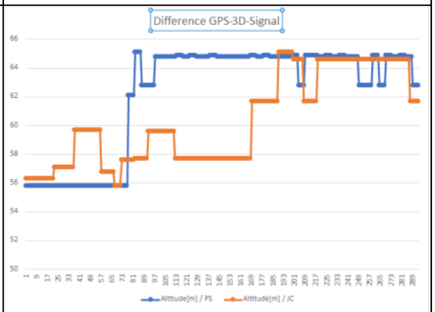
| | | <br>Figure 75: Entruck UI LL Hamburg |
| **Data collection** | All LCMM data of FTED is available in the LCMM portal as part of the T-Systems MS-Azure cloud. It can be accessed via Internet; data is evaluated according to the ISO-23795 evaluation scheme. For speed, the figures to the right shows the GUI and how it presents the information to users. Tec4u and Continental provide access to their Entruck and Conti-IOT device database on a different IT-platform. Data will be merged based on an agreed format and protocol. | <br>Figure 76: Signal quality GNSS LL Hamburg |

Table 15: LL_Hamburg_Storyboard_#4

# LL_HAMBURG_STORYBOARD_#5

| | | |
|---|---|---|
| **Storyboard ID** | LL_Hamburg_Story_#5 | |
| **UC** | Related UC 8/9, 10, 11:<br>5G-LOGINNOV Floating Truck & Emission Data (FTED)<br>5G-LOGINNOV 5G GLOSA & Automated Truck Platooning (GTP)-under 5G-LOGINNOV green initiative<br>5G-LOGINNOV dynamic control loop for environment sensitive traffic management actions (DCET) | |
| **KPIs** | H-KPI-13, H-KPI-15, H-KPI-16<br>Extended cellular bandwidth on urban roads by 5G network<br>5G communication systems will be able to support dedicated bandwidths (per user) over 500MBit/s - depending on deployed network structure. LL Hamburg will use the production network of T-Mobile with 5GNR (in 3.5 GHz spectrum) to get this high capacity. | |
| **Operational data** | The measurements of the 5G network in Hamburg are targeted to find out restrictions and limitations by the 5G public network (NSA release 15) and the planned rollout of services linked to the existing network. The KPI's planned do not include any baseline compared to new equipment to be installed within the mobile network but include the usage of existing operational 5G NSA features and their performance. In this regard it is planned to use a standard network performance measurement which allows defining the performance indicators of the network. The devices will be installed inside the platoon as well as on a private test cloud where T-Systems can collect datasets linked to the network. | |
| **Evaluation data** | The evaluation data will include autonomous mode local units which are installed in different floating cars and platoons to collect data in the test field of Hamburg. The different parameters will include generic topics such as data reliability and end-to-end latency, but also signal-to-noise performance parameters created in test reports and dashboards. | |
| **Action/sub UC / step** | **Description** | |
| **Selection of Floating Cars for 5G data collection** | According to the Telekom equipment and purchase-order department it will take six weeks to deliver the equipment and to install it on different vehicles single mode or platoon mode. The scenario for setting up the platoon tests as well as the single mode tests will be aligned with the operational phase of the field trial as described in the storyboards #1, #2, #3 and #4 linked to the specific road characteristics. The devices will include a strategy how to collect data in a synchronized way with the GLOSA App as well as with the synchronized datasets for the platoon testing (see floating car data setup in storyboard #1, #2, #3 and #4).<br><br>It is foreseen to measure 5G NSA KPI in a live network environment under real live conditions. The plan is to equip several trucks with measuring probes, to measure a variety of 5G KPI on the move: particularly the packet error rate in a 5G network. For Deutsche Telekom, the preferred equipment provider for executing this type of measurements is the company Mobileum, company's logo shown to the right.<br>Mobileum will | <br>*Figure 77: Platoon LL Hamburg*<br><br>*Figure 78: Logo 5G measurement equipment LL Hamburg* |

<table>
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<td>

- Deliver 1 to 10 Compact Local Units in Autonomous Mode (AWLU) to T-Systems, and install them on 1 to 10 different trucks
- Setup a private test cloud (SITE in Cloud, SiC) for T-Systems, and connect the AWLU to the SiC
- Setup a test campaign to run IP data tests which will deliver the required packet error rate KPI: The setup includes the provision of all test definitions and parameterizations, the test schedule, and the creation of test reports and dashboards, plus the export of the test data to external systems
- T-Systems will get access to the SiC, and it can activate deactivate the test campaign according to its needs

</td>
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<tr>
<td>Urban and TAVF road network</td>
<td>

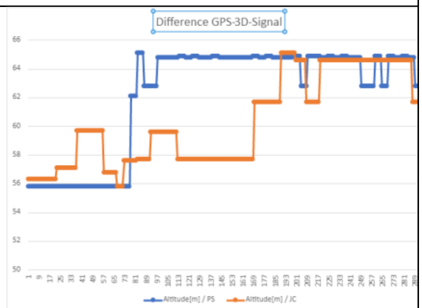

Tests will take place in the testfield TAVF
</td>
<td>


Figure 79: Signal quality GNSS LL Hamburg
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<tr>
<td>Preparation of the 5G performance testing</td>
<td colspan="2">Rental cars equipped with LCMM, Entruck and Conti-IOT via CAN bus and electric power supply.<br>A special KPI measurement equipment for 5G will be installed across the indicated test field autonomous driving and make some tests for the coverage of the network bandwidths, latency end-to-end and other 5G related features including bandwidths. The technology used by Telekom in such cases is the Mobileum software which offered the test equipment to be used in the test field of Hamburg. It is supposed that in this specific area in the city of Hamburg most of the coverage in 5G does already exist as density of cells and customers fit to the strategic rollout in Germanys tier one cities such as Hamburg.</td>
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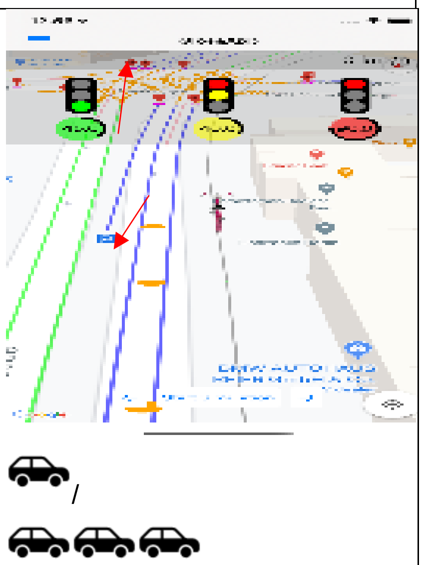
| | | |
|---|---|---|
| **Start of the 5G Mobileum tests within the test field (TAVF)** | Drivers will set-up testing as described in the scenarios of storyboard #1 and #2.<br>The 5G KPI measurements based on Mobileum equipment will start similar to the platooning test on the central parking lot convenient for the trips on the test field. Given the limited time the test equipment is available (2 months) the test will be combined with the operational field trial in 2022 in LL Hamburg. It is foreseen to execute the tests in platoon and non-platoon mode depending on the available equipment and the general setup linked to the test equipment (cloud infrastructure availability etc.). It is foreseen to have a focus on the end-to-end latency in this specific intersection of the test field where Continental is also operating the collision warning from a department project in which T-Systems and Continental are both involved. Collision warning is of special importance as it requires low latency and is latency critical. Also, the combination and signal availability for GLOSA and traffic light forecast will be tested along the test field in Hamburg. Bandwidths and latency critical studies will be performed in combination with the equipment available. | <br>*Figure 80: Parking area for test starts LL Hamburg* |
| **Mobileum 5G test data collection** | Test will take place from the start where the equipment for 5G test trips was prepared in both directions of the TAVF. This is important as coverage and transmission of data from moving objects to antennas might have different lead characteristics and coverage depending on the direction of the car. Additionally, single mode and platoon mode will be tested according to the different requirements. Special care will be taken to the intersection where collision warning is active and to some selected intersections where the traffic light forecast and the GLOSA App are running. All of these tests will be executed during the operational field trial, therefore experience of speed profile, acceleration and interacting platoon vehicle modes will exist to be complemented by the 5G KPI test data collection. | <br>*Figure 81: Data collection area LL Hamburg* |

| | | |
|---|---|---|
| **Arrival at the destinatio n / post-trip data evaluation** | After the arrival, which is the same as the destination, detailed test reports will be generated and be available in the cloud. Reports will be used for direct plausibility check after the test trip from the test driver team, notes taken for special events and events which might have affected the recording trip. Additionally, the test trip record including time, number of vehicles, traffic situation and test objectives will be included and added to the report to define the KPI's which must be handed over to the evaluation team. KPI's will also include the interaction between network features and UC requirements. | |

*Table 16: LL_Hamburg_Storyboard_#5*

# LL_HAMBURG_STORYBOARD_#6

| | | |
|---|---|---|
| **Storyboard ID** | LL_Hamburg_Story_#6 | |
| **UC** | Related UCs 8/9, 10, 11:<br>5G-LOGINNOV Floating Truck & Emission Data (FTED)<br>5G-LOGINNOV 5G GLOSA & Automated Truck Platooning (GTP)-under 5G-LOGINNOV green initiative<br>5G-LOGINNOV dynamic control loop for environment sensitive traffic management actions (DCET) | |
| **KPIs** | H-KPI-14<br>Positioning quality on urban road networks with 5G by 10 cm<br>The product solution of Deutsche Telekom with the partner Skylark will provide a precision level of 10 cm (comparable with 3 - 10 m for uncorrected GNSS signal). This solution will be integrated in the LL Hamburg UC to increase the precision by factor 10 and to reduce the complexity of the solution (map matching will be much simpler). | |
| **Baseline/operational/evaluation data** | As shown in the storyboards before, GNSS and accuracy must be quantified in every specific case to ensure the quality of services required for go to market activities. For the case of green light optimum speed advice and vehicle platooning, the accuracy of the signal must be recorded with corrected and uncorrected GNSS signals. The uncorrected baseline will be recorded during the storyboard 1, 2, 3 and 4, whereas the corrected baseline determination using skylark swift Deutsche Telekom product, will be compared directly in the same test fields. The tests will take place in 2021 as the equipment is not available for cost reasons for some more months. Therefore, the baseline data includes operational data and precise positioning results will be mapped according to the availability of the Skylark Swift equipment. Evaluation will take place comparing pure GNSS signals and corrected Skilark Swift signals. Precise positioning test results will also be used for the KPI data evaluation. | |
| **Action/sub UC / step** | **Description** | **Illustration** |
| **Start and Arrival of the Precise Positioning test trips** | In the figures Figure 84 to the right the parking place is shown. The skylark setup that will be used for precise positioning is illustrated in Figure 83 . Precise will be inside selected floating cars and the measurement has to be decided depending on availability and usability of the equipment. It has to be decided to have floating cars on a taxi base or to use them selected in rental cars depending on the test period foreseen. Requirements for floating cars include a statistically meaningful collection of data sets. | <br>*Figure 82: Intersection illustration for LL Hamburg* |

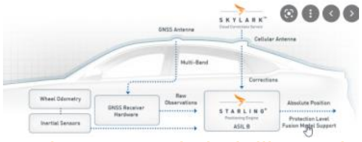
| | | |
|---|---|---|
| **Data collection and post trip data evaluation of Precise Positioning test trips** | Corrected GNSS data sets will be available for T-Systems provided by Swift and Deutsche Telekom. The uncorrected GNSS data will be recorded in LCMM and tec4u databases complemented by Continental IOT GNSS data planned to be ready during the operational phase in 2022. Altogether, 3 uncorrected GNSS data sources (with inaccuracies ranged 3-10m) will be available per storyboard trip, thus measured differences and deviations relative to the corrected GNSS signal will show that an improvement up to 10 cm while using 5G enabled Precise Positioning can be achieved. The related 5G KPI (H-KPI-14) has direct impact to all UC planned to be implement in LL Hamburg. Therefore, the Precise Positioning KPI is of strong horizontal impact with regards to accuracy of the entire LL. | <br>*Figure 83: Skylark illustration LL Hamburg*<br><br>*Figure 84: Parking area for test starts LL Hamburg* |

*Table 17: LL_Hamburg_Storyboard_#6*

## 4.3 KOPER

## LL_KOPER_STORYBOARD_#1

| | |
|---|---|
| **Storyboard ID** | LL_Koper_Story_#1 – MANO 5G IoT |
| **UC** | UC #1 |
| **KPIs** | K-KPI1; K-KPI2; K-KPI3; K-KPI4; K-KPI5; K-KPI6 |
| **Operational data** | Data, describing how fast the 5G IoT backend elements can be ready to use and what service availability for 5G IoT can we expect, will be collected within this storyboard:<br>– Components Onboarding and Configuration (5G IoT backend): elapsed time from the beginning of component configuration and onboarding process via the orchestrator until the components are ready to deploy,<br>– Deployment Time (5G IoT backend): elapsed time from the moment the deployment is started via the orchestrator until the system is ready to use,<br>– Time to Scale (5G IoT backend): elapsed time from the moment the scaling request is triggered until the component is scaled and ready to use,<br>– Service Availability (5G IoT backend): percentage of successful connection tests (RTT) and service tests (WEB) to the reference service endpoint over a period of time,<br>– Components Onboarding and Configuration (agent): elapsed time from the beginning of component configuration and onboarding process via the orchestrator until the components are ready to deploy,<br>– Deployment Time (agent): elapsed time from the moment the deployment is started via the orchestrator until the system is ready to use.<br>Data will be collected by monitoring several system, network and application parameters. |
| **Targeted results** | During the preparation and definition of the UC and KPIs, certain expectations have been set in terms of what should be recognized as success regarding the operational data evaluated within this storyboard:<br>– Components Onboarding and Configuration (5G IoT backend): 5 min per single component,<br>– Deployment Time (5G IoT backend): 15 min,<br>– Time to Scale (5G IoT backend): 5 min,<br>– Service Availability (5G IoT backend): 99,99 %,<br>– Components Onboarding and Configuration (agent): 3 min per single component,<br>– Deployment Time (agent): 10 min. |
| **Data evaluation** | Evaluation will be based on comparing data collected vs. targeted results. In case of targeted results not met, further optimizations of the setup will be explored, e.g. onboarding procedures, configurations, etc. |
| **Action/sub-UC / step** | **Description** |
| **Test procedure specification** | Specify the process for each KPI to be tested and evaluated:<br>– specify test-flow for each KPI test<br>specify prerequisites for each test-flow (e.g., sufficient environment capabilities, other components and support tools readiness, etc.)<br>– specify how to check that the test has completed successfully or not (e.g. component has been successfully onboarded and configured)<br>– define points in the process representing start and stop time regarding the KPI metrics introduced<br>– specify the method for checking/monitoring service availability (with regard to “service availability” KPI)<br>– specify how to extract start, stop time and service availability from the OSM/orchestrator log files (or any other source in case approach proposed may prove inefficient) |

| | |
|---|---|
| | – specify further data processing of data captured and extracted |
| **Test procedure preparation** | – Provide the environment and all prerequisites required<br>– Prepare tools required for the test-flow execution<br>– Check that the environment is up and running |
| **Test procedure execution** | – Check that OSM/orchestrator logging service and other components required for the test to start are up and running<br>– Start the test-flow<br>– When completed, check for the successfulness of the test<br>– Continue with the post-test tasks – data extraction and evaluation |
| **Collecting data** | Logs from OSM orchestrator will be used as source. Relevant data will be extracted and stored in Koper LL database. Data can be further exported into various formats, transferred to another database (e.g., ELK-based 5G-LOGINNOV data repository) or to business analytics tools such as Grafana or Tableau in order to be further processed and evaluated. |

*Table 18: LL_Koper_Storyboard_#1*

# LL_KOPER_STORYBOARD_#2

| | |
|---|---|
| **Storyboard ID** | LL_Koper_Story_#2 – MANO 5G SA network |
| **UC** | UC #1 |
| **KPIs** | K-KPI7; K-KPI8; K-KPI9; K-KPI10; K-KPI11 |
| **Operational data** | Data, describing how fast the 5G SA network components can be ready to use, reconfigured, scaled, and what network service availability we expect, will be collected within this storyboard:<br>– Components Onboarding and Configuration (5G CN and 5G BBU): elapsed time from the beginning of component configuration and onboarding process via the OSM orchestrator until the components are ready to deploy,<br>– Deployment Time (5G CN and 5G BBU): elapsed time from the moment the deployment is started via the OSM orchestrator until the system is ready to use,<br>– Time to Scale (5G CN and 5G BBU): elapsed time from the moment the scaling request is triggered until the component is scaled and ready to use,<br>– Service Availability (5G CN and 5G BBU): percentage of successful connection tests (RTT) and BW tests (Iperf) to the reference service endpoint over a period of time,<br>– Slice Reconfiguration (5G CN and 5G BBU): elapsed time from the moment the slice reconfiguration is requested until the slice is reconfigured and ready to use. |
| **Targeted results** | During the preparation and definition of the UC and KPIs, certain expectations have been set in terms of what should be recognized as success regarding the operational data evaluated within this storyboard:<br>– Components Onboarding and Configuration (5G CN and 5G BBU): 10 min per single component,<br>– Deployment Time (5G CN and 5G BBU): 20 min,<br>– Time to Scale (5G CN and 5G BBU): 10 min,<br>– Service Availability (5G CN and 5G BBU): 99,99 %,<br>– Slice Reconfiguration (5G CN and 5G BBU): 5 min. |
| **Data evaluation** | Evaluation will be based on comparing data collected vs. targeted results. In case of targeted results not met, further optimizations of the setup will be explored, e.g. onboarding procedures, configurations, etc. |
| **Action/sub-UC / step** | **Description** |
| **Test procedure specification** | Specify the process for each KPI to be tested and evaluated:<br>– specify test-flow for each KPI test<br>– specify prerequisites for each test-flow (e.g. sufficient environment capabilities, other components and support tools readiness, etc.)<br>– specify how to check that the test has completed successfully or not (e.g. slice has been successfully reconfigured)<br>– define points in the process representing start and stop time regarding the KPI metrics introduced<br>– specify the method for checking/monitoring service availability (with regard to "service availability" KPI)<br>– specify how to extract start, stop time and service availability from the OSM orchestrator log files (or any other source in case approach proposed may prove inefficient)<br>– specify further data processing of data captured and extracted |
| **Test procedure preparation** | – Provide the environment and all prerequisites required<br>– Prepare tools required for the test-flow execution<br>– Check that the environment is up and running |

| | |
|---|---|
| **Test procedure execution** | – Check that OSM orchestrator logging service and other components required for the test to start are up and running<br>– Start the test-flow<br>– When completed, check for the successfulness of the test<br>– Continue with the post-test tasks – data extraction and evaluation |
| **Collecting data** | Logs from OSM orchestrator will be used as source for KPI collection. Relevant data will be extracted and stored in Koper LL database. Data can be further exported into various formats, transferred to another database (e.g., ELK-based 5G-LOGINNOV data repository) or to business analytics tools such as Grafana or Tableau in order to be further processed and evaluated. |

*Table 19: LL_Koper_Storyboard_#2*

# LL_KOPER_STORYBOARD_#3

<table>
<tr><td>Storyboard ID</td><td colspan="2">LL_Koper_Story_#3 – 5G drive test in Koper LL</td></tr>
<tr><td>UC</td><td colspan="2">UC #1</td></tr>
<tr><td>KPIs</td><td colspan="2">K-KPI12; K-KPI13; K-KPI14; K-KPI15; K-KPI16; K-KPI17; K-KPI18</td></tr>
<tr><td>Baseline data</td><td colspan="2">The (5G NR) radio network planning will be based on certain assumptions that should suffice performances required by the Koper LL use cases. These parameters will be specified before 5G network deployment:<br>– <u>Area Traffic Capacity</u>: The total traffic throughput served per geographic area (in bps/m2),<br>– <u>Connection Density</u>: The total number of connected and/or accessible devices per unit area (per km2),<br>– <u>Coverage Area Probability</u>: The percentage (%) of the area under consideration, in which a service is provided by the mobile radio network to the end user in a quality (i.e., data rate, latency, packet loss rate) that is sufficient for the intended application.</td></tr>
<tr><td>Operational data</td><td colspan="2">Drive tests will provide a detailed insight into (dynamic) conditions in the field. It is expected that conditions within the majority of the area of interest covered by 5G network can be rated this way. The following key network parameters/KPIs will be observed:<br>– <u>Availability</u>: percentage of successful network connection tests (RTT) and application tests (WEB) to the reference service endpoint over a period of time,<br>– <u>Bandwidth</u>: uplink and downlink bandwidth measured from the end user device (5G UE) on 5G RAN to the reference server located in 5G core,<br>– <u>End-to-End Latency</u>: measured round trip time (RTT) from the moment the ICMP Echo Request packet leaves the source host until the ICMP Echo Reply is received from the destination host,<br>– <u>Reliability</u>: the percentage (%) of the amount of sent network layer packets successfully delivered to a given system node (incl. the UE) within the time constraint required by the targeted service, divided by the total number of sent network layer packets.</td></tr>
<tr><td>Data evaluation</td><td colspan="2">Evaluation will be based on comparing data collected vs. targeted results. In case of targeted results not met, further optimisations of the setup will be explored, e.g. 5G RAN optimization.</td></tr>
<tr><td>Action/sub-UC / step</td><td colspan="2">Description</td></tr>
<tr><td>Test procedure specification</td><td>• Specify qMON test modules needed to collect required data<br>• Specify qMON system components and configurations<br>• Specify reference server capabilities required for qMON<br>• Specify test client devices<br>• Specify test drive track(s)<br>• Specify test drive schedule (dates/times), specify expected test vehicle velocity, etc.</td><td><br>Figure 85: Targeted 5G network area LL Koper<br>(map source Google)</td></tr>
</table>

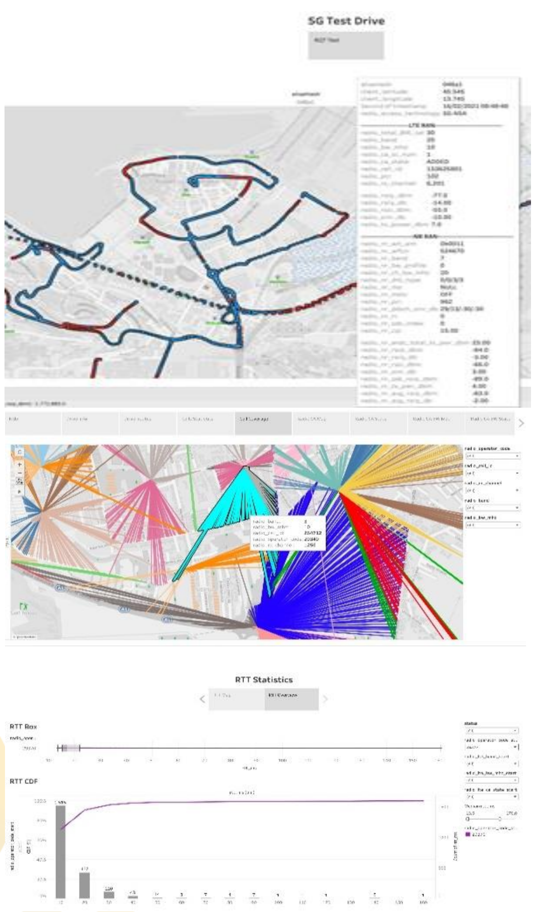
| | | |
|---|---|---|
| | | <br>Figure 86: qMON System components with 5G test modules |
| **Test procedure preparation** | • Prepare, install and configure qMON system components (Reference servers, Collector, Management)<br>• Prepare qMON agent on 5G UE, use appropriate 5G-enabled USIM card<br>• Mount test equipment into the test vehicle, check that all requirements are met<br>• Test/verify that the qMON system setup is set correctly (check that data are recorded and transferred to the Collector when qMON agent is running) | |
| **5G drive test execution** | • Start qMON system (power on qMON Agent)<br>• Verify that tests are performed<br>• Start with the drive test, stick to the drive track, maintain velocity as specified<br>• Stop the qMON system when arriving at the end of the planned track | |
| **Collecting and evaluating data** | Data are transferred from the qMON agent to the qMON Collector in (near) real-time and can be further exported into various formats, transferred to another database (e.g. ELK-based 5G-LOGINNOV data repository) or to business analytics tools such as Grafana or Tableau in order to be further processed and evaluated. | <br>Figure 87: Representation of 5G Drive testing KPI collected by qMON LL Koper – 5G coverage, cell coverage and RTT as CDF distribution |

Table 20: LL_Koper_Storyboard_#3

# LL_KOPER_STORYBOARD_#4

| | |
|---|---|
| **Storyboard ID** | LL_Koper_Story_#4 – 5G Network continuous testing in Koper LL (using qMON) |
| **UC** | UC #1 |
| **KPIs** | K-KPI12; K-KPI13; K-KPI14; K-KPI15; K-KPI16; K-KPI17; K-KPI18 |
| **Baseline data** | The (5G NR) radio network planning will be based on certain assumptions that should suffice performances required by the Koper LL use cases. These parameters will be specified before 5G network deployment:<br>– Area Traffic Capacity: The total traffic throughput served per geographic area (in bps/m2),<br>– Connection Density: The total number of connected and/or accessible devices per unit area (per km2),<br>– Coverage Area Probability: The percentage (%) of the area under consideration, in which a service is provided by the mobile radio network to the end user in a quality (i.e., data rate, latency, packet loss rate) that is sufficient for the intended application. |
| **Operational data** | Continuous testing will give us an insight of how conditions are changing in the field. Based on key parameters/KPIs monitored on several Koper LL locations, short- and long-term changes will be detected, evaluated and may possibly affect the network optimization process:<br>– Availability: percentage of successful connection tests (RTT)/ service tests (WEB) to the reference service endpoint over a period of time,<br>– Bandwidth: uplink and downlink bandwidth measured from the end user device (5G UE) on 5G RAN to the reference server located in 5G core,<br>– End-to-End Latency: measured round trip time (RTT) from the moment the ICMP Echo Request packet leaves the source host until the IP ICMP Echo Reply is received from the destination host,<br>– Reliability: the percentage (%) of the amount of sent network layer packets successfully delivered to a given system node (incl. the 5G UE) within the time constraint required by the targeted service, divided by the total number of sent network layer packets. |
| **Data evaluation** | Evaluation will be based on comparing data collected vs. targeted results. In case of targeted results not met, further optimizations of the setup will be explored, e.g., 5G RAN optimization. |
| | |
| **Action/sub-UC / step** | **Description** |
| **Test procedure specification** | – Specify qMON test modules needed to collect required data<br>– Specify qMON system components and configurations<br>– Specify server capabilities required for qMON<br>– Specify test client devices<br>– Specify physical locations for continuous testing (also pay attention on physical and legal feasibility of mounting devices)<br>– Specify testing schedule (e.g. data capture cadence, start and stop data capturing, etc.)<br>– Specify continuous<br><br>Figure 88: Targeted LL area LL Koper (map source Google) |

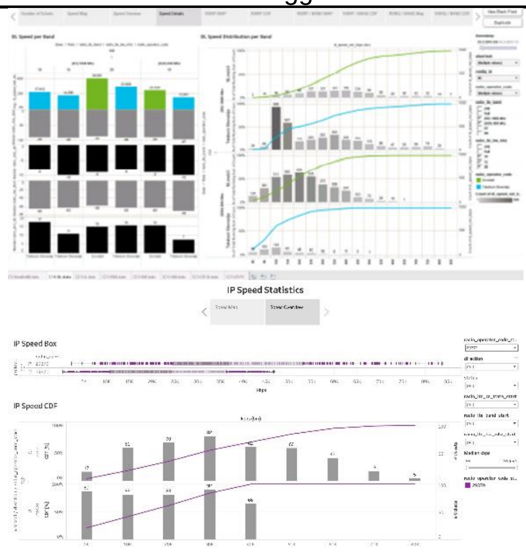
| | | |
|---|---|---|
| | monitoring of the tests and recovery procedures in case tests are failing, i.e., tests need to run on all devices continuously and without interruption |  Figure 89: qMON NetworkSesnsor for 5G KPI collection in active and passive mode |
| **Test procedure preparation** | – Prepare – install and configure qMON components (Reference servers, Collector, Management)<br>– Prepare qMON agent on 5G UE, use appropriate 5G enabled USIM card<br>– Mount test equipment to the locations specified, check that all requirements are met<br>– Test/verify that the qMON system setup is set correctly (check that data are recorded and transferred to the Collector when qMON agent is running) | |
| **5G network continuous testing execution** | – Start qMON system (power on qMON Agent)<br>– Start qMON system<br>– Verify that tests are performed<br>– Monitor that tests on all test devices are running as expected and act according to the recovery procedure in case alarm is triggered | |
| **Collecting and evaluating data** | Data are transferred from the qMON agent to the qMON Collector in (near) real-time and can be further exported into various formats, transferred to another database (e.g. ELK-based 5G-LOGINNOV data repository) or to business analytics tools such as Grafana or Tableau in order to be further processed and evaluated. |   Figure 90: Representation of data collected by qMON LL Koper – collected KPI prepared as CDFs, Histograms, Box Plots |

*Table 21: LL_Koper_Storyboard_#4*

5GLOGINNOV

# LL_KOPER_STORYBOARD_#5

| | |
|---|---|
| **Storyboard ID** | LL_Koper_Story_#5 – Conti IoT device data collection |
| **UC** | UC 5 |
| **KPIs** | K-KPI25-29 |
| **Operational data** | Data collected by Continental IoT devices installed in vehicles operating within Luka Koper port range:<br>– GNSS information collected internally by devices (including position, speed, acceleration etc.),<br>– Data collected from vehicles CAN Bus (e.g. fuel consumption). |
| **Targeted results** | – Collect and monitor evolution of targeted KPIs, also check impact of certain measures on KPIs |
| **Data evaluation** | Collected data will be evaluated on a continuous basis, to see the progress of collected KPIs (e.g. reduction in fuel consumption compared to beginning of evaluation) |
| | |
| **Action/sub-UC / step** | **Description** |
| **Test procedure specification** | – Specify Conti backend requirements and minimal specs of equipment on which it will be installed<br>– Specify type of vehicles used in test<br>– Specify installation procedure and prerequisites |
| **Test procedure preparation** | – Configure IoT device and install in targeted vehicle<br>– Install Conti backend in Luka Koper port IT infrastructure |
| **Test procedure execution** | – Perform test drives with the targeted vehicles<br>– No interaction with the IoT device is required |
| **Collecting data** | The Continental IoT device records data collected from the vehicle and data internally generated (e.g. GNSS information) and transfers the data live to the IT infrastructure. |

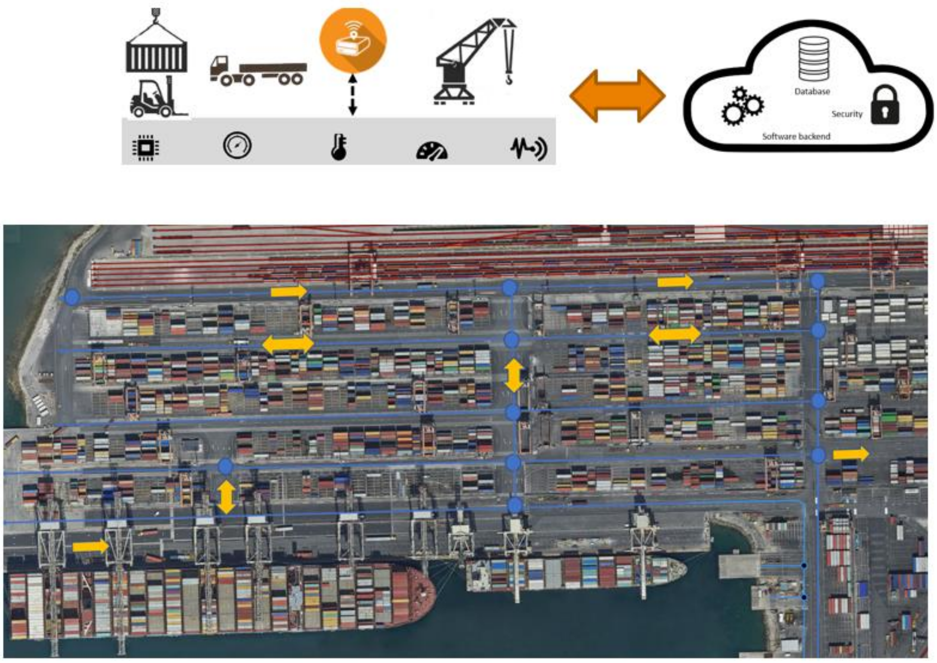
| | |
|---|---|
| |   Figure 91: Port loading/Unloading<br>LL Koper |

*Table 22: LL_Koper_Storyboard_#5*

# LL_KOPER_STORYBOARD_#6

| | |
|---|---|
| **Storyboard ID** | LL_Koper_Story_#5 – Optical Character Recognition of container markings and Container Damage Detection (Koper LL) |
| **Title** | 5G-LOGINNOV Automation for Ports: Port Control, Logistics and Remote Automation (Container OCR and Damage Detection) |
| **UC** | UC5 |
| **KPIs** | K-KPI19 - Model accuracy/reliability<br>K-KPI20 - Model Inference Time |
| **Baseline data** | UC5 is based on advanced video analytics. The baseline data for the KPIs for UC5 (Container OCR and Damage Detection) will be set out as person-hours allocated to a worker to manually perform inbound/outbound traffic check procedures. The baseline data refers to transhipment operations at the Container terminal in Koper.<br><br>To evaluate K-KPI19 - Model accuracy/reliability, the baseline will be compared with a dataset annotated manually to be used as ground truth. Model accuracy/reliability means ratio of success of the computer vision model for detection of container damages.<br>To evaluate K-KPI20 - Model Inference Time, the baseline will be compared with the processing time for the data acquired from STS cameras and port operations plans (e.g. stowage or discharge plan). Model inference time means time to analyze each image.<br><br>STS crane will be equipped with industrial cameras for capturing and transferring of UHD streams to the cloud-based video analytics system for identification of container markers and detection of structural damage of containers using advanced AI/ML based video processing techniques. Targeted STS crane will have up to 5 cameras installed for capturing UHD images of containers being transhipped from/to a vessel. Cameras will cover at least 4 different container angles (surfaces) - left, right, front, and door side. Collected information (images) will be transferred through 5G NSA network to the Koper LL backend system for further image processing (Optical Character recognition, Container doors direction, IMDG label identification, etc.). Results of video-analytics and the supporting data will be made available to other port operating systems.<br><br>In addition, STS crane will be equipped with up to 4 cameras for container damage detection. Images of containers being transhipped from a vessel will be analysed for possible heavy container structural damages or deformations. Collected information (images received from cameras) will be transferred to Koper LL backend system for further image analysing (damage detection). Results of video-analytics and the supporting data will be made available to other port operating systems.<br><br>State of play:<br><br>The working process is done manually. An employee (so-called tallyman) checks container markings and doors direction of each container being loaded to a vessel. For the discharged containers, besides container markings, also presence of IMDG labels, seal presence and other attributes are checked. In addition, tallyman performs visual check of containers being discharged from a vessel, giving emphasis on possible structural damages. At the last stage, the tallyman manually enters number of the dedicated yard truck, on which the container(s) are loaded. All the data obtained from the visual inspection are manually entered to the terminal operating system (TOS) using the industrial tablet (figure 89). |

| | |
|---|---|
| | <br>Figure 92 Industrial tablet, LL Koper<br><br>Currently, it takes about 15 seconds for the tallyman to enter the data to the TOS system (container ID, ISO code, IMDG label, yard truck number, etc.). In parallel, it takes up to 30 seconds for another worker to do the container inspection for possible damages and the seal presence check. The two activities mostly run in parallel, which means that on average it takes about 25 seconds per container. In case of twin moves (two containers at the same time), up to 30 seconds are needed to do the necessary checks. Delays attributed to manual inspection of containers are directly related to unnecessary waiting times (STS crane idling, unevenly distributed movements on the yard, etc.). |
| **Operational data** | The operational data for UC5 (Container OCR and damage detection) will be derived from the terminal database and from the transhipment capacity database, which are part of the terminal operating system. All the information obtained will be compared with the data collected by STS cameras and processed by the back-end system. |
| **Evaluation data** | Evaluation will be primarily based on assessing video stream quality in terms of being good enough to be used for the OCR system purposes. MOS value of 3 will represent a minimum video quality requirement; MOS value 5 will present the best expected performance. Other data collected (image and video stream context) will be analyzed and used for further evaluation/assessment of the introduced solution. These data are not in the scope of the 5G-LOGINNOV project end they will not be revealed. |
| **Action/sub UC / step** | **Description** |
| **Selection of 5G-IoT device and deployment locations** | The figures below show locations where 5G devices and components used for data collection will be installed, including 5G-IoT supporting devices for UC5 activities described in other storyboards for LL Koper (i.e., telematics devices installed on trucks for gathering engine operating data, devices for transmission of working instructions for truck drivers over the 5G NSA, etc.).<br><br>In Koper LL, the STS crane designated as KD60, located at Pier I will be used to deploy 5G-IoT devices and perform trials that will then allow 5G KPIs to be evaluated (figure 87). |

Figure 90: Port of Koper - Pier I: Location of  STS crane KD 60

Figure 88 shows STS crane at Container terminal in Port of Koper to be employed for 5G-IoT device deployment and trials execution of UC5 in Koper LL.

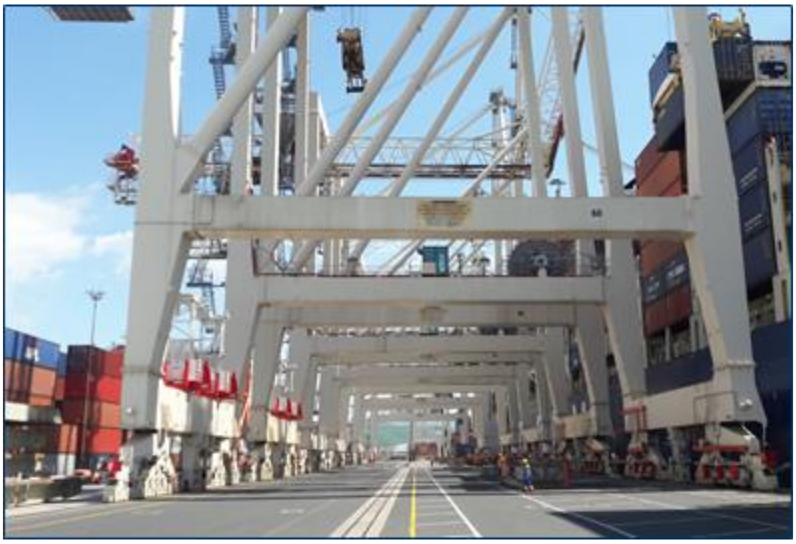
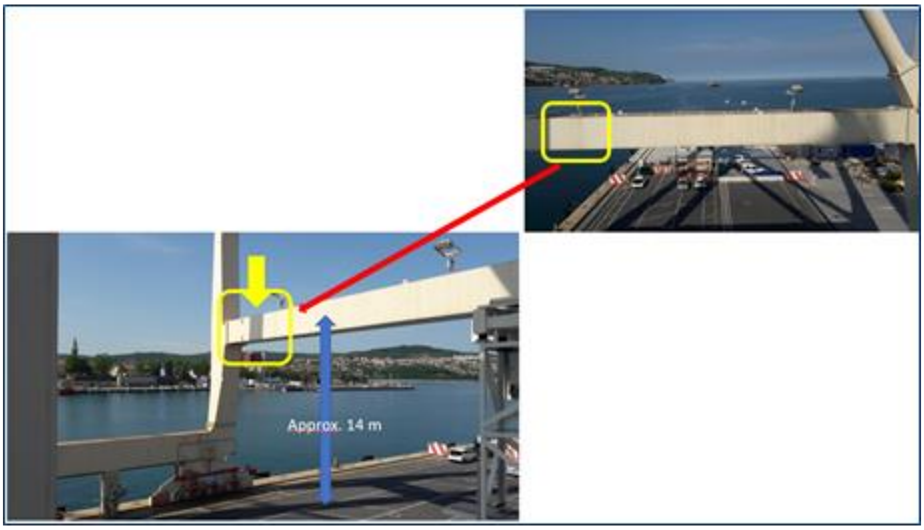
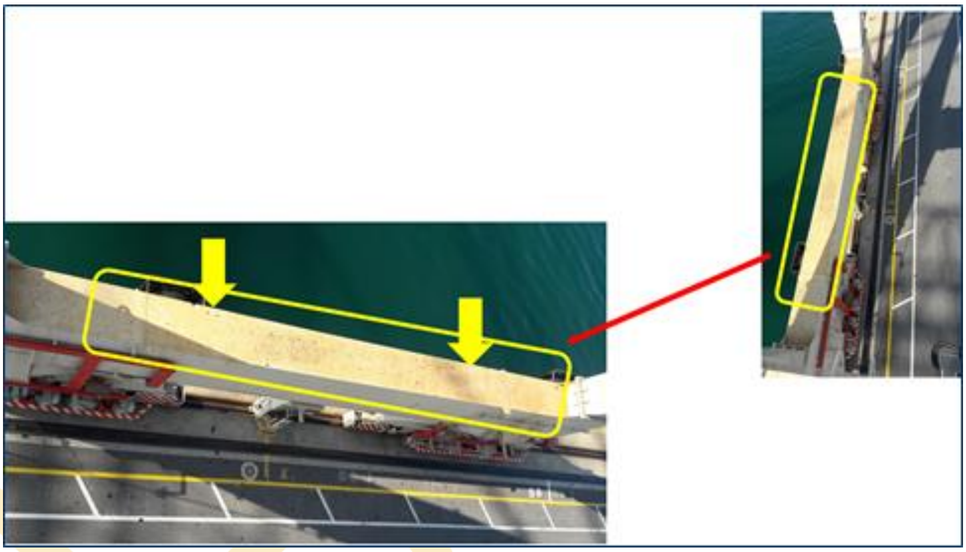
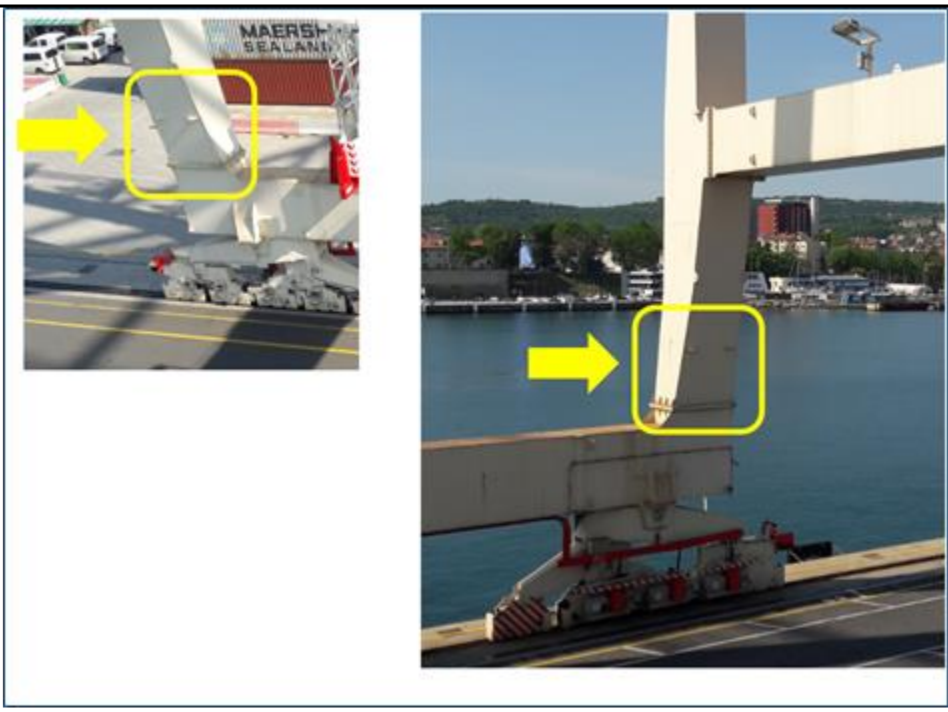
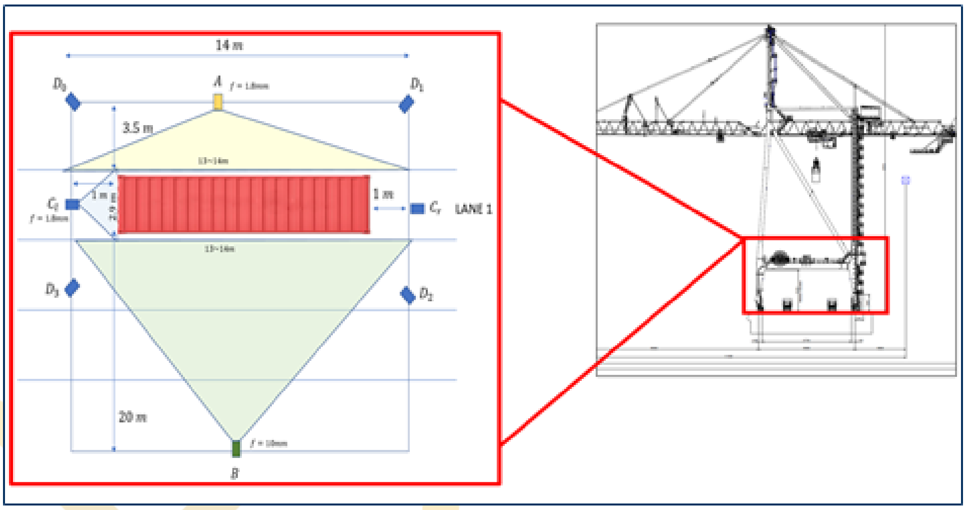


Figure 91: STS crane KD 60 (side view)

Figure 89 shows cabins for employees (for the tallyman), who performs manual checks of each transhipped container from/to a vessel. The scope of activities performed by the worker under the STS crane is presented in the Baseline data section.


Figure 89: STS crane KD 60 – tallyman cabins in Koper LL (right - elevated position of the cabin; left - ground position of the cabin)

| | |
|---|---|
| **5G-IoT device placement on STS crane; NFV-MANO enabled far-edge computing service operation for container seal detection** | Cameras, 5G-IoT devices and supporting components will be installed on the STS crane. Gathered information (video stream) will be transmitted over 5G NSA to the LL Koper backend system for processing.<br><br>Cameras for the **OCR activity** will be mounted on the crane's horizontal beams – two cameras on the lower crane beams (figure 90), which are positioned parallel to quay, and two cameras on the upper horizontal crane beams (figure 91), which are positioned perpendicular to quay.<br><br><br><br>Figure 90: STS crane KD 60 – upper horizontal crane beams and the planned locations for mounting cameras for the OCR activity (indicated by yellow shape)<br><br><br>Figure 91: STS crane KD 60 – lower horizontal crane beams (at sea-side rail) and the planned locations for mounting cameras for the OCR activity (yellow shape)<br><br>Cameras for **Damage detection activity** will be mounted on the crane's corner positions to simultaneously cover two angles of each transhipped container (figure 92). |

| | |
|---|---|
| | <br>Figure 92: STS crane KD 60 – crane corner positions<br><br>Backend system devices will receive input video stream for the video-analytics for both tasks - container markers recognition (OCR) and the damage detection. Performance of the computer vision / video-analytics algorithms will depend on camera locations to provide video streams from multiple views and angles. Figure 93 illustrates positions for cameras, where positions A, B and C indicate planned positions for OCR cameras, while D positions present planned locations for damage detection cameras.<br><br><br>Figure 93: Schematic overview of STS crane cameras deployment, UC5, LL Koper |
| **Data Collection** | The collected data will be transmitted over the 5G NSA to Koper LL database for processing. Results of the analyzed and processed data, namely OCR readings and damage detections will be made available to the terminal operating system. UHD video streams will be stored for possible future cargo-damage claims. Personnel will have access to the video-stream for operations purposes.<br><br>Figure 94 illustrates an example of data (container markings) that will be subject to optical character recognition. |

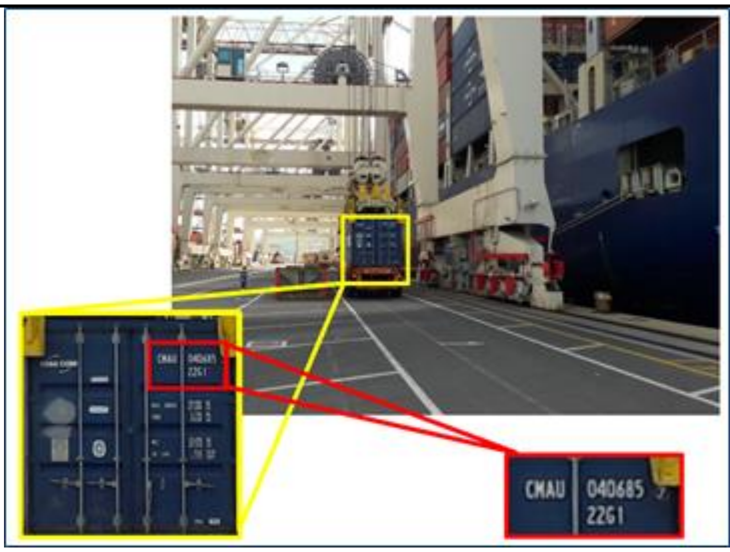



Figure 94: Container markings subject to OCR, UC5, Koper LL

During the implementation phase of the 5G-LOGINNOV project, the 5G NSA network will be used also for testing the transmission of operational data between the TOS system and horizontal machinery (UTRs, forklifts, etc.). The information exchanged serves primarily to provide work instructions to machinery operators, which are displayed on the industrial tablet in the vehicle cabin. Information received is essential for drivers to know their working task (e.g. where on terminal to drive for loading a container, which container to pick, where to drive for unloading, etc.). Delays on reception of data has significant impact on operations processes (congestions, extended planned completion time, etc.), which could be caused by network failure. 5G NSA network will therefore be tested as a redundancy to the existing WIFI network.

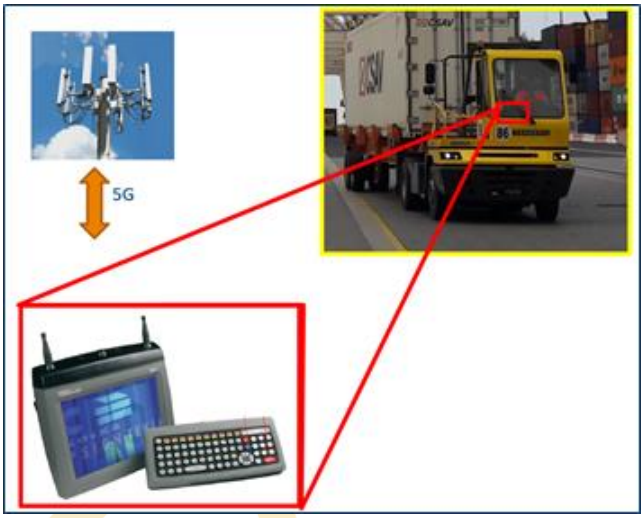
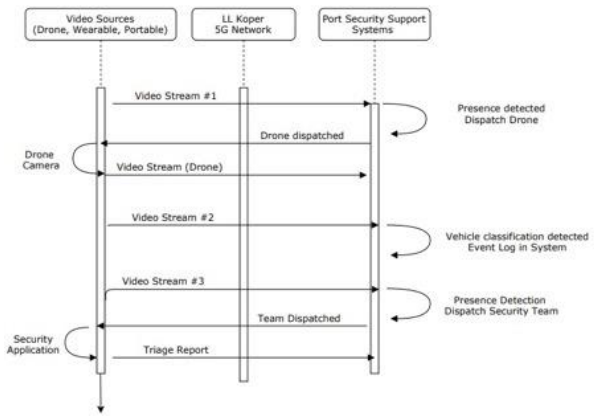


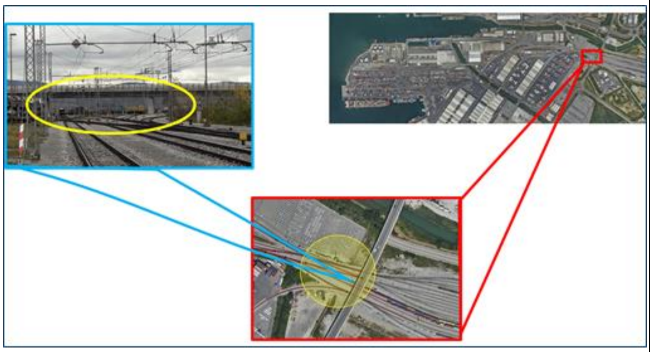

Figure 95: UTR vehicle and the industrial tablet, Koper LL

*Table 23: LL_Koper_Storyboard_#6*

# LL_KOPER_STORYBOARD_#7

| | |
|---|---|
| **Storyboard ID** | LL_Koper_Story_#7 – Drone and body worn camera based video streaming |
| **UC** | UC #6 |
| **KPIs** | For the storyboard evaluation subjective metrics will be used to evaluate functional operation of the system and live video stream user quality (e.g. video MOS scoring from 1 to 5). As such, no technical (measurable) KPIs have been defined for the particular Storyboard. |
| **Baseline data** | Storyboard is targeting part of the UC 6 activities, where several novel technologies and procedures related to the port security operation will be introduced to the LL Koper. A real-time video surveillance will be implemented using 5G-enabled body-worn cameras carried by security personnel to support their regular and mission critical operations and to provide additional personnel security. In addition, automated and coordinated drone-based surveillance will be implemented for extended ad-hoc video surveillance support, where 5G network will be used to transfer video streams in real time to the port Security Operation Centre. |
| **Operational data** | Storyboard deployment and operation will be performed in several stages following an iterative approach. First installation and integration of several types and form-factors of the video sources (e.g. wearable cameras, drone-based cameras) will be introduced and connected to available 5G capabilities in the LL Koper. Based on the defined security scenario, captured video streams from the deployed video sources will be transferred in real time over the deployed 5G system to be available or used by different security and operational support systems inside the Koper LL. |
| **Targeted results** | Final goal of the verification process is to evaluate, from the operational perspective, new security capabilities introduced to Koper LL with the following targets:<br>- Real-time video surveillance will be enhanced using body-worn cameras and drone-based video streaming.<br>- Private security operation management and support will be enhanced.<br>As part of the evaluation results, smooth video stream (drone-based or body worn camera) with assured video stream user quality is required and will be subjectively scored (MOS 1 to 5) by the security personnel. This information will serve as an input to evaluate possible enhancements of the established and newly introduced security procedures that are assured with drones or body worn cameras. Used security operational procedures are not in the scope of the 5G-LOGINNOV project end they will not be revealed. |
| **Data evaluation** | Evaluation will be primarily based on assessing video stream quality in terms of being good enough to be used by the security operation centre personal. MOS value of 3 will represent a minimum video quality requirement; MOS value 5 will present the best expected performance. On the other hand, (other) data collected (image and video stream context) will be analyzed and used for further evaluation/assessment of the introduced solution. These data are not in the scope of the 5G-LOGINNOV project end they will not be revealed. |
| **Action/sub UC / step** | **Description** |

| | | |
|---|---|---|
| **Test procedure specification** | - Specify security operational flow that includes body worn and drone-based video streaming<br>- Specify video streaming protocols, application(s) and video stream requirements (resolution, frames per second, buffering, etc.) for pre-set profiles (e.g. low, medium, high for mobile devices, computers or dashboards)<br>- Specify video proxy component (e.g. VNF/CNF) requirements<br>- Specify drone video proxy capable mobile terminal to use as a video proxy between drone and 5G RAN<br>- Specify client devices capable of playing video stream in real-time (e.g. mobile devices, computer and dashboards)<br>- Specify 5G RAN capabilities to support video transmission<br>- Specify drone trajectory, flight schedule (dates/times, arrange flight authorizations), etc. | <br>Figure 93: Example of the security operational flow supported by the drone-based and body worn camera video streaming: LL Koper |
| **Test procedure preparation** | - Prepare, install and deploy video streaming proxy component as a VNF/CNF<br>- Prepare and configure mobile terminal used as video proxy between drone and 5G RAN (use appropriate 5G-enabled USIM card) | |

| | | |
|---|---|---|
| | - Prepare, install and configure client devices to play the live streams from drones<br>- Prepare and deploy 5G RAN components (e.g. VNF/CNF) qMON agent on 5G UE, use appropriate 5G-enabled USIM card | <br><br>Figure 94: Drone remote control connected to 5G UE:<br>LL Koper<br><br>Figure 95: Body worn security camera:<br>LL Koper |
| **Test execution** | Test execution for drone based video streaming<br>- Start video proxy application<br>- Start with the flight according to the schedule, stick to the flight trajectory as required<br>- Verify that video streaming is working on all client devices (e.g. mobiles phones, computers, dashboards)<br>- Stop video streaming applications when arriving at the end of the planned track.<br><br>Test execution for body worn camera video streaming<br>- Start video application and video proxy<br>- Start with the defined security procedure<br>- Verify that video | <br>Figure 96: Arial view of targeted security area (Railway entrance): LL Koper |

| | | |
|---|---|---|
| | streaming is working on all client devices (e.g. mobiles phones, computers, dashboards)<br>- Stop video streaming applications when arriving at the end of the planned security procedure. | |
| **Collecting and evaluating data** | Video stream will be delivered to the client devices depending on the user requirements (e.g. low, medium or high pre-set). | |

*Table 24: LL_Koper_Storyboard_#7*

# LL_KOPER_STORYBOARD_#8

| | |
|---|---|
| **Storyboard ID** | LL_Koper_Story_#8 – AI/ML based video analytics |
| **Title** | 5G-LOGINNOV Mission Critical Communications in Ports: Real-time video surveillance (people and vehicle detection in the controlled area) |
| **UC** | UC 6 |
| **KPIs** | K-KPI21 - Model accuracy/reliability<br>K-KPI22 - Model Inference Time |
| **Baseline data** | UC6 is targeting Mission Critical Communications in Ports. Storyboard #8 is targeting part of the UC6 activities, namely AI/ML based video analytics, where inovative technologies related to port security operations will be introduced to Koper LL.<br><br>Video surveillance will be implemented using UHD cameras covering the railway entrance area to support on-site security operations and to increase security level in the Port of Koper. The baseline data for the UC6 KPIs (Real-time video surveillance) refer to inbound/outbound railway freight traffic (i.e. trains entering the port from the public railway network) and will be set out as number of trainsets pasing the railway entrance.<br><br>To evaluate both k-KPI21 and K-KPI22, a literature review of current state-of-the-art machine learning algorithms for detecting human presence will derive the base line data for both; the time required to process the input of video stream(s) and infer the presence/absence of people (A-KPI21), and the achieved accuracy/reliability of the model with respect to established state-of-the-art approaches for this task (A-KPI22).<br><br>Railway entrance to the port is a controlled area where presence or movement of unauthorized persons is restricted. The targeted area will be covered with industrial UHD cameras for capturing of UHD streams of trainsets passing the controlled area and transferring them to the cloud-based video analytics system for detection of unauthorized entry/exit of persons to the port using advanced AI/ML based video processing techniques.<br>Collected information (video stream, images) will be transferred to the Koper LL backend system for further image processing. Results of video-analytics will be made available to other port operating systems. Video stream will be transferred to the port security operations centre in a real time through the 5G network. |
| **Operational data** | Storyboard deployment and operation will be performed in two stages. First, installation and integration of video sources (UHD cameras and equipment) will be connected to available 5G capabilities in Koper LL. Second, based on the defined security scenario, captured video streams from the deployed video sources will be transferred in real time over the 5G system to be available for further proccesing or to be used by different security and operational support systems in the Koper LL. |
| **Targeted results** | Final goal of the verification process is to evaluate, from the operational perspective, new security capabilities introduced to Koper LL with the following targets:<br>• Real-time video surveillance will be enhanced using UHD cameras video streaming over 5G network.<br>• Security operations management will be enhanced. |
| **Data evaluation** | For the evaluation of results, smooth video stream from surveillance UHD cameras will be required, which will serve as an input for the assessment of possible improvements of the established and newly introduced security procedures that are assured with the new security cameras.<br><br>Evaluation will be primarily based on assessing video stream quality in terms of being good enough to be used by the security operation centre personnel. A 90% accuracy/reliability value will represent a minimum video quality requirement, and an accuracy/reliability value |

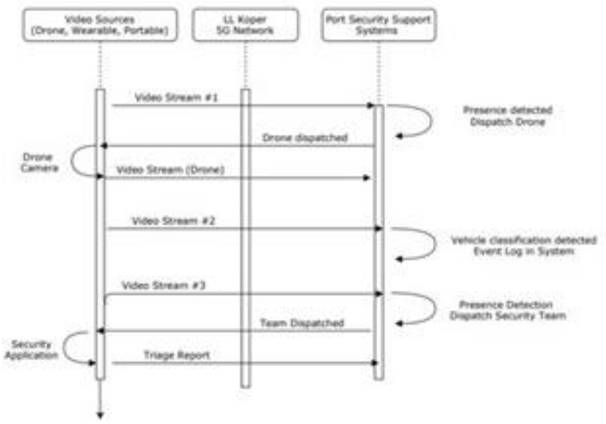
| | |
|---|---|
| | above 98% will present the best expected performance. The information collected relates to security procedures and is subject to internal restrictions and will not be disclosed. |
| **Action/sub UC / step** | **<u>Description</u>** |
| **Test procedure specification** | Security operational flow, which includes UHD surveillance cameras and other video streaming is shown in Figure 84.<br>• <u>video streaming protocols, application(s) and video stream requirements (resolution, frames per second, buffering, etc.)</u><br>• <u>video components and requirements (e.g., VNF/CNF)</u><br>• <u>5G RAN capabilities to support video transmission</u><br><br><br>Figure 84: Example of the security operational flow of video streaming (Koper LL) |
| **Test procedure preparation** | • <u>Prepare, install, and deploy video streaming cameras</u><br>• <u>Configure devices for live video-streams</u><br>• <u>Prepare and deploy 5G RAN components</u> |
| **Test execution** | • <u>Start video application</u><br>• <u>Start with the defined security procedure</u><br>• <u>Verify that video streaming is working on all installed devices</u><br>• <u>Stop video streaming applications when arriving at the end of the planned security procedure.</u><br><br>Figure 85: Arial view of targeted security area (Railway entrance): LL Koper |
| **Collecting and evaluating data** | The collected data (video stream) will be transmitted over the 5G network to Koper LL backend system for processing. Results of the analyzsed data, namely detection of people and vehicle in controled area will be made available to port security systems and will be delivered to the port security control center. UHD video streams will be stored for any future security needs. For day-to-day tasks, security personnel will have permanent access to the live video stream. |

*Table 25: LL_Koper_Storyboard_#8*

# 5 LL INITIAL TRIAL PLANS

The trial planning by each LL will cover the following aspects to visualize and make transparent the status of preparation, execution and data collection by each LL and for each UC.

| Object | Description |
|---|---|
| **Name of the LL** | Name of the LL |
| **Date** | Date of the version edited |
| **Version** | Version of the planning |
| **Storyboard Number** | ID of the storyboard defined for the storyboards |
| **KPI and name of KPI** | ID and name of the related KPI |
| **Number of iterations** | Number of planned iterations |
| **Baseline Data collected** | Date to confirm baseline data for the Storyboard/KPI are collected |
| **Baseline KPI calculated** | Date to confirm baseline data are finally calculated |
| **Baseline data pushed for evaluation** | Data to confirm baseline data are transferred to central data storage |
| **Status UC deployment** | Date to confirm deployment has been finalized for the storyboard |
| **Test setup ready** | Date to confirm test/trial setup has been finalized for the storyboard |
| **Operational data collected** | Date to confirm operational data for the Storyboard/KPI are collected |
| **Operational KPI calculated** | Date to confirm operational data are finally calculated |
| **Operational data pushed for evaluation** | Data to confirm operational data are transferred to central data storage |

Table 26: LL trial -planning objects: Overview

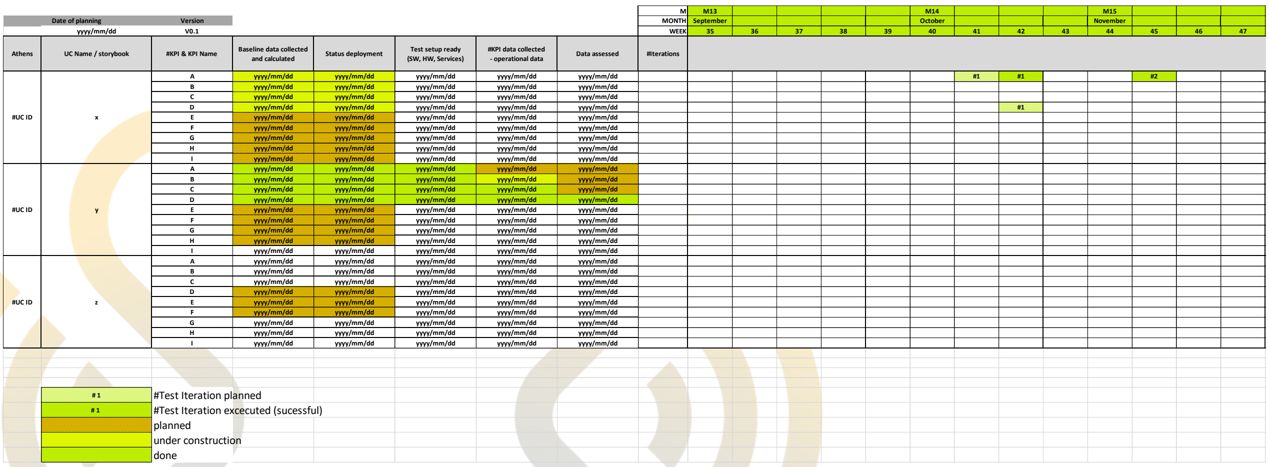



Figure 97: Illustrated template of the LL trial planning sheet

For the initial planning by the LL see Annex 1. Based on this the initial planning these plans will be revised by the LL frequently during the performance of tasks T3.2, T.3.3 and T3.4 – (M10-M32) each related to one LL (Athens, Hamburg, Koper) and the revisions will be documented in deliverable D3.2 'Living Labs trials preparation report' (M22).

# ANNEX 1: WP3 LL INITIAL TRIAL PLANS

The initial planning by the LL is documented within the following Excel file:

5G-LOGINNOV_D3.1_
LL_Trial_Plans_v10.xlsx

# REFERENCES:

D1.4 ‘Initial specification of evaluation and KPI’s’ version V1.4 M12

D2.2 ‘Data collection and evaluation procedures’ M15

D3.2 ‘Living Labs trials preparation report’ M22

D3.5 ‘Evaluation of operation optimization’ M32

D3.6 ‘Evaluation of social, economic and environmental impacts’ M32

ISO/DIS-23795: https://www.iso.org/

5G-LOGINNOV Trial Planning:

| LL | Date | Version | Link |
|---|---|---|---|
| Athens | 31.08.2021 | V1.0 | Goto Athens |
| Hamburg | 31.08.2021 | V1.0 | Goto Hamburg |
| Kopper | 31.08.2021 | V1.0 | Goto Koper |

| Color Code | Meaning |
|---|---|
| **# 1** | #Test Iteration planned |
| **# 1** | #Test Iteration excecuted (sucessful) |
| | planned |
| | under construction |
| | done |
| | na (not applicable) |

| Date of planning | Version |
|---|---|
| 31.08.2021 | V1.0 |

| | |
|---|---|
| M | M13 |
| MONTH | September |
| WEEK | 35 |

Content: date (yyyy/mm/dd), na (not applicable)

| Athens | UC Name / storybook | #KPI & KPI Name | Baseline data collected | Baseline calculated | Baseline data pushed fro evaluation | Status UC deployment | Test setup ready (SW, HW, Services) | Operational data collected | Operational KPIs calculated | Data pushed for evaluation | #Iterations | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #UC 2 | Device Management Platform Ecosystem | A-KPI1: CO2 Emissions | 31.01.2022 | 31.01.2022 | | 31.01.2022 | 28.02.2022 | 10.06.2022 | 15.06.2022 | 20.06.2022 | 3 | |
| | | A-KPI2: Fuel Consumption | 31.01.2022 | 31.01.2022 | | 31.01.2022 | 28.02.2022 | 10.06.2022 | 15.06.2022 | 20.06.2022 | 3 | |
| | | A-KPI5: Percent of Empty Containers Runs | 31.01.2022 | 31.01.2022 | | 31.01.2022 | 28.02.2022 | 10.06.2022 | 15.06.2022 | 20.06.2022 | 3 | |
| | | A-KPI6: Mean time of container job | 31.01.2022 | 31.01.2022 | | 31.01.2022 | 28.02.2022 | 10.06.2022 | 15.06.2022 | 20.06.2022 | 3 | |
| | | A-KPI7: Time needed the device to open a network connection | 31.01.2022 | 31.01.2022 | | 31.01.2022 | 28.02.2022 | 10.06.2022 | 15.06.2022 | 20.06.2022 | 3 | |
| | | A-KPI25: End-to-end Latency | 31.01.2022 | 31.01.2022 | | 31.01.2022 | 28.02.2022 | 10.06.2022 | 15.06.2022 | 20.06.2022 | 3 | |
| | | A-KPI26: One-way Latency | 31.01.2022 | 31.01.2022 | | 31.01.2022 | 28.02.2022 | 10.06.2022 | 15.06.2022 | 20.06.2022 | 3 | |
| #UC 3 | Optimal selection of yard trucks | A-KPI1: CO2 Emissions | 2022/01/31 | 2022/01/31 | | 2022/01/31 | 2022/02/28 | 2022/06/10 | 2022/06/15 | 2022/06/20 | 3 | |
| | | A-KPI2: Fuel Consumption | 2022/01/31 | 2022/01/31 | | 2022/01/31 | 2022/02/28 | 2022/06/10 | 2022/06/15 | 2022/06/20 | 3 | |
| | | A-KPI3: Truck Travel Distance | 2022/01/31 | 2022/01/31 | | 2022/01/31 | 2022/02/28 | 2022/06/10 | 2022/06/15 | 2022/06/20 | 3 | |
| | | A-KPI4: Assets Idling | 2022/01/31 | 2022/01/31 | | 2022/01/31 | 2022/02/28 | 2022/06/10 | 2022/06/15 | 2022/06/20 | 3 | |
| | | A-KPI25: End-to-end Latency | 2022/01/31 | 2022/01/31 | | 2022/01/31 | 2022/02/28 | 2022/06/10 | 2022/06/15 | 2022/06/20 | 3 | |
| | | A-KPI26: One-way Latency | 2022/01/31 | 2022/01/31 | | 2022/01/31 | 2022/02/28 | 2022/06/10 | 2022/06/15 | 2022/06/20 | 3 | |
| #UC 4 | Optimal surveillance cameras and video analytics | A-KPI8: Human resource optimization (person-hours) | 2022/01/31 | 2022/01/31 | | 2022/03/31 | 2022/04/30 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI9: Model Inference Time (Human Presence) | 2022/01/31 | 2022/01/31 | | 2022/03/31 | 2022/04/30 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI10: Mode Accuracy/Realiability (Human Presence) | 2022/01/31 | 2022/01/31 | | 2022/03/31 | 2022/04/30 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI11: User Experienced Data Rate | 2022/01/31 | 2022/01/31 | | 2022/03/31 | 2022/04/30 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI12: Deployment Time (Human Presence) | 2022/01/31 | 2022/01/31 | | 2022/03/31 | 2022/04/30 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI26: One-way Latency | 2022/01/31 | 2022/01/31 | | 2022/03/31 | 2022/04/30 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| #UC 5 | Automation for ports: port control, logistics and remote automation | A-KPI8: Human resource optimization (person-hours) | 2022/01/31 | 2022/01/31 | | 2022/03/31 | 2022/04/30 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI14: Model Inference Time (Container Seal) | n/a | n/a | | 2022/03/31 | 2022/04/30 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI15: Mode Accuracy/Realiability (Container Seal) | n/a | n/a | | 2022/03/31 | 2022/04/30 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI11: User Experienced Data Rate | n/a | n/a | | 2022/03/31 | 2022/04/30 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI12: Deployment Time (Container Seal) | 2022/01/31 | 2022/01/31 | | 2022/03/31 | 2022/04/30 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI13: Vessel Operation Completion Time | 2022/01/31 | 2022/01/31 | | 2022/03/31 | 2022/04/30 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| #UC 7 | Predictive Maintenance | A-KPI4: Assets idling | 2022/01/31 | 2022/01/31 | | 2022/01/31 | 2022/02/28 | 2022/06/10 | 2022/06/15 | 2022/06/20 | 3 | |
| | | A-KPI16: Parts in Stock | 2022/01/31 | 2022/01/31 | | 2022/01/31 | 2022/02/28 | 2022/06/10 | 2022/06/15 | 2022/06/20 | 3 | |
| | | A-KPI17: Vehicle Breakdowns | 2022/01/31 | 2022/01/31 | | 2022/01/31 | 2022/02/28 | 2022/06/10 | 2022/06/15 | 2022/06/20 | 3 | |
| | | A-KPI18: Vehicles Under Maintenance | 2022/01/31 | 2022/01/31 | | 2022/01/31 | 2022/02/28 | 2022/06/10 | 2022/06/15 | 2022/06/20 | 3 | |
| | | A-KPI19: Vehicles Unexpected Breakdown | 2022/01/31 | 2022/01/31 | | 2022/01/31 | 2022/02/28 | 2022/06/10 | 2022/06/15 | 2022/06/20 | 3 | |
| | | A-KPI20: Maintenance Costs of Vehicles | 2022/01/31 | 2022/01/31 | | 2022/01/31 | 2022/02/28 | 2022/06/10 | 2022/06/15 | 2022/06/20 | 3 | |
| 5G Network KPIs | LL_Athens_story_#1 | A-KPI21: Area Traffic Capacity | 2022/01/31 | 2022/01/31 | | n/a | 2022/01/31 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI22: Bandwidth | 2022/01/31 | 2022/01/31 | | n/a | 2022/01/31 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI23: Connection Density | 2022/01/31 | 2022/01/31 | | n/a | 2022/01/31 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |
| | | A-KPI24: Reliability | 2022/01/31 | 2022/01/31 | | n/a | 2022/01/31 | 2022/06/30 | 2022/07/05 | 2022/07/10 | 3 | |

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| # 1 | #Test Iteration planned |
| # 1 | #Test Iteration excecuted (sucessful) |
| | planned |
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| 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
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| | | M20 | | | | M21 | | | | M22 | | | | | M23 | | | | M24 | | | | | M25 | | | |
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| | | April | | | | May | | | | June | | | | | July | | | | August | | | | | September | | | |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
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| M26 | | | | M27 | | | | | M28 | | | |
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| 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 |

| | Date of planning | Version |
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| | 31.08.2021 | V1.0 |

| Hamburg | Storyboard # | #KPI & KPI Name |
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| 1 | Storyboard #1 | H-KPI1 Increase average truck speed single mode up to 5% |
| | | H-KPI2 Reduction of avg. acceleration activities single mode up to 5% |
| | | H-KPI3 Reduction of stillstand time in single mode up to 5% |
| 2 | Storyboard #2 | H-KPI4 Increase average truck speed platoon mode > 5% |
| | | H-KPI5 Reduction of avg. acceleration activities platoon mode > 5% |
| | | H-KPI6 Reduction of stillstand time in platoon mode with equipped vehicles |
| 3 | Storyboad #3 | H-KPI7 Reduction of fuel consumption in single mode up to 10% |
| | | H-KPI8 Reduction of CO2 emission in single mode up to 10% |
| | | H-KPI9 Reduction of fuel consumption in platoon mode up to 20% |
| | | H-KPI10 Reduction of CO2 emission in platoon mode up to 20% |
| 4 | Storyboad #4 | H-KPI11 Increase value of 'EPI - cl per ton and km' up to 10% for vehicle trips |
| | | H-KPI12 Increase value of API 'KWh per ton and km' up to 10% for vehicle trips |
| 5 | Storyboad #5 | H-KPI13 Extended cellular bandwidth on urban roads by 5G network |
| | | H-KPI14 Positioning quality on urban road networks with 5G by 10 cm |
| | | H-KPI15 Average signal latency in the 5G environment will be reduced thru Mobile Edge Computing (MEC) to 10 ms during vehicle trips |
| | | H-KPI16- 5G-NSA-Packed-Error-Rate |
| 6 | Storyboad #6 | H-KPI14 Positioning quality on urban road networks with 5G by 10 cm |

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| # 1 | #Test Iteration planned |
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| | under construction |
| | done |
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| Content: date (yyyy/mm/dd), na (not applicable) | | | | | | | | WEEK |
| Baseline data collected | Baseline KPI calculated | Baseline data pushed for evaluation | Status UC deployment | Test setup ready (SW, HW, Services) | Operational data collected | Operational KPI calculated | Operational data pushed for evaluation | #Iterations |
| 2021/12/31 | 2021/12/31 | na | 2021/02/28 | 2021/02/28 | 2022/06/15 | 2022/06/15 | 2022/06/15 | 3 |
| 2021/12/31 | 2021/12/31 | na | 2021/02/28 | 2021/02/28 | 2022/06/15 | 2022/06/15 | 2022/06/15 | 3 |
| 2021/12/31 | 2021/12/31 | na | 2021/02/28 | 2021/02/28 | 2022/06/15 | 2022/06/15 | 2022/06/15 | 3 |
| 2021/12/31 | 2021/12/31 | na | 2021/02/28 | 2021/02/28 | 2022/06/15 | 2022/06/15 | 2022/06/15 | 3 |
| 2021/12/31 | 2021/12/31 | na | 2021/02/28 | 2021/02/28 | 2022/06/15 | 2022/06/15 | 2022/06/15 | 3 |
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| 2021/12/31 | 2021/12/31 | na | 2021/02/28 | 2021/02/28 | 2022/06/20 | 2022/06/20 | 2022/06/20 | 3 |
| 2021/12/31 | 2021/12/31 | na | 2021/02/28 | 2021/02/28 | 2022/06/20 | 2022/06/20 | 2022/06/20 | 3 |
| 2021/12/31 | 2021/12/31 | na | 2021/02/28 | 2021/02/28 | 2022/06/20 | 2022/06/20 | 2022/06/20 | 3 |
| 2021/12/31 | 2021/12/31 | na | 2021/02/28 | 2021/02/28 | 2022/06/20 | 2022/06/20 | 2022/06/20 | 3 |
| 2021/12/31 | 2021/12/31 | na | 2021/02/28 | 2021/02/28 | 2022/06/20 | 2022/06/20 | 2022/06/20 | 3 |
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| September | | | | | February | | | | March | | | | | Ap | |
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| August | | | | September | | | | October | | | | November | | | |
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| 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
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| | December | | | |
| 48 | 49 | 50 | 51 | 52 |

| Date of planning | | Version | | | | |
|---|---|---|---|---|---|---|
| 31.08.2021 | | V1.0 | Content: date (yyyy/mm/dd), na (not appl | | | |

| Koper | UC Name / storybook | #KPI & KPI Name | Baseline data collected | Baseline calculated | Baseline data pushed fro evaluation | Status UC deployment |
|---|---|---|---|---|---|---|
| #UC 1 | LL_Koper_story_#1 | K-KPI1: Components Onboarding and Configuration (Backend) | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI2: Deployment Time (Backend) | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI3: Time to Scale (Backend) | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI4: Service Availability (Backend) | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI5: Components Onboarding and Configuration (Agent) | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI6: Deployment Time (Agent) | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | LL_Koper_story_#2 | K-KPI7: Components Onboarding and Configuration (Backend) | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI8: Deployment Time (Backend) | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI9: Time to Scale (Backend) | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI10: Service Availability (Backend) | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI11: Slice Reconfiguration (Backend) | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | LL_Koper_story_#3 | K-KPI12: Area Traffic Capacity | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI13: Availability | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI14: Bandwidth | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI15: Connection Density | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI16: Coverage Area Probability | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI17: End-to-End Latency | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI18: Reliability | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | LL_Koper_story_#4 | K-KPI12: Area Traffic Capacity | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI13: Availability | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI14: Bandwidth | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI15: Connection Density | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI16: Coverage Area Probability | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI17: End-to-End Latency | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| | | K-KPI18: Reliability | 2022/01/31 | 2022/01/31 | | 2022/01/31 |
| #UC 5 | LL_Koper_story_#5 | K-KPI25: Time Trucks Parked in the Area | 2022/04/30 | 2022/04/30 | | 2022/04/30 |
| | | K-KPI26: Truck Speed | 2022/04/30 | 2022/04/30 | | 2022/04/30 |
| | | K-KPI27: Truck Acceleration | 2022/04/30 | 2022/04/30 | | 2022/04/30 |
| | | K-KPI28: Truck Stand Still Time | 2022/04/30 | 2022/04/30 | | 2022/04/30 |
| | | K-KPI29: Fuel Consumption | 2022/04/30 | 2022/04/30 | | 2022/04/30 |
| | LL_Koper_story_#6 | K-KPI19: Model accuracy/reliability | 2022/04/30 | 2022/04/30 | | 2022/04/30 |
| | | K-KPI20: Model Inference Time | 2022/04/30 | 2022/04/30 | | 2022/04/30 |
| #UC 6 | LL_Koper_story_#7 | subjective metrics apply here only | 2022/04/30 | 2022/04/30 | | 2022/04/30 |
| | LL_Koper_story_#8 | K-KPI19: Model accuracy/reliability | 2022/04/30 | 2022/04/30 | | 2022/04/30 |
| | | K-KPI20: Model Inference Time | 2022/04/30 | 2022/04/30 | | 2022/04/30 |

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| # 1 | #Test Iteration planned |
| # 1 | #Test Iteration excecuted (sucessful) |
| | planned |
| | under construction |
| | done |
| | na (not applicable) |

| | | | | M | M13 | | | | | M14 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MONTH | September | | | | | October | | | |
| icable) | | | | WEEK | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
| Test setup ready (SW, HW, Services) | Operational data collected | Operational KPIs calculated | Data pushed for evaluation | #Iterations | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/01/31 | 2022/05/31 | 2022/06/10 | 2022/06/15 | 3 | | | | | | | | | |
| 2022/04/30 | 2022/06/20 | 2022/06/25 | 2022/06/30 | 3 | | | | | | | | | |
| 2022/04/30 | 2022/06/20 | 2022/06/25 | 2022/06/30 | 3 | | | | | | | | | |
| 2022/04/30 | 2022/06/20 | 2022/06/25 | 2022/06/30 | 3 | | | | | | | | | |
| 2022/04/30 | 2022/06/20 | 2022/06/25 | 2022/06/30 | 3 | | | | | | | | | |
| 2022/04/30 | 2022/06/20 | 2022/06/25 | 2022/06/30 | 3 | | | | | | | | | |
| 2022/04/30 | 2022/06/20 | 2022/06/25 | 2022/06/30 | 3 | | | | | | | | | |
| 2022/04/30 | 2022/06/20 | 2022/06/25 | 2022/06/30 | 3 | | | | | | | | | |
| 2022/04/30 | 2022/06/20 | 2022/06/25 | 2022/06/30 | 3 | | | | | | | | | |
| 2022/04/30 | 2022/06/20 | 2022/06/25 | 2022/06/30 | 3 | | | | | | | | | |
| 2022/04/30 | 2022/06/20 | 2022/06/25 | 2022/06/30 | 3 | | | | | | | | | |

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| M15 | | | | M16 | | | | | M17 | | | | M18 | |
| November | | | | December | | | | | January | | | | February | |
| 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 1 | 2 | 3 | 4 | 5 | 6 |
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| | | March | | | | | April | | | | May | | | |
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| June | | | | | July | | | | August | | | | | September |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
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| | | | M26 | |
| | | | October | |
| 37 | 38 | 39 | 40 | 41 |