5GMOBIX

5G for cooperative & connected automated MOBIlity on X-border corridors

D3.1

Corridor and Trial Sites Rollout Plan

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Control sheet

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V0.3	19/07/2019	Doruk Sahinel and Fikret Sivrikaya (GTARC)	Added Verification Section, Figure and table formats are added
V0.4	06/08/2019	Doruk Sahinel(GTARC), Section editors	Methodology Section is updated, Vehicle Adaptation Section is updated
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V2.4	19/02/2021	Fikret Sivrikaya (GTARC)	Version ready for QA review
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ABBREVIATIONS

Abbreviation	Definition
AD	Autonomous/Automated Driving
APM	Authorities and Policy Makers
CAV	Connected and Automated Vehicle
CBC	Cross Border Corridor
CCAM	Cooperative, Connected and Automated Mobility
CIP	Communication Infrastructure Provider
CN	China
CPM	Collective Perception Message
CTS	Centralized Test Server
C-ITS	Cellular Intelligent Transport System
C-V2X	Cellular Vehicle to Everything
DE	Germany
EC	European Commission
EDM	Edge Dynamic Map
ES	Spain
EU	European Union
FI	Finland
FR	France
GDPR	General Data Protection Regulation
GR	Greece
HD	High Definition
ITS	Intelligent Transport System
KM	Kilometre
KPI	Key Performance Indicator
KR	Korea
LDM	Local Dynamic Map

Abbreviation	Definition
LTE	Long-Term Evolution
MCM	Manoeuvre Coordination Message
MCS	Manoeuvre Coordination Service
MEC	Multi-access/Mobile Edge Computing
mmWave	Millimetre Wave
MNO	Mobile Network Operator
NSA	Non-Standalone Architecture
NFV	Network Function Virtualization
NL	Netherlands
OBU	On Board Unit
OEM	Original Equipment Manufacturer
PLMN	Public Land Mobile Network
PT	Portugal
RAN	Radio Access Network
RIO	Road Infrastructure Operator
ROI	Region of Interest
RSU	Roadside Unit
SA	Standalone Architecture
SAE	Society of Automotive Engineers
TC	Technology Centre
TR	Turkey
TS	Trial Site
UCC	Use Case Category
UE	User Equipment
US	User Story
VBM	Video-Based Monitoring
V2I	Vehicle to Infrastructure
V2X	Vehicle to Everything

Abbreviation	Definition
Wi-Fi	Wireless Fidelity
WP	Work Package
X-border	Cross-border
3GPP	The 3rd Generation Partnership Project
5G NR	5G New Radio

EXECUTIVE SUMMARY

This deliverable aims to provide a common timeline and guidance for the alignment of deployment activities across different trial sites in 5G-MOBIX. It describes the methodology and tools for the coordination of all sites regarding the deployment and rollout, followed by the activity plans for vehicle adaptation (T3.2), 5G integration (T3.3), CCAM infrastructure development and integration (T3.4), evaluation data collection and management (T3.5) and verification (T3.6) tasks, with a clear mapping to the activities in the cross-border corridors and trial sites.

The "corridor and trial sites rollout plan" is part of T3.1 (5G Corridor Rollout Coordination) within WP3 (Development, Integration and Rollout) in 5G-MOBIX. The objectives of WP3 are to: *(a)* coordinate the infrastructure and technology rollout across all corridors of 5G-MOBIX; *(b)* upgrade and integrate vehicular technology for supporting enhanced CCAM use case categories; *(c)* deploy and integrate 5G technologies as well as overall infrastructure components (radio, core, cloud) and devices at the trial sites; *(d)* define the data management and collection mechanisms; and *(e)* verify the corridor readiness prior to the beginning of trials.

In this context, this deliverable defines the scope and the timeline that each pilot site should follow to achieve coherent progress of site development and to facilitate cross-site knowledge sharing. In particular, a 5-phase rollout plan is introduced for the 5G deployment and integration, CCAM infrastructure development and integration, vehicle adaptation, and evaluation data collection and management activities in the project. This rollout plan and methodology are commonly applied to all cross-border corridors and trial sites to ensure the coherent progress and monitoring of the rollout activities of 5G-MOBIX. Furthermore, the verification methodology provides the approach and plans to validate and ensure the readiness of all trial sites before the actual trials start in the second half of the project.

It is important to highlight that the focus of this deliverable is on the high-level planning and methodology for the rollout activities and it serves as an entry point for the actual deployment work that takes place in the remainder of WP3. For the technical details of the individual cross-border corridors and trial sites in 5G-MOBIX, the reader is referred to the subsequent deliverables of WP3, namely **D3.2** (Vehicle development and adaptation for 5G enabled CCAM use cases), **D3.3** (5G technologies integration and roll-out), **D3.4** (Corridor infrastructure development and integration), **D3.5** (Evaluation data management methodology and tools), and **D3.6** (Trial readiness verifications).

The plans and roadmaps presented in this deliverable reflect the project participants' best estimate for completion of the deployment and rollout phases at the respective trials sites as of February 2021. Due to the uncertainties and delays introduced from the COVID-19 lockdown measures, preventing partners from proceeding with their field work, the roadmaps presented in this deliverable have been adjusted to reflect the partners' current assessment of the situation regarding the potential completion of their field work.

1. INTRODUCTION

1.1. About 5G-MOBIX

5G-MOBIX aims to showcase the added value of 5G technology for advanced Cooperative, Connected and Automated Mobility (CCAM) use cases and validate the viability of the technology to bring automated driving to the next level of vehicle automation (SAE L4 and above). To do this, 5G-MOBIX plans to demonstrate the potential of different 5G features on real European roads and highways and create and use sustainable business models to develop 5G corridors. 5G-MOBIX also utilizes and upgrades existing key assets (infrastructure, vehicles, components), and ensures the smooth operation of 5G within a heterogeneous environment comprised of multiple incumbent technologies such as ITS-G5 and C-V2X.

5G-MOBIX executes CCAM trials along cross-border (x-border) and local corridors using 5G core technological innovations to qualify the 5G infrastructure and evaluate its benefits in the CCAM context. The project also defines deployment scenarios and serves to identify and respond to standardisation and spectrum gaps.

In D2.1 [1], the required features to enable advanced CCAM deployments on the 5G-MOBIX user stories, are thoroughly investigated. The expected benefits of 5G for these identified user stories are planned to be tested during trials on 5G corridors in different EU countries as well as in Turkey, China and Korea.

The trials allow 5G-MOBIX to conduct technical and business evaluations and assessments as well as perform cost/benefit analysis. As a result of these evaluations and international consultations with the public and industry stakeholders, 5G-MOBIX aims to identify new business opportunities for the 5G-enabled CCAM and propose recommendations and options for its deployment.

Through its findings on technical requirements and operational conditions, 5G-MOBIX is expected to actively contribute to standardisation and spectrum allocation activities.

1.2. Purpose and Structure of the Deliverable

The main objective of this deliverable is to provide a rollout methodology and a description of the 5G-MOBIX rollout plans for cross-border corridors and trial sites of 5G-MOBIX. In order to serve the purpose of T3.1 – "5G corridor rollout coordination", this document describes a 5-Phase rollout plan to facilitate the alignment of the deployment and integration activities at all cross-border corridors and local trial sites. It also divides the deployment and integration tasks of the defined 5G technologies into common groups. The project management tool adopted by the consortium for monitoring these tasks is also presented briefly, serving as guidance for project members to keep track of the rollout plan and maintain the workflow by coordinating among all corridors and trial sites.

By taking these objectives into account, the document is structured as follows:

- **Section 1, Introduction,** briefly describes the 5G-MOBIX project and the purpose of this document together with its intended audience.
- **Section 2, 5G-MOBIX Trial Sites,** provides a brief overview of the cross-border corridors and trial sites of 5G-MOBIX, also including (i) an overview of the integration and asset transfers among local trial sites and cross-border corridors, and (ii) trial site heritage, which presents the components reused from previous H2020 projects.
- **Section 3, 5G-MOBIX Rollout Methodology and Roadmap,** describes the overall rollout planning approach, stakeholder involvement and readiness for the deployment activities, and the use of management tools for activity tracking.
- **Section 4, Five-Phase Rollout Timeline**, introduces a common roadmap and check points for the alignment of deployment, integration and verification activities at all trial sites.
- **Section 5, 5G Deployment and Integration,** presents the 5G network deployment plans for CCAM trials to be executed alongside T3.3 of the project.
- **Section 6, CCAM Infrastructure Development and Integration,** presents the rollout plan for CCAM infrastructure development and integration, to be executed in T3.4 of the 5G-MOBIX project.
- **Section 7, Vehicle Adaptation,** presents the vehicle adaptation plans for CCAM user stories, to be executed in T3.2 of the project.
- **Section 8, Evaluation, Data Collection, and Management,** presents the rollout plan for evaluation data collection for CCAM trials in 5G-MOBIX, to be executed in T3.5 of the 5G-MOBIX project.
- **Section 9, Verification,** presents the rollout plan for trial readiness verifications in 5G-MOBIX, to be executed in T3.6 of the 5G-MOBIX project.
- **Section 10, Conclusion,** ends the document with a summary and further pointers.

1.3. Intended Audience

The deliverable D3.1 – Corridor and Trial Sites Rollout Plan is a public deliverable and it is addressed to any interested reader. However, it specifically aims at providing the 5G-MOBIX consortium members with the timeline and guidelines for the alignment of setup, deployment, and integration activities across trial sites; and it serves as an entry point for the detailed deployment activities reported in the subsequent deliverables of Work Package 3 in 5G-MOBIX.

2. 5G-MOBIX TRIAL SITES

5G-MOBIX user stories are tested and validated in two cross-border corridors (Spain – Portugal and Greece – Turkey), which are further complemented and assisted by six local trial sites to realize an additional diverse set of 5G corridors rolled out in Europe (France, Germany, Finland, and Netherlands) as well as Asia (China and South Korea). A short overview of each CBC/TS is presented here, while the details of individual site characteristics regarding the deployed vehicles, 5G networks, and CCAM infrastructure are provided in deliverables D3.2 [2], D3.3 [3], and D3.4 [4], respectively.

2.1. Overview of Cross-Border Corridors and Local Trial Sites

Spain – Portugal (ES-PT) Cross-Border Corridor

The ES-PT cross-border corridor is at the border of the north of Portugal with Spain, connecting the cities of Vigo and Porto with a distance of around 250km. The main outcome and impact of 5G-MOBIX are to set up the foundations for the deployment of 5G CCAM services and applications, and this border provides ideal conditions to showcase the advantages offered by these deployments, as international trade and large passenger commuting flows are of great importance. The partnership of the corridor is composed of several complementary stakeholders covering the complete value chain including vehicle manufactures, telecom companies, public administrations, and research institutions.

Greece – Turkey (GR-TR) Cross-Border Corridor

The GR-TR trials take place on the most commonly used border crossing between Greece and Turkey in the area of Kipoi (GR) - Ipsala (TR), covering a stretch of 2.5 km for testing. This cross-border corridor constitutes the south-eastern border of the European Union providing a challenging geopolitical environment due to the existence of actual, physical borders, where customs agents perform rigorous border checks. The participation of the two largest MNOs in Greece and Turkey demonstrates the level of support provided for the deployment of CCAM use cases at EU border conditions with heavy traffic, and the guaranteed cell-edge conditions at the border will provide important insights about the performance limits of 5G deployments. Besides the trials at the GR-TR border, initial tests are also planned to be carried out in the Ford Otosan Inonu trial site to support the cross-border trials.

Germany (DE) Trial Site

Germany participates in 5G-MOBIX with a single trial site located in Berlin. The Berlin corridor is situated in the centre of Berlin, Straße des 17. Juni and it is a 4 km long road extending from Ernst-Reuter-Platz to Brandenburger Gate. This is an urban corridor with three lanes in each direction, two complex roundabouts (with 5 roads and multiple lanes), and a high traffic intensity during working hours. The very dense driving environment of the Berlin corridor, having a rich amount of digitized street infrastructure and different types of sensors, provides ideal testing capabilities for the various use case categories of automated driving in especially those borders exhibiting heavy and heterogeneous traffic. Due to the urban setting of the Berlin test field with real road traffic, the trials at the DE TS will always be conducted with a human driver in control of the vehicle. This will enable continuous testing of 5G for CCAM functionalities without requiring road closures or other regulatory restrictions. Accordingly, the platooning use-case trials will employ an 'emulated platooning operation' mode, without actuation of platooning control messages by the L4 vehicles and instead prompting the driver for corresponding actions.

Finland (FI) Trial Site

The Finland (Espoo) trial site utilizes continuous roads of a combined distance 2 km within the Otaniemi area of Aalto University. Otaniemi is home to some of the largest and principal research and high-tech companies in Finland and has the vibrant Nordic start-up scenery. The 5G-MOBIX testbed builds on a legacy of 4G/5G testbeds deployed in the Otaniemi area in past/ongoing national projects. This testbed is targeted for testing, piloting, and validating a multitude of 5G user stories, and to drive automated mobility adoption in the Nordics.

France (FR) Trial Site

Two trial sites are used in France: The first one is in Satory, which is situated in the neighbourhood of Versailles and is composed of private test tracks. The Satory trial site will have highly configurable private 5G networks operating on 26 GHz bands installed by NOKIA/TDF. This site has not been included in the project deliverable D2.2 [5] since the installation of the mmWave network at Satory was not yet confirmed at the time of D2.2 submission. Thus, Satory site will provide to the FR TS more capacity of adaptation and flexibility in integrating 5G features like V2X application server since it will be private and very configurable. It will also be used as a pre-testing of all the automotive functionalities related to AD before going to UTAC/CERAM for communication aspects. The second trial site is the TEQMO centre, owned by UTAC/CERAM and located in the suburb of Paris, Linas-Montlhéry. This closed site provides a variety of road configurations, including a road infrastructure that has 2.2km-long three-lane highways, traffic lights and a parking area. In these highways, high velocity is permitted when joining the urban circuit; therefore, the effect of high velocity to 5G network KPIs can be tested at this trial site. In addition, TEQMO centre has ready-to-be-commercialized 5G networks provided by both Bouygues and Orange. In addition to terrestrial 5G communications technologies, FR TS will also use LEO satellites, which can ensure end-to-end delay in the range of 30 to 50 ms, making the trial site suitable for most URLLC-type applications.

Netherlands (NL) Trial Site

The NL trial site combines a variety of roads in local, inter-urban and motorway settings with a high share of C-ITS installations, covering a road distance of approximately 10 km. The trial is located at the motorway A270/N270 connecting the cities of Eindhoven and Helmond in the Netherlands, which has road exemptions to support automated driving in mixed traffic conditions. Additional Roadside Units (RSUs) in the A270/N270 segment and intelligent traffic light controllers along the route makes the trial site an ideal location for testing and evaluation. In-vehicle platforms and services are to be developed and tested locally in the campuses of the NL partners for evaluation.

China (CN) Trial Site

The Jinan trial site is located nearby Shandong Academy of Sciences, which is the north-western part of Shandong province, about 400 kilometres south of the national capital of Beijing. Jinan city is the capital of Shandong province in Eastern China, and it is a major national administrative, economic, and transportation hub. It is also one of the most congested cities in China, making the local traffic condition ideal for evaluation of 5G-MOBIX CCAM user stories. The Jinan trial site has two main roads equipped with 5G V2X communication infrastructure for advanced tests and evaluation of 5G technologies. The trial site includes both an urban road and a highway setup. The distance of urban road used to test the heavier traffic scenarios is approximately 5km, and the road distance of highway is approximately 26km.

South Korea (KR) Trial Site

The Yeonggwang trial site in South Korea is an urban-type-proving ground location that is constructed at the end of 2019. The 5G infrastructure development within this trial site is facilitated by another national project (years 2018 – 2022), and it consists of various types of test roads such as intersections, pebble roads, test hills, circular roads, which are under the supervision of a real-time monitoring system that is based on a V2X network equipped with mmWave-band 5G NR and Wi-Fi connectivity along with novel network technologies (like NFV, etc.). The Yeonggwang proving ground aims to be a local testbed to pilot and validate not only the Korean user stories, but also the scenarios used in international projects.

2.2. Local Trial Site – Cross-Border Corridor Integration

The contributions of each local trial site to cross-border corridors create added-value for testing various features of 5G network components and technologies for CCAM use cases to be realized at 5G-MOBIX cross-border corridors. In Table 1, we provide a brief overview of the local trial site contributions to the two cross-border corridors, together with the user stories they develop. For more details about each of the user stories and the use case categories, please refer to D2.1 [1]. Furthermore, in this section, we summarize the plans for the transfer from local trial sites to cross-border corridors and the integration of the applications, technologies and any other assets given in Table 1. The numbers in parenthesis identify main transfer plans, which are described along this document.

Since this deliverable is on the deployment and roll-out activities (WP3), the TS-CBC integration plans presented here focus on the concrete technologies and assets that are to be transferred from local trial sites and deployed at cross-border corridors before or during the trials. More concrete 5G features and technologies to be tested through such cross-site integrations are reported in D4.1 [6] and D4.2 [7] as part of the trial planning and coordination activities in WP4.

It should also be highlighted that the trial sites in China (CN) and Korea (KR) are not included in the following list, because they mainly serve as complementary pilots in 5G-MOBIX, without any plans for the transfer of concrete assets to the European cross-border corridors. The involvement of CN and KR trial sites aim at the testing, validation, and alignment of 5G for CCAM features in a wider international context and for the exchange of information and findings among the European and the Asian trials in 5G-MOBIX. This is further explained at the end of this section.

Table 1: Cross-Border Corridor Contributions from Local Trial Sites

User Story	Local Trial Site	Cross-Border Corridor Contribution
Advanced Driving (ES-PT)	FR	**(1) 5G OBU for Interoperability Issues** By bringing a connected car installed with a 5G OBU, FR TS will explore the interoperability issues of a "foreign" car with the local network and vehicles. To do so, the seamless handover solution for a user story.
	NL	**(2) 5G-Based MCS Application** Application of the Manoeuvre Coordination Service (MCS) [8] used in Cooperative Collision Avoidance (CoCA) user story will be transferred to the ES-PT corridor to evaluate MCM/MCS communication framework and overtaking service with MCM at CBCs.
Vehicles Platooning (GR-TR)	FI	**(3) LEVIS Video Streaming** LEVIS video streaming application developed at FI trial site and is going to be transferred to the GR-TR cross-border corridor together with 4K cameras, client devices, client and server software to be used in "see-what-I-see" platooning user story. Initial development and testing of the LEVIS video streaming application in FI TS will be carried out within the remote driving user story context in a 5G Multi-PLMN environment. Modifications are being made for use of LEVIS in platooning user story in GR-TR CBC, as high-resolution video streaming is going to be shared between vehicles in a platoon to enhance safety and driving experience. Part of trials in the CBC will involve testing of continuity of this critical video stream under different roaming mechanisms (HRO and LBO) between the 5G NSA networks on either side of the GR-TR CBC.
Extended Sensors (ES-PT)	DE	**(4) MEC, eRSU Platform, and Vehicle** DE TS will provide vehicles, MECs and RSUs to ES-PT corridor to deploy their own user story "EDM-enabled extended sensors with surround view generation" within the "HD maps" scenario conditions. Deployment of the DE user story will be tested in new scenarios (different speed and traffic conditions), as well as under roaming conditions. The interoperability of RSU and ROI-based discovery

		service, Edge Dynamic Map (EDM) system with MEC Broker interconnection will be explored in different countries (recommendations for inter-country deployments). Benchmarking LDM and HD maps results.
	FI	**(5) Edge Discovery Service** Consisting of a DNS-like name resolution service, the edge discovery service developed at FI TS is going to be transferred to ES-PT cross-border for assuring the application connectivity with ES and PT networks when passing from one country to the neighbouring. The asset will enable uninterrupted HD video streaming (upload), for surveillance purposes in this user story. In the FI TS, the 5G feature deployed in both sites is "edge computing in 5GC". In the CBC, this will be done only in the PT side.
Agnostic (ES-PT)	FI	**(6) 5G Multi-SIM OBU Solution - FI** Multi-SIM OBU based mobile IP tunnelling technology is first configured and tested in FI-TS 5G Multi-PLMN environment before being re-deployed and tested between ES-PT CBC 5G networks to benchmark handover latency parameters and service continuity against conventional 5G NSA roaming with Single-SIM OBU implemented in ES-PT CBC. The field tests on the CBC will include an alternative multi-SIM OBU solution from FR TS (described below, after this table). The Multi-SIM OBU testing is a precursor to the ongoing 5G NR multi-SIM enhancements in 3GPP Release 17 (see 3GPP technical docs RP-193263[1] and SP-200091[2]). Moreover, additional motivation is provided from increased industry momentum behind embedded SIM (eSIM) solutions for connected vehicles (examples from GSMA[3] and Ericsson[4]).
	FR	**(7) Multi-PLMN OBU Solution - FR** To benchmark handover latency parameters and service continuity in a Multi-PLMN OBU solution integrated into a connected vehicle that will be developed in the FR TS, with the FI Multi-PLMN solution and with the conventional Single-PLMN solution existent on the ES-PT CBC. The expected results include o milliseconds of disconnection period for the application flow of the remote driving user story.

Further details and timelines about the cross-border contributions from local trial sites are provided below:

[1] 3GPP RP-193263 : Support for multi-SIM devices in Rel-17, 3GPP, 2020
[2] 3GPP SP-200091: Revised SID: Study on system enablers for multi-SIM devices, 2020
[3] https://www.gsma.com/esim/transforming-the-connected-car-market/
[4] https://www.ericsson.com/en/blog/2020/9/esim-driving-global-connectivity-in-the-automotive-industry

(1) The FR TS connected car will be installed with an OBU and a smart routing algorithm to demonstrate application continuity by redundant connections (5G and 5G, 4G and 5G, 5G and LEO sat) during the handover phase (i.e., seamless handover). This development phase at CATAPULT premises was completed at **M26** (Dec. 2020). The integration of the intelligent router with VEDECOM 5G OBUs and its testing are to be carried out until **M29**. The adaptation of the solution to the ES-PT CBC is planned to take place between **M29** and **M30**. This phase is mainly dedicated to adapt the solution to the ES-PT configuration: VPN tunnels configurations between the vehicle and the endpoint in the cloud, multiple 5G sim cards and LEO Sat integration, IP addresses configuration, flow type to be transmitted to the remote centre in the cloud, etc. The testing phase can be started at the ES-PT corridor once the contribution is validated at the local site. With this contribution, FR intends to explore the interoperability of a "foreign" vehicle with the local network and vehicles for the US with stringent URLLC-requirement. Moreover, FR and ES-PT will experiment with seamless and non-seamless handover solutions with 5G-OBUs.

(2) NL trial site expects to complete the installation of MEC application that enables infrastructure centred management with MCMs at the ES-PT cross-border corridor at **M28**. After the installation, the OBU that uses the application is going to be transferred to CBCs and message exchange between the vehicles and the MEC and setup of the servers at CBCs is going to be implemented. Finally, MCM/MCS communication framework and overtaking service with MCM will be evaluated at CBCs. With this contribution, NL and ES-PT intend to benchmark the outcomes of an autonomous overtake between the in-vehicle decision-making approach implemented in ES-PT and the infrastructure decision-making approach implemented in NL.

(3) LEVIS video streaming application developed at FI trial site and to support CCAM infrastructure is going to be transferred to GR-TR cross-border corridor to be used in the "see-what-I-see" platooning user story. During truck platooning, the leader vehicle will use the LEVIS application to stream high-resolution video from its front camera to follower truck through the 5G network. Follower vehicle driver requests live stream. Once the request is received by the cloud, it sends a request to the leader vehicle to start the live stream and launches the RTSP server. Once the stream request is received, the leader vehicle driver can accept or reject this request. Once the request is accepted, the leader vehicle (running LEVIS-Client) starts the live streaming process, receives a raw video from the camera, encodes, and sends it to the server over UDP. Once the stream is available on the LEVIS server, the LEVIS clients in the follower vehicle establish an RTSP session with the server and start receiving the live stream. Initial testing of the LEVIS application will be done by **M28** through remote deployments of the LEVIS server and clients between FI and GR due to lockdown restrictions. As the lockdown restrictions are relaxed, lab testing of the LEVIS application will be organized (estimated by **M29**) between FI and GR-TR partners working on the "see-what-I-see" user story. The LEVIS integration at the GR-TR cross-border corridor is expected to be completed in **M32** by completing the deployment of Jetson TX2 to the leader vehicle, the RTSP server to the server, and the player code to the follower vehicle.

(4) The DE trial site is going to transfer an EDM application and a portable version of its eRSU platform to be integrated to the CCAM infrastructure of ES-PT cross-border corridor after the DE TS Demo in Berlin in

M34. Before the completion of these tasks, a CBC contribution integration plan is to be defined in **M29** after creating a scenario for comparing and evaluating LDM and HD maps systems, and assuring the logistics for transferring and then running the EDM-enabled extended sensors approach should take place in **M35**. This also includes to obtain the necessary authorizations from local authorities. The aim of this contribution is to demonstrate interoperability and cooperation between countries, so that a scenario can be deployed outside the owner country. Furthermore, adapting the scenario to the new conditions will broaden the approaches tested by DE inside their local trial site.

(5) The ES-PT vehicles need a way to discover the IP of the MEC in each network domain, so that all application functionalities resume after crossing the border. The integration of Edge Discovery Service from FI will allow vehicles to maintain application connectivity between countries. To that end, the edge discovery service developed at FI TS is planned to be transferred to ES-PT cross-border corridor in **M31**. The edge discovery service provides a DNS-like name resolution service to the MECs and the UEs. The MEC registers itself in the edge discovery service and the UE discovers the MEC's IP address with the service's domain name. The following tasks are required to be completed as part of this integration:

- Register the applications' domain names in the Coordinator and DNS servers,
- Transfer CBC's 5G network topology into the Coordinator, which will be used for service discovery (done either by active measurement on the vehicles or by document provided by Telecom operators),
- Deploy the UPF in the 5GC (Telecom operator side) for service discovery,
- Deploy the DNS server (Telecom operator side) in the 5GC and connect it to the UPF,
- Assign the DNS server to the UEs on registration,
- Deploy the MEC (Telecom operator side) in the 5GC that uses the edge discovery service to expose its interface.

(6) (7) The OBUs used for the different ES-PT user stories allow for attachment to only a single PLMN at a time. FI trial site and FR trial site, on the other hand, are working together to integrate two different seamless 4G/5G to 4G/5G handover solutions using multiple SIMs. FR TS proposes a seamless handover solution driven by a smart router and FI TS is providing seamless-handover solution based on mobile IP tunnelling. The two solutions will be implemented in the same vehicle provided by VEDECOM to ES-PT CBC. The stakeholders aim to complete this integration in **M30**. The first step towards completing this task is to bring a French connected vehicle (by VEDECOM) to the ES-PT CBC to check interoperability and participate in user stories at the ES-PT CBC. Using this connected vehicle, different communication flows will be tested during these benchmarks including CAMs and CPMs. By the end of **M29**, the field logistics should be provided for Multi-SIM (Intelligent router) OBU service continuity task. FR trial site is also going to take part in this activity at the cross-border corridor, and it will be responsible for OBU related tasks. The combined FR and FI contribution of a multi-SIM OBU aims to extend the connectivity scenarios tested in the ES-PT corridor, which are limited to the use of a single-SIM OBU. This will enable the benchmarking of different approaches within the same network configuration.

In summary, the above-presented TS-CBC integrations mainly take place during the "early trials" stage (**M28-M34**) of the 5-phase plan presented in Section 4, in preparation for the "full trials" that feed the actual measurements and analysis in 5G-MOBIX. This is also reflected as the aggregated "TS to CBC delivery and integration" activity in the overall **Gantt chart** presented in the **Annex**.

Apart from these integration activities, 5G-MOBIX has an active collaboration and liaises regularly with the CN and KR sites, as is obvious by the inclusion of the CN-KR user story definitions, architecture and trial setup plans in the 5G-MOBIX deliverables and their inclusion in the 5G-MOBIX project management and monitoring tool (See Section 3.4). However, as the CN and KR sites are not receiving any EU funding, it is not feasible for them to provide tangible contributions to the European Cross-Border Corridors of 5G-MOBIX due to resource restrictions and financial constraints. 5G-MOBIX opted to liaise with these two projects/trial sites to enhance international collaboration in 5G for CAM related research and to broaden the reach of its scope and results. In this context, 5G-MOBIX collaborates with the CN and KR sites in the following ways:

- Knowledge and expertise transfer among experts regarding implementation of cross-border trials for 5G for CAM,
- Complementary use case definitions to cover a broad spectrum of scenarios for CAM service provisioning over 5G,
- Exchanging trial results among the projects to deepen the understanding and gain additional insights regarding the performance and impact of the various 5G technologies on cross-border CAM service provisioning,
- Joint dissemination efforts to enlarge the footprint of 5G-MOBIX trial results to CAM communities beyond Europe.

2.3. Trial Site Heritage – Reused components from previous H2020 projects

5G-MOBIX has the ambitious goal of building some of the most advanced trial sites to date, in order to experiment with autonomous driving and CAM services over 5G connectivity in cross-border conditions. Such an ambitious goal requires the design, development, and deployment of a very large number of components (SW and HW) and their interconnection. These components range from 5G network elements such as gNBs, antennas, core networks, MEC/Edge nodes, etc., to autonomous vehicles and their components such as OBUs, RSUs and driving applications. As the 5G-MOBIX trials deal with aspects and locations that were not addressed before (i.e. cross-border locations & issues), the majority of these components were developed and deployed from scratch for the purpose of the 5G-MOBIX trials. This is especially true for the two cross-border corridors, ES-PT and GR-TR, as no previous 5G testbeds existed in the border areas of development.

Nevertheless, 5G-MOBIX partners did make sure to re-use knowledge and components from previous EU funded R&D activities and 5G PPP projects, in order to maximize their utilization and to reduce the development costs for 5G-MOBIX. Table 2 below provides an overview of the components that were reused (inherited) from previous EU funded projects per site. ***All other components***, as reported in the 5G-MOBIX WP3 deliverables (D3.2 – D3.5), ***were specifically developed for the 5G-MOBIX trials***. An overview of the vehicles & OBUs, 5G network components, and roadside components is presented in deliverables **D3.2**, **D3.3** and **D3.4** respectively, together with their implementation details [2] [3] [4].

Table 2: List of inherited components from previously EU-funded projects per site

CBC/TS	Inherited from Project	Components Inherited
GR-TR	ICT-17-2017 5G-EVE	The 5G-EVE Athens 5G testbed, is used for the testing and validation of the WINGS OBU and Application, as well as the validation of the ICCS "See-what-I-see" application, before deployment at the borders.
ES-PT	ICT-7-2016 5GCAR	The functionality of cooperative perception for manoeuvres of connected vehicles (through on-board camera and laser support) was inherited.
	H2020 5G IN-FIRE	Virtual vehicular services and MEC processing functionalities were inherited.
	ICT-20-2019 INSPIRE-5Gplus	Alignment of testing scenarios with 5G-MOBIX with a reference vehicular test-case provided with cybersecurity and GDPR assurance modules.
NL	CEF CONCORDA	The following components were reused from the CONCORDA project: • Fiber routes • Internet connection • Developed protocols using MQTT message exchange including developed software • The 4G test network (for reference purpose) • Some small software tools

3. 5G-MOBIX ROLLOUT METHODOLOGY AND ROADMAP

The scheme for planning the rollout of trial sites in WP3 of 5G-MOBIX is depicted in Figure 1, which illustrates that the rollout begins by carefully analysing the user stories, as well as the vehicle, 5G architecture, CCAM infrastructure, and KPI & evaluation data specifications created in tasks T2.1 to T2.5. All the deliverables created in these WP2 tasks feed into T3.1 to create the plan for deployment, integration, and rollout. In addition, the deliverables created in tasks T2.2 to T2.5 are mapped with tasks T3.2 to T3.5 correspondingly, and the activities in WP3 tasks take place under the guidance of the mapped WP2 specifications. The mapping between WP2 tasks and WP3 tasks are also shown in Figure 1.

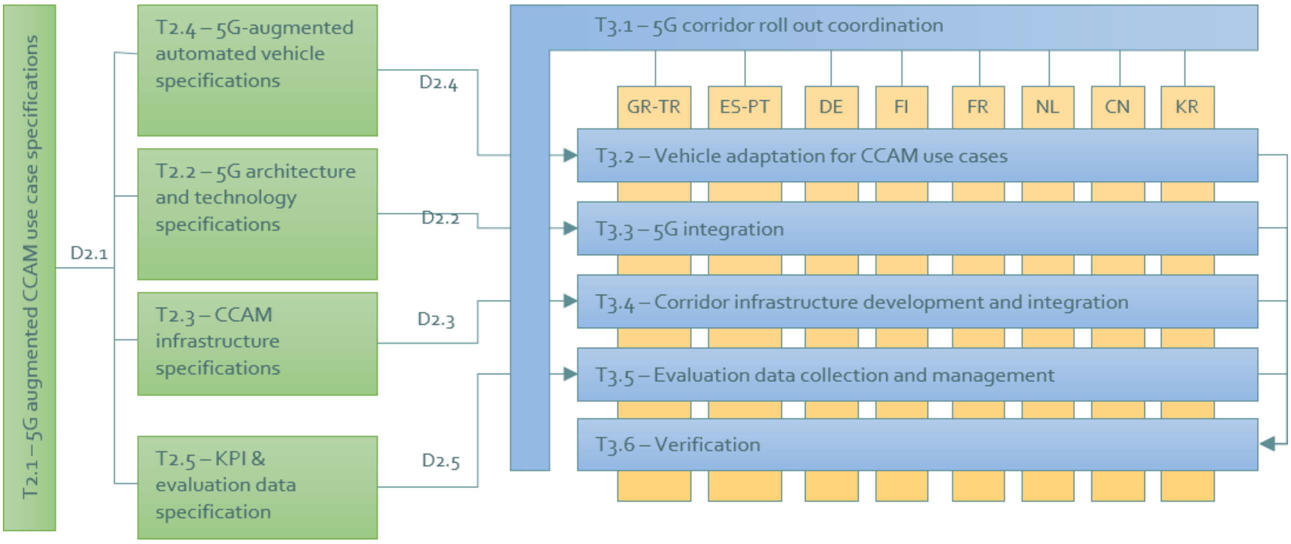


Figure 1: 5G-MOBIX Scheme for Planning Rollout of Trial Sites & Cross-Border Corridors

3.1. Rollout Planning Approach

Rollout coordination plan aims to ensure that the rollout deployment is carried out in harmony with the proposed work structure in 5G-MOBIX. For this reason, we first introduce this approach before explaining the rollout coordination plan and activities.

The proposed work structure of 5G-MOBIX begins by identifying the cross-border specific issues in each use-case category. The issues are divided into four main groups; namely, cross-border telecommunication issues, application issues, security and data privacy issues and regulation issues. The mapping between these issues and the use-case categories that aim to resolve these issues are provided in deliverable D2.1 [1], together with a list of cross-border corridors and trial sites that work in cooperation to solve the particular issue. For each issue, an expert group is created from 5G-MOBIX partners to identify the potential solutions. These potential solutions and a more detailed analysis of the identified telecommunications issues are discussed in D2.2 [5], application issues are covered in D2.3 [9], security and data privacy issues are elaborated on partially in D2.2 [5], D2.3 [9], and D2.4 [8]; and regulation issues are the focus of D2.5 [10].

As the experts of each issue belong to different trial sites, establishing cross-site coordination is essential to progress solutions by providing the necessary means for discussing the tests and analyses for evaluation.

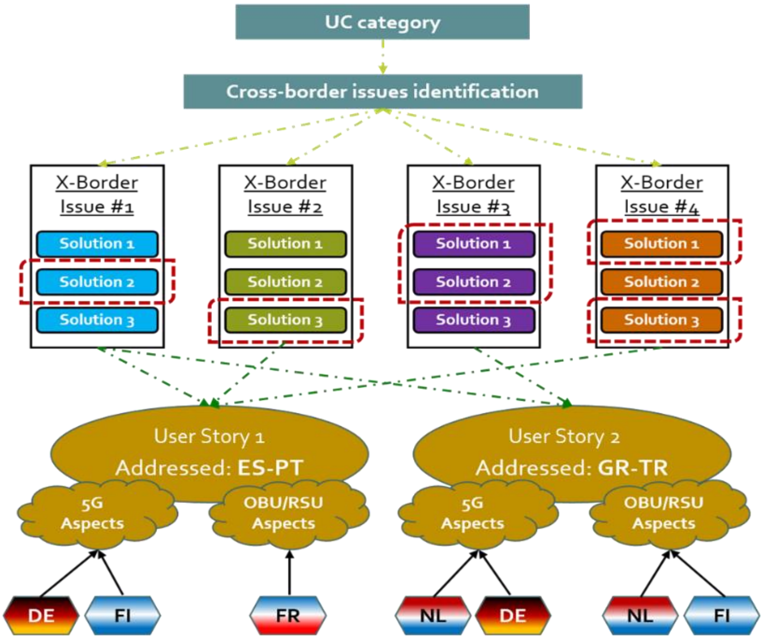


Figure 2: 5G-MOBIX Proposed Work Structure

As illustrated in Figure 2, the discussions on the solutions for cross-border level are then inherited by the use-case working groups to apply the solutions under each use-case category. For each use case category, a set of the provided solutions is to be selected, as shown by the dashed red boxes around the solutions in the figure. Cross-site coordination is also needed at this level to ensure that all trial sites are capable of applying the solutions provided by the experts for the specific user stories. Use case category working groups involve partners of trial sites in which a user story from the same use case category is planned for demonstration. The concrete contribution of each trial section in applying the solutions for the use case category specific issues are meant to be clarified in the regular meetings among use case category working groups. The outcomes of these use case category specific meetings and the rollout plans to realize these user stories are to be discussed in bi-weekly task specific WP3 meetings, with necessary feedback to be provided by the experts and task leaders.

3.2. Stakeholder Readiness

Before starting with rollout coordination approach and the detailed 5-Phase corridor rollout plans of 5G-MOBIX, we provide in Table 3 an overview of the composition of key stakeholders at each trial site, which is crucial for the proper deployment of the 5G and CCAM infrastructure and technologies as well as their longer-term sustainability.

Table 3: Involvement of Key Stakeholders for the Successful Rollout of Trial Sites

<table>
<tr><th rowspan="2">Trial Sites</th><th colspan="5">Involved Stakeholders and their Roles</th></tr>
<tr><th>Mobile Network Operator (MNO)</th><th>Communication Infrastructure Provider (CIP)</th><th>Authorities and Policy Makers (APM) / Road Infrastructure Operator (RIO)</th><th>OEM / Automobile Maker</th><th>Technology Centres (TC) / Universities</th></tr>
<tr><td rowspan="2">GR-TR</td><td>Cosmote</td><td rowspan="2">Ericsson GR, Ericsson TR</td><td rowspan="2">2 GR ministries (Infra & Transport, Telecommunications), BTK (TR authority for Information & Communications including frequency allocation)</td><td rowspan="2">Ford Otosan</td><td rowspan="2">Tübitak BILGEM, IMEC, WINGS, INTRA</td></tr>
<tr><td>Turkcell</td></tr>
<tr><td rowspan="2">ES-PT</td><td>Telefonica</td><td rowspan="2">Nokia ES, Nokia PT</td><td>DGT (Directorate General of Traffic)</td><td rowspan="2">CTAG (PSA), ALSA</td><td rowspan="2">CTAG, CCG, IT, ISEL, UMU</td></tr>
<tr><td>NOS</td><td>IMT (governmental), INFRAPT (national infrastructure manager), ATOBE (technology solutions for mobility service providers) and NORTE (highway concession), SIEMENS</td></tr>
<tr><td>FI</td><td>Aalto</td><td>Aalto</td><td>Traficom (Transport and communications regulator)</td><td>Sensible 4</td><td>Aalto</td></tr>
<tr><td>DE</td><td>Deutsche Telekom</td><td>TUB</td><td>Berlin Senate</td><td>Valeo</td><td>TUB, GT-ARC, VICOM</td></tr>
<tr><td>FR</td><td>Orange, Bouygues, TDF</td><td>CATAPULT, Vedecom, Ericsson</td><td>UTAC/CERAM</td><td>Vedecom</td><td>Vedecom, AKKA</td></tr>
</table>

Trial Sites	Involved Stakeholders and their Roles				
	Mobile Network Operator (MNO)	Communication Infrastructure Provider (CIP)	Authorities and Policy Makers (APM) / Road Infrastructure Operator (RIO)	OEM / Automobile Maker	Technology Centres (TC) / Universities
NL	KPN, TNO, TUe	KPN, TNO	Ministry of transport, City of Eindhoven, City of Helmond, Industry cluster organization (Mobility Movez, Traffic Innovation Centre), Agentschap Telecom (Spectrum Licensing)	TNO, TUe	SISSBV, VTT
CN	China Mobile	-	QILU	CNHTC, SHANDONG	SHANDONG, DUT
KR	-	ETRI	-	KATECH	KATECH

3.3. Rollout Coordination

To support the day-to-day work planning and continuous alignment of the rollout activities among all tasks in WP3, a biweekly work plan has been adopted. This is implemented through task-specific meetings once every two weeks, the results of which are then reported and discussed within WP3 / T3.1 coordination meetings, as depicted in Figure 3. This biweekly schedule of synchronization and planning meetings (conducted online, each lasting at most one hour) is to continue until at least the deployments are completed and trials are ready to begin in WP4.

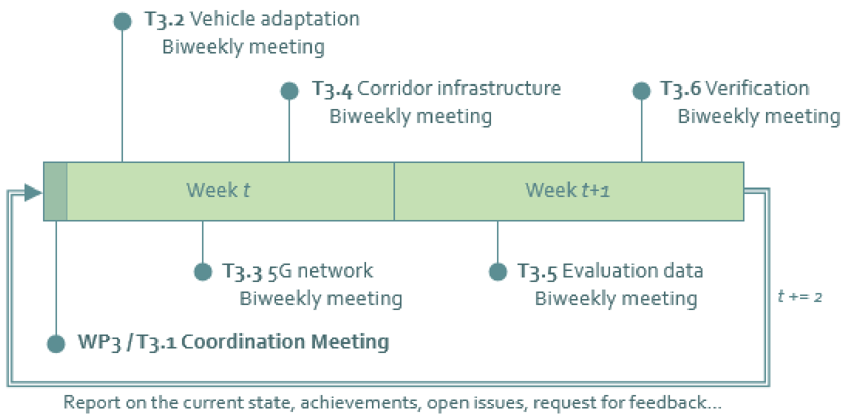


Figure 3: Biweekly Meeting Cycle to Monitor and Align the Day-to-day Rollout Activities in WP3

As mentioned above, the rollout plans are created by each cross-border corridor and local trial site to reveal their initial plan. However, during the rollout phase, these inputs may need to be regularly updated. For regular activity checks, task-specific biweekly meetings of WP3 are used. In T3.2, T3.3, T3.4, T3.5, and T3.6 meetings, the status of the sub-activities inside an activity can also be discussed in detail. The task leaders are then responsible to summarize the outcomes and explain the effects of the issues in sub-activities to the common rollout plan in the biweekly meetings of T3.1. In order to overcome a technical issue that causes a delay in plan, each cross-border corridor and trial site has the option to use expert meetings to discuss the alternative solutions and suggestions, and user story specific meetings to come up with alternatives and minimize any potential delay on user story implementation. The results and outcomes of these discussions are to be used to update the rollout plans with constant communication between cross-border corridors, local trial sites and task leaders of WP3.

If no concrete result is obtained from these monitoring procedures inside WP3 to overcome a deviation in the common plan or a technical issue that arises during the rollout, then this issue should be defined as a risk to the project by following the procedure described in D1.1 [11]. These problems should be considered under the risk category "Actual implementation deployment and rollout of CBCs diverges from deployment planning" ([11], pg. 41), and a mitigation strategy has to be created accordingly to avoid delays in trial executions. The mitigation strategy should be created under the direction of the technical management team (TMT) and should be reported in the ordinary TMT meetings. If the risk is considered too high based on the risk evaluation methods in D1.1, then extraordinary meetings should also be arranged with the TMT.

3.4. Activity Planning and Progress Monitoring

Since the deployment activities in 5G-MOBIX span across eight different sites and several technical domains (network, vehicle, CCAM infrastructure and applications, and measurement tools), the adoption of a management tool for the daily work planning and progress tracking is not a trivial task. In order to address this complexity in the work organization, the project management tool ClickUp[5] was adopted due to the flexibility it provides in terms of hierarchical work organization and monitoring features.

As depicted in Figure 4, a layered work structure has been adapted, where the set of all deployment activities in 5G-MOBIX WP3 correspond to a "space" in ClickUp, which is broken down into "folders" for each CBC/TS. For each site, the deployment activities are further broken down into "lists", each of which correspond to the WP3 tasks, with the addition of a "security and privacy" list for explicit handling of the related issues.

[5] http://www.clickup.com/

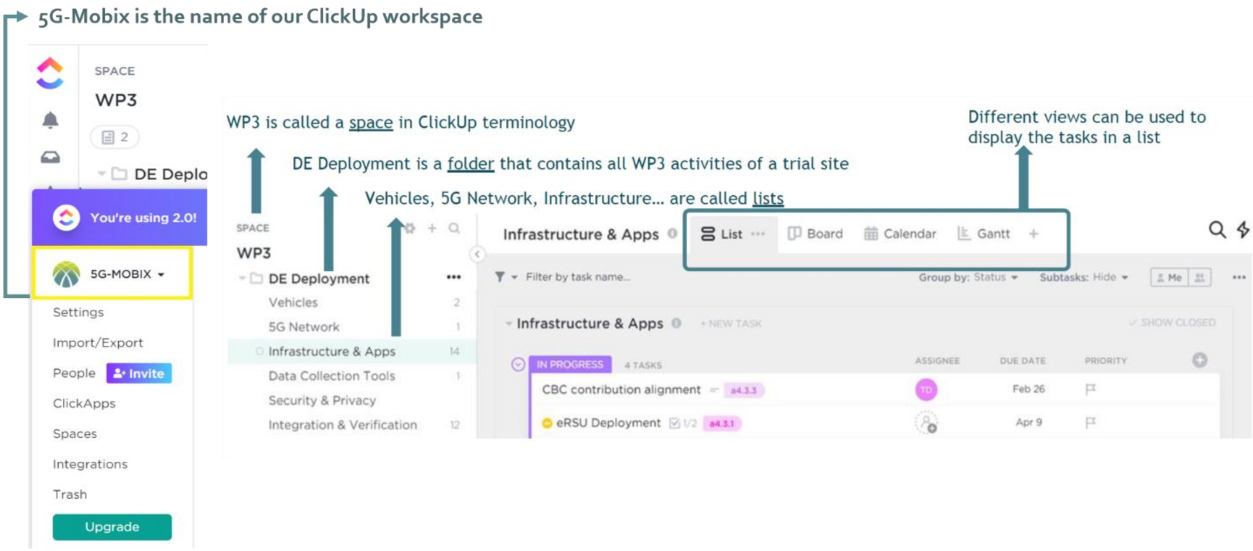


Figure 4: Mapping of the Hierarchical Work Organization in ClickUp with 5G-MOBIX Deployment Planning

4. FIVE-PHASE ROLLOUT TIMELINE

Here we introduce a 5-Phase roadmap, depicted in Figure 5, which reflects the timeline for successfully deploying all the required assets and resources in preparation for the 5G-MOBIX trials. The phased rollout plan of T3.1 ensures synchronization of all trial site activities at five internal reference points at the end of Phase 1 (M19), Phase 2 (M27), Phase 3 (M30), Phase 4 (M34), and Phase 5 (M41). These five phases are briefly explained in the subsections below. A more detailed **Gantt chart** for the overall deployment and integration timeline in 5G-MOBIX is given in the **Annex** (Figure 16).

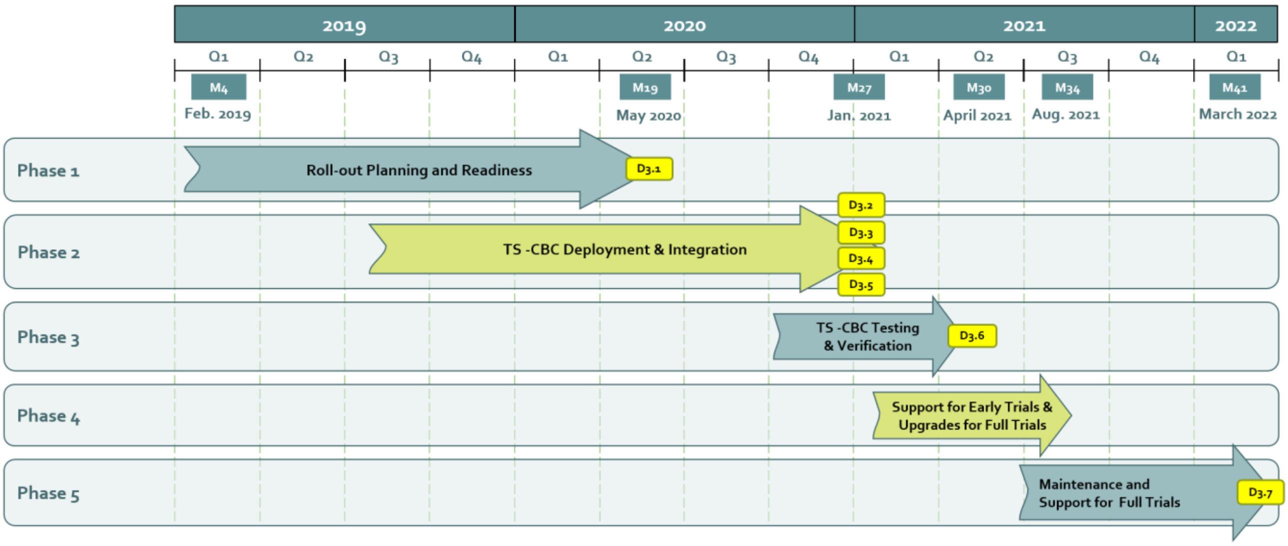


Figure 5: 5-Phase Rollout Timeline in 5G-MOBIX WP3

4.1.1. Phase 1 - Rollout Planning and Readiness [M4 – M19]

Phase 1 of the rollout in 5G-MOBIX targets the development of a deployment strategy and a timeline, which is coherent across all sites, and the initial provision of required hardware and software assets at each trial site, e.g., vehicle acquisition. Although Phase 1 was originally planned to end at M13 just after the completion of the deliverables in WP2, it was prolonged until M19, together with a nine-month project extension, mainly due to the site access restrictions and uncertainties caused by the COVID-19 pandemic. *The rest of the project timeline and this 5-Phase plan is also adjusted according to the consortium's assessment of the situation as of February 2021*.

In this phase, the focus is on finalizing the common rollout plan for all TS/CBCs. The plan is completed by achieving synchronization on various levels (admin, development, rollout, knowledge sharing) across different stakeholders and trial sites. Each trial site then has the option to elaborate the common plan with their specific needs.

While this phase focuses mainly on rollout planning, early deployment of some hardware and software components based on existing 4G+ networks and SAE L3 vehicles have also started within this phase in order to increase the readiness for the deployment of 5G for CCAM infrastructure in Phase 2. Creating a global deployment strategy for the RAN and core networks, finalizing the road infrastructure execution plan and global alignment among trial site infrastructures, and vehicle acquisition are also completed within this period. D3.1, the current document, is due at the end of this phase at M19.

4.1.2. Phase 2 - Trial Site and Cross-Border Corridor Deployment & Integration [M14-27]

Phase 2, running from M14 to M27, covers all the development and integration activities that ensure trial kick-off at M26. 5G core and RAN deployment, sensory infrastructure deployment, vehicle acquisition and OBU integration, and the development of data collection mechanisms can be listed as the main tasks to be completed in this phase. Deployment of the main road infrastructure components, including roadside units, traffic infrastructure, sensors on vehicles and the RSUs; defining the evaluation data format and creating the tools and applications for data collection; network equipment, technologies, and the deployment of subsystems and components for robust connectivity at core and RAN layers are carried out in this phase. Regarding trial site - cross-border corridor integration, all the essential components of vehicles, 5G network, and CCAM infrastructure need to be transferred from local trial sites to cross-border corridors.

All functionalities and components, as specified in deliverables D2.2 [5], D2.3 [9], D2.4 [8] and D2.5 [10], must be ready and deployed at the end of this phase. Each of the 5G-MOBIX CBCs/TSs has already defined in detail all the activities needed for the successful completion of this phase and under the supervision of the respective Task leader, each of these activities have been registered in the ClickUp tool, containing the details of the activity (e.g., Integration of component A from partner X with component B from partner Y), the start and due dates, the responsible people within the respective organizations, the dependencies with other activities, and the progress achieved so far. Examples are provided in the following sections (Sections 5 to 9), while the full list of activities are available in the ClickUp – 5G-MOBIX workspace. Access to the full planning of 5G-MOBIX can be provided to EC officials and reviewers upon request.

At the end of Phase 2, the following deliverables are released:

- D3.2 – Report on vehicle development & adaptation for 5G enabled CCAM user stories
- D3.3 – Report on the 5G technologies integration and rollout
- D3.4 – Report on corridor infrastructure development and integration
- D3.5 – Report on the evaluation data management methodology and tools

4.1.3. Phase 3 - Testing and Verification at Trial Sites and Cross-Border Corridors [M24 – M30]

The phase from M24 to M30 involves the testing and verification of rollout activities. In this phase, the focus is on verification of all equipment, components, systems and solutions developed and integrated in WP3. The verification step ensures that all systems are ready to initiate the trials in a harmonised way to produce consistent sets of data at any corridor and trial site. Regarding TS-CBC integration, TSs should perform their initial tests for the transferrable software and hardware assets before handing them in to the CBCs in this phase. At the end of this phase, "D3.6 – Report on trial readiness verifications" is to be completed. The deliverable should contain the process for and outcome of the verification of user stories in the corresponding trial sites. Another important task in this phase is to transfer remaining complementary components from individual trial-sites that can run on top of the integrated cross-border deployments.

4.1.4. Phase 4 - Support for Early Trials and Upgrades for Full Trials [M28-M34]

After the completion of testing and verification for all rollout components, Phase 4 focuses on providing deployment maintenance for initial trials of all user stories between M28 and M34. Ensuring interoperability between CBCs and TSs is an important task in this phase as testing of transferred complementary assets in CBCs are also planned as part of initial trials. This way, initial trial results can be compared at the TSs and the CBCs and upgrades can be made on these assets before the full trials. After receiving WP4 early trials progress report within this phase, upgrades for full trials should begin at all trial sites. The feedback obtained from the progress report are going to be broken down into 5G Network, Vehicle and OBU, CCAM and Data Evaluation to upgrade the relevant tasks in the WP3 ClickUp space. To begin full trials, these upgrade tasks must be completed by M34, which marks the end of Phase 4.

4.1.5. Phase 5 - Maintenance and Support for Full Trials [M32 – M41]

The activities in WP3 Phase 5 between M32 and M41 focus on maintaining the site infrastructure and on supporting the CCAM trials in WP4. Throughout Phase 5, each task leader in WP3 needs to make sure to update their plans as needed for integrating the changes or extensions required to better support the coherent execution of full trials. These updates are to be performed in a more agile form in this phase. Moreover, it is indispensable that further upgrades and fine tuning on the deployed infrastructure will be required as the commercial 5G networks are rolled out and as autonomous driving technologies evolve. In addition to upgrades due to technological developments, a feedback cycle facilitated by periodic monitoring across all WP3 tasks will enable direct communication with all site contacts and expert groups.

Just before the end of Phase 5, in M40, D3.7 - Final report on development, integration and rollout delivery will be completed. Based on the trial site outcomes, a strategy for the use of the CCAM infrastructure beyond the end of the project will also be provided in D3.7.

5. 5G DEPLOYMENT AND INTEGRATION

This section presents an overview and timeline for the 5G network deployment plans for CCAM trials of 5G-MOBIX to be executed in T3.3 of the project, where more detailed plans and step-by-step deployment strategies have been developed for each CBC and TS. In alignment with the specifications in D2.2 [5], the common 5G network deployment activities at all trial sites can be broken down into the following categories:

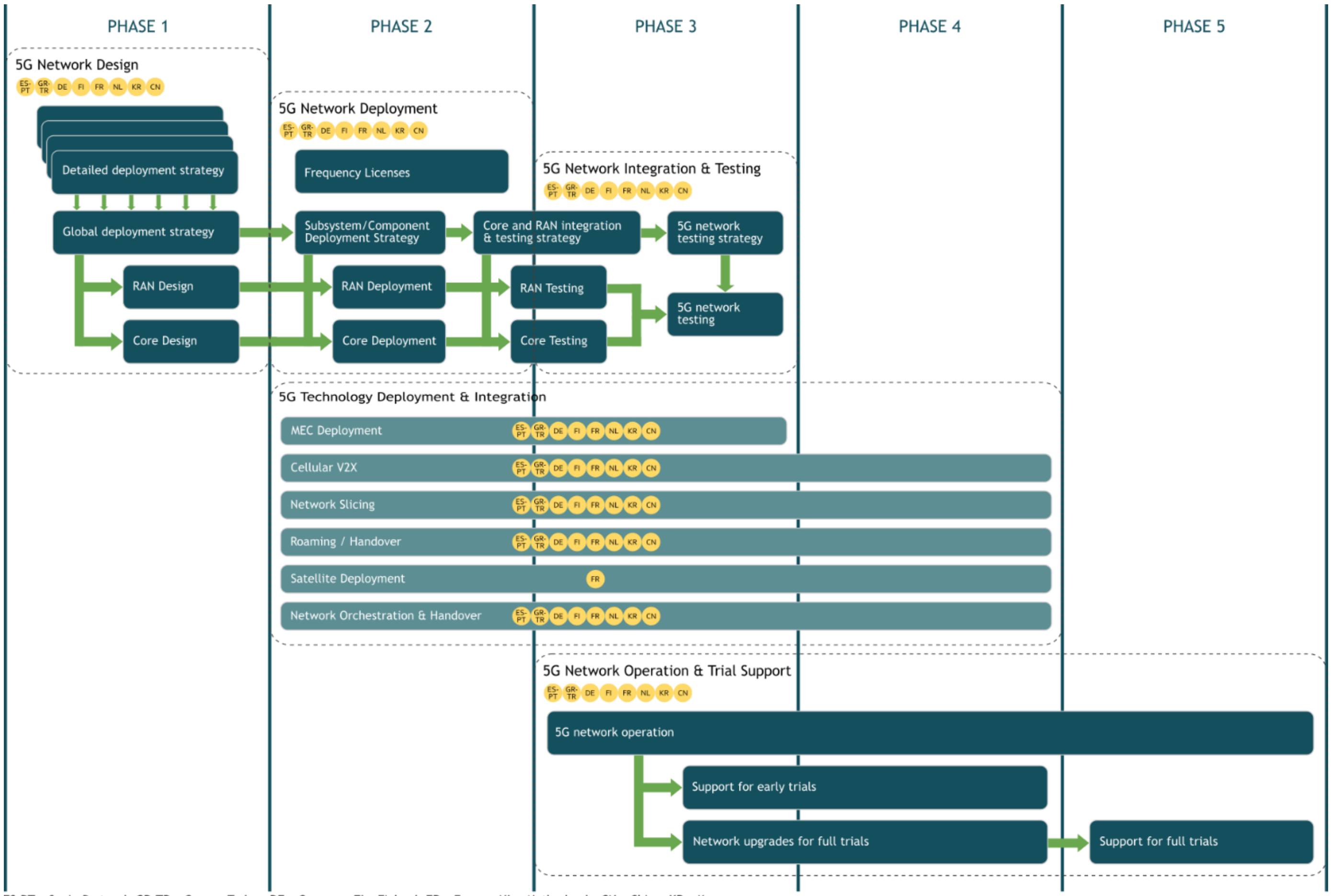
- 5G Network Design:
  - Radio network design,
  - Core network design.
- 5G Network Deployment:
  - Radio network deployment,
  - Frequency License Acquisition,
  - Core network deployment.
- 5G Network Integration and Testing
- 5G Network Operation and Trial Support:
  - Support for early and full trials,
  - Network upgrades.

In addition to those categories, which also map directly to the high-level timeline for the work to be carried out, T3.3 has defined a specific activity to monitor and plan the deployment and integration of specific 5G technologies relevant to CCAM use cases at cross-border locations:

- 5G Technology Deployment and Integration:
  - Cellular V2X [12],
  - Multi-Access Edge Computing (MEC) [13],
  - Network slicing [14],
  - Roaming and handover [15],
  - Network orchestration [16].

T3.3 focuses on 5G deployment and integration, according to the specifications defined in D2.2 [5] and 3GPP study on enhancement of support for 5G V2X Services [17]. This task consists of the aforementioned 5G technology deployment and integration activities, as shown in Figure 6. The latter further illustrates the mapping of the five activities of T3.3 to the 5-Phase plan developed in T3.1.

Phase 1 focuses on the network design issues, for both RAN and core, defining a set of detailed deployment strategies at the TS and CBC, which inform the global deployment strategy. During Phase 2, T3.3 will deploy the subsystems and components, gain necessary frequency licenses and prepare the core and RAN integration strategy as well as start core and RAN testing. Testing takes place during Phase 3, which integrates RAN and core elements, and also performs end-to-end 5G network testing. The following subsections provide the details of these phases. In parallel to the deployment of the network, a set of advanced network technologies will be deployed and integrated, in some cases as part of the initial deployment, while in others as subsequent network upgrades – the corresponding activities thus span from Phase 2 to Phase 4. Beginning in Phase 3, operating the deployed networks and supporting the trials performed in WP4 will be the main tasks of T3.3. In Phase 4, the networks will support the early trials, while in parallel integrating required upgrades to be able to support the full trials in Phase 5.



ES-PT = Spain-Portugal, **GR-TR** = Greece-Turkey, **DE** = Germany, **FI** = Finland, **FR** = France, **NL** = Netherlands, **CN** = China, **KR** = Korea

Figure 6: Overall Picture of the 5-Phase Rollout Plan for the MOBIX 5G Networks

As seen in Figure 6, the activities of T3.3 in Phase 1 involve all cross-border corridors and all local trial sites, to develop the respective detailed deployment strategies and align them in the global deployment strategy of T3.3. Further design and subsequent deployment of the radio and mobile core network segments are performed by each CBC and TS and take place in Phase 1 and Phase 2 respectively, including deployment of the subsystems and corresponding testing. Similarly, network integration and testing are performed by each CBC and TS, though this task receives special attention at the CBCs, where it includes integration between the different networks at each side of the border. In addition, the focus on 5G technology deployment and integration as a separate, horizontal activity provides a clear overview during phases 2 to 4 over the progress on 5G technology deployment across the different CBCs and TSs. Therein it should be noted that satellite integration is only planned for the FR TS, as indicated in Figure 6.

To monitor the work progress, all T3.3 activities are defined in ClickUp tool for each TS and CBC, together with the planned start & end dates and task assignees. An example Gantt chart view of high-level T3.3 activities for the ES-PT CBC is depicted in Figure 7.

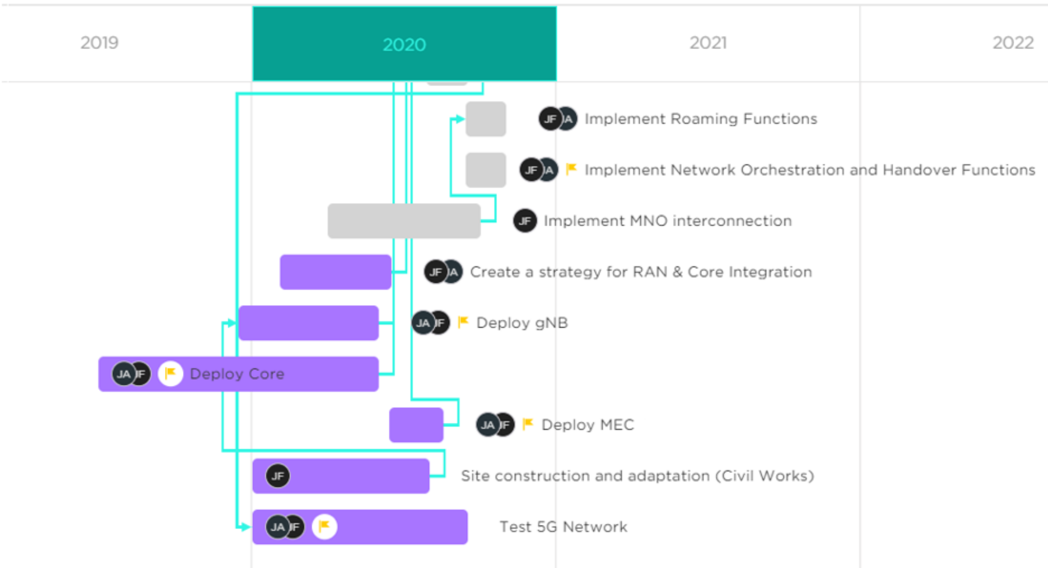


Figure 7: Example Excerpt from the 5G Deployment and Integration Activity Planning in ES-PT CBC

5.1. 5G Network Design

This activity addresses the development of network design and deployment plans, based on the specifications identified in T2.2 and reported in D2.2 [5]. The activity follows a parallel top-down and bottom-up approach, where an initial set of local deployment plans and a given global high-level deployment strategy and timeline iteratively converge to a coherent set of deployment plans. The global deployment plan, on the other hand, remains applicable to all CBCs and TSs.

The global deployment plan consists of the 5G network rollout plan shown in Figure 6 and a minimum set of specific tasks to be performed within each activity and sub-activity outlined therein. This set of tasks is further specified by and for each CBC and TS and expanded upon through the addition of additional CBC and TS tasks to develop the respective fully detailed deployment plans.

The network design tasks focus on the design of the overall network as well as on providing detailed designs for the core and RAN network segments, based on the solution outlined in T2.2 and reported in D2.2 [5]. This typically involves a more detailed specification of the chosen solution, high-level and low-level designs as well as the preparation of requirements, implementation and test documents to be followed during deployment, integration and testing. Finally, it involves the identification of the targeted deployment sites and respective required licenses and permissions as well as the identification and selection of the hardware and software components to be acquired and deployed.

For the design of the radio access network segment, this includes the definition of the planned network coverage, the identification of the targeted radio sites and frequency bands (and required licenses and permissions), and the selection of possible radio equipment, as well as the definition of the targeted front- and backhauling architecture.

Similarly, for the design of the core network, this includes the selection and deployment of the required core network functions, the identification of the required software and hardware components as well as the identification of the data network structure.

5.2. 5G Network Deployment

The deployment of the 5G networks at the CBCs and TSs forms the main activity of T3.3 and takes place in Phase 2 of the 5-Phase rollout plan, as discussed previously. In this activity, the rollout plans previously developed in Phase 1 are executed. The structure of this activity follows that of the planning prepared in Phase 1, as illustrated in Figure 6. From the global and detailed deployment strategies, the specific deployment strategies for each component and subsystem are extracted to guide the actual deployment. A detailed work plan is developed for the deployment at each CBC and TS and is maintained and monitored in ClickUp, assigning the responsible personnel for each task, defining and tracking the relevant deadlines and prioritizing the work in order to avoid delays, and minimize any potential risks.

For the RAN network, the deployment includes the surveying and preparation of the radio sites, the acquisition of the required hardware and software, their delivery to and installation at the radio sites, their configuration and commissioning as well as their integration and optimization at radio site level. Depending on the chosen system solution and architecture, the RAN deployment further includes establishing connectivity for front- and/or backhaul to the radio sites.

The core network deployment similarly includes the acquisition, installation and configuration of the relevant software and hardware as well as their integration towards the establishment of a functional core network. The deployment of the core network will vary, depending on the chosen deployment scenario, i.e., whether the network will operate in standalone (SA) or non-standalone (NSA) mode as detailed in D2.2 [5]. In the case of NSA operation, the core network may consist of an upgrade of an already deployed LTE evolved packet core (EPC) to a 5G EPC or the dedicated deployment of a 5G EPC. For SA operation on the other hand, a new 5G core will be deployed. It should be noted that a subsequent upgrade from NSA to SA is being considered by a number of CBC/TS, however this may not fall within the initial deployment in Phase 2, but rather to be considered as an upgrade during Phase 4. For the initial deployment, the majority of CBCs/TSs has opted for an NSA deployment (ES-PT, GR-TR, DE, FI, FR, CN), while the NL and KR TS will provide a SA deployment directly.

In addition to the RAN and core network deployments, the 5G network deployment activity further includes the acquisition of the necessary frequency licenses. The procedure for acquiring spectrum licenses may differ between countries and is handled locally by each CBC or TS. The acquired licenses may be in the form of commercial spectrum assignments or in the form of testing licenses or experimentation purposes.

5.3. 5G Network Integration & Testing

The 5G network integration and testing activity is designed to ensure the deployed network components and subsystems are fully integrated and to verify functionality of the different 5G networks deployed. The 5G network integration and testing activity commences within Phase 2 with the testing of the deployed RAN and core subsystems and culminates with the testing of the overall 5G network by the end of Phase 3. Detailed test plans to be executed in this activity are derived from the requirements specified in D2.2 [5], the test and verification documents prepared during the network design as well as based on the network KPIs defined in D2.5 [10]. The detailed test plans for RAN, core and the overall 5G networks are entered and monitored in ClickUp as for the previous activities, assigning the responsible personnel for each task, defining and tracking the relevant deadlines and prioritizing the work in order to avoid delays, especially on the critical path.

The testing of the network first includes the testing of the deployed nodes, test of connectivity between the different nodes in the core network as well as between the core and RAN nodes. Second, it includes the end-to-end (E2E) testing of the deployed network and verification of the required connectivity and coverage. Finally, it includes the verification of the required network functionality and performance.

In the case where multiple 5G networks are deployed at a CBC or TS, this task further includes establishing the required interconnections between the networks and their respective testing.

5.4. 5G Technology Deployment & Integration

The 5G technology deployment and integration activity is designed to differ from the other activities in T3.3, in that it provides a dedicated activity to monitor the deployment and integration of specific 5G technologies, independent of the rollout stages of planning, deployment, and testing. As such, the 5G technology deployment and integration activity runs in parallel to the deployment, testing, and early operation of the network in Phases 2, 3, and 4. As many of the 5G technologies may not yet be available during the initial rollout of the 5G networks, this task specifically foresees the upgrade of the networks with the advances of 5G technologies, to fulfil the CBC and TS requirements posed by the trials or to allow the evaluation of their performance and value for CCAM use cases in cross-border settings.

Based on the cross-border issues and network solutions identified in D2.2 [5], a number of 5G technologies were identified to be specifically monitored in this activity:

- *MEC deployment* plans and monitors the deployment of MEC solutions at the different CBC and TS. This may come in for ETSI MEC deployments or regular edge computing and depending on the CBC/TS needs or solution design a single or multiple MECs may be deployed per operator.
- *Cellular V2X* is central to address the requirements from CCAM use cases and may be deployed in many flavours, e.g., as direct/short-range vehicle to vehicle (V2V), as vehicle to network/long-range (V2N) or between vehicle and infrastructure (V2I). This sub-activity monitors the deployment, integration and use of the different V2X variants across the different CBCs and TSs.
- *Network Slicing* is key to achieving guaranteed service level or quality of service or to deeply isolate traffic of different types or different priority. This sub-activity monitors the use of slicing at the different CBCs and TSs and the chosen solutions for both NSA deployments (e.g., using different access point names (APNs) or prescheduling and advances subscriber group handling (ASGH)) as well as for SA deployments with 5G slicing (as per 3GPP Rel. 15).
- *Roaming / handover* is a key challenge at cross border corridors setting and this sub-activity monitors the deployment and integration of different solutions for roaming and handover at the different CBCs and TS and provides an overview of the selected roaming variant, e.g., home routed roaming or roaming with local breakout.
- *Satellite deployment* tracks and monitors the integration of the satellite network with the 5G network at the FR TS.
- *Network orchestration and handover* tracks and monitors the deployment of different network management and orchestration solutions at the different CBCs/TSs and their impact on the available parameters and options for handover management.

In addition to monitoring the deployment of these advanced 5G technologies, the activity is further designed to provide an overview of the selected solutions and variants for each of these technologies and to stimulate the knowledge exchange and innovation on these activities between the CBC and TS.

5.5. 5G Network Operation & Trial Support

The 5G network operation and trial support activity is designed to support the network testing in Phase 3 and take over operation of the network after completion of testing. It will support the early trials in Phase 3 and 4 and in parallel will deploy network upgrades to prepare for support of the final trials in Phase 5. The activity further monitors and manages the 5G networks across both Phase 4 and 5. Analog to the previous activities, the work related to 5G network operation and trial support as well as that for the network upgrades to be deployed is entered and tracked via ClickUp.

The planned network upgrades mainly fall in one of two categories: first, the upgrade from NSA to SA operation and, second, the upgrade or inclusion of the 5G technologies previously discussed in order to address the specific challenges posed by the trials and/or to evaluate additional functionality and/or support improved service quality for CCAM use cases in cross-border settings.

6. CCAM INFRASTRUCTURE DEVELOPMENT AND INTEGRATION

This section presents the rollout plan for CCAM infrastructure development and integration, to be executed alongside T3.4 of the 5G-MOBIX project. In alignment with the CCAM infrastructure specifications in D2.3 [9], the CCAM infrastructure deployment activities at all trial sites aim at delivering complete road facilities in M30. The road infrastructures are expected to meet the designed objectives for the TSs user stories and to capture various performance values according to the trial plans defined in WP4, prior to evaluation activities defined in WP5. The main infrastructure components identified in the specification in D2.3 are listed as in the following:

- Roadside sensor/actuator platform integrated with 5G communication infrastructure,
- Roadside unit (RSU) platform with required network interfaces for V2X and cloud communication,
- Cloud infrastructure platform integrated with 5G and non-5G auxiliary communication infrastructure for V2X communication,
- CCAM Application development and integration with roadside and cloud infrastructure.

The CCAM infrastructure deployment and integration tasks are grouped in three main activities and sub-activities that focus on enhancing the road infrastructure, integrating the road infrastructure with 5G network, and the evolution of the road infrastructure platforms with extended toolboxes, applications and interfaces. These activities are carried out in five phases which partially overlap, as depicted in Figure 8. The first phase of activities focuses on the execution plans and global alignment efforts, and the beginning of the development and deployment activities. The focal point of the second phase is the sensor, edge, and cloud infrastructure deployment and their integration with 5G networks. This is followed by infrastructure testing and verification activities in Phase 3. The activities of the fourth phase aim at supporting early trialling with the CCAM infrastructure, while facilitating further upgrades to the deployments. Having completed these activities, Phase 5 then focuses on the maintenance of the CCAM infrastructure to support the full trialling. The details of the T3.4 activities conducted in the phases are detailed in the following subsections.

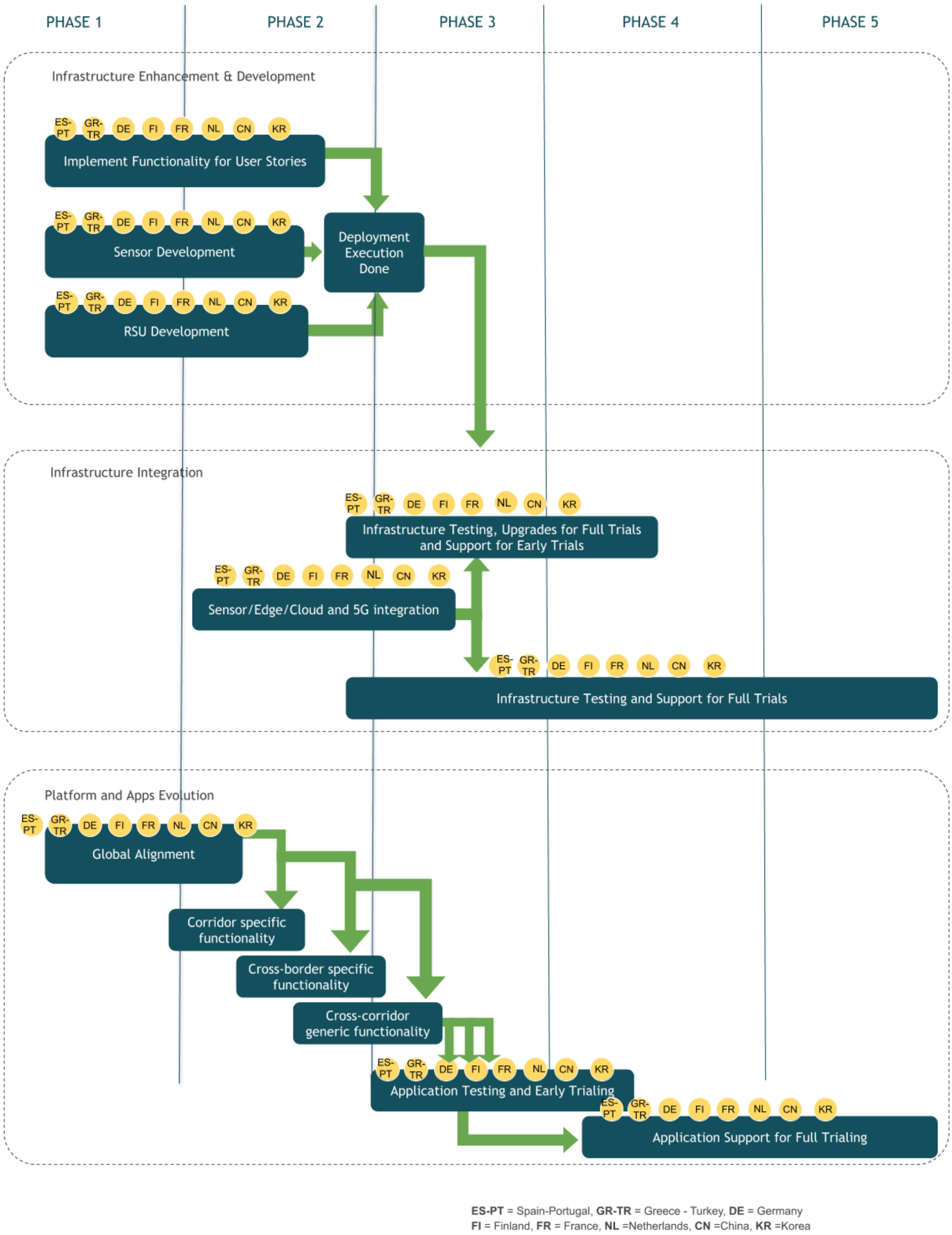


Figure 8: Overall Picture of the 5-Phase Rollout Plan for CCAM Infrastructure

To monitor the work progress, all T3.4 activities are defined under the Clickup tool for each TS and CBC, together with the planned start & end dates and task assignees. An example Gantt view of the high-level T3.4 activities for the FI TS is depicted in Figure 9.

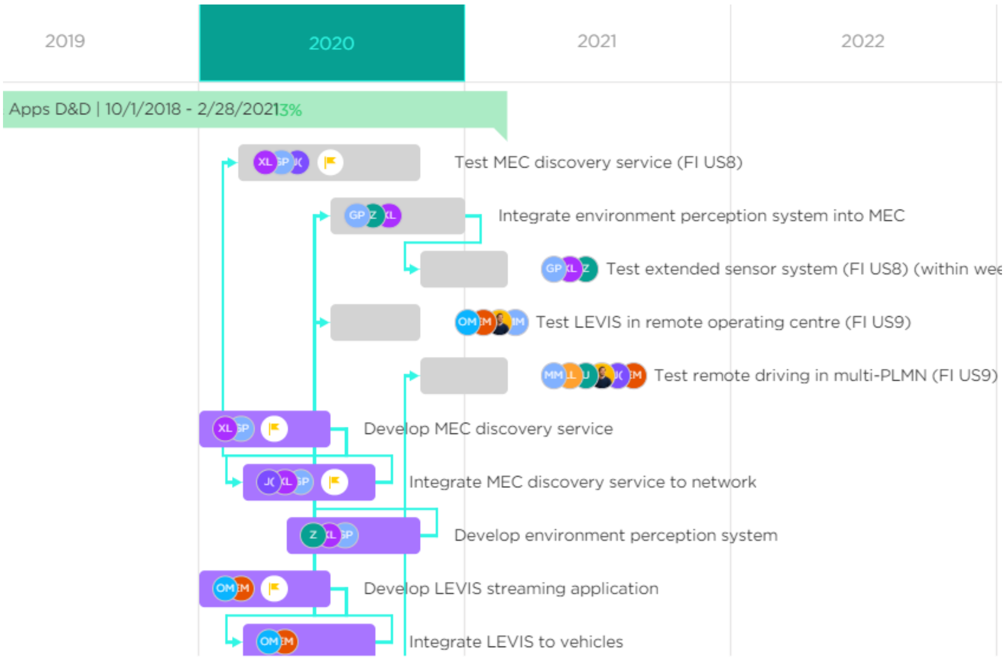


Figure 9: Example Excerpt from CCAM Infrastructure Development and Integration Activity Planning in FI TS

6.1. Infrastructure Enhancement & Development

This subsection provides an overview on the corridor specific infrastructure enhancement and development conducted at the different trial sites and cross-border corridors to realize the CCAM infrastructure.

The roadside infrastructure developed and deployed at the ES-PT cross border corridor comprises 5G RSU infrastructure components, which are a prerequisite for the Traffic Radar and Pedestrian Detector system to be implemented and deployed on both sides of the corridor. The deployment of two servers (one in ES, one in PT) to host the ITS centre cloud applications completes the required infrastructure enhancement for the ES-PT cross border corridor.

The infrastructure enhancement activity on the GR-TR cross-border corridor comprises 5G RSUs developed and designed by IMEC that are a prerequisite for the LDM for truck routing application on the Inönü and Ipsala sites. Apart from the RSU, the development for the GR-TR user stories further includes the functionality enhancements related to sensors for the traffic light, border gate, license plate reading camera, etc.

For the German trial site, the infrastructure enhancement activity comprises the installation of RSUs along the urban corridor, which are extended with C-V2X capabilities, MEC units, and ROI-based discovery services. Furthermore, the roadside infrastructure is extended with HD video camera sensors, which are required for the DE TS user stories, such as the EDM-enabled extended sensors with surround view generation. Finally, a control centre is deployed that provides a centralized overview on the roadside infrastructure and sensors.

The Finnish trial site enhances the infrastructure with a MEC discovery service which enables the integration of an environmental perception system with the MEC in the FI TS extended sensors user story.

The French trial site enhances and develops the infrastructure with components of the MEC system according to the ETSI standard. A sensor data fusion module, also developed in the scope of T3.4, is located in the MEC and is responsible to consolidate the data collected from roadside sensors, and vehicles (through V2X messages) aiming at increasing the reliability of the identification of the different activities on the highway and delivering output to the risk assessment application. Further infrastructure enhancement tasks include the development of speed limit and autonomous driving zone V2X announcements. Finally, a cloud platform allows the French trial site to deploy VEDECOM applications in a cloud environment provided by CATAPULT and based on Kubernetes. This will allow the FR TS to test a Far-MEC deployment option.

The Netherlands trial site enhances the CCAM infrastructure by deploying RSUs for an extended sensor use case, where a Video-based monitoring system will be used with existing roadside camera along highway N270. The RSUs of the VBM system are ready. No RSUs are used for direct communication.

6.2. Infrastructure Integration

This subsection describes the corridor specific infrastructure integration conducted at the different trial and cross border corridor sites to attain the 5G-enabled and fully integrated road infrastructure. The integration activities conducted at the cross-border corridors and local trial sites can be grouped into different types of integration categories, such as sensor device integration, sensor backend configuration, edge or cloud integration. The main focus of this activity lies therefore on the integration of the roadside infrastructure and sensors by means of proper network setup and configuration, sensor backend configuration or middleware integration. For the 5G related aspects, this activity aligns closely with T3.3. The infrastructure integration activity also includes testing the proper functioning of the integrated components, however, the testing and verification of software and / or infrastructure components developed by multiple partners on the other hand is conducted within the scope of T3.6.

In the following, we provide a short summary of the tasks that cover the infrastructure integration activities at each CBC and TS.

The ES-PT CBC infrastructure integration tasks focus on the integration of the Traffic Radar and Pedestrian Detector System sensors with the RSUs, aiming at the installation and configuration on both the ES and the PT sides. Regarding the integration of cloud infrastructure, both countries plan the deployment of cloud server hardware, which can then be used for deployment of the cloud applications in the cloud infrastructure.

The GR-TR infrastructure integration focuses on the integration of the roadside infrastructure (provided by the IMEC RSU) with the lidar sensor and 5G network, which is a pre-requisite for the "Assisted BC" use case. Further integration work for this use case comprises the integration of WINGS roadside infrastructure with 5G network and further sensor components (e.g. camera, border bar, traffic light, etc.) to the trial site. Regarding the integration of Edge/MEC infrastructure with the 5G Network, the GR-TR CBC tackles the integration of a WINGS infrastructure solution with Ericsson's 5G EPC, as well as the integration of a server with 5G EPC. Finally, the TR 5G network will be integrated with the TÜBİTAK Cloud.

At the German trial site, the infrastructure integration focuses on the integration of the camera-based sensors with the RSUs by applying the proper installation and network configuration, in order to provide the video for the EDM-enabled extended sensors with surround view generation use case. In addition, the integration of the sensor backend and 5G network with the RSU are required to attain a fully integrated V2X solution for secured 5G video streaming.

The Finnish trial sites' infrastructure integration activity focuses on the integration of the environment perception system into the MEC, as part of the FI TS extended sensors user story. This includes the proper network connection setup to connect the deployed edge server, DNS server and 5GC to the UPF.

At the French trial site, the infrastructure integration aims to integrate the following components in the MEC platform, in order to assist the autonomous vehicles in their advanced driving manoeuvres: The integration of Lidar data source model and objects extraction, the integration of CP application, the integration of a multi-source data fusion module, the integration of situation assessment and trajectory guidance modules, and finally the integration of a Manoeuvre Coordination application.

The NL TS infrastructure integration activity focuses on the integration of the Video-based monitoring system with MQTT servers at the TNO edge and at the KPN edge for CPM.

6.3. Platform & Apps Evolution

The Platform and Apps Evolution activity described in this subsection covers all the tasks that aim at incrementally evolving the TS/CBC platform with additional applications, interfaces, and toolboxes to attain the specific use cases. In addition, this activity pursues the global alignment of the TSs and CBCs to enable cross-corridor activities. The global alignment should therefore help the overall project to identify synergies among TSs and CBCs or to spot potential problems early. As depicted in Figure 8, the global alignment spans over the platform & apps development for three distinct abstraction levels: First an application is developed for the trial site where the use case is executed, which we denote as corridor-specific functionality. Then the validation takes place at the cross-border corridors to attain the cross-border corridor specific functionality. Finally, as the most refined iteration of the platform the final goal of interchangeable applications, tools, services, etc. is reached, which we refer to as cross-corridor generic functionality. In the remainder of this subsection we describe the individual tasks that are conducted as part of the corridor-specific functionality. More details on the integration of this functionality into the CBCs can be found in Section 2.2.

The ES-PT CBC implements a specific HD Maps Application for its platform, which includes the development of a Sensor Data Processing Component specific for the sensors deployed at each side of the CBC. In addition, an HD Map creation and distribution platform is developed, and a functionality which enables the ES-PT CBC to share ADTF packaged sensor data from the trial site location. Furthermore, a monitoring functionality as well as a DENM notification functionality for ES and PT is developed within the scope of this activity.

The development activities to evolve the GR-TR platform and apps include the See-what-I-see app, the truck routing application, the LDM for both sides of the CBC, as well as a network based platooning application.

The DE TS develops an EDM infrastructure application as a part of its platform and apps activities, which provides the functionality for the EDM-enabled extended sensors approach. Further work items include the MEC multi-cloud orchestration app development and the MEC network controller app that provide edge resource management for the DE TS use cases.

The FI TS develops an environmental perception system to be integrated with the MEC in the FI TS extended sensors user story. Another development activity within the scope of platform and apps is the development of the LEVIS (Live strEaming VehIcle System) application that will be leveraged in the remote driving user story to obtain HD video streams (with location tags) from the vehicle.

The FR TS development activities for platform and apps comprise a V2X application server that implements a V2X message forwarding functionality. This V2X application server is responsible for the handling and delivery of data to the vehicle or V2X device in a target area. In addition, several applications are being integrated into the MEC platform in order to assist the autonomous vehicles in their advanced driving manoeuvres. This includes the integration of a Lidar data source model and objects extraction, the integration of a CP Application, the integration of a multi-source data Fusion module, the integration of situation assessment and trajectory guidance modules, and the integration of a Manoeuvre Coordination application.

7. VEHICLE ADAPTATION

As part of the rollout plan of 5G-MOBIX, this section presents the vehicle adaptation plans for CCAM use cases to be executed in T3.2 of the project. In alignment with the specifications in D2.4 [8] and 3GPP "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services" document [18], the common vehicle adaptation activities at all trial sites can be broken down into the following groups:

- Vehicle – sensor – device integration,
- Software functionalities development and integration,
- OBU development and integration,
- Integration of Trial Site contribution to Cross-Border Corridor vehicles/OBUs.

Following the 5-Phase plan, Figure 10 shows the activities identified for vehicle integration for each trial site and cross-border corridor. As seen in Figure 10, three groups of activities and their subtasks extend over the five phases, starting, in Phase 1, with the creation of the rollout plans to determine when the trial sites are to perform their vehicle integration related activities. The purchase of the required devices and early installation are also the main activities of Phase 1. In Phase 2, the vehicle integration is carried out, which involves sensor and devices' integration, the development of the AD functions for the user stories and their integration for testing in the vehicle. OBU development and integration, which includes the procurement of the 5G chipsets and OBU software development and deployment activities, is also to be completed in this phase. Testing and verification of all integration done in the Phase 1 and 2 is going to be carried out in Phase 3. Phase 3 is also devoted to cross-testing with other WP3 tasks to ensure the correct operation of the whole system. In Phase 4, a support to early trials is targeted, with all partners keeping all CBC and TS systems operational to develop the first steps of the trials, and making the necessary upgrades for full trials. Finally, in Phase 5, maintenance and support of vehicles and OBUs for full trials is required from partners.

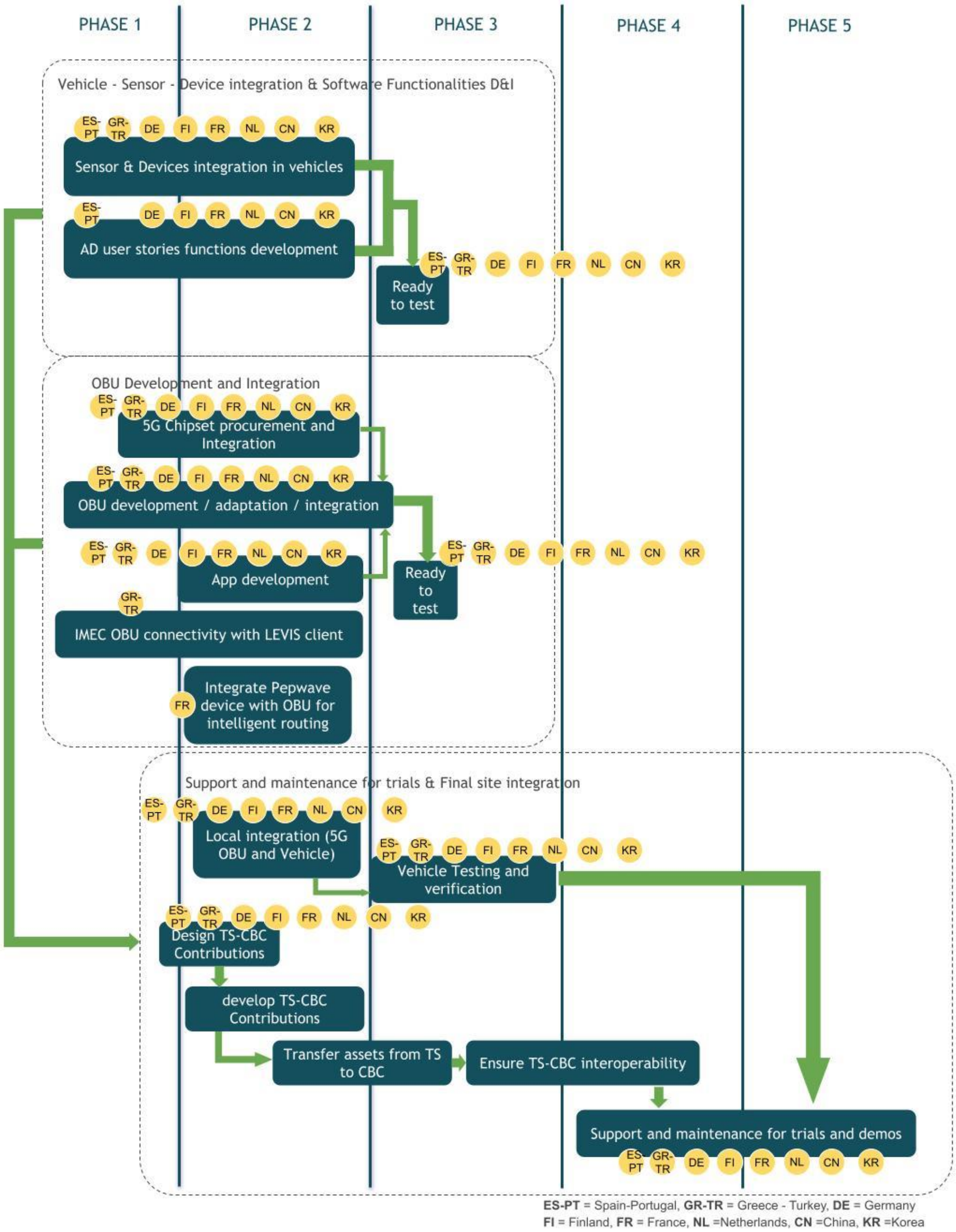


Figure 10: Overall Picture of the 5-Phase Rollout Plan for Vehicle Adaptation

In the following subsections, each of these phases is described in greater depth, focusing on the specific activities to be carried out in each phase and referencing the activities by phase. An example Gantt view of the high-level T3.2 activities in DE TS is also depicted in Figure 11.

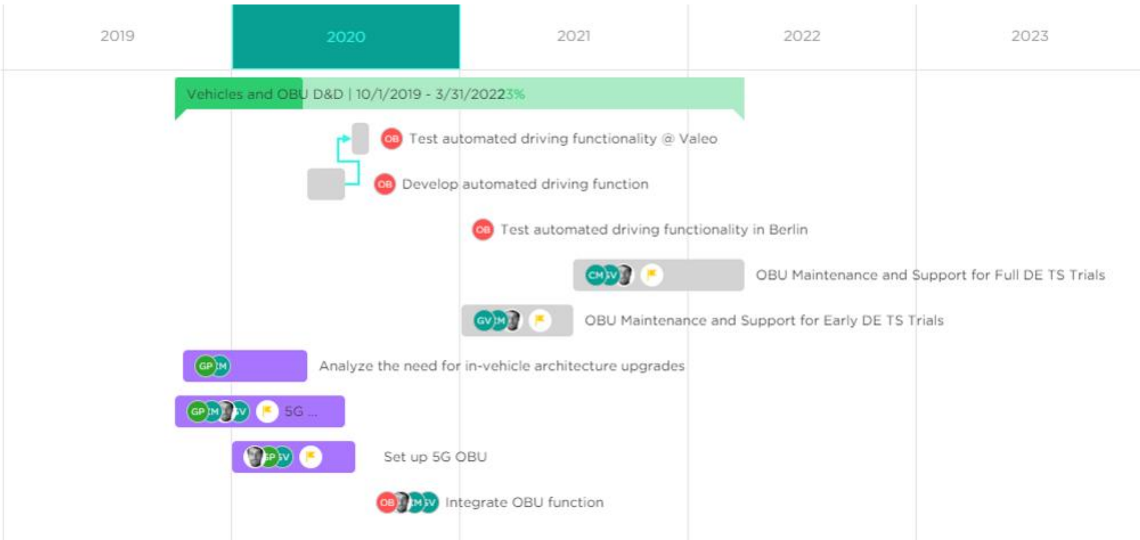


Figure 11: Example Excerpt from the Vehicle Adaptation Activity Planning in DE TS

7.1. Vehicle - Sensor - Device Integration

This subtask extends from Phase 1 to Phase 3 and includes all the work related to integrating the necessary sensors and devices to the vehicles to realize the user stories. The activities in this task range from the purchase or selection of the vehicles to the acquisition and integration of the sensors and devices to each vehicle. Other activities of this subtask are solving the issues related with the integration and creating a small unit test to check if all the integrated hardware runs properly on the vehicle.

During Phase 1, all sites should purchase the necessary equipment to be installed in the vehicles and, after that, in Phase 2, all TSs and CBCs assemble these acquired sensors and devices in the vehicles. This phase is described in Clickup under a common activity for all sites:

- Integrate vehicle sensors & devices: Under this activity title, TS and CBC leaders and all stakeholders can monitor whether the sensors and devices are installed in each vehicle, and when those integrations are to be done during the Phase 2. This activity is a successor to the vehicle procurement activity, and it blocks the deployment and testing of the automated driving functionalities in the procured vehicles.

Finally, in Phase 3, all these integrated sensors together with the software functionalities are to be tested and verified to ensure seamless operation with the OBU and connection to 5G network.

7.2. Software Functionalities Development and Integration

Spanning over the first three phases, this subtask includes all AD functions and those functionalities that must be developed to carry out the user stories. During Phase 1, each site should make vehicle related software function creation part of their rollout plan. Then in Phase 2, the proposed software functions are to be developed, which include AD functions and all the software components required in vehicles to realize the user stories using the 5G network. The main activities registered in ClickUp for this subtask are:

- Develop vehicle functions: In this activity, each site should register all the software functionalities, including automated driving applications and communication functionalities inside vehicles as mentioned in the introduction, and the time plan for that activities. This activity has a dependency to sensor and devices' integration and blocks the unit tests of vehicles at all trial sites.
- Develop remote driving functionality: The implementation to perform the remote driving of the vehicle activity is specific to FI TS user story, and is marked as a blocker to the integration of this functionality in the FI vehicles.

In Phase 3, the software components are merged with the hardware components to run the necessary tests and check whether the communication between all these software components is available. This activity is defined in ClickUp as follows:

- Test software functionality: In this activity, all software components should be tested in vehicles with the integrated hardware component. This is test is run to ensure that the vehicles are ready to communicate over the 5G infrastructure and to verify the user stories.

7.3. OBU Development and Integration

During this subtask, the partners involved obtain the OBU and the 5G chipsets and develop and integrate these components to test the user stories. In this task, the functions to send and receive information through the 5G network are also developed. Same as in previous subtasks, this subtask spans over Phase 1, 2, and 3. This action starts in Phase 1, where all stakeholders obtain the OBUs. As most stakeholders had problems in obtaining 5G chipsets to be installed in the OBUs, this activity continues in Phase 2, as explained in "5G Chipset Procurement" ClickUp cards:

- 5G Chipset procurement: This card is used to track the procurement of the 5G chipsets to be integrated in the OBU. Due to the limited availability of these products on the market, a lot of partners had difficulty in obtaining them in Phase 1. As a result, an expert group was created to work on a solution to get them in an easier way. This activity continues in Phase 2 and it is a blocker to the most of OBU development activities. The integration of this chipset in OBUs is a crucial point to continue developing and assembling OBU components.

In Phase 2, 5G chipsets procurement continues and OBU development starts. All partners are required to develop the software components to use this 5G chipset and integrate it to other car components & the network to carry out the user stories. In ClickUp the following cards are created to track these activities:

- Develop OBU: This activity includes developing the physical structure of the OBU, implementing the software functions, and the integration of 5G chipsets. As the integration of 5G chipset is essential to continue with the deployment of communication unity using 5G network, this activity is dependent on 5G chipset procurement activity. The activity to integrate the 5G OBU in vehicle and the unitary tests are blocked by this activity.

- Develop IMEC OBU: In GR-TR CBC, the OBU is developed by IMEC to provide support for both 5G connectivity and C-V2X PC5 short range connectivity. The OBU is to be installed in two Ford Trucks for "See-What-I see/Platooning" and "Assisted Cross Border crossing (Truck guidance to scanner)" use cases. The IMEC OBU is waiting for the 5G chipset and it is blocking all activities that have dependencies to it, such as test, integration with LEVIS client and verification activities.
- Integrate smart routing device with OBU for intelligent routing: This is an activity from FR TS to register the integration between the smart routing device with the OBU to get intelligent routing using 5G network. This activity takes place in Phase 2 and is dependent on testing intelligent routing with the smart routing device. After completing this activity at the FR trial site, this technology is to be transferred to the ES-PT CBC, as explained in Section 2.2. As part of this subtask, FR TS will also develop and integrate the V2X services such as CPS, MCS, CAS, DEN in the OBU. This activity has blocked the activity to integrate the V2X services in OBU.
- Develop Multi-PLMN OBU connectivity solution: This activity is from Finland TS and as its title declares, it is linked to implementing the connectivity solution of Multi-PLMN. This activity is dependent on the procurement of the OBU, modems and components and it is blocking the test of this solution. After completing this activity at the FI trial site, this technology is to be transferred to the ES-PT CBC, as explained in Section 2.2.

In Phase 3, unit tests of the OBU should be carried out. The integration of this OBU to the vehicle and verification of all OBU related functionalities are also to be completed in this phase.

7.4. Support and maintenance for trials

In Phase 4 and Phase 5, all partners are required to give support and maintenance to the vehicles and their components to perform the trials. All TS and CBCs should also provide feedback about the implementation process, software components and adaptations to develop the user stories.

8. EVALUATION DATA COLLECTION AND MANAGEMENT

This section presents the rollout plan for evaluation data collection activities of the CCAM trials in 5G-MOBIX to be executed in T3.5 of the 5G-MOBIX project. In alignment with the specifications in D2.5 [10] and work on Evaluation Methodology[6], the common data collection and management, activities at all trial sites can be broken down into the following groups:

- Specification of data logging requirements,
- Measurement tools,
- Trial site data management tools,
- Centralized test server (CTS).

Following the 5-Phase plan, Figure 12 shows the activities identified for developing the evaluation data collection and management for each trial site and cross-border corridor.

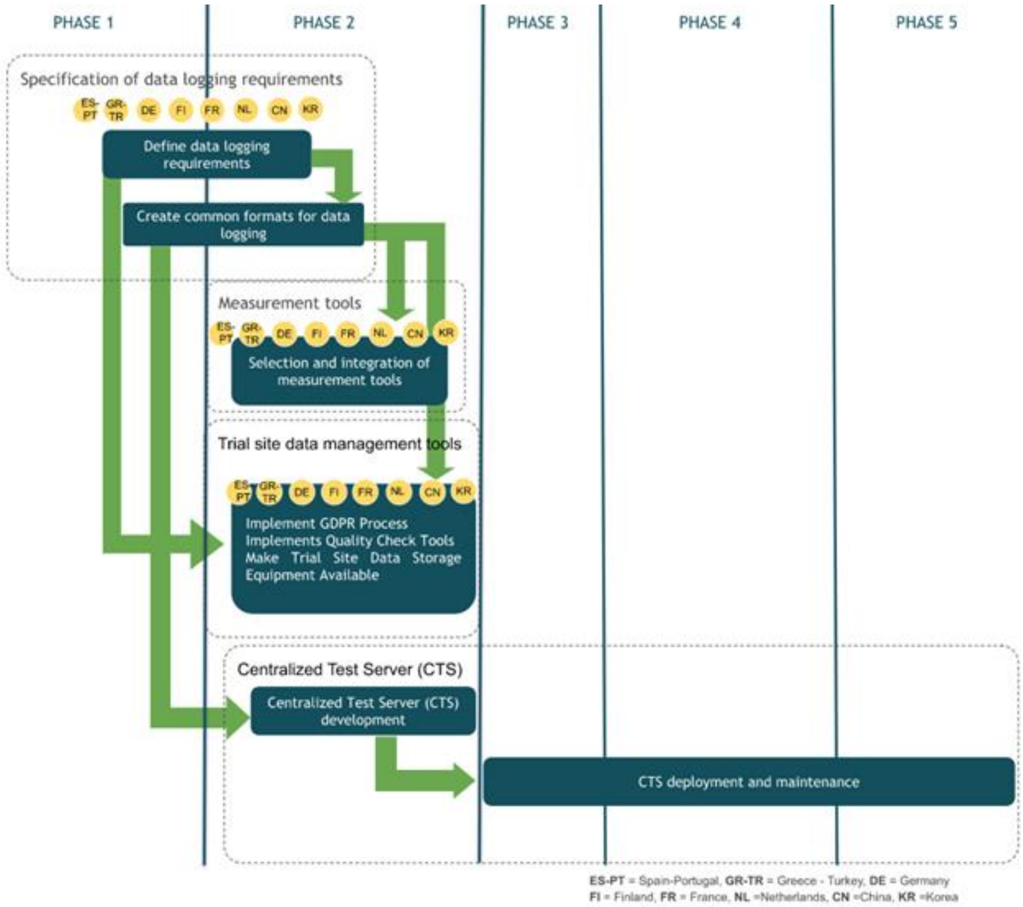


Figure 12: Overall Picture of the 5-Phase Rollout Plan for Evaluation Data Collection and Management

[6] To be reported in D5.1.

Phase 1 starts with the definition of data logging requirements. In parallel, another activity titled "common data formats for data logging" starts in this phase. These two tasks continue during the second phase as well. In Phase 2, the main objectives are to complete the selection and the integration of the measurement tools, to implement the data management tools and processes at each CBC/TS (also called distributed data management platform), and to develop the centralized data management platform. Finally, in Phases 3, 4 and 5, the main objectives are to deploy and maintain the centralized test server during the trialing phases.

To monitor the work progress, all T3.5 activities are defined under the Clickup tool for each TS and CBC, together with the planned start & end dates and task assignees. An example Gantt view of the high-level T3.4 activities in FR TS is depicted in Figure 13.

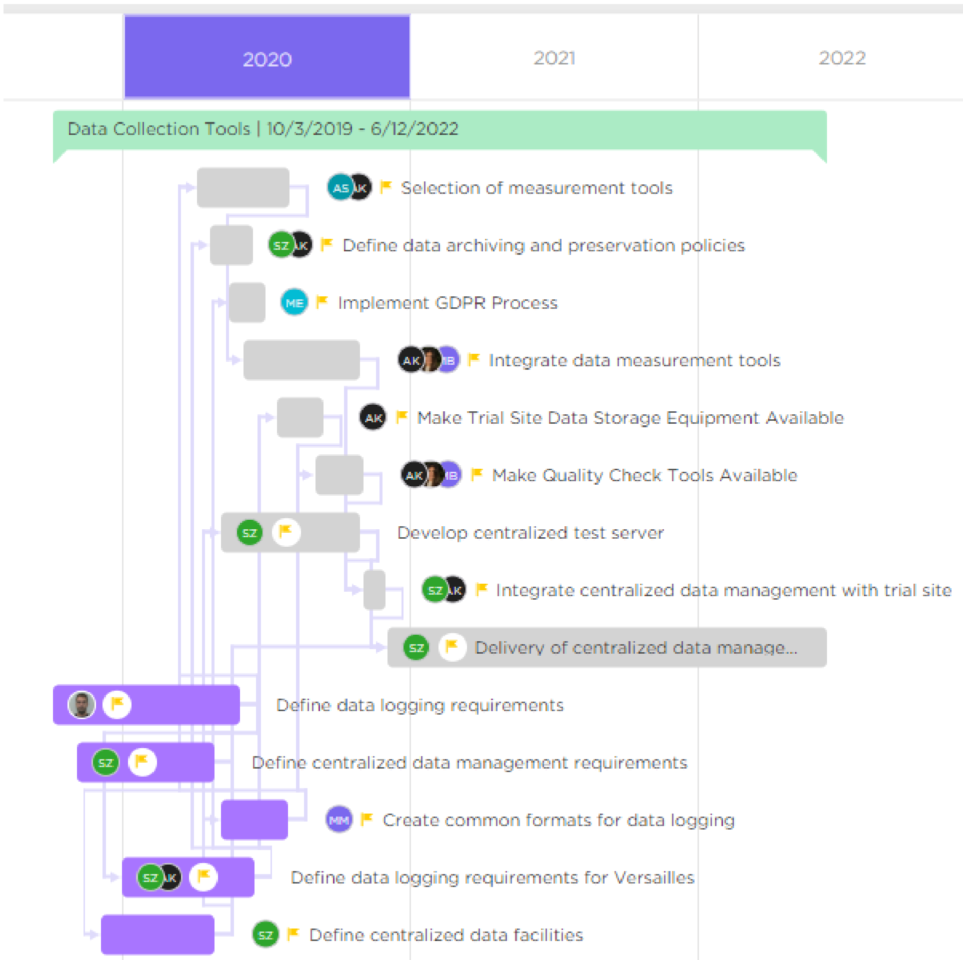


Figure 13: Example Excerpt from the Evaluation Data Collection Activity Planning in FR TS

In the following sections, the main activities of each of the four activity groups are detailed.

8.1. Specification of Data Logging Requirements

In the specification of data logging requirements activity group, the following activities are carried out:

Define data logging requirements: This activity corresponds to a requirement gathering process, which identifies all functional requirements and non-functional requirements of the evaluation data collection. Thereby, common data collection requirements are used to define a common methodology for evaluation data collection, centralized data server requirements are used to specify the Centralized Test Server (CTS) and finally Trial Site (TS) specific requirements are used to identify TS specificities. During the execution of this activity, CBC/TSs are to review the deliverables D2.5 and D5.1 to agree on the KPIs to be provided for the evaluation by each user story and on the common evaluation methodology's requirements.

- This process is common to all TSs. It starts at M13 and ends at M19.
- This activity uses inputs from D1.4, D2.5, and D5.1.
- The output of this task is used by "Create common formats for data logging" activity and for the implementation of "Trial site data management tools" and "Centralized Test Server (CTS)".

Create common data format definition: The goal of this task is to define a common format for data logging on the basis of the requirements defined in the previous activity and also on the basis of the new requirements that are identified during the collaboration with T2.5 and T5.2. This collaboration should finalize the KPI definitions and set the quality requirements for the data to be logged and stored in the CTS (information to be logged, parameters detailed definition, accuracy, range, units, etc.), and used in the technical evaluation.

- This process is common to all TSs. It starts at M13 and ends by M20.
- As inputs, this activity uses the requirement defined in "data logging requirements" activity in D5.1 and during T3.5 & T5.2 cross WP activities.
- The output of this task is used by "Measurement Tools", and CTS activities groups.

8.2. Measurement Tools

Under the measurement tools activity group, the selection and integration of data measurement tools are carried out:

Selection and integration of data measurement tools: During the selection phase of this task, CBCs/TSs decide and denote the tools they select for the measurements. Different tools can be selected to support different measurements e.g., measuring network capabilities (UCC/US agnostic) against measuring UCC/US specific logging information. Several presentations will help to see how each CBC/TS address this task (identification of measurement tools) and to check if they are using the right tools for the data collection. During the integration phase, selected tools are integrated into the foreseen reference architecture at predefined points of control and observation (PCO). Whatever the tools used for collecting the measurement necessary for the evaluation, they must provide the data defined by task 5.2 in the predefined common format for data logging.

- This process is specific to each CBC/TS, but follows the same timeline. It starts at M19 and ends at M26.
- As inputs, this activity uses the requirements defined in "Create common formats for data logging" activity.
- The output of this task will be used by T3.6.

8.3. Trial Site Data Management Tools

In the trial site data management tools activity group, the following activities are carried out:

Implement GDPR process: During this activity, each CBC/TS must implement the GDPR process.

Implement data quality tools: During this activity, a list of data quality check requirements is defined and implemented in a common tool named *Data quality check Tool (DQCT)* to be used by each CBC/TS. DQCT will check the quality of measurement data and evaluation data.

Make trial site data storage available: During this activity, each CBC/TS defines the processes, tools and servers needed to collect and store measurement data and evaluation data prior to any data transfer to CTS. At M28, each CBC/TS starts integration and verification tests. At the end of M28, Trial Site Data storage equipment and data quality check tools should be available for early trials and verifications.

- This process is specific to each CBC/TS but follows the same timeline. It starts at M19 and ends at M28.
- As inputs, this activity group uses the requirements as defined in "data logging requirements" and "Create common formats for data logging" activities.
- The output of this task will be used for the deployment of CBC/TS data management tools and processes. The verification results will be used as input to D3.6.

8.4. Centralized Test Server Development

In the Centralized Test Server activity group, the following activities are carried out:

Centralized test server development: The CTS is a set of tools, servers, and scripts deployed in the cloud that is dedicated for evaluation data collection and sharing. It applies all requirements defined during the specification phase and paves the way for 5G-MOBIX project moving towards ORDP and its FAIR principles. The CTS guarantees proper data collection, description, quality and storage at central level. AKKA develops CTS components, which include evaluation data sharing interface (web interface, Rest API), evaluation data uploading / downloading/ monitoring, evaluation data storage (disk and database), data harmonization and data quality check, evaluation data builder, etc.

- This process is executed by AKKA. It starts at M19 and ends at M27.
- As inputs, this activity uses the requirements defined in "data logging requirements" and "create common formats for data logging" activities.

- The output of this task is the CTS.

Centralized test server deployment and maintenance: The deployment of the first release of the CTS is performed at M28. After a short period of integration and bugs correction between M28 and M30, a second release will be deployed taking into account verification phase change requests. Then a long period of operations and maintenance will start and go on until the end of the project at M45.

- This process is executed by AKKA. It starts at M19 and ends at M30.
- As inputs, this activity uses the requirements defined in "data logging requirements" activity and "create common formats for data logging" activity.
- The output of this task is the production version of the CTS.

9. VERIFICATION

9.1. Overall Target

The verification process in T3.6 aims to provide the necessary methodology and tools to ensure that the WP3 tasks are ready to initiate the trials and to evaluate the components and systems of trial sites successfully. The verification activities of T3.6 can be broken down into the following categories:

- Creating verification methodology, test cases and tools.
- Verification of network components, CCAM infrastructure, vehicles and their applications and evaluation data collection tools.
- Cyber-security checks and monitoring developed components based on data privacy regulation and policies.

The verification addresses the necessary 5G infrastructure and technology, vehicle adaptations and software tools in order to enable the corridor trials as specified in WP2, developed and integrated into WP3, executed in WP4 and evaluated in WP5. To commence with verification, the above-mentioned subjects must be mature, stable and in principle ready for running the trials.

The verification is performed during the Phase 3 of the 5-Phase plan (Figure 5), and will be reported in detail in the deliverable **D3.6** [19].

9.2. Dependencies of Verification

The generic verification development process is highly dependent on other 5G-MOBIX WPs and their inputs, as described in Figure 14. The development process contains the following elements:

1. T3.6 provides an overall description of the verification process for reference in T3.1, which provides the overall description of verification for independent WP3 T3.2-3.5.
2. For development of verification methodology, test cases and tools in T3.6:
   2.1. T3.2-3.5 provide their development and rollout plans for reference.
   2.2. WP2 provides the user story sequence diagrams of each corridor and trial site for reference.
3. The verification methodology, test cases and tools are provided for guidance by T3.6 for verification work at local level (Phase 3) .
4. The local evaluation is performed across the cross-border corridors and trial sites, based on the guidelines, which report back their verification results to T3.6.
5. The verification methodology is also applied to the transferred assets at the cross-border corridors.
6. The results of the local evaluation (step 4) and the evaluation of the transferred assets are integrated in the report D3.6.

The release of D3.6 should approve and confirm the readiness of the user stories for execution in WP4 "Trials" and to support WP5 "Evaluation".

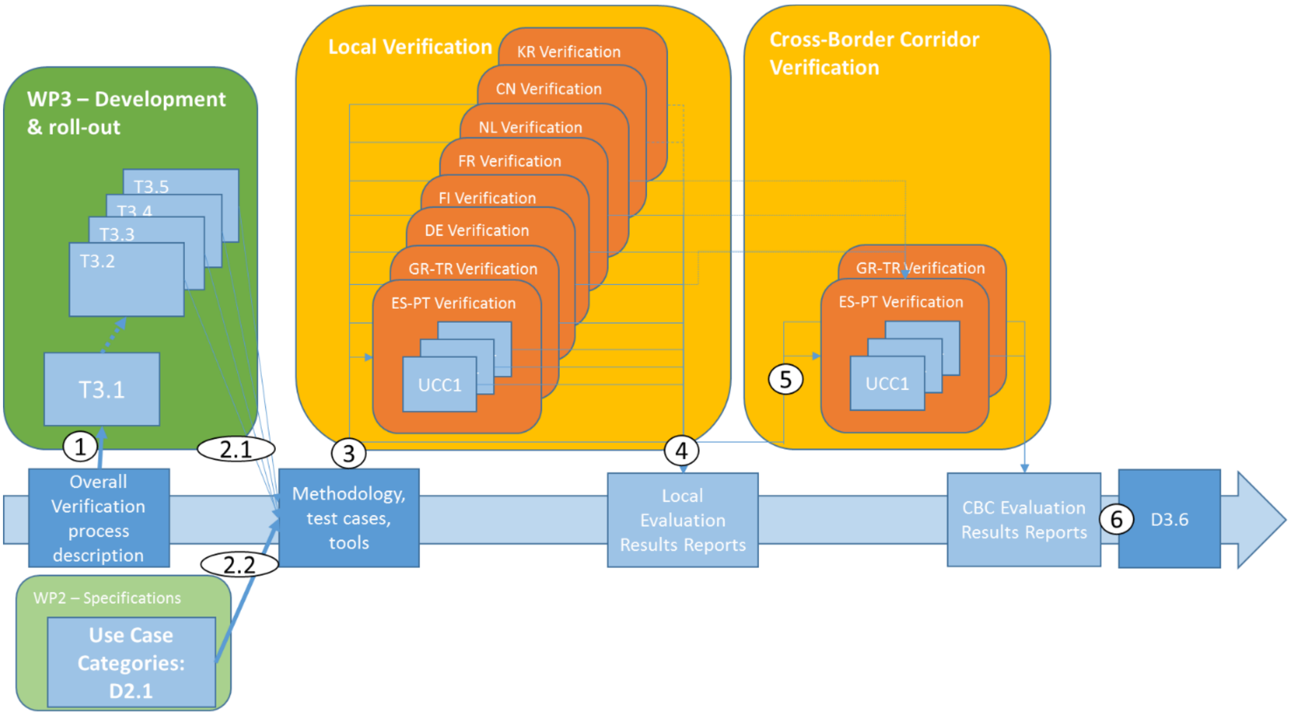


Figure 14: D3.6 Development Process in Wider Context

Specifically, in WP5, T5.2 should comprehensively evaluate the technical performance of technologies and solutions implemented in the corridors and the trial sites and, especially, the cross-border behaviour of the network and solutions implemented, taking into account the architecture and technical specifications of the user stories defined in WP2 and the common evaluation methodology defined in T5.1.

9.3. User Stories and Verification Process

In the verification process, the technologies of the four major domains, namely 5G network technologies, CCAM facilities, in-vehicle systems of the connected and automated vehicles (CAVs) as well as cyber-security and privacy functions are subject to verification. Verification includes both the standalone verification of the different components developed by the partners and the verification of the integration of the components. The self-assessment of the developing partners is required for the verification of these components. For this purpose, a checklist is created and relevant tasks are assigned in the project management tool ClickUp to track the progress.

Regarding the verification of the integration of the different components, this verification task concentrates on the user stories for each corridor and trial sites summarized in Section 2. The WP2 specification deliverables (D2.1-2.5) defined the contents of the sequence diagrams for each user story. For several of the user stories, there are different scenarios, related to different manoeuvres or different communication configurations. The verification is performed at user story scenario level.

The sequence diagrams define the data flow for each of the user story scenarios. In order to report when the corridor and trial sites are ready to proceed into the actual end-to-end deployment of their user stories, the verification process targets to test the data communications between components, which are provided by different partners. When the individual message sequences for the user story scenario have passed the verification test cases, the user story scenario is considered as verified for trial deployment.

9.4. Verification Approach

The cross-border corridors and trial sites carry out the actual verification tests using the user story scenario specific test cases. The test cases are targeted to the *checkpoints* where information exchange takes place between components developed by different partners. The verification may take place when the components to be tested are considered mature, stable and ready for operative use or when the predefined set of cooperative technologies are mature, stable and operational.

Figure 15 depicts the example of the user story CoCa (Cooperative Collision Avoidance), for the scenario where a CoCa app at the MEC gives advices to the vehicles. In the app, the different checkpoints are marked corresponding to interactions between different components and outputs of specific components, e.g. algorithms for collision detection. The checkpoints are coloured, corresponding to whether there is only a single actor involved in the development (orange) or several actors (green). The verification will concentrate on the checkpoints involving different actors.

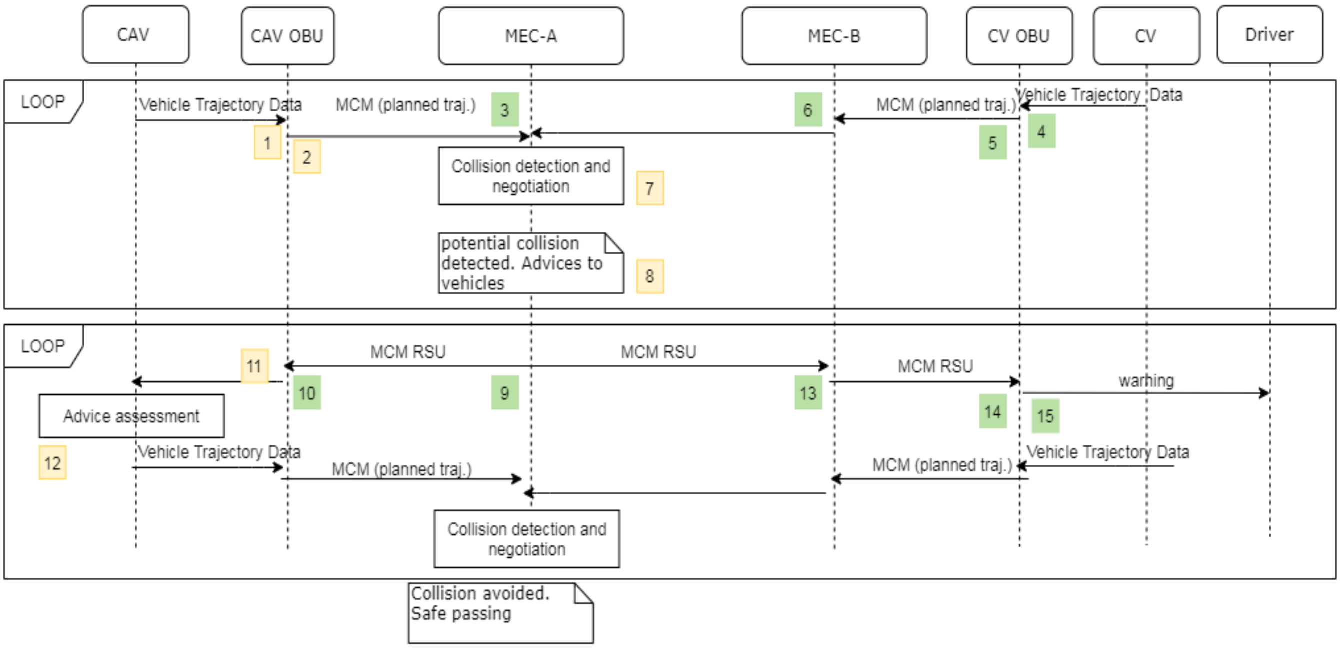


Figure 15: Sequence Diagram for RSU Negotiation Scenario of CoCa User Story

For each of the multi-actor checkpoints one or more test cases will be developed. The test case definition will describe how the test case is to be performed, including an assessment whether the test case can be performed remotely or not.

9.5. Verification Reporting

The verification reporting is kept clear and simple. Each step defined in the site-specific user story specifications (sequence diagrams) is checked against the specific success criteria. The main tools are the user story sequence diagrams and the test case definitions (checklists) for each user story that is to be tested. For the verification reporting purposes of each information exchange protocol, a test report template is prepared. The components that work as specified pass the verification test. When all components required for the specific user story have been cleared in the tests, then the user story as a whole is cleared for end-to-end deployment, piloting and eventually presenting for technical and operational evaluation in WP5.

9.6. Partner Involvement for Verification

The local experts of the cross-border corridor and trial sites should run the verification procedures at site level. Thus, the procedure to run the tests should be made as simple and as descriptive as possible. Each site is responsible to agree which entity would be the most convenient actor for the task. The cross-border corridor or trial site manager/leader is in charge of the site's verification results and their reporting. The partner involvement and resources for verification are agreed locally and managed by the local partners.

10. CONCLUSION

This deliverable aimed at providing a methodology and describing the activities of the rollout plan in 5G-MOBIX, to facilitate proper alignment of the setup and deployment activities among different trial sites. After providing a brief description of all trial sites and cross-border corridors, we first emphasize the plans for the integration of local trial sites to cross-border corridors, as this integration is among the most challenging tasks of the project and shapes all the local activities and contributions until the beginning of trials.

A 5-Phase rollout time plan for deployment and integration was presented, which helps all stakeholders to create an aligned timeline to complete their rollout and deployment activities, taking into account the specific issues of trial sites. The rollout plan provides a compact view about the activities, the relations between the activities, and the participating trial sites inside a task. According to this plan, all trial sites shall be up and running with their vehicle, 5G network, CCAM infrastructure, and measurement components integrated and verified by Month-30 of the project (April 2021). This gives way to the execution of "early trials" in WP4 until Month-34 (August 2021), while WP3 activities continue with site maintenance and upgrades to revolve issues that may emerge during those early trials and TS-CBC integration activities. Finally, this should be followed by the "full trials" until Month-41 (March 2022), from which the measurements and KPIs should be collected for analysis in WP5.

While this common time plan is to be followed at each trial site and cross-border corridor in 5G-MOBIX, it is inevitable for such a large and complex undertaking to experience delays and deviations from the original plans. Towards circumventing or minimizing such risks, this deliverable also introduced the practical tools and methodologies to prevent or effectively resolve the deviations through continuous progress tracking and corrective actions when needed.

All activities planned during the 5-Phase plan are adapted to the five main WP3 tasks; namely "5G Deployment and Integration", "CCAM Infrastructure Development and Integration", "Vehicle Adaptation", "Evaluation, Data Collection, and Management", and "Verification". Full details of those sub-activities are provided in the respective 5G-MOBIX deliverables of T3.2 [2], T3.3 [3], T3.4 [4], T3.5 [19], and T3.6 [20].

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ANNEX

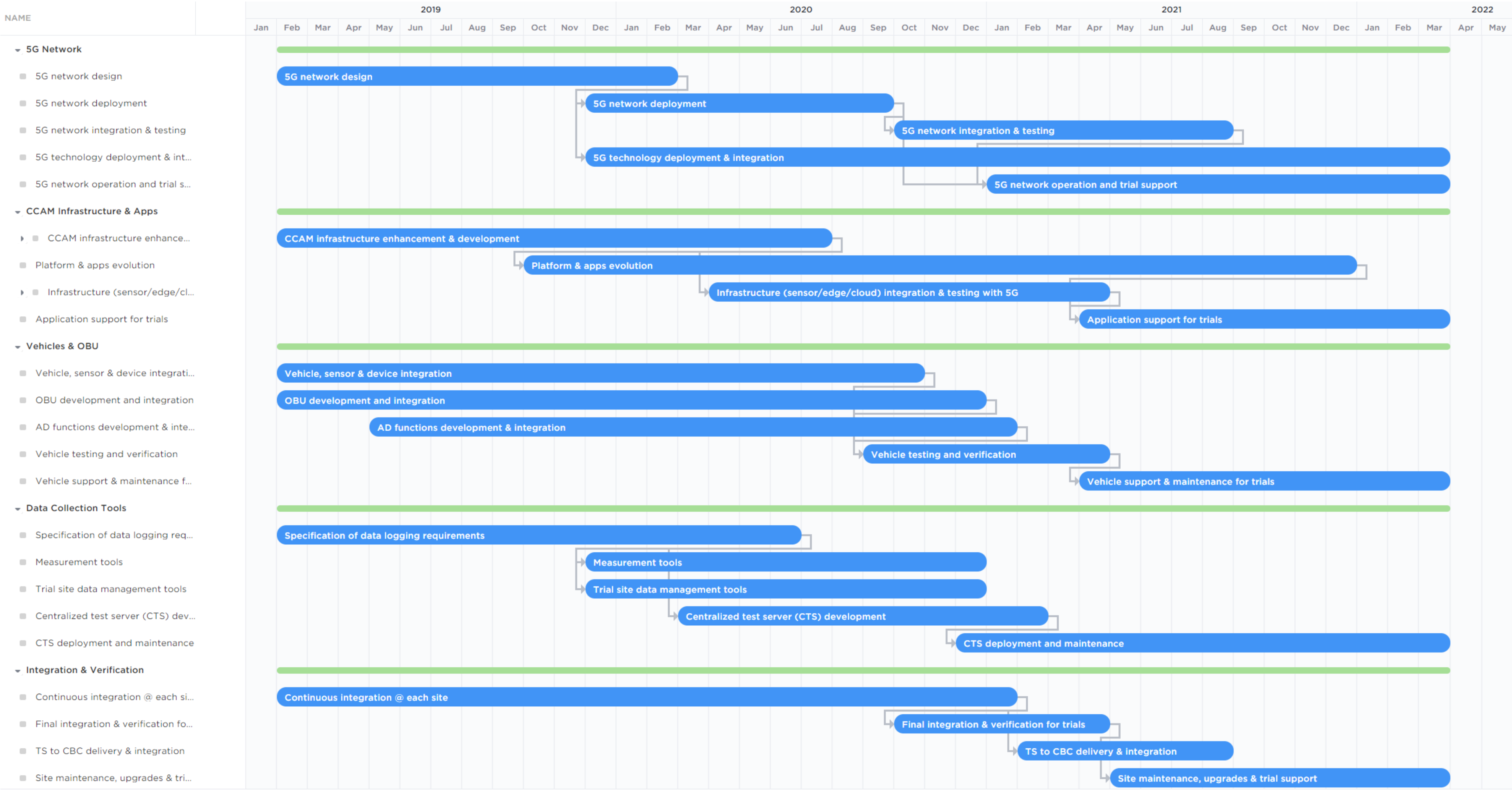

Figure 16: Common 5G-MOBIX development, deployment and integration timeline in WP3