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

D7.1 Deployment Plan and Operational Framework

Deliverable No.	D7.1	**Due Date**	31-OCT-2021
Type	Report	**Dissemination Level**	Public
Version	1.0	**WP**	WP7
Description	D7.1 documents plan of activities for deploying ASSIST-IoT in pilot sites, including technical, organisational, and operational aspects. Results of small-scale demonstrations are also reported, as well as integration of third parties		

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Executive Summary

This deliverable outlines the initial deployment plan and operational framework for all ASSIST-IoT pilots in order to identify all the required actions needed for their successful validation.

A planning of the required and forthcoming resources in ASSIST-IoT facilities, including hardware, software and platforms needed for the set-up of each testbed is presented in detail.

Based on the identified resources, the pilot-specific development activities, as well as ASSIST-IoT platform (including desired enablers) integration into testbeds, and final validation activities are also identified, including their time plan from M12 until the end of the project.

The deployment plan of this deliverable will be used as a basis for the activities to be carried out in parallel on each of the WP7 tasks (e.g., T7.1 – Port Automation Pilot, T7.2 – Smart safety of workers pilot, T7.3 – Cohesive vehicle monitoring and diagnosis pilot, and T7.4 – Open call integration).

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List of acronyms

Acronym	Explanation
AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
ASAM	Association for Standardization of Automation and Measuring Systems
CANBus	Controller Area Network Bus
CHE	Container Handling Equipment
COM	Component Object Model
CPU	Central Processing Unit
DLT	Distributed Ledger Technology
DoS	Denial of Service
FL	Federated Learning
FPGA	Field Programmable Gate Arrays
GPS	Global Positioning System
HW	Hardware
I/O	Input/Output
ISE	In-Service Emissions
JSON	JavaScript Object Notation
K8s	Kubernetes
LTSE	Long-Term Storage Enabler
MANO	Management and Orchestration
ML	Machine Learning
MQTT	MQ Telemetry Transport
OEM	Original Equipment Manufacturer
PAP	Policy Administration Point
PCM	Powertrain Control Module
PDP	Policy Decision Point
PEP	Policy Enforcement Point
PIP	Policy Information Point
PoC	Proof-of-Concept
RDE	Real Driving Emission
RTG	Rubber-Tyred Gantry (crane)
SDN	Software Defined Network
TBD	To Be Done/Defined/Determined
TEU	Twenty-foot Equivalent Unit
USB	Universal Serial Bus
UC	Use Case
WP	Work Package
XACML	eXtensible Access Control Markup Language
XCP	Universal Measurement and Calibration Protocol
XML	Extensible Markup Language

1. About this document

The main aim of this deliverable is to provide and to describe the initial deployment plan of all the project's pilots and ASSIST-IoT development, as well as to provide relevant insights about the operational framework, i.e., physical, and digital infrastructure available for the proper pilots' demonstrations. D7.1 will then, in summary, help identify all required activities to be carried out for a proper pilots' demonstration and validation.

The identified deployment plan per pilot, will be consequently used as a basis for the evaluation activities of the parallel WP7 activities (i.e., T7.1, T7.2, and T7.3). However, it should be noticed that this plan is an initial version, which although not desired, may be subject to changes depending on the development achieved in other ASSIST-IoT WPs, as well as on the availability of testbeds' infrastructure to be leveraged for project's deployments. Any deviation from the initial planning proposed in this deliverable will be informed in the subsequent WP7 deliverables accordingly.

1.1. Deliverable context

Keywords	Lead Editor
Objectives	**O6:** D7.1 defines the deployment plan of ASSIST-IoT development over real-life pilots, which is the main outcome expected on Objective 6.
Work plan	D7.1 takes input from WP3 (Requirements, Specification and Architecture) work. In particular, business scenarios and associated requirements were identified in deliverables *D3.2* (*Use Cases Manual & Requirements and Business Analysis – Initial*) and *D3.5 (ASSIST-IoT Architecture Definition – Initial)*. In another vein, the core and transversal enablers that have been defined in WP4 and WP5 deliverables (i.e., *D4.1 Initial Core Enablers Specification* and *D5.1 Software Structure and Preliminary Design*), have also been collected in order to generate the pilots-specific requirement traceability matrix and the associated enabler to fulfil it. Finally, deliverable *D6.1 DevSecOps Methodology and Tools* has also been served as input to D7.1 as a cornerstone of the development and deployment methodology/philosophy agreed and adopted in the project, and which, in turn, should be followed in the ASSIST-IoT pilots' deployments. The deployment plan, including set-up, integration, and verification activities foreseen in D7.1 will serve as input to the forthcoming WP7 deliverables, as well as to the evaluation and assessment work to be carried out within WP8 tasks.
Milestones	This deliverable does not mark any specific milestone completion. However, it contributes towards MS4 – Pilots deployed in M18, and MS7 Integrated solution in M30.
Deliverables	This deliverable receives inputs from D3.2, D3.5, D4.1, D5.1, and D6.1.

1.2. The rationale behind the structure

The deliverable is divided into two main parts. The first part is formed by Section 1 and Section 2, which provide a high-level overview of the defined ASSIST-IoT architecture and DevSecOps methodology, along with a list of all the identified enablers. The second part, which is formed by Sections 3-6, focuses on describing the four ASSIST-IoT Testbeds, which will be the cornerstone for the realization of the use cases. They also aim at identifying the required resources, the development activities, the integration activities, and the validation activities needed at every pilot, so that all Proof of Concepts (PoCs) and demonstrations will be reliably on time. These different activities per pilot are listed from the beginning of WP7 work (i.e., M12), until the end, identifying when everything will become ready for testing and demonstrations purposes. Finally, Section 8 acts as a summary of the document, setting the path for the continuation of the work to be done.

1.3. Outcomes of the deliverable

In order to guarantee the successful deployment of ASSIST-IoT pilots' demonstrations, a set of required resources, development activities, integration activities, and validation activities have been formalised in this deliverable, including their tentative starting and ending dates. Next, pilot specific outcomes are summarised:

- For the expected three demonstrations of Pilot 1 – Port automation, 18 set-up activities, i.e., required hardware such as (RTG cranes, Terminal Tractors, PLCs, IoT gateways, GPSs, etc.), software (MTS, PDS, TOS), or network (FluidMesh system) have been identified. In addition, 5 pilot-specific development activities, 12 integration activities, and 10 validation activities have been presented.
- For the four business scenarios to be demonstrated in Pilot 2 – Smart safety of workers, 19 assets, including, among others, AR goggles, measuring equipment, connectivity, edge gateways, and wearables have been identified. Regarding development/integration/validation activities, 17 pilot-specific development activities, 14 integration activities, and 10 validation activities have been planned.
- For the expected two demonstrations phases of Pilot 3A – Vehicle In-Service emission diagnostics, 12 current and forthcoming resources, including Ford Vehicle, Powertrain Control Modules, USBcan interfaces, or AR system engine have been detected. In addition, 10 pilot-specific development activities, 7 integration activities, and 4 validation activities have been planned.
- For the two demonstrations contemplated within Pilot 3B – Vehicle exterior condition inspection and documentation, 8 either already in place or expected procured equipment have been detected, such as Vehicle scanner system, Local Storage servers, or end-user tablets. In addition, 5 pilot-specific development activities, 7 integration activities, and 3 validation activities have been planned.

1.4. Lessons learnt

From all the work carried out throughout the first year of the project, the following insights have been extracted with regards to WP7 activities:

- **Lesson 1:** Since WP7 has started in M12 and D7.1 was committed for end of M12, project partners have only had 3 ½ weeks for the identification of pilot deployment activities, which has resulted short in time for a proper analysis. Hence, potential deviations of the initial planning are likely to occur, but it is expected that they will be noticed in the following WP7 deliverables.
- **Lesson 2:** Although not desired, it is likely that the outcomes of other activities throughout the project will affect the schedule of pilots' deployment (i.e., prioritisation of WP4/WP5 enablers might imply out of sync delivery of needed technology for a use case in some pilot). Again, any deviations that might be noticed, will be reported in the following WP7 deliverables.

1.5. Deviation and corrective actions

D7.1 describes in detail a plan of activities for deploying ASSIST-IoT in pilot sites, including technical, organisational, and operational aspects. According to the GA, it was also expected to report the results of small-scale demonstrations already carried out. However, due to the recent start of the WP7 (one month before the submission of this document), these demonstrations are still in their infancy, and no relevant results are available yet. It is expected that in the upcoming WP7 deliverable, D7.2, scheduled for M18, initial demonstrations will be reported, as well as the envisioned integration of third parties coming from granted open callers.

2. ASSIST-IoT architecture, enablers, and methodology

WP7 is in charge of deploying an integrated version of all the enablers to be developed in WP4 and WP5 of ASSIST-IoT, by making use of the Continuous Integration / Continuous Deployment DevSecOps methodology described in WP6. All these elements will be used to appropriately carry out deployment of the ASSIST-IoT pilot applications. This section aims at providing an overview of the efforts done so far in the parallel WPs of the project, so that D7.1 can be considered as a self-contained document.

2.1. ASSIST-IoT architecture

The initial definition of ASSIST-IoT reference architecture has been described in D3.5, being the first of a series of three iterations in order to be further refined based on the new insights obtained throughout the project. The architecture responds to the perspectives and objectives identified for the Next Generation IoT (NG-IoT) and it is based on the expertise of the technical partners of the project as well as on the initial requirements of the stakeholders involved.

Conceptually, ASSIST-IoT architecture is a multidimensional architecture that consists of horizontal layers called "Planes", which represent collections of functionalities that can be logically layered on top of one another, and "Verticals", which represent cross-cutting functions and properties of NG-IoT that exist on different planes or require coordination among them. In particular, on the one hand, 4 horizontal layers, i.e., Planes, have been proposed for ASSIST-IoT architecture: (a) Device and Edge, (b) Smart Network and Control, (c) Data Management, and (d) Application and Services. On the other hand, ASSIST-IoT architecture is comprised of 5 Verticals: (i) Self-*, (ii) Interoperability, (iii) Security, Privacy and Trust, (iv) Scalability and (v) Manageability. The conceptual architecture of ASSIST-IoT is presented in Figure 1.

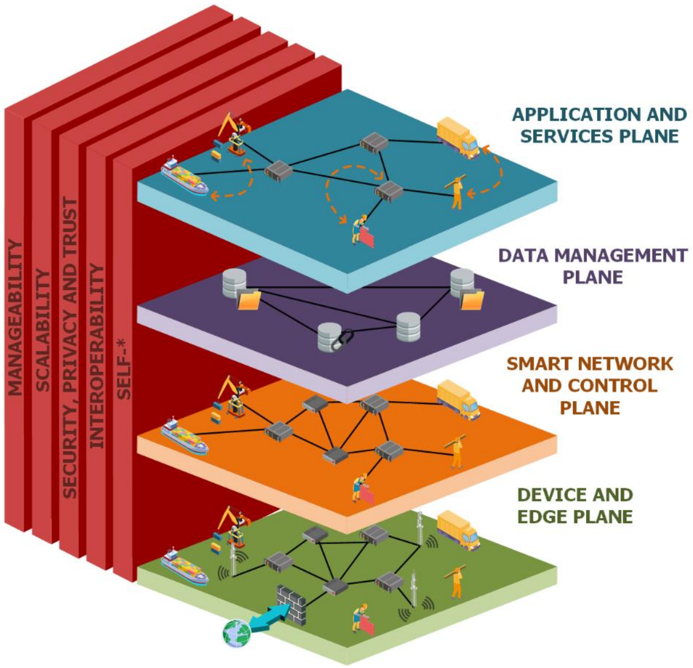


Figure 1. ASSIST-IoT Conceptual Architecture

In order to address additional concerns of stakeholders of an NG-IoT architecture, two additional Views have been included, namely "Node" and "Deployment", aiming at identifying those aspects related to the characteristics of nodes and devices, as well as actual implementations of an ASSIST-IoT architecture. For more details of ASSIST-IoT architecture, please refer to D3.5 [1]

2.2. ASSIST-IoT enablers

As a key architectural element, ASSIST-IoT introduces the term "encapsulated enabler (or "enabler" for short) as the main vehicle for delivering the functions promised by ASSIST-IoT innovations and future capabilities within the different Planes and Verticals. Enablers each offer a coherent set of functionalities, delivered as a set of containerized software, that exposes services. Enablers are, in principle, independent, which means, that they can be deployed and controlled individually, as needed. Composition of enablers as parts of ASSIST-IoT deployments directly responds to the modularity requirement placed on ASSIST-IoT architecture.

From the perspective of an unprivileged user (i.e., not an administrator), enablers can be viewed as atomic, interacting modules. Internally, enablers consist of components that can be deployed across different nodes and work together to deliver the functionality of the whole enabler. The encapsulation principle ensures that the internal communication between components and their operational details or internal network configuration, are not exposed to the outside world. Enabler components may not communicate outside of the scope of their enabler. Instead, enablers expose official, secure channels of communication, that together form the enabler interface used for outside communication.

Encapsulation implemented with the use of containerization ensures that enablers can be run in a multitude of environments and allows for pre-configuring complex software with rich internal interactions as a single deployable package, to deliver outside-facing services. Regardless of the deployed enablers, the environment requirements for ASSIST-IoT stay relatively constant due to virtualization. Containerization also allows for flexibility in resource usage by replication of containers and dynamic definition of reserved resources, to achieve high overall scalability.

Although an enabler can be abstracted away as a distinct module (and must be logically separable from the rest of the system in which it is deployed), enablers may depend on one another to deliver what they promise. For example, if an enabler requires an authentication server (or e.g., a Policy Access Point), it may use the authentication functionality exposed by another enabler. Although, in principle, any authentication server could be used, ASSIST-IoT architecture requires encapsulation of software inside enablers, to deliver global manageability, monitoring, deploy ability and modularity across the whole deployment.

Within the ASSIST-IoT architecture, enablers may be logically assigned to a functional block from a specific plane or to a vertical (see, Figure 2). This division may help guide the choice of enablers to fulfil every need of each individual ASSIST-IoT deployment. It is also intended to help introduce new administrators into the ASSIST-IoT ecosystem. Regardless of the logical division, the most important part for each enabler is its functionality delivered through the exposed services. Combinations of multiple enablers are used to deliver more complex functionalities and implement complex applications, that synergise services offered by individual enablers. D3.5 describes in length ASSIST-IoT's architecture and each enabler's part within it.

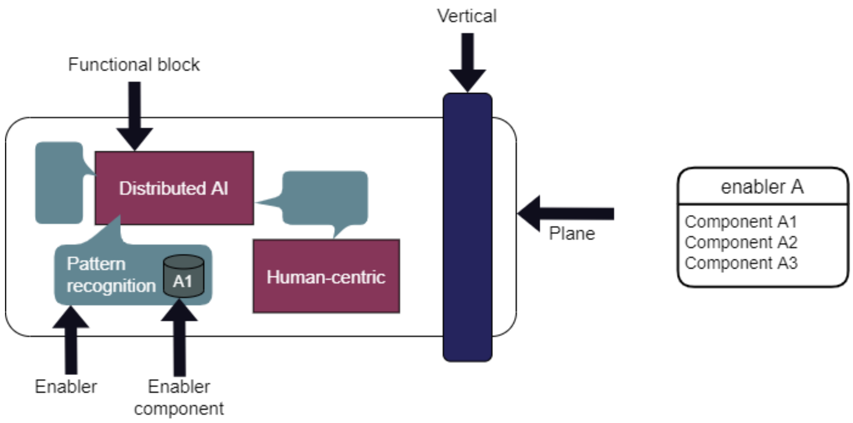


Figure 2. ASSIST-IoT enabler diagram

ASSIST-IoT will deliver a set of already identified "core" enablers, as well as supporting enablers, which will be defined in the future to complement the existing ones, as well as the results of developments carried out in Open Calls. The table below presents core enablers identified up to this point and relevant to pilot deployments. For more details about the functionalities, candidate technologies, components description, and HW/SW requirements, please refer to D4.1 [2] and D5.1 [3].

Table 1. ASSIST-IoT enablers identified at M12.

		Enabler ID	Enabler Name	Description
Plane	Smart Network and Control	T42E1	Smart orchestrator enabler	This enabler facilitates the interaction of user interfaces and other enablers with the main components of the MANO framework, namely the Network Function Virtualisation Orchestrator (NFVO) and the Kubernetes clusters, exposing only the required inherent functionalities. In particular, this enabler will control the whole lifecycle of Virtualised Network Functions (VNFs), from their instantiation to their termination, allowing their deployment in any k8s cluster available.
		T42E2	SDN controller	The SDN Controller is the key element of an SDN-enabled network, being the software that takes over the responsibilities of the control plane from the hardware elements (switches mostly), including monitoring and management of packet flows.
		T42E3	Auto-configurable network enabler	This enabler provides optimised network routing configuration capabilities to the SDN Controller of an ASSIST-IoT ecosystem. This enabler will consist of an application that consumes the northbound APIs of the SDN Controllers to generate a policy that improves the performance of one/many KPIs of the network (e.g., latency).
		T42E4	Traffic classification enabler	The aim of this enabler is to classify network traffic into a number of application classes (video streaming, VoIP, Network control, best effort, OAM, etc.), making use of an AI/ML framework and dedicated algorithms. The traffic classification enabler can be seen as a service of the application layer of the general SDN architecture.
		T42E5	Multi-link enabler	Multi-link wireless network capabilities provide the possibility of sending video streams of data over different Radio Access Networks and different channels in each of them (for instance, regarding cellular, using more than 1 connection). Besides, it should provide reliability mechanisms: in case one channel is down, signal cannot be lost or at least it should be recovered almost in real time.
		T42E6	SD-WAN enabler	The objective of this enabler is to provide access between nodes from different sites based on SD-WAN technology.
		T42E7	WAN acceleration enabler	This enabler aims at increasing the efficiency of data transfer in Wide Area Network. This enabler will contain a set of independent, standalone VNFs with that purpose. These functions can be either chained (so data that requires of different techniques travels through the different functions) or selected for specific purposes.
		T42E8	VPN enabler	This enabler will facilitate the access to a node or device from a different network to the site's private network using a public network (e.g., the Internet) or a non-trusted private network.
	Data Management	T43E1	Semantic repository enabler	This enabler offers a "Nexus" for data models and ontologies, that can be uploaded in different file formats, and served to users with relevant documentation. This enabler is aimed to support files that describe data models or support data transformations, such as ontologies, schema files, semantic alignment files etc.
		T43E2	Semantic translation enabler	Semantic Translation enabler offers a configurable service to change the contents of semantically annotated data in accordance with translation rules – so called "alignments", or alignment files.

		T43E3	Semantic annotation enabler	This enabler offers a syntactic transformation service, that annotates data in various formats and lifts it into RDF. Full list of formats is yet to be decided and the first version will support JSON.
		T43E7	Edge data broker	It enables the efficient management of data demand and data supply from/to the Edge Nodes. It optimally distributes data where it is needed for application, services, and further analysis.
		T43E8	Long-term data storage	The role of this enabler is to serve as a secure and resilient storage, offering different storage sizes and individual storage space for other enablers (which could request back when they are being initialising in Kubernetes pods). It also guarantees that the data will be kept safe, in face of various kinds of unauthorised access requests, or hardware failures, by only allowing access to the data once the Identity Manager and the Authorisation enablers have confirmed their access rights.
	Application and Services	T44E1	Tactile dashboard enabler	The Tactile Dashboard enabler has the capability of representing data stored in the ASSIST-IoT pilots, through meaningful combined visualisations in real time. It also provides (aggregates and homogenises) all the User Interfaces for the configuration of the different ASSIST-IoT enablers, and associated components.
		T44E2	Business KPI reporting enabler	This enabler will illustrate valuable KPIs within Graphical User Interfaces embedded into the tactile dashboard. It will facilitate the visualisation and combination of charts, tables, maps, and other visualisation graphs in order to search for hidden insights.
		T44E3	Performance and Usage Diagnosis enabler	PUD enabler aims at collecting performance metrics from monitored targets by scraping metrics HTTP endpoints on them and highlighting potential problems in the ASSIST-IoT platform, so that it could autonomously act in accordance or to notify to the platform administrator to fine tuning machine resources.
		T44E4	OpenAPI management enabler	The OpenAPI management enabler will be an API Manager that allows enablers that publish their APIs, to monitor the interfaces lifecycles and also make sure that needs of external third parties (including granted open callers), as well as applications that are using the APIs, are being met.
		T44E5	Video augmentation enabler	This enabler receives data (mainly images or video streams) captured either from ASSIST-IoT Edge nodes, or from ASSIST-IoT databases, and by means of Machine Learning Computer Vision functionalities, it provides object detection/recognition of particular end-user assets (e.g., cargo containers, cars' damages).
		T44E1	MR enabler	The MR enabler receives data and transforms it in a format suitable for visualisation through head-mounted MR devices. Data, which may come from long-term storage or real-time data streams, are requested according to its relevance to the user.
Vertical	Self-*	T51E1	Self-healing device enabler	Aims at providing to IoT devices with the capabilities of actively attempting to recover themselves from abnormal states, mainly divided in three categories: security (jamming, DoS), dependability (data corruption, network protocol violation), and long-term (HW's end-of-life, HW unsupported capabilities), based on a pre-established routines schedule
		T51E2	Resource provisioning enabler	This enabler will be able to horizontally scale (up or down) the resources devoted to a specific enabler (inside a node) in a dynamic fashion.

		T51E3	Geo (Localisation) enabler	To solve challenges of pilots we need to localise physical objects (containers in ports, workers on construction sites), some devices should be aware of their position in relation to each other (aligning cranes and tractors). We might need to realize localisation using absolute coordinates (GPS) or relative (coordinates in a port).
		T51E4	Monitoring and notifying enabler	This enabler could be viewed as a general purpose by representing it as a combination of high-level monitoring module (which would allow to monitor devices, logs, etc.) and notifying module that could send custom messages to predefined system components.
		T51E5	Automated configuration enabler	Automated Configuration Enabler keeps heterogenous devices and services synchronised with their configurations. User can update configuration and define fallback configurations in case of errors. Self-* component will be responsible for reacting to changing environment and updating configuration as necessary.
	Federated Learning	T52E1	FL Orchestrator	The FL orchestrator is responsible of specifying details of FL workflow(s)/pipeline(s). This includes FL job scheduling, managing the FL life cycle, selecting, and delivering initial version(s) of the shared algorithm, as well as modules used in various stages of the process, such as training stopping criteria. Finally, it can specify ways of handling different “error conditions” that may occur during the FL process.
		T52E2	FL Training collector	The FL training collector will consist of two components: (i) the combiner responsible of providing updates with respect to the shared averaged model, and (ii) the I/O component which will carry out the input and output communications of the enabler.
		T52E3	FL Repository	This repository will store (and deliver upon request/need) the ML algorithms or ML models. The FL repository will consist of four main components: ML Algorithms libraries (that gathers ML algorithms without involving any modelling associated with a particular training data set), ML models libraries (which have been already trained with a particular data set), Collectors (averaging algorithms to be used on the FL training process), and Auxiliary component (for any needed additional module, such as privacy mechanisms or stopping criteria).
		T52E4	FL Local Operations	The FL Local Operation enabler will consist of four components: Local data transformer component (that will be in charge of guaranteeing that data is appropriately formatted for the FL model in use), Local Model training component, Local Model inference component, and Communication component (to enable in and out communications between involved local parties and FL orchestrator and FL collector).
		T52E5	FL Privacy	Enabler that guarantees that different parties are not able to derive insights about each other's training data, based on messages exchanged during the training process (e.g., weights). Methods of creating differentially private noise, and homomorphic encryption will be available.
	Cybersecurity	T53E1	Authorisation enabler	Authorisation server offers a decision-making service based on XACML policies. It has different modules that interact and can be deployed independently such as, PEP (Policy Enforcement Point), PAP (Policy Administration Point), PIP (Policy Information Point) and PDP (Policy Decision Point).
		T53E2	Identity manager enabler	Using OAuth2 protocol, it will offer a federated identification service where service requester and provider will be able to establish a trusted relation without previously knowing each other. This way a secure identification process is completed without the service provider having received the requester credentials.
		T53E3	Cybersecurity monitoring enabler	Provides security awareness and visibility and infrastructure monitoring. Having raw data as input, the enabler will set a series of processing steps that will enable the discovery of cybersecurity threats, going through a sequence step: (i) collecting, parsing, and normalizing input events, (ii) enriching normalized events, (iii) correlating events for detecting cybersecurity threats.

		T53E4	Cybersecurity monitoring agent enabler	Perform functions of an endpoint detection and response system, monitoring and collecting activity from end points that could indicate a threat. Security agent runs at a host-level, combining anomaly and signature-based technologies to detect intrusions or software misuse.
	DLT-based	T54E1	Logging and auditing enabler	This enabler will log critical actions that happen during the data exchange between ASSIST-IoT stakeholders to allow for transparency, auditing, non-repudiation, and accountability of actions during the data exchange.
		T54E2	Data integrity verification enabler	This enabler will provide DLT-based data integrity verification mechanisms that allow data consumers to verify the integrity of the exchanged data.
		T54E3	Distributed broker enabler	This enabler will provide secured data sharing mechanisms as regards the data exchange between different heterogeneous IoT devices belonging to various edge domains and/or between different enablers of the architecture.
		T54E4	DLT-based FL enabler	This enabler will foster the use of DLT-related components to exchange the local, on-device models (or model gradients) in a decentralised way avoiding single point of failures acting as a component to manage AI contextual information in an immutable form and avoiding alteration as well to the data.
	Manageability	T55E1	Management of enablers existence in a deployment	This enabler will serve as a registry of enablers and, in case they are deployed, the retrieval of their status. In particular, it will: (a) Allow the registration of an enabler (this is, from an ASSIST-IoT repository). Essential enablers will be pre-registered, (b) Retrieve a list of currently running enablers, (c) Depict the status and the specific logs of an enabler (the latter only if the enabler with log collection capabilities is in place), (d) facilitate the deployment of standalone enablers (mostly for those that have to be present at any deployment).
		T55E3	Management of services and enablers workflow	This enabler will present a graphical environment where ASSIST-IoT administrators can instantiate the enablers required to work, and also to connect them to compose a composite service (i.e., a workflow). Having information about the physical topology and available k8s nodes/clusters, it will allow the user to decide whether to select the proper node or cluster for deploying an enabler, or let the system decide based on pre-defined architectural rules.
		T55E4	Management of devices in an ASSIST-IoT deployment	The main functionality of this enabler will be to register: (i) a k8s node in an ASSIST-IoT k8s cluster, (ii) a smart IoT device in a deployment, and (iii) a cluster in an ASSIST-IoT deployment, including in the latter case all the necessary messages to notify it to the smart orchestrator. It will also execute all the required actions related to networking for enabling connectivity among isolated/independent clusters, including those that have been added via VPN/SD-WAN technology. Besides, It will allow monitoring any registered node and device in the deployment, including its status (i.e., available and used resources) and current instantiated enablers' components.

2.3. ASSIST-IoT DevSecOps CI/CD methodology

ASSIST-IoT Consortium has agreed on applying a DevSecOps methodology, based on adding a continuous security model over regular DevOps philosophy. Hence, target activities and concrete security controls for each stage of the DevSecOps workflow have been associated with DevOps stages from Continuous Integration to Continuous Delivery, and Continuous Deployment (CI/CD). DevSecOps is a natural extension of DevOps that advocates for shifting security-left to security-by-design and continuous security testing by making use of automated security controls in the DevOps workflow. Figure 3 illustrates how DevSecOps adds a continuous security assurance embedding security controls across a DevOps workflow.

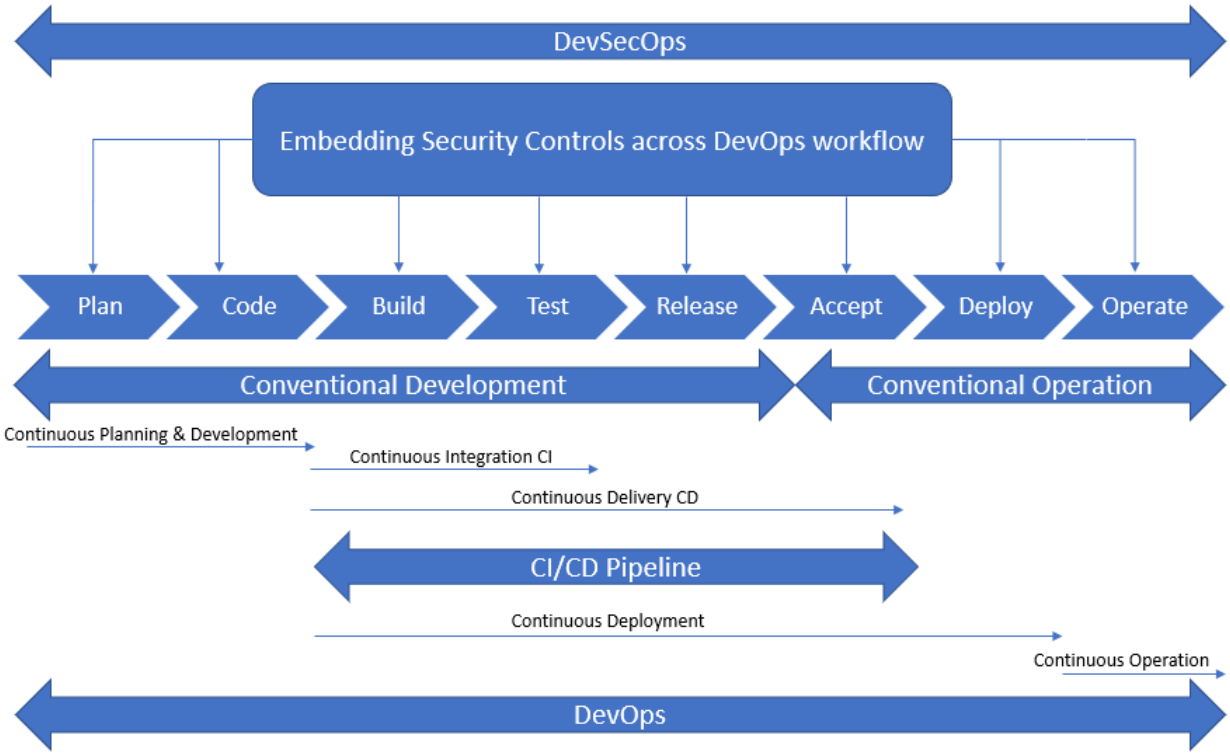


Figure 3. DevSecOps [4]

Since ASSIST-IoT methodology is based on three supporting pillars: continuous workflow, open-source tools and cloud-native deployment technologies, the Consortium will make use of GitLab as DevSecOps open platform. Thus, it will be used for the development set up for WP4 and WP5 enablers, as well as the further testing, integration and documentation activities across the efforts pursued in WP6.

3. Pilot 1: Port Automation

3.1. MFT container terminal

The Port Automation pilot will be driven by the Industrial partner Terminal Link Group (TL)[1], which manages more than 13 container terminals and is related with another 12 terminals (from CMA-CGM Terminals) and CMA-CGM shipping line (3rd largest shipping line in the world, with ~500 vessels). Specifically, this scenario will be carried out and validated in the Malta Freeport infrastructure (MFT[2]), which amalgamates the activities of container handling and industrial storage, being a critical node of the European sea-logistics.

Figure 4. MFT overall view

Having been established in 1988, MFT has experienced remarkable growth since its inception and currently is the main port of transhipment in the Mediterranean region, where more than 2,000,000 containers are transhipped each year, from 130 origins to 130 destinations. MFT steadily interest comes due to its location in the centre of the Mediterranean, but also due to its immaculate handling equipment, advanced technology, highly skilled personnel, and an effective security system that ensures that MFT clients' demands are met. Other factors include vast network connections, ease of access to markets, safe manoeuvrability of vessels and cost-effectiveness. The significant volume of containers being handled is a result of the Freeport's track record and the positive international recognition which the Company enjoys with global carriers as being a reliable and credible port. Even though the curve regarding number of Twenty-foot Equivalent Unit (TEUs) handled and Port Calls managed is currently down due to COVID-19 healthcare crisis, figures are good enough nowadays (3.8 million TEUs expected to be managed by 2021) and the expectation for the coming years is to reach 4.5 million of TEUs and over.

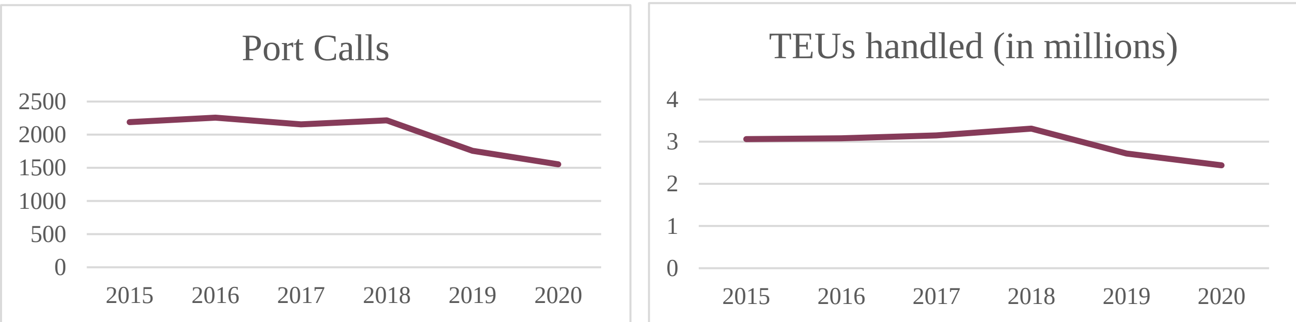


Figure 5. 2015 – 2020 MFT port calls (left) and handled TEUs in millions (right).

Having said that and as consequence of the high volume of TEUs managed and the increased number of Port Calls expected in the short and mid-term, MFT is near to reach its maximum capacity in terms of yard occupation leading to a saturation of the terminal, with almost permanent congestion and occasional collapses[3] with an important impact in the business operations. If the above was not enough, this is a capital challenge since the same issue is affecting other terminals/ports managed by TL group (e.g., Tanger Med in Morocco) around the world. Congestion of terminals and, even more, a collapse, result in four major negative effects within terminals,

[1] https://www.cmacgm-group.com/en/group/at-a-glance/terminals (Accessed in December 2019)
[2] http://www.maltafreeport.com.mt (Accessed in December 2019)
[3] Collapse is an event during which productivity falls, and terminal service cannot be served neither executed

particularly in transhipment hubs like MFT[4]: (i) longer stay times of vessels; (ii) increase in the vessels berthing-wait-time; (iii) vessels being diverted to other terminals, of the group, in other ports which obviously causes additional transport costs for the cargo operator and (iv) cost of useful movements increases.

Table 2. MFT infrastructure figures.

Malta Freeport Terminal	
Quayside cranes	20
Total number of RTG cranes	60
Total operational deep-water quays	2,463 m
Total number of reefer points	1.658
Total area for operational processes	771,000 m^2
Total number of ground slots	15,297
Present capacity of millions of TEUs handled (2021)	3,8
Target capacity of millions of TEUs handled (> 2022)	4,5
Currently ready for the management of 23.000 TEUs vessels and over	Yes

Since October 2004, when the container terminal was privatised, more than 300 M€ have been invested in the infrastructure: heavy investment in equipment like STS cranes, technological enhancements like the deployment of the Navis N4 TOS, yard expansion, etc. While MFT is investing in industrial assets and heavy machinery, in order to avoid bottlenecks and improve operational efficiency, it is also necessary to invest in smart services like the ones that are going to be developed, deployed, and validated within ASSIST-IoT.

Figure 6. Malta Freeport Container Terminal

3.2. Requirement's traceability

The Port Automation Pilot of ASSIST-IoT aims at helping container terminal operators to improve operational efficiency by means of including smarter devices that will improve the availability of information over which the operators can interact with. These features envisioned in ASSIST-IoT will help on making better decisions. To do so, ASSIST-IoT Port automation pilot identified 3 business scenarios, with their associated requirements and acceptance criteria in D3.2 [5], which are summarised below.

BS-P1-1: Tracking assets in terminal yard: The main problem to solve is to enable traceability of containers within the port to avoid losing them, and to enhance the operational efficiency of terminal operators (including internal-external drivers). To achieve this, the position of all Container Handling Equipment (CHEs (i.e., cranes, terminal tractors, and trucks) within the container yard, must be tracked. Additionally, the containers that are

4 The main unit cost in a terminal is the cost per useful container movement and one of the main performance KPI is the throughput measured in useful BOX (containers) per hour. The other main KPI is capacity, defined as the maximum throughput of BOXES per unit of time, typically monthly and annually.

being handled, must be identified by CHEs, either automatically, or manually by the driver. All this information is combined in the Terminal Operating System (TOS) in order to track the location of all containers and CHEs within the yard. ASSIST-IoT will allow to reuse the gathered information on the edge, so that those actors that require this type of data from specific assets can obtain them in a fast and secure manner. **Associated requirements:** R-P1-1 (CHE location services), R-P1-2 (CHE location availability), R-P1-3 (CHE positioning accuracy), R-P1-5 (Container ID tracking system), R-P1-6 (Terminal data access), R-P1-22 (Multilink wireless network capabilities)

BS-P1-2: Automated CHE cooperation: This scenario focuses on the enhancement of the operational performance, by the CHEs cooperation, from an alignment automation perspective. The machines should be able to identify and authenticate each other before starting the operation. Then, the Rubber Tyred Gantry (RTG) crane guides the truck (terminal tractor, or external) to the correct position using LIDAR sensors. The guidance can be provided in a variety of ways, depending on the type of truck. This can be achieved using machine-to-machine (M2M) communication, signalled using positioning guidance traffic lights, or through some movement recommendation on mobile application available in truck driver's cabin. **Associated requirements:** R-P1-1 (CHE location services), R-P1-2 (CHE location availability), R-P1-3 (CHE positioning accuracy), R-P1-4 (CHE authentication range), R-P1-5 (Container ID tracking system), R-P1-6 (Terminal data access), R-P1-10 (CHE identification), R-P1-11 (CHE machine-to-machine communication), R-P1-12 (CHE authentication), R-P1-15 (Alignment exposure), R-P1-25 (Mesh network capabilities).

BS-P1-3: RTG remote control with AR support: This scenario includes the completely remote operation of RTG cranes. Relying on the architecture of the ASSIST-IoT project, this scenario will empower the crane operators with all the extended capabilities developed in the pilot to effectively control and drive a crane from a control room. Furthermore, in order to alleviate infrastructure and set-up costs, the operator will be able to remotely control the RTG wirelessly using a console, which will be further enhanced in ASSIST-IoT by including built-in enhanced visuals to aid crane drivers in performing the work order in a more friendly human-to-machine interface. **Associated requirements:** R-P1-6 (Terminal data access), R-P1-16 (Open/Accessible Remote capabilities), R-P1-17 (Customizable remote desktop), R-P1-18 (Industrial and safety protocols support), R-P1-19 (Remote bandwidth capabilities), R-P1-20 (Remote latency capabilities), R-P1-21 (Remote reliability capabilities), R-P1-22 (Multilink wireless network capabilities), R-P1-23 (AR support), R-P1-24 (Wireless remote capabilities).

In order to fulfil the requirements of the three business scenarios, Table 3 lists the enablers that have been identified (please refer to Table 1 in Section 2.2 for more details). The following list do not preclude potential future inclusion of additional enablers:

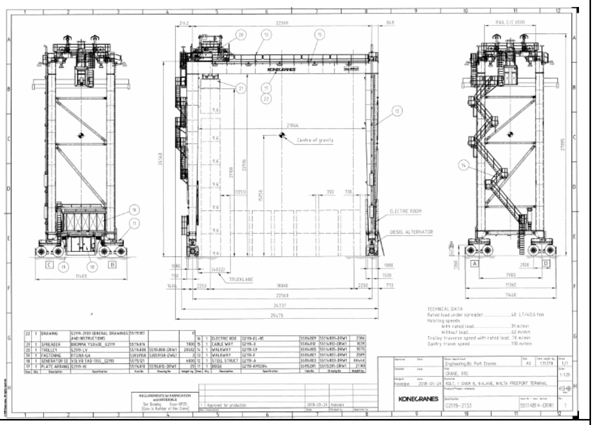
Table 3. Port Automation pilot enablers

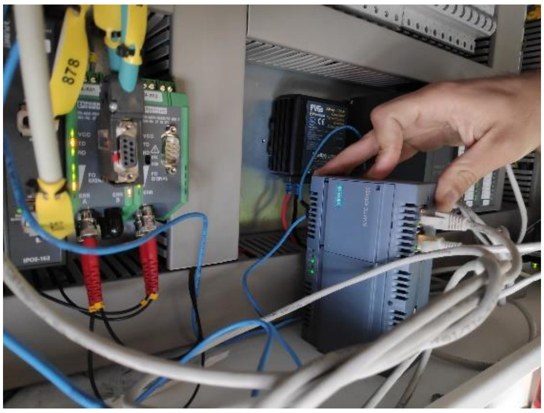
T42	• **T42E1:** Smart orchestrator enabler • **T42E3:** Auto-configurable nw enabler • **T42E4:** Traffic classification enabler • **T42E5:** Multi-link enabler	**T44**	• **T44E1:** Tactile dashboard enabler • **T44E2:** Business KPI reporting enabler • **T44E3:** PUD enabler • **T44E4:** OpenAPI management enabler • **T44E5:** Video augmentation enabler
T51	• **T51E3:** Geo (Localisation) enabler • **T51E4:** Monitoring and notifying • **T51E5:** Automated configuration	**T53**	• **T53E1:** Authorisation enabler • **T53E2:** Identity manager enabler
T52	• **T52E3:** FL repository	**T55**	• **T55E1:** Management of enablers existence in a deployment • **T55E2:** Management of enablers' results • **T55E3:** Management of services and enablers workflow • **T55E4:** Management of devices in an ASSIST-IoT deployment

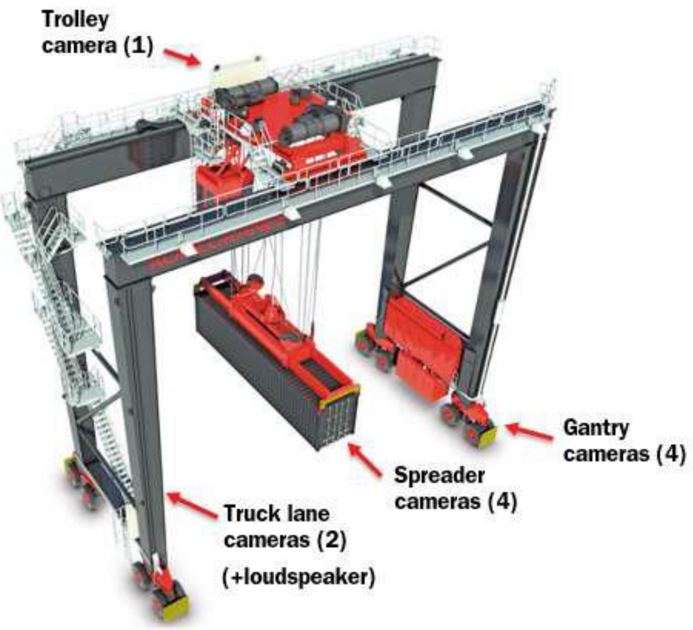
3.3. Existing and forthcoming resources

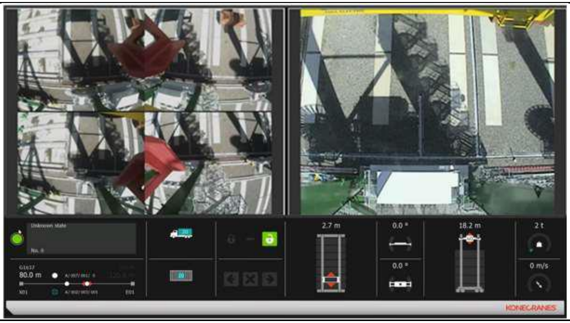
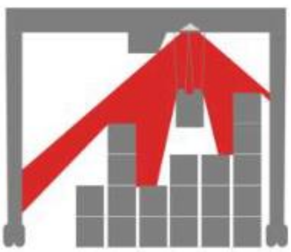
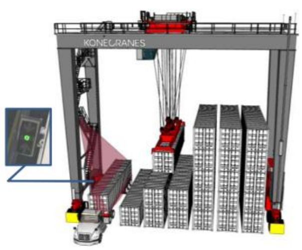
List and a planning of required resources, facilities, connectivity, and logistics for the set-up of Pilot 1 testbed is presented in the next table.

Table 4. Pilot 1 set-up activities

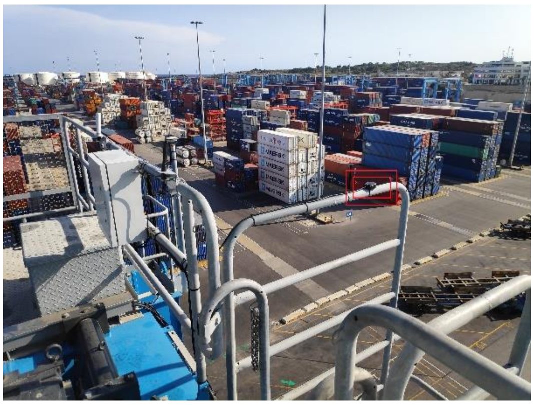
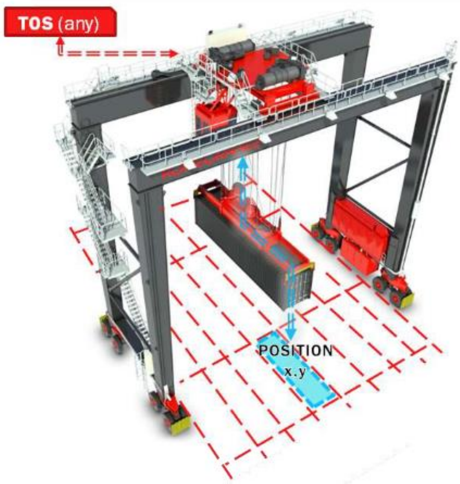
Set-Up activity ID	**Pilot1_SetupAct_ID1**
Resource type	Crane
Resource description	RTG crane (Konecranes series G2119-2133). Steel sturdy, rigid and fatigue-resistant structure capable of carrying out around 40 containers movement per hour, mounted over 8 wheels for horizontal movements along the yard. Dimensions (vertical: 1-over-6 stacked containers; horizontal: 5+truck lane). Among its main modules, it includes (i) a quick and safe access for operator and maintenance; (ii) an optimized cabin for truck & train handling, with advanced GUI technology and excellent ergonomics; (iii) an active load control system for core of lifting trolley components (speeds from 31 m/min up to 62 m/min); (iv) headblock spreader easy to maintain.  TECHNICAL DATA: • Rated load under spreader: 40LT/40,6 ton • Hoisting Speed with rated load: 31 m/min • Hoisting speed without load: 62 m /min • Trolley traverse speed with rated load: 70 m/min • Gantry travel speed: 130 m/min 
Ready to be used	Yes
Set-Up activity ID	**Pilot1_SetupAct_ID2**
Resource type	Hardware / Software

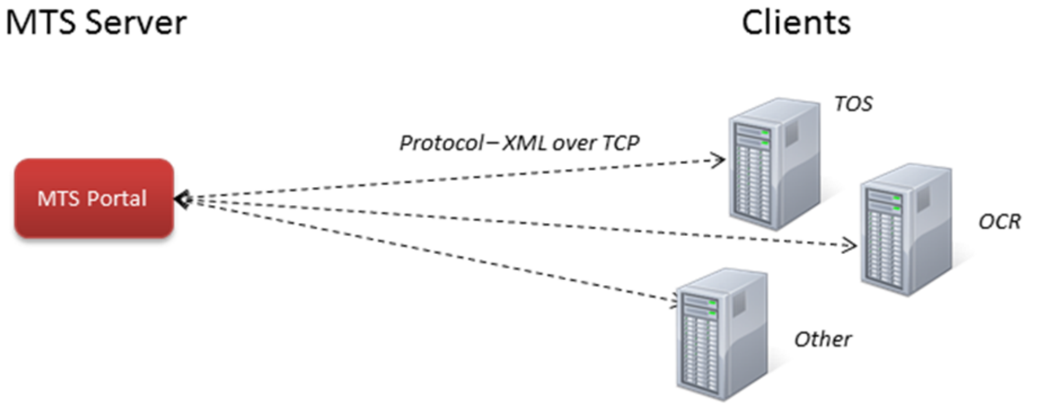
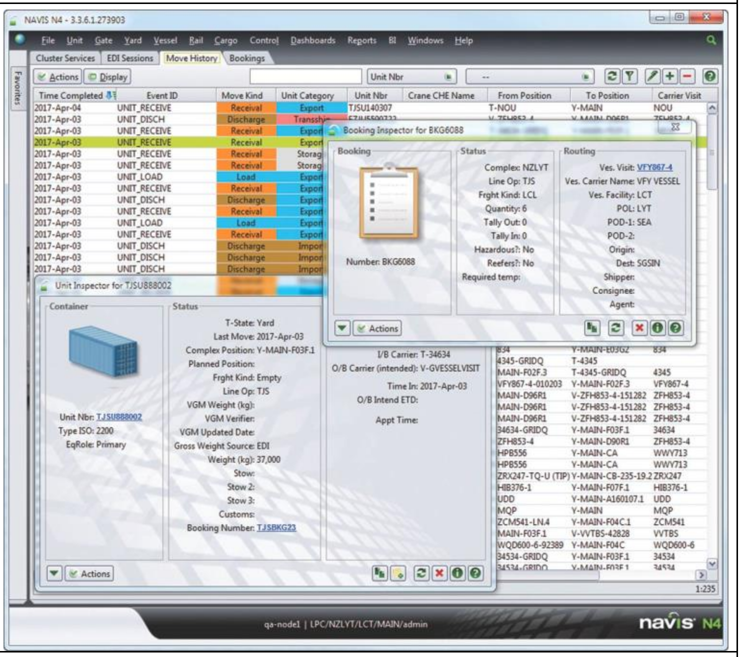
Resource description	CRANE PLC (Siemens Simatic S7-300): The Simatic S7-300 forms part of the SIMATIC ET 200 systems range. They are designed with the high degree of protection IP65/67 are small, rugged, and powerful. They are ideal for use in harsh industrial environments like cranes cabinets, directly at the machine. The time-saving setup enables the most flexible implementation of automation solutions. The SIMATIC ET 200SP IO-Link Master is based on the current IO-Link specification V1.1 It can be easily integrated in automation systems via PROFIBUS or PROFINET. Features: CPU 312-CPU 314, Work memory: 256 KB, Instructions: 85K, Number of I/Os: 2048. 
Ready to be used	Yes
Set-Up activity ID	**Pilot1_SetupAct_ID3**
Resource type	Hardware / Software
Resource description	CANBUS Converter (CAN232): CAN232 is an interface converter that implements the data exchange between the CAN-bus network and the RS-232 device. It also supports data exchange between the CAN-bus network and the Modbus RTU protocol. This product supports 1 CAN port and 1 RS-232 serial port, and adopts wall mounting that can meet the requirements of different scenes. 
Ready to be used	Yes
Set-Up activity ID	**Pilot1_SetupAct_ID4**
Resource type	Hardware / Software
Resource description	IoT Gateway (Siemens Simatic IoT2040): To read, extract, pre-process and publish data from the PLC an IoT2040 is used based on NodeRed open-source software (over Linux). The IoT2040 is a robust, compact and flexible IoT gateway solution with a focus on the IoT environment and round off the SIMATIC IPC product range in the lower output range. The connexion between the IoT2040 and the PLC is done by ethernet through the internal ethernet network of the CHE. The data once processed by the IoT 2040 is published through an external CHE network on VLAN 140 (software isolated network) by the WiFi network of the terminal. IoT2040 can be installed in the PLC cabinet or any other cabinet (IT cabinet) with an PLC DIN Rail 35mm standard profile. Features: Intel Quark X1020 processor, 1 GB RAM, 2x Ethernet interfaces, 2x RS232/422/485 interfaces, Battery-buffered real-time clock, SIMATIC MicroSD flash card 

Ready to be used	Yes
Set-Up activity ID	**Pilot1_SetupAct_ID5**
Resource type	System
Resource description	**AUDIO-VISUAL SYSTEM:** The Audio-Visual System (A/V system) oversees audio and video streaming across the entire system. It streams low latency audio and video from the Remote RTGs to the ROSs and displays data from the crane to the remote operator through a graphical user interface.  **A/V SERVER:** A/V server is a software located in the server room. The A/V server keeps track of the active connections in the A/V system. If there are multiple connections to an A/V device with a back-flow stream (e.g. a loudspeaker, a PTZ camera), then the A/V server will decide which connection gets the back-flow connection. This is decided on a first-come, first-first-served basis. **CAMERA SYSTEM:** 4x spreader cameras, fixed, 1x trolley dome camera, fixed, wide FOV, 4x gantry cameras, fixed, 4x truck lane cameras, fixed, 1x truck lane overview dome camera, PTZ, 1x bay overview dome camera, PTZ **LOUDSPEAKERS:** The crane sillbeam can be equipped with two loudspeakers so the remote operator can instruct the truck driver if necessary. The loudspeakers are IP intercom devices that are directly connected to the A/V network. **TROLLEY MICROPHONE:** The crane trolley can be equipped with a microphone so the remote operator can listen to the crane operation. The microphone is an IP intercom device that is directly connected to the A/V network.
Ready to be used	No, procurement and commissioning activities will be needed. Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot1_SetupAct_ID6**
Resource type	Hardware
Resource description	**REMOTE OPERATING DESK STATION:** The Remote Operating Station (ROS) controls the movement of the Remote RTG. The ROS has all of the crane controls available at full movement speeds. The ROS can connect to any of the Remote RTGs in the system: **DESK:** Electrically height adjustable desk with arm rests. 

	TOUCH PANEL (10”): Crane selection, crane controls, alarms and job information. **MAIN DISPLAYS:** Two 37,5” displays for Remote RTG camera feeds. **JOYSTICKS:** Two industrial multi-axis controllers. **ELECTRICAL CUBICLE:** Contains the network switches and industrial PCs. 
Ready to be used	No, procurement and commissioning activities will be needed. Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot1_SetupAct_ID7**
Resource type	Software
Resource description	**CRANE TASK MANAGEMENT SERVER:** The Crane Task Management Server (CTMS) receives work instructions to all Remote RTGs in the system from the TOS. The CTMS list the available work instructions to a ROS according to the selected filters (selected blocks or cranes). The CTMS collects movement and inventory data from the Remote RTG’s. If the TOS experiences a severe malfunction, the CTMS can also be used to send container movement instructions to the Remote RTG. Hardware requirements are identified in Pilot1_SetupAct_ID17
Ready to be used	No, procurement and commissioning activities will be needed. Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot1_SetupAct_ID8**
Resource type	Hardware / Software
Resource description	**CENTRAL PLC (Siemens Simatic S7-1500):** It connects the control signals from the ROSs to the Remote RTGs. S7-1500 is a modular, scalable, IP20 degree of protection PLC, especially designed for automation applications, providing position detecting signals up to 1 MHz. It provides PROFINET I/O 2 port switches from CPU, plus additional PROFINET interfaces for connecting further PROFINET devices or for high-speed communications. 
Ready to be used	No, procurement and commissioning activities will be needed. Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot1_SetupAct_ID9**
Resource type	Hardware and Software
Resource description	**LIDAR System:** 3D laser sensors are installed to the trolley and between the crane legs on the truck lane side for two use cases. On the one hand, the trolley sensors are used for profiling the container stack, reducing the risk of collision with containers while the RTG   operates in the bay. The RTG´s PLC will constantly monitor the distance between the spreader and the stack. When the distance between the trolley and the container stack goes below a pre-defined safe distance, the PLC will reduce the trolley speed to try to avoid the collision. Stack profiling system can also be used to limit the lowering speed when putting a container in the stack or when picking up a container. By knowing the profile of the stack, the system limits

	the hoist speed so that the hoist speed at the time of impact is limited and the landing is soft. On the other hand, the legs sensors/laser scanner measures the profile stack of the truck beneath the crane and detects whether it is loaded, partly loaded, or empty. Next, it communicates with guiding lights that are installed on the crane structure, visible to the truck operator, signalling the driver to park the truck in the desired position.
Ready to be used	No, purchasing process will start on M15, and commissioning activities will start once the equipment is shipped. Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot1_SetupAct_ID10**
Resource type	Hardware / Software
Resource description	**GPS Banner (IoT):** The Banner GPS unit uses 10 Modbus registers to store the GPS readings for latitude, longitude, altitude (in meters), date, and time. Read the data from the GPS using one of two formats: 32-bit signed integer or 32-bit floating point. Additional details: Positional accuracy (CEP50) autonomous positional error less than 2.5 meters, Satellite-based augmentation systems: WAAS, EGNOS, MSAS, GAGAN; Modbus slave device; RS-485 half-duplex serial communications; Environmental rating: IP69K per DIN 40050.  **GPS (TTs):** CrossCore XA All-Integrated is a slim and highly integrated communication gateway with functions like wireless communication and GPS positioning. It is designed to be integrated directly into a distributed control system solution. Main specifications: Processor: ARM9, Atmel 240 MHz; Storage: 256 MB NAND flash; RAM: 2 GB flash memory (up to 8 GB); Interfaces: 2xCAN ISO 11898, Max. 1 Mbit/s; 1x RS232; GPS NMEA-0183, Linux OS, IP67; Quadband GPRS (optional 3G modem), WLAN 802.11 b/g 
Ready to be used	Yes
Set-Up activity ID	**Pilot1_SetupAct_ID11**
Resource type	Hardware
Resource description	D-GPS/RTK-GPS (Antenna): The VEXXIS GNSS-800 series antennas feature a patented multi-point feeding network and radiation pattern optimization technology. In additional to having enhanced performance in multipath environments, the GNSS-802 antenna is able to maintain a low profile while achieving both high peak zenith gain and low gain roll-off from zenith to horizon, without sacrificing tracking performance. 

	D-GPS/RTK-GPS (Module): The multi-frequency Novatel OEM729 offers future ready precise positioning. Advanced interference mitigation features maintain high performance in challenging environments. Form factor and pin compatible with Novatel previous generation OEM628™ receiver, the OEM729 provides the most efficient way to bring powerful GNSS products to market quickly. With centimeter level positioning utilizing TerraStar satellite-delivered correction services, the OEM729 ensures globally available, high-performance positioning without the need for expensive network infrastructure. 
Ready to be used	Yes
Set-Up activity ID	**Pilot1_SetupAct_ID12**
Resource type	Platform
Resource description	Terminal Tractor (Terberg YT193): Electric motor performance with battery capacity up to 222 kWh, featuring a thermal management system (TMS), so that it can be used in both very cold and warm climates. The universal charging connector complies with the CCS2.0 automotive standard. The EV drive has regenerative braking to reduce the energy consumption. Terberg Connect telematics is included as standard and provides remote monitoring of the status and performance of each vehicle. 
Ready to be used	Yes
Set-Up activity ID	**Pilot1_SetupAct_ID13**
Resource type	Software
Resource description	**PDS (Auto TOS reporting):** Produces accurate and reliable position information of container moves and sends the information to the TOS (see Pilot1_SetupAct_ID15), so that the latter is constantly aware of what is really happening in the container yard. The position information is a combination of several D-GPS and encoders (see Pilot1_SetupAct_ID11), possibly also a radio radar or distance lasers (see Pilot1_SetupAct_ID9). RTG crane specific information such as the state of the twist locks and size of the spreader and encoder values are sent to the positioning system by the crane PLC (see Pilot1_SetupAct_ID2 and Pilot1_SetupAct_ID8). Twist lock information acts as a trigger for pick and place messages. 

Ready to be used	Yes
Set-Up activity ID	**Pilot1_SetupAct_ID14**
Resource type	Software
Resource description	 **MTS (Cargotec MTS):** The container transition message is the single, most important message in the system. The message is sent from MTS to the TOS whenever a container is handled/moved by a piece of handling equipment, by a terminal truck, by an over-the-road truck, or by a quay crane. The primary purpose of the message is to inform the TOS of a change of location of a container.
Ready to be used	Yes
Set-Up activity ID	**Pilot1_SetupAct_ID15**
Resource type	Software/System
Resource description	**TOS (Navis N4 Release 3.8):** Navis N4 is a sophisticated and modern technology platform that optimizes efficiency and helps to power the intelligent movement of goods through the supply chain. Each release of N4 is extensively tested and certified for up to 10 million TEU. Advanced Yard Options enable optimized use of yard space and CHE's and optimized Equipment Control. navis N4 
Ready to be used	Yes
Set-Up activity ID	**Pilot1_SetupAct_ID16**
Resource type	Network

<table>
<tr><td>Resource description</td><td>FluidMesh 3500 ENDO is designed and manufactured for backhauling mission critical video, voice and data. It can be used to create point-to-point, point-to-multipoint, and mobility networks with a throughput up to 500 Mbps. Main specifications: Rugged die cast aluminium housing; Fluidthrottle enabling user to select the needed throughput; MPLS transmission protocol with intelligent QoS; Web-based interface to easily configure, monitor, and troubleshoot the network; 4.9 GHz, and 5.1-5.8 GHz; 802.3at PoE Gigabit; NTP-1 threaded cable gland for conduit direct mounting </td></tr>
<tr><td>Ready to be used</td><td>Yes</td></tr>
<tr><td>Set-Up activity ID</td><td>Pilot1_SetupAct_ID17</td></tr>
<tr><td>Resource type</td><td>Hardware</td></tr>
<tr><td>Resource description</td><td>Server HW requirements: Remote RTG server environment includes Virtual machines (server) running in VMware environment. Servers as ready-built operational virtual machine image files (e.g. in .mf / .vmdk / .ovf / .nvram formats) including all the required software will be supported. Virtual machines will be installed into customer´s Virtual server environment onsite in Malta Freeport Terminal. Below table shows the VMware resources required for each virtual machine in the Remote RTG system from the customer´s VMware environment. Server´s required OS licenses or subscriptions are provided and managed by the customer IT.
<table>
<tr><th></th><th>Service applications</th><th>Operating system</th><th>Cores</th><th>Memory (GB)</th><th>Disk space (GB)</th></tr>
<tr><td>1</td><td>AV Server</td><td>Debian Linux 10 (Buster, released mid-2019)</td><td>2</td><td>4</td><td>25</td></tr>
<tr><td>2</td><td>Diagnostics Server</td><td>Windows Server 2019 (64 bit)</td><td>4</td><td>16</td><td>250</td></tr>
<tr><td>3</td><td>CMS Server</td><td>Windows Server 2019 (64 bit)</td><td>4</td><td>16</td><td>120</td></tr>
<tr><td>4</td><td>Commissioning Server</td><td>Windows Server 2019 (64 bit)</td><td>4</td><td>16</td><td>250</td></tr>
<tr><td>5</td><td>NTP & Netmon server</td><td>Red Hat Enterprise Linux 8 (64 bit)</td><td>4</td><td>8</td><td>250</td></tr>
<tr><td>6</td><td>FM-MONITOR</td><td>Red Hat Enterprise Linux 8 (64 bit)</td><td>4</td><td>8</td><td>250</td></tr>
<tr><td colspan="3">TOTAL</td><td>22</td><td>68</td><td>1145</td></tr>
</table>

Recommended to use VMware vSphere 6.5 or newer
Recommended to have VMware High Availability setup
2x server hardware with shared storage (SAN, RAID 6)
Scheduled and automatic back-ups of virtual machines
Antivirus software for windows machines (Symantec, Kaspersky)
UPS to power servers and ROS desks with managed shutdown functionality in case UPS power runs out.

Identical server hardware in another building with synchronization (VMware site Recovery Manager)</td></tr>
<tr><td>Ready to be used</td><td>No, purchasing process will start on M15, and commissioning activities will start once the equipment is shipped. Expected: 01/08/2022 (M22) – 31/10/2023 (M36)</td></tr>
<tr><td>Set-Up activity ID</td><td>Pilot1_SetupAct_ID18</td></tr>
<tr><td>Resource type</td><td>Hardware</td></tr>
<tr><td>Resource description</td><td>Tablet (Honeywell Thor VM1A): Vehicle-mounted Android 8 based computer. Dimensions 10.6 x 8.4 x 1.7 inches. Bluetooth v5.0, 32 GB Flash, 4 GB RAM, 2.2 GHz Qualcomm Snapdragon 660 octa-core. Display size 8 inches, 1280x768 resolution. Connection interfaces include RS-232, Ethernet, USB, and CANbus. </td></tr>
<tr><td>Ready to be used</td><td>No. Terminal Link already possesses several tablets embedded into their Terminal Tractors, but for the sake of development, some units will be sent to development team. Expected: 01/01/2022 (M15) – 31/10/2023 (M36)</td></tr>
</table>

3.4. Development and integration activities

In this chapter Pilot 1 development, integration, and validation activities are listed and discussed in the following tables.

3.4.1. Development activities

Table 5. Pilot 1 development activities

Development Activity ID	**Pilot1_DevAct_ID1-SEC**
Development Activity Required	Truck & crane apps mutual authentication and validation
Dependency	Pilot1_DevAct_ID3, Pilot1_IntAct_ID1-SEC
Start and End Dates	01/11/2021 (M13) – 01/04/2022 (M17)
Development Activity ID	**Pilot1_DevAct_ID2-SEC**
Development Activity Required	Provide a solution for incident management and response
Dependency	Pilot1_DevAct_ID3, Pilot1_IntAct_ID2-SEC
Start and End Dates	01/11/2021 (M13) – 01/04/2022 (M17)
Development Activity ID	**Pilot1_DevAct_ID3**
Development Activity Required	Smartphone application for PDS of internal/external truck drivers
Dependency	Pilot1_SetupAct_ID17, Pilot1_DevAct_ID1-SEC
Start and End Dates	01/11/2021 (M13) – 30/04/2022 (M17)
Development Activity ID	**Pilot1_DevAct_ID4**
Development Activity Required	AI/ML container recognition development for Demo 3 of the Port Automation pilot. It will involve image set collection, model training, and model testing
Dependency	Pilot1_SetupAct_ID5, Pilot1_SetupAct_ID6, Pilot1_SetupAct_ID7, Pilot1_SetupAct_ID8
Start and End Dates	01/12/2021 (M14) – 31/10/2022 (M24)
Development Activity ID	**Pilot1_DevAct_ID5**
Development Activity Required	LIDAR system development for Demo 2 of the Port Automation pilot
Dependency	Pilot1_SetupAct_ID9, Pilot1_IntAct_ID6
Start and End Dates	01/03/2022 (M17) – 31/05/2022 (M19)

3.4.2. Integration activities

Table 6. Pilot 1 integration activities

Integration Activity ID	**Pilot1_IntAct_ID1-SEC**
Integration Activity Required	Integration with T53Ex enablers, in order to incorporate authorization enabler to mobile APP
Dependency	Pilot1_DevAct_ID3, Pilot1_IntAct_ID8, Pilot1_IntAct_ID11
Start and End Dates	01/12/2021 (M14) – 01/04/2022 (M17)
Integration Activity ID	**Pilot1_IntAct_ID2-SEC**
Integration Activity Required	Incorporate monitoring and incident response cybersecurity operation centre. Integration and deployment of security agents and integration of other log sources. Set up and configuration for incident detection and response.
Dependency	Pilot1_IntAct_ID7
Start and End Dates	01/12/2021 (M14) – 01/04/2022 (M17)
Integration Activity ID	**Pilot1_IntAct_ID3**
Integration Activity Required	Network ROS Commissioning
Dependency	Pilot1_IntAct_ID4, Pilot1_IntAct_ID5
Start and End Dates	01/08/2022 (M22) – 30/09/2022 (M23)
Integration Activity ID	**Pilot1_IntAct_ID4**
Integration Activity Required	Crane PLC and Central PLC Commissioning for ROS
Dependency	Pilot1_IntAct_ID3, Pilot1_IntAct_ID5
Start and End Dates	01/08/2022 (M22) – 30/09/2022 (M23)
Integration Activity ID	**Pilot1_IntAct_ID5**
Integration Activity Required	A/V system commissioning activities for ROS operation
Dependency	Pilot1_IntAct_ID3, Pilot1_IntAct_ID4
Start and End Dates	01/08/2022 (M22) – 30/09/2022 (M23)
Integration Activity ID	**Pilot1_IntAct_ID6**
Integration Activity Required	Commissioning of LIDAR system
Dependency	Pilot1_SetupAct_ID9
Start and End Dates	01/08/2022 (M22) – 30/09/2022 (M23)
Integration Activity ID	**Pilot1_IntAct_ID7**

Integration Activity Required	Integration of T44Ex dashboards enablers and T55Ex global manageability enablers in Malta testbed
Dependency	Pilot1_DevAct_ID3
Start and End Dates	01/07/2022 (M21) - 30/06/2023 (M32)
Integration Activity ID	**Pilot1_IntAct_ID8**
Integration Activity Required	Integration of T42Ex enablers with particular emphasis on the T42E5 multi-link enabler for enabling the support of multi-wireless networks of ROS operation
Dependency	Pilot1_SetupAct_ID5, Pilot1_SetupAct_ID6, Pilot1_SetupAct_ID7, Pilot1_SetupAct_ID8, Pilot1_IntAct_ID3
Start and End Dates	01/10/2022 (M24) - 31/07/2023 (M33)
Integration Activity ID	**Pilot1_IntAct_ID10**
Integration Activity Required	Integration of M2M protocols (handshake) with the LIDAR system
Dependency	Pilot1_IntAct_ID6, Pilot1_DevAct_ID3, Pilot1_IntAct_ID7
Start and End Dates	01/10/2022 (M24) - 31/07/2023 (M33)
Integration Activity ID	**Pilot1_IntAct_ID11**
Integration Activity Required	Integration of mobile app with PDS system and GPS structure of Malta
Dependency	Pilot1_DevAct_ID3, Pilot1_IntAct_ID1-SEC
Start and End Dates	01/05/2022 (M19) - 31/01/2023 (M27)
Integration Activity ID	**Pilot1_IntAct_ID12**
Integration Activity Required	Integration of AI/ML container recognition development into ROS A/V system
Dependency	Pilot1_DevAct_ID4, Pilot1_IntAct_ID5
Start and End Dates	01/11/2022 (M25) - 31/07/2023 (M33)

3.4.3. Demonstration and Validation activities

Table 7. Pilot 1 validation activities

Validation Activity ID	**Pilot1_ValAct_ID1-SEC**
Validation Activity type	Operation authorization validation
Validation Activity description	Check that a port operation is correctly authorized or denied based on previously defined information and correct context data
Data	Operation context data, decision, and a valid response to requester

Start and End Dates	01/03/2022 (M17) – 01/06/2022 (M19)
Validation Activity ID	**Pilot1_ValAct_ID2-SEC**
Validation Activity type	Operation authorization validation
Validation Activity description	Check that a port operation is correctly authorized or denied based on previously defined information and correct context data
Data	Operation context data, decision, and a valid response to requester
Start and End Dates	01/03/2022 (M17) – 01/06/2022 (M19)
Validation Activity ID	**Pilot1_ValAct_ID3**
Validation Activity type	ROS tests
Validation Activity description	General: • Selection - ROS can be connected to the 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 (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 - Quick stop button functional • Selection - Crane controls can be deactivated • Selection - Crane can be disconnected from the ROS Crane Control: • 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' (45' 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 - Additional bypasses (optional, if any) • Crane controls - Traffic light controls • Crane controls - Floodlights • Crane controls - Wheel turning park/normal • Crane controls - Fault reset
Data	Correct operation of ROS
Start and End Dates	01/08/2022 (M22) – 30/09/2022 (M23)
Validation Activity ID	**Pilot1_ValAct_ID4**

Validation Activity type	A/V device tests
Validation Activity description	Trolley camera view • Video OK • Pan, tilt and zoom functional (optional, only if PTZ camera is used) • Preset correctly set (optional, only if PTZ camera is used) Bay camera view • Video OK • Pan, tilt and zoom functional (optional, only if PTZ camera is used) • Preset correctly set (optional, only if PTZ camera is used) Truck lane camera views • 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 - Video right OK • 20' truck trailer cameras - Video left OK • 40'/45' truck trailer cameras - Video right OK • 40'/45' truck trailer cameras - Video left OK Spreader camera view • Video upper right OK • Video lower right OK • Video lower left OK • Video upper left OK Bogie camera view • Video upper right OK • Video lower right OK • Video lower left OK • Video upper left OK Audio devices • Trolley intercom OK • Truck lane loudspeaker OK
Data	Correct operation of A/V devices
Start and End Dates	01/08/2022 (M22) – 30/09/2022 (M23)
Validation Activity ID	**Pilot1_ValAct_ID5**
Validation Activity type	LIDAR Hardware tests
Validation Activity description	LIDAR system is properly integrated, and data is fluid among the different parts that form the system (sensors, crane PLC, traffic lights and audio devices), as well as received by the ASSIST-IoT mobile application.
Data	3D environment properly handled by the lasers. Guiding signals received by Crane PLC Guiding signals received and printed in traffic lights Guiding signals received in ASSIST-IoT mobile app
Start and End Dates	01/08/2022 (M22) – 30/09/2022 (M23)
Validation Activity ID	**Pilot1_ValAct_ID6**
Validation Activity type	Software

Validation Activity description	Optimal route tested over the mobile app in the tablet
Data	XML file with a sequence of coordinates depicted on top of the cartography embedded within the mobile application
Start and End Dates	01/04/2022 (M18) - 31/01/2023 (M27)
Validation Activity ID	**Pilot1_ValAct_ID7**
Validation Activity type	Network
Validation Activity description	Verification of multi-access networks over the ROS. Throughput, and latency requirements identified in D3.2 must be fulfilled
Data	TCP data packets
Start and End Dates	01/05/2023 (M31) – 31/10/2023 (M36)
Validation Activity ID	**Pilot1_ValAct_ID8**
Validation Activity type	Network
Validation Activity description	Validation of M2M nearby protocol are illustrated in the mobile application, and interconnected with the LIDAR system
Data	Telemetry information properly exchanged
Start and End Dates	01/10/2022 (M24) – 31/10/2023 (M36)
Validation Activity ID	**Pilot1_ValAct_ID9**
Validation Activity type	Video software
Validation Activity description	Validation of AI/ML container recognition development into ROS A/V system (first on Konecranes laboratory, last on Malta testbed)
Data	Video annotation feeds received via TCP packets
Start and End Dates	01/09/2022 (M23) – 31/10/2023 (M36)
Validation Activity ID	**Pilot1_ValAct_ID10**
Validation Activity type	System testing.
Validation Activity description	Open call support. Experimental activities for demonstration of the Open calls in the pilot.
Data	Unknown
Start and End Dates	01/05/2022 (M19) – 31/10/2023 (M36)

3.5. Initial Planning

This pilot plans to carry out four different demonstrations associated with the three business scenarios described in Section 3.2. For M18, aligned with D7.2 it is expected to have a very first version of Demo-1, which is linked with Business Scenario BS-P1-1. The other three demonstrations (Demo-2 associated with BS-P1-2, and Demo-3/Demo-4 covering BS-P1-3) cannot be trialled in Malta environment until the commissioning of all resources regarding LIDAR and ROS are finalised. Nevertheless, it is planned that preliminary demonstrations in Prodevelop, and/or Konecranes laboratories can be performed before deploying ASSIST-IoT platform enablers in Malta Freeport.

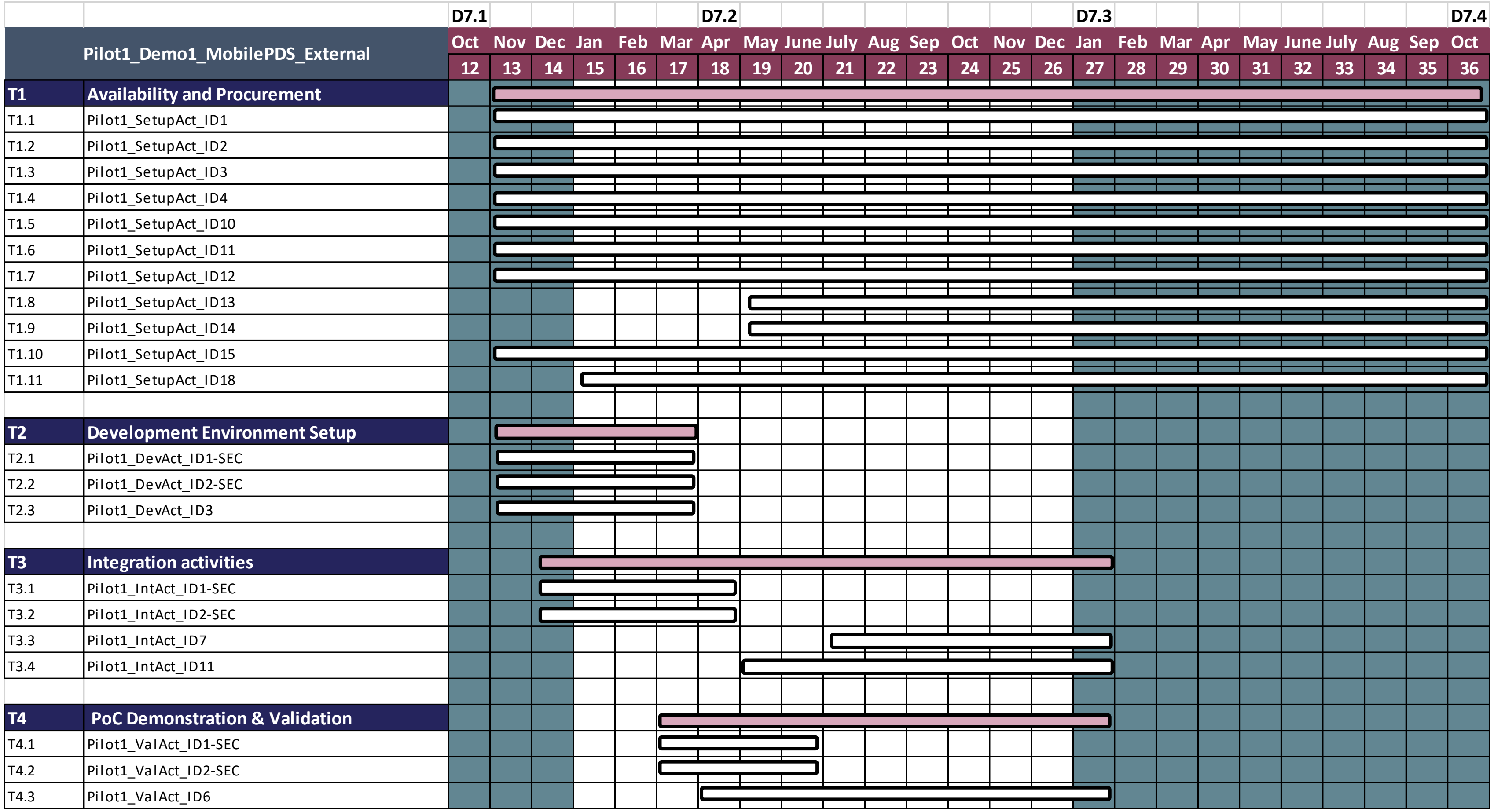


Figure 7. Pilot_1_Demo_1 Gantt chart.

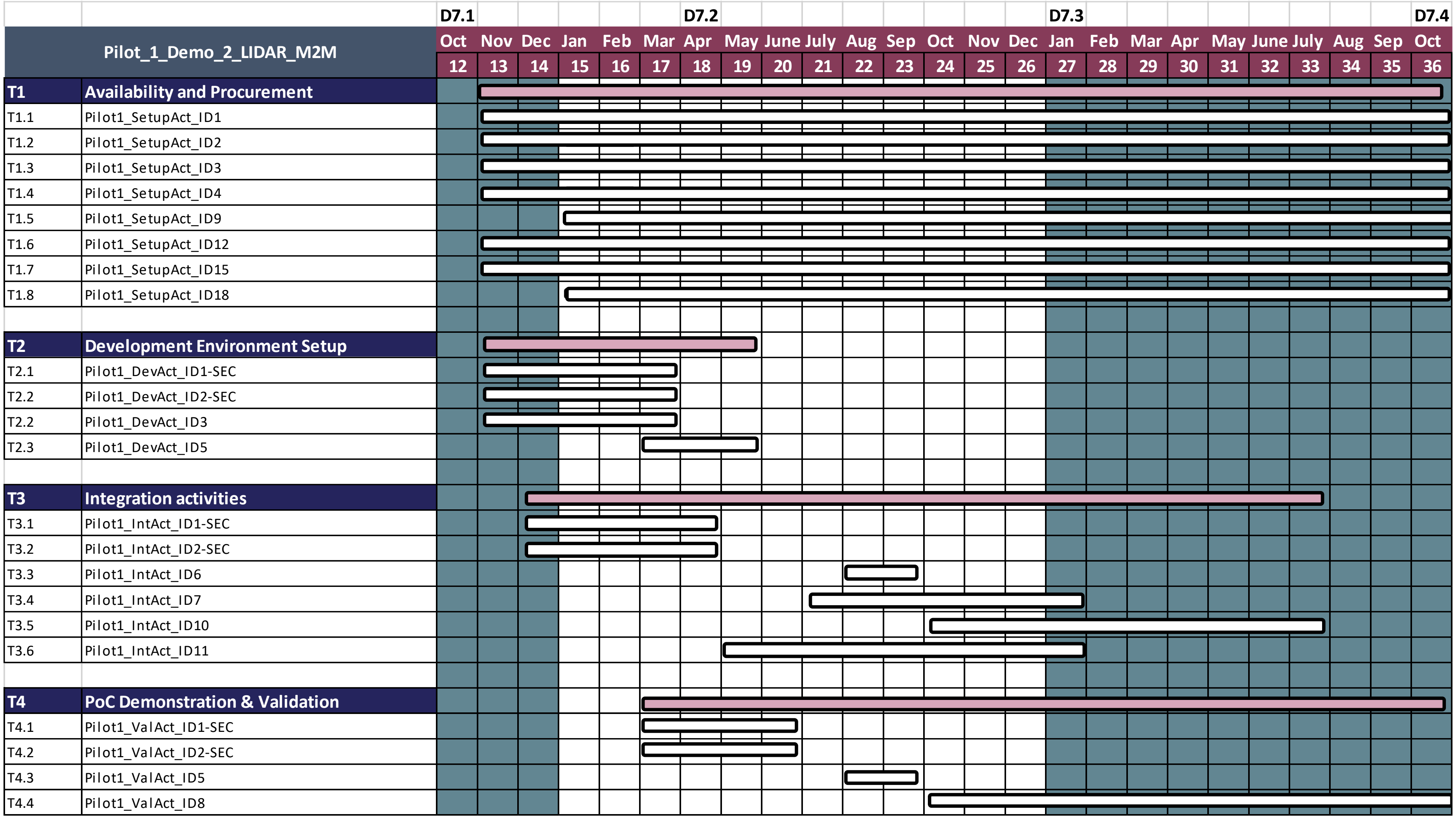


Figure 8. Pilot_1_Demo_2 Gantt chart

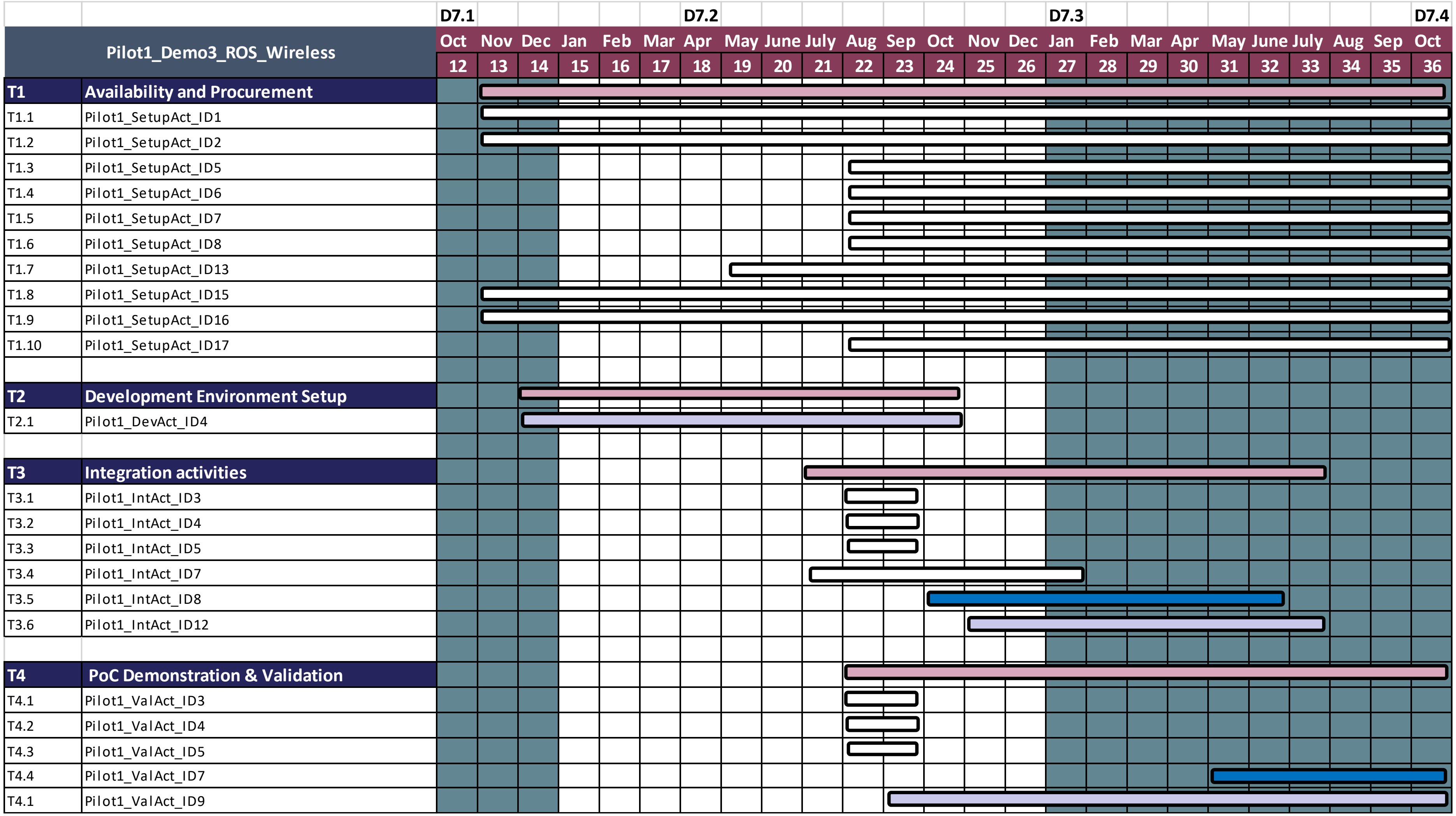


Figure 9. Pilot_1_Demo_3 (blue) and Demo_4 (purple) Gantt chart

4. Pilot 2: Smart safety of workers

4.1. Szczecin and Warsaw Buildings

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.

Mostostal Warszawa is founding member of the association "Agreement for Safety in Construction. The agreement, set up in 2010, brings together the largest general contractors in Poland. Its aims at the complete elimination of fatal accidents at construction sites in Poland. To meet this goal, its members have prepared a number of projects introducing systemic OHS solutions at construction sites throughout the entire country..

The pilot will take place at the construction site of Marshal's Office in Szczecin (Poland). Mostostal carries out construction works of passive building at Mazowiecka Str. 14 in Szczecin. It will have 8 floors (2 underground for parking). Its total area is about 14 thousand m^2. In the building, apart from offices, there will be conference rooms. The laser scanning of the new building was performed in September 2021. The point clouds have been used to compare it with the BIM models. The Common Data Environment (CDE) and BIM models are used to manage the project documentation.

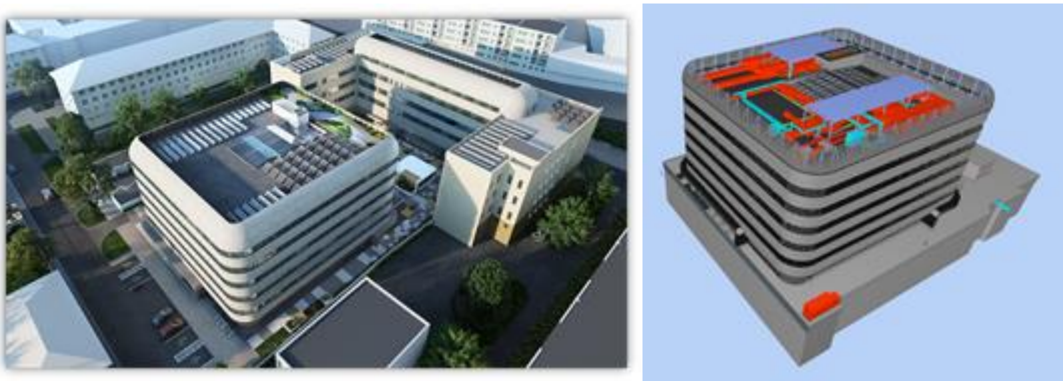


Figure 10. The visualization and BIM model of a demonstration building in Szczecin

Due to the fact that 5G technology is still not available in Szczecin, Mostostal has reserved another construction site for demonstration purpose, located in Warsaw at Zwirki i Wigury str. The 8-storey building with a total area of 26 600 m^2 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 start of construction works is in October 2021 and the duration is around 2.5 years. The building will be certified according to BREEEM.

Figure 11. The visualization and BIM model of a demonstration building in Warsaw.

Figure 12. 5G network coverage in Poland in October 2021.

4.2. Requirement's traceability

The Smart safety of workers Pilot is focused on the improvement of health and safety at the construction site by providing human-centric modular solutions and enablers capable to effectively support the operations. To achieve it, this pilot identified 4 business scenarios included related requirements and acceptance criteria as analysed in D3.2 [5], and described shortly in the following paragraphs.

BS-P2-1: Occupation safety and health monitoring: Regarding the personal safety of the construction workers, their health condition is monitored in real-time (UC-P2-1) using the ASSIST-IoT edge node (R-C-5, R-C-7, R-P2-16) and the wristband (R-P2-3). The level of their exposure to UV radiation (R-P2-9) is assessed based on the environmental condition values collected by a weather station (R-P2-7). The detection of abnormalities such as high-level of stress/fatigue and slip/falls are achieved with the use of intelligent detection algorithms (R-P2-10); Federated Learning enablers (T52E1, T52E, T52E3, T52E4) and Cybersecurity enablers (T53E2, T53E3, T53E4) are utilized ensuring data privacy and persistence (R-C-3, R-P2-4, R-C-6). In case of undesirable behaviour, ASSIST-IoT generates notifications (R-P2-12), including location incidents (SELF13) and life-threating events (SELF14), and publish them to the stakeholders.

In the entrance of the construction plant and any worksite within it, the eligibility of the construction workers and plants to enter is verified (UC-P2-4), where the information is extracted through construction worker and operator wristbands (R-P2-2, R-P2-3, R-P2-5). To prevent workers from entering areas without authorisation (UC-P2-2), the Geo(Localisation) enabler (SELF13) provides the necessary information to localise them inside the construction area (R-P2-1, R-P2-11) through the worker's wristband (R-P2-3), while the collaboration between the Identity Manager (T53E2) and Authorisation (SELF13) enabler provides the access restriction rules of the construction workers based on BIM information (R-P2-15). The Geo(Localisation) enabler is also utilized to track the position of operating construction equipment (R-P2-2) and the Notifying and Monitoring enabler (SELF14) is responsible to alert construction worker (R-P2-12) in the vicinity of them (UC-P2-3) via their wristbands (R-P2-5).

BS-P2-2: Fall arrest monitoring: In the case that construction workers perform tasks at height (UC-P2-5), the ASSIST-IoT fall arrest detector will be introduced to identify fall events (R-P2-13) and notify instantly the OHS manager (R-P2-12) about the accident and its location (R-P2-1, R-P2-3, R-P2-5). The ASSIST-IoT also provides safe navigation or evacuation instructions (R-P2-14, R-P2-12) to the construction workers in case of normal operating or emergency conditions (UC-P2-6), respectively, based on their location (R-P2-1) and the approved walking paths (R-P2-15).

BS-P2-3: Safe navigation: Regarding the safe navigation of the construction workers into the worksite (UC-P2-6), guidance instructions will be given that navigate the workers from their current location (R-P2-1) to a worksite. In case of an emergency, evacuation instructions (R-P2-14) will be provided to the workers that are updated by the OSH manager according to the evolving situation (R-P2-14), while all paths and routes should be indicated on the BIM (R-P2-15).

BS-P2-4: Health and safety inspection support: Apart from the previously mentioned use cases referred to health & safety of each construction worker, the MR enabler (T44E6) is employed to support the Health & Safety inspector at the construction site (UC-P2-4) by providing relevant information (R-P2-12, T44E1, SELF14) of construction workers (R-P2-3) and on-going operations (R-P2-15) through the visualisation of BIM (R-P2-15) on MR devices.

In order to fulfil the requirements of the aforementioned scenarios, Table 8 lists the enablers that have been identified (please refer to Table 1 in Section 2.2 for more details), although it does not preclude potential future inclusion of additional enablers

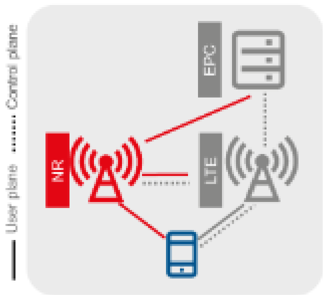
Table 8. Smart safety of workers pilot enablers.

T42	• **T42E1:** Smart orchestrator enabler • **T42E1:** SDN controller • **T42E3:** Auto-configurable network enabler • **T42E4:** Traffic classification enabler • **T42E5**: Multi-link enabler • **T42E6:** SD-WAN enabler	**T43**	• **T43E1:** Semantic repository enabler • **T43E2:** Semantic translation enabler • **T43E3:** Semantic annotation enabler • **T43E7:** Edge data broker enabler • **T43E8:** Long-term data storage enabler
T44	• **T44E1:** Tactile dashboard enabler • **T44E2:** Business KPI reporting enabler • **T44E3:** Performance and Usage Diagnosis enabler • **T44E4:** OpenAPI management enabler • **T44E6:** MR enabler	**T51**	• **T51E3:** Geo (Localisation) enabler • **T51E4:** Monitoring and notifying • **T51E5:** Automated configuration
T52	• **T52E1:** FL Orchestrator • **T52E2:** FL Training collector • **T52E3:** FL repository • **T52E4:** FL Local Operations	**T53**	• **T53E1:** Authorisation enabler • **T53E2:** Identity manager enabler • **T53E3:** Cybersecurity monitoring enabler • **T53E4:** Cybersecurity monitoring agent enabler
T54	• **T54E1:** DLT Logging and Auditing		

4.3. Existing and forthcoming resources

List and a planning of required resources, facilities, connectivity, and logistics for the set-up of Pilot 2 testbed is presented in the next table.

Set-Up activity ID	**Pilot2_SetupAct_ID1**
Resource type	Microsoft HoloLens 2
Resource description	The Microsoft Hololens 2 is the most popular MR device, equipped with multiple sensors, advanced optics, and holographic processing that melds seamlessly with its environment, This hologram will be used to display information to the OSH manager during the inspection, while the Hololens 2 features are: 7x SIMD Fixed Point (SFP) for 2D processing, 6x Floating Vector Processor (FVP) for 3D processing, 125Mb SRAM and PCIe 2.0 x1 at 100 MB/s bandwidth to Snapdragon 850 
Ready to be used	Yes
Set-Up activity ID	**Pilot2_SetupAct_ID2**

Resource type	Construction site
Resource description	Mostostal will guarantee access to the construction site where developed solutions in ASIST-IoT project will be tested. An openBIM model will be provided in terms to integrate it with the platform. At the construction will be one crane and machinery to test access control and alerts between machine to machine or machine to workers. The control entrance must be purchased for the project need. Mostostal will guarantee OSH trainings on Talent LMS platform.
Ready to be used	BIM models (YES)
Set-Up activity ID	**Pilot_SetupAct_ID3**
Resource type	Network 5G, 4G LTE
Resource description	5G network is installed in selected cities in Poland (see map at right). Currently 5G NR NSA version in 2100MHz band is available.   During the pilot testing the 5G coverage will be expanded to other cities. The 5G SA version is planned to be installed in 2022. To setup access to 5G network LTE SIM card or eSIM is required. For the connectivity setup the 5G enabled router or IoT gateway will be required.
Ready to be used	Yes. Required setup activities.
Set-Up activity ID	**Pilot2_SetupAct_ID4**
Resource type	Network
Resource description	The network infrastructure between the anchors and edge node/gateway consists of: Ethernet, Power over Ethernet (PoE) and Wifi.
Ready to be used	Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot2_SetupAct_ID5**
Resource type	Network
Resource description	The network infrastructure between the edge node/gateway and the OSH management system consists of: Ethernet and 4/5G
Ready to be used	Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot2_SetupAct_ID6**
Resource type	Network
Resource description	The network infrastructure between the OSH management system and mobile phone Safety officer consists of 4/5G and WiFi.
Ready to be used	Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot2_SetupAct_ID7**

Resource type	Hardware
Resource description	The Edge Node/Gateway consists of: SMARC 2.1 Compute Processing module: Dual ARM Cortex-A53 application processor up to 1.8GHz, ARM Cortet-M7 real time processor @ 800MHz, Machine learning accelerator, 4GB DDR4 SDRAM memory and GB eMMC FLASH. Memory extension: Micro SD 3.0 Card interface. Wired Interfaces: 2*Ethernet 1Gbps, 2*CAN FD/2.0, 2*USB 3.0 (type-a/c), RS232, RS485, etc. Wireless Interfaces: 4G/5G wireless network module (M.2 interface), UWB, WiFi-6.0, BLE. Supportive functions: Clock & Reset, Watchdog, Local Power supply, PSU monitor, Expansion connector, JTAG/Debug and status LED's. Enclosure: metal IPX68
Ready to be used	Expected: 01/06/2022 (M20) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot2_SetupAct_ID8**
Resource type	Firmware
Resource description	Yocto operating system (OS) an open-source collaboration project based on Linux that helps developers creating custom Linux-based systems regardless of the hardware architecture.
Ready to be used	Expected: M20 (June 2022) fully functional. Intermediate/alternative versions before.
Set-Up activity ID	**Pilot2_SetupAct_ID9**
Resource type	Firmware
Resource description	Hardware Abstraction Layer (HAL), consists of device driver as interface between the electronics and the OS.
Ready to be used	Expected: M20 (June 2022) fully functional. Intermediate/alternative versions before.
Set-Up activity ID	**Pilot2_SetupAct_ID10**
Resource type	Firmware
Resource description	Configuration and initialisation of the standard interfaces (Ethernet, Serial, etc.), SSH and a default user will be preconfigured on the Edge node, making the node fully functional and ready to run enablers on.
Ready to be used	Expected: M20 (June 2022) fully functional. Intermediate/alternative versions before.
Set-Up activity ID	**Pilot2_SetupAct_ID11**
Resource type	Firmware
Resource description	Container runtime, Docker is used and K8s/K3s/K0s
Ready to be used	Expected: M20 (June 2022) fully functional. Intermediate/alternative versions before.
Set-Up activity ID	**Pilot2_SetupAct_ID12**
Resource type	Software

Resource description	Pre-installed software: It is expected that some software will be used by several enablers and at the same time, it must be possible to update the Edge node firmware. For this reason, the following supportive software will be pre-installed at the Edge node: *Python:* Python is a general-purpose programming language that will be used by many enablers. It is used for web development, AI, machine learning, mobile application development, etc. As Python will be used on the Edge node, it will be preinstalled. *Software update support:* Software update support is needed to be able to update the HAL, OS and specific device drivers e.g., to apply security patches, deploy new features or bug fixes. The update mechanism is to be determined e.g. “swupd” or “mender.io” can be used. The software update support is used to support the configuration enabler.
Ready to be used	Expected: M20 (June 2022) fully functional. Intermediate/alternative versions before.
Set-Up activity ID	**Pilot2_SetupAct_ID13**
Resource type	Hardware
Resource description	The UWB anchor devices consist of: UWB transceiver, Microcontroller, battery, Power supplier, push button, buzzer, LEDs, Program/Debug interface. Wired interfaces: Ethernet and PoE. Wireless interfaces: Wifi and BLE (for configuration)
Ready to be used	Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot2_SetupAct_ID14**
Resource type	Firmware
Resource description	UWB Anchor configuration and initialisation consist of: an interface (UWB, BLE, Ethernet, etc.), SSH, WSN node protocol stack, sensor-to-app security and default user settings will be preconfigured on the anchor, making the node fully functional and ready to run.
Ready to be used	Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot2_SetupAct_ID15**
Resource type	Hardware
Resource description	The Workers tag consist of a UWB transceiver, Microcontroller, battery, push button, buzzer, LEDs, Program/Debug interface. (Optional: NFC and BLE)
Ready to be used	Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot2_SetupAct_ID16**
Resource type	Hardware
Resource description	**Smart devices:**  • **Fall arrest device** consists of the combination of an off-the-self force sensor (the mechanical construction of the fall force sensor shall be accordingly the fall safety standards) with an add-on fall arrest tag (consist of a UWB transceiver, microcontroller, force sensor interface, battery, push button, buzzer, LEDs, program/debug interface). • **Wristband** for personal identification, physiological parameters and location monitoring • **Monitoring station** for analyzing weather conditions, air quality, and UV radiation. • **Clothing** with integrated personal cooling system • **Tags** integrated with PPE • **Smart protective helmet** with thin film capacitive sensor.

	• **Beacons** for geofencing boundaries over controlling access to dangerous points, as well as vicinity with machinery • **Mobile devices** that support location-based services and has a display
Ready to be used	Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot2_SetupAct_ID17**
Resource type	Firmware
Resource description	The UWB workers- and fall arrest-tag device configuration and initialisation consists of an interface for UWB (optional: BLE & NFC), force sensor interface, Program/Debug interface, SSH, WSN node protocol, sensor-to-app security and default user settings, which will be preconfigured on the tag device, making the smart IoT device node fully functional and ready to run.
Ready to be used	Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot2_SetupAct_ID18**
Resource type	Infrastructure
Resource description	The UWB localisation infrastructure consists of workers tags, fall arrest detector, anchors, edge node gateway, network switch, Server, OSH management system, 4/5G, Smart Phone
Ready to be used	Expected: 01/08/2022 (M22) – 31/10/2023 (M36)
Set-Up activity ID	**Pilot2_SetupAct_ID19**
Resource type	Measuring equipment
Resource description	Measuring equipment for testing and evaluation of various kinds of personal protective equipment, in particular: • The laboratory stands for dynamic tests of personal equipment protecting against falls from a height. A fast-speed digital camera from Mikrotron GmbH records the movement of the dummy during a fall arrest.   • Measuring equipment for evaluation of functionality of technologically advanced personal protective equipment, which is suitable for performing tests in both laboratory and operational conditions (i.e. at the construction site).  • In terms of evaluation of eye and face protective equipment, a unique apparatus for optical and mechanical tests equipped with a spectrophotometer and unique equipment for testing all types of eye and face protection
Ready to be used	Yes

4.4. Development and integration activities

In this chapter Pilot 2 development, integration, and validation activities are listed and discussed in the following tables.

4.4.1. Development activities

Table 9. Pilot 2 development activities

Development Activity ID	**Pilot2_DevAct_ID1-SEC**
Development Activity Required	Identification & authorization of construction workers
Dependency	Operation enforcer
Start and End Dates	01/11/2021 (M13) – 01/04/2022 (M17)
Development Activity ID	**Pilot2_DevAct_ID2-SEC**
Development Activity Required	Provide a solution for incident management and response
Dependency	Data and log sources of information from enablers, application, network devices, etc.
Start and End Dates	01/11/2021 (M13) – 01/04/2022 (M17)
Development Activity ID	**Pilot2_DevAct_ID1**
Development Activity Required	Stress and fatigue detection algorithm.
Dependency	Pilot2_SetupAct_ID7, Pilot2_SetupAct_ID16
Start and End Dates	01/08/2022 (M22) – 31/03/2023 (M29)
Development Activity ID	**Pilot2_DevAct_ID2**
Development Activity Required	Training, medical test validity and personal information tracking
Dependency	None
Start and End Dates	01/01/2022 (M15) – 01/08/2022 (M22)
Development Activity ID	**Pilot2_DevAct_ID3**
Development Activity Required	Smart fall arrest incident detection
Dependency	Pilot2_SetupAct_ID16
Start and End Dates	01/08/2022 (M22) – 31/03/2023 (M29)
Development Activity ID	**Pilot2_DevAct_ID4**

Development Activity Required	Safe navigation and evacuation instructions for workers.
Dependency	Pilot2_DevAct_ID7, Pilot2_IntAct_ID4
Start and End Dates	01/06/2022 (M20) - 31/03/2023 (M29)
Development Activity ID	**Pilot2_DevAct_ID9**
Development Activity Required	This activity is centered in the MR-based functionalities that should be developed to support the “Health and safety inspection support” use case (UC-P2-7). • The first functionality relies on the loading of the BIM model in a way that can be visualized in the MR device, how to use the attached information on the model parts and how to interact with it in a user-friendly way • The second one reflects the visualization of the worker-related information such as medical & training data or real-time health-based data. • The third is the development of AR-based report templates to be used by the OSH manager during the inspection. The latter is the implementation of a workflow that will include all the previous steps in a way that will fulfil the needs of the Health and Safety inspection procedure
Dependency	Pilot2_DevAct_ID1, Pilot2_DevAct_ID2, Pilot2_DevAct_ID6, Pilot2_IntAct_ID7
Start and End Dates	01/10/2021 (M10) - 31/07/2023 (M33)
Development Activity ID	**Pilot2_DevAct_ID10**
Development Activity Required	Worker and construction equipment location tracking, as well as algorithm for location events detection. This will include tracking the location of workers and equipment in relation with each other and the BIM model.
Dependency	Pilot2_IntAct_ID8
Start and End Dates	01/05/2022 (M19) - 31/03/2023 (M29)
Development Activity ID	**Pilot2_DevAct_ID11**
Development Activity Required	Development of an enclosure with Edge note electronics, consists of an enclosure, carrier board, computing Processing module, Memory, Physical Network Interface, local Power supplies, supported functions, Smart IoT device interfaces, if needed dedicated onboard sensors and actuators.
Dependency	Availability of HW components
Start and End Dates	M13-M20
Development Activity ID	**Pilot2_DevAct_ID12**
Development Activity Required	Development of Edge node firmware, consist of Yocto OS, Hardware Abstraction Layer, Configuration and initialisation and Container runtime.
Dependency	Availability of and FW and SW Electronics development Kit
Start and End Dates	M15 – M19
Development Activity ID	**Pilot2_DevAct_ID13**

Development Activity Required	Development of an enclosure with Anchor note electronics, consists of an enclosure, carrier board, computing Processing, Memory, Physical Network Interface, wireless network interface (UWB, WiFi) local Power supplies, supported functions, Smart IoT device interfaces, if needed dedicated onboard sensors and actuators.
Dependency	Availability of HW components
Start and End Dates	M13-M22
Development Activity ID	**Pilot2_DevAct_ID14**
Development Activity Required	Development / porting of Anchor node firmware. Consist of: Hardware Abstraction Layer, configuration, and initialisation.
Dependency	Availability of and FW and SW Electronics development Kit
Start and End Dates	M15 – M19
Development Activity ID	**Pilot2_DevAct_ID15**
Development Activity Required	Development of an enclosure with worker tag device electronics, consists of an enclosure, carrier board, computing processing, Memory, wireless network interface (UWB, BLE) local Power supplies, supported functions, if needed dedicated onboard sensors and actuators.
Dependency	Availability of HW components
Start and End Dates	M13-M22
Development Activity ID	**Pilot2_DevAct_ID16**
Development Activity Required	Development of an enclosure with fall arrest device electronics, consists of a tag enclosure, carrier board, computing processing, Memory, wireless network interface (UWB, BLE) local Power supplies, supported functions, a force sensor interface and if needed dedicated onboard sensors and actuators.
Dependency	Availability of: HW components and off-the-self force sensor.
Start and End Dates	M13-M22
Development Activity ID	**Pilot2_DevAct_ID17**
Development Activity Required	Development / porting of worker and fall detect Tag device firmware. Consist of: Hardware Abstraction Layer, configuration and initialisation.
Dependency	Availability of Tag HW, FW and SW Electronics development Kit
Start and End Dates	M13-M22

4.4.2. Integration activities

Table 10. Pilot 2 integration activities

Integration Activity ID	**Pilot2_IntAct_ID1-SEC**
Integration Activity Required	Integrate identity and authorization service in workflow. Create security policy
Dependency	Operation enforcer
Start and End Dates	01/12/2021 (M14) – 01/04/2022 (M17)

Integration Activity ID	**Pilot2_IntAct_ID2-SEC**
Integration Activity Required	Incorporate monitoring and incident response cybersecurity operation centre. Integration and deployment of security agents and integration of other log sources. Set up and configuration for incident detection and response.
Dependency	Data and log sources of information from enablers, application, network devices, etc.
Start and End Dates	01/12/2021 (M14) – 01/04/2022 (M17)
Integration Activity ID	**Pilot2_IntAct_ID3**
Integration Activity Required	Integration of stress and fatigue level detection with notifications.
Dependency	Pilot2_DevAct_ID1
Start and End Dates	01/01/2023 (M27) – 31/05/2023 (M31)
Integration Activity ID	**Pilot2_IntAct_ID4**
Integration Activity Required	Integration of location events detection with notifications. Workers and occupational health & safety inspectors should be informed of relevant location events.
Dependency	Pilot2_DevAct_ID10
Start and End Dates	01/11/2022 (M25) - 31/05/2023 (M31)
Integration Activity ID	**Pilot2_IntAct_ID5**
Integration Activity Required	Integration of fall arrest incident detection with notifications.
Dependency	Pilot2_DevAct_ID3
Start and End Dates	01/11/2022 (M25) - 31/05/2023 (M31)
Integration Activity ID	**Pilot2_IntAct_ID7**
Integration Activity Required	3D model BIM integration. It will be necessary to extract the 3D models from BIM to be used in visualizations.
Dependency	Pilot2_DevAct_ID9
Start and End Dates	01/01/2022 (M10) - 30/09/2023 (M35)
Integration Activity ID	**Pilot2_IntAct_ID8**
Integration Activity Required	Ontologies for BIM and worker safety that will provide an interoperable data model for describing events and entities on the construction site. Configuring semantic annotation for BIM models. Provide necessary alignments for performing the annotation.
Dependency	None
Start and End Dates	01/05/2022 (M19) - 31/12/2022 (M26)
Integration Activity ID	**Pilot2_IntAct_ID9**

Integration Activity Required	MR devices initialization and integration with the developed functionalities, described in Pilot2_DevAct_ID9. This activity includes the integration tasks with the authorization enabler to get device's permission, the integration with the data storages in which the the BIM model, the construction-related & worker-related information and reports are saved, and the interaction with the edge data broker to receive real-time data.
Dependency	Pilot2_DevAct_ID9, Pilot2_IntAct_ID2
Start and End Dates	01/02/2022 (M16) - 31/10/2023 (M36)
Integration Activity ID	**Pilot2_IntAct_ID10**
Integration Activity Required	Integration of Edge node firmware, consist of Yocto Linux OS, Hardware Abstraction Layer, Configuration and initialisation and Container runtime and Pre-installed SW on Edge note electronics HW.
Dependency	Availability Edge node electronics (Pilot2_DevAct_ID10) and FW (Pilot2A_DevAct_ID11)
Start and End Dates	M20-M21
Integration Activity ID	**Pilot2_IntAct_ID11**
Integration Activity Required	Integration of UWB Anchor nodes firmware. Consist of configuration and initialisation of: RTLS manager, RTLS nodes, Physical Network Interface, wireless network interface (UWB, WiFi, BLE)
Dependency	Availability anchor node electronics (Pilot2_DevAct_ID12) and FW (Pilot2A_DevAct_ID13)
Start and End Dates	M22-M23
Integration Activity ID	**Pilot2_IntAct_ID12**
Integration Activity Required	Integration of UWB worker and fall tag devices firmware. Consist of configuration and initialisation of: RTLS manager, RTLS nodes, wireless network interface (UWB, BLE)
Dependency	Availability anchor node electronics (Pilot2_DevAct_ID14 and Pilot2_DevAct_ID15) and FW (Pilot2A_DevAct_ID16)
Start and End Dates	M22-M23
Integration Activity ID	**Pilot2_IntAct_ID13**
Integration Activity Required	Integration of Edge node firmware, consist of configuration and initialisation RTLS manager, RTLS nodes, wireless network interface (UWB, BLE)
Dependency	Availability Edge node electronics (Pilot2_DevAct_ID10, Pilot2_DevAct_ID12, Pilot2_DevAct_ID14 and Pilot2_DevAct_ID15) and FW (Pilot2A_DevAct_ID11, Pilot2A_DevAct_ID13 and Pilot2A_DevAct_ID16)
Start and End Dates	M20-M21
Integration Activity ID	**Pilot2_IntAct_ID14**
Integration Activity Required	Integration work and setup of connectivity for the networking devices (IoT gateway). Configuration of networking resources, integration with smart orchestrator or SD-WAN enabler.
Dependency	N/A
Start and End Dates	01/02/2022 (M16) - 31/10/2023 (M36)

Integration Activity ID	**Pilot2_IntAct_ID15**
Integration Activity Required	Integration of T44Ex dashboards enablers and T55Ex global manageability enablers in Mostostal testbeds
Dependency	None
Start and End Dates	01/07/2022 (M21) - 30/06/2023 (M32)

4.4.3. Demonstration and Validation activities

Table 11. Pilot 2 validation activities

Validation Activity ID	**Pilot2_ValAct_ID1-SEC**
Validation Activity type	Operation authorization validation
Validation Activity description	Check that an access request is correctly authorized or denied based on previously defined information and correct context data, as well as in terms of access to personal data protected by GDPR
Data	Operation context data, decision, and a valid response to requester
Start and End Dates	01/03/2022 (M17) – 01/06/2022 (M19)
Validation Activity ID	**Pilot2_ValAct_ID3**
Validation Activity type	Hardware testing
Validation Activity description	Testing of developed/adopted hardware in terms of its functionality, accuracy and ergonomics in the construction environment: • Wristband for personal identification, physiological parameters and location monitoring • Weather conditions and air quality monitoring station • Personal cooling system • Identification devices • Tags integrated with PPE • Thin film capacitive sensor for monitoring a use of protective helmet • Hardware for geofencing boundaries enforcement • Controlled-access points • Fall arrest detector • Mobile device that supports location-based services and has a display • Augmented Reality Glasses • Radio communication equipment for data transfer
Data	Near real-time data streams from measurements of: physiological parameters, location, UV, ambient temperature, soil, wind velocity, skin temperature/temperature in the undergarment microclimate, cooling efficiency, capacity, force Databases for identification of workers, PPE, BIM model
Start and End Dates	01/08/2022 (M22) - 31/08/2023 (M34)
Validation Activity ID	**Pilot2_ValAct_ID4**

Validation Activity type	Software testing
Validation Activity description	Testing of functionalities of the ASSIST-IoT platform, as well as the integrated software providing that must be developed by technical partners and included in 4.4.1 and 4.4.2. • Alerts of hazardous situations to OSH manager (motionless, fall from a height, entrance to the dangerous zone, workers' health abnormalities) • Other information provided to OSH manager (e.g., lack of required PPE, identification of workers with a use of AR) • Information about the number of workers and their location • Weather conditions • Adaptation of interface based on the BIM model • Creation of evacuation routes • Creation of dangerous zones • Prevention from thermal load • Implementation of data related to subcontractors and workers
Data	IFC model, number of workers, weather data, location data
Start and End Dates	01/08/2022 (M22) - 31/08/2023 (M34)
Validation Activity ID	**Pilot3_ValAct_ID6**
Validation Activity type	System Testing
Validation Activity description	UC-P2-7 demonstration. This activity will be used for demonstrating the implementation of use case UC-P2-7 "Health and safety inspection support". During the demonstration, the OSH is equipped with the HoloLens 2 to be informed about the type of construction activity, the safety measures and the training records of the construction workers that participate in the activity at their location.
Data	BIM model, Health-related data, Training records, Safety measures,
Start and End Dates	01/10/2021 (M31) - 31/10/2023 (M36)
Validation Activity ID	**Pilot2_ValAct_ID7**
Validation Activity type	Validation of the Edge node firmware: Yocto Linux OS, Hardware Abstraction Layer, Configuration and initialisation and Container runtime and Pre-installed SW on Edge note electronics HW.
Validation Activity description	Availability Edge node electronics (Pilot3A_DevAct_ID11) and FW (Pilot3A_DevAct_ID12)
Start and End Dates	M20-M21
Validation Activity ID	**Pilot2_ValAct_ID8**
Validation Activity type	Edge node Validation of network UWB, Ethernet, 4/5G module
Validation Activity description	Availability Edge node electronics (Pilot2_DevAct_ID10) and FW (Pilot2A_DevAct_ID11)
Start and End Dates	M22-M24

Validation Activity ID	**Pilot2_ValAct_ID9**
Validation Activity type	Validation of UWB infrastructure and network, Ethernet, UWB, WiFi, BLE
Validation Activity description	Availability Edge node electronics (Pilot2_DevAct_ID10, Pilot2_DevAct_ID12, Pilot2_DevAct_ID14 and Pilot2_DevAct_ID15) and FW (Pilot2A_DevAct_ID11, Pilot2A_DevAct_ID13 and Pilot2A_DevAct_ID16)
Start and End Dates	M22-M25
Validation Activity ID	**Pilot3_ValAct_ID10**
Validation Activity type	Networking Testing
Validation Activity description	Testing of the 5G connectivity for the pilot. Demonstration of the networking functionalities.
Data	Testing data, data from the pilot applications.
Start and End Dates	01/10/2021 (M31) - 31/10/2023 (M36)

4.5. Initial Planning

This pilot plans to carry out several demonstrations in order to successfully demonstrate the four business scenarios described before. However, due to the scarcity of equipment until M20 of the project, only PoCs on laboratory premises for this pilot will be carried out and described on D7.2. Nevertheless, it is expected that all the demos will be validated before the end of the project.

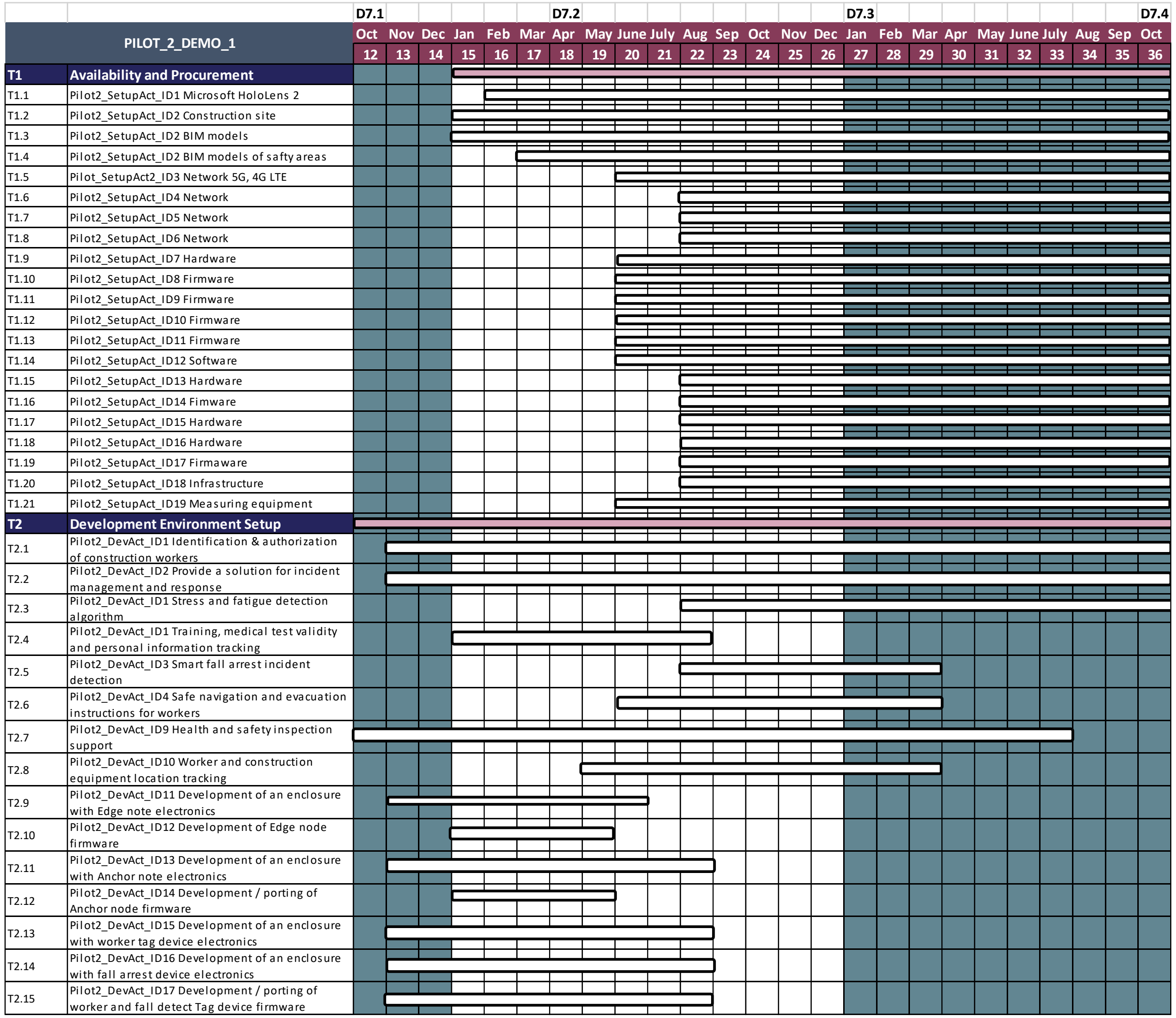


Figure 13. Pilot_2_Demo (Set-up and Development activities) Gantt chart.

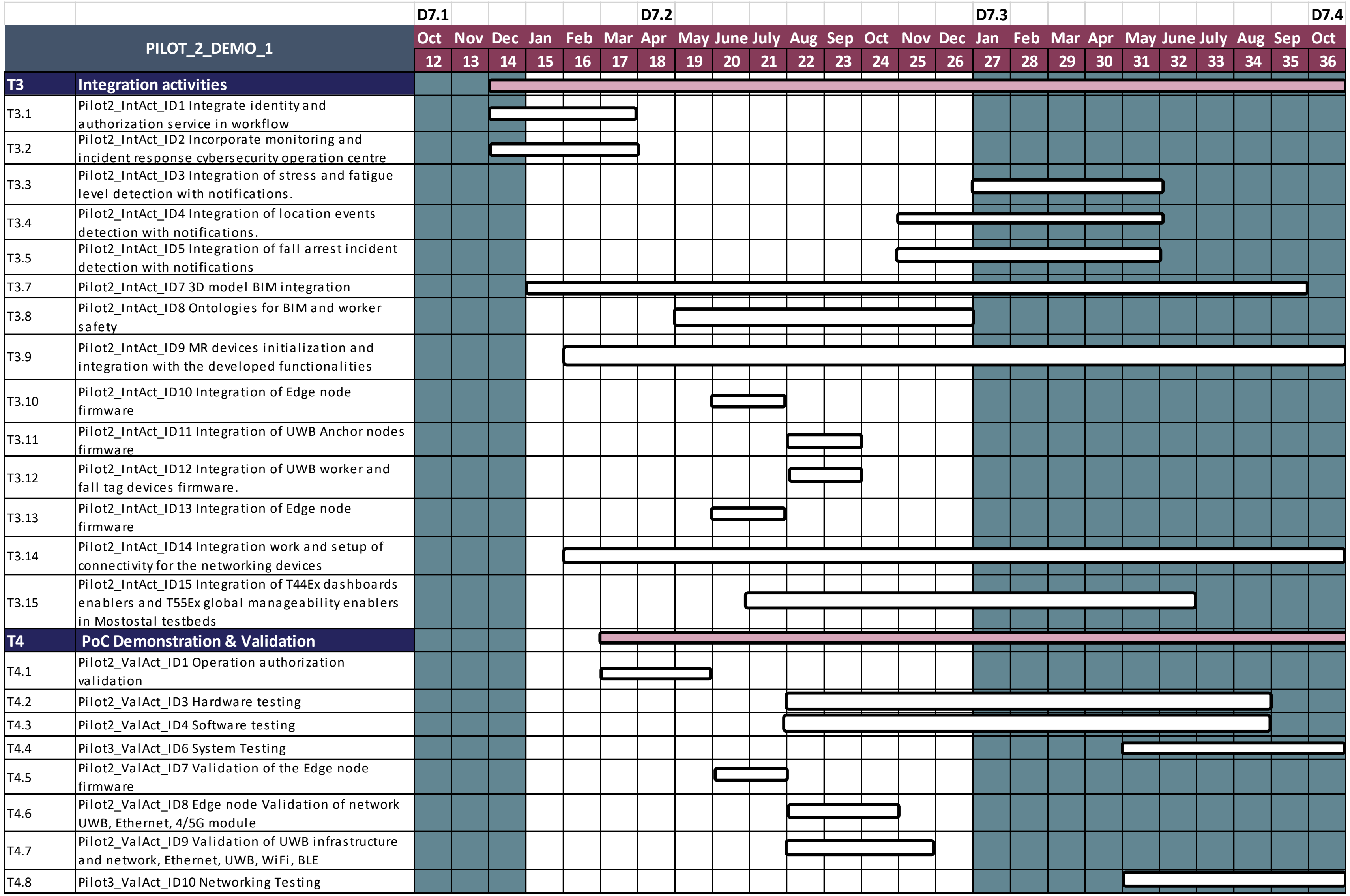


Figure 14. Pilot_2_Demo (Integration and Validation activities) Gantt chart.

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

5.1. Ford car and UPV monitoring premises

Pilot 3A is centred around emissions and enhanced diagnostics at vehicle fleet level. For this purpose, Ford-Werke GmbH has provided a state-of-the-art current production Ford Kuga, which is located at UPV, to allow the intensive driving and testing planned within Pilot 3A. The Ford Kuga is a compact Sports Utility Vehicle (SUV) in the C-size segment, which is built in the Ford Body and Assembly plant in Valencia, Spain. It is sold with a large variety of options, including various Gasoline and Diesel propulsion systems and, depending on the variant, can be offered as a Plug-In Hybrid or Mild-Hybrid.

This part of the Pilot 3A will focus on vehicle emissions and here especially on nitrogen oxides (NOx). Compared to Petrol driven propulsion systems, Diesel propulsion systems are naturally emitting higher amounts of NOx, driving the need for technical solutions on vehicle manufacturer side, like emission aftertreatment, to ensure these NOx levels are below the legal thresholds. Therefore, to ensure a challenging real-world test environment, the decision was made to use a vehicle with a 2.0L EcoBlue Diesel engine and MHEV capabilities. Details of the vehicle are provided in section 5, together with the different hardware and software elements used in the pilot.

Emissions (here especially NOx) can either be measured on the outside of the vehicle, e.g., with the help of a so-called Portable Emission Measuring Systems (PEMS), which is attached to the back of the vehicle during driving and is directly measuring the emissions of the vehicle. This PEMS unit is only useful during designated test drives and neither from size nor from cost perspective a reasonable solution for a vehicle fleet. Another method is to utilise the internal sensors of the vehicle, which are giving enough data to allow vehicle operation within the current legal limits. As these standard production NOx sensors are not accurate enough to account for the likely changes to be seen in the post-EU6 emission legislation context, the idea is to add additional sensors to increase accuracy over vehicle lifetime to the desired level.

Another aspect covered within Pilot 3A are enhanced diagnostic functions in the propulsion system domain. ASSIST-IoT will be utilised to run in-depth diagnostic routines and enhanced data logging functionalities, supported by the ML/AI capabilities, which the infrastructure offers. These enhanced diagnostic functions will offer innovative, close to real-time insight into the vehicle, reducing the time to analyse unknown failures significantly.

In the pilot implementation, and as sketched in the next diagram, different sensors will be available to the ASSIST-IoT framework: series sensor of the engine, series vehicular sensors (available through the vehicle CAN line), additional high fidelity (HiFi) emissions sensors, plus the possibility of including any sensor provided by third parties. A state-of-the-art acquisition system will be used for gathering all these data, and to allow modifications into the vehicle control software.

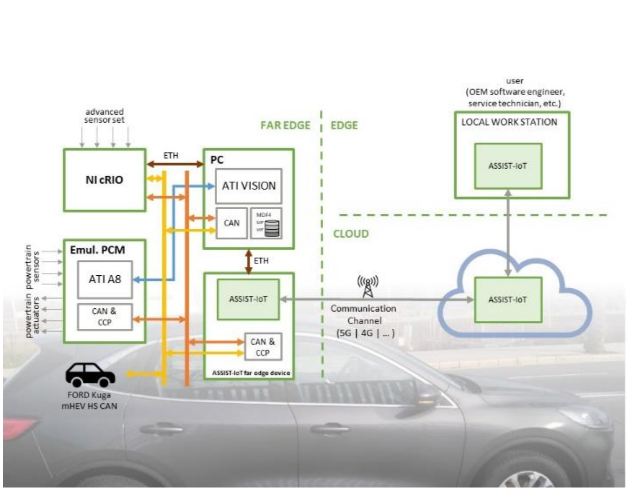


Figure 15. Vehicle provided for the pilot 3A (left); Main schematic of the system setup (right)

The vehicle will be driven in A real-life operation and a variety of cases will be tested, either with respect to driving conditions (urban, road, highway, suburban, long-distance travel, etc.) and to the existence of non-critical faults (sensor bias, clogged air valves, after-treatment malfunction, etc.).

5.2. Requirement's traceability

This Pilot of ASSIST-IoT orbits around the monitoring of vehicle and fleet emission levels during real-life operation, and the deployment of corrective actions when critical levels are reached. Those actions can be done at fleet level, by modifying the Powertrain Control Module (PCM) calibration of a subset of the fleet (for example, for coping with sensor bias) or by detecting non-conformant vehicles and routing them to technical service. ASSIST-IoT is expected to provide an architecture able to ease the many challenges of the pilot: varying sensor sets and driving conditions, coexistent software versions, etc. The pilot has identified two business scenarios, which are detailed in D3.2 [5] and whose short summary is presented next:

BS-P3A-1: Fleet in-service emission verification: This business scenario is focused on determining, from the real-life operation of the vehicles, NO_x and CO_2 emission metrics and deriving fleet emission metrics on vehicle fleet level. We 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 recover desired emission levels (when possible), and the detection of vehicles which are outliers of the 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 must ensure that no malicious code is injected in the vehicle, since it could have significant consequences. **Associated requirements:** R-P3A-1 Monitored Data channels, R-P3A-2 Data models compliance, R-P3A-3 Original Equipment Manufacturer (OEM) Fleet data storage, R-P3A-4 PCM Parametrisation (Calibration) Update Safety and Security, R-P3A-5 Data Storage, R-P3A-9 Edge Intelligence, R-P3A-10 Vehicle Dashboard Notifications, R-P3A-11 Connectivity between OEM and fleet, R-P3A-12 Edge Connectivity, R-C-1 Data sovereignty, R-C-2 Data governance, R-C-3 Compliance with legal requirements on data protection, R-C-6 Data Persistence and Trust.

BS-P3A-2: Vehicle diagnostics: This business 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 developed into two business cases: the first is devoted to the identification of the fault cause by deploying a series of fault detection methods which are deployed to the edge; the second business case is centered on the development of such fault detection methods. **Associated requirements:** R-P3A-1 Monitored Data channels, R-P3A-2 Data models compliance, R-P3A-4 PCM Parametrisation (Calibration) Update Safety and Security, R-P3A-5 Data Storage, R-P3A-6 Active monitoring mode initiation by the OEM software engineer capability, R-P3A-7 Active monitoring mode initiation by the Aftersales service technician capability, R-P3A-8 Active monitoring mode initiation by the driver capability, R-P3A-9 Edge Intelligence, R-P3A-10 Vehicle Dashboard Notifications, R-P3A-11 Connectivity between OEM and fleet, R-P3A-12 Edge Connectivity, P3A-13 Augmented Reality Support at the Garage, R-C-1 Data sovereignty, R-C-2 Data governance, R-C-3 Compliance with legal requirements on data protection, R-C-6 Data Persistence and Trust, R-C-7 Edge-oriented deployment.

The identified enablers contributing to this pilot are identified in the next Table (please refer to Table 1 in Section 2.2 for more details), although it does not preclude potential future inclusion of additional enablers

Table 12. Vehicle in-service emission diagnostics enablers

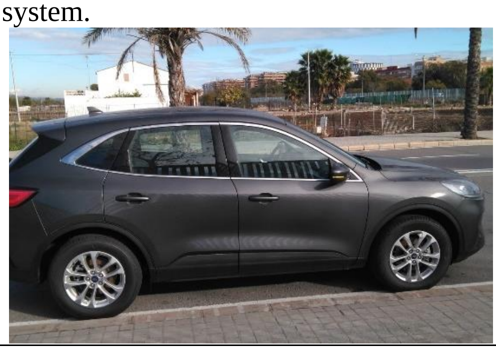
T42	• **T42E1:** Smart orchestrator enabler • **T42E5:** Multi-link enabler • **T42E8:** VPN enabler	**T51**	• **T51E1:** Self-healing device enabler • **T51E2:** Resource provisioning enabler
T43	• **T43E1:** Semantic repository enabler • **T43E2:** Semantic translation enabler • **T43E3:** Semantic annotation enabler • **T43E7:** Edge data broker	**T52**	• **T52E1:** FL Orchestrator • **T52E2:** FL Training collector • **T52E3:** FL Repository • **T52E4:** FL Local Operations

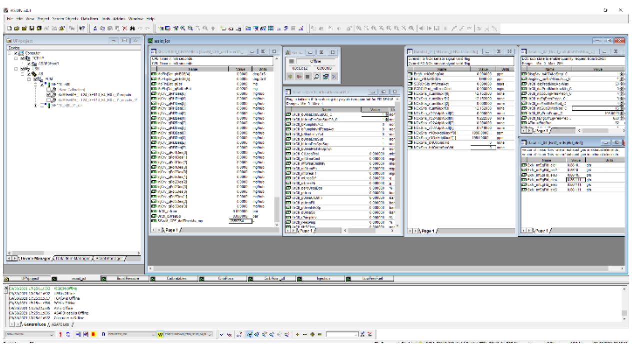
	• **T43E8:** Long-term data storage		• **T52E5** FL Privacy
T44	• **T44E2:** Business KPI reporting enabler • **T44E4:** OpenAPI management enabler • **T44E5:** Video augmentation enabler	**T53**	• **T53E1:** Authorisation enabler • **T53E2:** Identity manager enabler • **T53E3:** Cybersecurity monitoring enabler • **T53E4:** Cybersecurity monitoring agent enabler
T54	• **T54E1:** Logging and auditing enabler • **T54E2:** Data integrity verification enabler	**T55**	• **T55E1:** Management of enablers existence in a deployment • **T55E2:** Management of enablers' results • **T55E3:** Management of services and enablers workflow • **T55E4:** Management of devices in an ASSIST-IoT deployment

5.3. Existing and forthcoming resources

List and a planning of required resources, facilities, connectivity, and logistics for the set-up of Pilot 3A testbed.

Table 13. Pilot 3A set-up activities

Set-Up activity ID	**Pilot3A_SetupAct_ID1**
Resource type	Vehicle
Resource description	Ford KUGA 2.0 mHEV (2020), 6 gear manual transmission vehicle, ready for its use on roads with required documentation and insurance. The vehicle is equipped with a 2.0 common rail direct injection turbocharged Diesel engine, and, as a mild hybrid electrical vehicle- uses advanced start and stop strategies -with a generator-starter working at 48 V. The vehicle has been certified according to EURO 6d-TEMP levels. Between other relevant sensors, the engine has a couple of NO_x/O_2 sensors located upstream and downstream the SCR+DPF system.  
Ready to be used	Yes
Set-Up activity ID	**Pilot3A_SetupAct_ID2**
Resource type	Hardware

Resource description	Open PCM with A8 connection. The powertrain control module of the engine is a research grade unit with A8 Serial Interface module, enabling external access through ASAM XCP protocol on USB. This allows to read data from and write data to the PCM microprocessor memory regions. In this way, the data from the different sensors and internal calculations of the PCM can be externally accessed, and PCM parametrisation (i.e., calibration) may be modified. 
Ready to be used	Yes
Set-Up activity ID	**Pilot3A_SetupAct_ID3**
Resource type	Software
Resource description	PCM control software and base calibration. The PCM is flashed with a production ready software and calibration. This means that the PCM software is equivalent to that of series EURO 6 vehicles in the market. Since in this case the base software is flashed on an open PCM (Pilot3a_SetupAct_ID2) the software parametrisation can be externally varied.
Ready to be used	Yes
Set-Up activity ID	**Pilot3A_SetupAct_ID4**
Resource type	Software
Resource description	ATI VISION 6.0.1 PC software implementing XCP and allowing flashing the open PCM, modifying its parametrisation, and registering the PCM variables. The software can also integrate in the same measurement file variables coming from a USB CAN device (whose messages can be defined in the corresponding *.dbc file), thus allowing to include in the measured data CAN messages from the vehicular HS CAN, or additional sensors connected to the CAN line.  Measured data can be registered into ASAM MDF4 files. Significantly, a Component Object Model (COM) API is also available, thus making possible interfacing ATI VISION with any other program, which allows a series of advanced configurations.
Ready to be used	Yes
Set-Up activity ID	**Pilot3A_SetupAct_ID5**
Resource type	Hardware
Resource description	ATI KVASER USBcan Pro 2xHS V2. USB to dual-channel CAN or CAN FD interface with scripting capabilities. It will be used for connecting to the vehicular HS CAN line for integrating relevant vehicle information (as, for example, GPS data), and for interfacing with external CAN sensors. 
Ready to be used	Yes

Set-Up activity ID	**Pilot3A_SetupAct_ID6**
Resource type	Hardware
Resource description	 National Instruments CompactRIO. Rugged system with a real time controller with a processor running a Linux Real-Time OS and a chassis that contains a user-programmable FPGA. It supports a variety of interchangeable industrial I/O modules for integrating external sensors and actuating over a variety of systems. The system included is based on a cRIO-9049, 1.6 GHz Quad-Core, 325T FPGA, and has modules for analogue input (NI-9220, NI-9223 and NI-9775, allowing sampling rates up to 1 MHz in continuous operation or 20 MHz as a digitizer), CAN (dual-channel NI-9853) and high-speed digital input and output. The system may be programmed for crankshaft angle synchronous acquisition and actuation. This system may allow the integration of high speed sensors provided by third parties.
Ready to be used	Yes
Set-Up activity ID	**Pilot3A_SetupAct_ID7**
Resource type	Hardware
Resource description	Additional (HiFi) emission sensors. Additional sensors to be fitted on the engine exhaust for providing duplicated signal of the relevant emissions. Sensors are equivalent to the series ones but labelled as higher precision by the sensor supplier (the end-of-line data already being provided by the sensor supplier allows such classification). 
Ready to be used	Expected: M13
Set-Up activity ID	**Pilot3A_SetupAct_ID8**
Resource type	Hardware
Resource description	Vehicle onboard PC. A PC for running ATI Vision, connecting to the PCM by USB, and to the CAN lines (vehicular and sensors) with the USBcan. The computer will be also in charge of providing data backup, and orchestration of the data acquisition and segmentation via the API. This PC is also in charge of interfacing the ASSIST-IoT edge device with the PCM flashing and calibration update functionalities. Current configuration is a Intel Core i7-10510U CPU @ 1.80GHz-2.30 GHz, 16 GB RAM and 512 SSD (plus 512 SD card), but the computer may be replaced along the project.
Ready to be used	Yes
Set-Up activity ID	**Pilot3A_SetupAct_ID9**
Resource type	Hardware
Resource description	Dashboard communication system, including interface for driver initiated active monitoring mode.
Ready to be used	No. Developed in Pilot3A_DevAct_ID8

Set-Up activity ID	**Pilot3A_SetupAct_ID10**
Resource type	Hardware
Resource description	AR system for engine service. Augmented Reality system for aiding for service technicians during engine service.
Ready to be used	No. Developed in Pilot3A_DevAct_ID9
Set-Up activity ID	**Pilot3A_SetupAct_ID11**
Resource type	Hardware
Resource description	Remote servers and cloud computing cluster. The cloud computing cluster consists of (i) three servers (each of them with 2x Intel Xeon Gold 6320R, 512 GB RAM and 1 TB SSD), (ii) two high-performance switches (with 48 x 10 Gbps SFP+), and (iii) two Network-attached storage (NAS) servers, each of them with 16 TB SSD In a few months, this cluster will be enhanced with an additional server with the same characteristics, also managing 8 high-performance GPUs
Ready to be used	Yes
Set-Up activity ID	**Pilot3A_SetupAct_ID12**
Resource type	Hardware
Resource description	Raspberry Pi 4 Model B with CAN shield. As a contingency plan and in order to accelerate the integration activities of the project in case ASSIST-IoT far edge node is not available by M15, an available prototyping system has been decided: Raspberry Pi 4 Model B 8GB with power supply, fan and heat sinks, in a Hammond Manufacturing enclosure 1455T1602BK, with Micro SD Card High Speed Class 10 128 GB, 4G/LTE WiFi Dongle, 64 or 128 GB USB 3 Flash Drive and Sabrent Rocket Q Internal SSD 500gb.
Ready to be used	Expected: M12

5.4. Development and integration activities

In this chapter Pilot 3A development, integration, and validation activities are listed and discussed in the following tables.

5.4.1. Development activities

Table 14. Pilot 3A development activities

Development Activity ID	**Pilot3A_DevAct_ID1**
Development Activity Required	Vehicle setup. This activity is centred in the different tasks for adapting the vehicle to the operation of the ASSIST-IoT hardware and elements listed in the previous section. Main tasks are the setup and wiring of electronic systems in the vehicle (providing mechanical attachments, wiring, and powering); and the setup of HiFi sensors (mechanical setup of the additional HiFi sensors in the exhaust line, plus required CAN communication and power wiring).
Dependency	Setup activity.
Start and End Dates	M12 – M14
Development Activity ID	**Pilot3A_DevAct_ID2**

Development Activity Required	Development of vehicle data server. This activity covers the integration of the different elements -open PCM, NI CRIO, HiFi sensor, etc.- in a cohesive acquisition framework, with serves data to the ASSIST-IoT hardware (either via CAN stream or as a series of short MDF4 files). Beyond the development of the data acquisition system, the activity also covers the definition of the channels to be measured, OTA mechanism for varying such list of channels, and an application for segmenting long driving profiles into smaller, self-contained elements (drivelets). The data server is to be connected either to the ASSIST-IoT far edge node, or to an external data repository for research and testing purposes.
Dependency	Setup activity. Needs a certain degree of development of Pilot3A_DevAct_ID1.
Start and End Dates	M12 – M14
Development Activity ID	**Pilot3A_DevAct_ID3**
Development Activity Required	Development of OTA update server and SW update mechanism for updating PCM calibration or varying diagnostics functions within ASSIST-IoT framework. In this activity the procedure for the remote update of the PCM firmware must be stablished. The system will profit VISION API for modifying the calibration (i.e. PCM parameterisation). Two main options for the update process are foreseen: gradual, additive updates, where the parameters of the calibration in use is performed over the existing calibration; and replacement of the complete PCM calibration by a new calibration set.
Dependency	Setup activity. Needs a certain degree of development of Pilot3A_DevAct_ID1.
Start and End Dates	M12 – M14
Development Activity ID	**Pilot3A_DevAct_ID4**
Development Activity Required	Setup of the remote server. Setting up the remote server which, together with the ASSIST-IoT related functions, must provide support for the following pilot-oriented functionalities: storage of driving data and fleet database, server for calibration updates, sever for diagnostic methods.
Dependency	Setup activity.
Start and End Dates	M12 – M14
Development Activity ID	**Pilot3A_DevAct_ID5**
Development Activity Required	Development of data analytics for fleet ISE. The objective of this activity is to provide a set of tools for, on one hand, getting ISE metrics for the considered vehicle in real life operation, and in other hand, to evaluate the results with regards to the complete fleet for deriving conclusions on fleet emission metrics and detect outliers. Main tasks within the activity are: the development of NOx and CO2 emission observers, able to filter and improve the estimate of the pollutant emission from a set of measurements, considering that sensors of different precision may be present; the development of dynamic criteria verification of driving sections, based on Real Driving Emission (RDE) requirements; ISE distribution reporting and drift analysis; global modelling of ISE, for deriving models of the fleet as whole as a function of the driving and use conditions; and local modelling and hypothesis test for fault detection, with the focus of detecting if the considered vehicle is to be marked as faulty. From the experimental point of view, this activity will use data from driving profiles using the series calibration and without emulating any failure in the vehicle operation. Since the activity is to be performed while ASSIST-IoT architecture has not been deployed, data will be stored in MDF4 files and analyzed offline. This task is centred in the development of the *Main execution flow* of UC-P3A-1.
Dependency	Pilot3A_DevAct_ID1, Pilot3A_DevAct_ID2

Start and End Dates	M13 – M16
Development Activity ID	Pilot3A_DevAct_ID6
Development Activity Required	Development of learning methods for calibration update methods. The activity covers the development of methods for correcting In-Service Emission SE levels (ISE) by modifying the PCM calibration. For this purpose, the calibration is updated, assessed, and downloaded to target vehicles, either to a whole fleet or to a selected sub-fleet. Afterwards the effect of the calibration update will be confirmed using the edge node and cloud capabilities of ASSIST-IoT. Two different possibilities are to be investigated: manual, where the calibration is modified, its effect assessed and then downloaded to the target vehicles; and automated, where federated learning is to be harnessed. For supporting this activity, real-life data using the series calibration with bias included in different sensors or actuation variables will be generated. This task is centred in the development of the *Alternative execution flow* of UC-P3A-1.
Dependency	Pilot3A_DevAct_ID3, Pilot3A_DevAct_ID4, Pilot3A_DevAct_ID5
Start and End Dates	M17 – M22
Development Activity ID	**Pilot3A_DevAct_ID7**
Development Activity Required	Development of methods for vehicle diagnostics. The task covers the development of methods for, given a vehicle identified as an outlier of the ISE distribution, identifying the failure source. In a later step, this will be used for providing instructions to the driver and the service technician for solving the issue. The identification of the failure source is done assuming there is a pre-existent pool of failure models, which will be populated in this task for a list of selected failures. In order to provide this initial pool of models, non-destructive faults will be emulated or created in the vehicle. In this sense, data from Pilot3A_DevAct_ID6 containing bias in the calibration will also be profited. This task is centred in the development of UC-P3A-2.
Dependency	Pilot3A_DevAct_ID1, Pilot3A_DevAct_ID2, Pilot3A_DevAct_ID3, Pilot3A_DevAct_ID4, Pilot3A_DevAct_ID6
Start and End Dates	M22 – M27
Development Activity ID	**Pilot3A_DevAct_ID8**
Development Activity Required	Development of driver interface device. A driver interface able to communicate with ASSIST-IoT hardware will be developed. The driver interface will allow to send textual messages to the driver, and to initiate the active diagnostic mode.
Dependency	Setup activity
Start and End Dates	M23 – M25
Development Activity ID	**Pilot3A_DevAct_ID9**
Development Activity Required	Development of AR assistance for vehicle servicing. AR implementation of repairing instructions for selected fault(s), which will provide to the service technician instructions on identifying and fixing a detected fault (e.g., replace a clogged EGR valve, or replace a sensor).
Dependency	Setup activity
Start and End Dates	M26 – M31
Development Activity ID	**Pilot3A_DevAct_ID10**

Development Activity Required	Development of learning methods for diagnostics algorithms. In this activity a set of functions for automated and semi-automated development of diagnostic functions are targeted. It is foreseen that following steps will be taken: (1) supervised deployment of software emulated failures to vehicle (e.g., sensor bias, urea injection problems, etc.), mainly effecting vehicle emissions. (2) Creating a database, including emulated defect vehicle data (3) Identifying significant data patterns for different failure types (4) Use ML capabilities to identify similar patterns with the help of ASSIST-IoT in real-life. This task is centred in the development of UC-P3A-3.
Dependency	Pilot3A_DevAct_ID7
Start and End Dates	M26 – M31

5.4.2. Integration activities

Table 15. Pilot 3A integration activities

Integration Activity ID	**Pilot3A_IntAct_ID1**
Integration Activity Required	Integration of smart Network and Control (T42) and Self* (T51) enablers. The identified key enablers are: • T42E1 Smart orchestrator enabler, for function deployment and orchestration. • T42E5 Multi-link enabler: as a mobile system, the vehicle will suffer connection availability issues, frequent network changes (including international borders), etc. • T42E8 VPN enabler, which is expected to provide a secure connection between the far edge node and the remote servers. • T51E1 Self-healing device enabler, for system recovery. • T51E2 Resource provisioning enabler, for dynamic provisioning of resources. Some of the enablers in this task will be required for the initial integration of the Pilot, and hence three iterations are planned, corresponding with the different pilot demonstrations.
Dependency	• First iteration (to be validated in Pilot3a_ValAct_ID1): Pilot3A_DevAct_ID5 • Second iteration (to be validated in Pilot3a_ValAct_ID2): Pilot3A_DevAct_ID6 • Third iteration (to be validated in Pilot3a_ValAct_ID3): Pilot3A_DevAct_ID7 to ID10
Start and End Dates	• First iteration (to be validated in Pilot3a_ValAct_ID1): M15 to M18 • Second iteration (to be validated in Pilot3a_ValAct_ID2): M22 to M25 • Third iteration (to be validated in Pilot3a_ValAct_ID3): M31 to M34
Integration Activity ID	**Pilot3A_IntAct_ID2**
Integration Activity Required	Integration of semantic data management (T43) enablers. The identified key enablers are: • T43E1 Semantic repository enabler • T43E2 Semantic translation enabler • T43E3 Semantic annotation enabler All of them may contribute for data integration coming from sources corresponding to different vehicle variants, sensor sets, software versions, etc. This feature will be significantly needed for the integration of Pilot3a_DevAct_ID6, Pilot3a_DevAct_ID7 and Pilot3a_DevAct_ID10, since there is data coming from different software and failure cases is to be combined.
Dependency	• First iteration (to be validated in Pilot3a_ValAct_ID2): Pilot3a_DevAct_ID6 • Second iteration (to be validated in Pilot3a_ValAct_ID3): Pilot3a_DevAct_ID7 to ID10
Start and End Dates	• First iteration (to be validated in Pilot3a_ValAct_ID2): M22 to M25 • Second iteration (to be validated in Pilot3a_ValAct_ID3): M31 to M34
Integration Activity ID	**Pilot3A_IntAct_ID3**

Integration Activity Required	Integration of data broker. • T43E7 Edge data broker, for data management from edge side This data broker will be integrated when available, for replacing any ad hoc solution developed in the setup activities of the pilot.
Dependency	• First iteration (to be validated in Pilot3a_ValAct_ID2): Pilot3a_DevAct_ID6 • Second iteration (to be validated in Pilot3a_ValAct_ID3): Pilot3a_DevAct_ID7 to ID10
Start and End Dates	• First iteration (to be validated in Pilot3a_ValAct_ID2): M22 to M25 • Second iteration (to be validated in Pilot3a_ValAct_ID3): M31 to M34
Integration Activity ID	**Pilot3A_IntAct_ID4**
Integration Activity Required	Integration of LTSE, application and services (T44) enablers, and manageability (T55) enablers: • T43E8 Long-term data storage, for data management from server side. • T44E2 Business KPI reporting enabler, for reporting by filtering and analysing data repository (e.g., in service emission metrics, vehicle fleet clustering, detection of faulty units, etc.) • T44E4 OpenAPI management enabler, allowing the access to selected data by third parties. • T44E5 Video augmentation enabler AR support for engine service operations (needed for the integration of Pilot3a_DevAct_ID9). • T55Ex Manageability enablers for managing the deployment of ASSIST-IoT enablers, services, devices, and workflows.
Dependency	• First iteration (to be validated in Pilot3a_ValAct_ID1): Pilot3a_DevAct_ID5 • Second iteration (to be validated in Pilot3a_ValAct_ID2): Pilot3a_DevAct_ID6 • Third iteration (to be validated in Pilot3a_ValAct_ID3): Pilot3a_DevAct_ID7 to ID10
Start and End Dates	• First iteration (to be validated in Pilot3a_ValAct_ID1): M16 to M18 • Second iteration (to be validated in Pilot3a_ValAct_ID2): M22 to M25 • Third iteration (to be validated in Pilot3a_ValAct_ID3): M31 to M34
Integration Activity ID	**Pilot3A_IntAct_ID5**
Integration Activity Required	Integration of Federated Learning (T52) enablers: • T52E1 FL Orchestrator • T52E2 FL Training collector • T52E3 FL Repository • T52E4 FL Local Operations • T52E5 FL Privacy Federated learning is expected to be used for accelerating the optimization of the PCM calibration (Pilot3a_DevAct_ID6), and also for the development of failure detection models (Pilot3a_DevAct_ID10).
Dependency	• First iteration (to be validated in Pilot3a_ValAct_ID2): Pilot3a_DevAct_ID6 • Second iteration (to be validated in Pilot3a_ValAct_ID3): Pilot3a_DevAct_ID7 to ID10
Start and End Dates	• First iteration (to be validated in Pilot3a_ValAct_ID2): M22 to M25 • Second iteration (to be validated in Pilot3a_ValAct_ID3): M31 to M34
Integration Activity ID	**Pilot3A_IntAct_ID6**
Integration Activity Required	Integration of Cybersecurity (T53) enablers: • T53E1 Authorisation enabler • T53E2 Identity manager enabler • T53E3 Cybersecurity monitoring enabler • T53E4 Cybersecurity monitoring agent enabler Cybersecurity with emphasis of denying malicious connections and, significantly, software updates (hence related with Pilot3a_DevAct_ID6 and Pilot3a_DevAct_ID10)
Dependency	• First iteration (to be validated in Pilot3a_ValAct_ID1): Pilot3a_DevAct_ID5

	• Second iteration (to be validated in Pilot3a_ValAct_ID2): Pilot3a_DevAct_ID6 • Third iteration (to be validated in Pilot3a_ValAct_ID3): Pilot3a_DevAct_ID7 to ID10
Start and End Dates	• First iteration (to be validated in Pilot3a_ValAct_ID1): M16 to M18 • Second iteration (to be validated in Pilot3a_ValAct_ID2): M22 to M25 • Third iteration (to be validated in Pilot3a_ValAct_ID3): M31 to M34
Integration Activity ID	**Pilot3A_IntAct_ID7**
Integration Activity Required	Integration of DLT-based (T54) enablers: • T54E1 Logging and auditing enabler • T54E2 Data integrity verification enabler DLT is expected to be used for ensuring data integrity, with emphasis on emission metrics from the vehicles to observer third parties.
Dependency	• First iteration (to be validated in Pilot3a_ValAct_ID2): Pilot3a_DevAct_ID6 • Second iteration (to be validated in Pilot3a_ValAct_ID3): Pilot3a_DevAct_ID7 to ID10
Start and End Dates	• First iteration (to be validated in Pilot3a_ValAct_ID2): M22 to M25 • Second iteration (to be validated in Pilot3a_ValAct_ID3): M31 to M34

5.4.3. Demonstration and Validation activities

Table 16. Pilot 3A validation activities

Validation Activity ID	**Pilot3A_ValAct_ID1**
Validation Activity type	System testing.
Validation Activity description	This activity will focus 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). In this first iteration of the validation, the enablers expected to be integrated are those related to the network architecture and physical layer (Pilot3A_IntAct_ID1 Integration of smart Network and Control (T42) and Self* (T51) enablers), long term storage and application layer (Pilot3A_IntAct_ID4 Integration of LTSE, application and services (T44) enablers), and cybersecurity (Pilot3A_IntAct_ID6 Integration of Cybersecurity (T53) enablers). The goal is to demonstrate an initial system based on ASSIST-IoT architecture able to support ISE determination at both vehicle and fleet level.
Data	Real life data illustrating use cases for the scenario.
Responsible Partner	UPV
Start and End Dates	M17-M18
Validation Activity ID	**Pilot3A_ValAct_ID2**
Validation Activity type	System testing.
Validation Activity description	This activity will be centered in the validation and demonstration of the Alternative execution flow of UC-P3A-1 Fleet in-service conformity verification (i.e., 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, it is expected that all the identified enablers may be integrated, as described in the integration activities list. While in the first validation only monitoring of the system will be done, in this iteration the system will support interaction between a remote user (OEM software engineer) and the vehicle PCM.

Data	Real life data illustrating use cases for the scenario.
Responsible Partner	UPV
Start and End Dates	M25-M27
Validation Activity ID	**Pilot3A_ValAct_ID3**
Validation Activity type	System testing.
Validation Activity description	This activity 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 update of the UC-P3A-1 will be validated.
Data	Real life data illustrating use cases for the scenario.
Responsible Partner	UPV
Start and End Dates	M34-M36
Validation Activity ID	**Pilot3A_ValAct_ID4**
Validation Activity type	System testing.
Validation Activity description	Open call support. Experimental activities for demonstration of the Open calls in the pilot 3A.
Data	Training data and validation of the use cases.
Responsible Partner	UPV
Start and End Dates	M19-M36

5.5. Initial Planning

Due to the nature of the pilot, and because a single prototype vehicle is to be used, activities have been arranged in a serialized way. In this pilot, significant testing will be used for gathering relevant data for the technical development activities. These test campaigns will be interleaved with use case demonstration activities. The validation will be iterative in the sense that the complete features developed in previous phases of the project will also be checked. The shades of blue of the bars allow to relate the development, integration and validation activities for each one of the three demonstrations of the project

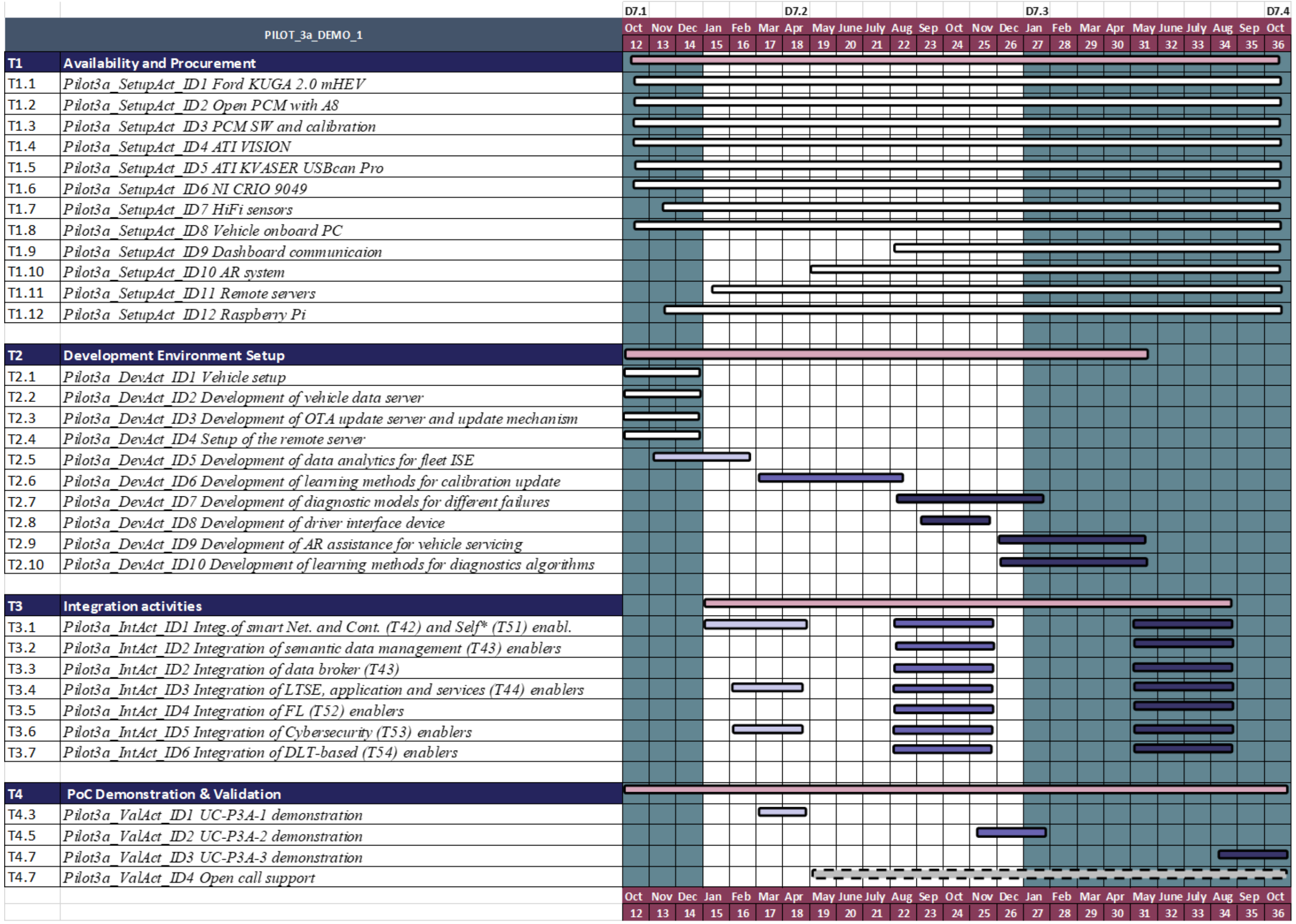


Figure 16. Pilot_3A_Demos Gantt chart.

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

6.1. Vehicle scanner warehouse

Pilot 3B aims at supporting humans active in the automotive industry with tasks relevant to the inspection and monitoring of the conditions of the exterior surface of the vehicles. Numerous entities hold an interest in the vehicles' exterior condition. Such entities are auto houses and repair garages, end-users as car owners, transporters, and fleet operators. These entities have different motivations that are associated with their business cases, but they have a vested interest in employing serviceable vehicles. Their interest stems from the fact that exterior damages have implications on a vehicle's valuation along with the ability to be reliable on the road.

TwoTronic is a pioneer in digitally scan vehicles of all relevant sizes with high resolution cameras towards a 360° acquisition & recording of their external shape. Vehicle digitalization can help in accelerating manual inspection tasks with physical presence, improving operational processes, and achieving higher accuracy. The digitalization process commences when a vehicle passes via the scanner which captures the vehicle's exterior condition in multiple camera frames. Beyond the manual inspection of the vehicle external condition by reviewing the scanned pictures, also automated, AI-based inspection substantially increases the overall process performance from both qualitative as well as business perspective. As the scanner is the cornerstone for TwoTronic's pilot, the partner will make available a scanner for tests on its premises (see corresponding picture below).

Figure 17. Digital scanner at TwoTronic premises

A full ASSIST-IoT technologies ecosystem will be continuously installed and used for the pilot operation with its tests and evaluation. Having all necessary components under own control, it facilitates a fast and effective deployment of next ASSIST-IoT technological components in an agile manner. As no real customer-related operations are daily ongoing, the scanner can be optimally exploited for the pilot project needs. Beyond this installation, originally foreseen for the project, additional discussions are currently ongoing with several pilot customers in the automotive and transport branches to add additional resources for the operation of the pilot 3B. They already have or will have such a scanner at their own premises, operating in their everyday operations, thus contributing with a vast amount of very useful data. Additionally, they may agree to test some of the ASSIST-IoT technologies in their application landscape, providing an additional testbed for the pilot phase of the project. In these cases, more actors would be interacting with the system, supporting more parameters and options to be tested during the pilot project. The whole landscape of such an operational system is given in the next picture.

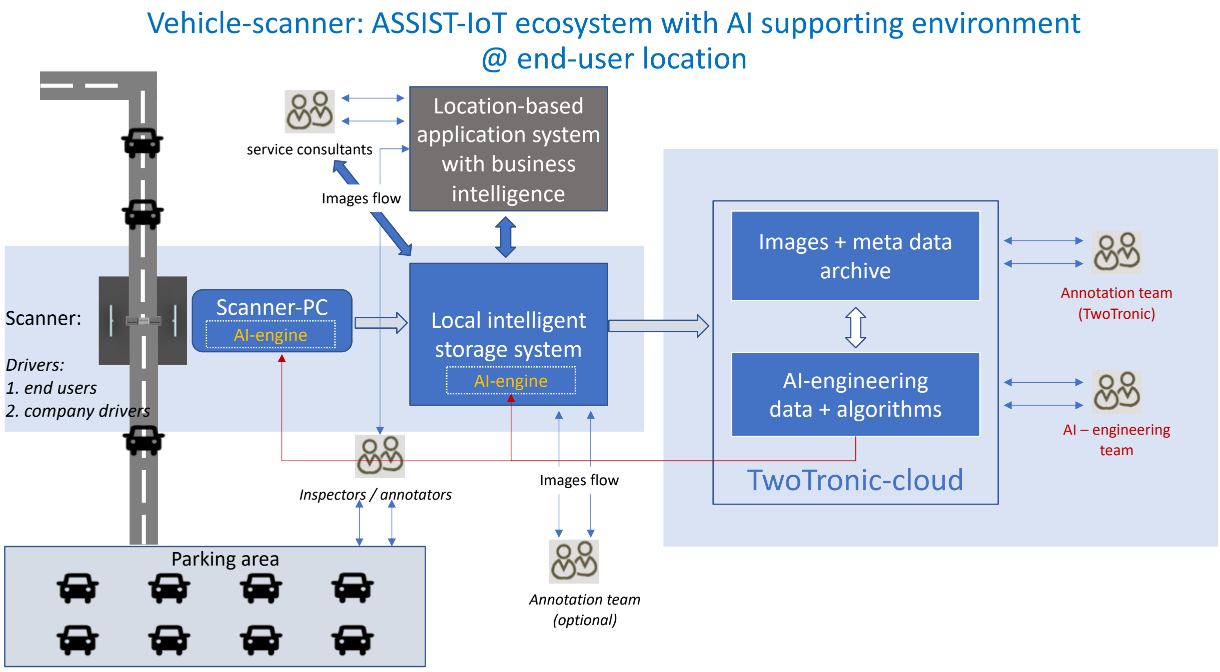


Figure 18. Testbed ecosystem with various optional elements

As one can deduct from the above, the scanner acts as the initial component of the pipeline to deploy the AI solution. The scanner captures the current condition of vehicles in frames. After acquiring the frames, the options are to either transmit the data or to have the scanner run algorithms with its local computational capacity. It is apparent that other components of the application are the image recognition algorithm and the cloud infrastructure. Essentially, the scanner offers machine-readable files that image recognition algorithms can make use of. The training currently is taking place in a centralized system deployed based on the cloud. It should be noted that human intervention is indispensable in the model's deployment. The necessity lies in the dependence on a ground truth to improve the performance of the models. Hereby, the annotation team accesses the images for reviewing by secured VPN-networks, what makes the annotation process more flexible with respect to the location of the annotation-team members.

The scanner is customisable as there are optional features that can enhance its operation. For instance, the AI-supporting inspection system and modules for underbody scanning and tread profiling are optional, and vendors can ask them to be included. An example of such a scanner for car-size vehicles at a pilot customer location is given in the following picture

Figure 19. Indoor scanner - car size

6.2. Requirement's traceability

In this specific pilot for the ASSIST-IoT project, the focal point is on the vehicular exterior condition and the consequent support of human tasks. Specifically, the pilot focuses on the documentation and monitoring of the vehicles' exterior conditions with advanced digitalisation technologies, ergonomic visualisation techniques, and AI-based automated inspection of surface damages. The vehicles' condition is a subject for any vehicle owner regardless of being a single person or an entity. The vehicle's exterior condition is a factor with a range of implications. A human can perform manual vehicle inspection, but the latest advances in the computer vision field are encouraging the adoption of an automated procedure that can be faster and more precise. ASSIST-IoT is expected to support the accelerated results and efficient data management in a secure and decentralized way with its suggested architecture. As the business uses are varying, a single and general business scenario with two use cases is identified and the two underlying use cases are presented in the following section.

The UC-P3B-1 is titled "Vehicle's exterior condition documentation" and concerns the vehicle scanning and the documentation of its condition in frames captured by the scanner.

The UC-P3B-2 is referenced as "External defects detection support" and is about the information verification recorded by the scanner and identified by an AI-based model.

T42	• **T42E1:** Smart orchestrator enabler • **T42E2:** SDN controller • **T42E3:** Auto-configurable network enabler • **T42E4:** Traffic Classification enabler • **T42E6:** SD-WAN enabler • **T42E7**: SD-WAN accelerator enabler	**T51**	• **SELF12**: Resource provisioning enabler • **SELF14**: Monitoring and notifying enabler • **SELF15:** Automated configuration enabler
T43	• **T43E3** Semantic annotation enabler • **T43E7** Edge data broker • **T43E8** Long-term data storage	**T52**	• **T52E1:** FL Orchestrator • **T52E2:** FL Training collector • **T52E3:** FL Repository • **T52E4:** FL Local Operations • **T52E5:** FL Privacy
T44	• **T44E1:** Tactile dashboard enabler • **T44E2:** Business KPI reporting enabler • **T44E4:** OpenAPI management enabler • **T44E5:** Video augmentation enabler	**T53**	• **T53E1:** Authorisation enabler • **T53E2:** Identity manager enabler • **T53E3**: Cybersecurity monitoring enabler • **T53E4**: Cybersecurity monitoring agent enabler
T54	• **T54E1** Logging and auditing enabler • **T54E2** Data integrity verification enabler • **T54E4:** DLT-based Federated Learning		

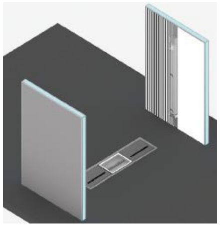
Table 17 Vehicle's exterior condition enablers

6.3. Existing and forthcoming resources

List and a planning of required resources, facilities, connectivity, and logistics for the set-up of Pilot 3B is presented in the next table

Table 18. Pilot 3B set-up activities

Set-Up activity ID	**Pilot3B_SetupAct_ID1**

Resource type	System
Resource description	 TwoTronic digital scanner 3.0 VAN: a scanner in VAN-version, ready to scan vehicles up to 2.8 m height, being ideally driven through the scanner with a velocity between 3-8 Km/h. Digital outdoor documentation system for vehicles up to 2.8m height as a basic system. The image acquisition panels with their re-positional, high-resolution cameras and the system lighting form the basic building blocks of the system. It optically records the exterior condition of the car, without underbody, in both directions of travel in an automated process incl. license plate recognition & position determination in the scanner. Included in the system are:    • An integrated Industrial PC-Server (motherboard with min. an i7 CPU, 32 GB main memory, local SSD-disc) as edge node • Several high-resolution global shutter cameras (12 Megapixel Flir-colour cameras), in the case of the VAN-version 4 cameras per side • Sensor technology for vehicle detection (a SICK-Lidar and optionally additional 3D-depth-sensors) • Motion drivers to rotate the camera-pillars according to the actual vehicle position inside the scanner • LED-signalling on both scanner sides to indicate to the vehicle driver the system readiness, that he can pass through the scanner (the scanner offers bi-directional vehicles travel) • High-bandwidth Giga-Ethernet network connecting all sensing cameras with the central control unit of the scanner • Advanced LED-based lighting system for optimal vehicle illumination according to the actual environmental light conditions, including deflectometry stripes to enhance the recognition of small surface damages (particularly dents and pain-chips) • A high-performance graphics subsystem to support the required power on the edge for several AI-based operations (like person- & licence plate anonymization, advanced colour image processing & AI-based surface inspection). The current implementation choice is the NVIDIA 30xx-series with CUDA. • Mobile network antenna to connect the scanner system with the internet (currently is 4G in plan).
Ready to be used	No, some current components will be replaced by newer versions in Dec-21 and additional components must be added for full functionality; actual delivery time is M18. The system can however start operation in M14. Over the pilot operation, several upgrade options will be checked and potentially executed, according to the intermediate results and expectations
Set-Up activity ID	**Pilot3B_SetupAct_ID2**
Resource type	System
Resource description	Local Intelligent Storage System: it has two functions. It expands the short-term, real-time oriented image storage system of the industrial PC-environment and serves as long-term imaged and meta-data storage system for information retrieval for user-requests as well as for AI-training operations, eventually supporting both distributed and federated learning. A QNAP NAS will be the starting system configuration. It is also capable to feature a high-performance graphic-card (current plan is the NVIDIA 30xx-series) for AI-support.

	
Ready to be used	Yes, detailed storage configuration is however expected to vary over the time.
Set-Up activity ID	**Pilot3B_SetupAct_ID3**
Resource type	Software
Resource description	Real time system controller to coordinate all scanner activities with main functionalities featuring vehicle images acquisition system with multiple queues to allow high-frequency vehicle scanning, vehicle position system, advanced illumination control, advanced image processing system, actuator control system for the rotation of the pillars, who carries the multiple cameras.
Ready to be used	Yes, with continuous improvements over the pilot project time to support the upcoming ASSIST-IoT modules with their functionalities and interfaces
Set-Up activity ID	**Pilot3B_SetupAct_ID4**
Resource type	Software
Resource description	Web-based frontend & visualization software to (i) handle the large amount of data and images incl. the local intelligent storage system, (ii) to serve user-requirements for information retrieval and ergonomic visualisation of the vehicle images towards manual damage inspections, (iii) to support the annotation and reviewing process for the creation of the ground truth base for the AI-training
Ready to be used	First pilot will be available in two months from the beginning of the corresponding WP, i.e., in M15 of the project
Set-Up activity ID	**Pilot3B_SetupAct_ID5**
Resource type	Software
Resource description	**AI-based automated surface inspection.** The underlying ML-algorithms to offer the automated vehicle surface inspection. A first concept will be developed on the base of common efforts of CERTH / TwoTronic to allow for a fast prototyping of the whole AI-process and AI-engineering. Subsequent versions will be available for the pilot system according to the core R&D plan of the project.
Ready to be used	First prototype is ready to be used. Additional concepts shall be implemented in an agile way and will be accordingly used to gain experience from the application.
Set-Up activity ID	**Pilot3B_SetupAct_ID6**
Resource type	Platform
Resource description	**Pilot scanners** installed at automotive garages & automotive branches and continuously delivering vast number of images from many different vehicle types.
Ready to be used	Currently it is possible to us multiple pilot scanners as images-delivering platforms under certain conditions. The gathered data can be used already now in manifold ways to support both centralizes, de-centralized as well as federated learning approaches for the AI-algorithms.

	Current negotiations with these pilot-owners aim to keep the data source during the pilot project, at least for one year.
Set-Up activity ID	**Pilot3B_SetupAct_ID7**
Resource type	Asset
Resource description	**Vehicle images and corresponding annotations** providing the necessary ground truth for the AI-machine learning
Ready to be used	Yes, continuously growing number of images & annotations, which is mandatory for a reasonable ground-truth base for the AI-training
Set-Up activity ID	**Pilot3B_SetupAct_ID8**
Resource type	Hardware - system
Resource description	**End-user-tablets and / or other smart mobile devices** like smartphones used as edge nodes to both gather information about the conditions of a scanned vehicle or display relevant application information, like vehicle images and defect-proposals, previously scanned and processed by the entire application chain of the ecosystem. Selected tablets could additionally have also depth-sensors to support AR-aspects for reviewing vehicles damages
Ready to be used	Hardware yes, first application software in M15 (depending on the availability of the web-based frontend software).

6.4. Development and integration activities

In this chapter Pilot 3B development, integration, and validation activities are listed and discussed in the following tables.

6.4.1. Development activities

Table 19. Pilot 3B development activities

Development Activity ID	**Pilot3B_DevAct_ID1**
Development Activity Required	Scanner preparation and setup. In this activity, the scanner and its underlying infrastructure will be prepared and adapted for the operations that will take place in ASSIST-IoT hardware and elements.
Dependency	Setup activity
Start and End Dates	M13 – M18
Development Activity ID	**Pilot3B_DevAct_ID2**
Development Activity Required	Design and set up the remote server for the activities in the pilot site. The activities are around the vehicle images, model learning, and the visualization of the results to users. The server should accommodate the storage of images, be in a position to support the federated learning architecture, and post visualization results to end-users.
Dependency	Setup activity
Start and End Dates	M14 – M33
Development Activity ID	**Pilot3B_DevAct_ID3**
Development Activity Required	Development of user interface device. End-users require results either in the images raw format or the results from the trained models. The visualization solutions can be adaptable

	as a wide range is applicable to each end-user. Solutions in the AR field can be revolutionary for the automotive sector.
Dependency	Pilot3B_IntAct_ID4, Pilot3B_IntAct_ID7
Start and End Dates	M14 – M33
Development Activity ID	**Pilot3B_DevAct_ID4**
Development Activity Required	Development of learning methods for vehicle exterior condition monitoring/inspection. The activity targets the support of deploying AI procedures for defect recognition on the vehicles. The collaborative training method of Federated Learning is an intriguing component to produce models with a plethora of data. The training that takes place in the pilot site belongs to the supervised learning methods and necessitates human interaction with the data to provide the ground truth for the newly acquired data that will be included in the training.
Dependency	N/A
Start and End Dates	M14 – M33
Development Activity ID	**Pilot3B_DevAct_ID5**
Development Activity Required	The application of security components is vital to safeguard privacy and deter any malicious actions. The activity is documented as part of the DevSecOps strategy that calls for the continuous adoption of security in every Development cycle.
Dependency	Pilot3B_IntAct_ID5, Pilot3B_IntAct_ID6
Start and End Dates	M14 – M33

6.4.2. Integration activities

Table 20. Pilot 3B integration activities

Integration Activity ID	**Pilot3B_IntAct_ID1**
Integration Activity Required	Integration of the smart network. The list of enablers for constructing the smart network are: • T42E1: Smart orchestrator enabler • T42E2: SDN controller • T42E3: Auto-configurable network enabler • T42E4: Traffic Classification enabler • T42E6: SD-WAN enabler • T42E7: SD-WAN accelerator enabler
Dependency	Pilot3B_ValAct_ID1-TWO (M15 – M18) Pilot3B_ValAct_ID2-TWO (M24 - M28) Pilot3B_ValAct_ID3-TWO (M32 – M36)
Start and End Dates	M16 – M35
Integration Activity ID	**Pilot3B_IntAct_ID2**
Integration Activity Required	Integration of smart plane with the self-capabilities. The list of enablers that can apply the self-capabilities are: • SELF12: Resource provisioning enabler • SELF14: Monitoring and notifying enabler • SELF15: Automated configuration enabler
Dependency	Pilot3B_ValAct_ID1-TWO (M15 – M18) Pilot3B_ValAct_ID2-TWO (M24 - M28) Pilot3B_ValAct_ID3-TWO (M32 – M36)

Start and End Dates	M16 – M35
Integration Activity ID	**Pilot3B_IntAct_ID3**
Integration Activity Required	Federated Learning deployment for the collaborative learning process. The relevant enablers are: • T52E1:FL Orchestrator • T52E2:FL Training collector • T52E3:FL Repository • T52E4:FL Local Operations
Dependency	Pilot3B_ValAct_ID1-TWO (M15 – M18) Pilot3B_ValAct_ID2-TWO (M24 - M28) Pilot3B_ValAct_ID3-TWO (M32 – M36)
Start and End Dates	M17 – M35
Integration Activity ID	**Pilot3B_IntAct_ID4**
Integration Activity Required	Procedures that will support the storage. The enablers are: • T43E3: Semantic annotation enabler • T43E7: Edge data broker • T43E8: Long-term data storage
Dependency	Pilot3B_ValAct_ID1-TWO (M15 – M18) Pilot3B_ValAct_ID2-TWO (M24 - M28) Pilot3B_ValAct_ID3-TWO (M32 – M36)
Start and End Dates	M17 – M36
Integration Activity ID	**Pilot3B_IntAct_ID5**
Integration Activity Required	Security components are to be incorporated along the whole procedure of development as part of the DevSecOps procedure. The enablers that are to be included are: • T53E1: Authorisation enabler • T53E2: Identity manager enabler • T53E3: Cybersecurity monitoring enabler • T53E4: Cybersecurity monitoring agent enabler
Dependency	Pilot3B_ValAct_ID1-TWO (M15 – M18) Pilot3B_ValAct_ID2-TWO (M24 - M28) Pilot3B_ValAct_ID3-TWO (M32 – M36)
Start and End Dates	M17 – M36
Integration Activity ID	**Pilot3B_IntAct_ID6**
Integration Activity Required	With the objective of security, the DLT infrastructure is to be supported in the pilot. The relevant enablers are: • T54E1: Logging and auditing enabler • T54E2: Data integrity verification enabler • T54E4: DLT-based Federated Learning
Dependency	Pilot3B_ValAct_ID1-TWO (M15 – M18) Pilot3B_ValAct_ID2-TWO (M24 - M28) Pilot3B_ValAct_ID3-TWO (M32 – M36)
Start and End Dates	M18 – M36

Integration Activity ID	Pilot3B_IntAct_ID7
Integration Activity Required	Application and Services Plane, as well as Manageability incorporation in pilot. The underlying enablers are envisioned to be: • T44E1: Tactile dashboard enabler • T44E2: Business KPI reporting enabler • T44E4: OpenAPI management enabler • T44E5: Video augmentation enabler • T55Ex Manageability enablers for managing the deployment of ASSIST-IoT enablers, services, devices, and workflows.
Dependency	Pilot3B_ValAct_ID1-TWO (M15 – M18) Pilot3B_ValAct_ID2-TWO (M24 - M28) Pilot3B_ValAct_ID3-TWO (M32 – M36)
Start and End Dates	M18 – M36

6.4.3. Demonstration and Validation activities

Table 21. Pilot 3B validation activities

Validation Activity ID	Pilot3B_ValAct_ID1
Validation Activity type	System testing
Validation Activity description	First prototype demo: A very first testing of the actual R&D deliverables will be conducted. Where no new ASSIST-IoT components will be yet available, conventional, or existing corresponding TwoTronic-modules shall schematically provide the missing functionality. In this way a smoother transition from existing technologies to the new, novel results can be planned. This first and initial round will aim to set the ground for network (Pilot3B_IntAct_ID1) and self-capabilities (Pilot3B_IntAct_ID2) and any component that is ready from the rest of the Integration activities, as it will allow room for validating these components.
Data	Real scans with vehicles with known exterior conditions will be passed through the scanner at TwoTronic premises
Start and End Dates	01/02/2022 (M16) - 30/04/2022 (M18)
Validation Activity ID	**Pilot3B_ValAct_ID2**
Validation Activity type	System testing
Validation Activity description	First real demo with completed integration of so far developed ASSIST-IoT technologies will be conducted. Real scans with vehicles with known conditions will be passed through the scanner at TWOT premises and the AI-engine results will be checked against the known list. Additionally, end-users will be invited to participate in the evaluation of the additional system characteristics, like ergonomical issues and added-value processes implemented. In this second round, there is the chance to validate the progress that is made through all of the Integration activities. The relevant integration activities are Pilot3B_IntAct_ID1, Pilot3B_IntAct_ID2, Pilot3B_IntAct_ID3, Pilot3B_IntAct_ID4, Pilot3B_IntAct_ID5, Pilot3B_IntAct_ID6, and Pilot3B_IntAct_ID7.
Data	Real scans with vehicle with known conditions will be passed through the scanner at TwoTronic premises. The involvement of additional physical scanners with end-user-participation is targeted, so that additional and larger data sets can be generated. Validation will be manually done on a subset of the acquired data.

Start and End Dates	01/09/2022 (M23) - 31/01/2023 (M27)
Validation Activity ID	**Pilot3B_ValAct_ID3**
Validation Activity type	System testing
Validation Activity description	Final demo with complete ASSIST-IoT based integrated system will be conducted in similar way than the first real demo. Opinion makers and other experts from the automotive sector will be invited to interact with the demo system and contribute to the results evaluation. This final round will provide the final results to validate the progress made in each integration activity by the partners. The relevant integration activities are Pilot3B_IntAct_ID1, Pilot3B_IntAct_ID2, Pilot3B_IntAct_ID3, Pilot3B_IntAct_ID4, Pilot3B_IntAct_ID5, Pilot3B_IntAct_ID6, and Pilot3B_IntAct_ID7.
Data	Real scans with vehicle with known conditions will be passed through the scanner at TwoTronic premises. The involvement of additional physical scanners with end-user-participation is targeted, so that additional and larger data sets can be generated. Validation will be manually done on a subset of the acquired data.
Start and End Dates	01/08/2023 (M34) - 31/10/2023 (M36)
Validation Activity ID	**Pilot3B_ValAct_ID4**
Validation Activity type	System testing
Validation Activity description	This phase is about the open callers who will test and validate their results of their research. The time period is susceptible to changes due to the unknown availability of resources for running multiple tests by the participants.
Data	Real scans with vehicle with known conditions will be passed through the scanner at TWOT premises. The involvement of additional physical scanners with end-user-participation is targeted, so that additional and larger data sets can be generated. Validation will be manually done on a subset of the acquired data.
Start and End Dates	01/01/2023 (M27) - 31/10/2023 (M36)

6.5. Initial Planning

This section is the presentation of an initial Gantt diagram for the activities that will take place in Pilot 3B. Conditions that may hinder the progress of the pilot are coming from the environment, as there is currently a worldwide supply chain problem and a subsequent unavailability of devices. Another thing to consider is the unavailability of multiple scanners placed in TWOT customers premises. Mitigation plans on these risks are either to use the scanner available in TWOT premises or lean on historical data from real-world applications. Considering all the above, activities can follow a circular procedure of implementation and testing. In this pilot, significant testing will be used for gathering relevant data for the technical development activities. The validation will be iterative in the sense that in each one of the activities, the complete features developed in previous phases of the project will also be checked.

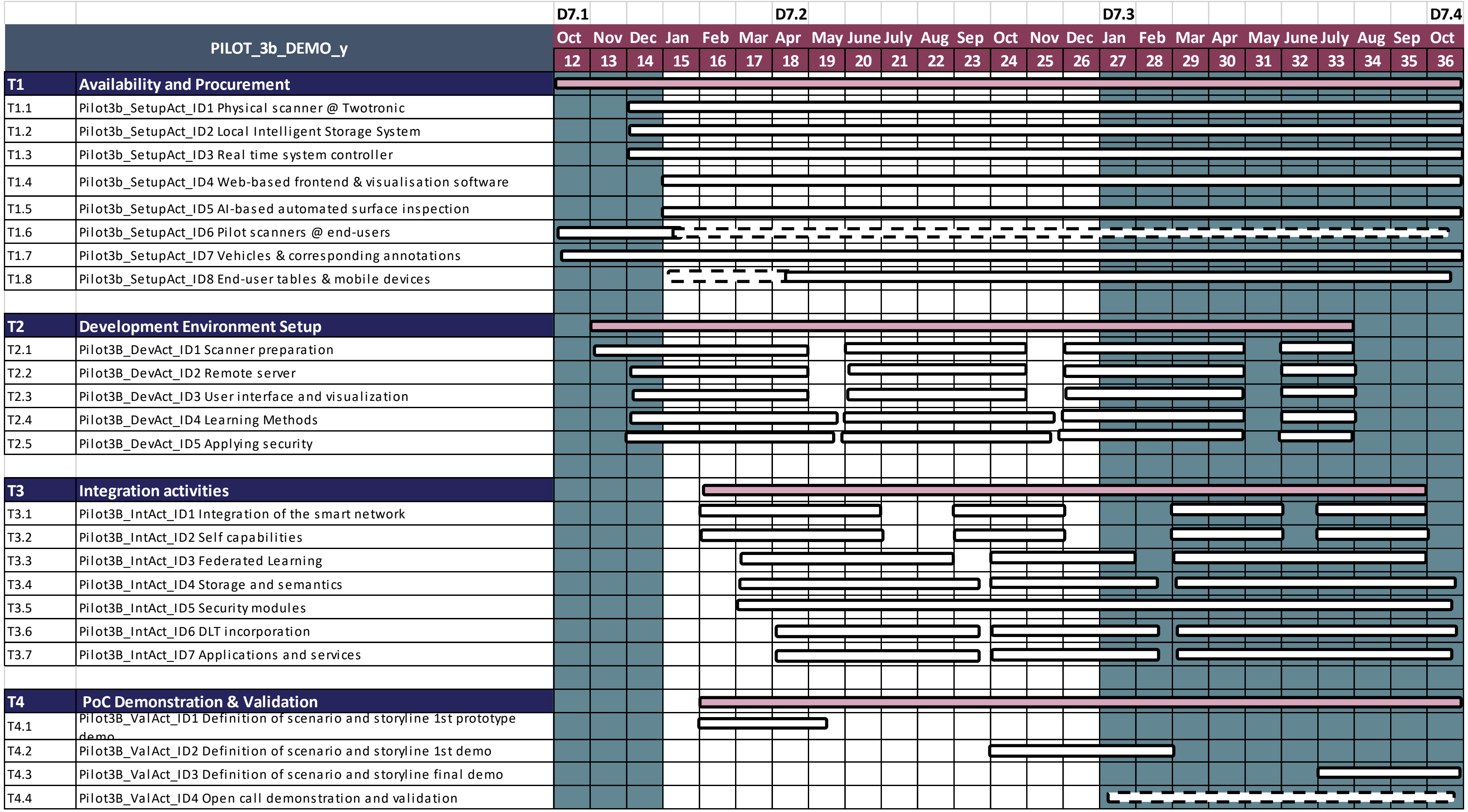


Figure 20. Pilot_3B_Demo Gantt chart

7. Conclusions

According to the ongoing outcomes extracted from WP3 (Use cases, requirements, and ASSIST-IoT architecture), WP4 (Horizontal planes enablers), and WP5 (transversal views enablers), this report has described all the activities related to the deployment plan of the four ASSIST-IoT pilots (Port automation, Smart safety of workers, Vehicle in-service emission diagnostics, and Vehicle exterior condition inspection and documentation), and has provided relevant insights about the operational framework of the different real testbeds of the project.

Planning of the required resources (existing and forthcoming) at ASSIST-IoT facilities has been detected. Based on this information, the development, integration, and validation activities required and their time plan from M12 until the end of the project have been described, so that all Proof of Concepts (PoCs) and demonstrations of ASSIST-IoT will be reliably on time.

The identified deployment plan per pilot, will be consequently used as a basis for the evaluation activities of the for parallel WP7 tasks (i.e., T7.1, T7.2, T7.3, and T7.4). However, it has be noticed that the deployment plan identified in this deliverable is considered as the initial version that may be subject of changes depending on the potential deviations in the project, including procurement dates, or development advancements of linked WPs. These deviations that will affect to the deployment will be subsequently informed in D7.2, D7.3 and D7.4.

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