This project has received funding from the European's Union Horizon 2020 research innovation programme under Grant Agreement No. 957258

Architecture for Scalable, Self-human-centric, Intelligent, Secure, and Tactile next generation IoT

D7.3 Pilot Scenario Implementation – Intermediate version

Deliverable No.	D7.3	**Due Date**	31-JAN-2023
Type	Report	**Dissemination Level**	Public
Version	1.0	**WP**	WP7
Description	ASSIST-IoT pilots implementation activities reporting		

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History

Date	Version	Change
20-Jul-2022	0.1	Table of content
16-Jan-2023	0.5	Final contributions – version ready for internal review
27-Jan-2023	0.9	Internal review comments addressed and sent to PIC/PCC review
31-Jan-2023	1.0	Final version submitted to EC

Key Data

Keywords	Pilots, Deployment, Testbeds
Lead Editor	P08 MOW – Piotr Dymarski P02 PRO – Eduardo Garro
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Executive Summary

D7.3 serves as a continuation of the previous *D7.1 Deployment Plan and Operational Framework*, and *D7.2 Pilot Scenario Implementation – First Version*. Hence, the present document is the intermediate version of the "Pilot Scenario Implementation" and describes the associated implementation activities carried out during the M19-M27 period. The main objective is to guarantee the successful development of the four pilots of the project, as well as a further ease of integration with the ASSIST-IoT platform enablers.

Each pilot has been divided into one or more trials, based on the business scenarios, and use cases identified in WP3 deliverables, all of them trying to solve a real need of industrial stakeholders by means of the application of one or more than one ASSIST-IoT enabler.

The Port Automation pilot objective is to help container terminal operators to improve the operational efficiency, by means of improving the availability of information over which the operators can interact with. During this 9 months period, most of the procurement and development activities are already available and integrated in the pilot, and the integration of ASSIST-IoT enablers with the current systems of the terminal has begun. However, due to global chip shortage, undesired procurement delays on the remote operating system for the cranes have occurred. Nevertheless, all the spare parts will be shipped to Malta during February 2023, so that it should not pose significant risks to Pilot 1 implementation, given the project extension until M41.

Most of the Smart safety of Workers pilot all equipment is in place, except for the ASSIST-IoT GWEN and UWB devices. Moreover, as some project's essential enablers have not been integrated, and given that the building project will be finalised in M38, a close collaboration with project partners and Pilot 2 stakeholders is mandatory.

The reported works during M19-M27 for the Vehicle in-service emission diagnostics pilot (centred around emissions and enhanced diagnostics at vehicle fleet level) correspond to the integration of the pilot with ASSIST-IoT essential enablers (EDBE, LTSE, Smart Orchestrator and Manageability enablers). This has allowed to achieve the second iteration of the demonstration, in which the test vehicle has been (and is currently using) the system implementation within ASSIST-IoT. Last phase of the demonstration is scheduled for M39-M41, in which the ensemble of all the planned enablers and functionalities are expected to be operative and deployed over the ASSIST-IoT GWEN.

Finally, the vehicle exterior condition inspection and documentation pilot 3B that aims at enhancing the inspection and monitoring of exterior surface of the vehicles, have developed several software modules that that cover essential functionalities and are going to be substituted by corresponding ASSIST-IoT enablers before summer 2023. Thus, the integration activities will be intensified over the next months.

One last remark refers to the status report of first round of open calls of the project. Seven funded projects were called upon to sign a Collaboration Agreement before initiating their executive actions since June 2022. During their actions, several discussions, and interactions with ASSIST-IoT partners (mostly via stakeholders and the associated technical partners) are being taken place. They are split in two open calls on Pilot 1 (ADDICTIVE, SPINE), two more for Pilot 2 (ATHEMS, SMART SONIA), and 3 more for Pilot 3A (RAZOR, HAIR, BREATHE). For more details, please go to Section 6 of this report.

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List of acronyms

Acronym	Explanation	Acronym	Explanation
AI	Artificial Intelligence	**KPI**	Key Performance Indicator
API	Application Programming Interface	**LAN**	Local Area Network
AR	Augmented Reality	**LED**	Light-Emitting Diode
ASAM	Association for Standardization of Automation and Measuring Systems	**LIDAR**	Light Imaging Detection and Ranging
AV	Audiovisual	**LTE**	Long Term Evolution
BIM	Building Information Modelling	**LTSE**	Long-Term Storage Enabler
BIP	Background IP	**MANO**	Management and Orchestration
BS	Business Scenario	**MB**	Megabytes
CAN	Control Area Network	**MFT**	Malta Freeport Terminal
CAS	Crank Angle Synchronous	**MHEV**	Mild Hybrid Electric Vehicle
CCS	Crane Control System	**ML**	Machine Learning
CHE	Container Handling Equipment	**MQ**	Messaging and Queuing
CMS	Crane Management System	**MQTT**	MQ Telemetry Transport
COM	Component Object Model	**MR**	Mixed Reality
CPU	Central Processing Unit	**MTS**	Microsoft Transaction Server
CRIO	Compact Reconfigurable Input/Output System	**NAS**	Network-Attached Storage
DLT	Distributed Ledger Technology	**NFC**	Near Field Communication
DPF	Diesel Particulate Filter	**NG**	Next Generation
ECU	Engine Control Unit	**NTP**	Network Time Protocol
EDBE	Edge Data Broker Enabler	**OCR**	Optical Character Recognition
EU	European Union	**OEM**	Original Equipment Manufacturer
FL	Federated Learning	**OS**	Operating System
FPGA	Field Programmable Gate Arrays	**OSH**	Occupational Safety and Health
GB	Gigabyte	**OTA**	Over-The-Air
GDPR	General Data Protection Regulation	**PAP**	Policy Administration Point
GIS	Geographic Information System	**PASCAL**	Preservation And Storage Centre For Academic Libraries
GPS	Global Positioning System	**PC**	Project Coordinator
GUI	Graphical User Interface	**PCM**	Powertrain Control Module
GWEN	Gateway Edge Nodes	**PCS**	Port Community System
HMD	Head Mounted Display	**PDP**	Policy Decision Point
HMI	Human-to-Machine Interface	**PDS**	Positioning Detecting System
HW	Hardware	**PEMS**	Portable Emissions Measuring Systems
ID	Identifier	**PEP**	Policy Enforcement Point
IDE	Integrated Development Environment	**PIP**	Policy Information Point
IDM	Instructional Device Manager	**PLC**	Programmable Logic Controller
IFC	Industry Foundation Classes	**PPE**	Personal Protective Equipment
IMU	Inertial Measurement Unit	**RAM**	Random Access Memory
IP	Internet Protocol	**RDE**	Real Driving Emission
ISC	In-Service Conformity	**RMG**	Rail Mounted Gantry
ISE	In-Service Emissions	**ROS**	Remote Operation Station
IT	Information Technology	**RPA**	Relative Positive Acceleration
JS	JavaScript	**RTG**	Rubber-Tyred Gantry (crane)
JSON	JavaScript Object Notation	**RTK**	Real Time Kinematics

1. About this document

The scope of the deliverable is to report about the implementation activities of the pilots of the project. It includes trial[1] plans for the procurement, development, integration, and verification activities of each pilot. This deliverable is part of a three report-series, that started with *D7.2 Pilot Scenario Implementation – First Version* in M18 and will have a final point with *D7.4 Pilot Scenario Implementation – Final Version* in M41. Reporting work done in this deliverable helps to clarify what activities are behind or advanced with respect to the original schedule and tackle appropriate mitigation measures if needed.

1.1. Deliverable context

Keywords	Lead Editor
Objectives	**O6:** D7.3 documents the three pilots and integrated third parties, addressing the proposed use cases and scenarios, which is the main outcome expected on Objective 6.
Work plan	D7.3 takes inputs from D7.1 [1], D7.2 [2], as well as from D3.3 [3] deliverables. In addition, the integration of the core and transversal enablers being developed in WP4 and WP5 onto the project's pilots have just started. The implementation activities reported in D7.3 will be concluded with the final WP7 deliverable.
Milestones	This deliverable follows the execution of MS7 – Integrated solution.
Deliverables	This deliverable receives inputs from D3.3, D4.2, D5.3, D7.1, D7.2.

1.2. The rationale behind the structure

The deliverable includes four main sections (2 to 5) that report the implementation activities of each pilot scenario of the project. Each pilot section is in turn split into (i) a context review part, which summarises the testbed scenario for the pilots, followed by (ii) a report of the different implementation activities per trial of the pilot (e.g., procurement, development, integration, and verification activities), and ending with (iii) highlights of deviations from the original planning, if any. Section 6 reports the status of the First open calls of the project that started their work since June 2022 and will end during next month February 2023. Finally, Conclusions are drawn in Section 7.

1.3. Outcomes of the deliverable

Like described in the introductory section of this document, D7.3 updates the status of the implementation activities planned since *D7.1 Deployment Plan and Operational Framework*, and *D7.2 Pilot Scenario Implementation – First Version* deliverables. Hence, on the one hand D7.3 describes the progress being made in the different Pilot projects within ASSIST-IoT from M19 to M27.

In general, as D7.3 is the second in a series of three Pilot evolution reporting documents (final D7.4 is scheduled for M36), the work in the different pilots have been mainly focused on finalizing the procurement of Pilot specific infrastructure, both hardware and software, as well as the pilot-specific developments. Henceforth, the integration, and especially validation activities are still on their infancy in most of the pilots. This was already foreseen via D7.1, therefore no relevant deviations are to be declared.

Regarding pilot specific outcomes, the following ones have been identified:

- Pilot 1 trials #1 and #2 are in good shape. While most of the procurement and development activities are already available and integrated in the pilot, the integration of ASSIST-IoT enablers with the current systems of the terminal has just started. On the other hand, Pilot 1 Trial #3 is still affected by global chip shortage, and undesired procurement delays on the remote operating system for the cranes have

[1] The selection of trial terminology for WP7 activities, instead of the previous ones used in other parts of the project was justified in Section 1.4 of D7.2.

occurred. Nevertheless, since mid-January 2023, all the spare parts are ready and will be shipped to Malta during February. Therefore, the original plan will be delayed 2-3 months, but it should not pose significant risks to Pilot 1 implementation, given the project extension until M41.

- Most of Pilot 2 equipment is placed at the educational building being of the campus of the University of Warsaw. Unfortunately, the engineering delays with respect to GWEN and UWB devices procurement, as well as the finalization of stable versions of project's essential enablers have led to a slow start of the development/integration/validation activities of Trial #1 and Trial #2. This is considered as a key risk that should be considered, given that the final building execution from Mostostal is planned for M38, so that all the planned activities should be finished by then. On the other hand, Trial #3 that merged the original Safe navigation, and Health and Safety inspection support business scenarios is much more advanced than the others. In detail, BIM model showing possible evacuation routes on the construction site based on the recommendation of the site's OSH manager were developed and successfully tested. In the final release, an improved user-friendliness version of the visualisation of the alerts will be provided.
- Pilot 3A has added two new HMI for the pilot (a 7" tablet embedded into the vehicle, plus a set of Moverio AR glasses). In addition, the reported works during M19-M27 of this document correspond to the integration of the pilot with ASSIST-IoT essential enablers (EDBE, LTSE, Smart Orchestrator and Manageability enablers). This has allowed to achieve the second iteration of the demonstration. The test vehicle has been (and is currently using) the system implementation within ASSIST-IoT. Last phase of the demonstration is scheduled for M39-M41, in which the ensemble of all the planned enablers and functionalities are expected to be operative and deployed over the ASSIST-IoT GWEN.
- In Pilot 3B there are no substantial project deviations. However, several software modules that have been formerly developed by TwoTronic continue to cover essential functionalities and have not been substituted by corresponding ASSIST-IoT enablers, which are still under development, yet. Thus, the integration activities will be intensified over the next months. The time of the environment availability for testing, demonstrations, as well as validation has been re-scheduled to cover the additional project time.

1.4. Lessons learnt

From the work carried out after the finalization of D7.2, the following lesson learnt have been extracted with regards to WP7 activities:

- **Lesson 1:** In order not to generate catastrophic delays, it is especially relevant that pilot stakeholders fully understand the scope and objective of the different enablers of the project. Hence, a more proactive and agile approach by pilot stakeholders have been agreed. In particular, it is expected that pilot technical leaders will not wait until the final release of ASSIST-IoT enablers is available, and on the contrary will deploy previous, but stable releases, and request periodic support from enabler's responsible in case any trial is being affected by a wrong and unexpected behaviour of an specific enabler.
- **Lesson 2:** The advancement on pilot development activities have led to a clearer view of the final KPIs to be fulfilled for the project (which were not fully addressed in previous deliverables of the project). Their fulfilment will be reported in D7.4 from the pilot validation point of view, while their numerical evaluation will be addressed in D8.3.

1.5. Deviation and corrective actions

The procurement of GWENs turned out to be an additional driver in pilot activities, as essential ASSIST-IoT devices were not available. This has led to different pilot partners to develop and deploy a temporary replacement infrastructure and consequently resulting in additional tasks to be considered before the final validation of the pilots. In addition, as mentioned in D7.2, pilots are directly dependent of the advance of WP4 and WP5 enablers. However, all essential enablers already provide an MVP version. Hence, integration activities (although slightly misaligned with respect to the original planning) have successfully begun with enough time for successfully validating the trials of ASSIST-IoT pilots.

1.6. Version-specific notes

Although mentioned in D7.2, it is worth remarking that how the classification in D7.1 and the structure of pilots in D7.2 and D7.3 map by the following illustration:

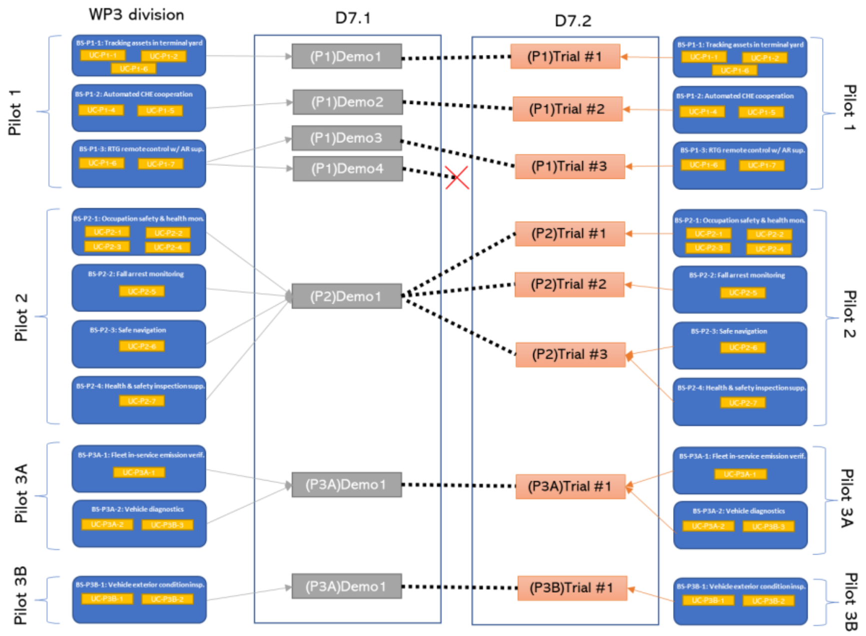

Figure 1. Mapping of terms/classification of pilots between D7.1 and D7.2/D7.3.

1.7. Ethical issues

Consent forms have been prepared and delivered to beta testers of ASSIST-IoT platform in Pilot 2. These consents (approval or rejection) are added as appendix in this deliverable. Until the time of the current deliverable, no ethical issue occurred.

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2. Pilot 1: Port Automation

2.1. Context review

The Port Automation Pilot of ASSIST-IoT aims at helping container terminal operators improve the operational efficiency of their cargo handling activities. ASSIST-IoT will help make better decisions to container terminal stakeholders by means of improving the availability of information over which the operators can interact with, as well as facilitating the automation of repeating workflows. Three trials were identified in D7.1. Their associated implementation activities during the M19-M27 period are described in the following sections.

2.2. Trial #1: Tracking assets in terminal yard

2.2.1. Scope

This trial aims at enabling the traceability of containers within the port infrastructure to prevent losing them, as well as to enhance the operational efficiency of terminal operators (including not only internal, but also external drivers). To achieve this, the positions of all CHEs within the yard, also including external trucks, will be tracked. All this information is combined in the Terminal Operating System in order to link the location of all CHEs with the job orders, i.e., containers handled in the yard.

2.2.2. Implementation activities reporting

2.2.2.1. Procurement activities

The status of the procurement activities related with this trial of Pilot 1 is updated next.

Pilot1_SetupAct_ID1 RTG crane: Available and integrated within the pilot. Most of RTG cranes deployed in MFT yard are already connected with a previous IoT system. However, two of them will be subject of testing with the different ASSIST-IoT enablers, as well as specific pilot development activities.

Pilot1_SetupAct_ID2 RTG PLC: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot1_SetupAct_ID4 IoT Gateways: Available and integrated within the pilot. Currently, Siemens IoT2040 Gateways are available and integrated within the pilot. Two of the IoT2040 gateways will be replaced by one Siemens IoT2050 and one GWEN. These two new gateways are received, but the ASSIST-IoT software stack will be installed on them during the following months, with a tentative deadline before July 2023.

Pilot1_SetupAct_ID10 IoT-GPS and **Pilot1_SetupAct_ID11 D/RTK-GPS:** Available and integrated within the pilot.

Pilot1_SetupAct_ID12 TT (Terminal Truck): Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot1_SetupAct_ID14 TT MTS Server (position): Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot1_SetupAct_ID15 TOS Navis: Available, but not fully integrated within the pilot. As informed in D7.1 and D7.2, the TOS is the core system for operational management, so that none of the ASSIST-IoT development should affect its regular performance. See more details about it in the Pilot1_DevAct_ID8 development activity.

Pilot1_SetupAct_ID18 Tablet Honeywell VM1A/VM2: Available and integrated within the pilot**.** For more details, please refer to D7.1 and/or D7.2.

Pilot1_SetupAct ID19 Honeywell VM1A/VM2 GPS: Regular GPS (from Banner brand) are ready for its integration with VM1A/VM2 Honeywell tablets.

2.2.2.2. Development activities

Pilot1_DevAct_ID1-SEC authentication: In progress. Please, refer to Section 2.3.2.2 for more details.

Pilot1_DevAct_ID2-SEC Incident Management: This development activity has been finally decided not to be developed, as the access to the required MFT infrastructure is not allowed for operational safety management limitations.

Pilot1_DevAct_ID4 Smartphone application: In progress. PRO is developing a native smartphone application that will become the ASSIST-IoT entry gate for external users (either MFT terminal administrators, internal RTG and TT drivers, as well as external drivers). Next, some screenshots of the updated status of the app are attached.

When opening the app, the Sign In screen is presented. For the time being, this access management is not automated (solved via code), but it will be replaced by the IdM and Authorization enablers once its associated integration activity is finalised.

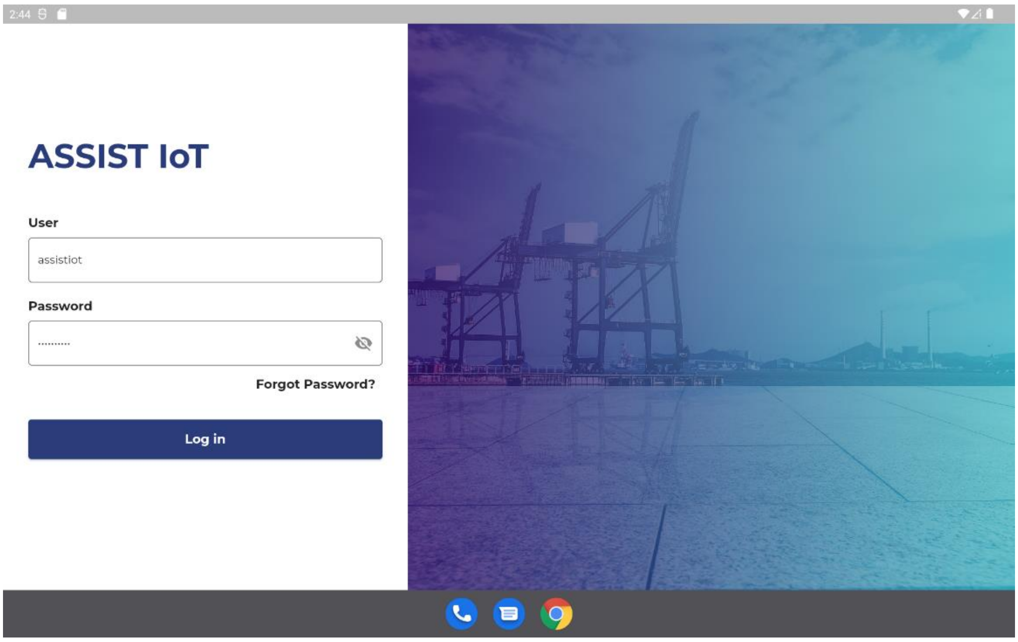


Figure 2. ASSIST-IoT Pilot 1 mobile app Sign In screen

Once logged-in, the user accesses to the main screen of the app as shown below. It is split in several modules:

- In the left pane, the list of working instructions assigned to the truck driver is presented. The bottom part of the left pane provides a human-centric translation from the working instruction message in order to help drivers about their origin and destination, as well as container ID, and the current status of the working instruction itself. This list is obtained by connecting to the TOS (see Pilot1_SetupActID15 above).
- At the bottom pane of the application, different action buttons such as Confirm order (i.e., working instruction), Abort order, Stop Order, and Emergency are available in order to allow a communication channel between the user (i.e., truck driver) and the system (i.e., terminal operations team) through the TOS interface.
- The main panel presents the yard map with the location of the different CHEs of the terminal (RTG cranes, STS cranes, and TTs), which is retrieved by subscribing to the MQTT topic managed by the Edge Data Broker that connects with the MQTT client installed over the IoT Gateways. As commented in previous section, Malta IoT gateways are Siemens IoT2040, but they are going to be replaced by IoT2050 and GWEN in a near future, given they have been already received in Prodevelop laboratories.

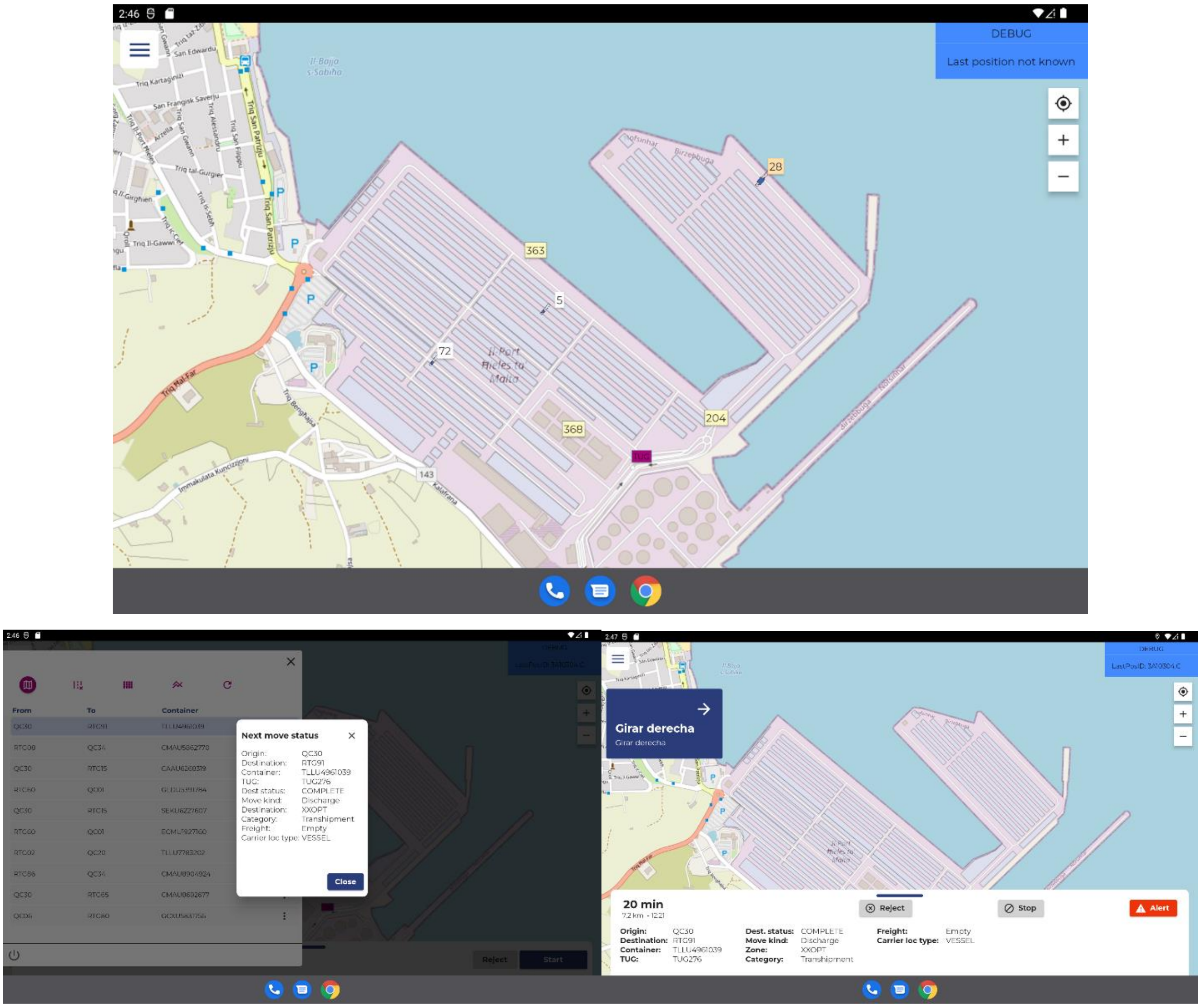


Figure 3. ASSIST-IoT Pilot 1 mobile app Route map screen.

Finally, a completely new interface for the drivers' statistics has been implemented. A screenshot is provided below in which a driver can observe three different KPIs (cycle time, idle time, and number of boxes/containers) across different timespans (per hour, per shift/day, per week, per month, per year).

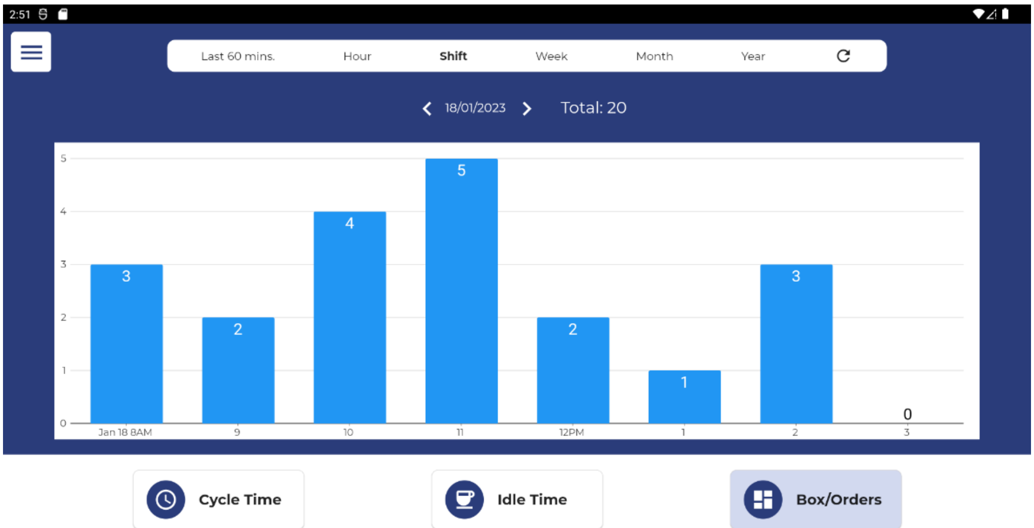


Figure 4. ASSIST-IoT Pilot 1 - Trial 1 statistic interface

<u>Pilot1_DevAct_ID6 GIS Cartography:</u> In progress, but almost finished. Terminal Link has generated a Geographic Information System mapping data. It has required the generation of 27288 polygons, which are directly correlated with worldwide coordinates according to the WGS 84 / UTM zone 33N, EPSG: 32633 navigation system. A screenshot of the different blocks of Malta Freeport terminal data for the pilot is illustrated below.

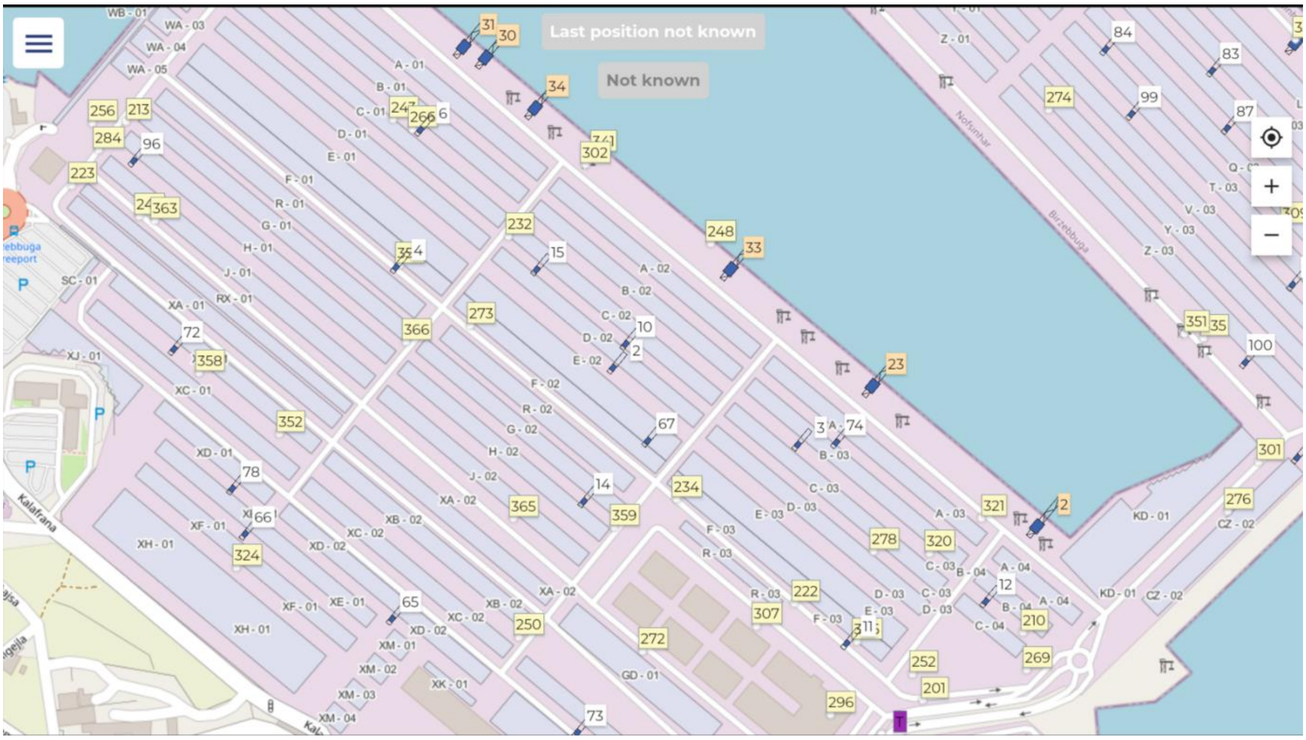


Figure 5. Malta Freeport GIS data.

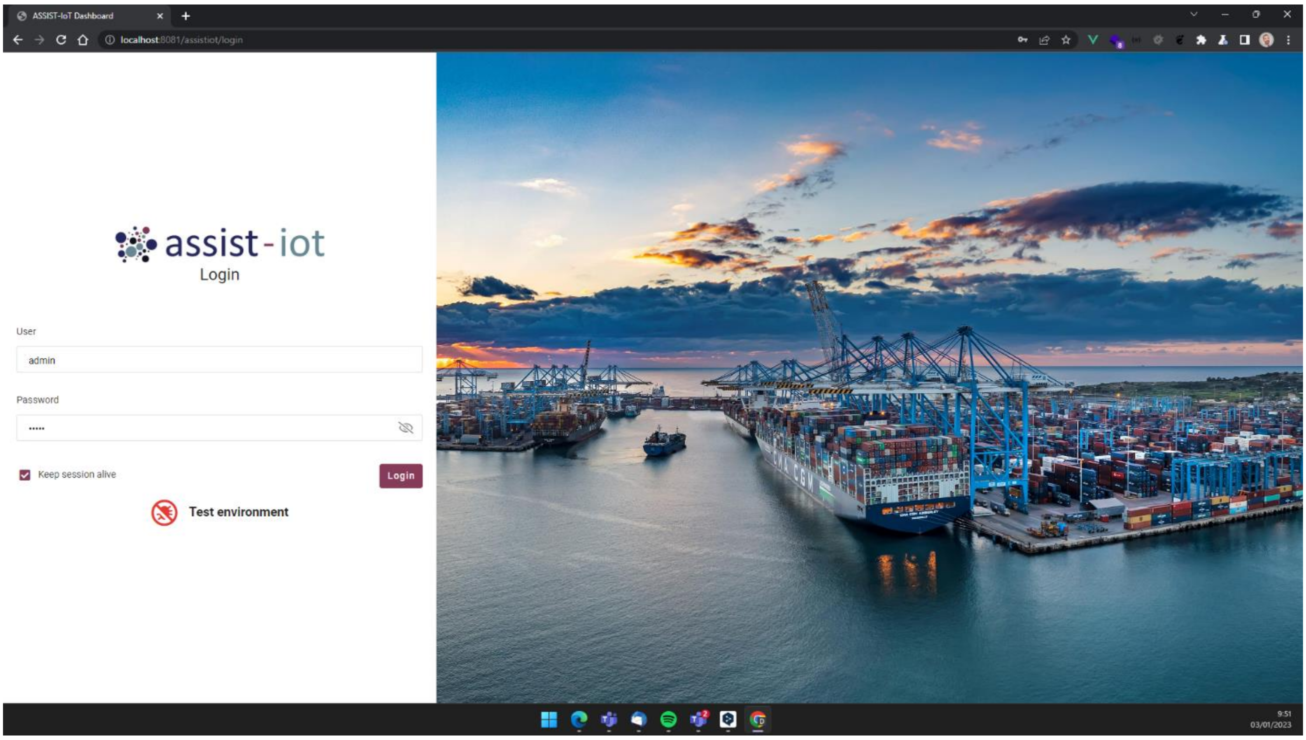
<u>Pilot1_DevAct_ID7 Optimal route:</u> Not started yet. It was postponed until Malta Freeport Terminal GIS cartography data was available (Pilot1_DevAct_ID6 GIS Cartography). Given the almost-ready status of that development activity, the technical team has carried out an analysis for the identification of the optimum open-source solution available, and the pgRouting service has been identified as the proper one for the type of GIS data managed in the project.

<u>Pilot1_DevAct_ID8 TOS custom component:</u> In progress. Since initial trigger-based development led to some overloads of the TOS system, a new query-based solution has been developed. This query based provides a more stable solution for retrieving the list of completed work instruction from the TOS that are allocated in the XPS (Synchronous Planning and Real-time Control System). However, this is not valid for fetching the list of planned (or to be dispatched) work instruction from the ECN4 (Equipment Control for N4) module of the TOS, that acts as the central hub for managing CHEs. Thus, a second custom component in the form of an XMLRDT (XML-based protocol for communication between ECN4 and external software systems, such as ASSIST-IoT platform) listener is under development. It is expected to have it ready for the end of May 2023.

2.2.2.3. Integration activities

Integration activities in this pilot are in principle associated to the integration of the different identified ASSIST-IoT enablers. In order to provide a more easy-to-read text, Pilot1_IntAct_ID7 is described first. Next, the regular ordering of integration activities is followed.

<u>Pilot1_IntAct_ID7 Tactile Dashboard, LTSE, and Business KPI integration:</u> In progress. As it can be seen below, a specific Tactile dashboard is being generated and integrating with different enablers. In particular, for the time being, the GPS data of the MFT CHEs is pulled from the current Kafka topics used in the terminal. Once the procured IoT2050 and GWEN gateways described in previous section are set up, they will be integrated into two RTG cranes of the terminal, which will push their telemetry and GPS data across the MQTT topics handled by the EDBE.



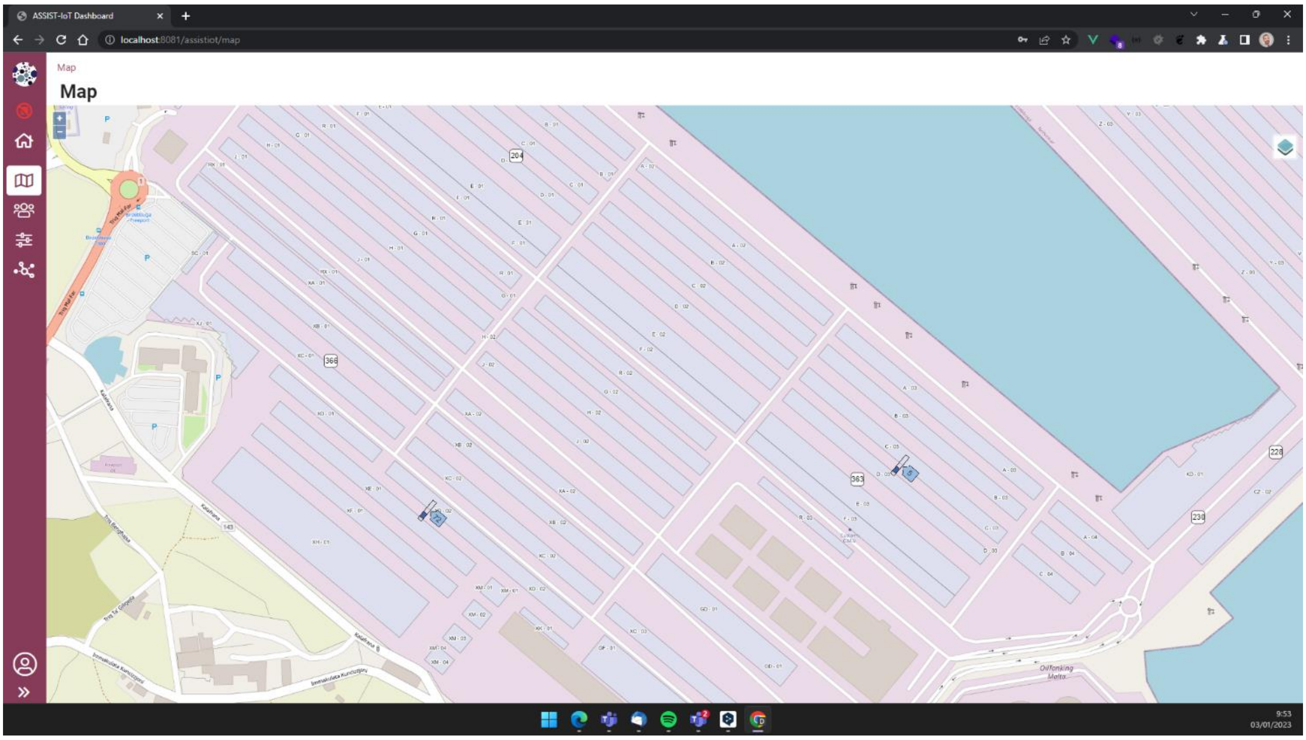


Figure 6. A couple of screenshots of Pilot 1 Tactile dashboard (Login page on top; navigation map on the bottom).

In addition, an LTSE instance that stores a sample data from the terminal is also integrated, and properly visualized in the Business KPI enabler. This is shown in the following figure. As next step, same as previous part of this activity, once the gateways are commissioned and pushing CHE MQTT data across the EDBE, the MFT server that is acting as cloud system and which has the T44Ex enablers deployed, will subscribe to that topic and stored the data in the LTSE, which will be later on visualized in the aforementioned Business KPI enabler. Other T44 enabler envisioned for this trial is the addition of the PUD, which will provide in a graphical interface embedded within the tactile dashboard the infrastructure performance in terms of resources capabilities.

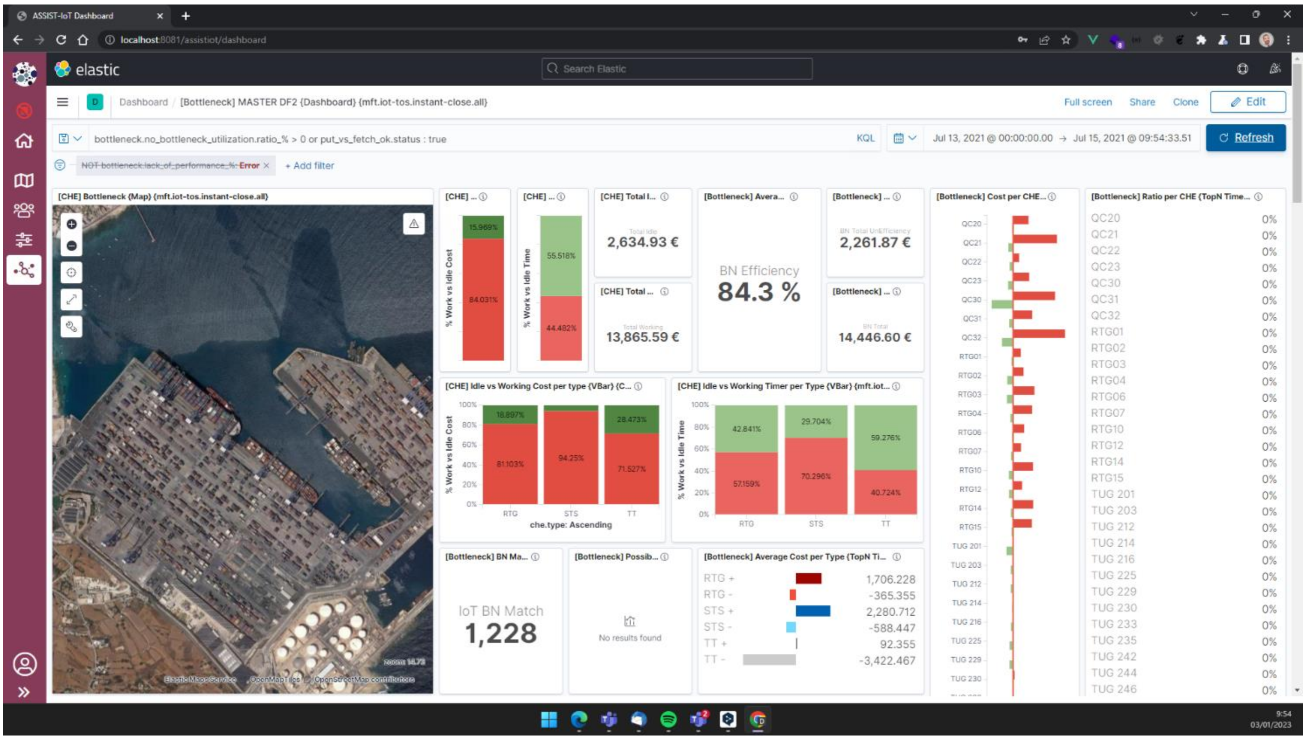


Figure 7. LTSE and Business KPI enablers integrated with the tactile dashboard of Pilot 1.

<u>Pilot1_IntAct_ID1-SEC IdM and Authorization enabler integration:</u> In progress. This integration activity refers to the integration of the pilot tactile dashboard with the IdM and Authorization enablers from task T5.3. As it can be seen in the below screenshot, some initial tests have been performed in local environment, but given that the cybersecurity enablers are not properly packaged as helm charts yet (related to WP6 interaction, that will end later in the project), their integration into the pilot pre-production environment is postponed. In addition, these enablers will also be in charge of the access control of users (i.e., drivers) in the mobile app under development.

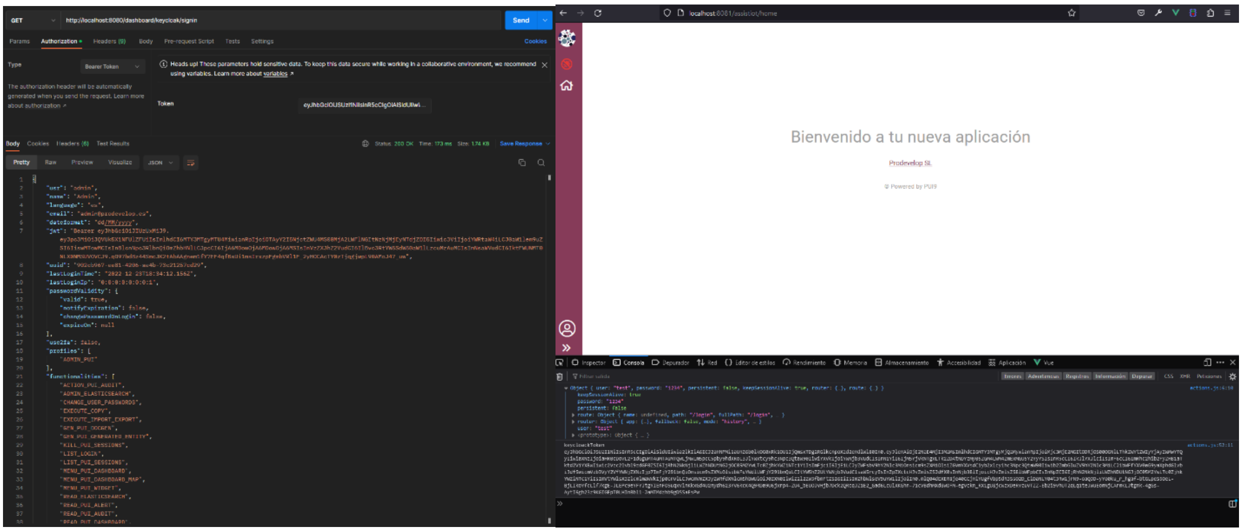


Figure 8. Left: API call from the tactile dashboard to the IdM for getting the access token. Right: User logged in through the token provided by IdM.

<u>Pilot1_IntAct_ID2-SEC Incident management:</u> Like DevAct_ID2_SEC, this activity has been dropped from the original list, given the forbidden access to the required MFT components.

<u>Pilot1_IntAct_ID13 Smart Orchestrator, Manageability, and EDBE integration:</u> Not started yet. Although not explicitly mentioned in previous WP7 deliverables, additional enablers that are envisioned for this trial are the T42 Smart Orchestrator, T51 Self-* enablers, and T55 Manageability enablers. They will allow to auto scale the K8s clusters of the pilot in case some of them are under performance. In addition, as mentioned before, the MQTT pipeline managed by the EDBE will also be supported for the final demonstration of the trial.

2.2.2.4. Validation activities

Same as development and integration activities, the validation activities related to the ASSIST-IoT enablers have been postponed until such enablers are fully operational, properly packaged and ready for deploying on Pilot 1. Nevertheless, in order to illustrate the advances performed in this regard during the period M19-M27, their operational context and validation process to be addressed is included in this deliverable.

Pilot1_ValAct_ID1-SEC Operation authorization:

Context: The operational data managed within a container terminal is very sensitive and should not be exposed to external stakeholders unless they are authorized to. However, the scope of trial #1 is to provide this information to new users that enter into the port. Therefore, a software service which will be able to maage user access to data is mandatory.

Expectation: This activity will confirm that an already registered user in the pilot 1 platform is authenticated through IdM (i.e., gets the required tokens), as well as have access to the authorized frontend pages and parameters configured in the AuthZ server of the authorization enabler

Validation proof: In progress. As described in the integration activity above, first validations tests in a local development environment have been performed. However, its validation in the pilot environment is not carried out yet.

Pilot1_ValAct_ID1-SEC Operation validation: Like DevAct_ID2_SEC and IntAct_ID2_SEC, this activity has been dropped from the original list, given the forbidden access to the required MFT components.

Pilot1_ValAct_ID6 Optimal route:

Context: In terminal yards there are terminal lanes suffering traffic jams due to different reasons very often, including issues along the loading/unloading process of containers, or lack of knowledge about the status of the terminal yard streets (internal drivers), or even lack of knowledge of the terminal at all (external drivers).

Expectation: This trial #1, by making use of the mobile app will allow truck drivers to know exactly the location of the univocally crane assigned to their work instruction, providing additionally, the most optimum route to their destination. To do so, the most up-to-date cartography of the terminal yard, and a guiding route software which considers is needed. The almost real-time GPS position of all working CHEs should be received.

Validation proof: Not available yet. It was postponed until Malta Freeport Terminal GIS cartography data was available (Pilot1_DevAct_ID6 GIS Cartography).

2.2.3. Deviations from original planning

Gantt chart summarising the task implementation for Trial #1. Major changes are related to the delays on the development and integration activities, which at the end are also postponing the kick off of the validation activities. In addition, three new development activities have been identified since D7.2 (Pilot1_DevAct_ID6, Pilot1_DevAct_ID7, and Pilot1_DevAct_ID8). Nevertheless, these delays and additions should not compromise the successful execution of the trial.

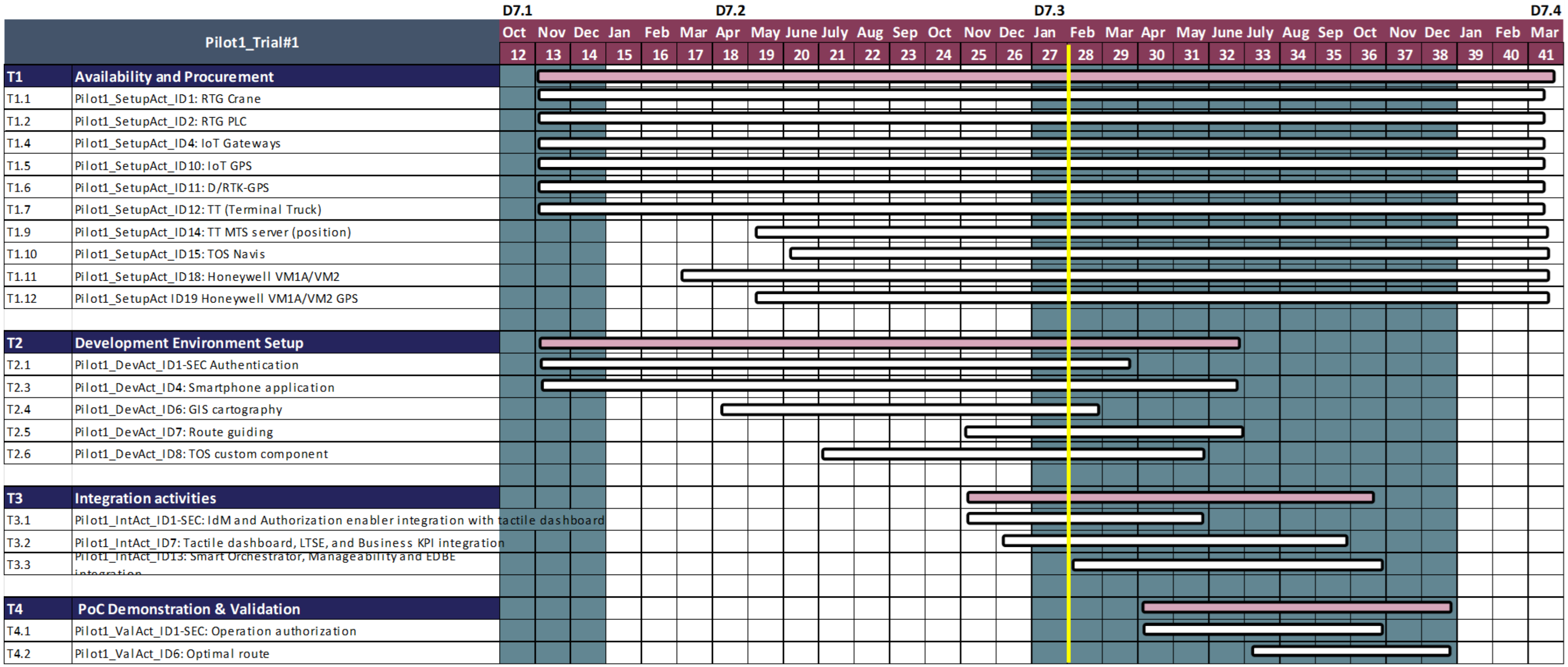


Figure 9. Pilot 1 – Trial #1 updated Gantt chart (M27).

2.3. Trial #2: Automated CHE cooperation

2.3.1. Scope

The scope of Pilot 1 – Trial #2 is to enhance the operational performance by enabling CHEs cooperation from an alignment automation perspective, so containers are moved automatically from RTG cranes to trucks (TT or external). To do so, the machines will first identify and authenticate each other before starting the operation. Then, the RTG will guide the truck to the correct position using LIDAR sensors and UWB location system. The process will be illustrated through positioning guidance lights, as well as a new screen over the ASSIST-IoT mobile app that will be installed in truck driver's cabin.

2.3.2. Implementation activities reporting

2.3.2.1. Procurement activities

The status of the procurement activities related with this trial of Pilot 1, which were identified in D7.1, is updated next.

Pilot1_SetupAct_ID1 RTG crane: Same SetupAct in Trial #1. Go to Section 2.2.2.1 for more details.

Pilot1_SetupAct_ID2 RTG PLC: Same SetupAct in Trial #1. Go to Section 2.2.2.1 for more details.

Pilot1_SetupAct_ID4 IoT Gateways: Same SetupAct in Trial #1. Go to Section 2.2.2.1 for more details.

Pilot1_SetupAct_ID9 LIDAR System: The LIDAR system can be divided into two separate systems; stack profiling system and truck guiding system.

- **Stack profiling**: Needed HW has been purchased, shipped to Malta, and installed to the RTGs. Last SW test ongoing at Konecranes test site.

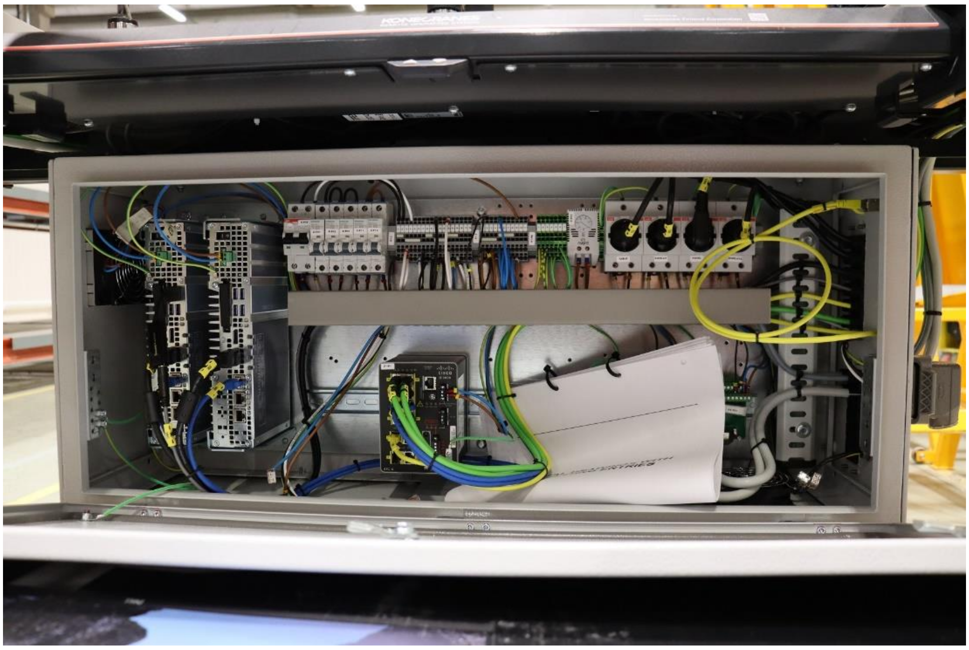


Figure 10. Stack profiling HW needed for the LIDAR system.

- **Truck guiding**: All needed HW purchased. It will be shipped to Malta during February and then installed to the RTG cranes.

Pilot1_SetupAct_ID12 TT (Terminal truck): Same SetupAct in Trial #1. Go to Section 2.2.2.1 for more details.

Pilot1_SetupAct_ID15 TOS Navis: Same SetupAct in Trial #1. Go to Section 2.2.2.1 for more details.

Pilot1_SetupAct_ID18 Tablet Honeywell: Same SetupAct in Trial #1. Go to Section 2.2.2.1 for more details.

Pilot1_SetupAct_ID20 UWB system: Available, but not integrated within the pilot yet. For the identification and authentication process triggering, it has been decided to set up the Decawave MDEK1001 UWB communication system. Their specifications were provided in previous deliverable.

2.3.2.2. Development activities

Pilot1_DevAct_ID1-SEC authentication: In progress. This development activity is focused on truck and RTG crane mutual authentication and validation when they are in close proximity. To do so, two sub-development activities are in progress. The first one requires to customize the procured UWB modules in order to enable the reception of RTG crane telemetry data (UWB anchor) by the truck (UWB tag) when they are close enough and making use of the accurate distance measurement that the system provides. The main advancement with respect to previous report have been achieved on the customization of the message that is delivered between the UWB components, so instead of a single integer value, now the system is capable of delivering JSON files, which contains this telemetry data. The next step in this sub activity is the support of pulling this JSON data through the serial port of the attached device to the UWB tag. On the other hand, the second sub activity will not only require that the two UWB modules are close enough, but also that are authenticated and authorized by means of the cybersecurity enablers.

Pilot1_DevAct_ID2-SEC incident management: This development activity has been removed from the list, as it was considered not relevant for the purpose of the trial, which is more focused on the cooperation between CHEs, rather than the container positioning within the terminal yard.

In order to clearly separate the two sub use cases identified in D7.2, the original activities Pilot1_DevAct_ID3 and Pilot1_DevAct_ID5 activity have been merged and split at the same time. Now, they are called **Pilot1_DevAct_ID3 Smartphone application - Container handling reporting**, and **Pilot1_DevAct_ID5 Smartphone application – RTG-Truck alignment**. Their status is presented next.

Pilot1_DevAct_ID3 Smartphone application - Container handling reporting Finished. The main advancement with respect to D7.2 is that the in the new release of the mobile application, the Container handling reporting view not only provides the real-time position and movements of the spreader of the crane under work, but also the actual container stack in the specific bay over which the truck and crane are located. To do so, the mobile application connects to the corresponding database of the TOS XPS system. An illustration is depicted below.

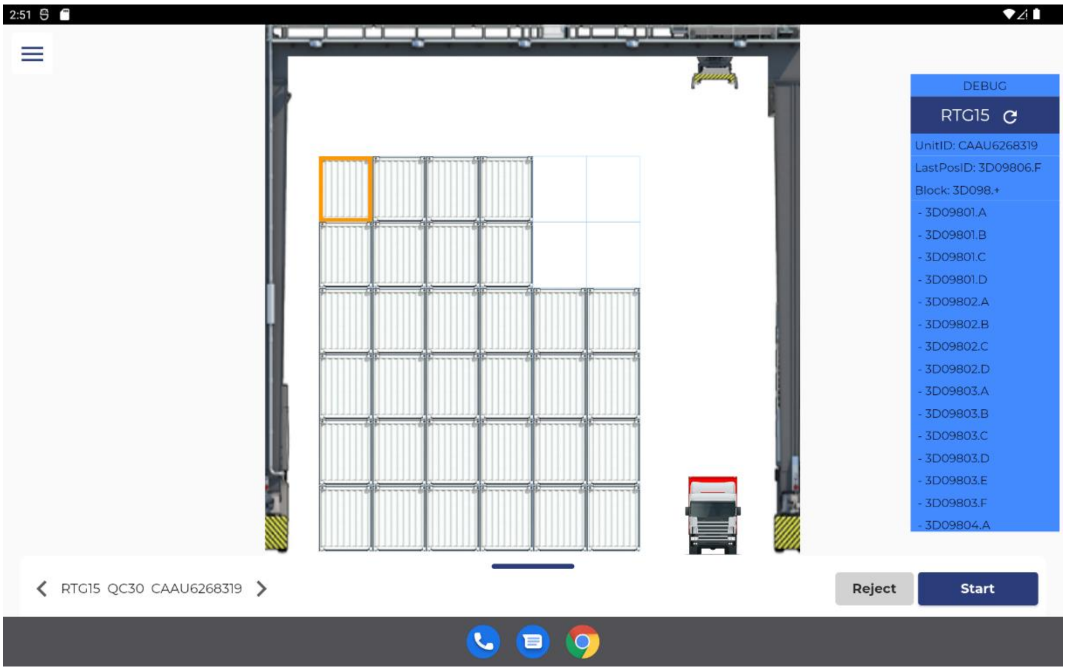


Figure 11.Container handling reporting interface of Pilot 1.

Pilot1_DevAct_ID5 Smartphone application – RTG-Truck alignment: In progress. This activity is related to the development of the mobile app view that presents the truck position within the truck lane by retrieving the PLC messages from the LIDAR system (see Pilot1_SetupAct_ID9 LIDAR System). Since the LIDAR system has not been installed yet in MFT, a backup solution has been agreed between partners in order to kick off the development on a local environment. In that sense, KONE has delivered the documentation of the LIDAR system, pointing out in which PLC registers and databases are stored the corresponding LIDAR positioning values. On the other side, PRO has generated some mocked-up data with this information, but further development is still needed.

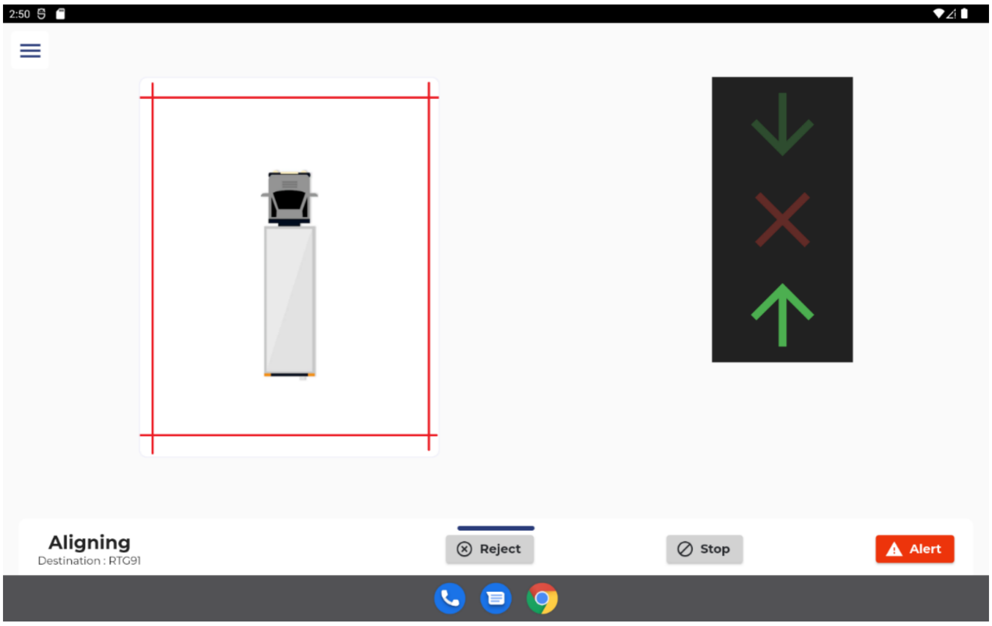


Figure 12. RTG-Truck alignment intefrace of Pilot 1.

2.3.2.3. Integration activities

Integration activities in this pilot are in principle associated to the integration of the different identified ASSIST-IoT enablers.

<u>Pilot1_IntAct_ID2-SEC IdM and Authorization enabler integration:</u> In progress. This integration activity refers to the integration of the GWEN provisioned for the pilot with the IdM and Authorization enablers of task T5.3. The main difference with respect to Pilot1_IntAct_ID1-SEC is that in this activity the cybersecurity enablers are going to be installed not on the central server but on the GWEN and IoT2050 gateways attached to the cranes, so that they will ensure that the UWB tags of the trucks are authenticated and authorized accordingly. To do so, those two IoT gateways are being upgraded, and first tests will be performed once the UWB system is ready (see Pilot1_DevAct_ID1-SEC authentication in previous section).

<u>Pilot1_IntAct_ID6 Commissioning of LIDAR:</u> Commissioning of the LIDAR system to be carried out during Q1-Q2/2023 together with the whole Remote-RTG system.

2.3.2.4. Validation activities

The validation activities related to the ASSIST-IoT enablers are:

<u>Pilot1_ValAct_ID1-SEC Operation authorization:</u>

Context: The main goal of Trial#2 is to enable communication between CHEs (trucks and RTG cranes). However, even in close proximity, before opening a working data channel between the RTG crane and a truck an authentication and authorization process must be done.

Expectation: It is expected that this validation activity will prove that the IdM and Authorization enablers are properly installed on the IoT gateways and are configured to enable the access to those users that have attached an UWB tag.

Validation proof: Not available yet.

Pilot1_ValAct_ID5 LIDAR Hardware tests:

Context: For the RTG-Truck alignment, LIDAR system should be up and running.

Expectation: To confirm that the LIDAR system is properly working, different verification tests listed below should be carried out by Konecranes manufacturer.

Initial Conditions	Test Procedure	Expected result	Pass/Fail
TOS has sent pick up task to the truck lane: 20' Container from rear position.	Gantry is driven to the target bay and stops. Truck arrives to the target bay.	Truck guiding lights activate when gantry is in position. Arrows guide the truck to stop in correct position. When truck is within 10 cm of correct position, truck is shown stop indicator.	
TOS has sent pick up task to the truck lane: 20' Container from front position.	Gantry is driven to the target bay and stops. Truck arrives to the target bay.	Truck guiding lights activate when gantry is in position. Arrows guide the truck to stop in correct position. When truck is within 10 cm of correct position, truck is shown stop indicator.	
TOS has sent pick up task to the truck lane: 40' Container from middle position.	Gantry is driven to the target bay and stops. Truck arrives to the target bay.	Truck guiding lights activate when gantry is in position. Arrows guide the truck to stop in correct position. When truck is within 10 cm of correct position, truck is shown stop indicator.	
TOS has sent place task to the truck lane: 20' Container to rear position.	Gantry is driven to the target bay and stops. Truck arrives to the target bay.	Truck guiding lights activate when gantry is in position. Arrows guide the truck to stop in correct position. When truck is within 10 cm of correct position, truck is shown stop indicator.	
TOS has sent place task to the truck lane: 20' Container to front position.	Gantry is driven to the target bay and stops. Truck arrives to the target bay.	Truck guiding lights activate when gantry is in position. Arrows guide the truck to stop in correct position. When truck is within 10 cm of correct position, truck is shown stop indicator.	
TOS has sent place task to the truck lane: 40' Container to middle position.	Gantry is driven to the target bay and stops. Truck arrives to the target bay.	Truck guiding lights activate when gantry is in position. Arrows guide the truck to stop in correct position. When truck is within 10 cm of correct position, truck is shown stop indicator.	

Validation proof: Not available yet.

Pilot1_ValAct_ID8 UWB Nearby protocol:

Context: The main goal of Trial#2 is to enable communication between CHEs (trucks and RTG cranes). However, before opening a working data channel between the RTG crane and a truck, they should be close enough.

Expectation: For this activity, it should be proved that the data generated by the RTG crane is only accessible to the UWB tag attached to the smartphone / Honeywell tablet of the truck when it is close enough, according to a predefined distance allowance.

Validation proof: In progress. Initial tests have been performed on local environment, but not in MFT premises.

2.3.3. Deviations from original planning

Gantt chart summarising the task implementation for Trial #2. Major changes include the delay of the procurement, integration, and validation of the LIDAR system. Nevertheless, considering that it is expected to install the system early 2023, the rest of activities that depend on the laser scanning and traffic lights will have enough time for integration and functional testing before the project ends.

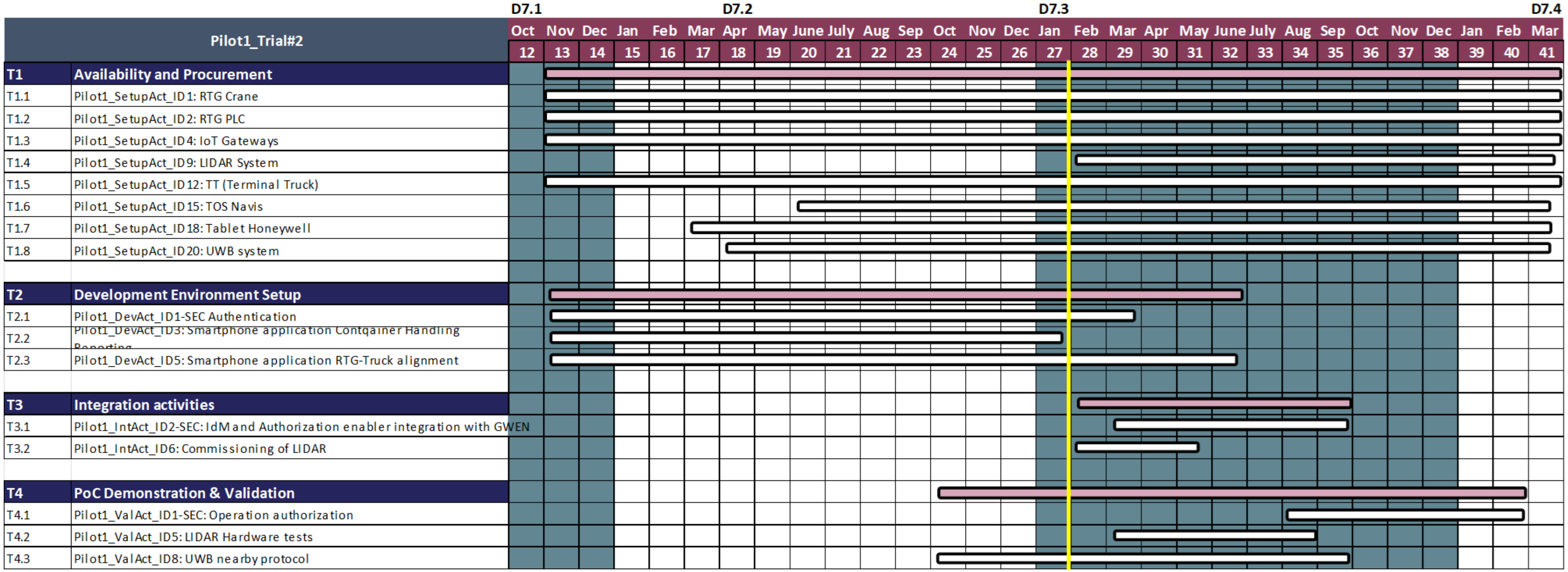


Figure 13. Pilot 1 - Trial #2 updated Gantt chart (M27)

2.4. Trial #3: RTG remote control with AR support

2.4.1. Scope

Trial #3 includes the completely remote operation of RTG cranes, which by means of ASSIST-IoT enablers will on the one hand reduce the deployment costs by enabling the connection between the operator and the RTG via wireless communications, with multiple redundant links and, on the other hand, empower the crane operators with visuals indicating which container should be handled and where should it be placed afterwards in the remote screens.

2.4.2. Implementation activities reporting

2.4.2.1. Procurement activities

Pilot1_SetupAct_ID1 RTG crane: Same SetupAct in Trial #1. Go to Section 2.2.2.1 for more details.

Pilot1_SetupAct_ID2 RTG PLC: Same SetupAct in Trial #1. Go to Section 2.2.2.1 for more details.

Pilot1_SetupAct_ID5 RTG Audio-visual: Engineering activities finished. Most of the HW received and waiting for shipment at Konecranes warehouse. Once the last missing components are received everything will be shipped to Malta and installed to the RTGs.

Pilot1_SetupAct_ID6 RTG Remote Operating Desktop station: Engineering activities finished. All remote desk HW received. Desks have been assembled at the Konecranes factory, tested, and dissembled for shipping. Waiting for shipment at Konecranes warehouse.

Figure 14. Remote desktop assembled at Konecranes factory.

Pilot1_SetupAct_ID7 RTG Crane task management server: Engineering and purchasing activities delayed due to global chip shortage. Expected delivery for M28.

Pilot1_SetupAct_ID8 Central PLC: Engineering and purchasing activities delayed due to global chip shortage. Expected delivery for M28.

Pilot1_SetupAct_ID15 TOS Navis: Same Setup Activity as in Trial #1. Go to Section 2.2.2.1 for more details.

Pilot1_SetupAct_ID16 Fluidmesh: Although the equipment is available and integrated within the pilot, the license supporting higher bandwidths will be upgraded in M28.

Pilot1_SetupAct_ID17 Virtual servers: In progress. AV Server, Diagnostics Server, and NTP & Netmon Server are being set up by IT department of MFT. In addition, the 8 VLANs that are needed for the proper function of the ROS system are also still under construction.

2.4.2.2. Development activities

Pilot1_DevAct_ID4 AI/ML container recognition: In progress. The AI/ML container recognition will help remote crane drivers with the visual guidelines highlighting the container over which he/she has to operate with. As reported in D7.2, The TotalLoss obtained for the ssd_resnet50_v1_fpn_640x640 ML model with the project's current annotated dataset was 7.94, which was considered not enough for the expected accuracy of the project. To enhance the pre-trained ML model, additional datasets are needed, but unfortunately, due to chip shortage, the AV system for the ROS crane has not been fully deployed yet, as introduced in Pilot1_SetupAct_ID5. As soon as that procurement activity is finished, available and integrated within the pilot, new images will be recorded, and this development activity will be resumed.

2.4.2.3. Integration activities

Pilot1_IntAct_ID3 Network ROS commissioning: Not started yet. Commissioning of the system delayed due to global chip shortage.

Pilot1_IntAct_ID4 Crane PLC and Central PLC: Not started yet. Commissioning of the system delayed due to global chip shortage.

Pilot1_IntAct_ID5 A/V system: Not started yet. Commissioning of the system delayed due to global chip shortage.

Pilot1_IntAct_ID8 T42 Multilink: Not started yet. Postponed until Multilink enabler is developed, and ready for integration, as well as the above procurement and integration activities are finished.

Pilot1_IntAct_ID12 AI/ML container recognition: Not started yet. Postponed until a more accurate ML model is obtained in Pilot1_DevAct_ID4, so that new datasets are required, which will be gathered once Pilot1_SetupAct_ID5 is available and integrated within the pilot.

Pilot1_IntAct_ID14 Tactile Dashboard and Video Augmentation enabler integration: Not started yet. This activity not devised in previous WP7 deliverables has been included as a manner of presenting in a human-friendly interface the visual guidelines generated by the VA enabler. It will start in M29 once other enablers GUIs are properly integrated with the pilot 1 tactile dashboard.

2.4.2.4. Validation activities

Pilot1_ValAct_ID3 ROS tests:

Context: Remotely operated cranes require remote controlled sensors and actuators.

Expectation: The remote-controlled system should be verified for the proper functioning. The following tests will be performed.

GENERAL	Result
Selection - ROS can be connected to a crane	
Selection - Crane controls can be activated	
AV controls - Video streams can be changed and PTZ controlled	
AV controls - Audio streams can be selected and horn sounded	
User interface - Crane position (logical position, trolley, hoist)	
User interface - Spreader status (twistlocks, landed, telescope length)	
User interface - Spreader position (trim, skew)	
User interface - General data (container weight, wind speed)	
User interface - Job container data (container size & ID)	
User interface - Job truck data (truck ID, container size, container position)	
User interface - Traffic lights (forward, stop, reverse)	
Safety - Stop button functional	

Selection - Crane controls can be deactivated	
Selection - Crane can be disconnected from the ROS	

Crane controls	**Result**
Crane controls - Drives ON/OFF	
Crane controls - Trolley forward and backward	
Crane controls - Gantry left and right	
Crane controls - Hoist up and down	
Crane controls - Telescope 20’/40’/45'/TWIN (45' and TWIN optional)	
Crane controls - Trim left and right	
Crane controls - Micro-move all directions	
Crane controls - Micro-move reset	
Crane controls - Twistlocks open and close	
Crane controls - Bypass slack rope	
Crane controls - Bypass gantry anti-collision	
Crane controls - Bypass truck anti-lift (optional)	
Crane controls - Bypass stack profiling in trolley direction (optional)	
Crane controls - RTG traffic light controls	
Crane controls - Floodlight controls	
Crane controls - Wheel turning park/normal	
Crane controls - Fault reset	

ROS connectivity	**Result**
ROS can be connected to all the available cranes	

Validation proof: Not available yet.

Pilot1_ValAct_ID4 A/V device tests:

Context: For the proper remote operation, crane driver should receive the current environment under the crane is operating.

Expectation: Video cameras as well as loudspeaker and microphones should be proper installed. In addition, video feeds should be received at the AV server without a quality reduction. The following verification tests are scheduled:

Trolley camera view	**Result**
Video OK	
Pan, tilt and zoom functional (optional, only if PTZ camera is installed)	
Preset correctly set (optional, only if PTZ camera is installed)	

Bay camera view	**Result**
Video OK	

Truck lane camera views	**Result**
General view PTZ camera - Video OK	
General view PTZ camera - Pan, tilt and zoom functional	
General view PTZ camera - Preset correctly set	
20' truck trailer cameras - Right video on split view OK	
20' truck trailer cameras - Left video on split view OK	
40'/45' truck trailer cameras - Right video on split view OK	
40'/45' truck trailer cameras - Left video on split view OK	

Spreader camera views	**Result**
Upper right video on quad view OK	
Lower right video on quad view OK	
Upper left video on quad view OK	
Lower left video on quad view OK	

Bogie camera view	**Result**
Upper right video on quad view OK	
Lower right video on quad view OK	
Upper left video on quad view OK	
Lower left video on quad view OK	

Audio device	**Result**
Trolley intercom OK	
Truck lane loudspeaker OK	

Validation proof: Not available yet

Pilot1_ValAct_ID5 LIDAR Hardware tests: Same ValAct in Trial #2. Go to Section 2.3.2.4 for more details.

Pilot1_ValAct_ID7 Multilink:

Context: Trial #3 is about enabling a redundant and sufficiently capable wireless network to the remote RTG operation. To do so, it is considered that having only a single wireless radio interface is not enough, and backup networks will be needed in case the primary access does not provide the required bandwidth needs.

Expectation: The ASSIST-IoT multilink enabler that will be deployed on the network routers/switches installed both at cranes IT rooms, as well as at Remote server rooms will allow to switch between at least 2 wireless communication channels: FluidMesh (as primary network), and 4G.

Validation proof: In progress. Initial local tests with the latest multilink enabler release have been performed. However, this version of the multilink supports one wireless access plus one wired access (Ethernet).

Pilot1_ValAct_ID9 Video AI/ML software:

Context: A second objective of this trial is that the guiding visuals will be incorporated to the remote desktop screens, helping remote RTG operators with the identification of the specific container to be handled for the working instruction being dispatched.

Expectation: The Video Augmentation enabler will be integrated with the ROS system of the crane, and by applying a trained ML model over the streams captured by the crane's cameras, the enabler will guide the driver to the container he/she has to work with. This ML model should provide an TotalLoss <= 2 for the dataset captured during the training phase.

Validation proof: In progress. Initial local tests with the latest VA release have been performed (as presented during D7.2). However, the adopted ML model requires further training with new datasets that are not available due to the AV system procurement delays.

2.4.3. Deviations from original planning

Gantt chart summarising the task implementation for Trial #3. As it can be seen, global chip shortage is delaying the procurement and commissioning of all the ROS spare parts (in D7.2 it was estimated that they should be finished by the end of 2022, but they will in principle started from M28 – February 2023). This impacts on their consequent integration and validation activities, which are expected to be finished during Summer 2023. Once they are ready, the two additional functionalities of ASSIST-IoT (multilink capabilities integrated, plus ML-based recognition features will be integrated and validated in the testbed). All in all, it is expected that all activities will finalise in time and the pilot will be successfully deployed.

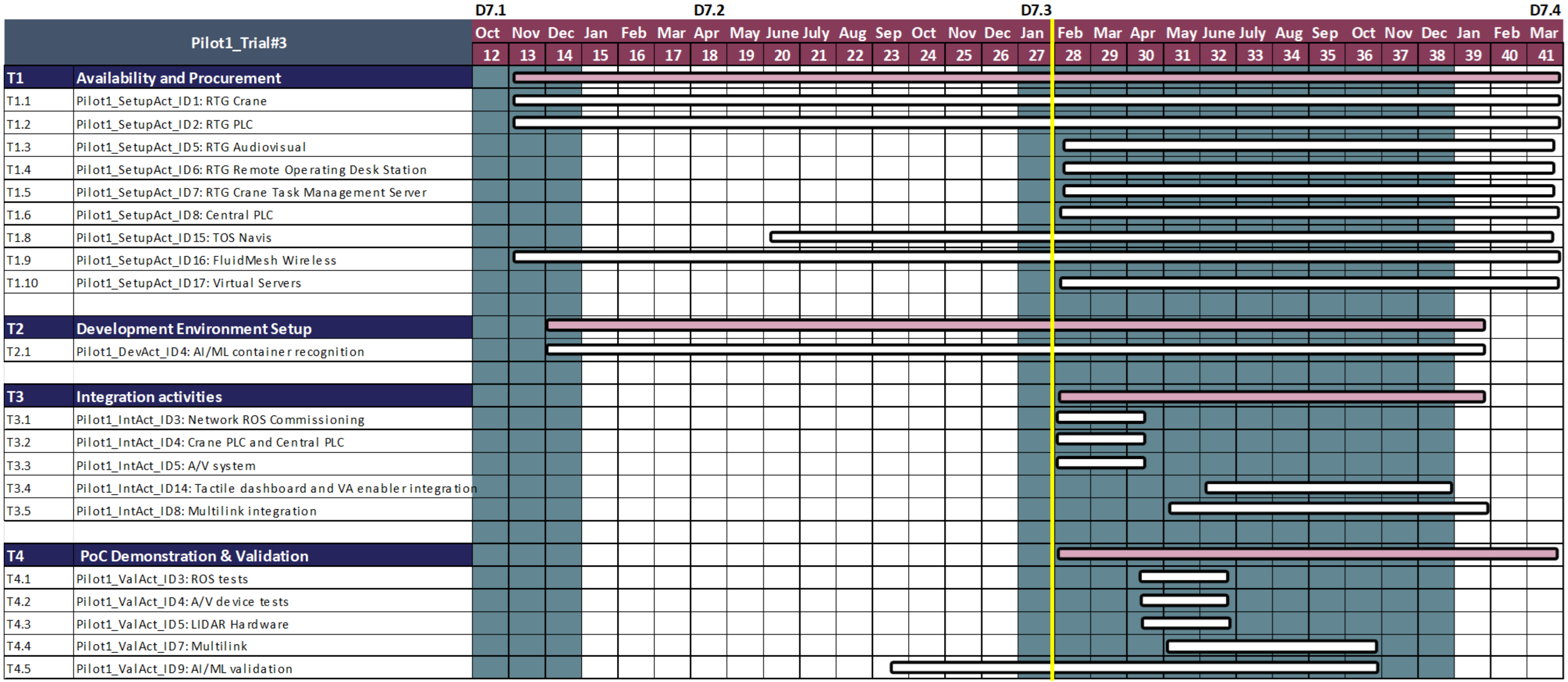


Figure 15. Trial #3 updated Gantt chart (M27)

3. Pilot 2: Smart safety of workers

3.1. Context review

Mostostal Warszawa S.A. is one of the largest building companies in Poland. The company is active in all basic sectors of the construction market focusing on steel construction, public buildings, environmental protection projects, as well as roads constructions.

For the purpose of the pilot, construction of educational building on the campus of the University of Warsaw has been selected in order to integrate the architectural proposal and technologies developed by ASSIST-IoT. The 8-storey building with a total area of 26 600 m2 will provide 30 lecture halls for nearly 400 students at the University of Warsaw. The project is dedicated towards sustainability, by providing energy-saving electrical installations, the use of heat recovery systems and renewable energy sources. The new location in Warsaw guarantees access to the 5G network. The project is being managed by project partner MOW.

3.2. Trial #1: Occupational safety and health monitoring

3.2.1. Scope

The Trial aims to increase worker safety through the use of a system that can be split into three parallel sub-trials:

1. **Workers are equipped with locator tags and sensors.** The system detects if certain worker health parameters have passed a safe threshold by taking readings from sensors located on the worker.
2. **Worker's location will also be monitored**, helping **prevent unwarranted access to dangerous areas on the construction site**.
3. **The system will be monitoring the workers and alert supervisors** of potentially unsafe situations.

More information about the scope can be founded in Deliverable D7.2 Pilot Scenario Implementation – First Version.

3.2.2. Implementation activities reporting

The list of specific activities has been updated from those listed in D7.2. Please **note** that the numbering of some activities has changed due to the ordering of tasks by time of their completion. Minor changes in the tasks naming were made due to the unification of naming in the task management tool used for Pilot 2 – Asana.

3.2.2.1. Procurement activities

Pilot2_SetupAct_ID1-Camera purchase: The chosen camera is a Dahua IPC-HFW5449T-ASE-LED-0360B. Along with the camera, mounting equipment, cables, and a cable tube were acquired for the installation.

Pilot2_SetupAct_ID2-Weather station purchase: A Davis Vantage Pro2 weather station was purchased along with mounting equipment. The station is able to gather data on outdoor environmental conditions including weather (temperature, humidity, etc.) and solar and UV radiation.

Figure 16. The weather station

Pilot2_SetupAct_ID3-Wristband purchase for communication testing: The previously chosen wristband was acquired and a total of ten PineTime smartwatches and one development kit were purchased. They were chosen for their relatively low cost, long battery life, dust and water resistance, and re-programmability. The product does not rely on any manufacturer's cloud services, which would jeopardize worker data privacy. These wristbands do not come with long-range wireless communication such as Wi-Fi or UWB, having only a Bluetooth Low Energy interface. Therefore, the location tags will relay the wristband's communications.

Figure 17. PineTime – open source smartwatch.

Pilot2_SetupAct_ID4- Set up an AWS account: An Amazon web services account was set up in order to access Amazon Recognition, which is used to detect worker PPE compliance through the camera feed.

Pilot2_SetupAct_ID5-Server purchase and installation: A server was purchased for the construction site. In order to fulfil the needs of the pilot, the following specifications were needed: processor – Intel Xeon Gold 5218 16 cores; memory – 2x 64GB DDR4 RDIMM; RAID controller – PERC H730P; disks and drives – 2x 4TB HDD SATA 7.2k, 2x 960GB SSD SATA RI; integrated network card – dual port 10GbE LOM; remote control – iDRAC9 Express; power – 2x1100W (Hot-Plug). The server was installed successfully on the construction site.

Figure 18. The server installed in an office container.

Pilot2_SetupAct_ID6-Smartphone and tablet purchase: A Samsung Galaxy A53 5G smartphone was purchased. For the tablet, a Samsung Galaxy Tab Active was chosen for its durability in construction conditions as well as due to the requirement for it to have NFC support. In addition, operating using Android allows for more functionalities to be accessed and more ease in development.

Pilot2_SetupAct_ID7-Wristband purchase for development and deployment: Same as SetupAct ID3. Wristbands for development and deployment were purchased at the same time.

Pilot2_SetupAct_ID8-Camera installation: The camera was installed on the construction site. It was mounted on a pole next to the path workers take to enter the construction site. The camera is directly linked via cable to the on-site server.

Figure 19. The camera mounted on a pole

Pilot2_SetupAct_ID8-Weather station installation: The weather station has been installed in the headquarters of SRIPAS, which given its proximity to the pilot site, will provide accurate measurements for the project.

Pilot2_SetupAct_ID10-PCS procurement for development and testing: Hardware (controller – 2 pieces) is ready to use and already equipped with the required UWB module for communication with ASSIST-IoT. Delivered PCS pieces are outcomes of the fifth stage of the National Programme "Improvement of safety and working conditions" supported from the resources of the National Centre for Research and Development. task no. III.PB.09, entitled "Development of the protective clothing with an active cooling function based on the thermoelectric effect (Peltier modules)". The Central Institute for Labour Protection—National Research Institute is the Programme's main coordinator. Existing controllers of PCS have not yet been integrated with ASSIST-IoT.

Pilot2_SetupAct_ID11-GWEN and localization system prototype delivery: A prototype GWEN device was delivered to the worksite, along with a hardware set for testing the localization system (4 anchors and 2 worker location tags).

Pilot2_SetupAct_ID12- 2nd GWEN delivery and HW upgrade, full localization system delivery: Not started yet. This activity also englobes the former ID13 and ID15 UWB anchors and tags procurement activities, respectively.

3.2.2.2. Development activities

Pilot2_DevAct ID1-Camera collector & AWS interface: A component was prepared that: captures the video stream from the camera, pre-processes it to remove unimportant frames, forwards the video to AWS Recognition, and interfaces with the rest of the system.

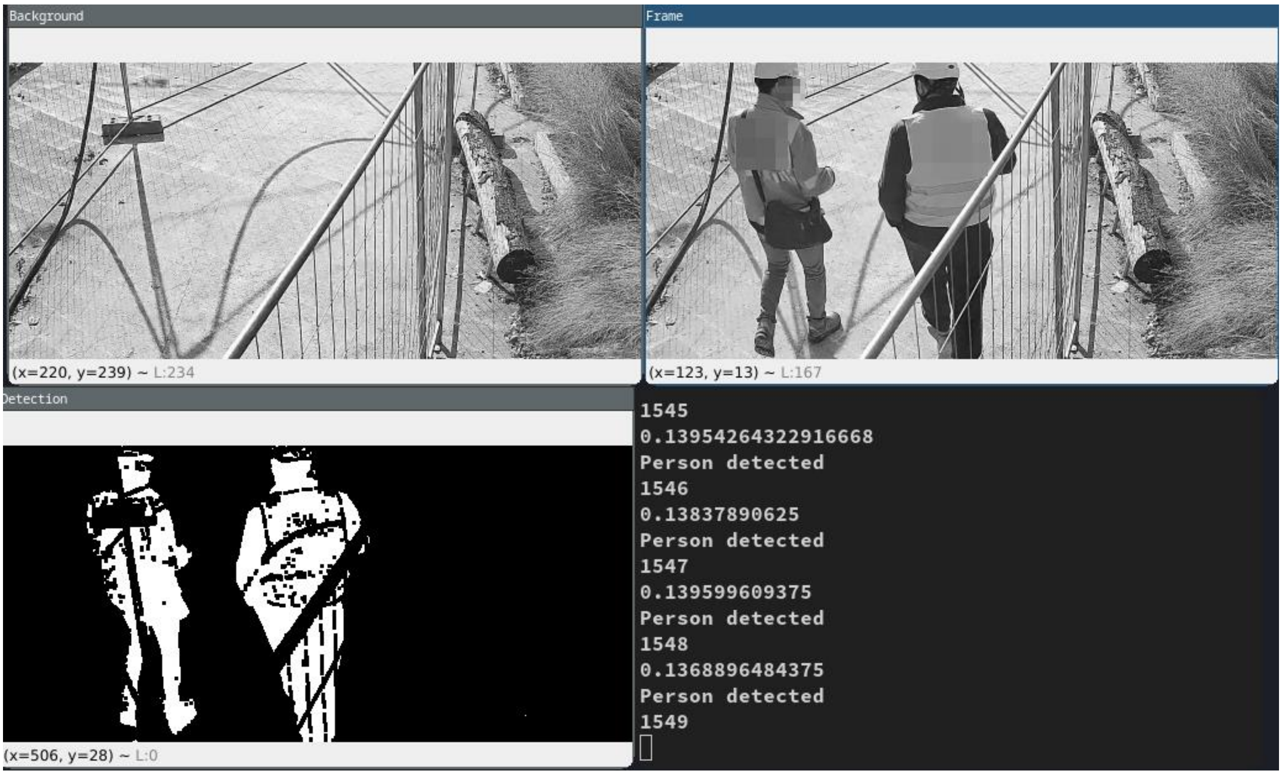


Figure 20. Camera collector component demonstration. The video stream is pre-processed to discard frames with no significant activity (no people entering or leaving the worksite). This reduces the costs of running the machine learning models.

Pilot2_DevAct ID2-Weather station collector: A component was prepared that collects real-time weather data from the weather station and sends it to consumers via MQTT.

Pilot2_DevAct ID3-CSC & WSC skeletons: The base skeletons of the Workplace safety controller and the Construction site controller components was prepared on top of which further features will be developed. Further development plan and software design were also prepared.

Pilot2_DevAct ID4-PCS controller software: The existing controller consists of software enabling its autonomous operation. However, in order to integrate it with ASSIST-IoT, additional software needs to be developed, launched and made available in the form of source code. Moreover, data transmission format (frames) will be developed and specified. This software will be provided within a service. Currently, essential formal procedures have been carried out. Development of such additional software will take place later in the project.

Pilot2_DevAct ID5-Initial wristband interface: In progress.

Pilot2_DevAct ID6-BIM processing pipeline: In progress.

Pilot2_DevAct ID7- UV tracking: loading weather data streams: Not started yet.

Pilot2_DevAct ID8- Extend the BIM processor to also extract indoor/outdoor coords: Not started yet.

Pilot2_DevAct ID9-PCS interface: Not started yet.

Pilot2_DevAct ID11- Develop the skeleton for the mobile application: Implementation technology was selected (tactile dashboard enabler with the PUI9 framework). Interactions with other enablers were planned. Code development not started yet.

Pilot2_DevAct ID11- Configure the Location Processing enabler to determine (in/out) door locations: Not started yet.

Pilot2_DevAct ID11- UV exposure component (Docker + Helm): Not started yet.

3.2.2.3. Integration activities

Pilot2_IntAct_ID1-Wristband communication test: The preliminary testes has been done.

Pilot2_IntAct_ID2-Initial worksite server integration: The operating system was installed on the server and the network was configured.

Pilot2_IntAct_ID3-Semantic integration of worker data: Preliminary investigation for how to perform the integration was carried out.

Pilot2_IntAct_ID4-Semantic integration of the weather station: In progress. The ontology for describing the data and the RML mappings were prepared. Currently pending is the semantic translation configuration for converting units of measure.

Pilot2_IntAct_ID5- Integrate the wristband with UWB comm.: Not started yet.

Pilot2_IntAct_ID6-Semantic integration of location data: In progress. The ontology for describing the data has been prepared and now the RML mapping for the Semantic Annotation enabler is being prepared.

Pilot2_IntAct_ID7- Semantic integration of the camera: Not started yet.

Pilot2_IntAct_ID8-WSC incident logging integration: Not started yet.

Pilot2_IntAct_ID9- Integrate the BIM processor with the Semantic Repository: Not started yet.

Pilot2_IntAct_ID10-Semantic integration of the wristband: Not started yet.

Pilot2_IntAct_ID11-WSC notification integration: Not started yet.

Pilot2_IntAct_ID12-Camera collector and WSC integration: Not started yet.

Pilot2_IntAct_ID13-Location tracking and processing integration: Not started yet.

Pilot2_IntAct_ID14-BKPI reporting and mobile application integration: Not started yet.

Pilot2_IntAct_ID15-Semantic integration of the PCS: Not started yet.

Pilot2_IntAct_ID16-Mobile application notification integration: Not started yet.

Pilot2_IntAct_ID17-Logic integration for UC-P2-1: Not started yet.

Pilot2_IntAct_ID18-Logic integration for UC-P2-2: Not started yet.

Pilot2_IntAct_ID19-Logic integration for UC-P2-3: Not started yet.

3.2.2.4. Validation activities

Pilot2_ValAct_ID1-UWB construction site range test:

Context: Before setting up a full set of UWB anchors for localization on the worksite, range tests must be performed to estimate what is the effective range of the system in a construction site environment.

Expectation: Recommendations can be made for how to place anchors on the worksite and what adjustments in software need to be made before future trials.

Validation proof: The test was carried out successfully and the range was found to be: 25 metres without obstructions, and 10 metres with a calcium silicate wall (typical of the pilot site) in between the antennas. Optimal locations for placing the anchors were proposed that would allow to cover the demonstration area. Several software issues were identified in the prototype, which will be fixed before further trials. The most important software change was to allow the Location Tracking enabler to report the approximate location of a worker in situations when only one or two anchors are visible to the location tag.

Figure 21. Left: Prototype GWEN in a protective enclosure on the construction site, during the range test. Right: Measuring UWB range on the construction site

Pilot2_ValAct_ID2-Wristband human parameter monitoring test:

Context: The wristband used for collecting the worker's heart rate are off-the-shelf devices with very limited accuracy. To ensure that the measurements can be relied upon, tests must be carried out to establish how inaccurate are these heart rate measurements and in which situation does the wristband fail to produce reliable data.

Expectation: Accuracy of the wristband's heart rate sensor is established in comparison to professional laboratory equipment. Recommendations as for how to pre-process the heart rate data from the wristband to remove the inaccuracies are made.

Validation proof: In progress – laboratory tests with human participants were started. Before conducting the tests all procedures according to the Ethics and privacy protection manual (D2.4) were followed and consulted with the ASSIST-IoT Ethics Manager. The informed consent statement was prepared, and each participant gave personalized permission to ASSIST-IoT to collect, analyse and publish/report their data (when necessary) as provided in the Information Sheet and in compliance with standards and regulations.

Pilot2_ValAct_ID3- 5G coverage tests on construction site:

Context: For connectivity purposes inside the building at the construction site, the radio signal coverage tests are needed. It is planed two series of the tests during the evolving construction of the building. The localization of the constructed building is on the edge of three 5G base stations causing more difficulties in providing reliable connectivity. Analysis of the coverage will be performed.

Expectation: Expected result is radio signal coverage map inside the building and based on the results to design most effective solution for 5G connectivity.

Validation proof: Not started yet.

Pilot2_ValAct_ID4- 5G coverage tests on construction site before validation:

Context: Same Context ValAct ID3

Expectation: Same Expectation ValAct ID3

Validation proof: Not started yet.

Pilot2_ValAct_ID5-UV exposure tracking:

Context: UV radiation is highest during summer months especially between the hours of 10-16 and has a direct effect on workers performing outdoor activities. The goal of this task is to ensure that workers do not exceed the maximum dose of UV while working. The weather monitoring station will be located in a position where it will be exposed to UV radiation.

Expectation: UV radiation data from the weather station passes through Edge Data Broker, then Semantic Annotator and if the amount of UV radiation the worker is exposed to surpasses a threshold, the Workplace safety controller sends an alert to the worker and records the incident.

Validation proof: Not started yet.

Pilot2_ValAct_ID6- Construction worker location tracking:

Context: For the successful completion of many validation activities in Pilot 2, it is important to have accurate location data. Accurate location data is necessary for identifying geo-fencing breaches as well as for enabling faster response times to dangerous situations. Location data is sent via location tags that users will have equipped. For the purposes of validation, the location of all tags will be displayed, however the final solution will only display this information when a dangerous situation arises.

Expectation: The tags will be tested in multiple locations on the construction site including inside the building on three levels, one underground, with several workers near the staircase as well as on one entire floor. The tests will also be tested outside, at the entrance between the office area and construction area. The tests will be performed with 10 participants. Before starting the tests, all procedures according to the Ethics and privacy protection manual (D2.4) will be followed and consulted with the ASSIST-IoT Ethics Manager.

Validation proof: Not started yet.

Pilot2_ValAct ID7-Crane operator physiological parameters monitoring:

Context: The first level of alert is for the workers themselves, warning them of potential dangers (e.g., heart rate is too high, overheating) and provide recommendations such as taking a break to prevent a worsening of their condition. The second, and more serious level, is for emergency situations where intervention is needed (e.g., no heartbeat or immobility). In this situation the OSH manager will be directly notified of the situation. The manager will only be notified of a dangerous situation, with appropriate context (e.g., the average heart rate in the last minute).

Expectation: First level – simulated too high heart rate data from the wristband passes through Edge Data Broker, then Semantic Annotator and the Workplace safety controller provides an alert with recommendations which is sent to the worker's wristband. Second level – simulated immobility data from the wristband and the location tag passes through Edge Data Broker, then Semantic Annotator and Workplace safety controller provides an alert with information about its location data from the location tag which is sent to the OSH manager’s device. Time between appearance of simulated hazards and the moment an alert is received is measured.

Validation proof: Not started yet.

Pilot2_ValAct_ID8- Geo-fencing boundaries enforcement tests – crane:

Context: Geofencing is the creation of a virtual boundary which in this activity will mark this area. This area should be detected and placed within the BIM model and will be used in conjunction with location tags to help detect if the boundary has been crossed.

Expectation: As part of this test, virtual danger zones will be created within the BIM model based on the location of the crane on the construction site. At the corresponding real area on site, the location accuracy, correct identification of the danger site, as well as the speed of notifying both the employee wearing the tag and OSH manager of the event will be tested. In this case, the scenario that will be tested is a worker without proper permissions attempting to climb onto the crane. If the worker's location matches and their elevation reaches 2 meters above ground, a notification should be sent out.

Validation proof: Not started yet.

Pilot2_ValAct_ID9- Geo-fencing boundaries enforcement tests-plant operator:

Context: The plants will be equipped with paired location tags that will allow the system to track the plant's location and orientation in real time. The vicinity of a plant operator will be geo-fenced, allowing for the detection of potential collisions between workers and machinery. These areas will be mapped virtually in real time and will be used in conjunction with location tags to help detect if the boundary has been crossed.

Expectation: As part of this test, virtual danger zones will be created based on data received from location tags about the location and orientation of a construction plant. At the corresponding real areas on site, the location accuracy, correct identification of the danger site, as well as the speed of notifying both the employee wearing the tag and OSH manager of the event will be tested.

Validation proof: Not started yet.

Pilot2_ValAct_ID10- Geofencing boundaries enforcement tests-danger zone:

Context: Certain areas on site have been identified as having elevated risks such as the area around openings or excavations. These areas have been outlined within the BIM model and will be used in conjunction with location tags to help detect if the boundary has been crossed.

Expectation: As part of this test, virtual danger zones will be created based on locations on the construction site within the BIM model. These sites will only be simulating danger zones and for the purposes of validation, a safe area will be used to test this. At the corresponding real areas on site, the location accuracy, correct identification of the danger site, as well as the speed of notifying both the employee wearing the tag and OSH manager of an unauthorised entrance will be tested.

Validation proof: Not started yet.

Pilot2_ValAct_ID11- Construction site access control:

Context: Controlling access to a construction site is an important safety practice to ensure that unauthorised people do not enter the site and cause potential dangers to themselves or others. At the entrance to the construction site, the UWB localization system and a camera using the Amazon Rekognition video analytics service will be used for access control to the site.

Expectation: A few scenarios will be tested as part of this activity, including tests with individuals as well as groups of workers entering simultaneously. Workers entering the worksite should wear the required PPE (helmet and vest) – the system should alert the OSH manager in case of irregularities. For workers entering with a location tag, the system should also check if they have appropriate permissions and training. The test will check the accuracy of the data collected by the ASSIST-IoT systems compared to what is actually done during the test.

Validation proof: Not started yet.

Pilot2_ValAct ID12- Blue-collar worker physiological parameters monitoring:

Context: Same Context in ValAct ID7.

Expectation: Simulated too high heart rate data from multiple wristbands (e.g. five at once) passes through Edge Data Broker, then Semantic Annotator and the Workplace safety controller provides an alert with recommendations which is sent to the worker's wristband. Appropriate alerts are also issued to the OSH manager. Checking if the number of too high heart rate notifications sent matches the actual number of times the simulated event occurred. Time between appearance of simulated hazards and the moment an alert is received is measured.

Validation proof: Not started yet.

Pilot2_ValAct_ID13- Office worker physiological parameters monitoring:

Context: Same Context in ValAct ID7.

Expectation: Same Expectation in ValAct_ID12.

Validation proof: Not started yet.

Pilot2_ValAct_ID14- Thermal discomfort reduction tests:

Context: The PCS system should be able to automatically regulate its output depending on the environmental conditions using data from the weather station and taking into account user physiological parameters such as heart rate and skin temperature. The focus of this validation activity is to confirm user acceptance of the technology. The personal cooling system will be tested under various conditions included in the sun or shade as well as while working under increased and decreased physical activity.

Expectation: Heart rate data from wristband, environmental data from weather station and skin temperature data from PCS passes through Edge Data Broker, then Semantic Annotator and the Workplace safety controller send the PCS instructions on how to adjust the cooling power to these conditions.

Validation proof: Not started yet.

Pilot2_ValAct_ID15- Construction site environmental conditions monitoring:

Context: To be able to perform further validation activities, the data regarding environmental conditions on the site must be checked. The data is obtained from the weather station, and it must be processed to be able to warn of dangerous conditions if certain parameters are exceeded.

Expectation: Evaluate the accuracy of the obtained results as well as to identify when limits are exceeded and alert relevant parties when that occurs. Three scenarios have been identified for validation: high temperatures, strong winds, as well as high UV radiation.

Validation proof: Not started yet.

3.2.3. Deviations from original planning

Gantt chart summarising the task implementation for Trial #1. As it can be seen, a slightly different colour structure has been included, due to the use of the collaborative project management online tool called Asana for this pilot. Nevertheless, it can be seen that all the procurement activities except for the GWEN are available, and the main work being carried out currently is the finalisation of development activities, as well as expected integration with ASSIST-IoT enablers by March 2023. The goal is to successfully validate this trial during M34, August 2023.

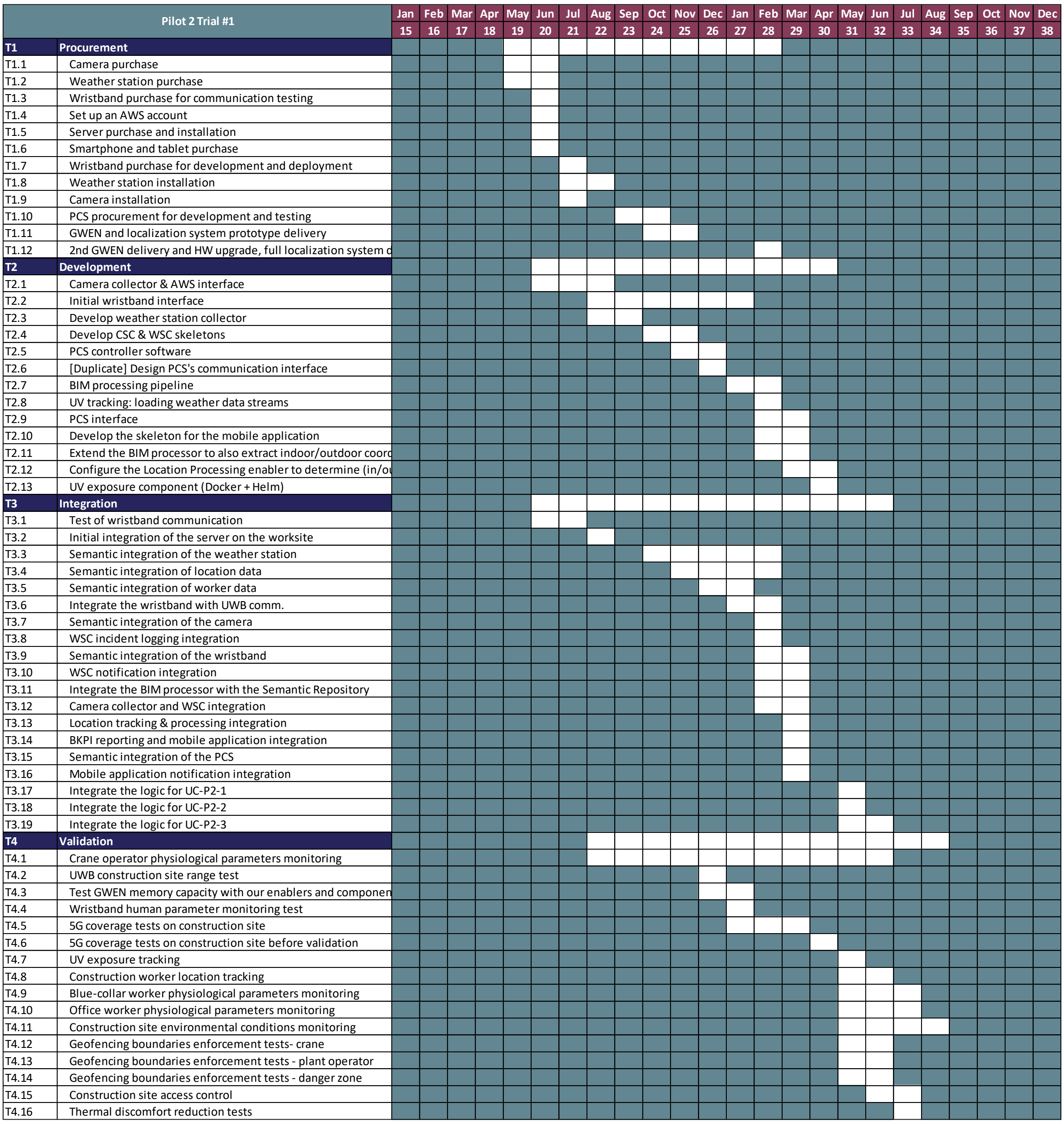


Figure 22. Pilot 2 – Trial #1 updated Gantt chart (M27).

3.3. Trial #2: Fall-related incident identification

3.3.1. Scope

The main purpose of this Trial is to detect fall-related incidents. This Trial focuses on the detection of construction worker's slips, trips, falls and immobility. If either a fall from a height is arrested by the protective equipment or construction worker is falling as a consequence of slipping, tripping or loss of consciousness, the incident should be detected and automatically reported, along with the location and the identity of the worker, in order to be further investigated. If the worker remains suspended from the fall arrest equipment, an alert should be raised, and help should be sent to the location of the incident immediately. The place of the incident is known due to the localization tag placed on the worker.

More information about the scope can be founded in Deliverable D7.2 Pilot Scenario Implementation – First Version.

3.3.2. Implementation activities reporting

The list of specific activities has been updated from those listed in D7.2. Please **note** that the numbering of some activities has changed due to the ordering of tasks by time of their completion. Minor changes in the tasks naming were made due to the unification of naming in the task management tool used for Pilot 2 – Asana.

3.3.2.1. Procurement activities

Pilot2_SetupAct_ID4-AWS account setup: Same SetupAct as in Trial #1.

Pilot2_SetupAct_ID5-Server purchase: Same SetupAct as in Trial #1.

Pilot2_SetupAct_ID6-Smartphone and tablet purchase: Same SetupAct as in Trial #1.

Pilot2_SetupAct_ID11-GWEN+UWB delivery: Same SetupAct as in Trial #1.

3.3.2.2. Development activities

Pilot2_DevAct_ID1- Design the attachment mechanism for the location tag: The details have been determined on how the location tag will be attached to the worker.

Pilot2_DevAct_ID2-ML fall detection data collection plan: A data collection / lab test plan was prepared. The necessary hardware and software were identified. The tests will include several scenarios with humans in non-risky situations (walking, running, falling on a mattress), as well as specialized body doubles in risky situations (fall from a height). Several dataset enhancement techniques will be applied to the collected data to improve the quality of the machine learning models. Before starting the tests, all procedures according to the Ethics and privacy protection manual (D2.4) will be followed and consulted with the ASSIST-IoT Ethics Manager.

Pilot2_DevAct_ID3- Selection of the final attachment mechanism for the location tag: For the purpose of stable installation of the tag on the human body, a tactical belt with a MOLLE[2] (acronym of Modular Lightweight Load-carrying Equipment) system was selected, being a standard solution for modular carrying equipment in the military sector. It is based on rows of webbing straps stitched onto the vest/backpack/belt to allow for the attachment of compatible pouches and accessories. In the selected attachment mechanism, tag is put into the pouch of dimensions ensuring its tight adjustment and attached through the webbing straps of the MOLLE system to the tactical belt.

Pilot2_DevAct_ID4-Gather data for fall detection algorithm: Not started yet.

Pilot2_DevAct_ID5-Train the initial fall detection model: Not started yet.

Pilot2_DevAct_ID6-FL solution for fall detection: Not started yet.

[2] https://en.wikipedia.org/wiki/MOLLE

3.3.2.3. Integration activities

Many integration activities are the same as in the Trial 1. Below have been listed only the new ones.

Pilot2_IntAct_ID1-ML fall detection method and WSC integration: Not started yet.

Pilot2_IntAct_ID2-UC-P2-4 logic integration: Not started yet.

3.3.2.4. Validation activities

Some validation activities are the same as in the Trial 1. Below have been listed only the new ones.

Pilot2_ValAct_ID1-Fall-related incident identification – laboratory tests:

Context: The system must be able to detect falls and be able to relay that information to the OSH manager through a notification. The laboratory tests using dummies will be used to collect data for training the system, so that it will be able to detect what a fall is. Several workers in the construction site will participate to the activity in order to identify false positives (e.g., jumping).

Expectation: Acceleration and location data from the location tag is forwarded to the Workplace safety controller and the FL Local Operations enabler. The machine learning model makes the appropriate decision, and the Workplace safety controller issues a notification to the OSH manager.

Validation proof: Not started yet.

Pilot2_ValAct_ID2-Fall-related incident identification-construction site tests:

Context: The system should be able to identify a slip or fall based on data from laboratory tests. This will be tested in construction site conditions in different locations using simulating falling. Site tests will not make use of dummies to detect a slip or fall, however this will be simulated from multiple locations to check signal propagation. Human participants will be used to test the false positive rate in various situations and positions.

Expectation: Same expectation as in Pilot2_ValAct_ID1.

Validation proof: Not started yet.

3.3.3. Deviations from original planning

Gantt chart summarising the task implementation for Trial #2. As it has been noticed before, a localization tag has been procured and is being used to detect slips, trips, falls and immobility of the construction worker, not a fall arrest detector as planned at the beginning.

PILOT 2 TRIAL #2		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
T2	**Development**																								
T2.1	Design the attachment mechanism for the location tag																								
T2.2	Selection of the final attachment mechanism for the location tag																								
T2.3	ML fall detection data collection plan																								
T2.4	Gather data for the fall detection algorithm																								
T2.5	FL solution for fall detection																								
T2.6	Train the initial fall detection model																								
T3	**Integration**																								
T3.1	ML fall detection method and WSC integration																								
T3.2	UC-P2-4 logic integration																								
T4	**Validation**																								
T4.1	Fall-related incident identification - laboratory tests																								
T4.2	Fall-related incident identification - tests at the construction site																								

Figure 23. Pilot 2 – Trial #2 updated Gantt chart (M27).

3.4. Trial #3: Health and safety inspection support

3.4.1. Scope

A challenge that OSH managers face on a construction site is to properly assess and communicate evacuation paths. Typically, physical markers are located throughout the construction site that give workers information regarding escape routes, however there is a risk that these markers are not kept up to date. This trial has a goal of testing innovative AR solutions to provide this information by utilizing data provided by BIM models.

The nature of construction sites leads to a high turnover of blue-collar workers due to the variety of tasks and disciplines involved. It is crucial to be able to easily locate and identify all workers, to ensure that they are authorized to be present on site. In the case of an individual disregarding health and safety protocols, it is crucial to support the OSH mangers in worker identification as well as checking whether permissions are up to date.

More information about the scope can be founded in Deliverable D7.2 Pilot Scenario Implementation – First Version.

3.4.2. Implementation activities reporting

The list of specific activities has been updated from those listed in D7.2. Please **note** that the numbering of some activities has changed due to the ordering of tasks by time of their completion. Minor changes in the tasks naming were made due to the unification of naming in the task management tool used for Pilot 2 – Asana.

3.4.2.1. Procurement activities

Pilot2_SetupAct_ID1- Procurement of MR device: HoloLens 2 has been purchased.

3.4.2.2. Development activities

Some development activities are the same as in the Trial 1. Below have been listed only the new ones.

Pilot2_DevAct_ID1-MR device and VPN connection: The MR enabler is ready to be functional in any IoT network via VPN configuration settings. In the following image, the configuration page is presented, which allows users to modify their credentials.

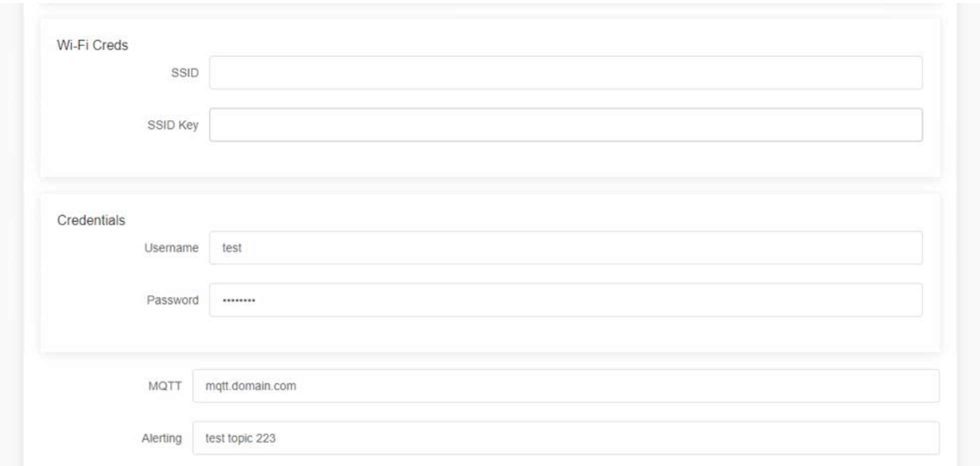


Figure 24. Access control configuration for the MR device through VPN connection.

Pilot2_DevAct_ID2-BIM model evacuation route MR visualization: The model of the previous development activity has successfully been loaded and visualised to the MR device.

Pilot2_DevAct_ID3-Design database to store data about workers: The database for storing the data from the workers that will be used in the Pilot 2 was designed.

Pilot2_DevAct_ID4- Develop a BIM model, that includes evacuation routes: A BIM model showing possible evacuation routes on the construction site was developed. The evacuation routes were created based on the recommendation of the site's OSH manager.

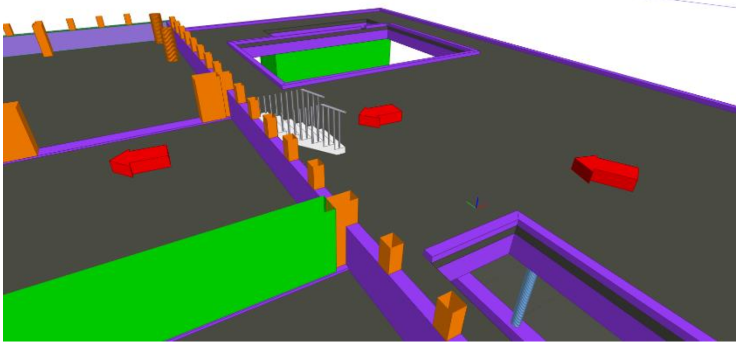


Figure 25. evacuation routes in BIM model.

Pilot2_DevAct_ID5-Notification schema design: The schema for the notifications that will be used in the Pilot 2 was designed. Using the schema, devices and systems can distribute their notifications in a standardised way through the ASSIST-IoT architecture.

Pilot2_DevAct_ID6-MR-based alerts: The user interface of the various alerts is developed and tested in the MR device. The receiving of notification coming from other systems (such as the weather station, fatigue monitoring and location management system about danger zones unauthorised access) have been tested and presented in the following figure.

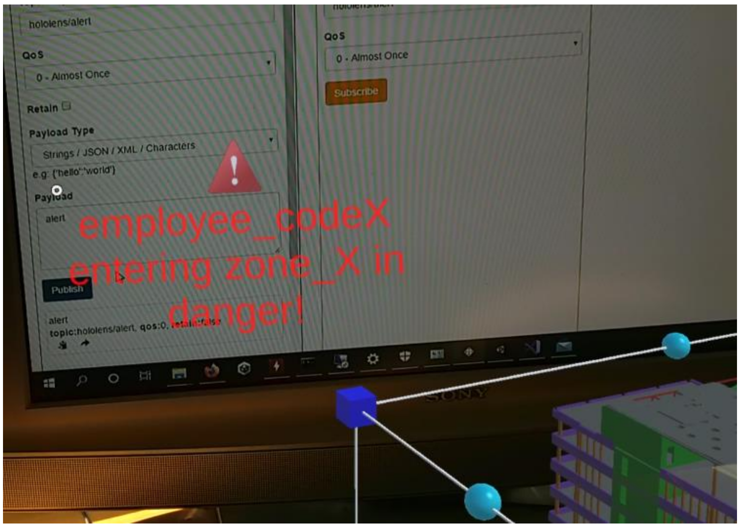


Figure 26. MR-based receiving alert interface.

In the following months, the user-friendliness of the visualisation of the alerts will be improved, as well as the process of extracting information from the notification schema. (For example, to visualise only the location of the event and the worker who is enrolled.)

Pilot2_DevAct_ID7-Mobile app worker data modification: Not started yet.

3.4.2.3. Integration activities

Many integration activities are the same as in the Trial 1. Below have been listed only the new ones.

Pilot2_IntAct_ID1- Integrate MR headset with Semantic Repo: Done.

Pilot2_IntAct_ID2-MR headset and long-term storage integration: Not started yet

Pilot2_IntAct_ID3-Integration of MR device with Long-Term Storage to retrieve health-related and medical-relate data to be visualised in the MR: Not started yet

Pilot2_IntAct_ID4-MR device and location management system integration: Not started yet

Pilot2_IntAct_ID5- Integrate the logic for UC-P2-5: Not started yet

Pilot2_IntAct_ID6- Integrate the logic for UC-P2-6: Not started yet

3.4.2.4. Validation activities

Some validation activities are the same as in the Trial 1. Below have been listed only the new ones.

Pilot2_ValAct_ID1-Health and safety inspection support – BIM visualization:

Context: As part of the health and safety inspection support, it will be possible to display the BIM model on the MR device. This will allow the OSH manager to gain a general overview of the site and aid in tracking the location of dangerous events as they have been defined at the latest BIM model.

Expectation: The BIM model can be moved through the MR device. Users should be able to move and rotate the model freely, with a total of 6 Degrees of Freedom (DOF). The validation will take place in Mostostal's office with a goal of testing the user interface of the solution along with the accuracy of the model.

Validation proof: Not started yet.

Pilot2_ValAct_ID2- Health and safety inspection support - laboratory tests:

Context: As part of the health and safety inspection service, it will be possible to display various information on the MR device. Therefore, it is important to check whether the device does not increase the psychophysical load of the user and allows him to perform tasks correctly. The task is a partial validation, and thus will bring important information about what needs to be improved from the user's point of view to improve the functionality of the MR device before integration with other ASSIST-IoT elements.

Expectation: Laboratory tests in the SMART PPE TESTLAB including objective evaluation and subjective evaluation (surveys, interviews). Tests will be conducted using an eye-tracker and a cross-apparatus to assess the impact of HoloLens on the user's eye-hand coordination and cognitive functions (check influence of AR visualizations on time of reaction, number of missed reactions, number of mistakes and heat map - if possible).

Validation proof: Not started yet.

Pilot2_ValAct_ID3-Safe navigation instruction tests:

Context: Due to the ever-changing nature of the construction site, evacuation routes on the site are constantly being updated. It is not always possible to mark the most up-to-date evacuation routes on the site itself, therefore it is beneficial to have a virtual model of the routes as well. Construction site evacuation routes have been added to the site's BIM model in order for the OSH manager to be able to visualize it using AR/MR technology.

Expectation: Validation of this task will be performed in the office. An arbitrary area will be chosen on the BIM model of the construction site. From this area, it will be tested how effective and accurate the visualized evacuation routes are, compared to the ones in the BIM model. The user-friendliness will also be tested in this scenario.

Validation proof: Not started yet.

Pilot2_ValAct_ID4-Health and safety inspection support – Worker data visualization:

Context: At any given time, there is a large number of workers from various subcontractors at the site, and this group of people is always changing. It is vital to be able to identify individuals especially during an emergency, when obtaining data as quickly as possible improves reaction time and response. As part of the health and safety inspection support, it will be possible to display worker's information through the MR device.

Expectation: The validation will take place at the construction site with the goal of selecting a worker based on the data from the location tags as this is being provided by the location management system, and displaying the acquired information from the central database of ASSIST IoT (LTSE enabler). The test will be performed for both single tags as well as for a group of workers.

Validation proof: Not started yet.

Pilot2_ValAct_ID5-Health and safety inspection support – Reporting:

Context: A major role of the OSH manager is to carry out or oversee health and safety inspection on the construction site. As part of the health and safety inspection support, it will be possible to create inspection reports using the MR device.

Expectation: The validation will occur on the construction site where health and safety inspection reports will be prepared. Along with the input from the OSH manager, the location of the reported occurrence will be attached to the report and will be transferred to the central database of ASSIST IoT (LTSE enabler). The ease of creating these reports, which include pictures, using MR technology as well as the location of the reported occurrence will be tested.

Validation proof: Not started yet.

Pilot2_ValAct_ID6-Health and safety inspection support – Danger zone restriction visualization:

Context: As part of the health and safety inspection support, in the developed BIM visualization it should be possible to display the danger zones that have been marked by other activities (danger zones, construction plants, crane). This is usually performed off-site in order to help familiarize people of the locations of the dangers on the construction site.

Expectation: The visualization of the danger zones will be tested regarding their effectiveness and accuracy compared to the ones at the BIM model. The user-friendliness will also be tested. The tests will be performed off-site.

Validation proof: Not started yet.

Pilot2_ValAct_ID7-Health and safety inspection support – Alerting:

Context: As part of the health and safety inspection support, the OSH supervisor should be alerted of dangers on the construction site as they happen. The system records the history of alerts and detected hazards.

Expectation: Notifications on the MR device will be tested by simulating dangerous events. As part of this test, the visualization of the message conveyed, and user-friendliness of the notifications will be tested.

Validation proof: Not started yet.

3.4.3. Deviations from original planning

The following Gantt chart provides an update of Pilot 2 Trial #3. In particular, the development activities are mainly assigned to further enhancements of the MR system to be completed by end of May 2023 (M31), which will allow to successfully carry out the verification activities of this trial, although some of them have already started. It is expected to finalize this trial by end M32.

Pilot 2 Trial #3		Jan 15	Feb 16	Mar 17	Apr 18	May 19	Jun 20	Jul 21	Aug 22	Sep 23	Oct 24	Nov 25	Dec 26	Jan 27	Feb 28	Mar 29	Apr 30	May 31	Jun 32	Jul 33	Aug 34	Sep 35	Oct 36	Nov 37	Dec 38
T1	Procurement																								
T1.1	Procurement of MR device																								
T2	Development																								
T2.1	Design the database to store data about the workers																								
T2.2	BIM model evacuation route MR visualization																								
T2.3	Notification schema design																								
T2.4	MR device and VPN connection																								
T2.5	Develop a BIM model, that includes evacuation routes																								
T2.6	MR-based alerts																								
T2.7	Mobile app worker data modification																								
T3	Integration																								
T3.1	Integrate MR headset with Semantic Repo																								
T3.2	Integration of the MR device with Long-Term Storage																								
T3.3	Integration MR device with Long-Term Storage to retrieve hea																								
T3.4	Integration of the MR device with the location management sy																								
T3.5	Integrate the logic for UC-P2-5																								
T3.6	Integrate the logic for UC-P2-6																								
T4	Validation																								
T4.1	Health and safety inspection support - Workers' data visualisat																								
T4.2	Health and safety inspection support - BIM Visualisation																								
T4.3	Health and safety inspection support - laboratory tests																								
T4.4	Safe navigation instructions tests																								
T4.5	Health and safety inspection support- Reporting																								
T4.6	Health and safety inspection support- Danger zone restriction																								
T4.7	Health and safety inspection support - Alerting																								

Figure 27. Pilot 2 – Trial #3 updated Gantt chart (M27).

4. Pilot 3A: Vehicle in-service emission diagnostics

4.1. Context review

Pilot 3A is centered around emissions and enhanced diagnostics at vehicle fleet level. For this purpose, Ford-Werke GmbH (FORD) has provided a state-of-the-art current production Ford Kuga, located at UPV, to allow the intensive driving and testing planned within Pilot 3A. The vehicle is equipped with an open access Powertrain Control Module (PCM) which is being integrated into ASSIST-IoT reference architecture, thus allowing remote access to powertrain parameters and over-the-air update of diagnostics firmware. Detailed description of the Pilot 3A are provided in *D7.1 Deployment Plan and Operational Framework*, and *D7.2 Pilot Scenario Implementation-First Version*.

Figure 28. FORD Vehicle provided for the Pilot

4.2. Trial #1: Fleet in-service emission verification

4.2.1. Scope

As described in *D3.3 Use Cases Manual & Requirements and Business Analysis – Final* and developed as reported in the aforementioned D7.X deliverables, Pilot 3A addresses a pair of use cases related with vehicle emission monitoring and system diagnostics, namely:

BS-P3A-1: Fleet in-service emission verification: This business scenario is focused on determining, from the real-life operation of the vehicles, NOx and CO2 emission metrics and deriving them at fleet level. The partners in charge of this Business Scenario consider that a given quantity of the vehicles may be fitted with additional, high-precision, emission sensors, thus making possible to determine the drift of the series sensors. In addition to the vehicle monitoring and fleet In-Service Emissions (ISE) distribution reporting, the business scenario also covers the update of the PCM calibration in order to ensure desired emission levels (when possible), and the detection of vehicles which are outliers of the fleet's emission distribution. Note that the studied scenario has certain particularities: the vehicle is mobile by definition, which challenges network stability and even availability (e.g., underground parking lots or remote countryside areas); and, in addition to obvious data protection, cybersecurity mechanisms must be in place to ensure that no malicious code is injected in the vehicle, since it could have significant consequences.

BS-P3A-2: Vehicle diagnostics: This scenario covers the identification of the fault source for vehicles tagged as non-compliant (either by the ISE monitoring in BS-P3A-1, by the driver, or by a service technician). The scenario is split into two use cases: the first one is devoted to the identification of the fault cause by deploying at the edge (e.g., the outlier vehicle) a series of fault detection methods; the second use case is centered on the development of such fault detection methods.

4.2.2. Implementation activities reporting

This chapter will document the work in progress for Pilot 3A, focusing on vehicle emission and diagnostics. The original planning was defined in *D7.1*, and in the present document the state of development of the different tasks is reviewed, tracking their evolution according to the foreseen planning. Note that the reported period corresponds to M19-M27 (see planning in Section 4.2.3). The reader will be referred to *D7.1* or to *D7.2* in order to avoid repeating sections of the document, when appropriate. Most of the reported works in the current version of the document correspond to the integration of the pilot with ASSIST-IoT essential enablers (EDBE, LTSE, Smart Orchestrator and Manageability enablers).

4.2.2.1. Procurement activities

The identified procurement activities for the pilot, from D7.1 and D7.2, are listed below with their current state. The general description of the elements was provided on D7.1, or D7.2 so that they are not repeated here.

Pilot3a_SetupAct_ID1 Ford KUGA 2.0 mHEV: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot3a_SetupAct_ID2 Open PCM with A8: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot3a_SetupAct_ID3 PCM SW and calibration: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot3a_SetupAct_ID4 ATI VISION: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot3a_SetupAct_ID5 ATI KVASER USBcan Pro: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot3a_SetupAct_ID6 NI CRIO 9049: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot3a_SetupAct_ID7 HiFi sensors: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot3a_SetupAct_ID8 Vehicle onboard PC: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot3a_SetupAct_ID9 Dashboard communication*:* Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

A 7” tactile screen has been adapted and integrated in the vehicle using the space in front of the gearshift lever. The screen is able to replicate the screen of the vehicle onboard PC (Pilot3a_SetupAct_ID8) and serves as a tactile driver interface system for requesting diagnostics actions or receiving instructions from the cloud-based part of the ASSIST-IoT platform.

Figure 29. 7” tactile screen for driver interface

<u>Pilot3a_SetupAct_ID10 AR system</u>: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2. In addition, EPSON MOVERIO BT augmented reality glasses have been procured and are ready to be used in the pilot, as shown in the figure below.

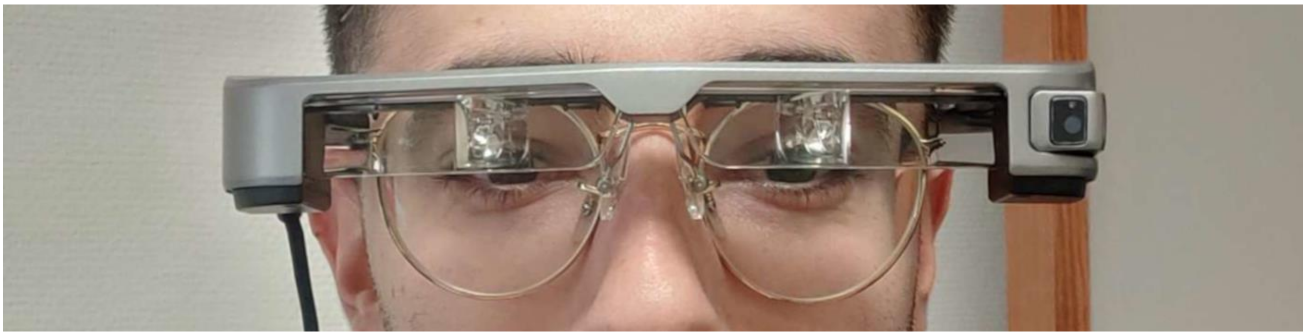


Figure 30. EPSON MOVERIO BT AR glasses

<u>Pilot3a_SetupAct_ID11 Remote servers</u>: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2

<u>Pilot3a_SetupAct_ID12 Raspberry Pi</u>: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2

<u>Pilot3a_SetupAct_ID13 GWEN</u>: Available but not integrated within the pilot. This task has been added beyond those tasks proposed in D7.2 for considering the procurement of the GWEN. At the present time, the GWEN is already available and waiting for its integration in the pilot. For the reported period the GWEN has not been used, and all reports corresponds to the placeholder Raspberry Pi (Pilot3a_SetupAct_ID12); the first round of open calls will be served with the Raspberry Pi hardware in order to provide a stable version for the application developers.

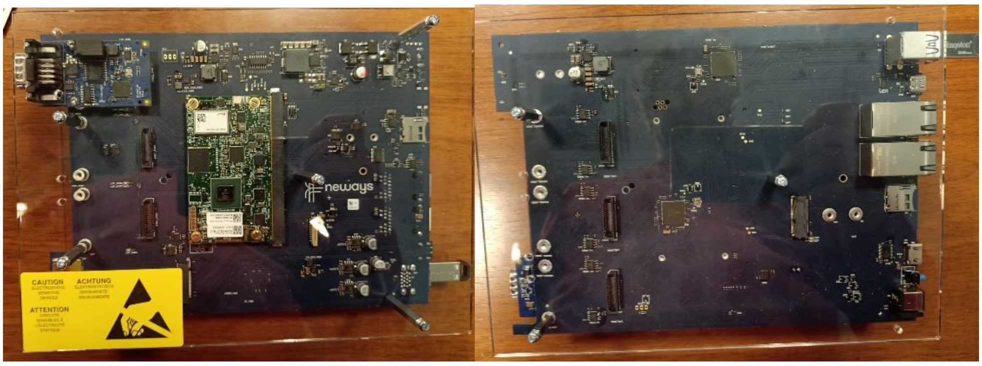


Figure 31. ASSIST-IoT GWEN (top and bottom views)

4.2.2.2. Development activities

<u>Pilot3a_DevAct_ID1 Vehicle setup.</u> No major updates since D7.2, except for the inclusion of the tactile screen (Pilot3a_SetupAct_ID9). See D7.2 for further details on this task.

<u>Pilot3a_DevAct_ID2 Development of vehicle data server.</u> No major updates since D7.2. See D7.2 for further details. The data server is fully functional and integrated into the pilot workflow.

<u>Pilot3a_DevAct_ID3 Development of OTA update server and update mechanism.</u> No major updates since D7.2. See D7.2 for further details. The function is ready to be used and will be integrated within the pilot workflow in the next evolution.

<u>Pilot3a_DevAct_ID4 Setup of the remote server</u>. No major updates since D7.2. See D7.2 for further details. The remote server is ready to be used and integrated into the pilot workflow.

<u>Pilot3a_DevAct_ID5 Development of data analytics for fleet ISE.</u> While the bases of the ISE (In-Service Emissions) metrics were stablished in D7.2 (c.f.), a series of features have been added in the reported period:

- Real-life data library has been increased to a total number of 12730 drivelets (as 8th Jan 2023). *Drivelet* library includes, in addition to driving cases of the nominal operation of the engine, specific tests with bias in different sensors (see Pilot3a_DevAct_ID7 description for further details).

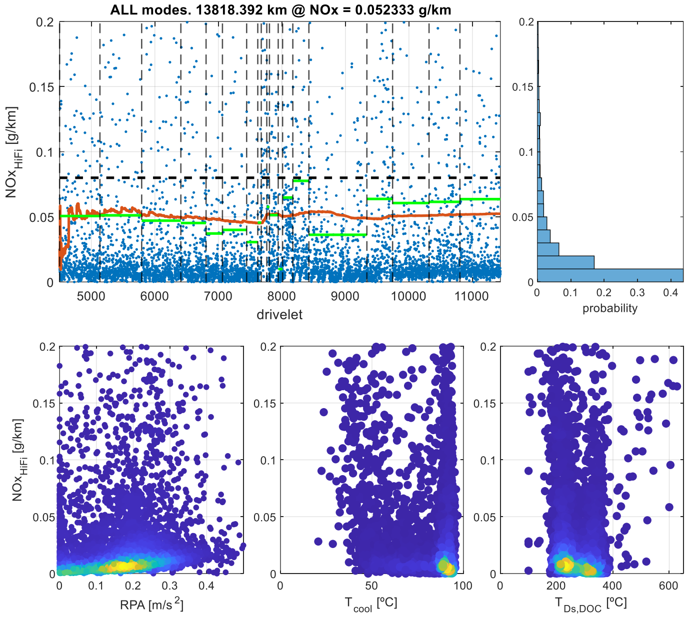


Figure 32. ISE for different drivelets (note that specific driving conditions as idling or traffic jams have not been removed from the plot, and that there are tests where failures have been included). Top left: NOx emissions per each drivelet and cumulated emissions, as measured with the HiFi sensor. Top right: histogram of the specific emissions per drivelet. Bottom: density plots of the emissions with the relative positive acceleration (left), the coolant temperature (centre), and the SCR inlet temperature (right)

- A study on the effect of the tailpipe NOx sensor accuracy has been performed, in order to assess the effect of the sensor bias on the perceived NOx emission metrics. This, combined with the sensor bias estimation methods developed in Pilot3a_DevAct_ID6, allows determining the confidence interval for ISE metrics.

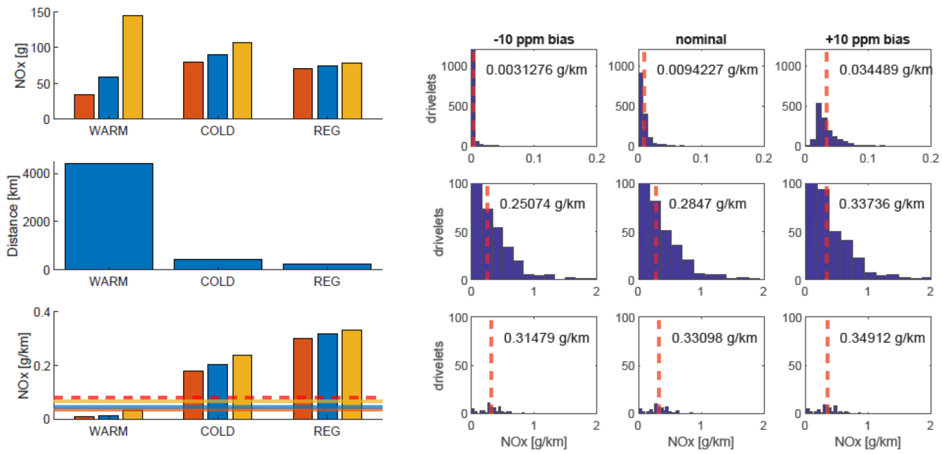


Figure 33. Left: effect on perceived ISE level as a function of the engine operation mode and the downstream NOx sensor bias (red: -10 pm, yellow; +10 ppm). Right histograms show the distribution for the drivelets metrics in warm (top), cold (centre) and DPF regeneration modes.

Pilot3a_DevAct_ID6 Development of learning methods for calibration update. In the reported period, the state of the task as reported in D7.2 has been advanced and tested in real life in the vehicle. A number of real-life driving tests were performed including bias in the NOx sensors. Figure 34 identifies the drivelets were bias has been injected in the upstream (engine-out) or downstream (tailpipe) series NOx sensor.

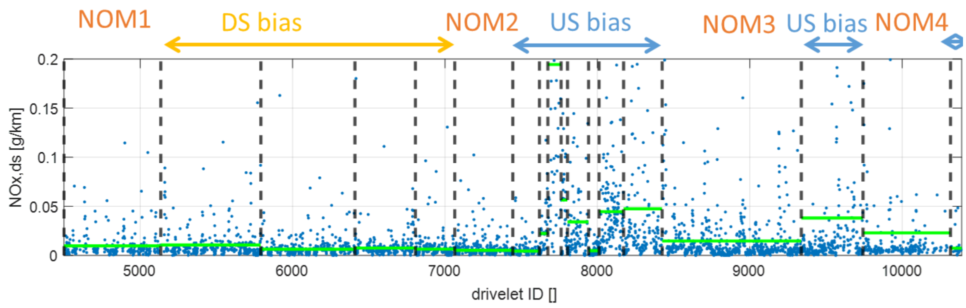


Figure 34. Tests with synthetic bias in engine-out (upstream, US) and tailpipe (downstream, DS) NOx sensors

For the case of the bias in tailpipe sensor, drivelets 5135 to 5790 had a -10 ppm bias injected, drivelets 5792 to 6408 had +10 ppm, 6409 to 6805 +30 ppm, and finally drivelets 6806 to 7062 had -30 ppm. These tests were used for verifying (both in real time and emulating the system) the capability of the ASSIST-IoT implementation for correcting the injected bias when both the original (biased) signal from the series sensor and the HiFi sensor are present. Figure 35 shows the results of the adaptation of the signal on a specific vehicle when both signals are available. The adaptation used the Kalman filter approach for lookup table adaptation presented in D7.2.

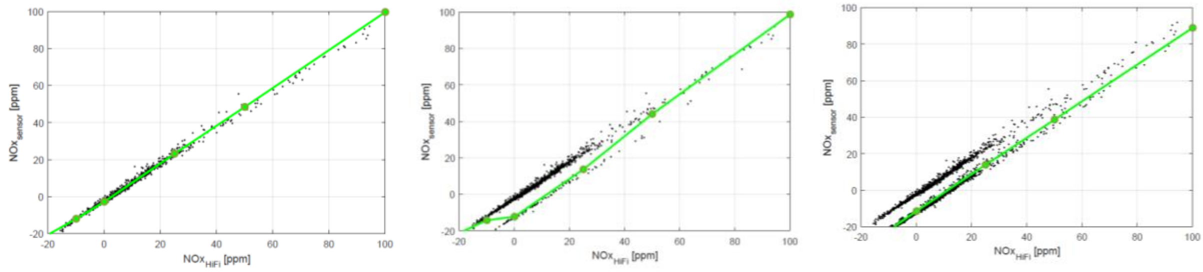


Figure 35. Illustration of the adaptation of the sensor model for concealing a bias in the sensor

On the other hand, the biased and unbiased drivelets were used for feeding the system emulating the behaviour of a fleet. In that case, the objective is not to adapt the specific sensor bias, but to estimate the error of the sensor for different measuring windows. As shown in the green fit in Figure 36, the model converges to the ensemble average value, and the errors may be used for computing the sensor population accuracy. Such information, combined with the study presented in Figure 33, serves for providing statistical ground for the ISE metrics.

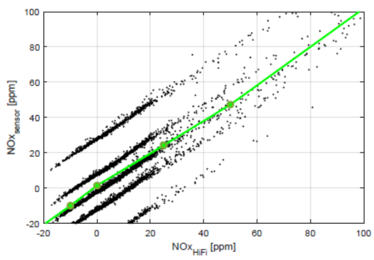


Figure 36. Correction of bias of the fleet by using a global fit.

Pilot3a_DevAct_ID7 Development of diagnostic models for different failures. In addition to bias on tailpipe sensor, the effect of injecting errors on the engine-out NOx sensor - located upstream the selective catalytic reduction (SCR) aftertreatment device has been investigated. This sensor is used for the urea dosing at the SCR, and thus its lack of accuracy has a direct impact on NOx emissions. Aiming at simulating a miscalibration of the sensor, its calibration was varied (sensor slope and offset, nominally 0.5 and -50), resulting in a set of tests with higher emissions when compared with the nominal operation of the vehicle. Note that if the sensor measures less than the real engine-out NOx, less urea is injected, then resulting in higher NOx emissions. On the contrary, excessive urea injection results in NH3 slip and an increase in the perceived tailpipe NOx due to the cross sensitivity of the NH3 with the NOx sensor. Figure 37 summarises the results for the different test blocks (in Figure 34)

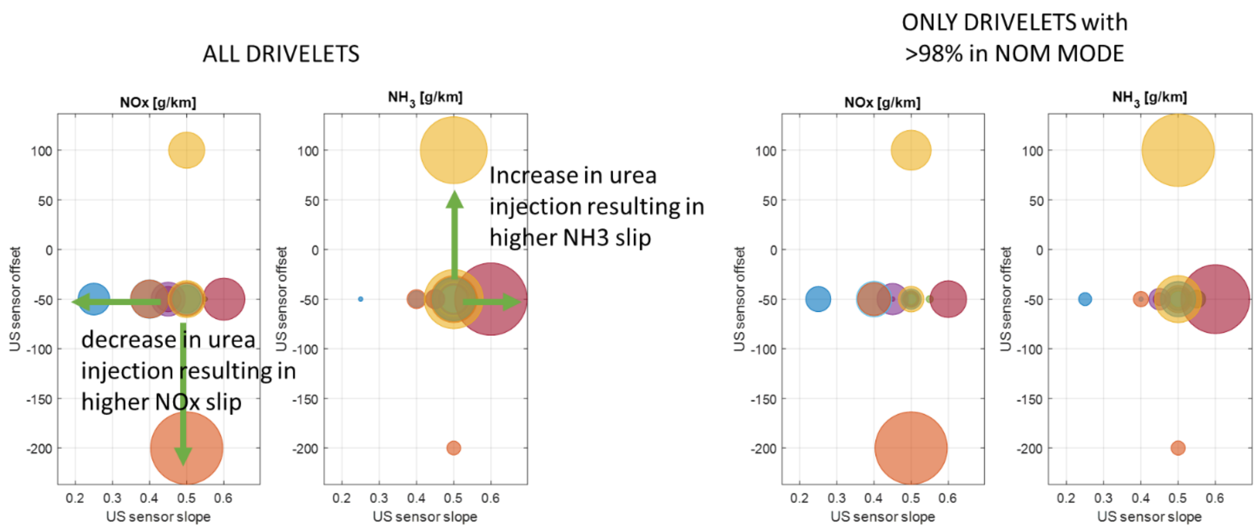


Figure 37. Effect of bias in upstream NOx sensor bias on ISE. Bubble size is proportional to ISE metric, and point at 0.5 slope and -50 ppm offset corresponds to the nominal operation of the engine.

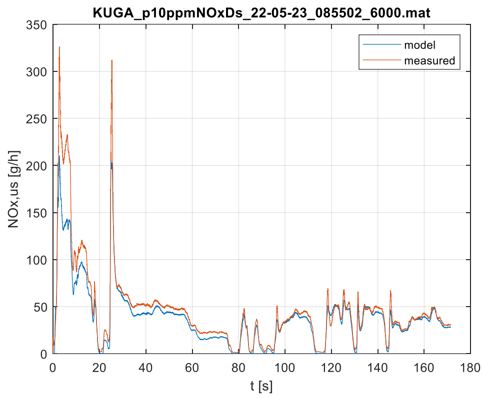


Figure 38. Example of measured (red) and modelled (blue) engine-out NOx for a given drivelet.

Pilot3a_DevAct_ID8 Development of driver interface device. An interface has been developed for accommodating the functions to be developed within the project (as identified in *D3.3 Use Cases Manual & Requirements and Business Analysis – Final*). The interface (right plot in Figure 39) is shown in the tactile dashboard of the vehicle, and can be toggled to the classical development view (adapted to the dimensions of the screen, as shown on the left) for controlling the data server setup and other functions that will not be used by the regular driver.

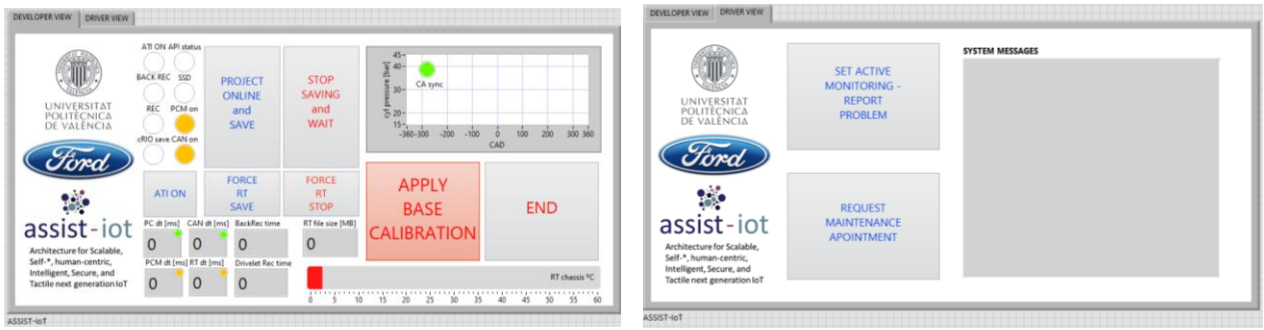


Figure 39. Driver interface screen. Left: update of developer view (DAQ control) for 7" screen. Right: driver interface for ASSIST-IoT functionalities

Pilot3a_DevAct_ID9 Development of AR assistance for vehicle servicing ***[planned for M28]***

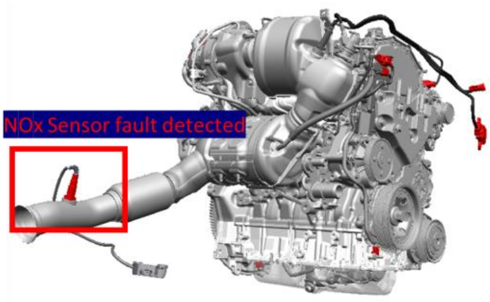


Figure 40. Principle of indicating a defect module with the help of AR, as identified in D3.3.

Pilot3a_DevAct_ID10 Development of learning methods for diagnostics algorithms ***[planned for M28]***

Pilot3a_DevAct_ID11 Development of user interfaces ***[planned for M28]***

A new task has been added for considering the setup of the different UI for the OEM SW to be used by the OEM SW engineer when accessing the pilot from its work terminal. Mock-ups for those UIs were presented in D3.3 and are reproduced in Figure 41

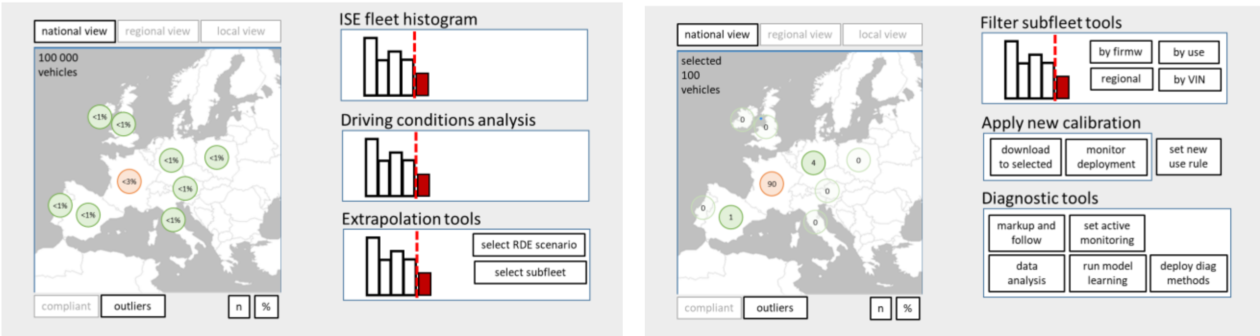


Figure 41. UI mock-ups for the use cases, as identified in D3.3. Left: Example UI to display the emission distribution of a vehicle fleet. Right: Example of an UI to deploy new calibrations or enhanced diagnostic methods to previously selected vehicles.

4.2.2.3. Integration activities

Integration activities are associated to the integration of the different identified ASSIST-IoT enablers (which were highlighted in the architectural diagram in the "Scope" section above). The integration stage significantly differs between enablers, according to their availability at the time of integration and the importance for setting up the pilot. So far, those enablers needed for the existence of the ASSIST-IoT architecture, plus the Edge Data Broker Enabler (EDBE) and the Long-Term Storage Enabler (LTSE) are operational. On the other hand, those enablers enabling additional functionalities as DLT, cybersecurity and federated learning are under evaluation.

Pilot3a_IntAct_ID1-Integ.of smart Net. And Cont. (T4.2) and Self-*(T5.1) enablers. In this moment, the current version of the Smart orchestrator of Task 4.2 has been successfully deployed in the pilot premises, being a key element as it eases the deployment of enablers from different Planes and Verticals within the computing elements of the pilot. It has been integrated with the EDBE (see Pilot3a_IntAct_ID3) and the LTSE to handle the scalability requirements demanded by the pilot. Regarding other enablers from this activity, the integration of the Multi-link enabler (T4.2) will be evaluated once it is more mature. With respect to self-* enablers (T5.1), the self-healing enabler and the resource provisioning enabler, which provide fail recovery and auto-scaling automatic mechanisms in the edge devices, respectively, will be integrated during the next two months, whereas the use of the Automated configuration enabler will be studied.

Pilot3a_IntAct_ID2-Integration of semantic data management (T4.3) enablers. Following technical discussion in Warsaw plenary meeting, it has been decided to not use this enabler within the pilot framework. Consequently, this task will be dropped from the task list.

Pilot3a_IntAct_ID3-Integ.of data broker. The EDBE has been successfully integrated in the pilot, being installed in all the computing nodes. It has entailed performing some integrations, especially with the Smart orchestrator, concretely with its Kafka component, as the volume of messages that it might handle can be too large, thus aiming at tackling scalability requirements (see Figure 42). This integration is due to the need of an alternative schema for deploying enablers in cars' clusters, which lack of public and static IP addresses. This schema is accompanied by a topic-based strategy for sending orchestration, control and business-related data, as well as a data model to handle the information about the enablers to be deployed in the distributed cars, along with their status.

<u>Pilot3a_IntAct_ID4-Integ.of LTSE, application and services (T4.4) enablers.</u> The LTSE is a service that provides SQL and NoSQL storage of data, which can be posted or queried via HTTP. Apart from deploying it, it is important that services/applications/enablers that require storage space can realise calls to the provided endpoint, considering the accepted formats. Integration with pilot-related services is done by a service in charge of checking new car entries in the pilot service and sending the data to the LTSE via the EDBE.

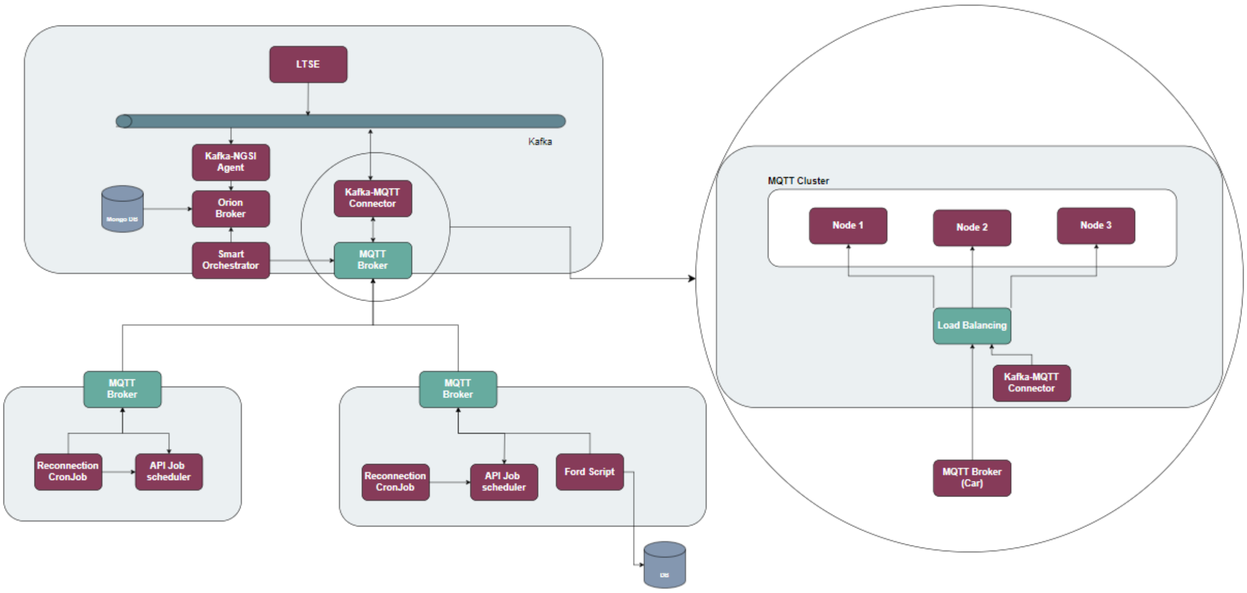


Figure 42. Basic schema of the EDBE operation within the pilot

Besides, this activity also involves the integration of T4.4 enablers. Among them, the manageability enablers have been successfully installed, providing a set of interfaces to add cars (i.e., their clusters) to the system and deploy enablers (and correctly packaged services, considering Helm) with it. It will be also the main entry point to the pilot-related user dashboards (see Pilot3a_DevAct_ID11), once integrated. The Performance and Usage Diagnosis (PUD) enabler is already part of the clusters, and it is already able to retrieve metrics from the system and the rest of enablers, whereas the Business KPI reporting enabler, although deployed, has not been adapted to show any metric or KPI related to the pilot yet. With respect to the other enablers of T4.4, the OpenAPI will be integrated once its development status is more advanced; the Mixed Reality (MR) enabler will not be used as it requires the use of HoloLens glasses, however, custom development for leveraging Moverio Augmented Reality (AR) glasses will be used instead (see Pilot3a_DevAct_ID9), as are the ones available; finally, the Video Augmentation enabler will be evaluated to be used for such development activity to assist in the real-time detection of faulty sensors.

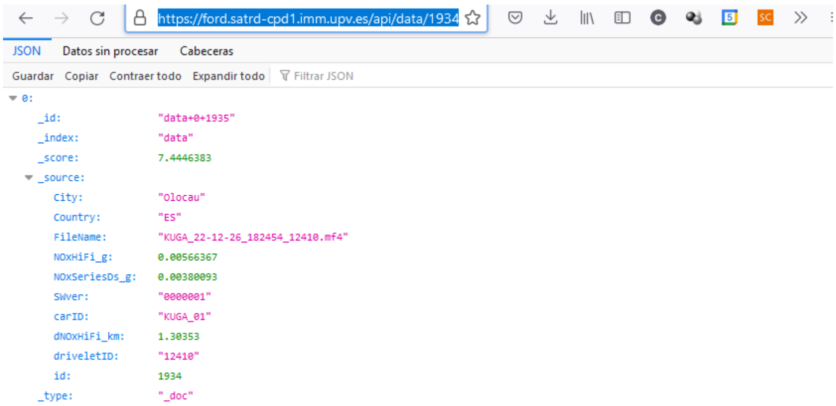


Figure 43. Download of drivelet data from the server via an ad-hoc API.

Pilot3a_IntAct_ID5-Integ.of FL (T5.2) enablers. Federated Learning (FL) enablers are currently under evaluation for the pilot. Identified potential is on subsystem modelling (engine-out emissions) and the use of federated approach for deriving local (vehicle) and global (fleet) models. The core of the activity is to start in M28.

Pilot3a_IntAct_ID6-Integ.of cybersecurity (T5.3) enablers. Cybersecurity enablers will be use for the OTA update of the PCM firmware. The core of the activity is to start in M28.

Pilot3a_IntAct_ID7-Integration of DLT-based (T5.4) enablers. DLT will be used for verifying emission data integrity when served to third parties (as NGOs or regulation bodies). The core of the activity is to start in M28.

4.2.2.4. Validation activities

Demonstration policy. Along the project, the pilot will be evolved with new features added to the existing ones, providing a continuous improvement of the same trial (Trial #1). Three demonstration tasks have been prepared: Pilot3A_ValAct_ID1, Pilot3A_ValAct_ID2 and Pilot3A_ValAct_ID3, each of them adding new features to the pilot implementation, and correcting and improving the previous iterations:

- ***Demonstration task #1:*** *Pilot3A_ValAct_ID1* was focused on the validation and demonstration of the main execution flow of UC-P3A-1 Fleet in-service conformity verification (i.e., analytics of ISE emissions), with focus on the edge Pilot3A software developments (because some of the required WP4/WP5 enablers were not ready at the time of the demonstration).
- ***Demonstration task #2:*** *Pilot3A_ValAct_ID2* was centered in the validation and demonstration of the main and alternative execution flow of UC-P3A-1 Fleet in-service conformity verification (i.e., ISE metrics, and calibration update mechanisms for recovering ISE levels), plus an update of the main execution flow of the use case. At this step of the project, core enablers are expected to be integrated, as described in the integration activities list.
- ***Demonstration task #3:*** *Pilot3A_ValAct_ID3* will be used for demonstrating the implementation of use cases related with the vehicle diagnostics: UC-P3A-2 Vehicle Diagnostics-Vehicle's non-conformance causes identification, and UC-P3A-3 Vehicle Diagnostics-Updating the diagnostics methods pool. In addition, the final version of the UC-P3A-1 will be validated, which will integrate all the foreseen ASSIST-IoT enablers.

Pilot3A_ValAct_ID1 demonstration.

Context. Initial demonstration was centred on verifying the different main components of the pilot, even without using essential ASSIST-IoT enablers. The demonstration was done encapsulating the software developments (e.g., for data processing, driving metrics, emission metrics, etc.) into Docker containers deployed with Kubernetes, but no cloud system was provisioned, nor data was sent to the cloud (other than file backups). Additional details may be found on D7.2.

Expectation. The following features were expected to be operative during the demonstration activity: data file loading and pre-processing; calculation of drivelet metrics (overall data about the drivelet, average driving metrics, RDE metrics, etc.); engine mode detection; emission metrics; NOx sensor drift detection; recursive update of NOx sensor drift model; results integration into SQL database; compression of the file and storage into a folder; verification of the number of files in storage, and space saving policy application; send request to PC for PCM update from calibration repository; send request to PC for update of the measurement channel list.

Validation proof. All listed features but PCM calibration update were validated in on-road operation of the vehicle. The system was able to perform the real-time processing of the data, calculating driving and emission metrics, calculating (and compensating) NOx sensor drift, and storing data locally at the edge. With respect to PCM calibration update, it was demonstrated in laboratory premises and not in real-life operation.

<u>Pilot3A_ValAct_ID2 demonstration.</u>

Context. The second iteration of the demonstration has been implemented using the ASSIST-IoT core enablers, using EDBE and the LTSE, as explained in *Pilot3a_IntAct_ID1*, *Pilot3a_IntAct_ID3* and *Pilot3a_IntAct_ID4*. The test vehicle has been (and is currently using) the system implementation within ASSIST-IoT.

Expectation. To showcase the deployment and operation of the Pilot 3A software using ASSIST-IoT architecture and core enablers. From the functional point of view, the list of features of Pilot3A_ValAct_ID1 is extended to include aspects related to connectivity, and the capability of sending the information to the cloud, to be stored in the LTSE.

Validation proof. In order to illustrate the operation of the system, as specific long travel was scheduled (far-East to far-West Spain two-way travel, as depicted in left plot in Figure 44). The travel lasted more than 15 hours of driving split into two different days. The vehicle was continuously generating data that was processed at the edge and sent via the EDBE to the LTSE at the UPV server (Valencia, eastern Spain). Along the travel, more than 400 drivelets were generated (#12017 to #12410). Drivelets contained 311 measurement channels, with most of them acquired at 100 Hz (10 ms); all data were successfully processed and files compressed at the edge without an error. In addition to the storage of the compressed files in the file system, SQL database was populated, and NOx sensor adaptation tasks were successfully performed.

Concerning the operation of the EDBE, the enabler was able to successfully transmit most of the data which were successfully stored at the LTSE. The exception to that were 4 cases in remote regions along the travel (see right plot in Figure 44): a single data was lost in the Valencian region border, while consecutive drivelets were lost in three zones in Extremadura and its border with Castilla-La Mancha.

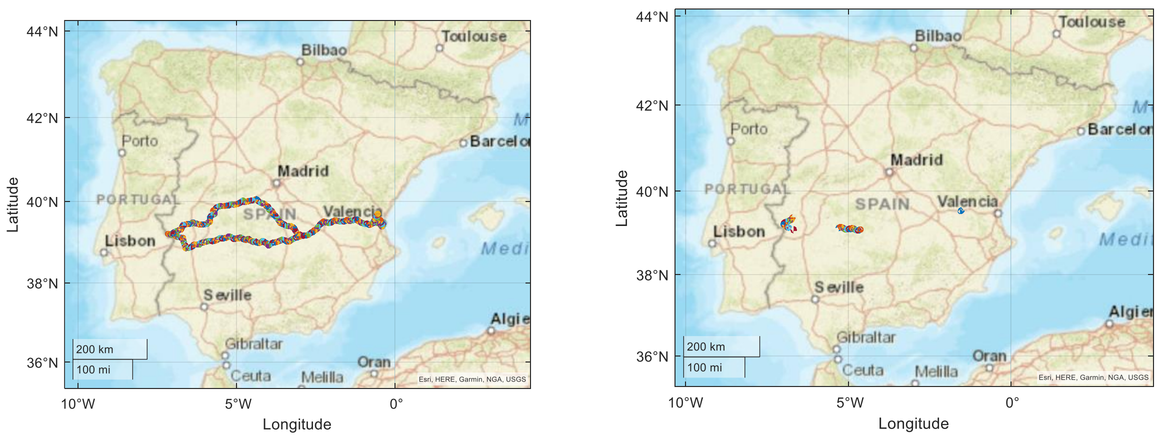


Figure 44. Left: Valencia to Portugal border round travel. Right: drivelets with communication problems along the travel.

Figure 45 shows, for a couple of the cases, the data retrieved from the LTSE (obtained with an ad-hoc API) and the SQL at the edge. It may be appreciated that the system is able to recover from the out of network situation; however, the data sent during those moments were not successfully uploaded when the connection was recovered.

{[1600]}	{'12074'}	{'KUGA_22-12-23_132356_12...'}	{'Requena'}
{[1601]}	{'12075'}	{'KUGA_22-12-23_132627_12...'}	{'Requena'}
{[1602]}	{'12076'}	{'KUGA_22-12-23_132858_12...'}	{'Utiel'}
{[1603]}	{'12077'}	{'KUGA_22-12-23_133128_12...'}	{'Caudete de las Fuentes'}
{[1604]}	{'12078'}	{'KUGA_22-12-23_133413_12...'}	{'Caudete de las Fuentes'}
{[1605]}	{'12079'}	{'KUGA_22-12-23_133644_12...'}	{'Fuenterrobles'}
{[1606]}	{'12080'}	{'KUGA_22-12-23_133914_12...'}	{'Villargordo del Cabriel'}
{[1607]}	{'12081'}	{'KUGA_22-12-23_134152_12...'}	{'Villargordo del Cabriel'}
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{[1609]}	{0×0 double}	{0×0 double}	{0×0 double}
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{[1612]}	{'12086'}	{'KUGA_22-12-23_135435_12...'}	{'Castillejo de Iniesta'}
{[1613]}	{'12087'}	{'KUGA_22-12-23_135704_12...'}	{'Castillejo de Iniesta'}
{[1614]}	{'12088'}	{'KUGA_22-12-23_135932_12...'}	{'Motilla del Palancar'}
{[1615]}	{'12089'}	{'KUGA_22-12-23_140200_12...'}	{'Motilla del Palancar'}
{[1616]}	{'12090'}	{'KUGA_22-12-23_140428_12...'}	{'Valhermoso de la Fuente'}
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{[1618]}	{'12092'}	{'KUGA_22-12-23_140925_12...'}	{'Alarcón'}
{[1619]}	{'12093'}	{'KUGA_22-12-23_141155_12...'}	{'Tébar'}
{[1620]}	{'12094'}	{'KUGA_22-12-23_141424_12...'}	{'Tébar'}
{[1621]}	{'12095'}	{'KUGA_22-12-23_141652_12...'}	{'Tébar'}
{[1622]}	{'12096'}	{'KUGA_22-12-23_141920_12...'}	{'Atalaya del Cañavate'}
{[1623]}	{'12097'}	{'KUGA_22-12-23_142148_12...'}	{'Vara de Rey'}
{[1624]}	{'12098'}	{'KUGA_22-12-23_142416_12...'}	{'Vara de Rey'}
{[1625]}	{'12099'}	{'KUGA_22-12-23_142644_12...'}	{'San Clemente'}
{[1626]}	{'12100'}	{'KUGA_22-12-23_142912_12...'}	{'San Clemente'}

id	carID	SWver	driveletID	NOxHiFi_g	dNOxHiFi_km	NOxSeriesDs_g	Country	City	FileName
1599	KUGA_01	0000001	12073	0.0348471	5.00254	0.0131705	ES	Requena	KUGA_22-12-23_132125_12073.mf4
1600	KUGA_01	0000001	12074	0.242308	5.00731	0.214139	ES	Requena	KUGA_22-12-23_132356_12074.mf4
1601	KUGA_01	0000001	12075	0.0613534	4.99756	0.0390005	ES	Requena	KUGA_22-12-23_132627_12075.mf4
1602	KUGA_01	0000001	12076	0.0389101	5.00445	0.0162253	ES	Utiel	KUGA_22-12-23_132858_12076.mf4
1603	KUGA_01	0000001	12077	0.142933	5.00029	0.116318	ES	Caudet...	KUGA_22-12-23_133128_12077.mf4
1604	KUGA_01	0000001	12078	0.182193	5.00557	0.152537	ES	Caudet...	KUGA_22-12-23_133413_12078.mf4
1605	KUGA_01	0000001	12079	0.182934	4.99883	0.151429	ES	Fuenter...	KUGA_22-12-23_133644_12079.mf4
1606	KUGA_01	0000001	12080	0.132563	5.0026	0.105907	ES	Villargor...	KUGA_22-12-23_133914_12080.mf4
1607	KUGA_01	0000001	12081	0.0743613	4.87264	0.0493734	ES	Villargor...	KUGA_22-12-23_134152_12081.mf4
1608	KUGA_01	0000001	12082	0.121324	4.99601	0.104975	ES	Villargor...	KUGA_22-12-23_134422_12082.mf4
1609	KUGA_01	0000001	12083	0.123918	4.99816	0.105697	ES	Minglanilla	KUGA_22-12-23_134700_12083.mf4
1610	KUGA_01	0000001	12084	0.0515129	5.00835	0.0339508	ES	Minglanilla	KUGA_22-12-23_134934_12084.mf4
1611	KUGA_01	0000001	12085	0.053786	5.00517	0.029413	ES	Graja d...	KUGA_22-12-23_135204_12085.mf4
1612	KUGA_01	0000001	12086	0.115146	5.00262	0.0928356	ES	Castillej...	KUGA_22-12-23_135435_12086.mf4
1613	KUGA_01	0000001	12087	0.206902	5.0055	0.1767	ES	Castillej...	KUGA_22-12-23_135704_12087.mf4
1614	KUGA_01	0000001	12088	0.0587661	4.99853	0.0332153	ES	Motilla d...	KUGA_22-12-23_135932_12088.mf4
1615	KUGA_01	0000001	12089	0.208846	5.00155	0.179018	ES	Motilla d...	KUGA_22-12-23_140200_12089.mf4
1616	KUGA_01	0000001	12090	0.110943	4.99967	0.0849867	ES	Valherm...	KUGA_22-12-23_140428_12090.mf4
1617	KUGA_01	0000001	12091	0.0838937	4.99907	0.0560168	ES	Valherm...	KUGA_22-12-23_140657_12091.mf4
1618	KUGA_01	0000001	12092	0.0793137	5.00183	0.0554588	ES	Alarcón	KUGA_22-12-23_140925_12092.mf4
1619	KUGA_01	0000001	12093	0.191351	5.00613	0.156728	ES	Tébar	KUGA_22-12-23_141155_12093.mf4
1620	KUGA_01	0000001	12094	0.253536	5.00381	0.221441	ES	Tébar	KUGA_22-12-23_141424_12094.mf4
1621	KUGA_01	0000001	12095	0.0780643	5.0013	0.0514383	ES	Tébar	KUGA_22-12-23_141652_12095.mf4
1622	KUGA_01	0000001	12096	0.058762	5.00681	0.0380677	ES	Atalaya ...	KUGA_22-12-23_141920_12096.mf4
1623	KUGA_01	0000001	12097	0.0286124	5.00113	0.012471	ES	Vara de ...	KUGA_22-12-23_142148_12097.mf4
1624	KUGA_01	0000001	12098	0.00952473	5.0079	0.000310559	ES	Vara de ...	KUGA_22-12-23_142416_12098.mf4
1625	KUGA_01	0000001	12099	0.0139353	5.00133	0.00114887	ES	San Cle...	KUGA_22-12-23_142644_12099.mf4
1626	KUGA_01	0000001	12100	0.0140835	4.99993	0.000221082	ES	San Cle...	KUGA_22-12-23_142912_12100.mf4
1627	KUGA_01	0000001	12101	0.0370887	4.99995	0.0145551	ES	San Cle...	KUGA_22-12-23_143140_12101.mf4
1628	KUGA_01	0000001	12102	0.0562696	4.9978	0.0320318	ES	San Cle...	KUGA_22-12-23_143409_12102.mf4

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{[1740]}	{'12213'}	{'KUGA_22-12-23_200451_12...'}	{'Malpartida de Cáceres'}
{[1741]}	{'12214'}	{'KUGA_22-12-23_200751_12...'}	{'Malpartida de Cáceres'}
{[1742]}	{'12215'}	{'KUGA_22-12-23_201052_12...'}	{'Malpartida de Cáceres'}
{[1743]}	{'12216'}	{'KUGA_22-12-23_201212_12...'}	{'Malpartida de Cáceres'}
{[1744]}	{'12217'}	{'KUGA_22-12-23_201513_12...'}	{'Arroyo de la Luz'}
{[1745]}	{'12218'}	{'KUGA_22-12-23_201812_12...'}	{'Aliseda'}
{[1746]}	{'12219'}	{'KUGA_22-12-23_202109_12...'}	{'Aliseda'}
{[1747]}	{'12220'}	{'KUGA_22-12-23_202410_12...'}	{'Aliseda'}
{[1748]}	{'12222'}	{'KUGA_22-12-23_202818_12...'}	{'Aliseda'}
{[1749]}	{'12223'}	{'KUGA_22-12-23_203118_12...'}	{'Aliseda'}
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{[1758]}	{'12232'}	{'KUGA_22-12-23_205759_12...'}	{'Alburquerque'}
{[1759]}	{'12233'}	{'KUGA_22-12-23_210059_12...'}	{'Alburquerque'}
{[1760]}	{'12234'}	{'KUGA_22-12-23_210400_12...'}	{'La Codosera'}

id	carID	SWver	driveletID	NOxHiFi_g	dNOxHiFi_km	NOxSeriesDs_g	Country	City	FileName
1735	KUGA_01	0000001	12208	0.000211615	0.246549	0	ES	Cáceres	KUGA_22-12-23_195355_12208.mf4
1736	KUGA_01	0000001	12209	0.0444712	1.7844	0.0326571	ES	Cáceres	KUGA_22-12-23_195420_12209.mf4
1737	KUGA_01	0000001	12210	0.0135294	2.60384	0.00664112	ES	Cáceres	KUGA_22-12-23_195720_12210.mf4
1738	KUGA_01	0000001	12211	0.00578878	0.930611	0.00248595	ES	Cáceres	KUGA_22-12-23_200021_12211.mf4
1739	KUGA_01	0000001	12212	0.0302082	2.36535	0.0205916	ES	Cáceres	KUGA_22-12-23_200150_12212.mf4
1740	KUGA_01	0000001	12213	0.0146388	3.52648	0.00725548	ES	Malparti...	KUGA_22-12-23_200451_12213.mf4
1741	KUGA_01	0000001	12214	0.00523492	3.13925	0.00261614	ES	Malparti...	KUGA_22-12-23_200751_12214.mf4
1742	KUGA_01	0000001	12215	0.00528192	1.01609	0.0026513	ES	Malparti...	KUGA_22-12-23_201052_12215.mf4
1743	KUGA_01	0000001	12216	0.0463018	3.09388	0.0349785	ES	Malparti...	KUGA_22-12-23_201212_12216.mf4
1744	KUGA_01	0000001	12217	0.00860026	5.00541	0.0037669	ES	Arroyo ...	KUGA_22-12-23_201513_12217.mf4
1745	KUGA_01	0000001	12218	0.0134859	5.00731	0.00553673	ES	Aliseda	KUGA_22-12-23_201812_12218.mf4
1746	KUGA_01	0000001	12219	0.0102522	4.00909	0.00437961	ES	Aliseda	KUGA_22-12-23_202109_12219.mf4
1747	KUGA_01	0000001	12220	0.0000321707	0.0219915	0.0000105011	ES	Aliseda	KUGA_22-12-23_202410_12220.mf4
1748	KUGA_01	0000001	12222	0.0885548	2.52541	0.00530619	ES	Aliseda	KUGA_22-12-23_202818_12222.mf4
1749	KUGA_01	0000001	12223	0.0161967	4.26787	0.010206	ES	Aliseda	KUGA_22-12-23_203118_12223.mf4
1750	KUGA_01	0000001	12224	0.0137862	4.9131	0.00702101	ES	Aliseda	KUGA_22-12-23_203419_12224.mf4
1751	KUGA_01	0000001	12225	0.011707	4.71473	0.00610664	ES	Aliseda	KUGA_22-12-23_203719_12225.mf4
1752	KUGA_01	0000001	12226	0.0204705	5.00249	0.0118468	ES	Villar del...	KUGA_22-12-23_204020_12226.mf4
1753	KUGA_01	0000001	12227	0.0172308	5.00483	0.0100526	ES	Alburqu...	KUGA_22-12-23_204314_12227.mf4
1754	KUGA_01	0000001	12228	0.0158702	5.00426	0.00864177	ES	Alburqu...	KUGA_22-12-23_204610_12228.mf4
1755	KUGA_01	0000001	12229	0.0108561	5.00061	0.00533876	ES	Alburqu...	KUGA_22-12-23_204903_12229.mf4
1756	KUGA_01	0000001	12230	0.018124	2.93221	0.0114393	ES	Alburqu...	KUGA_22-12-23_205158_12230.mf4
1757	KUGA_01	0000001	12231	0.0136987	2.2612	0.00692513	ES	Alburqu...	KUGA_22-12-23_205458_12231.mf4
1758	KUGA_01	0000001	12232	0.0505354	2.82463	0.0410278	ES	Alburqu...	KUGA_22-12-23_205759_12232.mf4
1759	KUGA_01	0000001	12233	0.021335	3.94352	0.0116296	ES	Alburqu...	KUGA_22-12-23_210059_12233.mf4
1760	KUGA_01	0000001	12234	0.0152067	4.14385	0.00797042	ES	La Codo...	KUGA_22-12-23_210400_12234.mf4

Figure 45. Left: data at LTSE recovered via an ad-hoc API. Right: data at the edge SQL. Top: data loss at the border between Valencia and Castilla-La Mancha regions (between Villargordo del Cabriel and Minglanilla). Bottom: data loss at a remote zone in Extremadura region (Sierra de San Pedro, between Aliseda and Alburquerque)

Pilot3A_ValAct_ID3 demonstration. Last phase of the demonstration is scheduled for M39-M41. For this activity, the ensemble of all the planned enablers and functionalities are expected to be operative and deployed on the ASSIST-IoT GWEN.

4.2.3. Deviations from original planning

Figure 46 provides the updated planning of Pilot 3A implementation for the reported time framework. A series of modifications have been included in order to adapt the plan to the project advancement. Main modifications are: the project has been extended to 41 months, moving the last validation activity *Pilot3a_ValAct_ID3* to the final months. Because of their maturity, some enablers planned to be included in *Pilot3a_ValAct_ID2* have been delayed to M28 along with their respective integration tasks, and only core enablers (plus EDBE and LTSE) have been showcased in *Pilot3a_ValAct_ID2*. Finally, two tasks have been added (*Pilot3a_DevAct_ID11 Development of use cases user interfaces*, and *Pilot3a_SetupAct_ID13 GWEN*) and one has been dropped (*Pilot3a_IntAct_ID2 Integration of semantic data management (T43) enablers*).

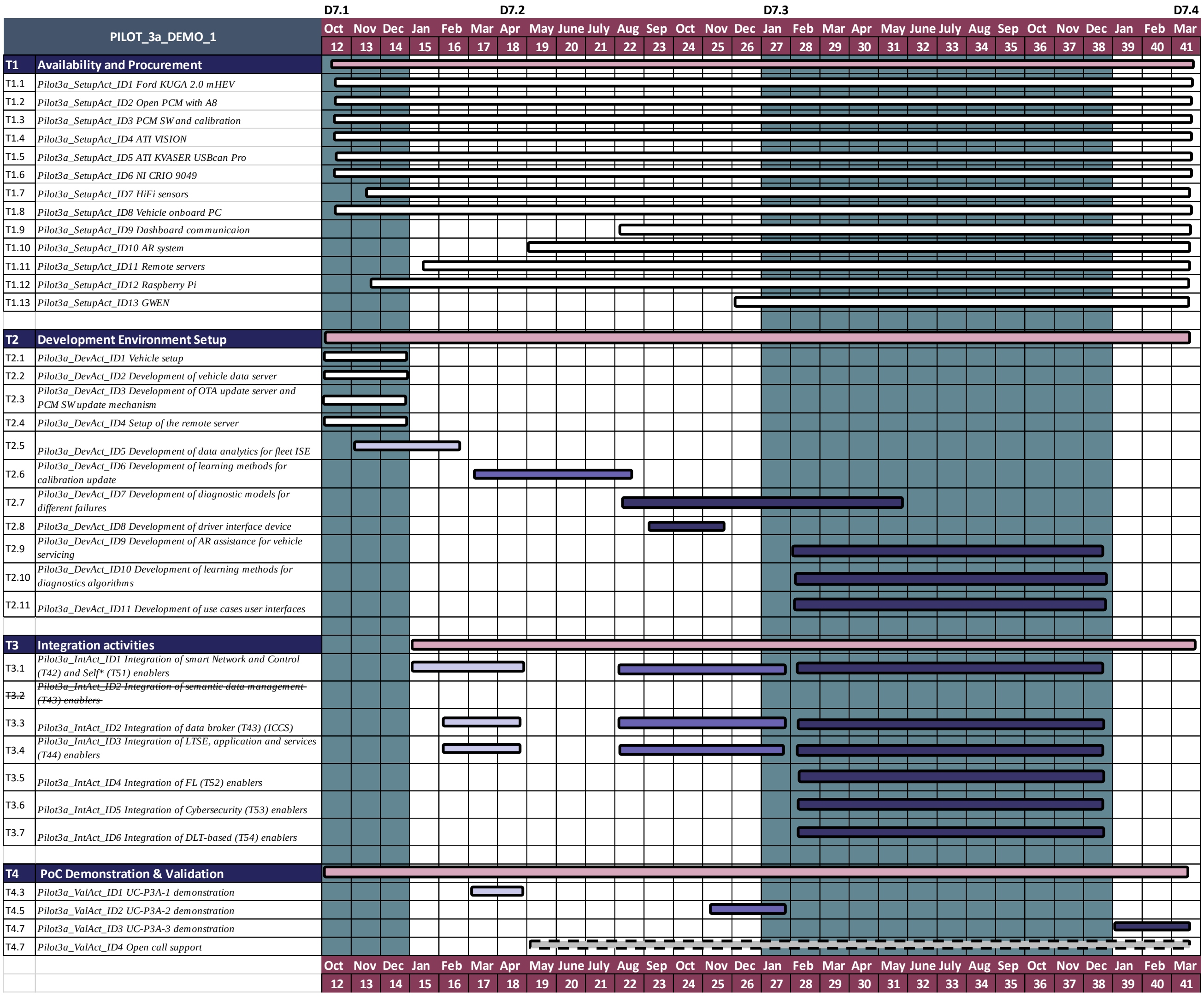

Figure 46. Pilot 3A general planning at M27.

5. Pilot 3B: Vehicle exterior condition inspection and documentation

5.1. Context review

The Pilot 3B of ASSIST-IoT aims at helping vehicle inspectors to improve their operational efficiency during their job of reviewing the vehicle's exterior condition for potential surface damages and documenting them. The associated inspection is done either manually, when the inspector reviews 360°-images of the scanned vehicle, or supported by automated surface inspection, usually implemented via AI-based techniques. A typical scanner at an automotive branch used for pilot activities is shown in the following picture:

Figure 47. Vehicle scanner as pilot outdoor installation at final user

According to the agile plan of the project, both the existing and the recently developed system modules are used to implement and test the targeted functionalities, aiming at being ready with the future project development. Naturally, many existing modules based on standard technologies are expected to be substituted by the innovative counterparts developed within the ASSIST-IoT project. One trial has been planned for this pilot.

5.2. Trial #1: Vehicle exterior condition inspection and documentation

5.2.1. Scope

The pilot 3B consists in one trial with two use cases, which are being developed and investigated in the ASSIST-IoT project framework: (i) the <u>documentation</u> and the monitoring over time of the exterior condition of the scanned vehicles; and (ii) the AI-based support for automatic inspection, considering the novel Federated Learning (FL) approach. A detailed description of these two use cases is given in deliverable D7.2. However, it is worth to mention here that the automated inspection is an optional functionality additional to the documentation one, which largely improves the ergonomic aspects of the application, making it much more efficient and attractive.

<u>Documentation of the exterior condition of the scanned vehicles</u>

For the scanned vehicle documentation, the following aspects are essential: data (images and metadata), from acquisition to storage and retrieval, and visualization tools to support the user to review by himself any potential damage or claim of the end customers and vehicle owners. The real-time acquisition system (i) determines the actual vehicle position, (ii) controls the LED-based adaptive lighting system according to the illumination conditions, (iii) processes the color image processing, and (iv) applies compression/decompression approaches. This is supported by an intelligent storage system with local buffering to cope with varying process speeds, following the actual demand (different hours of the day/month, different vehicle traffic volume). Finally, the system control unit triggers the communication system (including adaptive image packaging/unpackaging) to transfer the data into a local or cloud-based, long-term storage system. This storage system differs between configuration scenarios according to different aspects of the various applications. For example, it can be local and short-term for a few days' storage in rent-a-car cases or centralised and long-term for extended leasing contracts (e.g., thousands of vehicles for a time period of 2-3 years). For all these data, ergonomic and fast human-centered retrieval and visualisation mechanisms have to be implemented. In this concept, the real storage location is transparent for the user (edge, local organization, enterprise cloud), and the associated frontend software must handle more than hundred thousand of images, offering advanced, application-centered visualisation with optional focus on existing damages and AI-proposals. Additionally, this frontend must support the review and the annotation of the scanned images to create the needed ground truth training data for the AI-algorithms. The current design of the pilot concerning the documentation and monitoring aspects is given in the architectural diagram of previous D7.2 deliverable.

AI-based support for automatic inspection

In addition to the manual review and inspection of the images, an automated, AI-based inspection is strongly wished by the end-users to reduce their reviewing time and standardise their inspection. Whilst potential performance and usability of traditional AI-approaches are being researched for the individual business scenario needs, the federated learning suite developed in the project is also targeted in the pilot to investigate the benefits of its use. More data privacy and better user system acceptance; less data transfer volumes, with reduced communication costs; better utilization of existing computing resources on the edge, reducing implementation costs; and better integration of the users into the processes (human-centered approach), are some of its advantages. Open questions and challenges here are whether the FL-approach can offer AI-performances at least comparable with the other AI-approaches, how the end-users will accept the higher interoperability with the digitalisation processes, and how the validation of the AI-results can be achieved in an efficient way. The trial aims at providing answers to all these questions. The architectural diagram for the automated, FL-based AI approach was given in D7.2.

5.2.2. Implementation activities reporting

5.2.2.1. Procurement activities

As a result of the procurement activities, a first experimental scanner at the TwoTronic premises and two pilot scanners at customer sites are currently available. The first is intended to be used for internal developments, integrations, and tests, while the other two are foreseen for future, stress tests with high volume vehicle scans under real conditions. Due to the experimental nature of the pilot scanner at TwoTronic, an availability discontinuation could temporarily occur, i.e., some days the scanner may need some rework or re-configuration to scan vehicles. Naturally, only a few vehicles can be scanned there. The problems mentioned in D7.2 with respect to the LIDAR-sensors have been solved. Additionally, considerable efforts have been done to provide an upgrade of the project-related cloud-services to support additional project needs: more annotations for the Federated-Learning methodologies, more space for images to be analysed, and more Virtual Machines (VM) to host the needed computation, supporting Linux-environments. So, typical problems of moving VM-machines between Windows (needed for the edge computing of the scanner) and Linux-environments, mostly used by the project R&D partners, have been avoided. The availability situation for the various system components is individually given in the following paragraphs:

Pilot3b_SetupAct_ID1 Physical scanner @ TwoTronic: Available although with slightly changing availability in the range of a few days, due to spare parts availability.

Pilot3b_SetupAct_ID2 Local Intelligent Storage System: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot3b_SetupAct_ID3 Real time system controller: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot3b_SetupAct_ID4 Web-based frontend & visualisation software: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot3b_SetupAct_ID5 AI-based automated surface inspection: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

Pilot3b_SetupAct_ID6 Pilot scanners @ end-users: Available, producing new images for FL, additional ASSIST-IoT pre-installations as additional experimental environments for operations under real conditions.

Pilot3b_SetupAct_ID7 Vehicles & corresponding annotations: Available (10.000 images + 10.000 annotations (verified ground-truth examples of vehicle surface damages for AI-training)

Pilot3b_SetupAct_ID8 End-user tables & mobile devices: Available and integrated within the pilot. For more details, please refer to D7.1 and/or D7.2.

5.2.2.2. Development activities

By design, the Pilot 3B relies on ASSIST-IoT enablers for the implementation of the novel aspects of the application functionality. To support its fast realization without potential delays due to implementation dependencies, additional development activities are carried out by the TwoTronic development team to cover basic system functionalities of the automotive application beyond IoT aspects. Hereby, traditional methodologies are applied in parallel to the enabler technologies being developed in the main R&D roadmap of the project. A coherent overall design allows for the substitution of several modules of currently-used technologies with the innovative enablers as soon as they are available over time, regardless if they are part of edge or cloud environments. This approach allows for maximal flexibility and earlier adaptation possibilities over time. As a first step towards a Minimal Viable Product (MVP) for the Pilot 3B a subset of the original architectural diagram has been selected. This MVP can get a picture (or set of pictures of a vehicle scan) from the local storage system using the EDBE enabler and communicate with the cloud counterpart which collaborates with the LTSE enabler for persistent storage and data retrieval. The communication is based on a combination of MQTT and HTTP protocols. Later, the user/inspector can access the images via the Tactile Dashboard enabler also with the support of the Business KPI enabler, which supports the gathering of relevant administrative and application reporting data. Later, security and authorization mechanisms will be added by the security-related enablers, so exposed services are protected. The Smart Orchestrator shall organize the proper enablers administration and operation. Currently, the needed authentication on the server side is supported by commercial products, which adds administrative overheads and will be later substituted by ASSIST-IoT functionalities. The above MVP-scheme is given to the following picture.

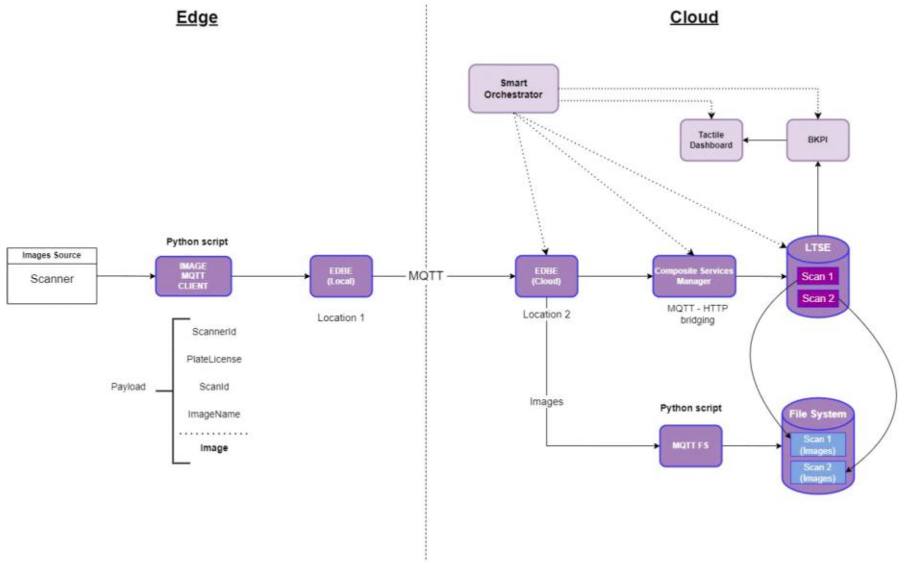

Figure 48. Edge-cloud continuum approach for Pilot 3B MVP.

Regarding the AI-based automatic inspection with the FL-approach (the inspector should have the possibility to perform such inspection either manually or AI-assisted), several efforts have been made on both edge and cloud sides. Technical partners have been developing the workflow of the FL-approach including the selection of first AI-algorithms, trained to support surface damages detection. For the corresponding training with ground-truth data, TwoTronic has organized additional server space. It includes 5.000 images and their needed annotations on pixel level (polygons), featuring two important types of damages (rim damages and scratches). First experiments have been performed by the partners and preliminary results are available, indicating the need for more annotations. Thus, additionally 5.000 images have been provisioned for further training. An evaluation set of images and their verified annotations have also been made available to check the performance of the whole FL environment. It has been set in a way that new AI algorithms could be added afterwards that (may) provide better operational performance with higher recognition rate and accuracy. Performance considerations can also be done with respect to the time needed for training, thus selecting appropriate strategies to balance the overall computational needs between the edge and the cloud part according to various criteria. On both corners of the computing space, there are appropriate graphic subsystems currently implemented via NVIDIA technology to accelerate computations.

Pilot3B_DevAct_ID1 Scanner preparation & setup: During the last project reporting period, the pilot scanner at TwoTronic has been basically built up. His inherent, industrial PC is seen as the computing platform for the edge part of the ASSIST-IoT software system. As the system software there is running under Windows, this platform has been also used for the first software environment for the edge part. In this early stage of the enablers technology, several compatibility issues have been faced between the basic R&D platform of Linux and the underlying Microsoft environment with respect to the container, virtualization, and the selected Kubernetes technologies. It is planned to add a second edge-server dedicated to ASSIST-IoT for the front-end processing to allow for faster software transfer between the R&D project partners and the pilot system. In this sense, most frontend functionalities related with the image acquisition and their management within the edge computer are being developed with a modular approach. Therefore, by using the saved images of a complete scan as a clear interface between the basic scanner acquisition and the remaining IT aspects the novel ASSIST-IoT approach can also be easily integrated later on. This has been possible due to the previous developing efforts of the refined real-time system controller: its new, now modular design allows a clear interfacing on several abstract levels and supports the stepwise introduction of new functionalities without severe side effects.

Pilot3B_DevAct_ID2 Design and set up the remote server supporting the activities in the pilot site: The cloud server is described in the D7.2 in detail. Its structure allows several functionalities, such as: (i) testing of the MVP on the server side with its interaction with the edge part, including the visualization of scanned images; (ii) accessibility for the FL team to test the AI algorithms for the automated surface inspection; (iii) access to images of the vehicle scans for the annotation team, for reviewing and verification of the AI proposals and corrections; (iv) easy re-organization of the application data flow from test scans saved on the VM to real-time scan streams from the already connected physical scanners, allowing various stress tests with real workload; and (v) appropriate space for the process flow of the associated FL aspects, including all relevant, cloud-targeted enablers.

Pilot3B_DevAct_ID3 Development of user interface: The intention here is to combine the ASSIST-IoT enablers, like the Tactile-Dashboard, with application-related user interface context. A modular design of the presented application-specific content in D7.2 is being further implemented and targeted to interface with the new, innovative, and application-agnostic technology of the project. This is subject to the integration activities of the pilot, described in the next subsection, which will take place in the next 6 months in several steps. It is important to consider the tactile property needs of the application, as the vehicles inspectors need the images to be provided in time and in an ergonomic way in their devices (i.e., office PCs, mobile devices). Otherwise, user acceptance problems may arise.

5.2.2.1. Integration activities

Necessary preparation activities with respect to the underlying application functionalities have been taken place, like architectural readjustments towards a finer grain-levelling, Application Programmable Interfacing (API) definitions and other preparing work to support a smother collaboration of existing software functionalities with upcoming ASSIST-IoT enablers.

Pilot3B_IntAct_ID1-Integration of smart Network enablers (T42Ex): in progress at early stage

Pilot3B_IntAct_ID2-Self-* enablers (T51Ex): Not started yet. Postponed until self-* enablers are developed, and ready for integration.

Pilot3B_IntAct_ID3-Federated Learning enablers (T52Ex): Application data are provided to support the setup of the appropriate FL workflow. Architectural provisions are met to support a later integration of these enablers as an optional feature for the end-user. Graphic subsystems have been installed at both edge and cloud sites to support the testing of computational balancing for FL processing.

Pilot3B_IntAct_ID4-Storage and semantic enablers (T43Ex): Not started yet.

Pilot3B_IntAct_ID5-Security modules (T53Ex): Not started yet.

Pilot3B_IntAct_ID6-DLT incorporation (T54Ex): Not started yet.

Pilot3B_IntAct_ID7-Integration of Application and services enablers (T44Ex): Not started yet.

5.2.2.2. Validation activities

Pilot3B_ValAct_ID1 Definition of scenario and 1st prototype:

Context: The digitalisation of vehicles with 360°-views is a new tool to improve process optimisation in several after-sales business areas in the automotive branch. Several details of the currently implemented enablers are validated upon suitability and refinement for the first Pilot 3B prototype. Particularly the efficient treatment of high-resolution colour images seems to be a challenging issue for the enablers design within the IoT-architecture. During the first-time operational compatibility problems with the various underlying OS for Kubernetes were faced.

Expectation: A first functional set of the application is working as a classical first prototype to check several aspects of the use case. A rich set of lessons hereby shall help several assumptions, next decisions of several fine-tuned parameters and give feedback to the core R&D team towards a real-world test case.

Validation proof: Started and in progress.

Pilot3B_ValAct_ID2: Definition of scenario and 1st trial:

Context: The second implementation scenario incorporates an enriched set of existing and upcoming enablers. Their integration will be based on won experience of the work with the 1st prototype. The scenario will also provide the integration of both use cases (UC1 & UC2), where the federated learning (FL) approach will be evaluated and adapted to the real needs and characteristics of the pilot systems.

Expectation: Expansion of all pilot functionalities to the next level of the use cases, defined by the next scenario of the 1st trial. Evaluation possibilities of the impact and influence of the application parameter setting for several variables of the system. Expected is also a mature trial to be run on selected pilot sites with real working conditions in everyday operations of interested customers & end-users.

Validation proof: not started yet.

Pilot3B_ValAct_ID3: Definition of scenario and 2nd trial:

Context: Both a full experimental installation will be available for fast changes and improvements as well as a few pilot systems shall be installed at final customer sides to evaluate the full system possibilities. Whilst the first type of installation allows for a continuous final tuning of the system modules, the pilot systems at customer sites are sensitive to changes and their impact to their everyday operations. Thus, we can only periodically update these end-user systems with new versions. Otherwise, they allow us to stress test the system, as many vehicles are passing these scanners under real market conditions. The associated, real experience of the pilot end-users set a very good validation base.

Expectation: A final trial will evaluate and validate the project approach for the business cases of Pilot 3B. Immediate feedback is expected to be given by both pilot end-users directly involved as well as with interesting market participants, who will get individual presentation of the project pilots. Additionally, based on additional annotation data, the used FL-algorithms will show their full-blown potential for those cases, where final customers are reluctant to share their images but also sensitive to high bandwidth & communication costs.

Validation proof: not started yet.

Pilot3B_ValAct_ID4: Open call demonstration and validation: Even if the Open Call 1 project ADDICTIVE is not formally associated with Pilot 3B, several actions have been conducted to check its potential use. The first examinations show also a good potential, as it could support the setting up of more performant AI-based surface inspection, by allowing both application-oriented users to experiment by themselves with their own algorithms setup, tailored to their individual needs (like varying vehicle models). It could also aid annotation teams to generate more efficient the necessary and steady needed ground truth facts for the AI-training. This is independent on a centralized or FL approach of the AI methodologies applied.

5.2.3. Deviations from original planning

There are no substantial project deviations in Pilot 3B activities resulting into any new risks for the main project targets. Nevertheless, several software modules by TwoTronic continue to cover essential functionalities of the envisaged application functionality. They are planned to be continuously substituted by corresponding ASSIST-IoT enablers, which are still under development. For both the edge and the cloud the development environment has been set up according to the project needs and many annotations of vehicle damages have been provided. The integration activities will be intensified over the next months when more enablers will be available for integration. The time of the environment availability for testing, demonstrations, as well as validation has been re-scheduled to cover the additional project time, although there is no yet final warranty from the automotive end-users, originally committed to support the project, that they can continue to provide their testbed with their scanners. However, in this case, we believe to find new testbeds with equivalent test possibilities.

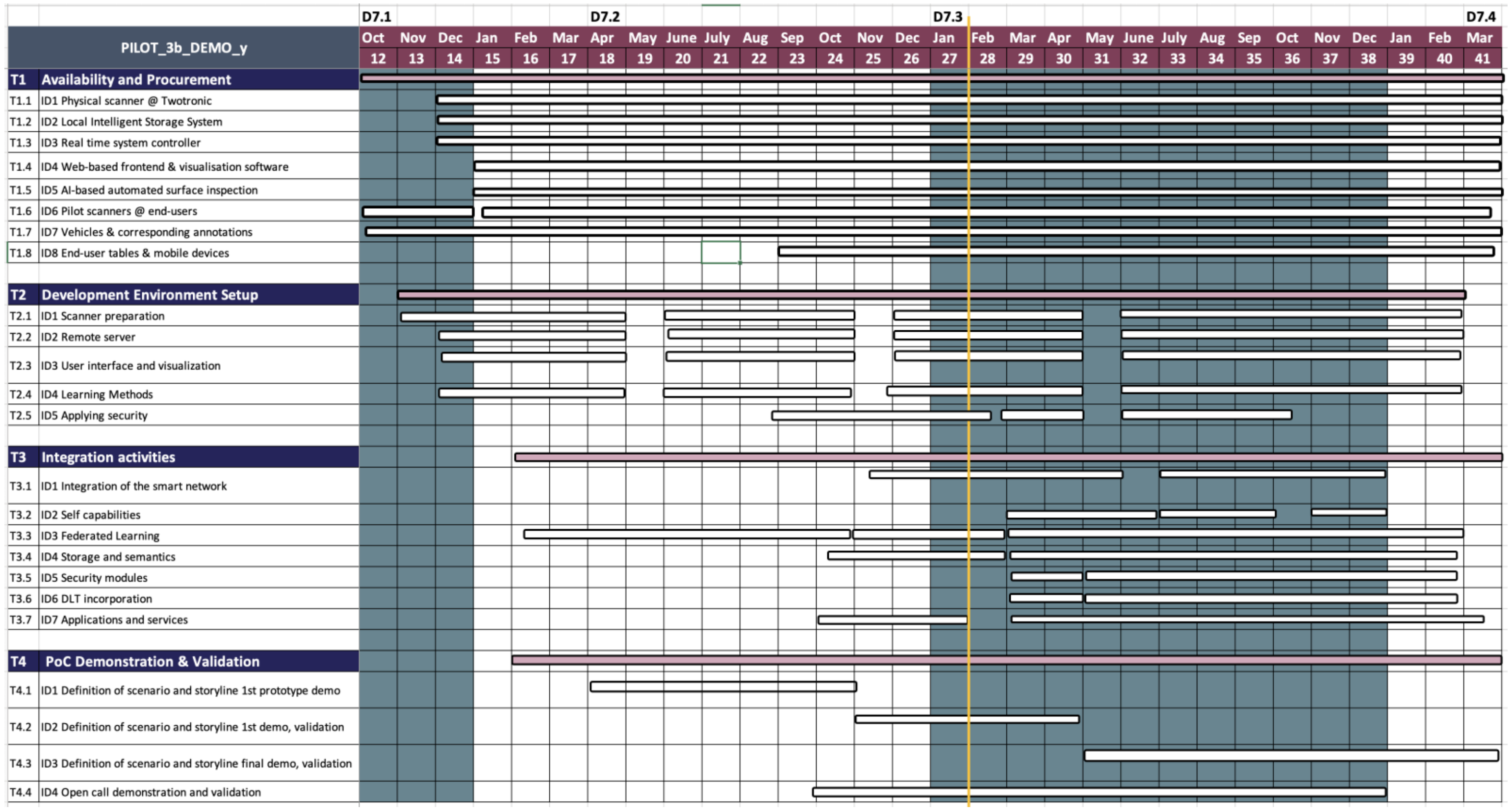

Figure 49. Pilot_3B_Trial Gantt chart (M27).

6. Open Calls (First round)

6.1. Introduction

ASSIST-IoT has reserved a total of 900.000 € for supporting third parties enhance the scope of the project by joining the project via Open Calls. ASSIST-IoT will perform **two rounds of Open Calls** where research entities and SMEs around Europe are summoned to:

- Validate and improve technical components of the architecture.
- Take up of ASSIST-IoT by application developers, domain experts and entrepreneurs to create new applications and services.
- Push ASSIST-IoT technology and service visibility on the market.
- Support an innovative, dynamic and industry open ecosystem around ASSIST-IoT results.

Gather new market relevant inputs ASSIST-IoT components and finding industry experts to improve technical capabilities as well as filling possible missing functions, needed adoptions or modifications

Up to now, **one complete procedure of Open Call application has been completed**. It was conducted as follows:

- Opening date: 1 November 2021
- Closing date: 28 February 2022
- Funding available: 420.000 €
- Number of proposals to be funded: 7
- Budget per proposal (lump sum): 60.000€

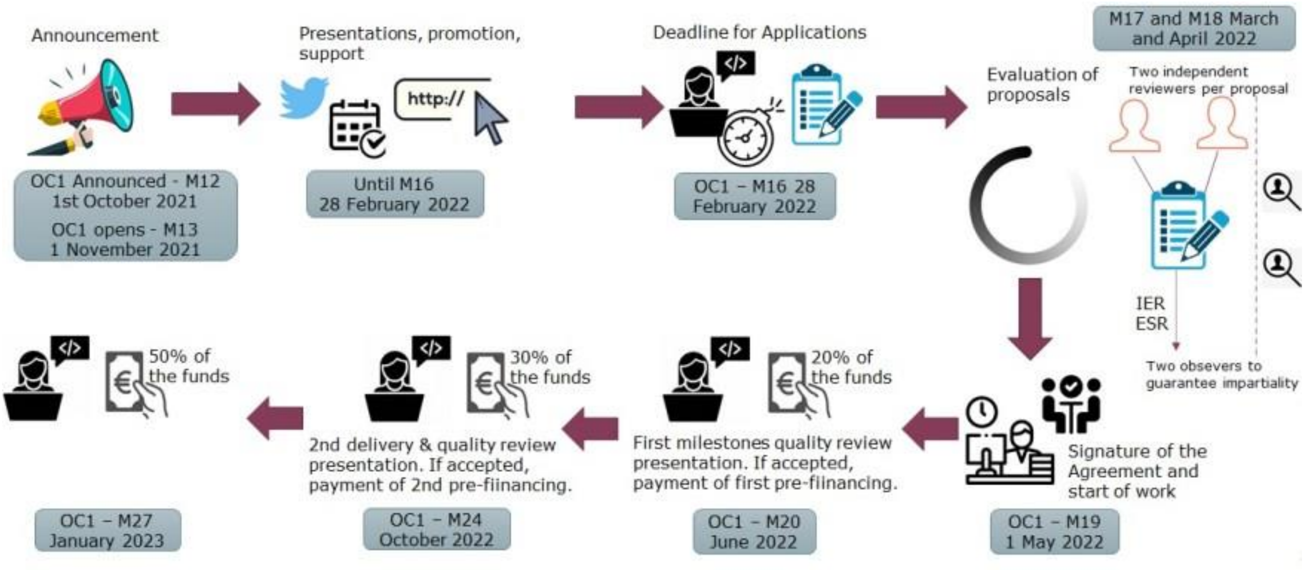

Figure 50. Timeline of Open Calls – Round #1

Once completed, the results were the following:

- Final number of proposals received: 37
- Final number of proposals surpassing the threshold (19 points out of 25): 15
- Proposals presented / funded per pilot:
  - P1 – 15 – 2 funded (ADDICTIVE, SPINE)
  - P2 – 11 – 2 funded (ATHEMS, SMART SONIA)
  - P3a – 10 – 3 funded (RAZOR, HAIR, BREATHE)

- P3b – 1 none funded

Afterwards, the seven funded projects were called upon to sign a Collaboration Agreement before initiating their executive actions. Since June, 1st, 2022, those projects have been being carried out. During their actions, several discussions and interactions with ASSIST-IoT partners (mostly via stakeholders and the associated technical partners) is being taking place.

In the sections below, there is a small reference of those projects, together with their scope and the contribution to the pilot.

6.2. Pilot 1 related Open calls

6.2.1. ADDICTIVE

6.2.1.1. General details

The following are the general details of the project ADDICTIVE:

- ***Title of the project***: AI-Driven **Data Annotation** for Interactive Process and Situation Discovery
- ***Company***: Bytefabrik.AI GmbH (www.bytefabrik.ai)
- ***Type of company***: SME
- ***Country***: Germany
- ***Duration (in months)***: 8 months (Jun22-Jan23)

6.2.1.2. Technical details

- ***Abstract***: ADDICTIVE develops an innovative approach to reduce the effort needed for annotating large sets of time-series images. The annotation tool combines a preference elicitation approach with explainable AI and addresses data experts and domain experts
- ***Technologies***:
  - AI-driven data annotation in images based on self-learning preference-based analysis and absolute labels in neural networks
  - AI-guided annotation, No-Code AI development and Hybrid Embedding
  - Apache StreamPipes, Docker, K8s
- ***Architecture and other diagrams***:

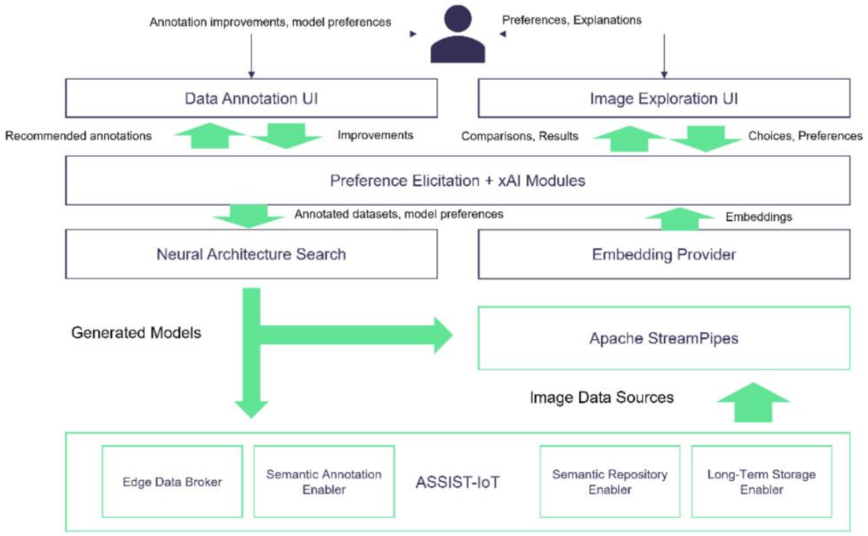

Figure 51. ADDICTIVE technical architecture

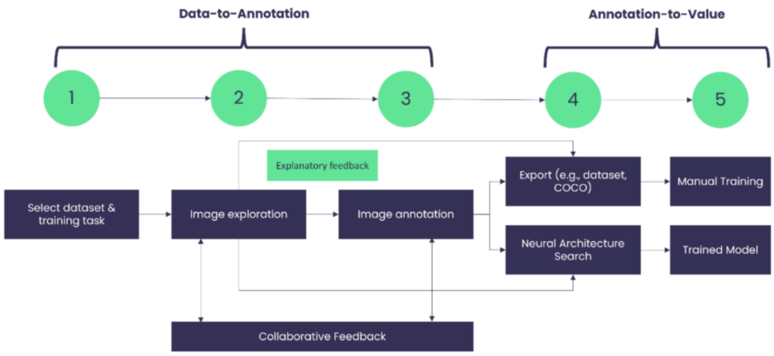

Figure 52. ADDICTIVE technical approach

6.2.1.3. Status of the advances

As per M6 of the project (corresponding to M25 of ASSIST-IoT), ADDICTIVE has performed the following activities:

- Finalization of the state of the art of AI technologies applicable to the problem.
- Design of an architecture for the automatic annotation of images.
- Definition of the underlying methods of the system: (i) user interaction process, (ii) image classification process, (iii) object annotation and (iv) preference-based comparison.
- Development of the previous process (first version).
- Ingestion of first bulk of images provided by ASSIST-IoT's stakeholder (KONECRANES).
- Dissemination of the project (including ASSIST-IoT material) on relevant industrial events.

Conducting to the successful achievement of the following results:

- First running prototype of backend of the image classification module (showcased at 2nd periodic review of the action)
- Functioning mockups of the frontend of the auto-labelling solution for the user.

6.2.1.4. Collaboration with the pilot and expected impact

The outcomes of ADDICTIVE will provide to ASSIST-IoT Pilot 1 partners the needed tools for accelerating the process image annotation, which has been noticed as the main bottleneck in the computer vision functionalities envisioned for Trial #3. Furthermore, the data annotation tool cannot only be used for Pilot 1 of the ASSIST-IoT project but for any AI-based activity of the project. For instance, with respect to Pilot 3B, they are looking to find synergies with the KI-aspects of the ADDICTIVE project. This is particularly meaningful as there is an essential need to create a big set of ground truth data, which is badly needing annotation support. Whilst a human reviewer is seen as necessary for the annotation process and images review an AI-supporting methodology not only during the initial set-up of the AI-processes, but also during the whole system life cycle of the automated inspection. The main reason is not only the changing illumination and climatic changes over the years, but also the fine modifications of the vehicle exteriors, which demand the continuous learning of the algorithms and the associated image annotation demands.

6.2.2. SPINE

6.2.2.1. General details

The following are the general details of the project SPINE

- ***Title of the project***: Supply Ports with **Innovative CV edge Nodes** to increase their Efficiency
- ***Company***: Ubiwhere (www.ubiwhere.com)
- ***Type of company***: SME

- ***Country***: Portugal
- ***Duration (in months)***: 9 months (Jun22-Feb23)

6.2.2.2. Technical details

- ***Abstract***: SPINE will supply ports with **innovative computer vision technology, running at the edge**, to increase the efficiency and safety of their workers' operations. Ubiwhere, a software development SME from Portugal will demonstrate the Port Nervous System. The main goal of this project is to develop an edge computing solution able to identify people and vehicles, analyse those distances from containers and give alerts to the operator, operating cranes remotely, if the distances are considered as dangerous situations.
- ***Technologies***:
  - Edge computing via an edge node equipped with NVIDIA Jetson Nano's video encoding and decoding performance
  - Video Augmentation with OpenCV and TensorFlow
- ***Architecture and other diagrams***:

Figure 53. SPINE architecture and planned devices

6.2.2.3. Status of the advances

As per M6 of the project (corresponding to M25 of ASSIST-IoT), the project ADDICTIVE has performed the following activities:

- Elicitation, identification, and purchase of equipment to deploy the prototype (1+ edge nodes – Avida's NVIDIA Jetson AGX Xavier Developer Kit-, cloud resources for the SPINE Cloud and a foot pedal for port operators to easily interact with the system to trigger a new alarm without a keyboard).
- Integration of the Interoperability Layer of ASSIST-IoT architecture with the SPINE Dashboard and the Knowledge & Real-Time Analysis Layers.
- Creation of an emulated set of images to train the algorithms to be run by the edge node (while real port images are unavailable).
- Test of various object detection algorithms over the simulated set of images (e.g., YOLOv5, Strong-SORT).
- UX/UI was designed and implemented.
- Dissemination of the project at relevant events, highlighting the Smart City Expo World Congress.

Conducting to the successful achievement of the following results:

- Edge node with custom running software.
- Draft prototype of the UX/UI system with backend data, functioning without real images from the port (not available) including first attempt of AI detecting algorithms.
- Incidents are being detected (still some false positives), maP larger than 40%, 15 frames per second processing.

6.2.2.4. Collaboration with the pilot and expected impact

In terms of the interaction with Pilot 1, and the expected added value, these are the main considerations at this moment:

- A new human-to-machine interface for remote crane drivers.
- An ML-based solution aiming at reducing hazardous situations when managing remote operated cranes.

Although, for the time being, SPINE outcomes are validated in a development environment, it is agreed that once all the remote operating functionalities of the cranes are commissioned, the software solution will be integrated and tested in the pre-production environment.

6.3. Pilot 2 related Open calls

6.3.1. ATHEMS

6.3.1.1. General details

The following are the general details of the project ADDICTIVE:

- ***Title of the project***: Active thermal load management system for PPE and workwear
- ***Company***: ComSensus, komunikacije in senzorika, d.o.o. (www.comsensus.eu)
- ***Type of company***: SME
- ***Country***: Slovenia
- ***Duration (in months)***: 9 months (Jun22-Feb23)

6.3.1.2. Technical details

- ***Abstract***: ATHEMS aims at **developing an active thermal load management system for PPE and other workwear**, supporting health and safety inspection at construction sites and/or other harsh working environments, preventing threatening situations that may lead to potential health issues for workers.
- ***Technologies***:
    - CompCooler cooling vest with placed flexible Peltier elements
    - Comsensus Liux-based eTag and IoT Gateway based on Yocto and Fledge
    - Environmental, bump and heart rate sensors, Docker, K8s
- ***Architecture and other diagrams***:

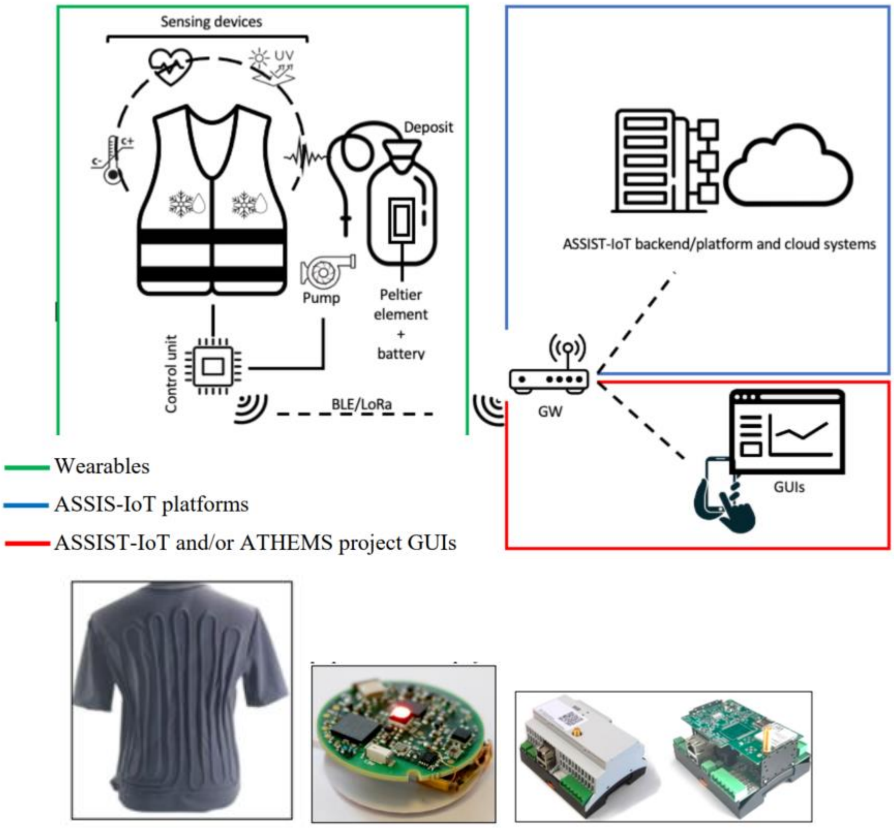

Figure 54. ATHEMS architecture, cooling vest design and planned devices.

6.3.1.3. Status of the advances

As per M6 of the project (corresponding to M25 of ASSIST-IoT), the project ADDICTIVE has performed the following activities:

- Evaluation of market available cooling vest and evaluation of the use of Peltier elements as part of the system to improve performance and cooling effect over time
- Development of biometric measurement system and dedicated control unit
- Development of dedicated mobile app as main user interface to support operation and testing of the system/solution
- Design and production of hardware enclosure
- Analysis and design of the software system architecture, focusing on monitoring and control capacities as well as data storage, processing, communication, and vertical security/privacy
- Development of data models and set up of supporting toolsets (VPN, graphing, storage, …)
- Review and testing of acquired infrastructural, software, and other pilot assets

Conducting to the successful achievement of the following results:

- Production of first hardware prototype
- Completed interaction app for using the solution

6.3.1.4. Collaboration with the pilot and expected impact

- Analysis of available ASSIST-IoT enablers, serving as a basis for the ATHEMS solution architecture.
- Protection against overheating of blue-collar workers using the developed cooling vest.
- Increase the comfort level of blue-collar workers.

6.3.2. SMART SONIA

6.3.2.1. General details

The following are the general details of the project SMART SONIA:

- ***Title of the project***: SMART SONIA (occupational Safety mONitoring and Interventions for health
- ***Company***: DotSoft (www.dotsoft.gr)
- ***Type of company***: SME
- ***Country***: Slovenia
- ***Duration (in months)***: 9 months (Jun22-Feb23)

6.3.2.2. Technical details

- ***Abstract***: The project focuses in delivering an intervention based mobile platform for human workers in the construction industry, to monitor their level of attention, fatigue and possible distractions, thus preventing potential hazardous situations that can provoke injuries. The main objective of SMART SONIA is to uninstructively detect and predict the quality of health of the workers while at the construction field and notify the OSH manager about their ability to work without possible injuries.
- ***Technologies***:
    - KeyCloak, WSO2 API Management
    - Big Data, OSH considerations, Docker, K8s
    - Smart watches, environmental sensors and Smart beacons
- ***Architecture and other diagrams***:

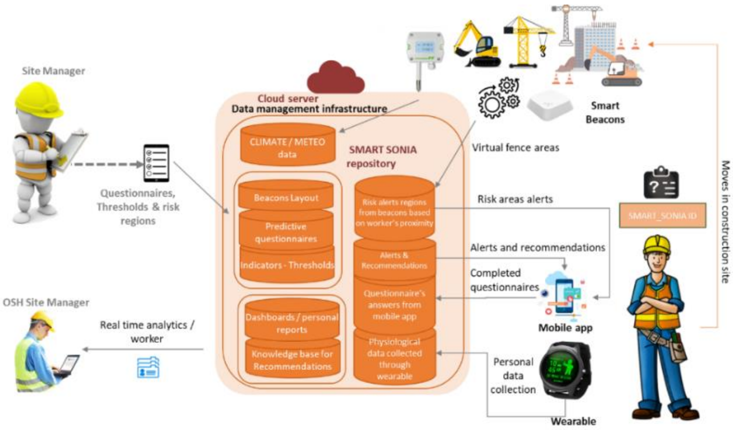

Figure 55. SMART SONIA planned solution.

6.3.2.3. Status of the advances

As per M6 of the project (corresponding to M25 of ASSIST-IoT), the project ADDICTIVE has performed the following activities:

- Purchase of necessary equipment: wearables, smartphones, beacons.
- Data modelling of all required operations: repo. of personal data, OSH point of management application.
- Analysis of the collection of data sources based on IoT techniques.
- Definition of a counselling / coaching strategy that involves specific recommendations to workers.
- Performance of a number of tests in order to check best results in terms of performance, app / workflow friendliness comparing app vs wearables approach.
- Creation of a specific website of the project

Conducting to the successful achievement of the following results:

- Mockups for the OSH point of management application and for the wearable application for workers

6.3.2.4. Collaboration with the pilot and expected impact

- Mapped comprehensive big data related with construction sites, in a reachable and manageable way, based on the application of the principles for sharing, reusability, scalability and interoperability, creating a network of knowledge by linking heterogeneous data sources and physiological biodata for monitoring health status and quality status to cope with potential high risky operations.
- Better and faster means of high-quality response to prevent or timely address the rise of likelihood of an accident to happen while at cons.

6.4. Pilot 3A related Open calls

6.4.1. RAZOR

6.4.1.1. General details

The following are the general details of the project RAZOR:

- ***Title of the project***: Road hAZard detectOR
- ***Company***: INSIGHIO P.C. (https://insigh.io)
- ***Type of company***: SME
- ***Country***: Greece
- ***Duration (in months)***: 9 months (Jun22-Feb23) (proposal 8 months – agreed to 9 months during CA signature).

6.4.1.2. Technical details

- ***Abstract***: RAZOR will develop a scalable **IoT application that can automatically detect road hazards in real time**. The outcome of the project will be a dynamic and active vehicle safety system, deployed over the ASSIST-IoT architecture, which will automatically monitor road network conditions, contributing to a significant reduction of accidents and vehicle damages. The system is built upon the proposer's own IoT technology and portfolio. In particular, it will be based on a **custom in-vehicle IoT board and a containerized backend software infrastructure**, towards timely alerting the involved stakeholders.
- ***Technologies***:
    - Big Data decision platform

   - A “thing” IoT hardware board consisting in a complex in-vehicle station with several sensors (including accelerometer, environmental and others) using MQTT, CoaP and LoRa, Docker, K8s,
   - Deep Learning Networks to estimate road hazards; vehicle abnormality requiring inspection; detect incident; correlate road conditions with fuel consumption (if available), etc

- ***Architecture and other diagrams***:

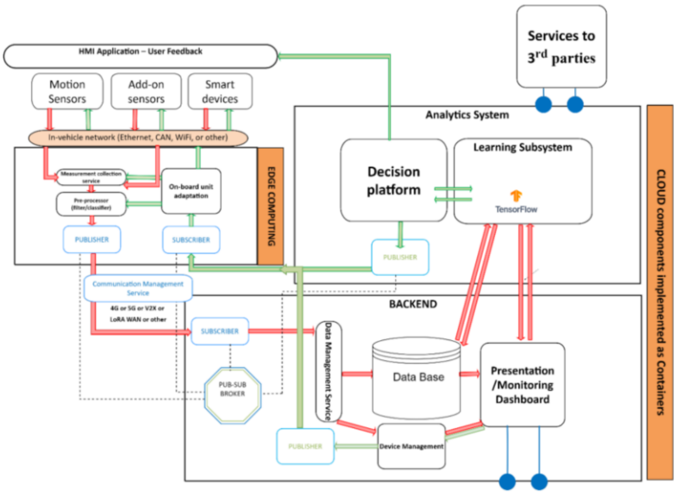

Figure 56. RAZOR planned architecture.

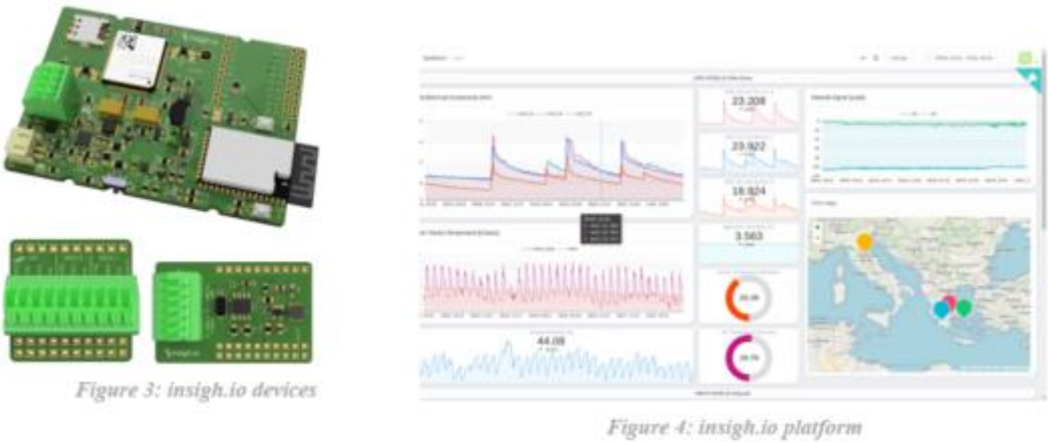

Figure 57. RAZOR devices and tentative visualization

6.4.1.3. Status of the advances

As per M6 of the project (corresponding to M25 of ASSIST-IoT), the project ADDICTIVE has performed the following activities:

- Sensor selection completed.
- PCB design was finalised. PCB was printed and has been already integrated in a functioning system.
- Firmware developed by insigh.io has been equipped within the HW and tested including real time optimization.
- Development of edge-software (in-board) and cloud software of RAZOR solution.
- Development of ML algorithm for the road hazard detection (focused in bumps).
- Development of front-end software for tracking the vehicle and inserting bumps information.
- Testing of the board and the system in a route in Greece.

- Substantial dissemination both in events and social media about RAZOR and ASSIST-IoT.

Conducting to the successful achievement of the following results:

- Complete prototype of the board that has been mounted and tested in real vehicles.
- Complete software analysis solution, showing defects in the road (showcased in a demo at the 2nd periodic review of the project).

6.4.1.4. Collaboration with the pilot and expected impact

RAZOR will allow the integration of vibration sensors into ASSIST-IoT Pilot 3A, with the objective of monitoring the state of the road and the existence of hazards. In addition, RAZOR will showcase the ability of ASSIST-IoT architecture to integrate smart devices, and of supporting 3rd party applications connected to the LTSE. All information flow in RAZOR will be routed through the EDBE, and specific enablers for bridging the smart devices with the ASSIST-IoT hardware are also being developed and orchestrated by ASSIST-IoT.

6.4.2. HAIR

6.4.2.1. General details

The following are the general details of the project HAIR:

- ***Title of the project***: Hyper-local air quality mapping and intelligent Low Emission Zones powered by ASSIST-IoT architecture
- ***Company***: Allbesmart, LDA (www.allbesmart.pt)
- ***Type of company***: SME
- ***Country***: Portugal
- ***Duration (in months)***: 9 months (Jun22-Feb23)

6.4.2.2. Technical details

- ***Abstract***: The HAIR project will implement and test **two new use cases** "hyper-local air quality mapping" and "intelligent management of Low Emission Zones" in the context of pilot P3A. These use cases have great market potential in the smart cities' domain, ensuring wide and sustainable use of ASSIST-IoT deployed solutions.
- ***Technologies***:
    - Pollution Resource Management (PRM) in own air quality management station at the edge
    - National Instruments CompactRIO system (NI cRIO) modules, Docker, K8s
    - ETSI 103 496 - C-ITS support for transport pollution management applications
- ***Architecture and other diagrams***:

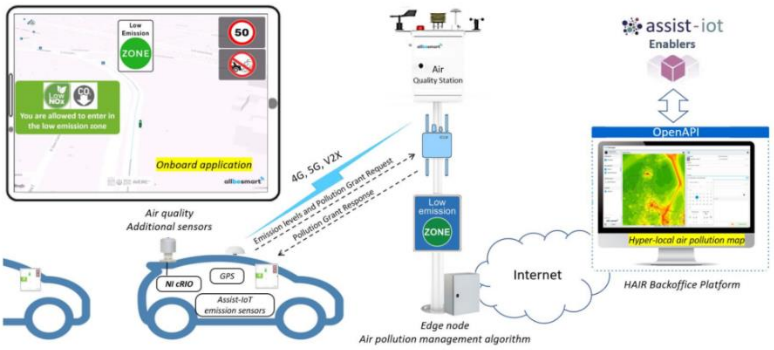

Figure 58. HAIR designed solution.

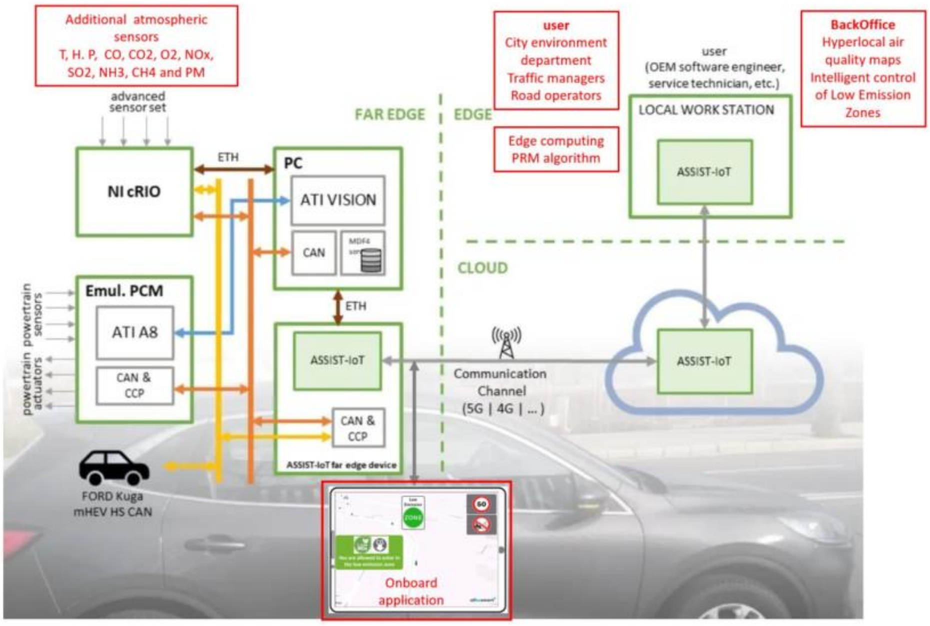

Figure 59. HAIR planned architecture

6.4.2.3. Status of the advances

As per M6 of the project (corresponding to M25 of ASSIST-IoT), the project HAIR has performed the following activities:

- Purchased and tested sensors to be equipped in Ford's ASSIST-IoT car: Temperature, Humidity, Pressure, CO, CO2, O2, NOx, SO2 and particle size (PM).
- The integration with the air quality stations provided by the European Environment Agency (EEA) for the city of Valencia in the C-ITS Platform was concluded.
- Custom software development to extend original Allbesmart's dashboard and application to include map of air quality stations and vehicle monitoring information of HAIR.
- Analysis of risks and establishment of a business plan for the solution of HAIR.
- Dissemination of the project (including ASSIST-IoT material) on relevant industrial events.

Conducting to the successful achievement of the following results:

- Complete software design interaction system between edge components of vehicles, cloud part of C-ITS and ASSIST-IoT enablers.
- First version of a driver assistance Onboard application that informs the driver about real-time air quality and triggers protective actions if required.
- First version of the PRM algorithm for Low Emission Zones (LEZ) to improve pollution control fairness and efficiency based on actual emission and air quality measurements.

6.4.2.4. Collaboration with the pilot and expected impact

HAIR will showcase the use of the vehicle of Pilot 3A as a mobile emission measurement station, and the integration of such mobile sources with static air quality stations. HAIR will make use of the EDBE and LTSE, and a web application will be developed accessing the data in the LTSE via an ad-hoc API.

The HAIR architecture follows the design principles that govern ASSIST-IoT architecture and solutions, namely (i) the use of microservices, (ii) their instantiation in containers, (iii) their grouping into "enablers", (iv) and their further orchestration using Kubernetes technology.

6.4.3. BREATHE

6.4.3.1. General details

The following are the general details of the project BREATHE:

- ***Title of the project***: Breaking through Air Pollution with Thinking Vehicles at the Network Edge
- ***Company***: Universidad Politécnica de Cartagena (https://upct.es)
- ***Type of company***: University
- ***Country***: Spain
- ***Duration (in months)***: 9 months (Jun22-Feb23)

6.4.3.2. Technical details

- ***Abstract***: BREATHE proposes an **in-cabin and crowdsensing air pollution monitoring system** to gather and intelligently process data **in a multi-tier edge computing platform**, to assure healthy conditions when traveling, driving and operating vehicles, and to analyze air quality in cities.
- ***Technologies***:
  - LP-WAN, LoraWAN
  - $PM_{2,5}$, PM_{10}, CO, CO_2, NO_2, SO_2 and O_3 and crowdsensing monitoring
  - Docker, K8s, Helm charts
- ***Architecture and other diagrams***:

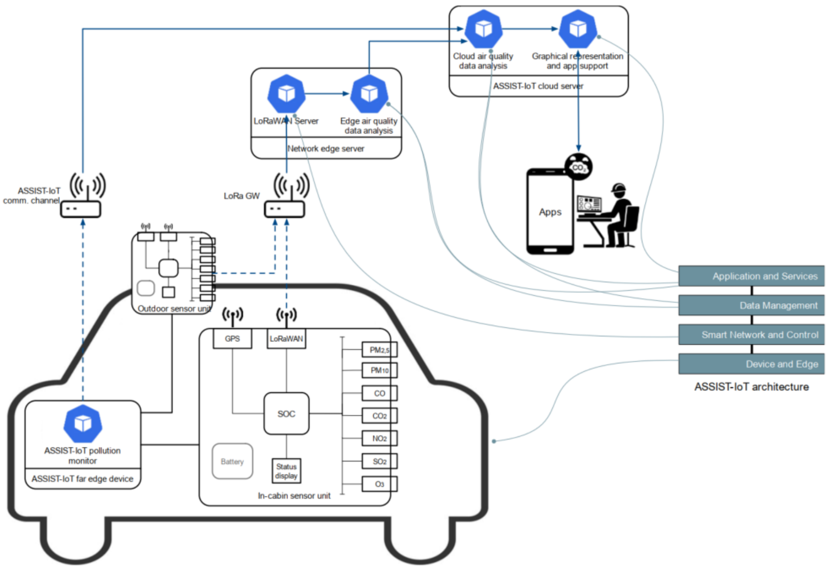

Figure 60. BREATHE planned architecture

6.4.3.3. Status of the advances

As per M6 of the project (corresponding to M25 of ASSIST-IoT), the project ADDICTIVE has performed the following activities:

- Definition of BREATHE architecture.
- Definition of data models to be used.
- Setting-up the testing environment in lab.
- Acquiring of equipment for developing on-board units.
- Design of on-board units covered.
- Development of on-board software for data acquisition and reporting.

- Web page ready for the project.
- Advances in the development of the Web application to monitor pollution indexes.

Conducting to the successful achievement of the following results:

- Complete set up of the system for testing in-vehicle during M7-M9.
- Hardware edge component and sensors complete and ready for testing (two PCBs to be used for sensor integration and main processor board)
- Deployment of LoRaWAN network ready
- A first version of the web application for both desktop and mobile platforms

6.4.3.4. Collaboration with the pilot and expected impact

BREATHE project is developing an On-Board Unit (OBU) for air quality measurements, that will demonstrate the use of swarm, distributed sensing for air quality determination in a dedicated cloud platform. BREATHE will make use of EDBE and LTSE and will connect through an API to the data stored by ASSIST-IoT. Dedicated enablers are being developed for providing suitable data sockets to the OBU, which are containerized and orchestrated by ASSIST-IoT.

7. Conclusions and Future Work

ASSIST-IoT WP7 is in charge of deploying an integrated version of all the enablers being developed in WP4 and WP5 in project's pilots. This document has reported all the implementation activities related to the deployment of the trials for the four ASSIST-IoT pilots (Port automation, Smart safety of workers, Vehicle in-service emission diagnostics, and Vehicle exterior condition inspection and documentation) in the period M19-M27 and provides relevant insights about the operational framework of the different real testbeds of the project.

In summary, as a conclusion of *D7.3 Pilot Scenario Implementation – Intermediate Version*, it can be stated that like in D7.2, all the Pilots are overall in a good track, within the targets defined in the planning done in the predecessor documents. As a second in a series of three Pilot evolution reporting documents, the deliverable has been consequently focused on the finalisation of procurement activities, update of development ones, and kicking off the integration of ASSIST-IoT enablers in the pilots. In addition, initial validation activities have also started, although most of them are still on their infancy.

Regarding pilot specific outcomes:

- In Pilot 1 most of the procurement and development activities are already available and integrated in the pilot, the integration of ASSIST-IoT enablers with the current systems of the terminal has just started. Unfortunately, Pilot 1 Trial #3 is experiencing procurement delays, but the spare parts will be shipped to Malta Freeport Terminal during February 2023. Therefore, it should not pose significant risks to Pilot 1 implementation.
- Most of Pilot 2 equipment is placed but GWEN. In addition, delays on MVP versions of project's essential enablers have led to a slow start of the integration and validation activities and given Pilot 2 testbed will only be available for tests until M38, all the planned activities should be finished by then. Regarding Trial #3, BIM model showing possible evacuation routes on the construction site based on the recommendation of the site's OSH manager were developed and successfully tested.
- Pilot 3A has added two new Human-to-Machine Interfaces (a 7" tablet embedded into the vehicle, and EPSON MOVERIO AR glasses). The integration of the pilot with ASSIST-IoT essential enablers (EDBE, LTSE, Smart Orchestrator and Manageability enablers) has been started, leading to achieve the second iteration of the demonstrations of the project.
- In Pilot 3B the already available TwoTronics scanner has been enhanced for enabling a secure and easy-to-access procedure for ASSIST-IoT technical partners. The integration activities, mainly focused on replacing current software modules is ongoing, including the integration of a human-friendly business analytics UI not available in TwoTronics suite yet.

As a future work, it is expected that the different trials on pilot sites will be successfully carried out during the following 14 months, and consequently reported in D7.4. Furthermore, the finalisation of first round granted open callers, as well as the execution of 2nd round open calls will lead to the validation of not add-ons functionalities over ASSIST-IoT pilots, which will be reported in D7.4.

A. Ethical forms of Pilot 2

This project has received funding from the European's Union Horizon 2020 research innovation programme under Grant Agreement No. 957258

Architecture for Scalable, Self-human-centric, Intelligent, Secure, and Tactile next generation IoT

Information Sheet:

Heart rate monitoring test

This Information Sheet is addressed to people who have been invited and express their willingness to take part in test under the ASSIST-IoT project. The information provided here is intended to clarify research issues and purposes, and to clarify research privacy and confidentiality issues. The participation in the following test is voluntary and the participant has the right to refuse taking part in the research in an any given moment. Only "healthy adults" will be allowed to participate in the tests; "healthy" in the sense that (i) they are capable of understanding the requirements of their involvement, and (ii) are able to decide about their participation on their own, and also (iii) that they have the physical and mental capacity to carry out the required tasks. By agreeing to participate in the study and signing the Informed consent, the study participant testifies that there are no contraindications to participate in the study, and his/her health condition allows him/her to participate in the study. Signed Informed consent forms will be retained in ASSIST-IoT project documentation and EU will have access to them. If any of the following is not clear, or if more information is needed, any questions can be directed to the Ethics Manager or to the Local pilot representative.

About ASSIST-IoT

ASSIST-IoT is a EU H2020 ICT-56-2020 funded research project which aims at design, implementation and validation of an open, decentralized reference architecture, associated enablers, services and tools, to assist human-centric applications in multiple verticals. ASSIST-IoT will design, implement and validate, in a realistic, measurable, and replicable way, a unified innovative multi-plane (semi-)autonomous decentralized edge-cloud reference architecture, supplemented by cross-cutting digital enablers. The architecture will support continuous integration and long-term sustainability of domain-agnostic, interoperable, self-* capable, intelligent, distributed, scalable, secure and trustworthy IoT ecosystems.

Purpose of the tests

The purpose of the test is to check the correctness of the heart rate indications from the smartwatch, which will be used in the ASSIST-IoT project in the Smart Safety of workers Pilot. Correctness will be verified by comparison with another commercially available system that collects heart rate data based on measurements from three ECG electrodes.

Information about test procedures and privacy issues

The ethics framework includes the appointment of a project-wide ethics manager, that will oversee all the project actions, as well as pilot-site ethical managers, who will be responsible for the operations taking place during the pilot demonstrations, including the developments, installations and execution of them.

In order to protect personal data and respect privacy, a research approach plan has been developed, which is presented below. Participation in the research is possible after the participant signs the informed consent, the signing of which is tantamount to reading this information card. During the tests the following data will be collected:

- Age,
- Weight,
- Height,
- Heart rate,
- Breathing rate,
- Skin temperature,
- Body Position,
- Acceleration in three directions.

The above personal data regarding age, height and weight will be anonymized and only the average of all test participants will be published. Only heart rate and acceleration data will be analyzed. Collected data will be anonymized by identifying it as participant no. X. Data processing will be done only in the anonymised datasets. Thanks to this approach, the principle of confidentiality and privacy will be maintained and the confidentiality of data collected about participant will be preserved. The test will include physical activity on a treadmill at a maximum speed of 5 km/h, exercises with the upper lift, as well as rest periods without physical activity. The test will last 1 hour 25 minutes. During the test, heart rate data will be collected using a smartwatch on the wrist and a telemetry system in the form of a vest worn directly on the chest. The exact test procedure will be fully explained to the participant immediately prior to testing. The tests will be carried out in the CIOP-PIB laboratory in Lodz. Security will be ensured by the supervision of the appropriate ASSIST-IoT team during technology testing.

The data collected in test/pilot can be used for publications and dissemination in an anonymized form mentioned above. The data collected in test/pilot will not be re - used for any other purposes than the original purpose of ASSIST - IoT project.

Contact details

Ethics Manager:	Local pilot representative:
Contact person: Georgios Stavropoulos	Contact person: Anna Dąbrowska
Tel.: +302311257729	Tel.: 0048 42 648 02 33
Email: stavrop@iti.gr	Email: andab@ciop.lodz.pl

This project has received funding from the European's Union Horizon 2020 research innovation programme under Grant Agreement No. 957258

Architecture for Scalable, Self-human-centric, Intelligent, Secure, and Tactile next generation IoT

Informed consent

Heart rate monitoring test

I, ▢ contractor ▢ ASSIST-IoT partner' member ▢ external participant, the undersigned, volunteer to participate in the test/pilot conducted by the **ASSIST-IoT** consortium, in the project titled "**Architecture for Scalable, Self-human-centric, Intelligent, Secure, and Tactile next generation IoT**". I confirm that (**please tick box as appropriate**):

No.	Statement	YES	NO
1.	I declare that my health condition allows me to participate in the research.	▢	▢
2.	I have read and understood the information provided in the Information Sheet attached with this consent form.	▢	▢
3.	I have read and understood the information about the ASSIST-IoT project, as provided in the Information Sheet attached with this consent form.	▢	▢

4.	I have been given the opportunity to ask questions about the ASSIST-IoT project to consider the information and have gotten satisfactory answers.	☐	☐
5.	I understand and agree on my eligibility to be a part of this test/pilot (i.e. I am not a minor, nor I fulfil any other exclusion criteria).	☐	☐
6.	I understand that my participation is voluntarily, and I can withdraw at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	☐	☐
7.	In the case of withdrawing, I understand that I should not disclose and/or share any confidential information about ASSIST - IoT project that I have learned during my participation.	☐	☐
8.	I understand that no payment of incentives and/or rewards will be made for my participation	☐	☐
9.	I understand the procedures regarding confidentiality and privacy as they have been explained in the Information Sheet attached with this consent form.	☐	☐
10.	I understand that the data collected in test/pilot can be used for publications and dissemination as explained in the Information Sheet attached with this consent form.	☐	☐
11.	I understand that the data collected in test/pilot will not be re - used for any other purposes than the original purpose of ASSIST - IoT project as explained in the Information Sheet attached with this consent form.	☐	☐
12.	I understand that the confidentiality of data collected about me will be preserved as explained in the Information Sheet attached with this consent form.	☐	☐
13.	I understand that my right to request access to any, and all, personal information that I have voluntarily provided as part of my participation, and that I may ask for that information to be rectified and/or amended if it is inaccurate, or request that all personal information that I have provided be deleted.	☐	☐
14.	I understand that any requests for data access, rectification and/or deletion must be done through representative of the ASSIST - IoT joint Ethics Manager (contact details below).	☐	☐
15.	I was informed by the ASSIST - IoT representative that in case of unexpected findings, the project consortium is obliged to inform: i) The ethical manager (…) ii) The Project Coordinator (…)	☐	☐

	iii) The European Commission via the ASSIST - IoT Project Officer I understand that the above mentioned bodies, will decide on the need, means and timing of communicating the findings to relevant stakeholders.		
16.	I, an external participant (………………………), along with the ASSIST - IoT team representative, agree to take part in the ASSIST - IoT study, and to sign and date this informed consent form.	▢	▢

I hereby, agree to give personalized permission to ASSIST-IoT to collect, analyse and publish/report my data (when necessary) as provided in the Information Sheet and in compliance with standards and regulations.

Participant:

Name of Participant   SignatureDate

ASSIST-IoT team representative:

Name of representative   SignatureDate

Contacts information

Ethics Manager: Contact person: Georgios Stavropoulos Tel.: +302311257729 Email: stavrop@iti.gr	Local pilot representative: Contact person: Anna Dąbrowska Tel.: 0048 42 648 02 33 Email: andab@ciop.lodz.pl

This project has received funding from the European's Union Horizon 2020 research innovation programme under Grant Agreement No. 957258

Architecture for Scalable, Self-human-centric, Intelligent, Secure, and Tactile next generation IoT

Data Subject Consent Withdrawal

Full Name	

I confirm that I would like to withdraw my consent to process my personal data from ASSIST-IoT project. ASSIST-IoT project no longer has my consent to process my personal data for the purpose described in the information sheet. I expect processing will be stopped as soon as possible, however, I understand that there maybe a short delay while the withdrawal is processed by all ASSIST-IoT parties.

Signed by data subject:__Data _

Request obtained by: ____ ASSIST-IoT partners name

Signature __