ENVELOPE

Evaluation and validation of connected mobility in real open systems beyond 5GS

Project deliverable D1.3

Innovation Management Plan

HORIZON JU Innovation Actions | 101139048 |
ENVELOPE - HORIZON-JU-SNS-2023

Co-funded by the European Union

6GSNS

Deliverable administrative information

Dissemination level	**PU - Public**
Type of deliverable	R – Document, report
Work package	WP1 – Project Management
Deliverable number	D1.3 – Innovation Management Plan
Status – version, date	V1.0 – 30/06/2024
Deliverable leader	CMS
Contractual date of delivery	30/06/2024
Submission date	30/06/2024

Quality control

	Name	Organisation	Date
Peer review 1	Dimitrios Fragkos	NCSRD	28/06/2024
Peer review 2	Gkatzikis Lazaros	ICCS	17/06/2024

Version History

Version	Date	Author	Summary of changes
0.1	24-03-2024	A. Edelmayer (CMS)	First draft of document and ToC
0.2	08-05-2024	A. Edelmayer (CMS)	1st draft shared for internal review
0.3	25-05-2024	A. Edelmayer (CMS)	Partners' background knowledge section added. 2nd draft shared for internal review
0.9	15-06-2024	A. Edelmayer (CMS)	Partners' background knowledge content integrated. Final draft shared for internal review
1	30-06-2024	A. Edelmayer (CMS)	Peer review comments addressed

Legal Disclaimer

Social Media links:

@envelope-project

For further information please visit www.envelope-project.eu

Table of contents

LIST OF TABLES

LIST OF FIGURES

Project Executive Summary

ENVELOPE aims to advance and open up the reference 5G advanced architecture and transform it into a vertical-oriented one. It proposes a novel open and easy-to-use 5G-advanced architecture to enable a tighter integration of the network and the service information domains by

- exposing network capabilities to verticals,
- providing vertical-information to the network; and
- enabling verticals to dynamically request and modify key network aspects,

all performed in an open, transparent and easy-to-use, semi-automated way.

ENVELOPE creates APIs that act as an intermediate abstraction layer which translate the complicated 5GS interfaces and services into easy-to-use services commonly accessible by network verticals. Aside the creation of an experimentation framework, the main innovations developed by the project are the following:

- MEC with service continuity support,
- zero-touch management,
- multi-connectivity and
- predictive QoS.

ENVELOPE will deliver three large scale Beyond 5G (B5G) trial sites in Italy, Netherlands and Greece, , adding and supporting novel vertical services with advanced exposure capabilities, moreover, new functionalities tailored to the services' needs. Although focused on the Connected and Automation Mobility (CAM) vertical, the developments resulting from the use cases (UC) will be reusable by any vertical.

The ENVELOPE architecture will serve as an envelope that can cover, accommodate and support any type of vertical services. The applicability of ENVELOPE will be demonstrated and validated by the CAM UCs and the experimentations performed by 3rd parties that will have the opportunity to conduct funded research and test their innovative solutions over ENVELOPE.

Deliverable executive summary

This document is a key deliverable (*D1.3 Innovation management plan*) of the ENVELOPE project which describes the plan and guidelines for innovation strategy and management applied to the project, including links to exploitation of new results where necessary. It is to serve as an on-going, concise work plan for setting out the main aspects of the innovation processes. It also makes sure that i) the impact of the project outcomes is maximized; ii) the use of results in further research fields other than those covered by the ENVELOPE action concerned is ensured; and iii) the development, creation and marketing of any further products, services or processes and standardisation activities are aware of and constructively use the project results.

The document is an incrementally advancing (evolutionary) deliverable of ENVELOPE which proceeds with the project lifetime. Deliverable *D1.6 Innovation management report* is the close counterpart of this document, and will give a cumulative overview of the undertaken innovation activities at the end of the project (M36) and summarize the project innovation achievements and the situation related to the adoption of ENVELOPE results.

This deliverable sets out measures of requested innovations, lays the foundation of the processes, lays out the type of innovation model applied to the project, and ensures that the results of the project meet the needs of the market, using the technologies available at the time. It will also ensure that the project work plan is adjusted as necessary to ensure that the results and objectives of the project are achieved.

The plan described in this document has a direct bearing on the performance of WP1 Task 1.1 (Administrative and financial coordination) and part of Task 1.2 (Technical coordination and innovation management).

The document is structured in the following sections:

Section 1 is a general introduction to the ENVELOPE project and the deliverable itself, followed by the project innovation plan in Section 2, which describes ENVELOPE's innovation concept and approach. The type of innovation model and the principles of ENVELOPE open innovation model is presented. The ENVELOPE innovation space is characterized in Section 3. Section 4 is the summary of initial KPI and KVI metrics the project plans to achieve. Section 5 presents the background and foreground knowledge provided by each partner to the project. Background knowledge is the elements of the main competence of participants upon which the party's project contribution is based and, on the basis of which new value will be collaboratively created. Management issues regarding innovations management are briefly reviewed in Section 6. A short summary of the document concludes the deliverable.

LIST OF ABBREVIATIONS

Acronym	Meaning
5G	5th generation mobile communications network.
5GS	5G System
ATSSS	Access Traffic Steering, Switching and Splitting
B5G	Beyond 5G
B5GS	Beyond 5G System
CA	Consortium Agreement
CAM	Connected Automated Mobility
CCAM	Connected, Cooperative and Automated Mobility
CM	Communication Manager
DL	Deliverable Leaders
DoA	Description of Action
EC	European Commission
EAB	External Advisory Board
HPLMN	Home Public Land Mobile Network
IA	Innovation Action
JU	Joint Undertaking
KPI	Key Performance Indicator
KVI	Key Value Indicator
LL	Living Lab
OCM	Open Calls Manager
PU	Public
PDI	Physical and digital infrastructure
PC	Project Coordinator
pQoS	Predictive Quality of Service
RIA	Research and Innovation Action

SC	Steering Committee
SNS	Smart Networks and Services
TC	Technical Coordinator
TM	Technical Manager
TMT	Technical Management Team
UC	Use Case
UCL	Use Case Leader
VPLMN	Visited Public Land Mobile Network
VRU	Vulnerable Road User
WP	Work Package

1 INTRODUCTION

1.1 Purpose of the deliverable

Innovation management is the responsibility of the project to generate new ideas and solutions in the technological domain of ENVELOPE that addresses new, long-lasting but still unsolved technical challenges.

This deliverable (D1.3 Innovation Management Plan) describes the plan and guidelines for innovation management to be followed during the execution of the ENVELOPE project and beyond to ensure the effective rollout of the administrative activities outlined in Task 1.1 (Administrative and financial coordination) and Task 1.2 (Technical coordination and innovation management) regarding the creation and use of new project results. As such, D1.3 is complemented by D1.1 (Project management plan), D1.2 (Quality management plan) and D1.4 – D1.5 (Data management plans), to provide the overall strategy for the organisation and execution of core tasks to achieve the objectives of the project management work in terms of both operational and technical coordination.

The Technical coordination activities of Task 1.2 are described in deliverable D1.1 which provides a brief overview of the ENVELOPE project, outlines the governance bodies, and the internal rules and procedures relating to or complementing the Grant Agreement and the Consortium Agreement, and specifies the risk management procedures.

D1.3 is an incrementally advancing (evolutionary) deliverable of the ENVELOPE project meaning the document proceeds with the project lifetime. The deliverable is specifically relevant for the execution of Task T1.2 (Technical coordination management). It describes the way, concepts and ideas on how the consortium as a whole manages innovations.

The deliverable D1.6 (Innovation management report) will be the concluding counterpart of D1.3 providing comprehensive summary of the ENVELOPE innovation activity in the end of project. It will serve as an informative report about ENVELOPE innovations for project participants as well as for external parties interested on different aspects concerning the potential and possible use of its results.

1.2 Intended audience

The dissemination level of document D1.3 is ‘public’ (PU), thus the deliverable is available for all 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 ENVELOPE beneficiaries, especially the governance bodies such as the General Assembly, the Technical Management Team, and the External Advisory Board. The main goal is for all beneficiaries to understand the procedures dealing with innovation management processes applied to the project.

2 PROJECT INNOVATION PLAN

2.1 Introduction

The innovation management plan is designed to guide the project and its initiatives to reach global management goals of ENVELOPE regarding new results and novel applications. The purpose is to identify targeted innovation actions, focus areas, strategic objectives, to ensure successful project execution, and also pose metrics to measure the success of innovation initiatives of the project.

The work for the ENVELOPE project will be carried out over a three-year period (36 months), starting on the 1st of January 2024 (M01) and ending on 31 December 2026 (M36). The work plan is broken down into 8 Work Packages (WPs), each of which is divided into specific tasks, such as is described in Table 1 below.

WP No.	WP Title	Lead partner	Start month	End month
WP1	Project management	ICCS	M01	M36
WP2	Architecture, requirements and specifications	NCSRD	M01	M12
WP3	Technical innovations and development	LINKS	M04	M24
WP4	Large scale trial sites deployment, integration and verification	ICCS	M07	M30
WP5	Open calls management and support to 3rd parties	EBOS	M07	M34
WP6	Evaluation, demonstrations and impact assessment	VICOM	M13	M36
WP7	Business analysis and sustainability strategy	INC	M04	M36
WP8	Dissemination, exploitation and international cooperation	ERT	M01	M36

Table 1: ENVELOPE work packages

To achieve the objectives of the ENVELOPE project, a work plan [5] that reflects the different components and phases of development has been developed by WP1.

WP2-WP4 focus on the specification and implementation (and integration) of the advanced 5GS, the CAM service requirements and the relevant APIs to support their co-operation and bilateral interaction, across the 3 pilot sites of the project.

WP5 is focused on the open calls that will be funded by the project including the preparations of the tender conditions, contracting the winning applications, onboarding them and further development activities.

WP6 is focused on evaluation, demonstrations and impact assessment while WP1, WP7 and WP8 are overarching support activities for the project management, business analysis and dissemination activities. From the above, it becomes evident that innovation management spans all ENVELOPE WPs. More details on the WPs and their structure and interdependencies with a flow chart based on the project's planned workflow are presented in ENVELOPE D1.1 Project Management Plan [5].

2.2 Consortium

The ENVELOPE project is a collaborative action which consists of 23 contributing partners from 10 member states of the European Union. Participants have been selected in a complementary way, ensuring an effective multidisciplinary R&D approach in line with the project objectives. The wide range of operational expertise of the contributors provides the basis to successfully address all aspects of the project objectives in relation to the creation and use of the project results in the innovation chain.

The consortium is a complementary mix of parties which exploits the benefits of an established partnership between enterprises and stakeholders from the telecommunication and transportation industry, academic, educational and training institutions, universities and research and development organisations, who can valorise the results directly, and/or indirectly, through subsequent cooperation with industrial partners and service providers.

Particularly, the consortium counts on major research organisations actively involved in national and EU 5G-PPP, SNS JU and CCAM partnership (and beyond) projects (ICCS, LINKS, NCSRD, UDE, TNO, ISI and VICOM), network operators with deployed 5G SA (COSM, KPN and TIM), OEMs/Vehicle providers (TEO and ISFM), ICT and CAM industrial suppliers (SISW and LNVO), highly expertized SMEs (ATH, NXW, FOGUS, CMS, IQU, EBOS and INC), a city council (COTO), and a CAM-related stakeholders' partnership (ERT). The consortium contains also enterprises (LNVO) and individuals that have hundreds of contributions each to the relevant standardization bodies like 3GPP and lead as rapporteurs of related work items.

ENVELOPE partners have not only the expertise to deal with advanced technologies in 5G systems and associated CCAM services, but also the mandates for leading local and regional research, innovation and business development on this EU priority topic.

Project beneficiaries are listed in Table 2 below.

No.	Short name	Legal name	Country
01	ICCS	EREVNITIKO PANEPISTIMIAKO INSTITOUTO SYSTIMATON EPIKOINONION KAI YPOLOGISTON (-- Project Coordinator)	EL
02	HPE	HEWLETT PACKARD ITALIANA SRL	IT
03	TIM	TELECOM ITALIA SPA	IT
04	LINKS	FONDAZIONE LINKS - LEADING INNOVATION & KNOWLEDGE FOR SOCIETY	IT
05	NXW	NEXTWORKS	IT
06	TEO	TEORESI S.P.A.	IT
07	COTO	COMUNE DI TORINO	IT
08	COSM	COSMOTE KINITES TILEPIKOINONIES MONOPROSOPI AE	EL
09	NCSRD	NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS"	EL
10	FOGUS	FOGUS INNOVATIONS & SERVICES P.C.	EL
11	ISFM	ISFM INTELLIGENT SYSTEMS FOR MOBILITY	FR
12	TNO	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO	NL
13	KPN	KONINKLIJKE KPN NV	NL
14	SISW	SIEMENS INDUSTRY SOFTWARE NETHERLANDS BV	NL

15	CMS	COMMSIGNIA Korlatolt Felelossegu Tarsasag (-- Technical Coordinator)	HU
16	LNVO	LENOVO DEUTSCHLAND GMBH	DE
17	UDE	UNIVERSITAET DUISBURG-ESSEN	DE
18	ISI/ATH	ATHINA-EREVNITIKO KENTRO KAINOTOMIAS STIS TECHNOLOGIES TIS PLIROFORIAS, TON EPIKOINONION KAI TIS GNOSIS	EL
19	IQU	IQUADRAT INFORMATICA SL	ES
20	VICOM	FUNDACION CENTRO DE TECNOLOGIAS DE INTERACCION VISUAL Y COMUNICACIONES VICOMTECH	ES
21	ERT	EUROPEAN ROAD TRANSPORT TELEMATICS IMPLEMENTATION COORDINATION ORGANISATION - INTELLIGENT TRANSPORT SYSTEMS & SERVICES EUROPE	BE
22	EBOS	EBOS TECHNOLOGIES LIMITED	CY
23	INC	INCITES CONSULTING SA	LU

Table 2: *ENVELOPE project participants list*

ENVELOPE is typically an industry-near innovation action where the usability of the results and the advancement of the technology is a primary concern. The large number of participants is a major challenge for the coordination of the project, both from a technical point of view and in terms of the management, creation and exploitation of the new results. This calls for an innovation management structure and strategy that is highly adapted to the collaborative nature of the project and allows for a free flow of ideas and concepts where individual corporate constraints do not hinder this joint undertaking.

2.3 The innovation value chain

Knowledge sourcing, transformation and exploitation of ideas (from ideas to applications) is a recursive process which comprises the *innovation value chain*. The innovation value chain comprises the three main phases of innovation processes i.e., *idea generation*, *conversion*, and *diffusion*. The particular stages of the innovation value chain embedded in the innovation model of ENVELOPE are discussed in the following sections. In the course of project execution new scientific knowledge will be created, and existing knowledge will be reinforced and extended. New methods, techniques and datasets provided and integrated by partners into existing architectures, which are then will be disseminated outside ENVELOPE will incrementally impact the 5G technology and pave the way to the seamless transition to 6G.

The ENVELOPE specific version of the innovation chain is shown in Fig. 1. This process is represented by the work package structure of the project as it follows:

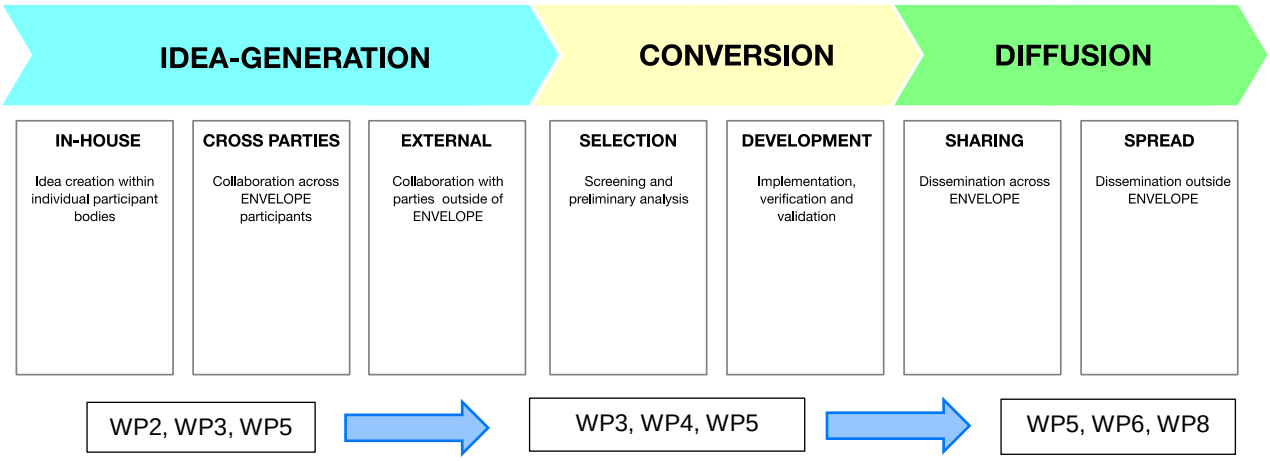


Figure 1: *ENVELOPE's innovation chain covered by the project work packages*[1]

IDEA GENERATION – The main input for the innovation generation process is described and structured in WP2 and mainly the deliverable D2.1 ENVELOPE use case description and specification [7]. Idea generation starts with in-house planning when individual project contributors take the solution elements retrieved from the individual use case descriptions into account and select the ones, they consider potentially useful or possible. In a later phase of the process collaborating parties coordinate the solution proposals with each other in a cross-parties action, and optionally seek third-party's opinion for the sake of harmonization with actual trends of the industry and/or standards. This activity is mostly done in an organised way in WP2 (Architecture, requirements and specifications, M01-M12) and partially in WP7 (Business analysis and sustainability strategy, M04-M36)

CONVERSION – Screening, preliminary analysis and finalization of the selected solution alternatives is the activity in WP3 (Technical innovations and development, M04-M24) followed by the implementation, verification and validation phase which are a compound activity of WP4 (Large scale trial sites deployment, integration and verification, M07-M30) WP5 (Open calls management, M07-M34) and WP6 (Evaluation, demonstrations and impact assessment, M13-M36).

DIFFUSION – It is essential that progressively evolving results are shared effectively and continuously with project participants during the life-cycle of the project, and that an appropriately selected subset of results is disseminated outside ENVELOPE during and after the project. ENVELOPE's dissemination strategy should rely on a balanced standardization strategy emphasizing important principles for ENVELOPE standardization endeavours. This activity is coordinated in WP8 (Dissemination, exploitation and international cooperation M01-M36).

Notice that WP5 involves the development and integration of novel 3rd party solutions to the ENVELOPE platform and hence can be considered as a horizontal activity spanning the whole value chain. New innovation is expected to come from the Open Call participants third parties and could be individually exploited by them or jointly with members the ENVELOPE consortium.

Modelling the complete innovation value chain highlights the structure and complexity of the process of translating project knowledge into business value and emphasises the role of contributors in the value creation process of ENVELOPE. The specific concepts and principles upon which the innovation model is based is discussed next.

2.4 Innovation concept and approach

ENVELOPE's innovation efforts range from idea generation and concept formulation to the implementation of complex solutions. This includes collective idea screening, preliminary analysis, solution validation through

[1] Adopted from the innovations management concept presented in [6].

experimentation involving highly skilled professionals, specialised equipment suppliers and technology providers, as well as competent customers, as collaborative partners throughout the whole innovation chain.

This section provides a general overview of the concepts and ideas that led to the innovation strategy selected for the ENVELOPE project.

2.4.1 Interdisciplinary approach

To successfully tackle the identified challenges described later, ENVELOPE requires knowledge and methodologies from various disciplines, such as ICT, data science, ITS, electrical and mechanical engineering, transport engineering, control engineering, with important contributions from administrative and social sciences (economics, ethics, business, communications, knowledge exchange, governance, management). These are interwoven within the ENVELOPE activities and will be brought together and integrated in pursuit of the project objectives, developing innovations in different fields.

In line with the requirements and taking advantage of the specificities discussed above, the implementation of the ENVELOPE project will be based on the *innovation concept and approach* presented in the following.

2.4.2 Open practices

First of all, the ENVELOPE consortium is committed to providing benefit to the European Community in terms of open access to scientific knowledge, standardisation, and economic impact. Partnership and cooperation of partners is key to ENVELOPE success. The general principle of ENVELOPE is therefore to build on open, harmonised foundations, results and standards, and to share and discuss innovation developments openly at the earliest possible stage of the innovation chain.

Project results and solutions should preferably use open-source code and implement standards-based solutions. Details and challenges of this general project innovation policy is set out in the ENVELOPE Consortium Agreement (CA), including IP rights with commercial potential being generated, background IPR and knowhow being placed at risk, or market position being undermined by following the open-source route.

2.4.3 Collaborative exploitation and IPR management

ENVELOPE is a collaborative innovation action project which capitalizes on various R&D approaches and methodologies. Collaborative efforts help project participants leverage the strength of working in a team having complementary skills, expertise and knowledges.

Any exploitation will be subject to the concepts and procedures on ownership of results and transfer of ownership as laid down in the ENVELOPE deliverable D8.5 Exploitation plan as well as in the corresponding articles of the ENVELOPE Consortium Agreement.

2.4.4 Data security

There is a strong ENVELOPE commitment that the consortium carefully manages research data generated and collected during the innovation phases of the project. The ENVELOPE deliverables D1.4 Data management plan [8] (and also D1.5 Updated data management plan [9]) define procedures on how to handle sensitive data to guarantee fundamental ownership rights of the participants and avoid misuse of the project results. They specify how the data will be securely stored and whether it will be destroyed at the end of the project or archived for further use by the research community. It will ensure that the data is made findable, accessible, interoperable and reusable (FAIR). Data privacy and security issues are also addressed. The aim is to ensure that the whole ENVELOPE innovation management processes fully comply with EU and international regulations and standards on data management and use. This should include encryption standards, access control mechanisms, and compliance with relevant regulations.

2.4.5 Sustainable innovation

The timeframe for ENVELOPE innovation action is planned to be incremental and evolutionary, fitting to existing approaches and focusing on gradual improvements of existing solutions of the recently fifth generation cellular communications technology (5G). The latest available version of this technology is most frequently referred to as the reference 5G-Advanced technology in this deliverable.

According to the planned innovation strategy, the results achieved can be further developed by others at a later stage, *i.e.,* the innovation action of ENVELOPE are in line with sustainable innovation by definition, see the principles of sustainable innovation in Fig. 2.

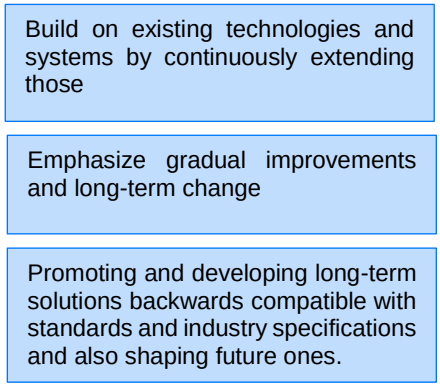


Figure 2: *Principles of sustainable innovation followed by ENVELOPE*

2.4.6 Open vs proprietary innovation

The technical scope and the structure and objectives of the project clearly indicate the need for a specific innovation management strategy to apply in order to comply with the highly collaborative nature of the ENVELOPE action. This strategy should fundamentally and effectively support multi-stakeholder cooperation without prejudice to the interests of each party.

Open innovation became the umbrella that encompasses, connects, and integrates industry and academics, developers and end-users in a networked world. Open innovation (which is usually contrasted with closed or proprietary innovation, where individual participants generate their own proprietary innovation ideas, and then develop, build, market, distribute them on their own) is a term originally defined by Chesbrough in his 2003 book [1] and further detailed in [4]. It consists in opening up the innovation process beyond specific business interests to seamlessly tap external resources and reap the benefits of collaboration.

Innovation is thus created through the interaction of internal and external ideas, concepts and technologies, with the aim of developing innovative ENVELOPE-based products and services that would not be possible without collaboration.

By using this idea, employees of beneficiary and organisations of ENVELOPE, academic institutions and stakeholders of the industry, customers, suppliers, competitors and/or companies of other industries can be integrated in a single R&D entity as shown in the strategic innovation map of ENVELOPE in Fig. 1.

The ENVELOPE project innovation strategy is, therefore, built on the *open innovation* principle as it will be further elaborated in the following sections.

2.5 Type of innovation model

2.5.1 The sustainable coupled innovation

Successive generations of cellular communication networks, as a result of the evolutionary development of telecommunication technologies, are continuously expanding the range of supported use cases and providing additional capabilities beyond basic network connectivity. 4G, 5G, 5G-advanced are the constantly evolving roadmap of interdependent technological development that is already opened towards 6G.

As part of this evolutive development ENVELOPE will build on the success of previous CAM related and SNS projects. The envisioned evolution comes with new challenges, namely with new Key Performance Indicators and Key Value Indicators (KPIs and KVIs) yet unknown.

Sustainable innovation is the act of continuously improving technology and processes to create a sustainable evolution in system architecture, solutions and technology elements that is able to incorporate system elements that can be permanently renewed at any later time. Backwards compatibility and interoperability of new methods and solutions with existing ones will support our efforts to ensure the sustainability of systems and processes.

ENVELOPE partnership brings together the pre-requisite expertise necessary for the successful delivery of the wide project objectives characterised above. The ENVELOPE innovation chain not only brings together very different user needs and aspirations in a collaborative and cooperative way, but it creates coupled innovations paving the way for the successful deployment.

- ENVELOPE's coupled innovation involves collaborative partnerships between project organizations to jointly develop and commercialize products, services, and technology innovations.
- ENVELOPE's coupled innovations create harmonisation and interoperability between heterogeneous requirement domains, such as between CAM and telecommunication.
- Examples include research collaboration between industry and universities to create the ENVELOPE strategic alliance to share resources and expertise, and initiatives with customers to develop tailored end-to-end solutions.

2.5.2 ENVELOPE's open innovation model

Our requirements for sustainability of the results and the interconnected, collaborative nature of ENVELOPE's innovation elements necessarily imply maximum openness of processes. The general scheme of the open innovation paradigm applied to ENVELOPE can be seen in Fig. 3. This paradigm is based on four pillars of cooperation that provide

- synergy between industry and academia,
- interaction between technology vendors and service providers,
- project collaboration with external partners,
- strong presence in cross technology domains.

Relying on the above foundations, a consistent innovation management will ensure that (i) the innovative *extension of existing technologies* with (ii) the *support of creative new ideas* based on beneficiaries' (iii) *collective expertise* will lead to the achievement of the planned objectives.

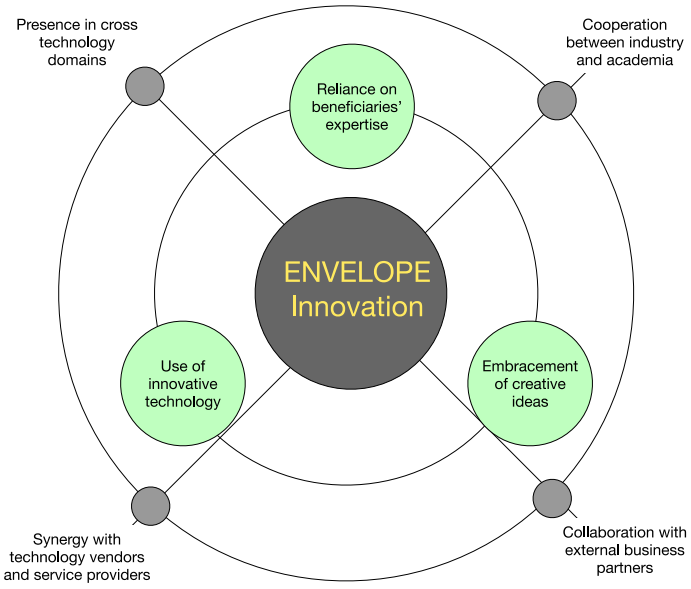


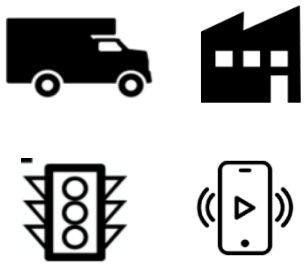
Figure 3: *ENVELOPE's open innovation model*

3 ENVELOPE INNOVATION SPACE

3.1 Focus areas

Focus areas are the topics and areas of innovation that ENVELOPE prioritizes. The main focus of ENVELOPE is to advance and open up the existing reference 5G-advanced architecture and transform it into a vertical-oriented one with the necessary interfaces tailored to critical applications belonging to CAM, CCAM and ITS services and their closely related applications.

ENVELOPE proposes a novel open and easy-to-use 5G-advanced architecture to enable a tighter integration of the network and the service information domains by



i) exposing network capabilities to verticals,
ii) providing vertical specific (control) information to the network; and
iii) enabling verticals to request and modify certain network aspects dynamically (e.g., routing, QoS, dynamic performance), in an open, transparent and easy to use, semi-automated way.

Although focused on the CAM/ITS services vertical, the developments resulting from the ENVELOPE Use Cases (UC) will be reusable by any vertical. Other vertical sectors such as automotive, dependable transport, media, and manufacturing will likely be the leading adopters of the results which depend on criticality (safety and security) solutions of ENVELOPE which have a high future commercialisation potential in the B5GS era.

3.2 Objectives

Objectives are the goals we want to achieve within the focus areas characterised above. The main objective of ENVELOPE is to set valid requirements for vertical services in the evolved infrastructures and create an open architecture with the vertical abstraction layer that will promote the seamless interaction between the network and the vertical. Based on the above ENVELOPE is structured around 6 main objectives:

Obj. 1/ Development of an open and dynamically reconfigurable B5G system supporting advanced Network Exposure Function (NEF) and Policy Control Function (PCF) services.

Obj. 2/ Develop novel services and specify the necessary open and easy-to-use interfacing of the network side (i.e., MEC, cellular communications) and the service side (i.e., Traffic Management Centre, Environmental perception, Digital Twin) of the ENVELOPE architecture (CAM services developed as per the UCs and services resulting from the open calls).

Obj. 3/ Advance key innovative technologies to enable the ENVELOPE architecture to meet the challenging B5GS requirements of automation and improved user experience via tighter integration of network and service information domains (i.e., zero touch management, multi-connectivity and PQoS).

Obj. 4/ Integration of MEC and enablers of cross-domain coordination to support operation across large geographical areas served by different stakeholders.

Obj. 5/ Create new business models and market services for the innovative use of cross-sector data, and validate the feasibility/viability of novel services linked to the availability and exposure of enhanced network capabilities.

Obj. 6/ Promote the project developments to standardisation bodies and policy makers, especially in relation with actions requiring coordination between the network operator and the verticals, and extended dissemination/communication of results.

The planned achievement of the above objectives the ENVELOPE architecture will serve as a technology '*envelope'* that can cover, accommodate and support any type of vertical services in the future.

3.3 Trials and use case validation

Trials. ENVELOPE aims to deliver three large scale Beyond 5G (B5G) infrastructure deployments, *i.e.,* individual trial sites in The Netherlands, Italy, and Greece, respectively, supporting novel CAM services and implementing functionalities tailored to the CAM services and advanced network exposure capabilities.

Trial site projects are initiatives taken to achieve ENVELOPE fundamental KPIs. Each ENVELOPE innovation will be integrated, shown and demonstrated in at least one location. They aim at the extensive validation, evaluation, demonstration and dissemination of the results to the relevant stakeholders, showcasing technical aspects of B5GS utilisation, the opportunities for entrepreneurs to utilize the ENVELOPE features and the capabilities of the proposed innovations overall to enable new business models, and as such, they fit in the *conversion* phase of the ENVELOPE innovation chain, see Fig. 1.

Use case validations. The three trial site projects focus on different set of features and scenarios to capture the broad range of CAM/ITS services and their diverse characteristics addressed by ENVELOPE. Projects are structured and conceptualised by *use-case implementations* to validate, show-case and demonstrate the feasibility of the innovations created during the 1st and 2nd phase of the innovation chain.

> *In fact, the individual use-case descriptions which are formulated in the use case description deliverable [7] of ENVELOPE in details are considered the most important input and main requirement specification for the innovation chain.*

3.3.1 Trial project I. (Italy)

The Italian site focuses on how advanced 5GS architectures can support dynamic reconfiguration of the vertical in case of application requests (i.e., emergency triggers). A main deployment scenario will be that of east/west-bound interfaces especially across different edge providers or MNOs.

The test site deployment implements two use cases (UC 1.1 and UC 1.2) to demonstrate

- dynamic reconfiguration of the network exploiting harmonised ENVELOPE APIs;
- exchange of information between CAM vertical applications and 5G network layers;
- setup the network reconfiguration according to trigger conditions from CAM vertical applications;
- MEC federation and MEC handover scenarios.

UC 1.1: Advanced In-Service Reporting for Automated Driving Vehicles

The goal of the in-service reporting use case is to increase the safety of automated driving vehicles by analysing information and sensors' data of reported events. This aim is to demonstrate that the 5GS can be configured performance-wise on demand to accommodate the sharing of raw sensor data (e.g., data streams from cameras, Lidar) from an automated driving vehicle when this is involved in an accident. It also to demonstrate the scenario in which edge servers of different MNOs are involved. MEC federation approaches will be investigated and tested.

UC 1.2: Dynamic Collaborative Mapping for Automated Driving

This use case focuses on how the network can be dynamically configured to provide the required communication and processing for realizing a collaborative map building and related services that run on the edge server. MEC handover strategies will be studied and implemented for demonstrating this specific scenario.

3.3.2 Trial project II. (The Netherlands)

The main focus of the Dutch trial project will be on the development and testing of new Open APIs to more efficiently support the uplink data traffic for data collection and creation of a Digital Twin with various performance requirement running at the server/edge side. The Dutch site is based on a commercial SA network hosting a digital twin service running in a MEC service environment.

UC 2.1: Periodic vehicle data collection for improving digital twin

This use case focuses on the periodic vehicle data collection for improving the digital twin model of certain principles. The periodicity and continuity of data requests impose a variety of performance requirements on the vertical system that the network must meet.

UC 2.2: Vehicle testing with mixed reality

This use case focuses on vehicle testing in mixed reality. The dynamic performance of the bidirectional communication channel is tested between the vehicle and the digital twin service in real-time. The digital twin service dynamically generates virtual objects and send them to the vehicle with the purpose of testing the vehicle control algorithm's reaction without having to rely on several real physical objects such as vehicles and pedestrians or other VRUs.

UC 2.3: Tele-operated driving aided by digital twin

This use case demonstrate how failed autonomous vehicles can hand over control to a teleoperator, e.g., in case of sensors malfunction, and navigate the vehicle to a safe position with the support of the digital twin of the road environment. Ultra-low-latency communication between the digital twin service and road objects (vehicles, VRUs) and/or roadside units is required to build a correct and real-time representation of the road environment. The communication channel must also be reliable and unaffected by general-purpose traffic. Testing and demonstration of edge reallocation to the location nearby the vehicle to better achieve the required low-latency communication.

3.3.3 Trial project III. (Greece)

The Greek site focuses on the control and information delivery in the network/vehicle verticals and the interaction between two fully operational private 5G SAs. Moreover, two key innovations of the project including ATSSS-like multi connectivity and PQoS will be further specified, developed and evaluated in the Greek site, independent of the use case.

UC 3: MEC handover between multiple MNOs

Demonstration of service continuity is a critical requirement when traveling across multiple mobile networks (MNOs). The use case is to demonstrate how stringent requirements at both the service and network performance levels can be satisfied effectively when the vehicle roams to a Visited PLMN (VPLMN) and/or during inter-PLMN handovers. In addition, application migration between Home PLMN (HPLMN) and VPLMN edge servers will be evaluated.

3.4 Open call projects

In addition to the trial sites activity the project will run SNS JU cascade founding open call projects in order to augment ENVELOPE core innovations activity directly engaging end-users as participants in large scale field trials. This is one of the main principles of the ENVELOPE open innovation scheme shown in Fig. 3.

The applicability of ENVELOPE results and capabilities in different vertical domains will be demonstrated and validated in the open call projects by external third-parties which will have the opportunity to test their innovative solutions, originally not considered for ENVELOPE, by using ENVELOPE native solutions and results and employing the ENVELOPE's toolkit for their experimental implementations.

The open projects will be organized in two distinct calls and at least nine third-party experiments will be selected for implementation and validation to validate the capabilities, functionalities and performance of ENVELOPE experimental facility in extended domains which will complement those of the internal use cases demonstrated in the main trial site activities.

> *The open projects extend the ENVELOPE innovation chain based on the principles of open systems design and fit in the coupled sustainable innovation model of ENVELOPE.*

They add further independent use cases to the ENVELOPE services portfolio, develop and deploy novel applications based on ENVELOPE native results that help to demonstrate the applicability and re-usability of the results in a vertical agnostic way.

3.5 Impact on standardisation

Under the umbrella of ENVELOPE, a broad stakeholder set can be identified which represent researchers, manufacturers, transportation agencies, network operators and infrastructure owner-operators, among others. Therefore, the domain knowledge of ENVELOPE with distinct technology elements rooted in telecommunication and transportation must be integrated in a comprehensive set of interoperable solutions in the cellular networks verticals in an attempt to satisfy the requirements of the customers in the ENVELOPE focus area. Clearly, adherence to standards helps to ensure that objectives of ENVELOPE are met which increasingly helps in taking-up of the new technology solutions.

Historically, standardised solutions and technologies used by telecommunication and transportation systems have been developed independently and separately from each other.

The ENVELOPE's innovation strategy should, therefore, rely on a balanced standardization strategy emphasizing important principles for ENVELOPE standardization endeavours. The identification and adoption of existing standards which are closely related with ENVELOPE's objectives is therefore an integral part of the idea generation phase of the innovation chain which must be supervised by WP2 activity. Experimental or not industrialized results at least must be aware of the existence of standardised solutions and they have to identify themselves relative to the related standards.

ENVELOPE will officially propose an extension of existing standards in cases when missing features and/or functionalities are identified in relevant standard documents. This requires the monitoring of standardization bodies and their working group activities as well as the active contributions from ENVELOPE members in the international standardisation work. A priority topic is shaping the 6G-related standards in 3GPP and other standardization bodies.

4 INDICATORS TO ACHIEVE

Key performance indicators (KPIs) are the measurable targets ENVELOPE set to track the progress of the objectives internally. Key value indicators (KVIs) are representative metrics of the chances for the implemented solutions to become market ready and provide measurable evidence of how ENVELOPE aims to deliver better value for end-users and customers. The ENVELOPE project consists of six main innovations objectives presented in Section 3.2. The tables below give the initial expected performance indicators to be achieved in the project life time for each objective. As the exact content and choice of the indicators will be discussed and developed in WP2 and WP3 of the project, the following indicators are considered the initial set to the WP discussions and will be extended as part of T2.3.

OBJECTIVE 1	
Development of an open and dynamically reconfigurable B5G system supporting advanced Network Exposure Function (NEF) and Policy Control Function (PCF) services.	
KEY PERFORMANCE INDICATORS	
KPI 1.1	Creation of three (3) large scale B5G trial site infrastructure deployments in Italy, Netherlands and Greece tailored to CAM vertical services' needs.
KPI 1.2	Creation of seven (7) key B5GS innovation/work items to advance beyond current state-of-the art 5GS towards 6G.
KPI 1.3	Development of a flexible open common platform for B5GS experimentation as a service with support of dynamic reconfiguration.
KPI 1.4	Percentage of successful on-demand and close-to-real-time deployment or re-configuration updates via URSP. Depending on the specific use case and its requirements, it is measured in terms of the time it takes to deploy or update a policy (target in ENVELOPE < 5 minutes), the accuracy of the policy updates (target in ENVELOPE > 99,9%), and the level of automation (target in ENVELOPE > 90% reduction in deployment time via automated process).
KEY VALUE INDICATORS	
KVI 1.1	Democracy: Digital inclusion: ENVELOPE aims to narrow down the gap in digital accessibility to B5GS infrastructures for experimentation by different groups of people.
KVI 1.2	Democracy: Digital inclusion & Trust: Digital Inclusion and Trust are key properties that are directly impacted by the work proposed in ENVELOPE, through the B5GS architecture reaching into the CAM vertical edge devices/applications, supporting the provisioning of a richer set of trusted and more reliable network services (e.g., QoS prediction).
KVI 1.3	Democracy: Trust-Failure rate: Achieve a reduction in the number of failures in deploying an open and dynamically reconfigurable system B5G compared to the previous years and similar attempts.
KVI 1.4	Democracy: Trust-Availability: Achieve a minimum of 99.9% availability of the system.
KVI 1.5	Ecosystem: Sustainability: ENVELOPE's innovative contributions will continue to operate long after the end of the project. The methodologies and developments are designed to be sustainable over time, minimizing any potential adverse impact and improving the quality of life for users of CAM (or other) services.
KVI 1.6	Ecosystem: Sustainability: ENVELOPE aims to advance sustainability by resolving the obstacles of 5GS towards evolution to 5G-Advanced and beyond. The project will transform the reference 5G-Advanced architecture into a vertical-oriented one that offers interfaces customized to CAM UCs. By establishing trial environments, ENVELOPE will provide advanced experimentation infrastructures that vertical industry players and SMEs can use and experiment on. This will contribute to sustainable development across various vertical domains.

Table 3: KPIs and KVIs related to ENVELOPE Objective 1

OBJECTIVE 2	
Develop novel services and specify the necessary open and easy-to-use interfacing of the network side (i.e., MEC, cellular communications) and the service side (i.e., Traffic Management Centre, Environmental perception, Digital Twin) of the ENVELOPE architecture	
KEY PERFORMANCE INDICATORS	
KPI 2.1	Creation of one flexible open common platform for B5GS experimentation as a service with support of simplified and extended interaction with the vertical domain.
KPI 2.2	Accuracy of the Digital Twin: Root Mean Squared Error (RMSE) < 0,5 m per kilometer of road network (the critical attributes), Mean Absolute Error (MAE) < 0.1 m per kilometer of road network (the critical attributes)
KPI 2.3	Completeness of the Digital Twin: Achieve at least 95% completeness for all physical attributes.
KPI 2.4	Measure the efficiency of the ENVELOPE digital twin framework reducing the scene recreation time to < 5 minutes.
KPI 2.5	Evaluate, select and integrate at least nine (9) open call project use cases.
KEY VALUE INDICATORS	
KVI 2.1	Democracy: Digital inclusion: ENVELOPE aims to narrow down the gap in digital accessibility to vertical services and applications (including CAM) among different groups of people.
KVI 2.2	Democracy: Trust & Innovation-Safety: ENVELOPE's work will strengthen trust and safety in the emerging technological context of B5GS CAM vertical services enabling advanced CAM data collection and fusion of information for the creation of DTs, especially on emerging situations like a road crash. The proposed DT will increase the level of trustworthiness in the collected data and provide safer transportation services through the almost immediate response to an emergency situation.
KVI 2.3	Innovation: Security/Privacy/Energy consumption: Increase the adoption rate of DT services used in transportation systems by the progress made by ENVELOPE.
KVI 2.4	Innovation: Security/Privacy/Energy consumption: Decrease by 90% energy required for scene recreation in transportation systems implementing ENVELOPE by eliminating the need for human intervention.
KVI 2.5	ENVELOPE process for the selection of the open call projects and the participants to them will be well documented and the processes will be fair among the participants. This will be secured with the participation of external reviewers.
KVI 2.6	Ecosystem: Open collaboration: ENVELOPE will utilize techniques that rely on cooperation and the exchange of information. The ENVELOPE open calls will promote proposals submitted by SMEs that further enhance openness.

Table 4: KPIs and KVIs related to ENVELOPE Objective 2

OBJECTIVE 3	
Advance key innovative technologies to enable the ENVELOPE architecture to meet the challenging B5GS requirements of automation and improved user experience via tighter integration of network and service information domains (i.e., zero touch management, multi-connectivity and PQoS).	
KEY PERFORMANCE INDICATORS	
KPI 3.1	Measure the efficiency of the ENVELOPE framework reducing the service time < 1 minute (measuring the time it takes to provision a service in a controlled test environment).

KPI 3.2	Accuracy of QoS prediction. Achieve a Mean Absolute Percentage Error (MAPE) < 5% and low Root Mean Square Error (RMSE).
KPI 3.3	Number of IQNs notifications. Generate at least 100 IQNs (standardized messages used in PQoS) notifications per day.
KPI 3.4	Reliability and latency enhancement by implementing multi-connectivity in an ATSSS (Access Traffic Steering, Switching and Splitting)-compliant approach.
KPI 3.5	Native AI framework service time: Achieve < 5 minutes to perform a Zero-Touch testing using the Native AI framework workflows and user-friendly frontend elements.
KPI 3.6	Native AI framework service accuracy: Achieve at least 95% accuracy rate of the Native AI framework in providing Zero-Touch support to the applications providers.
KPI 3.7	Decrease time to ~1 minute to perform a Zero-Touch decision and provisioning of service resources.
KEY VALUE INDICATORS	
KVI 3.1	Democracy: Privacy: ENVELOPE's work will strengthen Privacy in the emerging technological context of B5GS CAM vertical services. Considerations on privacy are highlighted by the technological focus on supporting appropriate native AI for Zero-touch resource management mechanisms and QoS prediction as a service for handling rich network and application-level monitoring data. The emphasis and impact of this work becomes more evident with the consideration of multi-stakeholder environments, especially when it comes to edge resources, that typically reside on the user space (i.e., vehicles, road users, road side units-RSUs, etc.).
KVI 3.2	Innovation: Energy consumption: ENVELOPE architecture incorporates innovations that take into consideration power consumption. ENVELOPE targets through the proposed CAM-related UCs and the open calls to have an impact in the transportation related energy consumption through the optimization of vehicle trips etc. (e.g., the DT-related UCs). For this goal, a strong collaboration with the 2Zero co-programmed Partnership is envisioned where ICCS is leading one of its main pillars.

Table 5: KPIs and KVIs related to ENVELOPE Objective 3

OBJECTIVE 4	
Integration of MEC and enablers of cross-domain coordination to support operation across large geographical areas served by different stakeholders.	
KEY PERFORMANCE INDICATORS	
KPI 4.1	Percentage of successful API calls between service client and the Edge server hosting the service (EAS). Achieve at least 99% success rate of API calls, indicating the robustness and reliability of the communication infrastructure.
KPI 4.2	Percentage of successful application context transfer between EASs. Achieve at least 90% success rate of application context transfer between EASs for service continuity, indicating the effectiveness of the support services.
KPI 4.3	Percentage of successful on-demand and close-to-real-time deployment or re-configuration updates via UE policies by the VPLMN in roaming scenarios. Depending on the specific UC and requirements, it is measured in terms of the time it takes to deploy or update a policy (target in ENVELOPE < 2 minutes), the accuracy of the policy updates (target in ENVELOPE > 99%), and the level of automation (target in ENVELOPE > 90% automated process).
KEY VALUE INDICATORS	
KVI 4.1	Democracy: Digital inclusion: ENVELOPE aims to narrow down the gap in digital accessibility to edge computing to different groups of people.

KVI 4.2	Democracy: Trust & Innovation-Safety: ENVELOPE's work will strengthen trust and safety in the emerging technological context of B5GS CAM vertical services enabling lower reaction time by the use of edge computing that reduces the communication latency.

Table 6: KPIs and KVIs related to ENVELOPE Objective 4

OBJECTIVE 5	
Create new business models and market services for the innovative use of cross-sector data, and validate the feasibility/viability of novel services linked to the availability and exposure of enhanced network capabilities.	
KEY PERFORMANCE INDICATORS	
KPI 5.1	Development of a unified evaluation methodology will be developed to monitor and operate the UCs.
KPI 5.2	Creation of a testing framework to automate and homogenize the UC evaluation.
KPI 5.3	Development of a fully automated management process for three (3) key domains, where no manual intervention or human involvement is required for tasks related to network management, application management, and security management.
KPI 5.4	Large scale integration and validation: Achieve at least 80% success rate on the CAM vertical services (from the ENVELOPE UCSs and the open call projects) that are validated using the specified interfacing of the network side and service side of the ENVELOPE architecture.
KPI 5.5	User Satisfaction: Achieve at least 80% satisfaction rate of the CAM vertical services during large scale validation, measured through user feedback and surveys.
KPI 5.6	At least 10 demanding technical performance KPIs defined in ENVELOPE UCs that stretch the physical and digital infrastructure performance capabilities beyond today's status.
KPI 5.7	Development of a business model for each ENVELOPE UC and techno-economic analysis for the selected ENVELOPE solutions.
KPI 5.8	Perform at least 100 questionnaire-based survey to identify the factors that can affect the adoption of ENVELOPE approach in the CAM vertical, both from the Economic (in terms cost savings) and Societal (in terms of improving the safety and reliability of critical infrastructure system) perspective. Target to achieve a response rate of at least 80% of insight from the questionnaire-based survey from the targeted sample population, which would indicate a high level of engagement and interest in the survey, and identify the top 3 factors that can affect the adoption of the ENVELOPE approach in the CAM vertical.
KPI 5.9	Efficiency of vehicle testing. Benchmark: Achieve at least a 30% reduction in the time and cost required for vehicle testing within the first year of adopting the Digital Twin service compared to the cost before this adoption.
KPI 5.10	Implementation of six (6) highly-demanding UCs, with each UC making use and advancing key technical 5GS functionalities related to interaction with the vertical service domain and validating the value of the ENVELOPE approach. Each UC demonstrates different scenarios with different requirements from the corresponding 5G system.
KEY VALUE INDICATORS	
KVI 5.1	Ecosystem: New value chain: ENVELOPE's contributions to the supply chain will involve adding new stakeholders from the networking and transportation domains in the CAM vertical services.
KVI 5.2	Ecosystem: Business value: New products will be emerged from the ENVELOPE UCs solving existing and emerging problems in the CAM vertical providing commercial value.

KVI 5.3	Ecosystem: Business value: Production of at least 1 business plan and techno-economic analysis. Production of a business model for each ENVELOPE UC.
KVI 5.4	Innovation: Security: ENVELOPE recognizes the significance of security in its open-source applications, open training sets, and data models that are intended to be collected in validation/evaluation phase and used widely. To safeguard ENVELOPE's repositories and contributions, the project aims to identify vulnerabilities through questionnaires and surveys, and subsequently, address them.
KVI 5.5	Innovation: Responsibility: ENVELOPE emphasizes the importance of accountability and control to ensure responsibility. The project aims to showcase its grasp of security in an open ecosystem and open calls by constructing procedures that assign responsibility to relevant parties and encourage them to take into account their influence on the broader ecosystem.

Table 7: KPIs and KVIs related to ENVELOPE Objective 5

OBJECTIVE 6	
Promote the project developments to standardisation bodies and policy makers, especially in relation with actions requiring coordination between the network operator and the verticals, and extended dissemination/communication of results.	
KEY PERFORMANCE INDICATORS	
KPI 6.1	At least five (5) open-source contributions in flexible licensing scheme for easy 3rd party
KPI 6.2	Participation and contribution to at least five (5) standardization bodies working groups
KPI 6.3	Dissemination through multiple stakeholders reaching a pan-EU network of 500+ actors.
KPI 6.4	Liaise with at least ten (10) EU and international R&D initiatives, policy makers and related organisations and networks.
KPI 6.5	Organize at least one (1) joint physical event together with other EC projects.
KPI 6.6	At least one (1) physical public demonstration event to be organized in each trial site i.e., at least three events (3) in total.
KPI 6.7	Publish at least ten (10) press releases and publications, ten (10) newsletters, ten (10) success stories and five (5) factsheets and ten (10) technical articles/policy briefs.
KPI 6.8	Target to publish at least thirty-five (35) research papers in relevant journals and conferences.
KEY VALUE INDICATORS	
KVI 6.1	Ecosystem: Sustainability: ENVELOPE's goal is to foster sustainable practices and solutions that enable the ecosystem to drive innovation, growth, and progress in a manner that benefits society overall. To achieve this goal, a comprehensive approach that considers not only technical factors but also ethical, legal, and regulatory issues is required. ENVELOPE intends to facilitate this approach by offering an accessible, clear, and collaborative platform that allows different stakeholders to experiment and work together sustainably.
KVI 6.2	Innovation: Safety: ENVELOPE targets CAM vertical services which aim to increase safety of road users. Through extended impact assessment questionnaires to involved stakeholders and end users during ENVELOPE's demonstration events, webinars and the Final Event the consortium will measure the increased perceived safety of the proposed CAM UCs.
KVI 6.3	Innovation: Regulation: ENVELOPE will shape the regulation frameworks related to CAM vertical with the extended contributions in several standardization groups and with the participation and contribution of key partners in major partnerships, like the CCAM partnership, the towards zero emission road transport (2Zero) co-programmed Partnership, etc.

Table 8: KPIs and KVIs related to ENVELOPE Objective 6

5 BACKGROUND AND FOREGROUND KNOWLEDGE NOTED BY THE PARTNERS

The innovation objectives of the project cannot be achieved through individual partner contributions, but require the tight collaboration of the consortium members. Nevertheless, the activities regarding the ENVELOPE specific innovation is very much based on the particular scientific and industrial profile of interests of individual partners which vary greatly. This heterogeneity is one of the main strengths of ENVELOPE open innovation strategy. Different partners have different backgrounds, which they make available to the project in the spirit of open innovation in accord with the rules of the ENVELOPE Grant Agreement. Background knowledge is the elements of the main competence of participants upon which the party's project contribution is based and, on the basis of which new value will be collaboratively created.

This background knowledge is registered and characterised in the following partner specific sections with an additional indication of the individual foreground knowledge planned within the ENVELOPE scope.

5.1 ICCS

ICCS as a research institute brings its knowledge and experience gained from previous projects in the field of CAM services and 5G Advanced/6G connectivity. In ENVELOPE, ICCS will provide its laboratory environment for project experimentation and will be extending it with advanced services and 5G functionalities, such as predictive QOS (pQOS).

COMPONENT NAME	SOLUTIONS CATEGORY	FUNCTIONALITY	ENVELOPE SCOPE
Open 5G experimentation platform	Experiment as a service	The platform developed in the 5G-IANA project enables the development, deployment and testing of automotive-related 5G applications. It also integrates a multi-domain orchestration system for CAM services in the far edge, edge, and cloud continuum. The availability of Edge and Far-edge devices, along with their capabilities, is kept updated by a Resource Orchestration System.	The application and resource orchestration system will be extended in the ENVELOPE project and will be integrated with the NEF and CAPIF APIs. The ENVELOPE orchestration system will leverage information from the CAM domain for zero-touch provisioning and configuration of CAM applications over far-edge devices, edge and cloud resources.

Predictive QoS	Service	Predictive QoS (PQoS) enables the graceful adaptation of vertical services/application to the anticipated conditions in the network. Applying analysis on historical and contextual data that describe network performance and conditions. PQoS enables the proactive identification of significant fluctuations and the generation of corresponding notifications (i.e., In-advance Quality of Service Notifications, IQNs) towards the vertical service/application, allowing the later to adjust its operation within the anticipated environment. Prior experience from 5G-IANA and Hi-Drive will be used.	ENVELOPE will support the provisioning of IQNs notifications towards consuming service end-points in the form of a complete, end-to-end service, incorporating info from both the MNO side and vertical/service provider(s). In particular, the envisioned service will use cross-layer information from the network side (e.g., RAN-level information such as cell load) and the UE side (e.g., radio conditions), including the PHY layer (e.g., RSRQ), the network layer (e.g., data rates), and the application layer (e.g., planned route, goodput, buffer state). The collected data will be fed to machine learning methods (e.g., Long-Short Term Memory, LSTM models) so as to enable high accuracy inference, which shall translate into IQNs.

5.2 HPE

HPE is the global edge-to-cloud company, built to transform everyday business by helping its customers to connect, protect, analyze, and act on all their data and applications wherever they live, from edge to cloud, turning insights into outcomes at the speed required to thrive in today's complex world. Effective from September 1st, 2023, HPE acquired Athonet S.r.l., which develops its own complete software-based mobile packet core solution for centralised or highly distributed edge-cloud deployments. HPE is bringing to ENVELOPE's Italian and Greek site its 5G core network solution set, which can be deployed in fully virtualised environments and can interoperate with any 3GPP-compliant RAN, including O-RAN solutions. As per ENVELOPE's Consortium Agreement, the Athonet 5G core network software is background knowledge made available by HPE on an "as is" basis, in accordance with the terms on which it is commercially available.

COMPONENT NAME	SOLUTIONS CATEGORY	FUNCTIONALITY	ENVELOPE SCOPE
5G core network	Software (part of the 5G network infrastructure)	The 5G core network manages functionalities like authentication, control signalling, quality of service policies, mobility, and data traffic forwarding between the base stations and the networks external to the 5G system. The HPE 5GC is compliant with 3GPP and ETSI standards. It includes the following main network functions: the Access and mobility Management Function (AMF), the Session Management Function (SMF), the User Plane Function (UPF), the Unified Data Management (UDM), the Authentication Server Function (AUSF), the Unified Data Repository (UDR), the Policy Control Function (PCF), the Network Repository Function (NRF).	Part of the 5G-and-beyond network infrastructure of the Italian and Greek sites.

5.3 TIM

TIM has decades of experience in participating in large national and European funded projects related to the topics of ENEVELOPE. As a telco operator, TIM aims at offering its customers a network with functionalities that meet their needs and considers the Collaborative Intelligent Transport Systems (C-ITS) domain as one

of the most significant and challenging in terms of advanced network infrastructure requirements. In this context, connected and automated cooperative mobility (CCAM) services represent one of the areas for which significant growth is expected and participation in these initiatives aims to identify network configurations and possible additional functionalities/infrastructure to optimise the offering to players in this market segment. This large amount of activity has been pursued by TIM on an ongoing basis because CCAM mobility offers a series of technological and business opportunities to exploit the most innovative features of the latest generation cellular networks (4.5G and 5G). Of particular interest are:

- integration of direct short-range communication on PC5 interface with network-mediated communication
- use of Edge platforms and network slicing;
- exploitation of the URLLC (Ultra Reliable Low Latency Communications) and eMBB (enhanced Mobile Broadband) capabilities inherent to 5G.

Exploiting these opportunities implies the definition of new business models and a new role for the network operator according to a logic in which operators in the IoT world, of which C-CAM services can be seen as a branch, evolve from a level of technology partner with the supply of basic services such as connectivity to one of strategic partner capable of supplying complete solutions that integrate telco and high-level ICT functions (such as AI, Big Data, etc.) with specific systems supplied by individual manufacturers. This knowledge base prompted TIM to participate in ENVELOPE in WPs 2, 3, 4, 6 and 8 in order to contribute to the development of new generations of mobile networks, 5G adv and beyond, so that they can offer high value-added services with functionalities that are increasingly adapted to the evolution of technology and the market.

5.4 LINKS

The LINKS Foundation, a private research institution specialized in applied research, operates across a wide number of ICT domains and beyond. The research team participating in the ENVELOPE project has expertise of over a decade in the CCAM field. LINKS has available a comprehensive suite of hardware and software designed to evaluate cutting-edge CCAM applications leveraging V2x, sensors, AI, among other technologies. The solutions offered by LINKS are versatile and adaptable, serving as research platforms for third parties to develop new services and assess the performance of various CCAM-centric elements. Additionally, the software developed is modular, containerized, and can be seamlessly orchestrated. In conclusion, LINKS's OBUs and RSUs are capable of connecting to the 5GA network, providing several vertical information that enhances network intelligence regarding CCAM.

COMPONENT NAME	SOLUTIONS CATEGORY	FUNCTIONALITY	ENVELOPE SCOPE
On Board Unit (OBU)	Hardware and software for a 5GA CCAM user equipment.	Flexible research platform that can exchange secure ETSI ITS standard messages over the Uu interface following the C-ROADS directive. The OBU can expose APIs to report its status or to be automatically programmed	The OBUs SW will be extended to be more linked with the 5GA network

MEC Software	Software to manage CCAM application on the edge/cloud of the 5GA network	Different SW spanning from the management of standard ETSI ITS messages to CCAM applications. Include a CCAM-related Digital Twin and different approaches for the scalable data-collection from the field	The SW will be used as base for the implementation of the Italian Pilot site use cases
3D reconstruction algorithms	Application software related to specific use cases	3D reconstruction algorithms from multimedia sources (video and still pictures) based on NeRF (neural radiance fields). NERF algorithms can learn to represent the 3D structure of a scene from a small input dataset	The SW will be used as starting point for the application needed in the two use cases of the Italian pilot site.

5.5 NXW

NXW is an SME in the ICT sector, providing consulting services as a third-party software developer and system integrator to network operators and vendors. In ENVELOPE, NXW will enhance its expertise in the orchestration and zero-touch (re-)configuration of CAM services in 6G networks, as well as in the development of edge (MEC) applications integrating AI/ML techniques for the CAM domain. In terms of software assets, NXW will integrate a set of tools for the zero-touch management and orchestration of network and computing resources, investigating the possibility of integrating AI-based algorithms to enhance decision-making.

COMPONENT NAME	SOLUTIONS CATEGORY	FUNCTIONALITY	ENVELOPE SCOPE
Service Orchestrator	Software/ System	The Service Orchestrator implements the mechanisms to manage the lifecycle of vertical services, coordinating the deployment and runtime operation of 5G network slices and service components (i.e., applications in the form of virtual functions) across the edge-to-cloud continuum. Tt implements Zero-Touch vertical service management mechanisms to (re-)configure services at runtime, allowing to integrate the decision-making system with intelligent AI-based algorithms.	In ENVELOPE, the Service Orchestrator will be improved to manage CAM services, by integrating CAM-specific parameters to the generic Service information model, allowing to fine-tune CAM services at runtime. The Service Orchestrator will be integrated with the ENVELOPE Experimentation AAS platform and with the network and virtualized computing resources

Resource Orchestrator	Software/ System	The Resource Orchestrator manages computing resources across the Extreme Edge/Edge/Cloud continuum, supporting different platforms (k8s, Openstack). It is composed by the Resource Discovery (Event-based discovery of computing resources) and Resource Inventory (Updated registry of computing resources, based on the info received from the Resource Discovery). It implements a unified resource model and exposes resource management APIs to transparently deploy cloud-native applications across the Extreme Edge/Edge/Cloud continuum.	In ENVELOPE, the Resource Orchestrator will be enhanced to model CAM devices as specialized extreme-edge devices. This will allow to deploy and manage cloud-native CAM applications within OBU/RSU devices.
Network Orchestrator	Software/ System	The Network Orchestrator acts as a Slice Manager, and coordinates 5G Network Resources across 5G RAN and core networks. It implements the mechanisms to deploy, operate and (re-)configure end-to-end 5G Network Slices, including the deployment of 5G network functions as cloud-native virtual functions. .	In ENVELOPE, the Network Orchestrator will be integrated in with the HPE 5G Core and the LINKS RAN system, through the exposure mechanisms that will be implemented by the ENVELOPE API.
Monitoring Platform	Software/ System	It is a programmable monitoring platform which consists of a set of open-source software for monitoring and data collection (Telegraf, Kafka, InfluxDB), properly managed by a custom configuration manager to create custom monitoring jobs. It allows to manage both real-time and time series data at either service, network or resource layer.	In ENVELOPE, the Monitoring Platform will play a fundamental role to enable the Zero-Touch mechanisms, as it provides the required metrics that will be processed by the decision-making system. It will be integrated with the CAM devices and applications to fetch CAM related service metrics, and with the 5G network (5G CORE and RAN) to retrieve network specific metrics

5.6 TEO

COMPONENT NAME	SOLUTIONS CATEGORY	FUNCTIONALITY	ENVELOPE SCOPE
Prototypes of autonomous vehicles	Hardware/ Software	The two prototypes are based on an electric microcar, equipped with 2 rotative LIDARs, 1 solid state LIDAR (or other sensors with same functionalities), 3 (or 4) cameras based on GMSL2 and related interfaces with ECU on board.	Prototypes of Autonomous vehicle for Italian Trial Site
Custom drive-by-wire system	Hardware/ Software	Custom drive-by-wire system based on two main layers: Actuators: Throttle, Brake, Steer, Gear selector. Low level algorithms for the actuators	Prototypes of Autonomous vehicle for Italian Trial Site

High level module for raw data streaming from sensors	Hardware/ Software	Custom module for streaming raw data from sensors.	Prototypes of Autonomous vehicle for Italian Trial Site
Digital Replication of microcar, sensors and actuators	Hardware/ Software	Digital Replication of the microcar, sensors and actuators in a 3D environment for development and testing of use cases	Prototypes of Autonomous vehicle for Italian Trial Site

5.7 COTO

Comune di Torino is engaged in diversification and innovation as an opportunity for development. Its goal is to foster the ecological and technological transition that can contribute to the revitalization of its territory and local innovation ecosystem in sectors like Smart Mobility (including Advanced Urban Air Mobility), Industry 4.0 and in general “Smart City Services”. Within this framework, “Torino City Lab” is an open innovation platform initiative promoted by the City of Turin and active since 2018 aimed at fostering co-creation and testing of innovative urban solutions in real conditions across all its territory. In ENVELOPE, the city of Turin is expected to contribute through the identification of requirements to implement the use cases, the required infrastructure (e.g., 5G enabled areas), the facilitation of testing through the obtainment of relevant permits and dissemination of project outcomes and open call activities at the local and national level through the CTE NEXT innovative ecosystem.

5.8 OTE

COMPONENT NAME	SOLUTIONS CATEGORY	FUNCTIONALITY	ENVELOPE SCOPE
5G and cloud laboratory infrastructure	Testbed Platform	Fully operational 5G SA infrastructure based on Athonet 5GC and Ericsson 5G SA gNB with enterprise-grade capabilities, including MOCN to support experimentational trial networks in synergy with NCSRD.	Part of the 5G-and-beyond network infrastructure of the Greek site offered as background. Its extension towards supporting MEC, roaming and application migration capabilities are the expected foreground.
5G spectrum	Resource	Right to operate 5G in the frequencies 3450 – 3500 MHz, 3500 – 3600 MHz	Background necessary to support the open-field, outdoor CAM use cases.
Situation Awareness UC Application	Software/ System	Application to showcase MEC hand-over in the Greek site by implementing a data sharing real-time situation awareness and traffic information.	Building blocks of this application (IoT front-end/back-end) delivered by OTE are considered background. The end-to-end integrated use case to be delivered is an expected foreground.

5.9 NCSRD

The currently available infrastructure of the Greek Site, comprising NCSRD and OTE testbeds, will serve as a full experimental platform to build on the experience and excellence on novel developments of integrating

the open B5GS reference architecture as defined in the context of the ENVELOPE project. Additionally, it will explore further the network exposure capabilities including the development of both NEF APIs and ENVELOPE APIs (i.e., tailored to CAM services).

COMPONENT NAME	SOLUTIONS CATEGORY	FUNCTIONALITY	ENVELOPE SCOPE
Open-Source NEF	Software	NCSRD's open-source NEF solution is an open experimentation framework that implements 3GPP NEF APIs on top of a simulated environment, to help evaluate northbound APIs consumption by third party applications (i.e., vertical applications). Event Monitoring and AsSessionWithQoS are the two APIs that allow verticals to access monitoring information about the UE's lifecycle, and to set up a session with the desired level of quality of service (QoS) for a given IP traffic flow respectively. Furthermore, several security features are built into the NEF design, such as server-side authentication, integrity, replay and confidentiality protection of the NEF-AF interface (N33) based on TLS protocol. Additionally, API requests from external applications are authorized using OAuth-based authorisation.	In the context of ENVELOPE, NEF will deliver an end-to-end solution, excluding the simulation environment and achieving communication with the 5GC APIs. Additionally, NEF will support transformation functions to map the NEF APIs with the ENVELOPE APIs, similar to the approach defined by the CAMARA initiative
Experi-mentation Platform	Experimen-tation as a service	Greek site is an advanced large-scale 5G experimental facility that allows experimenters coming from various vertical industries to define and run experiments in an automated way. It is spread across two different locations within the metropolitan region of Athens, namely OTE Academy campus and NCSR Demokritos campus, which are interconnected with a dedicated 10G dark fiber, and are shaping two fully operational networks, offering a variety of 5GS deployments including proprietary (e.g., ERICSSON RAN, HPE 5GC, AMARISOFT 5GS) and open-source solutions (e.g., Open5GS). In addition, the Greek Site have been involved in previous Horizon Europe and SNS JU projects serving as an experimentation platform, thus sharing previous knowledge on experimentation methodologies and tools.	Within ENVELOPE, the Greek Site will provide Experimentation as a Service including the methodology and automation of the experiments, storage and visualisation of the results (KPIs). Moreover, it will integrate and implement a common experimentation API/ approach to allow users trigger the experiment's lifecycle, as defined in the project

5.10 FOGUS

FOGUS Innovations & Services P.C. is a Greek SME focused on integrating state-of-the-art (SoA) technological advancements and cutting-edge research to create an immersive communication and computing experience. Founded by industrial and academic experts, FOGUS covers a broad spectrum of ICT disciplines. The company is a full member of ETSI and SNS-IA as well as part of the Greek startup registry, ELEVATE Greece. FOGUS's R&D activities primarily involve enhancing network architecture and evaluating network performance. The team has contributed to 5GPPP/SNS-JU initiatives related to 5G and beyond architecture, as well as scientific publications in the field. Additionally, FOGUS co-leads the ETSI Software Development Group OpenCAPIF (SDG OCF), which focuses on developing an open-source Common API Framework, as defined by 3GPP, for secure and consistent API exposure and consumption. In the ENVELOPE project, FOGUS leverages its experimentation approach from the 6G-SANDBOX project

(SNS Stream C project) and its 3GPP standardized API manager. These contributions serve as foundational elements for the architectural enhancements envisioned by the ENVELOPE project.

COMPONENT NAME	SOLUTIONS CATEGORY	FUNCTIONALITY	ENVELOPE SCOPE
Open API manager	Software	The open API manager realises a secure and interoperable solution for interactions among API providers and consumers. In addition. For API consumers it solves the discoverablity issue while for the API service providers, it brings a solution for efficient monitoring and event management. The open API manager will be based on OpenCAPIF by ETSI.	In the framework of ENVELOPE, the open API manager will be used to facilitate the exposure capabilities of the 5G core network. The implementation will mainly be part of the Trial scenario in Athens.

5.11 ISFM

Milla specializes in developing cutting-edge autonomous vehicle systems. Our core technology includes advanced sensor integration, AI-driven navigation algorithms, and robust vehicle-to-infrastructure communication systems. These components enable our autonomous vehicles to operate safely and efficiently in various environments, from urban settings to more complex road networks. Within the ENVELOPE project, ISFM is bringing to Greek's site an autonomous vehicle that will allow the partners in the whole project to test the MEC hand-over.

COMPONENT NAME	SOLUTIONS CATEGORY	FUNCTIONALITY	ENVELOPE SCOPE
Autonomous vehicle	Platform	Provides the autonomous vehicle to the Greek site with the AD system installed	For the Envelope project, the autonomous vehicle, used to the greek site, will allow us to test and optimize the MEC hand-over while collecting data
Data collection from the vehicle/Services applications	Software	ISFM has long experience with applications executed in the cloud context, mainly over 4G/5G environments.	In the ENVELOPE project, certain application will be adapted for execution on edge computing environments

5.12 TNO

New extensions to TNO's 5G core which is built upon an open-source core will be developed and tested in ENVELOPE. In particular, the Network Exposure Function (NEF) as well as new advanced Open APIs to support V2X vertical use cases will be added in a new Application Function (AF) layer.

COMPONENT NAME	FUNCTIONALITY	ENVELOPE SCOPE
TNO's 5G core	Provides basic functionalities as specified in 3GPP specifications regarding 5G core components (e.g., AMF, SMF, UPF, etc.) as well as provides additional standardized components such as NEF (Network Exposure Function)	The TNO 5G core will be used and extended as experimental core with internal 5G core functions exposed to Application Functions (AFs) via NEF
Application Function (AF) layer	The Application Function (AF) layer contains functions that are exposed via high-level Open APIs in order to abstract the complexity of the 5G core system from service providers.	The AF layer will be enhanced to expose high-level APIs that will be consumed by services running on top of the 5G network. One example of such API is the Quality on Demand (QoD) that will enable services to influence the QoS parameters of the network.

5.13 KPN

For the Dutch trial location KPN will supply the 5G radio access network together with edge compute facilities. In addition to the 5G core, edge and the underlying transport network, the radio network is one of the technical resource domains upon which the V2X use-cases will be deployed. To enable the involved V2X applications to configure real-time and E2E quality levels that are required for the data flows related to those use cases, APIs will be developed and implemented. KPN investigates how those APIs can result in a coordinated and E2E resource management and orchestration across the technical resource domains like radio, core and edge to enable automatic deployment and operation of the assured quality levels. This taking into account specified standards and frameworks such as GSMA's Operator Platform construct, ETSI MEC or 3GPP EdgeApp and, if necessary, open-source resource orchestration implementations such as ONAP or OSM.

5.14 SISW

Siemens Industry Software Netherlands is one of the leading simulation software suppliers for virtual verification of Advanced Driver Assistance Systems (ADAS) and autonomous vehicles. Simcenter Prescan enables a systematic development approach with shorter adaptation cycles, while covering a large number of possible scenarios. Validating the safety and reliability of CCAM could require up to billions of testing miles, including all possible scenarios under all possible circumstances. This is only feasible if the bulk of the validation work is done virtually – faster than in real-time – using simulation; therefore, engineers need a comprehensive physics-based platform that allows them to follow a systematic approach. This project will be essential to build a digital twin of CCAM using the latest communication technologies, the results are going to be exploited in commercial projects with European automotive OEMs and Tier-1 suppliers involved in the development and deployment of CCAM. Our current background information and know-how and the expected ENVELOPE foreground knowledge are listed below.

COMPONENT NAME	SOLUTIONS CATEGORY	FUNCTIONALITY	ENVELOPE SCOPE
	Simcenter SCADAS RS hardware	Boost multi-physics testing productivity in harsh environments and rely on rugged, flexible and performant data acquisition with unparalleled connectivity.	Building a digital twin system, developing a test
	Simcenter Prescan software	ADAS simulation with Simcenter Prescan enables the development and validation of ADAS and automated vehicle functionality.	

Digital Twin service	Simcenter Amesim software	Simcenter Amesim is a mechatronic systems simulation platform that allows design engineers to virtually assess and optimize the systems' performance.	environment for CCAM and considered use-cases.
	Simcenter HEEDS software	A powerful design space exploration and optimization software interfacing with CAD and CAE tools to drive product innovation.	
Test methodologies and test environments	Virtual verification and validation of automated driving systems	Using the integrated Siemens software toolchain, virtual testing is performed effectively and efficiently, accelerating the development process.	Test environment development for CCAM and considered use-cases.
	Scenario-based virtual verification and validation using MiL/SiL/HiL/DiL/ViL (XiL)	During the development process depending on which subsystems are virtualized, different type of tests is performed, which allow early detection of errors.	
	Distributed DiL environment	Distributed DiL environment, based on 5G communication, using MQTT protocol, which is a suitable test set-up for different CCAM applications.	
	Testing of automated driving functions using mixed reality	Test scenarios enhanced by injection of virtual objects - into the (scaled) vehicle CAN bus - via advanced communication networks. See project done with Siemens Mobility.	
	Data acquisition, data storage and data visualization	Data acquisition and data storage of on-board sensor signals, using a common timestamp. Data replay and data visualization.	
	Remote monitoring of vehicles	Remote monitoring of vehicles via 5G communication networks, using the MQTT protocol.	
Automated driving systems and CCAM	Dynamic driving task execution	Automated valet parking and vehicle platooning: from system requirements to implementation and tests considering test vehicles.	Developing and deploying automated driving systems, building demonstrators for the Dutch trial site.
		Off-line object detection, classification and depth estimation. Vehicle path planning, vehicle control, sensor fusion, multiple target tracking, dead time prediction and compensation.	
		Integration of open-source AV stack into Simcenter Prescan.	
		Remote operation (teleoperation) of 4-wheeled, drive by wire vehicles, see 5G-MOBIX project.	
		In-vehicle safety architectures, safety verification and validation, safety argumentation of automated driving systems (testing using XiL).	
		Use of wireless communications in safety-critical applications: vehicle platooning,	

	Safety of the automated driving systems	remote operation of automated driving systems	
		Automated valet parking and vehicle platooning: from system requirements to implementation and tests considering test vehicles.	
	Digital Twins	Digital Twins of the: environment, on-board sensors, vehicle and vulnerable road users, etc.	
	CCAM applications	Analysis, simulation and testing (using XiL) of GLOSA (Green Light Optimized Speed Advisory), TLP (Traffic light priority request), ISA (Intelligent Speed Assist).	
		MQTT broker for transmitting messages through cellular connection.	
		KIA vehicle equipped with sensors (camera, radar, Lidar) and data acquisition device. Toyota Prius vehicle (drive by wire) equipped with different sensors and data communication.	

5.15 CMS

CMS, being a key supplier of automotive V2X solutions for OEM and road and smart city deployments will develop specific communication methods and scenarios to demonstrate the concept of operations, including system requirements (technology and sensors) for the enhancement of the CCAM and ITS verticals of 5G networks. CMS solutions will facilitate real life experimentation with the ENVELOPE's basic services thus contributing to the validation of the new facility extension of fundamental 5G and B5GS services with using V2X specific knowledge elements. CMS will embed this related background knowledge in the ENVELOPE project to the extend specified in the following table. The table identifies the components selected from the existing standard solution portfolio that will be used in the innovation scope of the project for the specified solution categories.

COMPONENT NAME	SOLUTIONS CATEGORY	FUNCTIONALITY	ENVELOPE SCOPE
V2X application server (AS)	Message Distribution	Provides data connectivity between different clients. Ensures that all relevant messages are distributed to each client (based on subscription data, user preference, special routing mechanisms of V2X messages, etc.)	CCAM backend services running in MEC environment in close connection with the 5G/B5G system.
	Arbitration	Manages resource distribution and the scalability of the V2X services based on the requirements of client sessions.	
	Session management	Handles the clients subscribed to the V2X services provided by the V2X AS and their sessions. This includes handling client parameters/preferences, tracking the connectivity state, etc.	
	Routing	Performance oriented routing of V2X messages in MEC environments.	

	QoS management	Ensures optimal performance of V2X safety applications by monitoring client requirements and altering client parameters (e.g., transmission rate) on a use case and situation-specific basis.	New APIs between this component and the operator domain can be opened to enable QoS management (as in telco terminology) of the clients initiated by the V2X AS. These new APIs would enable sending requirements from the V2X AS towards the network and handling the response requiring latency and bandwidth for a given client.
OBU/RSU	V2X protocol stack	Implements the C-ITS protocols stacks used in different regions to ensure communication using standard protocols and message sets.	Compliance ensures that only standard compliant CCAM applications are present in the project's use cases.
	Middleware	Processes data from various sources (e.g., V2X (short-range), sensors, cloud/V2N) generating unified/merged entity/object information. Ensures that the required entity information is available for the applications by filtering and fusing/aggregating available data.	CCAM frontend services
	Safety applications	Low-latency, high-reliability safety applications from the CMS portfolio that depend on the entity information provided by the Middleware, such as e.g., Intersection Movement Assist, Forward Collision Warning, and VRU protection applications, etc.	CCAM frontend services
	Convenience applications	V2X/V2N-based convenience applications from the CMS portfolio for better traffic efficiency and driving experience, e.g., Green Light Optimised Speed Advisory.	CCAM frontend services
	Sensor integration	Methods for smart sensor integration in the Middleware for additional data sources (e.g., how smart cameras can be integrated in RSUs).	CCAM frontend services
Smartphone client	Client applications	They provide connectivity to VRUs via V2N. Capable of receiving certain alerts from the V2X AS or running safety app services on the client device itself generating alerts based on entity information provided by the Middleware.	CCAM frontend services
	Middleware	Processes data from the V2X AS generating entity/object information. Ensures that the required entity information is available for the client application by filtering and fusing/aggregating available data.	CCAM frontend services
	V2X protocol stack	Implements the C-ITS protocols stacks used in different regions to ensure communication using standard protocols and message sets.	Ensures that only standard-compliant CCAM applications are present in the project's use cases.

5.16 LNVO

LNVO has a strong background in edge computing, AI, cloud servers, and data-centre infrastructure, as well as in developing mobile communication networks like 5G, supporting vertical applications. LNVO aims to apply its edge computing expertise to develop optimized solutions for CAM systems, integrating AI to

enhance decision-making, traffic management, routing, and hazard prediction. Although LNVO doesn't provide any background components, will certainly apply its background knowledge, as well as its valuable experience in standardization activities, to assist with the project development.

5.17 UDE

As a university, UDE will utilize its expertise in multi-path connectivity and machine learning to create specialized, learning-based schedulers for CCAM vertical. This work will be implemented in the Greek site.

COMPONENT NAME	FUNCTIONALITY	ENVELOPE SCOPE
Packet duplication and deduplication software	In-network duplication and de-duplication of data packets over disjoint paths for increased reliability and fault tolerance.	The development of multi-path connectivity and multi-path scheduling mechanisms for CCAM vertical. This will primarily be a focus in the Greek site.

5.18 ISI/ATH

ISI/ATH is a leading R&D institute of excellence conducting basic research and exploratory development on Information and communications technology (ICT) for the Greek and European industry. It is a research institute with advanced knowledge and experience gained through its involvement in many National and EU-funded research projects by producing and publishing articles and papers for academic publications in journals and conferences capitalising on innovation, UC trials, repositories, KPIs and lessons learnt. Moreover, ISI promotes its achievements to the market through a strong collaboration of the Institute with SMEs and industrial partners and contacting with key stakeholders (Greece and other EU and Associated countries) to deliver its know-how related to Virtualization and AI/ML techniques for zero-touch resource management and orchestration of services and applications on B5G networks. In ENVELOPE will be contributing to the activity of Zero-Touch management.

5.19 IQU

Iquadrat Informatica S.L. (IQU) is a technology company founded in 1997. Iquadrat offers innovative and customizable platforms that integrate cutting-edge telecommunications and networking technologies for a wide portfolio of emerging applications (Smart homes/cities, energy management, industrial applications, sustainable mobility etc.). Our R&D department is involved in many National and EU-funded research projects and has extensive know-how in B5G technologies, SDN/NFC, AI/ML techniques for distributed network management, cloud native applications and services.

COMPONENT NAME	FUNCTIONALITY	ENVELOPE SCOPE
Zero-touch automation	Orchestration and execution of Decisions (solution for orchestration and execution of Decisions via the automatic generation of control loops with embedded intelligence)	Zero-touch automation of CAM services during large scale trial sites (termed as Zt-CAM).

5.20 VICOM

VICOM's focus on ENVELOPE is the integration of new functionalities and APIs in SDKs which are currently licensed and exploited in different success stories involving products from Tier 1 automotive companies and logistics systems for airports and public transport hubs. Thanks to the project, VICOM will maintain an active position as reference agent in Spain in research and development activities for the automotive domain.

COMPONENT NAME	FUNCTIONALITY	ENVELOPE SCOPE
Video/image anonymizator	Anonymize images or videos, blurring faces and car plates, to comply with GDPR.	Image or video sharing between different entities.

5.21 ERT

ERTICO – ITS Europe is a public-private partnership organisation with over 120 members, connecting 8 different sectors in the ITS Community, including service providers, suppliers, traffic and transport industry, research institutions and universities, public authorities, user organisations, connectivity industry as well as vehicle manufacturers. ERT embodies thought leadership and fostering stakeholder engagement. Together with leading pioneering and innovative Partners, ERTICO develops, promotes, and connects Intelligent Transport Systems and Services (ITS) through various activities, including European co-funded projects, innovation platforms, and international cooperation advocacy. ERT in ENVELOPE will participate in all activities of WP8 and the business and impact analysis of the ENVELOPE solution.

5.22 EBOS

EBOS, a pioneering SME in ICT services, is actively involved in 8 projects related to 5G and 4 ongoing 6G initiatives. As a member of the ENVELOPE consortium, EBOS will contribute to the design and creation of the reference architecture for the ENVELOPE platform. It will also support the R&D of AI-based solutions to manage the 5G-Advanced architecture and its associated services in a zero-touch manner, taking into account the specific needs of CAM services. EBOS will oversee the entire process of open calls, which includes raising awareness, creating the necessary documentation, initiating and evaluating the calls, supervising the contracting process, and offering support through the appropriate help desk. EBOS will lead the efforts to assess public acceptance of the ENVELOPE platform and the UCs. It will also evaluate and demonstrate the open call projects showcased at the trial sites. EBOS will assist with market analysis activities related to the innovations introduced in ENVELOPE. Leveraging its extensive market experience, EBOS will contribute in developing ENVELOPE's dissemination and communication plans, presenting ENVELOPE's results to key associations through its membership (e.g., BDVA/DAIRO, AIOTI, NGI, NESSI), ensuring maximum impact and outreach of the results. Finally, EBOS will lead the development of a methodology, metrics, and templates to create a consistent and effective exploitation plan for ENVELOPE. This includes defining business metrics, legal rights and obligations, IP rights procedures, and individual exploitation plans.

5.23 INC

INCITES is a consulting company dealing with the business aspects of the ENVELOPE project. Project related background knowledge includes tools and experience for business modelling and planning and technology road mapping that will lead to the collaborative creation of new value during the project lifetime and later.

6 MANAGEMENT ASPECTS

6.1 Innovation and technical management

ENVELOPE defined a set of procedures to ensure the innovation processes described above are efficiently executed and the project goals are met. To meet the technical challenges of the ENVELOPE project, the project Task 1.2 (T1.2 Technical coordination and innovation management, see [5]) is dedicated to ensure the seamless and efficient coordination of the technical activities of the project.

In accord with T1.2 responsibilities, the TM will play a crucial role in the overall coordination of the technical activities including monitoring of their compliance with the project advancement. The technical and innovation management ensures that the proposed solutions, and use case implementations conducted by ENVELOPE are technically sound, viable and in line with open standards.

In terms of innovation management, the role of the technical management is to have constant awareness of the project status with respect to the identified innovative outcomes, to monitor activities with respect to potential innovations (including new innovations driven by market needs), and to identify the readiness to generate new innovation pathways potentially exceeding the project objectives.

The processes and structure of technical and innovation management is further detailed in the respective ENVELOPE deliverable [5].

6.2 Technical Management Team

On behalf of the technical and innovation management an ad-hoc team of technical management (i.e., Technical Management Team, TMT) is collectively responsible for the management of the innovations processes of the project. TMT is composed of selected delegates of the project contributors (see [5]).

TMT will monitor risks and identify problems and delays early. This enables the TMT to proactively prevent conflict situations and anticipate deviations from the project plan. In addition, the TMT will meet physically during the GA/Plenary meetings. During these meetings, updates on the progress of the innovation processes are exchanged among the leadership of the project.

6.3 Use case innovators

ENVELOPE use cases are the main demonstrators of the innovation outputs of the project innovation chain. The successful rollout of the project activities critically depends on the construction and implementation of the use cases. Therefore, a use case leader (UCL) is assigned to each use case. These leaders orchestrate the innovation generation processes of use case implementation in collaboration with the use case innovators. They embody the bridge between the project's overarching goals and the unique challenges and opportunities at their specific sites. The UCLs also serve as the contact points for cross-UC collaboration and communication.

7 CONCLUSIONS

This document is an incrementally advancing (evolutionary) deliverable of the ENVELOPE project *D1.3 Innovation management plan.* The deliverable is specifically relevant for the execution of Tasks T1.2 (Technical coordination and innovation management). The document will be evolving with the project lifetime. It describes the way, concepts and ideas of how the consortium as a whole manages innovations.

The deliverable contains initial innovation management data, as some of the planned values and indicators in this document will be revised subject to further discussion during the WP work. Deliverable *D1.6 Innovation management report* is the concluding counterpart of this document that will summarize the final status and project innovations achievements at the end of the project M36.

The innovation model adopted by ENVELOPE and the principles of the open innovation model are presented. The ENVELOPE innovation space is formulated which is characterized by the focus areas, goals, implementation and verification strategies. KPI and KVI metrics that the project plans to achieve are presented. The background knowledge brought into the project by each partner is identified and summarized along with the corresponding expected foreground knowledge. The relevant management aspects regarding the innovation management process are briefly described.

Disclaimer of warranties

The information and views set out in this deliverable are those of the authors and do not necessarily reflect the official opinion of the European Union. Neither the European Union institutions and bodies nor any person acting on their behalf may be held responsible for the use which may be made of the following information.

This project has adapted several methodologies already developed in previous projects, e.g., PoDIUM (Grant Agreement number: 101069547). Ad-hoc modifications were added to comply with the Grant Agreement conditions for ENVELOPE (Grant Agreement number: 101139048).

8 REFERENCES

[1] Chesbrough H. W., *Open innovation. The new imperative from creating and profiting from technology.* Harvard Business School Press, Boston, Massachusetts. 2003.

[2] Chesbrough, H. W., and M. M. Appleyard, Open Innovation and Strategy. California Management Review, 50(1), 57-76. https://doi.org/10.2307/41166416. Berkeley, UCLA, 2007.

[3] Huizingh, K. R. E., Open innovation: State of the art and future perspectives. *Technovation*, Volume 31, Issue 1, pp. 2-9. Elsevier. 2011.

[4] West, J., and M. Bogers, Open innovation: current status and research opportunities. Innovation, 19(1), 43–50. https://doi.org/10.1080/14479338.2016.1258995. Taylor and Francis. 2017.

[5] ENVELOPE Project deliverable, D1.1 Project management plan. Due date 2024 April.

[6] Hansen M. T. and J. Birkinshaw, The Innovation Value Chain. Harvard Business Review Magazine, June 2007.

[7] ENVELOPE Project deliverable, D2.1 Use cases description and specifications. Due date 2024 Sept.

[8] ENVELOPE Project deliverable D1.4 Data management plan. Due date 2024 June.

[9] ENVELOPE Project deliverable D1.5 Updated data management plan. Due date 2026 January.