D1.3

Innovation management plan

PoDIUM

PDI connectivity and cooperation enablers building trust and sustainability for CCAM

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Table 1 List of Abbreviations and Acronyms

Abbreviation	Meaning
ATSSS	Access Traffic Steering, Switching & Splitting
CAV	Connected Autonomous Vehicle
CCAM	Cooperative, Connected and Automated Mobility
DoA	Description of Action
DT	Digital Twin
EAB	External Advisory Board
EC	European Commission
F2F	face-to-face
FR1	Frequency Range 1
GA	General Assembly
IMT	Innovation Monitoring Team
IPR	Intellectual Property Rights
KPI	Key Performance Indicator
MCM	Maneuver Coordination Message
MEC	Multi-Access Edge Computing
PC	Project Coordinator
PDI	Physical and Digital Infrastructure
PM	Person Month
PU	Public
SA	Standalone
SC	Steering Committee
SME	Small and Medium Enterprises
SW	Software
TCP	Transmission Control Protocol
TM	Technical and innovation Manager
TMT	Technical Management Team
TRL	Technology Readiness Level
UC	Use Case
UCL	Use Case Leader
VAM	VRU Awareness Message
VRU	Vulnerable Road User
WG	Working Group
WP	Work Package
WPL	Work Package Leader

Executive Summary

The main purpose of this deliverable is to set the main innovation management rules for the project. The innovation management actions and the main related procedures are defined. We highlight the coordination role of the technical and innovation manager in the Technical Management Team for the identification and update of the project innovations on a regular basis. We establish the collaboration framework for the TMT with the leader of Task 7.4 - Exploitation strategy and IPR management regarding the exploitation of innovation results coming from the technical project activities. The establishment of the innovation monitoring system is important to accurately follow the market trends and identify on time the true potential of the developed work within PoDIUM.

This deliverable also provides an overview of main expected innovations during the project. Those innovations are linked to the background knowledge that is brought to the project from partners and the foreground knowledge that will be generated by the project activities. The goal here is not comprehensiveness but a representation of the broad foreground and background knowledge brought into the consortium strived for by the partners. Accordingly, we devise an initial plan for the foreground knowledge to be generated within the project duration with respect to the various key innovative PDI technologies, following the related definition activities for the system architecture and the functional elements of the platform and the use cases.

1. Introduction

1.1. Introduction to PoDIUM

PoDIUM aims to support advanced Use Cases (UC) of connected and cooperative automated mobility in real traffic conditions. Building urban and highway UCs on the facilities of 3 well-equipped Living Labs in Germany, Italy and Spain, PoDIUM will tackle all the different requirements for availability and performance of connectivity as well as the different cooperation enablers per UC. The proposed UCs aim to advance a set of key technologies both in the physical and digital part of the infrastructure. In particular, the following non-exhaustive list of contributions will be pursued:

- A multi-connectivity approach to ensure reliability, availability and redundancy of the PDI system.
- Advance data fusion and integration of Multi-access Edge Computing (MEC) to the proposed hybrid data management environment to enable enhanced environment perception models towards digital twins.
- New C-ITS messages for enabling the specific advanced CCAM use cases.
- Ensure software integrity, trust and truthfulness of CCAM data, their exchange and their processing.
- Demonstration of urban and highway use cases in a diverse set of configurations with integration of Vulnerable Road Users (VRU).

1.2. Introduction to innovation management plan

The innovation management in PoDIUM is part of the technical management activities. This ensures that potential innovations are closely monitored and mapped to the progress of the technical developments. The technical management procedures are led by the technical and innovation manager (TM), who is working with the project coordinator (PC) and the Work Package Leaders (WPL) to plan, monitor and direct all general technical aspects. This includes identifying foreground knowledge development and potential innovations directly from the work within the WPs. Technical decisions can be examined alongside the target innovations on a WP level and therefore be interrelated directly to the planned innovations, and in turn to the project's exploitation activities. Moreover, it is within the responsibilities of the Technical Management Team (TMT) to efficiently handle any conflicting choices for technical developments, avoiding their escalation to the general assembly level, and to ensure that the project's administrative actions develop the required and favourable conditions for the target innovation and their exploitation after the end of the project.

1.3. Purpose of the deliverable

The following sections summarizes the key elements for the innovation management that will guide the related activities throughout the project and will be regularly updated according to the defined rules. Section 2 describes the general innovation management rules and procedures adopted by the project. Section 3 provides an inventory for the main expected innovations in PoDIUM, focusing both on the background knowledge that is brought to the project and foreground generated knowledge as the project implementations progress.

1.4. Intended audience

The dissemination level of D1.3 is 'public' (PU), thus the deliverable is available to members of the consortium, the European Commission (EC) Services and those external to the project. This document is primarily intended to serve as an internal guideline and reference for all PoDIUM beneficiaries.

2. Innovation management

This section highlights the main goals of the innovation management procedure, including the key performance indicators identified for classifying the target innovations and the overall monitoring system for the identification, listing and update of the generated innovations in PoDIUM. The overall innovation management approach utilizes and builds on top of the Innovation Radar methodology[1].

2.1. General outline of management

The main goals of innovation management are:

- the constant awareness of the project status with respect to the identified innovative outcomes;
- the monitoring of activities with respect to potential innovations (including new innovations driven by market needs);
- the readiness to generate new innovation pathways potentially exceeding the project objectives.

The TM is responsible to monitor the related activities and organize all the partners contributing to the project developments to report the status as well as new potential opportunities on a regular basis. The updates are monitored at plenary level by the completion of the project milestones and deliverables on technical activities.

The adopted procedure relies on the close collaboration between the TM and the technical development team of the project with the goal to exploit the potential of project innovations and provide guidance on project technology choices based on existing and emerging market trends. Task leaders submit information on innovations or technology choices arising within their tasks to the WPL as part of the task reporting procedures. This information will encapsulate the following:

- a description of the innovation or technology choice;
- justification for considering the particular outcome as innovation or justification for making this technology choice;
- analysis of alternatives choices and indications on market trends as perceived by the technical experts.

Each WPL is responsible to subsequently inform the TMT in the next TMT meeting. The TMT having the overall technical view of the project can efficiently handle any conflicting choices for technical developments.

This procedure creates the basis for T7.4 - Exploitation strategy and IPR management. It is expected that the results will significantly advance the state-of-the-art knowledge level in the field and that a subset of the innovations resulting from the project will be used for commercial or IPR exploitation.

[1] http://publications.jrc.ec.europa.eu/repository/bitstream/JRC96339/jrc96339.pdf.

2.2. Key Performance Indicators and monitoring system

For the effective monitoring of innovation, we determine the Key Performance Indicators (KPIs) related to PoDIUM innovation and in parallel we establish a monitoring system to examine the related progress and identify the potential of each activity.

2.2.1. Key Performance Indicators

In particular, we list innovation KPIs and link them to the expected outcomes of the PoDIUM developments:

- The prime KPI for the position of an innovation to the **market** is the **timing** which indicates the position of the innovation with respect to market needs and most importantly the estimated time for the market penetration. It is extracted after the market analysis and exploitation plan per innovation, following the studies in WP7.

There are also a number of KPIs which can affect timing and are listed below:

- **Innovation readiness (TRL level)**: This indicates the technology readiness level at the time of the project end and can also be linked to the exploitation plans after the end of the project with an indication towards TRL 9. The metric directly affects the decisions with respect to the time to market.
- **IPR potential**: This provides an indication of the expected IPR that could result from the innovation. It can be linked to partners exploitation plans and TRL phases.

The potential for exploitation and extraction of value from an innovation is determined by the following KPIs that are also to be considered:

- **Number of competitors**: This is extracted from the market analysis and identifies the overall competition in the specific targeted field. It is combined with the market share as well as with the SWOT analysis for the position of the proposed innovations with respect to competition
- **Expected market size**: This is expected from the market analysis and provides an estimation of the market size with projection for the targeted release year.
- **Opportunities and barriers**: This is part of the SWOT analysis, and its goal is to evaluate the market penetration potential of the planned innovations.

Notice that the KPIs above are compliant with the KPIs, like Innovation Potential Indicator, specified in Innovation Radar[2]. However, certain aspects like “Innovation management” are not used. The latter is capturing the capacity of the project consortium and its commitment to bring innovations to the market and hence cannot be evaluated by the consortium itself.

[2] De Prato, G., Nepelski, D., & Piroli, G. (2015). “Innovation Radar: Identifying Innovations and Innovators with High Potential in ICT FP7, CIP & H2020 Projects”. Seville: JRC Scientific and Policy Reports.

2.2.2. Innovation monitoring system

KPIs are to be followed up closely in relation to the work plan and related tasks. The TMT together with the leader of Task 7.4 - Exploitation strategy and IPR management form the core of an Innovation Monitoring Team (IMT) which actively monitors the activities and participates in the exchange of the development status information. This team fosters the innovation culture to come up with new ideas and innovation solutions and tracks innovation solutions planned and implemented during the course of the project.

For the monitoring of the innovation results, a system is to be formed and used rigorously, primarily after M06 of the project following the initial design phase of the project and prior to the development phase. The innovation monitoring system will be the main process of keeping track of the innovations and the related KPIs by means of:

- Monitoring external state-of-the art technologies and regularly evaluate them along with the internal project work. This is carried out in WP level and in cooperation with the WP7 activities of exploitation and IPR management.
- Ensuring favourable conditions for the planned project innovations by:
    - following the Consortium Agreement for industrial rights sharing protocol to guarantee a transparent cooperative working environment;
    - identifying and resolving potential conflicts at IMT level or at plenary level, if needed; and
    - reserving at each consortium F2F meeting, a dedicated time slot for monitoring and coordinating the development of innovation solutions.
- Periodic reporting of the development status of each innovation by the responsible partner at WP level. This enables the WPL to track the development of planned innovations, and trigger, if needed, any necessary corrective actions.
- Identifying and promoting to external stakeholders the innovations resulting from project work by:
    - utilizing the Innovation Radar[3] to list new ideas;
    - the IMT evaluating possible applications of new ideas

[3] https://www.innoradar.eu

3. PoDIUM background and foreground knowledge

This section provides a list of the background knowledge brought to the project and the foreground knowledge that will be generated as a result of the development activities of the project. It provides a starting point for the work on identifying the innovations that may lead to exploitable results and IPRs, which is pursued in Task 7.4 (Exploitation strategy and IPR management).

3.1. Background brought to the project

The background refers to the existing knowledge that is provided by partners to the project (in the form of software artefacts, modules, application algorithms and processing data, as well as infrastructure solutions and supporting hardware), in order to be used for the development activities as these are denoted by the project objectives. The background knowledge sets the basis to generate the project developments and results. The main background knowledge can be found in Table 2 Background knowledge.

The initial background has been declared by partners in the CA. At that time no transfer of background knowledge to another party had been identified. The goal of this document is to update the initial list with main identified background knowledge required for achieving the project goals. The aim of the presentation is to show the available range and diverse background that is brought into this project by the consortium members. This is therefore not to be seen as a complete or conclusive list, but rather as a starting point for the upcoming work. Even if partners are named together for a background, this does not imply a joint contribution or a joint use. Instead, these partners contribute background that can be assigned to the described background type. The list of declared background knowledge is associated with the most relevant key innovative PDI technologies (see PoDIUM main work items), namely:

- Traffic Management Centre
- Advanced Environmental Perception
- CCAM Digital Twins
- SW integrity and trust & data truthfulness
- CCAM services on MEC
- 5G mmWave use in CCAM
- Short-range and multipath comm. in CCAM
- CAVs and VRUs

Table 2 Background knowledge

BG No.	Relevant background description	Related PDI technologies	Main contributing partner(s)
01	**Digital and Physical Infrastructure for Traffic Management** Manufacturing and maintenance of infrastructure for traffic management	Traffic Management Centre	ETRA, AAE

	• Developing, operation and maintenance of digital and physical infrastructure for Traffic Management • Software for analysing traffic data and developing traffic management strategies • Platform for storage, processing and fusion of mobility data from various sources in a centralized (cloud) or distributed (edge) manner		
02	**Detection, Tracking and Prediction Methods and Software** Methods and Software for detection, tracking and prediction of vehicles and VRUs • Implemented through camera and LiDAR sensors in the infrastructure as well as in-vehicle • Detection and tracking of vehicles (CAV and regular vehicles) • Detection and racking of VRUs of different kinds, e.g., pedestrians • Prediction for improve situation handling	Advanced Environmental Perception	LINKS, BOSCH, UULM, AAE, IDIADA
03	**AI-Based Monitoring Knowhow** Knowhow on AI-based systems (cameras) dedicated to risk detection in open and closed public areas involving VRUs	Advanced Environmental Perception	ETRA
04	**MEC-server and Infrastructure Based Digital Twin** MEC-server and infrastructure based digital twin, enabling centralized cooperative planning/information for CAV and VRUs • Publications, e.g., “Infrastructure-supported perception and track-level fusion using edge computing” • Pre-existing pilot site for German Living Lab • Pre-existing race circuit for technology testing for Spanish Living Lab • Defined and validated platform for MEC, based on ‘off-the-shelf’ software (Linux, Dockers, Kubernetes, VMWare).	CCAM Digital Twins, Advanced Environmental Perception	UULM, BOSCH, NOKIA, LINKS, SWARCO, CRF, RETE, A22, i2CAT, ETRA, IDIADA
05	**Large Scale Digital Twin & Mobility Hub Platform** Large Scale Digital Twin Technology for monitoring larger areas and/or a large number of vehicles • Platform for storage, processing and fusion of mobility data from various sources in a centralized (cloud) or distributed (edge)	CCAM Digital Twins	i2CAT, AAE

	• Centralized backend that collects all the positions of road users		
06	**Traffic Models of the Network** CCAM Digital Twins based on traffic models of the network, which are stochastic models of data flows or data sources in a communication network. • Used for designing network applications and capacity planning of the network. • ETRA has a wide experience in developing, operating and maintaining these models as a part of the Traffic Management System. • Evolution of traffic models incorporating the additional information from other infrastructure elements and the vehicles with a visualization and actuation layer are the main building blocks of the CCAM Digital Twin.	CCAM Digital Twins	ETRA
07	**Reliability Estimation Methods** Reliability estimation of communicated data and communication channels and data sources • Long research experience including multiple scientific publications in the area of reliability estimation, e.g., using subjective logic	SW integrity and trust & data truthfulness	LINKS, UULM
08	**Edge/cloud C-ITS message Handler & V2X Communication Stack** V2X communications protocol stack for communication among connected systems, e.g., VRUs or CAVs • Sending and receiving C-ITS messages from/to connected infrastructure, VRU and CAVs. • Software that decodes/encodes ETSI C-ITS messages on edge/cloud/OBU • Implementation protocols Facilities layer messages, GeoNetworking and BTP protocols, and signature process • Rich body of publications on ITS messages and services	CCAM services on MEC	LINKS, UULM, i2CAT, IDIADA, TIM
09	**5G mmWave Communication** Knowhow and pre-existing technology in 5G communication • 5G SA communication in the 410 to 7125 MHz frequency bands (FR1)	5G mmWave use in CCAM	NOKIA, RETE

	• 5G communication in 22 GHz band, providing high-capacity coverage for crowed places.		
10	**Network-layer Multipath Communications** Knowhow on transport and network-layer multipath communications • Scientific publications, e.g., "Multipath QUIC: A Deployable Multipath Transport Protocol", "A programming model for application-defined multipath TCP scheduling" • Participation in the specification of the multipath 5G functionality (ATSSS) in 3GPP standardization	Short-range and multipath comm. in CCAM	UDE, ICCS
11	**On board C-ITS message Handler & V2X Communication Stack** V2X communications protocol stack for communication between vehicle and other connected systems, e.g. VRUs, CAVs, Roadside/MEC infrastructure • Sending and receiving C-ITS messages from/to connected infrastructure, VRU and CAVs. • Software that decodes/encodes ETSI C-ITS messages on edge/cloud/OBU • Implementation protocols Facilities layer messages, GeoNetworking and BTP protocols, and signature process	CAVs and VRUs	CRF, LINKS
12	**Connected and Automated Test Vehicles** Connected and automated test vehicles, optionally with clearance for public road tests, under respective saftety regulations (safety driver etc.) • For German Living Lab • For Italien Living Lab • For Spanish Living Lab	CAVs and VRUs	BOSCH, UULM, CRF, IDIADA
13	**Connected VRUs** Connected VRU specific background • VRU specific message support such as VAM or adapted MCM • Mobile phone support via apps including support for relevant messages • Small size OBUs for bicycles and electric scooters • Mobile app for user/passenger mobility	CAVs and VRUs	NOKIA, LINKS, ETRA, i2CAT, ENIDE, IDIADA

3.2. Planned new developments (foreground)

The foreground refers to the new knowledge that is generated by the project's partners (in the form of software artefacts, modules, application algorithms and processing data, as well as extensions in the infrastructure and supporting hardware) during the course of the project and according to the planned development activities following the project's objectives. Therefore, the foreground knowledge represents the innovation results and developments of the project.

The list of identified foreground knowledge is summarized in Table 3. This is an open list that collects information from the implementation activities of the project and will be updated it on a regular basis as defined in management of innovation, section 2. Notice that to avoid duplication of content, we provide here only an abstract and reduced description of the expected foreground to be generated by the project, whereas the details of which of this knowledge will be exploitable (and how) can be found in the deliverables resulting from Task 7.4 - Exploitation strategy and IPR management.

Similarly to the background description, the entries are associated with the most relevant key innovative PDI technologies (see PoDIUM main work items) and the expected TRL improvement is indicated.

Table 3 Foreground knowledge

FG No.	Relevant foreground description	Related PDI technologies	Main contributing partner(s)	TRL improvement
01	**Upgraded Traffic Management System** The current Traffic Management System will be upgraded by integrating the management of connected and autonomous vehicles and VRUs.	Traffic Management Centre	ETRA, AAE	TRL 5 -> 7
02	**Improved Physical and Digital infrastructure** The Physical and Digital infrastructure will be improved to allow an advanced perception of urban road risks and warn the connected road users about them.	Advanced Environmental perception	UULM, BOSCH, ETRA	TRL 4 -> 6
03	**Junction Digital Twin** Digital Twin specifically created to represent a junction with all the information needed to build high-level applications for different purposes. • DT will collect information from ETSI C-ITS messages, cameras, LiDARs and any other relevant data sources	CCAM Digital Twins	LINKS	TRL 5 -> 7
04	**Trust Building in Distributed Systems**	SW integrity and trust &	UULM, LINKS, BRE	TRL 3 -> 6

	Trust building in distributed systems to ensure and/or enhance the reliability of digital twin output • Assesses data before/during being incorporated in a digital twin • Fusion of data coming from different sources to assess a truthfulness level of the information	data truthfulness		
05	**Software Integrity Architecture** Software integrity architecture with remote attestation protocol fitted to OBU and RSU cases.	SW integrity and trust & data truthfulness	LINKS	TRL 3 -> 6
06	**Tunnel Risk Assessment** Creation of an algorithm that combines information coming from several data sources to give a real-time risk level of the situation inside the tunnel	CCAM services on MEC	LINKS, BRE	TRL 3 -> 6
07	**MEC orchestration for Distributed Systems** Develop 5G orchestration for MEC and Radio, introducing a cross-operator service that manages MNOs, neutral hosts and neutral road operators, by pooling resources from several operators to provide a distributed computing platform to run real-time CCAM services.	CCAM services on MEC	RETE	TRL 5 -> 7
08	**V2X Communication Gateway** Implementation of V2X communication gateway with support for selective recipients and geofencing • Implementation of Basic Transport Protocol, Geonetworking, Security Layer, Decentralized Congestion Control and Management Layers of the ETSI C-ITS protocol stack, that can be executed in the radio transmitter platform or virtualized in the edge/cloud. • V2X messages are disseminated among vehicles using different technologies (802.11p, C-V2X or IP protocol over cellular networks (4G/5G)), in different regions of interest, and different types of vehicles.	CCAM services on MEC	i2CAT, IDIADA	TRL 4 -> 6
09	**5G mmWave Development** Develop the use of 5G mmWave in licensed frequency bands, for UCs requiring high speed and low latency.	5G mmWave use in CCAM	RETE, NOKIA	TRL 5 -> 7

	Includes Evaluation of suitability of 5G mmWave for CCAM with moving vehicles.			
10	**Multi-Connectivity Data Traffic Flows** Improve multi-connectivity data traffic flows with the support of • partial duplication of selected C-ITS messages based on the context • scheduled redundancy on different channels with different characteristics, e.g., ITS-G5, ad-hoc 60GHz WiFi or mmWave 5G	Short-range and multipath comm. in CCAM	UDE, NOKIA, ICCS	TRL 5 -> 7
11	**Short-Range, Adhoc mmWave Communication** Develop and evaluate adaptive usage of short-range, adhoc mmWave communication for CCAM	Short-range and multipath comm. in CCAM	UDE	TRL 4 -> 6
12	**MEC-Server Based Multi-Vehicle Manoeuvres** Improved MEC-server based centrally coordinated multi-vehicle manoeuvres • For CAVs in mixed traffic • Including corridor management with two-way traffic on one lane	CAVs and VRUs	BOSCH, UULM, NOKIA	TRL 4 -> 6
13	**Inclusion of VRUs into Road User Management** Improved inclusion of VRUs into road user management/coordination systems • OBU for VRUs based on android cell phones. Sending and receiving of ETSI ITS messages like CAM, VAM, DENM, MCM or CPM • Early detection of risk situations and real-time warnings / recommended actions sent to CAVs and VRUs • Shuttle passenger app	CAVs and VRUs	BOSCH, UULM, NOKIA, ETRA I+D, i2CAT, ENIDE, IDIADA	TRL 4 -> 6
14	**V2X-based assistance applications at intersection and on highway** On board application using C-ITS messages to assist the driver or the automated driving function in crossing scenario and in highway tunnel scenario	CAVs and VRUs	CRF	TRL 3 -> 6

4. Conclusions

This deliverable summarizes the innovation management procedures of the project and extracts the initial list of background and foreground knowledge. The methodology described here will be also used to monitor the project developments and map them to the generated knowledge and to evaluate the potential of new innovations.

The offered (background) and potentially generated (foreground) knowledge is categorized based on the targeted development field in the project. Certain innovations will result from the foreground knowledge and are seen as significant stand-alone outcomes that can be separately exploited. The work in this deliverable provides the required inputs to WP7 T7.4 for the conduction of the exploitation and IPR management studies.