D7.2

EXPLOITATION, INNOVATION & IPR MANAGEMENT REPORT – INTERIM

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D7.2: Exploitation, Innovation & IPR management report – Interim

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Abstract	This report presents the interim Exploitation, Innovation and IPR Management Report produced at Month 18 under Task 7.3 of Work Package 7. The deliverable documents the outputs of the Agreement Phase (M13–M24) of the project's four-phase exploitation roadmap, covering: the IPR management framework; a catalogue of exploitable results at platform level — comprising open-source components such as the ETSI Hyper Orchestrator (HypO), ETSI SDG OpenSlice, Orion/Scorpio/Stellio Context Brokers, Eclipse Arrowhead, ColonyOS, and the OpenZiti Secure Integration Fabric — and at cluster level 33 vertical application assets; market potential analyses for all five clusters, confirming addressable markets; and individual exploitation plans for all 45 consortium partners.
Keywords	Exploitation strategy, IPR management, Market Overview, Exploitation Results, Exploitation Plans

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Nature of the deliverable:	R	
Dissemination Level		
PU	Public, fully open, e.g. web (Deliverables flagged as public will be automatically published in CORDIS project's page)	X
SEN	Sensitive, limited under the conditions of the Grant Agreement	
Classified R-UE/ EU-R	*EU RESTRICTED under the Commission Decision No2015/ 444*	
Classified C-UE/ EU-C	*EU CONFIDENTIAL under the Commission Decision No2015/ 444*	
Classified S-UE/ EU-S	*EU SECRET under the Commission Decision No2015/ 444*	

* R: Document, report (excluding the periodic and final reports)

DEM: Demonstrator, pilot, prototype, plan designs

DEC: Websites, patents filing, press & media actions, videos, etc.

DATA: Data sets, microdata, etc.

DMP: Data management plan

ETHICS: Deliverables related to ethics issues.

SECURITY: Deliverables related to security issues

OTHER: Software, technical diagram, algorithms, models, etc.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This deliverable is the interim exploitation deliverable produced at Month 24 (Agreement Phase) of the COP-PILOT project. It presents the exploitation strategy, the IPR management framework, the portfolio of exploitable results coming out of the project, a market analysis for the core platform and the five clusters of the project along with the individual partner exploitation plans developed across the consortium during the first half of the project lifecycle.

The COP-PILOT exploitation strategy is built around a four-phase roadmap spanning from project start and goes up to three years after project completion. The present deliverable presents the results of the exploration phase and partially that of the Agreement Phase (M13–M24). Key outputs of these phases include:

- A comprehensive portfolio of exploitable results catalogued at both platform and cluster level.
- Formal market analyses for each of the five vertical clusters and the core COP-PILOT platform.
- Identification of main challenges and opportunities for the core COP-PILOT platform and the five vertical clusters.
- Initial exploitation pathways per partner.
- The Hourglass Model applied across all clusters to visualise stakeholder-capability alignments.

The project's outputs are organised at two levels:

Platform level: Core open-source components including the ETSI Hyper Orchestrator (HypO), OpenSlice domain orchestrator, ColonyOS metaOS, OpenZiti Secure Integration Fabric, FIWARE NGSI-LD context brokers, AI-driven SLA enforcement, LLM-based portal, and a shared CI/CD platform. Most components target TRL 6–7 at project end and are released under open licences (Apache 2.0, MIT, Eclipse EPL 2.0).

Cluster level: 33 vertical application components across five clusters — Mining & Heavy Industry (CL1), Smart City & Port (CL2), Precision Agriculture (CL3A), Energy Management (CL3E), and Smart Viticulture & Winery (CL4) — targeting markets ranging from seismic processing to agri-food traceability and AI-driven grid flexibility management.

COP-PILOT targets substantial and fast-growing markets.

COP-PILOT's IPR management is governed by the Grant Agreement (No. 101189819), the Consortium Agreement (CA), and a suite of European regulatory instruments. The consortium operates on the principle of "as open as possible, as closed as necessary," balancing open-source platform releases with proprietary protection of commercially sensitive partner outputs.

Key Findings

- The COP-PILOT open platform creates a unique shared baseline from which 44 partners build commercial and research exploitation pathways.
- Industrial partners are actively defining commercialisation routes; academic partners focus on open-source contributions, research exploitation, and knowledge transfer.

- Joint exploitation opportunities, primarily by cluster, will be detailed in the final exploitation deliverable D7.4 (M36).
- European regulatory drivers — the AI Act, Data Act, GDPR, CAP digital agenda, and CSRD — create favourable policy conditions that reinforce the commercial case for COP-PILOT outputs across all clusters.
- Key challenges include fragmented market structures, conservative adoption cycles in critical sectors, and the need for clear multi-party business models in ecosystem-based markets.

ABBREVIATIONS

Abbreviation	Full Form / Explanation
ADMS	Advanced Distribution Management System
AI	Artificial Intelligence
AI-SGG	AI Security Guardrails Gateway
API	Application Programming Interface
ATSI	AgriTech Transformation and Sustainability Initiative
AWS	Amazon Web Services
B2B	Business to Business
BEMIS	Seismic monitoring system
BMC	Business Model Canvas
BSD	Berkeley Software Distribution
CAGR	Compound Annual Growth Rate
CAMARA	Linux Foundation project for Telco network API exposure
CAP	Common Agricultural Policy
CCaaS	Chaincode-as-a-Service
CI/CD	Continuous Integration / Continuous Deployment
CL1	Cluster 1
CL2	Cluster 2
CL3A	Cluster 3A
CL3E	Cluster 3E
CL4	Cluster 4
COSEM	Companion Specification for Energy Metering
CSRD	Corporate Sustainability Reporting Directive
DER	Distributed Energy Resource
DESCA	Development of a Simplified Consortium Agreement
DGS	Digital Ground Support
DLMS	Device Language Message Specification
DM	Data Management
DMP	Data Management Plan
DO	Domain Orchestrator
DPP	Digital Product Passport
DSO	Distribution System Operator
DSSC	Data Spaces Support Centre
EC	European Commission
ECIS	European Conference on Information Systems
EDC	Eclipse Dataspace Components

Abbreviation	Full Form / Explanation
eFTI	Electronic Freight Transport Information
EIC	European Innovation Council
EMS	Energy Management System
EPBD	Energy Performance of Buildings Directive
EPC	European Patent Convention
EPL	Eclipse Public Licence
ESO	End-to-end Service Orchestrator
ESPR	Ecodesign for Sustainable Products Regulation
ETSI	European Telecommunications Standards Institute
EU	European Union
EV	Electric Vehicle
FAO	Food and Agriculture Organization of the United Nations
FIWARE	Future Internet WARe
FMIS	Farm Management Information System
FTO	Freedom to Operate
GA	Grant Agreement
GAIA-X	European federated, secure data infrastructure initiative
GDPR	General Data Protection Regulation (EU) 2016/679
gRPC	Google Remote Procedure Call
HPA	Horizontal Pod Autoscaler
HypO	Hyper Orchestrator
IA	Innovation Action
ICIS	International Conference on Information Systems
IDM	Identity Management
IEC	International Electrotechnical Commission
IoT	Internet of Things
IP	Intellectual Property
IPR	Intellectual Property Rights
IQF	Individually Quick Frozen
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
KER	Key Exploitable Result
KPI	Key Performance Indicator
KVI	Key Value Indicator
LF	Linux Foundation
LLM	Large Language Model
LPWAN	Low-Power Wide-Area Network
MCC	Model Contractual Clauses
MCP	Model Context Protocol

Abbreviation	Full Form / Explanation
MDG	Module Development Group
MIT	Massachusetts Institute of Technology
ML	Machine Learning
MNO	Mobile Network Operator
MPN	Mobile Private Network
NaaS	Network as a Service
NB-IoT	Narrowband Internet of Things
NGSI-LD	Next Generation Service Interface with Linked Data
NIS2	Network and Information Security Directive 2
OCPP	Open Charge Point Protocol
OEE	Overall Equipment Effectiveness
OEM	Original Equipment Manufacturer
ONAP	Open Network Automation Platform
OPEX	Operational Expenditure
OSS	Operations Support System
PDO	Protected Designation of Origin
PGI	Protected Geographical Indication
R&I	Research and Innovation
RaaS	Routing as a Service
RBAC	Role-Based Access Control
ROI	Return on Investment
SaaS	Software as a Service
SCC	Standard Contractual Clauses
SDG	Software Development Group
SIF	Secure Integration Fabric
SLA	Service Level Agreement
SME	Small and Medium-sized Enterprise
SWOT	Strengths, Weaknesses, Opportunities, Threats
TCP	Transmission Control Protocol
TFI	Treatment Frequency Index
TMF	TM Forum
TRL	Technology Readiness Level
TSO	Transmission System Operator
UAV	Unmanned Aerial Vehicle
UC	Use Case
UGV	Unmanned Ground Vehicle
UI	User Interface
USD	United States Dollar
VPN	Virtual Private Network

Abbreviation	Full Form / Explanation
VRP	Vehicle Routing Problem
WaPOR	Water Productivity through Open access of Remotely sensed derived data
WEEE	Waste Electrical and Electronic Equipment
WIPO	World Intellectual Property Organization
WP	Work Package
XFSC	Eclipse Cross Federation Services Components
YOLO	You Only Look Once
ZSM	Zero-touch network and Service Management

1 INTRODUCTION

The purpose of D7.2: Exploitation, Innovation & IPR Management Report (Interim) is to present the activities that were implemented under Task 7.3 (Exploitation and IPR Management) of Work Package 7. It covers the following areas:

- The methodological approach to exploitation planning, the four-phase exploitation roadmap, the regulatory and governance framework governing intellectual property management, and the SWOT and Business Model Canvas templates to be completed in D7.4.
- A roadmap of how COP-PILOT can contribute to building a sustainable European Open-Source ecosystem around the developments of the project.
- A structured catalogue of exploitable assets at platform level (core open-source components) and cluster level (vertical application components), each characterised by ownership, licensing model, Technology Readiness Level (TRL), exploitation type, and target user group.
- Market analyses for the COP-PILOT platform and for each of the five industry vertical clusters: Mining & Heavy Industry (CL1), Smart City & Port (CL2), Precision Agriculture (CL3A), Energy Management (CL3E), and Smart Viticulture & Winery (CL4) covering market trends, competitive landscapes, target groups, opportunities and challenges.
- The individual exploitation strategies defined by each of the 45 consortium partners, reflect their specific roles, exploitable assets, business profiles, and planned pathways to commercial deployment, knowledge transfer, or open-source community engagement.

This deliverable does not contain the finalised joint exploitation plans per cluster, detailed SWOT analyses, Business Model Canvases, or go-to-market strategies. These outputs require the results of the project's piloting and validation activities to be mature and will be produced in D7.4.

The deliverable is addressed to the European Commission as a formal project output. It is classified as a public document (dissemination level: PU) and will be made available on the project website and CORDIS upon acceptance. It is also intended to serve as a working reference for consortium partners engaged in exploitation planning, IPR management, and business development activities during the second half of the project.

The document is organised into six chapters, structured to guide the reader progressively from strategic framing through to individual partner-level plans. The following overview describes the purpose and content of each chapter.

Chapter 1 – Introduction introduces the deliverable, defines its scope, and describes the document's structure.

Chapter 2 – Exploitation and IPR Strategy presents the four-phase exploitation roadmap and methodological approach, together with the regulatory and governance framework governing IPR management.

Chapter 3 – Exploitable Results catalogues the project's exploitable assets at platform level (core open-source components) and cluster level (vertical application components across CL1–CL4).

Chapter 4 – Market Potential provides market analyses for the COP-PILOT platform and each of the five vertical clusters, covering market trends, competitive landscapes, target groups, and key opportunities and challenges.

Chapter 5 – Exploitation Plans presents the individual exploitation plans of all 45 consortium partners.

Chapter 6 – Conclusions summarise the outputs and sets out the outlook towards the Final Exploitation Phase and D7.4.

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2 EXPLOITATION AND IPR STRATEGY

2.1 EXPLOITATION STRATEGY

This section describes the methodological approach that was adopted by the COP-PILOT consortium to identify the exploitable assets and plan the exploitation strategy of the project's innovative outputs, in alignment with the initial exploitation strategy that was defined in the Grant Agreement.

2.1.1 Objectives of the Exploitation Strategy

The exploitation strategy is built upon a step-wise, phased approach that evolves alongside the project's technical development. It integrates information from different sources such as market information, IPR management, business modelling, and partner-level planning into a cohesive framework aimed at maximising the impact of COP-PILOT's results.

The exploitation strategy of COP-PILOT pursues the following objectives:

- Identify and catalogue the full spectrum of exploitable assets produced by the project, including outcomes such as COP-PILOT core software components, tools, mechanisms, and services at platform and clusters level.
- Conduct a thorough and continuously updated market analysis, covering market segmentation, competitor positioning, and emerging trends in the areas of edge computing, IoT, intelligent orchestration and service application domains
- Define and manage an IPR strategy aligned with the principles in the Consortium Agreement (CA), ensuring clarity on ownership, licensing, and joint exploitation rights.
- Define and evaluate all applicable exploitation models, including an assessment of their viability and sustainability.
- Identify synergies and joint exploitation opportunities among consortium partners and support the definition of individual exploitation paths per beneficiary.

2.1.2 Exploitation Roadmap

The exploitation strategy is structured around three sequential phases that span the full project lifetime while a fourth one extends beyond project completion. Each phase produces defined outputs that feed into the next, ensuring continuity and progressive refinement of the exploitation strategy. An overview of the phases their timeline and the associated key activities is presented in Table 1.

Table 1: Phases of exploitation strategy

Phase	Timeline	Key Activities
Exploration Phase	M01–M12	Design & analysis of exploitable assets, stakeholder mapping, preliminary market scan
Agreement Phase	M13–M24	Initial market analysis, updated exploitable assets list, identification of challenges and opportunities, initial joint exploitation opportunities.

Final Phase	M24–M36	Finalization of sustainability studies, identification of go-to-market path, final exploitation plans per beneficiary and joint exploitation.
Post-Project Phase	M36+	Actual exploitation of project outcomes, collaboration for joint exploitation

The exploitation phases are also presented in a visual way in the figure below:

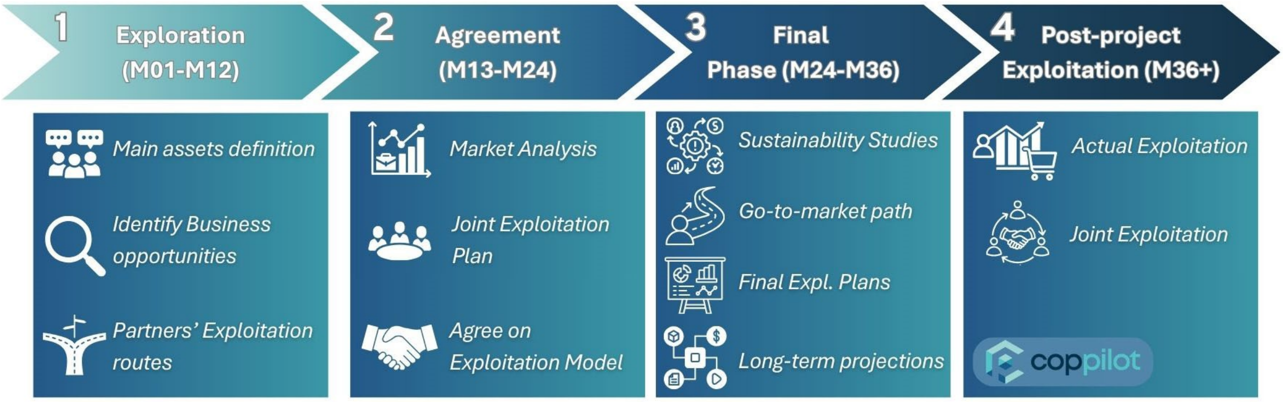

Figure 1: COP-PILOT Exploitation Roadmap — Four-Phase Strategy

2.1.2.1 Exploration Phase (M01–M12)

The Exploration Phase runs in parallel with the design and initial development activities of the project. Its primary purpose is to establish the foundational elements of the exploitation strategy before tangible technical outputs are available. Key activities in this phase include:

- Preliminary identification of exploitable assets based on the project's technical architecture and planned outcomes.
- Initial stakeholder mapping, identifying relevant actors within the target groups
- A first scan of the market landscape
- Alignment of exploitation planning with the IPR provisions of the CA.

The systematic identification of exploitable assets is a central activity of T7.3. Assets are classified according to their nature, development area, and the partner(s) contributing to their creation. The complete and detailed list of exploitable assets is being developed throughout the project lifecycle and will be finalised in D7.4. Each exploitable asset is mapped against the development area, the associated stakeholder and the potential exploitation model. This interrelation framework enables the consortium to identify synergies, avoid duplication, and optimise IPR assignments.

2.1.2.2 Agreement Phase (M13–M24)

The Agreement Phase, within which this deliverable (D7.2) is produced, marks the transition from preliminary analysis to structured exploitation planning. This phase initiates with a formal market analysis and integrates the outputs of the project's initial development work. Key activities include:

- Formal market analysis: includes aspects such as market overview, competitive landscape, and gap analysis.

- Updated and validated list of exploitable assets, cross-referenced with development progress and partner contributions.
- Initiation of IPR documentation and management processes in coordination with T1.3.
- Identification of initial joint exploitation opportunities among consortium beneficiaries.
- Definition of preliminary business models and exploitation pathways.

A comprehensive market analysis has been conducted to guide evidence-based commercialisation decisions and ensure that COP-PILOT outcomes remain aligned with market requirements. The analysis encompasses:

- Monitoring of major market trends to align project outcomes with an evolving competitive landscape.
- Competitor analysis comparing existing solutions with COP-PILOT innovations across features, accessibility, and cost-effectiveness.
- Market sizing at European and national levels
- Target group segmentation based on industry, geographical, and requirement-specific dimensions to deliver customised value propositions.
- Identification of unexplored market opportunities where COP-PILOT can deliver unique value through unmet needs, cost advantages, or novel features.

The exploitation plan reflects evolving market conditions, refined business concepts, and the project's final technical results. It provides a clearer identification of Key Exploitable Results (KERs), segmentation and engagement of target audiences, evaluation of technology maturity and market timing, and identification of exploitation routes at both partner and consortium levels.

The COP-PILOT exploitable results are presented in chapter 3 classified at platform and cluster level. Each result is characterised by its target TRL at project end, the associated owner(s), its type, and the intended form of exploitation. A market analysis is provided for the COP-PILOT platform and for each of the clusters.

The plans for exploitation are defined at two levels: individual (per beneficiary) and joint (per clusters of partners with shared exploitation interests).

Each partner has identified its exploitable assets, the exploitation pathways most relevant to its business profile, and the actions it intends to pursue. Industrial partners are particularly active in defining individual commercialisation paths, while research and academic partners focus on knowledge dissemination, open-source contributions, and technology transfer. The plans are presented in chapter 5.

Joint exploitation plans are developed for clusters of partners that share a common interest in specific exploitable assets or market segments. While more complex due to the multiplicity of IPR owners and combined artefacts involved, joint exploitation is enabled by the modular platform design and the open-source core, which provides a shared baseline from which individual added-value modules can be layered. Joint exploitation opportunities identified will be reported in details in the upcoming D7.4.

During this phase the Hourglass Model that has been proposed by the CEI-SPHERE (CEI-Sphere, n.d.) project has been used for all COP-PILOT clusters. The Hourglass Model (reference) is a conceptual framework that illustrates how different layers of digital capabilities and *corresponding* stakeholder groups interact to create intelligent, interoperable, and scalable digital ecosystems. The model wide at the top and bottom with a narrow central layer is relevant for complex systems as COP-PILOT. It illustrates how data flows from the physical world (sensors and devices) through enabling platforms and infrastructure, and ultimately up to applications and user interfaces.

Each layer (Figure 2) is structured to highlight a specific type of stakeholder, representing those responsible for building, enabling, or governing that part of the digital system. To the other side the key capabilities, the technological functions that make the system work are illustrated.

Together, these dual aspects of the model help visualise the alignment between people, processes, and platforms.

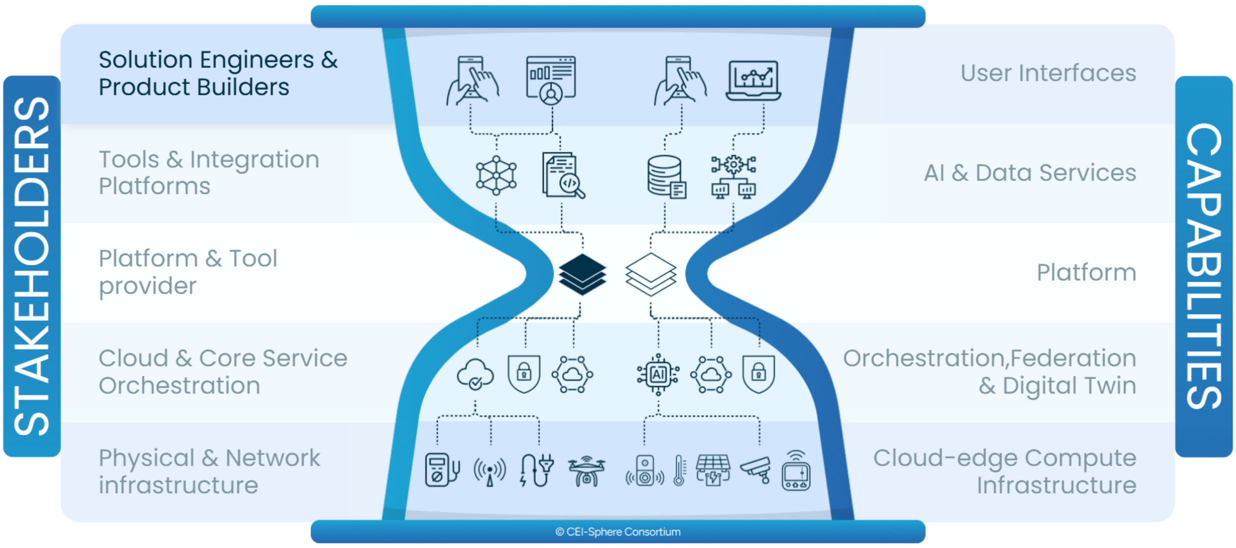

Figure 2: Hourglass model

Outputs of this phase are reported in the present deliverable (D7.2) and serve as the baseline for subsequent exploitation planning. The preliminary business models and exploitation pathways form the starting point of the next phase, which results will be reported in D7.4.

2.1.2.3 Final Exploitation Phase (M24–M36+)

This phase commences with the detailed sustainability and migration studies and integrates results from the validation and piloting activities. It produces the finalised exploitation plans and go-to-market strategy. Key activities include:

- Completion of the sustainability and viability analysis of the identified exploitation pathways.
- Extraction of the go-to-market path for the COP-PILOT platform and cluster-specific application outcomes.
- Finalisation of individual exploitation plans per beneficiary and joint exploitation plans for partner clusters.

- Long-term projections (up to 5 years post-project) for each exploitation direction.
- Engagement of partner business development teams for detailed market positioning and commercial strategy.

On the foundation of the market analysis, business models will be developed to ensure value creation beyond the project end. Key elements addressed include:

- Value proposition definition for each project result, tailored to specific target user groups.
- Identification of the most appropriate revenue models (licensing, subscription, pay-per-use, B2B sales).
- Exploration of scaling options, including cloud-based Software-as-a-Service models.
- Identification of essential resources, activities, and strategic partnerships for business sustainability.
- Income and expenditure projections over a one-to-three-year horizon post-project to assess financial viability.
- Matching each business model to an appropriate exploitation context (public sector, business markets, or open access).
- Consideration of sustainability dimensions in each model, including social value, environmental impact, and resource reuse.

SWOT and Gap Analysis

A SWOT analysis and gap analysis with respect to competing and complementary solutions will be completed during the final exploitation phase, as part of the detailed commercialisation strategy preparation for D7.4.

SWOT analysis is a foundational strategic planning tool used across industries—from business planning to marketing and project development. Whether you're evaluating a startup idea, refining a product strategy, or assessing a community project, this simple yet powerful framework helps you see the full picture.

Breaking Down the SWOT Framework

At its core, SWOT examines four critical dimensions:

- **Strengths**: What advantages do you have working in your favor?
- **Weaknesses**: Where might you need to improve or seek support?
- **Opportunities**: What external chances can you seize?
- **Threats**: What potential obstacles should you prepare for?

The analysis breaks down into two distinct layers:

Internal Factors (Within Your Control)

- **Strengths**: What sets your project apart? These are your advantages—unique resources, expertise, or capabilities that give you an edge over competitors.
- **Weaknesses**: Where does your project fall short? These are internal limitations, whether in resources, skills, or other constraints that could slow progress or reduce impact.

External Factors (Outside Your Control)

- **Opportunities**: What favorable conditions exist in the market or environment? These could include emerging trends, policy shifts, or technological advancements that you can capitalize on.
- **Threats**: What external risks could derail success? Consider competition, regulatory hurdles, economic instability, or changing stakeholder expectations.

Visualizing the Analysis

As it is presented in the figure below, SWOT is presented in a simple table, with internal factors (Strengths & Weaknesses) on top and external factors (Opportunities & Threats) below. This layout makes it easy to compare and prioritize strategic insights.

The following SWOT analysis captures the exploitation potential of the COP-PILOT platform and its associated exploitable results, evaluated in the context of the edge computing and intelligent service orchestration market. The analysis draws on inputs from all consortium partners that own exploitable results with commercial potential.

Table 2: SWOT Matrix Template

SWOT Component	Description	Partner's Input
Strengths	*Identified improvements, advancements in technological know-how, expertise, positive impact on cost, etc. (Internal origin)*	
Weaknesses	*A set of features that can be considered a disadvantage, e.g. investment costs, identified technical complexities, etc. (Internal origin)*	
Opportunities	*New unexplored territories, e.g. positive trends due to increased demand, identified market expansion opportunities, etc. (External origin)*	
Threats	*Identified external factors that could have a direct effect, e.g. trust, elevated costs, bureaucracy, etc. (External origin)*	

Business Model Canvas

The Business Model Canvas (BMC) provides a structured one-page overview of the key components of each COP-PILOT exploitation pathway. The following canvas template has been developed for the COP-PILOT project. BMCs for key components will be developed and consolidated in D7.4.

Table 3: Business Model Canvas (BMC) template

BMC Component	Guiding Questions / Description	COP-PILOT Content
Customer Segments	*The different groups of people or organisations the enterprise aims to reach and serve. For whom are we creating value? Who are our most important customers?*	
Unique Value Proposition	*The bundle of products and services that create value for a specific Customer Segment. What value do we deliver? Which problems are we solving? Which needs are we satisfying?*	
Channels	*How the company communicates with and reaches Customer Segments to deliver its Value Proposition. How are we reaching them? Which channels work best?*	
Customer Relationships	*The type of relationship established and maintained with each Customer Segment. What type of relationship do customers expect? Which have we established?*	
Revenue Streams	*Revenue from successfully offered value propositions. For what value are customers willing to pay? How would they prefer to pay?*	
Key Resources	*The assets required to offer and deliver the described elements. What key resources do our value propositions require?*	
Key Activities	*The most important activities to make the business model work. What do our value propositions, channels, and revenue streams require?*	
Key Partnerships	*The network of suppliers and partners that make the business model work. Who are key partners and suppliers? Which key resources do we acquire from them?*	
Cost Structure	*All costs incurred to operate the business model. What are the most important costs? Which key resources and activities are most expensive?*	

The outcomes of this phase are captured in D7.4 (M36).

2.1.2.4 Post project phase (M36+)

The outcomes of D7.4 extend beyond project completion and are used for supporting exploitation activities up to three years after the project ends.

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Industrial partners lead the promotion and refinement of validated prototypes towards market-qualified products, demonstrating interoperability, usability, and standards compliance. Key actions in this stage include:

Direct collaboration with existing pilots involving operators/service providers and system integrators for hands-on field testing.

Collaboration with Digital Innovation Hubs specialising in IoT-Edge-Cloud solutions to enhance platform exposure and adoption potential.

Engagement with standardisation groups to ensure alignment with industry standards and facilitate interoperability.

The final commercialisation stage targets full market readiness and product launch. Key actions include the establishment of direct customer channels with industries, infrastructure owners, and system integrators; final software debugging, documentation, and packaging; and strategic collaborations with industry leaders, research institutions, and government bodies to enhance product credibility and market reach. The establishment of the open COP-PILOT platform within a defined commercial environment serves as a catalyst for wider adoption and the generation of added business value through platform extension and new business segment adoption.

2.1.3 Building a Sustainable European Open-Source Ecosystem

Over the last 9 years (2017 to 2026), important EU projects have made substantial contributions to open-source software in Europe, while communities around this software are still growing. Figure 3 illustrates this situation for a set of projects that happened to be driven by some authors of this document, although more projects have contributed to the OSS communities shown in Figure 3.

Before COP-PILOT: The target OSS community behind COP-PILOT and the rest of EU projects depicted in Figure 3 is ETSI Software Development Group (SDG) OpenSlice. This SDG was created in October 2023 in the context of the ACROSS [2] EU project, however OpenSlice was initially conceived as an OSS tool for 5G network slicing during the 5G-VINNI [3] EU project back in 2019, when virtualization was mostly at the level of virtual machines. One year before the OpenSlice launch by 5G-VINNI, another orchestration platform titled Maestro appeared by the MATILDA [4] EU project, aiming at orchestrating custom service graphs atop distributed compute slices. Later in 2023, the leaders behind OpenSlice (University of Patras) and Maestro (UBITECH) coordinated a series of EU projects that drastically changed the European OSS ecosystem. Specifically, during ACROSS [2], P2CODE [5], and FIDAL [6] EU projects (2023-2025), OpenSlice was hosted under the ETSI umbrella and Maestro was integrated on top of OpenSlice, constituting a standards-compliant (based on TMF) hierarchical orchestration platform for slicing compute (VMs and containers) and network resources across distributed infrastructures. With the additional integration of OpenZiti [7]– another leading OSS networking platform for building secure, identity-first service overlays – these projects demonstrated that orchestration and secure connectivity can be treated as one integrated platform capability. OpenZiti allowed to expose orchestrated services across domains without relying on shared IP networks, traditional VPN integration, inbound firewall rules or broad network-level trust. This combination of orchestration and identity-defined reachability enabled state-of-the-art demonstrations in booths, standards developing organizations, and software development community events.

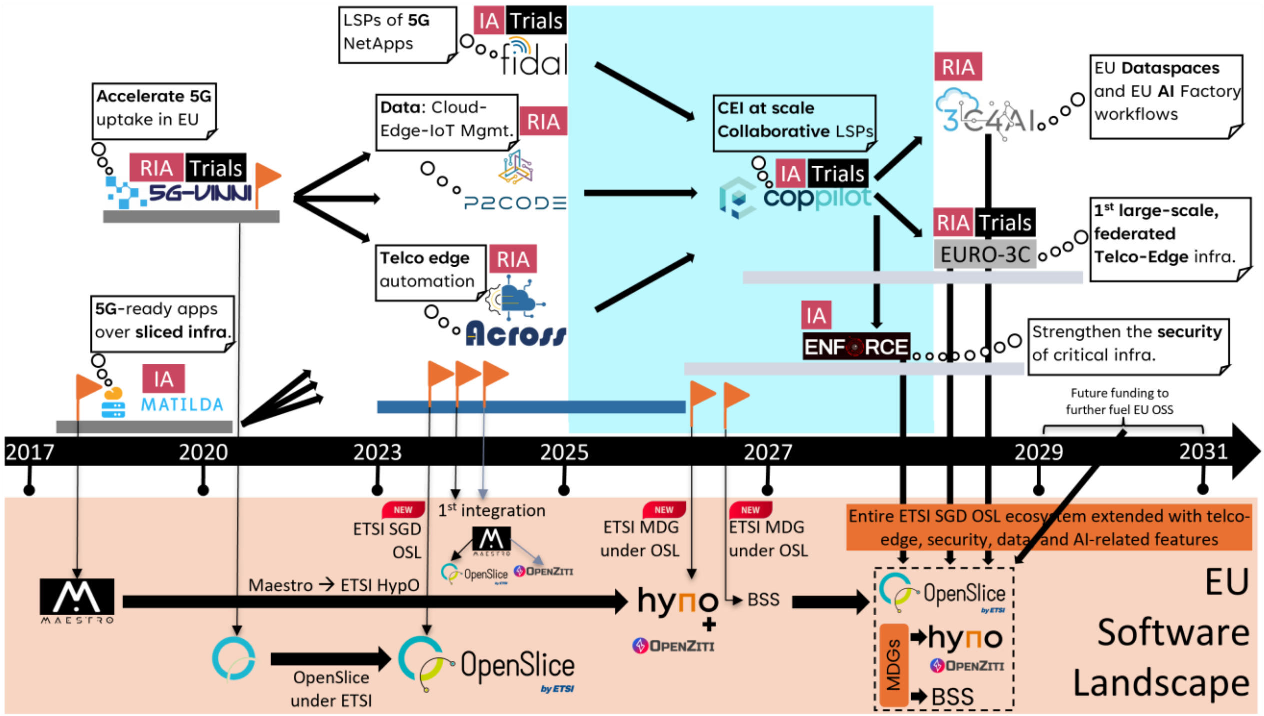

Figure 3: Years of open-source software development fuel COP-PILOT, creating a legacy for the future.

The COP-PILOT era: COP-PILOT was lucky to inherit the legacy by MATILDA, 5G-VINNI, ACROSS, P2CODE, and FIDAL as the Maestro-OpenSlice-OpenZiti platform was already tested across testbeds and use cases of medium to high technology readiness levels (TRL). However, during the first half of COP-PILOT (Jan. 2025 to June 2026) other important developments took place. Specifically, in Jan. 2026 Maestro entered the ETSI SDG OpenSlice ecosystem as a Module Development Group (MDG) titled Hyper Orchestrator (HypO [8]) and joined forces with OpenZiti under the same MDG. More recently (June 2026), another ETSI SDG OpenSlice MDG was created titled Business Support System (BSS. This was another COP-PILOT contribution materialized after the need to provide a standardised business layer atop the HypO-OpenSlice service orchestrators. A major telecom operator in Europe (i.e., Telefónica) took a leading role in the development of the BSS and joined forces with the OpenSlice leaders and a group of other COP-PILOT partners (AGE, ONE, IPN, SUITE5, TATA) to complement the OpenSlice ecosystem with an important new module that is key for the upcoming telco-edge era. While more COP-PILOT activities will further push the OpenSlice ecosystem during the second half of the project (July 2026 to Dec. 2027), COP-PILOT already contributes to creating a legacy for upcoming EU projects.

The COP-PILOT legacy fuels the future: New exciting EU projects have been recently started or prepare to kick-off during the second half of 2026. First, the ENFORCE [9] EU project aims at introducing HypO-OpenSlice-OpenZiti to the security world, building a standardised marketplace of orchestratable security, privacy, and trust services for 6G. Secondly, the 3C4AI (website not available yet) EU project addresses requirements for the newborn EU Data Spaces and the EU AI Act initiatives that aim to establish a sovereign infrastructure and dataspace ecosystem for EU-native AI workloads. In this ecosystem Hypo-OpenSlice-OpenZiti will provide a combined orchestration and secure-connectivity foundation, therefore new orchestration workflows are expected to be developed for supporting the diverse requirements of Data Spaces, AI services and agentic workflows. This is particularly relevant where data, tools, models and agents must interact across organisational boundaries while preserving identity, policy, auditability and least-privilege service access. Last but most important, the flagship EURO-3C [10] EU project that promises to build Europe's first integrated telco-edge infrastructure at scale. In this context, HypO-OpenSlice-OpenZiti-BSS will promote a decade of OSS development activities to seek for integration with real telco platforms and address immense telco-edge requirements of ultra large scale. These EU projects with take the legacy of COP-PILOT to 2029, while more EU projects expected in the next period will create additional requirements for the evolution of the ETSI SDG OpenSlice ecosystem.

2.2 IPR MANAGEMENT

This section maps the key European legal instruments that shape how COP-PILOT manages its intellectual property. It identifies the regulations and directives relevant to the project's specific outputs, from software and AI models to operational datasets, and highlights the IP considerations that partners should keep in mind when creating, sharing, or exploiting project results.

2.2.1 Relevant Regulatory Framework

COP-PILOT's approach to intellectual property management is shaped by a set of interlocking European legal instruments that together govern how project assets are created, protected, shared, and exploited. Understanding this regulatory landscape is a prerequisite for sound IP management across a consortium of 46 partners operating in multiple jurisdictions and producing a wide range of digital outputs, from orchestration software and AI models to cross-sector operational datasets. The following regulatory instruments are of particular relevance to the project.

Horizon Europe Regulation (EU) 2021/695 [8].

This Regulation establishes the overarching framework for the management of results in EU-funded research and innovation projects. Article 17 requires beneficiaries to protect their results where this is possible and reasonable, having regard to the legitimate interests of all parties, and to disseminate them openly wherever feasible. Article 39 mandates that any changes to the ownership of results be notified to the Granting Authority, and that access rights for other beneficiaries are preserved. These obligations are directly incorporated into the COP-PILOT Grant Agreement No.101189819 (GA) and constitute the primary legal basis against which all IPR decisions by the consortium must be assessed. The Regulation also enshrines the principle of "*as open as possible, as closed as necessary*," which guides the balance between open-source software releases and proprietary protection of commercially sensitive outputs in COP-PILOT.

Directive 2009/24/EC on the Legal Protection of Computer Programs [12].

This Directive is the primary EU instrument governing IP rights in software. It confers copyright protection on computer programs, including source code, object code, and preparatory design material, provided they are original in the sense of being the author's own intellectual creation. As a Directive, it does not apply directly but has been transposed into the national law of each EU Member State, meaning that software developed within COP-PILOT is protected by copyright in each country through its own implementing legislation. Thus, this Directive applies to the large majority of COP-PILOT's results, which include the service orchestration platform (Maestro, OpenSlice, ColonyOS), infrastructure controllers, AI-driven modules, and vertical application components developed across the project's clusters. The Directive does not protect the underlying ideas, algorithms, or data formats as such, but only their specific expression in code. Where a software component implements a technical method that produces a technical effect, for instance, a novel orchestration algorithm for managing SLA compliance across heterogeneous IoT-Edge-Core environments, patent protection may also be sought in parallel, subject to the requirements of the European Patent [13]. Partners releasing components under open-source licences (Apache 2.0, MIT, Eclipse EPL 2.0, as detailed in Section 3) do so within this legal framework, granting downstream users defined rights to use, modify, and distribute the code while retaining copyright ownership.

Directive 96/9/EC on the Legal Protection of Databases, as amended by Directive 2019/790 [14].

The Database Directive offers two distinct ways to protect collections of data. Copyright protection applies where the way the data has been selected or organised reflects genuine creative choices.

The *sui generis* right, by contrast, is available regardless of originality, and protects against the extraction or re-utilisation of substantial parts of a database's contents, provided its maker has made a substantial investment in obtaining, verifying, or presenting that content [4, Art. 7]. This right is particularly relevant to operational datasets compiled from COP-PILOT's piloting activities, for example, aggregated telemetry from IoT deployments in energy, agriculture, and smart city environments, where the volume of data and the effort involved in their collection and curation may satisfy the investment threshold. The *sui generis* right lasts for fifteen years from completion or first making available [4, Art. 10], and may be renewed if there is a new substantial investment. The right holder can prevent third parties from extracting or re-using a substantial part of the database's content without authorisation, though non-substantial parts of a publicly available database may be freely used provided that such use does not unreasonably prejudice the maker's legitimate interests [4, Art. 8].

Regulation (EU) 2023/2854 on Harmonised Rules on Fair Access to and Use of Data (Data Act) [15][14].

The Data Act, which became applicable in September 2025, introduces important qualifications to the Database Directive that are directly relevant to COP-PILOT. Article 35 of the Data Act provides that the *sui generis* database right shall not apply to databases containing data generated by the use of IoT devices or related services, where the making of the database does not involve substantial human effort beyond the automated collection process. This provision is specifically intended to prevent IP rights from hindering data sharing in the IoT economy and has direct implications for datasets generated from COP-PILOT's sensor-rich piloting clusters, particularly in energy grid monitoring, agricultural telemetry, and smart city applications. Partners may therefore assess on a case-by-case basis whether their specific datasets attracts *sui generis* protection under this new rule, and calibrate their IP protection strategy, accordingly, relying instead on contractual mechanisms, technical access controls, or trade secret law where statutory protection is unavailable. As contractual mechanisms, partners have at their disposal Model Contractual Clauses (MCCs) developed by the EC to facilitate business-to-business data sharing under the Data Act, and Standard Contractual Clauses (SCCs) for cross-border data transfers.

Regulation (EU) 2024/1689 laying down Harmonised Rules on Artificial Intelligence (AI Act) [16].

The AI Act introduces a risk-based classification system for AI systems that has implications for how COP-PILOT's AI components are developed, documented, and deployed. AI systems placed on the market or put into service in the EU must be classified according to the risk they pose (unacceptable, high, limited, or minimal risk), with the most stringent obligations applying to high-risk systems. Within COP-PILOT, the LLM-based user interaction interface, the intelligent SLA enforcement module (including its Intelligent Forecasting and Zero-Touch Invocation components), and the AI-based cluster scaling tool each involve machine learning techniques and interact with operational infrastructure in consequential ways. Depending on their final deployment context, some of these components may fall within the scope of Annex III of the AI Act as high-risk systems, particularly where they influence decisions relating to critical infrastructure management. While the AI Act does not create intellectual property rights per se, it introduces conformity assessment, transparency, and documentation obligations that interact with IP management: technical documentation and logs maintained for AI Act compliance may contain or reference confidential know-how that requires appropriate protection measures.

Regulation (EU) 2016/679 (General Data Protection Regulation, GDPR) [17].

Although the GDPR is primarily a data protection instrument rather than an IP law, it intersects with IP management wherever project outputs involve the processing of personal data. Across COP-

PILOT's piloting clusters, IoT devices and operational platforms collect data that may be directly or indirectly identifiable to individuals — for instance, energy consumption patterns linked to specific premises, mobility data in smart city environments, or worker activity data in industrial settings. The GDPR requires a lawful basis for processing [7, Art. 6], purpose limitation, data minimisation, and appropriate technical and organisational measures to ensure security [7, Art. 32]. From an IP perspective, this means that databases or datasets containing personal data cannot be freely exploited or licensed without ensuring GDPR compliance, and that data sharing contracts may address GDPR obligations, including the allocation of controller and processor roles among consortium partners [7, Art. 26–28].

2.2.2 IP Protection in COP-PILOT

Internal Governance Documents.

IP ownership and access rights within the project are regulated by two binding internal instruments. The *Grant Agreement (GA No. 101189819)* [18] sets out the beneficiaries' obligations to protect, exploit, and disseminate results, and establishes the conditions under which access rights must be granted to other beneficiaries for the purpose of implementing the project or exploiting their own results. The GA defines "*results*" broadly as any output of the action, tangible or intangible, including data, know-how, software, and any rights attached to them. The *Consortium Agreement (CA) [19]*, fills the operational detail that the GA leaves to the consortium's discretion. It addresses three categories of assets:

1. *background* (pre-existing IP each partner brings to the project, identified in Attachment 1 of the CA),
2. *results* (outputs generated in the course of the project, owned in principle by the partner that generates them), and
3. *software* (source code, object code, and APIs, subject to specific access-right provisions that govern the conditions under which other partners may use them).

Partners are required to keep the background declarations in Attachment 1 of the CA updated throughout the project lifetime and to notify the coordinator promptly of any new results that may require protection measures.

IP Asset Initial Overview and Protection Mechanisms.

COP-PILOT produces a diverse portfolio of outputs spanning software, data, and operational know-how. As the project progresses and results take shape, partners are encouraged to keep track of their assets and think about how each one can best be protected and exploited. As a starting point, the following offers a broad grouping of the main types of assets that COP-PILOT is likely to generate, and the legal protection tools that may apply to each.

Software and algorithms.

The platform's software components including the cloud-managed service orchestrator (Maestro, OpenSlice, ColonyOS), infrastructure controllers, the Secure Integration Fabric (OpenZiti), AI-driven SLA enforcement modules, and the LLM-UI plugin, are automatically protected by copyright from the moment of creation under Directive 2009/24/EC [12], provided they meet the originality threshold. This requires no registration. Where a component implements a novel technical method that produces a technical effect beyond the normal physical interactions between a program and the computer on which it runs, for example, a new algorithm for cross-domain resource orchestration or a technique for AI-driven SLA prediction, the component may additionally qualify for patent protection under the European Patent Convention [13]. Partners holding proprietary components are encouraged to consult the European Commission's IP Helpdesk [21] and to use the Horizon IP Scan service [22] to assess the patentability of their specific results before public disclosure. Open-source releases must be carefully managed: once code is released under an open-source licence, the licence terms bind downstream users but cannot be revoked, and certain licence types (notably copyleft licences) impose conditions on how the code may be combined with proprietary components.

Databases and operational datasets.

Datasets produced during COP-PILOT's piloting activities may attract copyright protection where the selection or arrangement of their contents reflects an original intellectual choice, or *sui generis* protection where the underlying investment in obtaining, verifying, or presenting the data meets the threshold set by the Database Directive [14]. However, as noted above, the Data Act [15] restricts *sui generis* rights for IoT-generated data, which constitutes a significant share of COP-PILOT's operational output. Partners must therefore assess each dataset individually. Where statutory IP protection is unavailable or insufficient, contractual protection through data access agreements, technical access controls such as authentication and encryption, and trade secret law under Directive 2016/943/EU [23] provide complementary safeguards. Partners are reminded that trade secret protection is conditional on the information being kept confidential and subjected to reasonable steps to maintain that confidentiality; disclosure without appropriate protections in place may result in the loss of this protection.

Data sharing protocols and platform service terms.

COP-PILOT's open platform facilitates data and service exchange between a diverse ecosystem of stakeholders. The contractual terms governing access to the platform and to data assets shared through it constitute an important layer of IP protection for outputs that may not attract robust statutory rights. These terms will specify the scope of permitted use, the conditions for sub-licensing or redistribution, and the liability of parties in the event of unauthorised access or misuse. They also serve as the legal basis for data processing activities that fall within the scope of the GDPR [17], allocating controller and processor roles and setting out the required data processing agreements. Given the cross-sector nature of the piloting clusters, terms must be tailored to the specific data sharing context, for example, distinguishing between data shared within the consortium for research purposes and data made available to third-party pilots via the open call mechanism.

Confidentiality safeguards.

The CA contains confidentiality provisions that bind all partners throughout the project and for a defined period after its conclusion. These provisions protect commercially sensitive know-how, proprietary technical information, and business-sensitive data that partners contribute as background or generate as results, but which they choose not to exploit through registered IP rights. Partners are encouraged to identify confidential information clearly in written communications and to restrict its circulation to those within the consortium who have a legitimate need for access. The confidentiality obligations in the CA interact with the open access requirements of the GA: the latter do not override confidentiality in relation to background IP or to results that are subject to a legitimate protection interest.

2.2.3 2.2.3 Joint Ownership

Given the large number of partners and the highly collaborative nature of COP-PILOT's technical work, situations will arise in which two or more partners jointly generate a result and it is not possible to establish the respective contribution of each partner or to separate the contributions for the purpose of applying for, obtaining, or maintaining protection. In such cases, the result is jointly owned, and the joint owners can agree in writing on the allocation of their respective rights and on the terms for exercising joint ownership, as explained by the GA and further detailed in the CA [18], [19].

CA Precedence and Joint Ownership Agreements.

The default rules of the applicable national law governing joint ownership of intellectual property, which vary considerably across Member States in terms of whether each owner can independently exploit or license the joint result, are explicitly derogated from in favour of the provisions of the CA, which take precedence as *lex contractus*. Under the CA's model (based on DESCA [10]), each joint owner may use the jointly owned result for non-commercial research and teaching activities without the prior consent of the other joint owner(s) and on a royalty-free basis. Commercial exploitation, by contrast, requires the prior written consent of all joint owners and the agreement of fair and reasonable compensation terms. Joint owners are required to inform one another in advance of any intended exploitation and to give the other owners a reasonable opportunity to object or negotiate. Where joint ownership involves software components that are subject to open-source licences, the joint owners must agree on the licence terms before any public release, as the choice of licence directly affects the rights of all co-owners and of downstream users.

Conflict resolution.

Disputes between joint owners over the allocation or exercise of rights should first be addressed through direct negotiation between the parties concerned. If this proves unsuccessful, the matter may be escalated to the consortium's governance bodies, which may call upon the project coordinator to facilitate a resolution. Where internal mechanisms do not lead to a satisfactory outcome, the dispute resolution provisions of the CA apply (Section 11.8): the parties are expected to endeavour to settle their differences amicably and, failing that, any dispute shall be submitted to mediation in accordance with the WIPO Mediation Rules, with Brussels as the place of mediation and English as the language of the proceedings. If the dispute has not been resolved through mediation within 60 calendar days of its commencement, the courts of Brussels have exclusive jurisdiction. It should be noted that this mechanism governs disputes between consortium partners; disputes between beneficiaries and the Granting Authority remain subject to the jurisdiction of the EU General Court, as established under the Grant Agreement. The consortium is particularly attentive to IP ownership questions arising from the participation of open-source communities and third-party infrastructure providers, where the boundary between background and foreground contributions may be less straightforward. To manage this proactively, partners are encouraged to ensure that any open-source contributions incorporated into the project's results are properly licensed and compatible with the intended exploitation pathway. The European Commission's Horizon IP Scan service [22] and the IP Helpdesk [21] are available to assist partners in identifying and resolving potential IP conflicts proactively, and their use is encouraged throughout the project lifetime.

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3 EXPLOITABLE RESULTS

This chapter presents the portfolio of exploitable results (ERs) generated throughout the project, organised into two main categories reflecting the project's layered architecture.

3.1 PLATFORM LEVEL (PLATFORM COMPONENTS)

This section covers the platform-level results that form the technical backbone of the COP-PILOT architecture. These include a range of components spread across different functional areas: the Business Management Portal, which brings together frontend and backend services, LLM-based AI assistants, observability and explainability tools, security guardrails, secure agentic communication through OpenZiti, and various telemetry dashboards. On the orchestration side, we have the ETSI HypO services for end-to-end service orchestration and ETSI OpenSlice for domain-level orchestration. For data management, the platform relies on NGSI-LD brokers such as Orion-LD, Scorpio, and Stellio, alongside Eclipse Arrowhead for secure industrial interoperability. The Secure Integration Fabric is realised through OpenZiti, while a dedicated CI/CD platform supports continuous integration and deployment across the project ecosystem. Lastly, Zero-Touch services address intelligence, security, and trust, including AI-based cluster scaling and related mechanisms. Taken together, these platform components provide the essential infrastructure for deploying, orchestrating, and securing the vertical applications described in the next section, while also offering a flexible environment for experimentation and validation. The table below summarises each platform-level result, with details on its name, architectural layer, lead partner, contributors, TRL, and licensing.

Table 4: Platform-level exploitable results – core platform components

ID	Name	Architecture level	Leader	Contributors	TRL (M36)	Licence
PI-1	COP-PILOT BMP Frontend	Business Management Layer (BM-L)	AGE	AGE	7	MIT
PI-2	COP-PILOT BMP Product Management Orchestrator		TID	TID, UoP	6	Apache 2.0
PI-3	COP-PILOT BMP MCP		AGE	AGE	6	Apache 2.0
PI-4	COP-PILOT BMP AI Assistant		ONE	ONE, AGE	6	MIT
PI-5	COP-PILOT BMP AI LLM Observability & Explainability		SUITE5	SUITE5	7	Apache 2.0
PI-6	COP-PILOT BMP AI Security Guardrails Gateway (AI-SGG)		IPN	AGE	6-7	Apache 2.0
PI-7	COP-PILOT BMP AI LLM Gateway; OpenZiti MCP Gateway; OpenZiti Agora		TATA	AGE	7	Apache 2.0

ID	Name	Architecture level	Leader	Contributors	TRL (M36)	Licence
PI-8	Smart City (CL2)	Business Management Layer (BM-L) Cluster-specific Business Observability views	TID	TID	7	Opensource
PI-9	AgroApps view (CL3A)		AGA	AGA,	9	Proprietary Commercial
PI-10	PowerFleet(CL3A)		iLINK	iLINK	9	Proprietary Commercial
PI-11	Blockchain Traceability view (CL3A)		iLINK	iLINK	7	Apache 2.0
PI-12	BioGas Pro (CL3E)		ENIC	ENIC	8	Proprietary Commercial
PI-13	EV Chargers App (CL3E)		ENIC	ENIC	8	Proprietary Commercial
PI-14	Gamaya Viewer (CL4)		TER	TER	9	SaaS
PI-15	The Torre (CL4)		JIG	JIG	7	0
PI-16	ETSI HypO Portal; An MDG under ETSI OpenSlice	End-to-end Service Orchestrator Layer (ESO-L)	UBI	UBI, ETSI OSL community	7	Apache 2.0
PI-17	MIRO portal		ONE	ONE	7	Proprietary Commercial
PI-18	ETSI HypO Backend; An MDG under ETSI OpenSlice		UBI	UBI, ETSI OSL community	7	Apache 2.0
PI-19	MIRO backend		ONE	ONE	7	Proprietary Commercial
PI-20	ETSI OpenSlice (OSL)	Distributed Domain Orchestration Layer (DDO-L)	UoP	UOP, ETSI OSL community	7	Apache 2.0
PI-21	MIRO backend		ONE	ONE	7	Proprietary Commercial
PI-22	ColonyOS		LTU	LTU, RISE, ColonyOS community	9	MIT
PI-23	Orion-LD (NGSI-LD)		FIWARE	FIWARE, Orion-LD community	8	AGPL 3.0
PI-24	Scorpio (NGSI-LD)		FIWARE	FIWARE, KON, Scorpio community	8	BSD Clause 3
PI-25	Stellio (NGSI-LD)		FIWARE	FIWARE, Stellio community	8	Apache 2.0
PI-26	Eclipse Arrowhead		LTU	LTU, RISE, Eclipse Arrowhead community	9	Eclipse EPL2.0
PI-27	Context Broker Data Observability		SUITE5	SUITE5	7	Apache 2.0

ID	Name	Architecture level	Leader	Contributors	TRL (M36)	Licence
PI-28	OpenZiti	Secure Integration Fabric Layer (SIF-L)	TATA	TATA, OpenZiti community	7	Apache 2.0
PI-29	CI/CD platform	CI/CD Platform (Cross-cutting layer for integration)	NETC	NETC, TATA, UBI, UOP, FW, LTU, AGE, RISE, UPV, AGA, PNET, ONE, HOS, TAB, AUA, BAR, ENIC, RZ, PAB, ROC, TOR, ILINK, JIG, AXON, S5, NOK	7	MIT

Table 5 lists additional exploitable results around the COP-PILOT Platform. These are developed as closed-loop services that loosely interact with the COP-PILOT platform through standardized APIs, therefore their development follows individual cycles, governed by the COP-PILOT Cluster partners and business needs.

Table 5: Platform-level exploitable results – Closed-loop platform services.

ID	Name	Leader	Contributors	TRL (M36)	Licence
PI-30	EdgeCloud Autoscaling with Priority Decay	LTU	LTU, RockSigma	5	Proprietary
PI-31	Location-based Alert system with distributed Edge processing	TAB	RockSigma	6	Proprietary
PI-32	Location-based Alert system with distributed Edge processing	TAB	RockSigma	7	Proprietary
PI-33	Dynamic Maritime Resource Provisioning	FVP, FIVE	FVP, FIVE	7	Proprietary
PI-34	Dynamic Maritime Resource Provisioning	FVP, FIVE	FVP, FIVE	7	Proprietary
PI-35	AI-driven Traffic Validation Loop	FIVE	FIVE, TID, VCH	7	-
PI-36	Adaptive Flood Monitoring Loop	FIVE	FIVE, ALM	7	Proprietary
PI-37	Adaptive Flood Monitoring Loop	FIVE	FIVE, ALM	8	Proprietary
PI-38	Multi-modal Environmental Alerter	UPV	UPV, VCH, FIVE, NES	7	Proprietary
PI-39	Blockchain SLA-Triggered Logistics Reconfiguration	iLINK	iLINK	7	Commercial / Proprietary
PI-40	PowerFleet Freshness-Aware JIT Rerouting Loop	iLINK	iLINK	8	Commercial / Proprietary

ID	Name	Leader	Contributors	TRL (M36)	Licence
PI-41	Adaptive DER Flexibility Optimization Loop	UoP	ENIK	6	Commercial / Proprietary
PI-42	EV Charger Fault Detection Loop	ENIK	PPC	8	Commercial / Proprietary
PI-43	Biogas Digestion Monitoring Loop	ENIK	BPO	8	Commercial / Proprietary
PI-44	HPA+: Predictive AI-based Kubernetes Autoscaler	ICCS	ICCS	5	Apache 2.0
PI-45	AI Driven Green Energy Vineyard NAC API	Nokia	Nokia	7	Commercial / Proprietary

3.2 TMFORUM-COMPLIANT SERVICE MARKETPLACE

The COP-PILOT ESO exposes a TMF-compliant marketplace of services around the 5 COP-PILOT Clusters, each pertaining to a different vertical sector. This section provides short evidence about the status of this marketplace during the first phase of the project (i.e., up to M18).

First, Figure 4 visualizes the COP-PILOT service marketplace organized in 5 TMF-Compliant Service Catalogues (one per Cluster), each associated with one or more TMF Service Categories, depending on the vertical sector concerns in each Cluster.

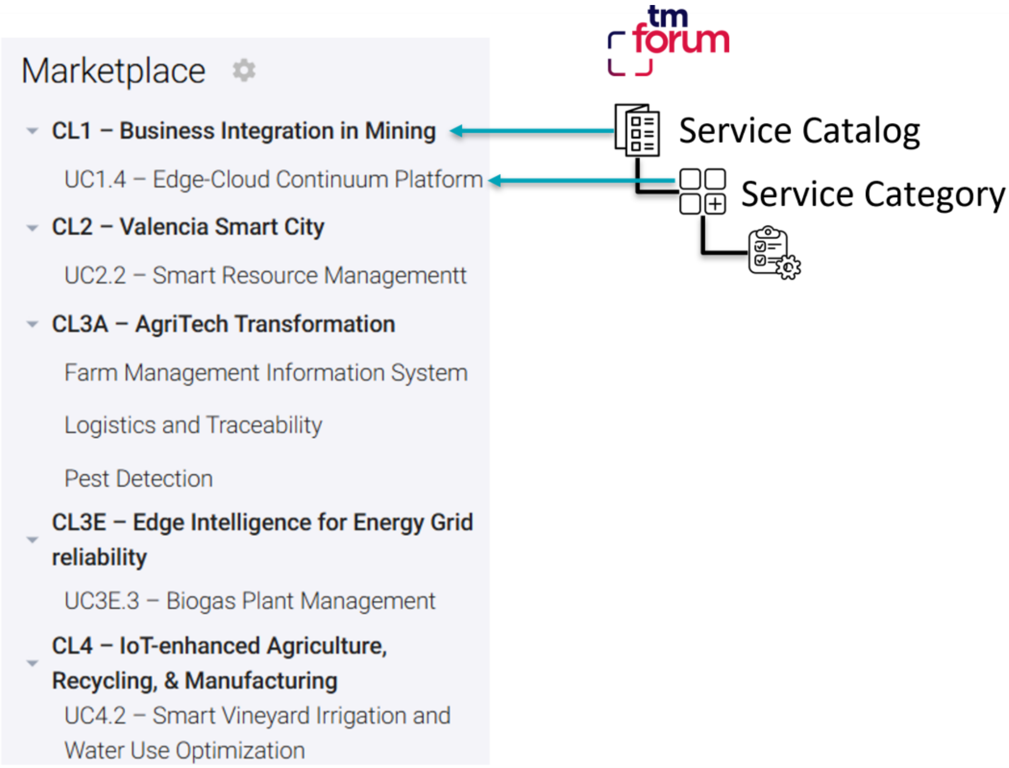

Figure 4: A view of the COP-PILOT service marketplace provided by the COP-PILOT ESO's Portal.

Next, Figure 5, Figure 6, Figure 7, Figure 8 and Figure 9 visualize Cluster-specific services that were designed to cover some early piloting activities of the 5 COP-PILOT clusters.

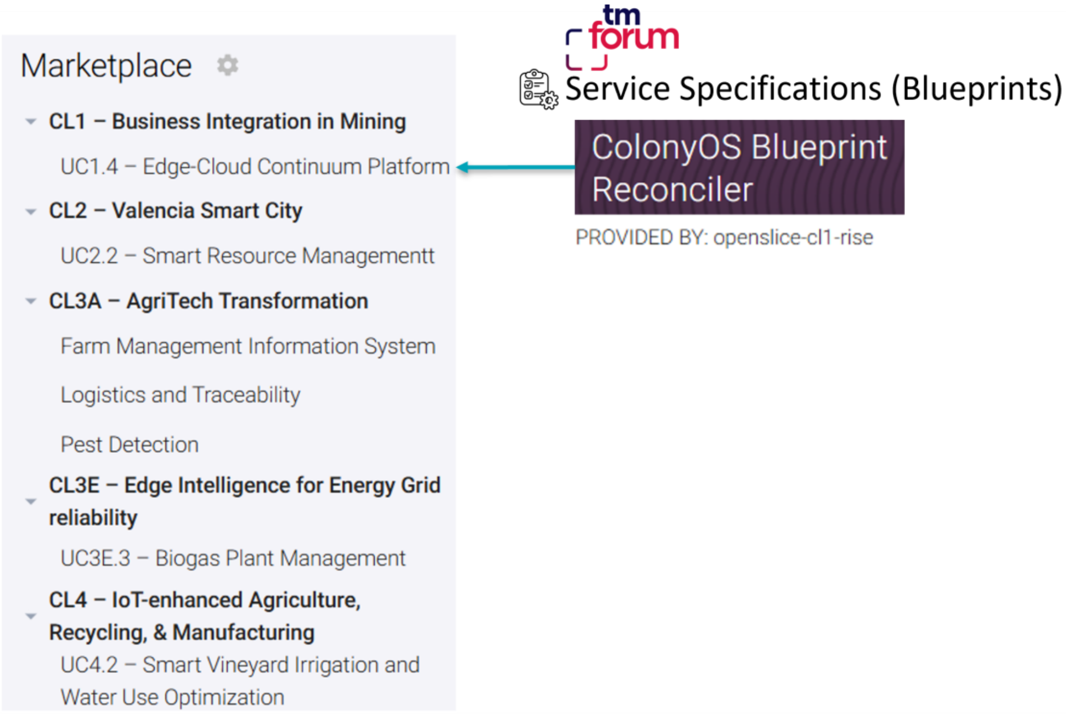

Figure 5: Cluster 1 services onboarded onto the COP-PILOT service marketplace provided by the ESO.

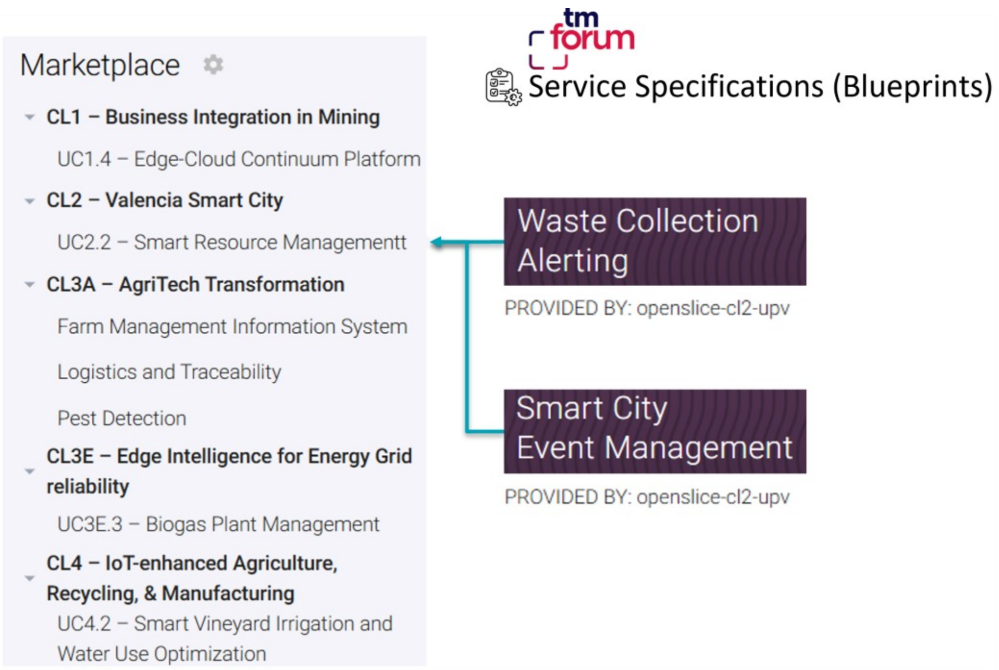

Figure 6: Cluster 2 services onboarded onto the COP-PILOT service marketplace provided by the ESO.

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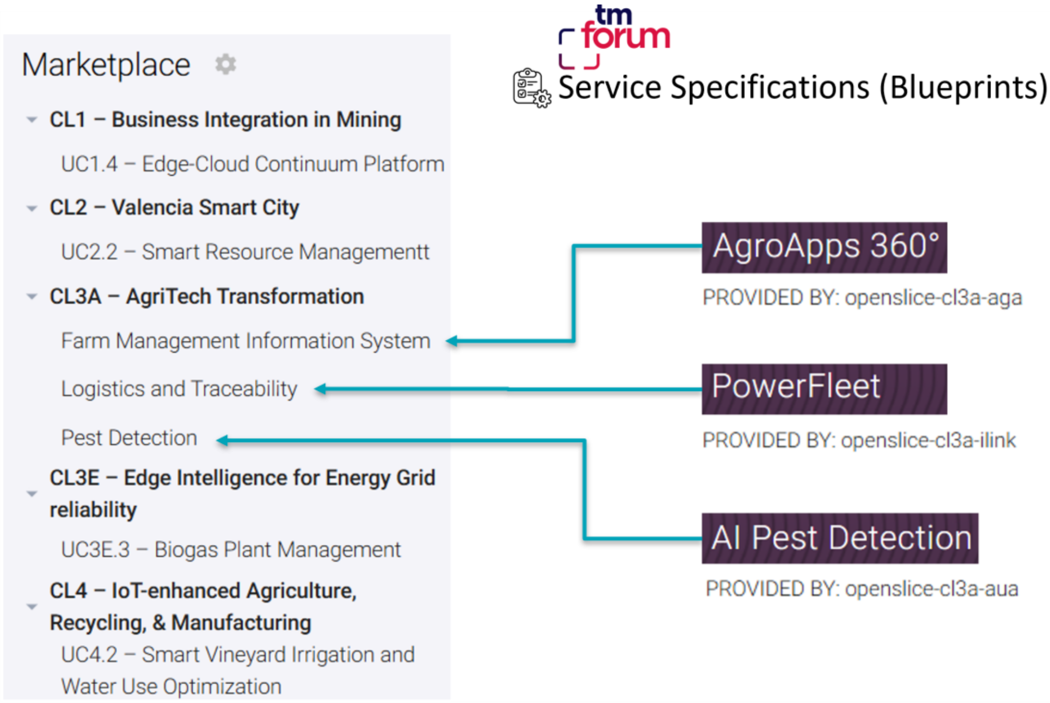

Figure 7: Cluster 3A services onboarded onto the COP-PILOT service marketplace provided by the ESO.

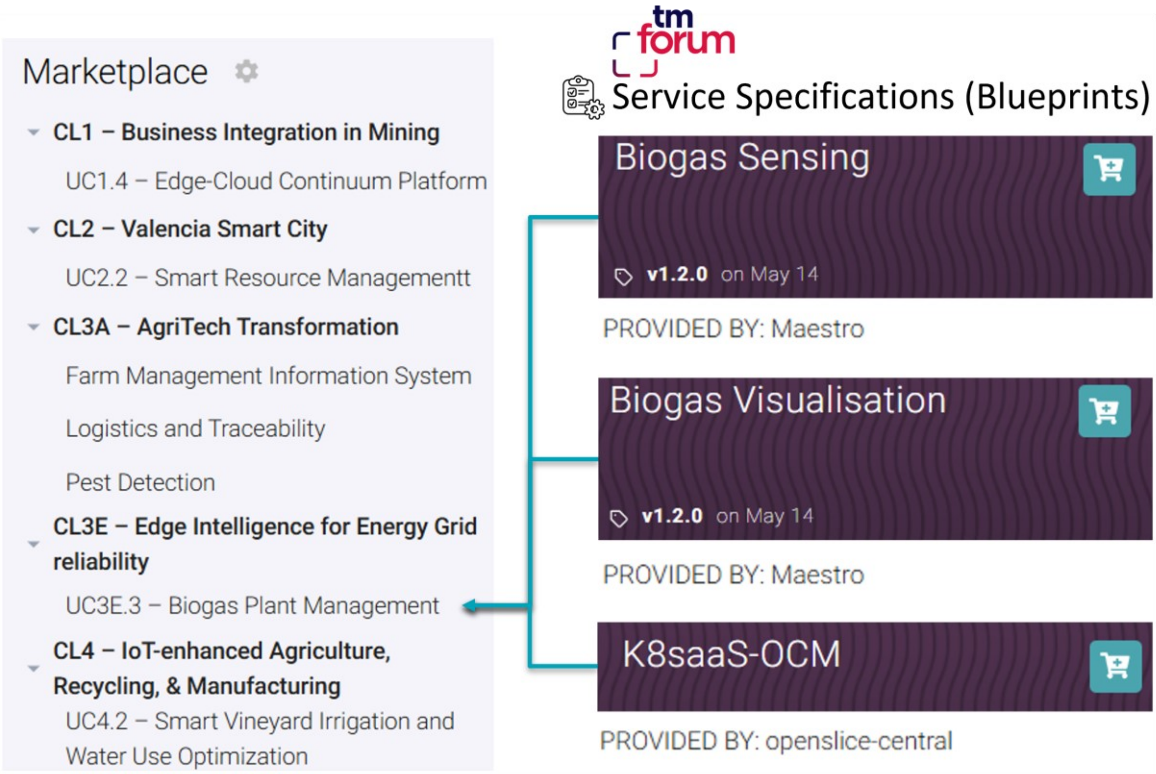

Figure 8: Cluster 3E services onboarded onto the COP-PILOT service marketplace provided by the ESO.

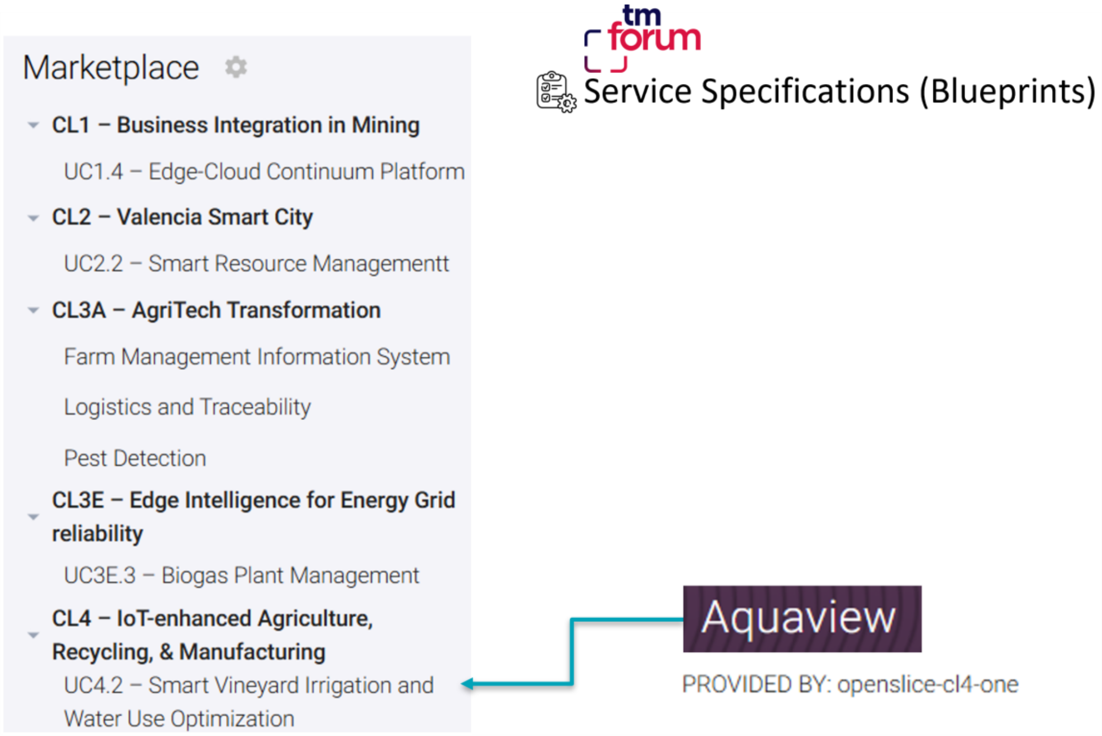

Figure 9: Cluster 4 services onboarded onto the COP-PILOT service marketplace provided by the ESO.

Finally, Table 6 lists recorded videos that demonstrate the COP-PILOT platform in action.

Table 6: COP-PILOT Platform demonstration activities by M18.

Material	Involved COP-PILOT Platform Components	Purpose	Link
Orchestrators (ESO-to-DO) Peering	ESO, DO, SIF	Demonstrates the ESO's ability to peer with a DO instance and obtain the desired services exposed by this DO through standardized TMF APIs.	Video on the COP-PILOT YouTube channel
Federated ESO Service Marketplace	ESO	After the ESO has peered with multiple DO instances spread across all COP-PILOT Clusters in Europe, it obtains and promotes a central Pan-European COP-PILOT service marketplace through standardized TMF APIs.	

3.3 CLUSTER LEVEL (VERTICAL APPLICATIONS COMPONENTS)

This section presents the cluster-level exploitable results, which comprise the application-specific assets developed across the project's five vertical clusters. **Cluster 1 (CL1)** focuses on mining and heavy industry, delivering results related to seismic processing, asset tracking, onboarding automation, and ColonyOS blueprint reconciliation. **Cluster 2 (CL2)** addresses smart city and port environments, offering a smart city stack, alert notification services, monitoring and frequency modifier tools, maritime traffic and 5G network management services, and a YOLO-based verification tool. **Cluster 3A (CL3A)** targets precision agriculture and agri-food, with results spanning the AgroApps 360 platform, AI-driven pest detection, autonomous UGV inspection, plant wearable sensors, blockchain-based traceability, PowerFleet logistics, and private 5G connectivity for rural areas. **Cluster 3E (CL3E)** covers energy management, including an ADMS, grid simulator, EV chargers management app, and biogas management app. Finally, **Cluster 4 (CL4)** addresses winery and vineyard optimisation, featuring IoT-enhanced OEE analytics, Aquaview, and 5G infrastructure and energy management solutions. Each of these results is detailed in the tables below, with information on ownership, licensing, TRL, type of exploitation, and target user groups

3.3.1 Cluster 1

Table 7: Vertical application components (CL1)

ID	Name	Owner (s)	Licence	TRL (M36)	Type of exploitation	Target users
Cl1-1	BEMIS - Multi-sensing seismic processing	ROC	Proprietary	7	Introduced as new to the market (Commercial exploitation)	Mining companies
Cl1-2	BEMIS - Auto-scaling seismic processing	ROC	Proprietary	6	Introduced as new to the market (Commercial exploitation)	Mining companies
Cl1-3	BEMIS - Distributed seismic processing	ROC	Proprietary	6	Introduced as new to the market (Commercial exploitation)	Mining companies
Cl1-4	EvoMining Asset tracking	TAB	Proprietary	7	Introduced as new to the market (Commercial exploitation)	Mining companies
Cl1-5	Splaice - onboarding automation	HOSCH	Proprietary	7	Introduced as new to the market (Commercial exploitation)	Mining companies
Cl1-6	Conveyor - onboarding automation	PAB	Proprietary	6	Introduced as new to the market (Commercial exploitation)	Mining companies
Cl1-7	Conveyor - Decision support UI update automation	PAB	Proprietary	6	Introduced as new to the market (Commercial exploitation)	Mining companies
Cl1-8	ColonyOS Blueprint Reconciler (demonstrated on M14 review)	LTU	MIT	6	Other (Open-Source contribution)	Mining companies

3.3.2 Cluster 2

Table 8: Vertical application components (CL2)

ID	Name	Owner (s)	Licence	TRL (M36)	Type of exploitation	Target users
Cl2-1	Smart City Stack	TID	Open source	7	New internal product SmartCity , and new internal process implemented at the end of the project	Any Townhall employees, police, municipal authorities, external users (citizens), port authorities, waste collection company.
Cl2-2	Alert Notification Service (on M14 it was Waste Collection Alerting)	UPV	Proprietary	7	Only deployed as new to the cluster, new internal processes implemented	Police, municipal authorities, external

ID	Name	Owner (s)	Licence	TRL (M36)	Type of exploitation	Target users
						users (citizens), port authorities, waste collection company
Cl2-3	AEMET Monitoring Tool	FIVE	Proprietary	7	Only deployed as new to the cluster, new internal processes implemented	Municipal authorities and public safety personnel
Cl2-4	Frequency Modifier Tool	FIVE	Proprietary	8	Only deployed as new to FIVE, new internal processes implemented	Tool tailored to FIVE's water level measurement devices
Cl2-5	Maritime Traffic Service	FVP	Proprietary	7	Only deployed as new to the cluster, new internal processes implemented	Port Authorities, moorers, port control entities
Cl2-6	5G Network Management Service	FVP	Proprietary	7	Only deployed as new to the cluster, new internal processes implemented	Network providers, 5G private network users (Valenciaport authority)
Cl2-7	YOLO-based Verification Tool	FIVE	Open source /Academic licence	7	Only deployed as new to the cluster, new internal processes implemented	Traffic management entities

3.3.3 Cluster 3A

Table 9: Vertical application components (CL3A)

ID	Name	Owner (s)	Licence	TRL (M36)	Type of exploitation	Target users
Cl3A-1	AgroApps 360 (enhanced)	AgroApps	Commercial / Proprietary	8	Commercial SaaS product; subscription licensing to agri-food businesses	Farmers, agronomists, agri-food processors, farm cooperatives, contract farming networks
Cl3A-2	AI-driven crop pest detection service	AUA	Open source /Academic licence	7	Research exploitation; licensing to agri-tech companies and crop protection service providers	Agricultural research institutions, agri-tech companies, crop protection advisors,

ID	Name	Owner (s)	Licence	TRL (M36)	Type of exploitation	Target users
						precision farming service providers
CI3A-3	Autonomous UGV inspection platform	AUA	Research licence	6	Licensing to agricultural robotics and precision farming companies; research exploitation	Agricultural robotics companies, precision farming service providers, research institutions
CI3A-4	Plant wearable sensor system for antinutrient monitoring	TOR	Research licence	6	Research exploitation; licensing; spin-off potential for agri-food quality assurance	Crop research institutions, food quality assurance services, agri-tech companies, food processors
CI3A-5	Blockchain-based agri-food traceability solution	iLink	Commercial / Proprietary	8	Commercial service; licensing to food producers and retailers; integration with certification schemes	Food producers, food processors, retailers, certification bodies, regulators, consumer-facing platforms
CI3A-6	PowerFleet for Agrifood (logistics and fleet dispatch platform).	ILINK	Commercial / Proprietary	8	Commercial service; licensing to agricultural cooperatives and logistics operators	Agricultural cooperatives, food processors, logistics operators, contract farming networks
CI3A-7	Private 5G connectivity service for precision agriculture	OTE	Commercial service	8	Commercial deployment; replication of MPN model for agricultural and rural enterprise environments	Agri-tech companies, farming cooperatives, rural enterprises, IoT service providers

3.3.4 Cluster 3E

Table 10: Vertical application components (CL3E)

ID	Name	Owner (s)	Licence	TRL (M36)	Type of exploitation	Target users
CI3E-1	ADMS	UoP, ENIK	Apache 2.0	5	Research exploitation	DSOs, Aggregators,

						Energy Market Operators
CI3E-2	Grid Simulator	UoP	Apache 2.0	5	Research exploitation	DSOs, Research Institutions
CI3E-3	EV Chargers Mgmt App	ENIK	Proprietary	8	Only deployed as new feature to the ENIK's existing product	EV Charger Owners, Asset Owners
CI3E-4	Biogas Mgmt App	ENIK	Proprietary	8	Licensing to biogas plant operators (commercial exploitation); Only deployed as new feature to the ENIK's existing product	Biogas Plant Owners, RES Owners

3.3.5 Cluster 4

Table 11: Vertical application components (CL4)

ID	Name	Owner (s)	Licence	TRL (M36)	Type of exploitation	Target users
Cl4-1	Sustainable optimized Winery Production Lines / IoT-Enhanced OEE Analytics platform	JIG	Proprietary	7	Introduced as new to the market (commercial exploitation)	Wineries
Cl4-2	Aquaview	TER	Proprietary	7	Introduced as new to the market (commercial exploitation)	Growers, Agronomists, Vineyard Managers
Cl4-3	5G Infra Management	NOK	Proprietary	7	Introduced as new to the market (commercial exploitation)	Growers, Agronomists, Vineyard Managers
Cl4-4	5G Energy Management	NOK	Proprietary	6	Introduced as new to the market (commercial exploitation)	Growers, Agronomists, Vineyard Managers, Research Institutions
Cl4-5	5G Smart Agro	NOK	Proprietary	6	Introduced as new to the market (commercial exploitation)	Growers, Agronomists, Vineyard Managers, Research Institutions
Cl4-6	Sensor Recycling	RZ	Proprietary	6	Introduced as new to the market (commercial exploitation)	Sensor companies, Vineyard managers,

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						Research institutions
CI4-7	Wallet	RZ	Propiet ary	6	Introduced as new to the market (commercial exploitation)	Sensor companies, Vineyard managers, Research institutions

4 MARKET POTENTIAL

4.1 PLATFORM LEVEL

4.1.1 Market Overview

While orchestration platforms are popular systems in the IT sector, especially for large service providers and network operators, existing solutions remain proprietary as big players keep the development and management of such platforms, strictly in-house. Indicative examples in the telco domain are the vendor-specific solutions by Cisco [24], Nokia [25], and Ericsson [26].

To promote a healthier and more sustainable ecosystem for service and network orchestration, the ETSI standards developing organization has created several software development groups with emerging orchestration solutions, including OpenSlice [27], HypO [8], Open-Source MANO [28], TeraFlowSDN [29], OpenCAPIF [30], and Open Operator Platform [31]. In parallel, interesting Linux Foundation projects, such as Nephio [32], and ONAP [25] have emerged. Both worlds offer solutions that are primarily engineered to streamline service onboarding, ordering, and automated service lifecycle management operations. This landscape is further strengthened by cloud-native deployments as per LF Sylva [26] and API-driven exposure of network capabilities as per LF CAMARA [35], reinforcing a strong focus on optimizing where and how services are deployed and operated. This entire ecosystem of projects formulates a strong background that aims to compete vendor-specific software stacks, thus emerging as an open alternative for transparent management of services in the ever-expanding cloud continuum.

At the data management level, mature open-source platforms have been around since the rise of the IoT era. To name a few, FIWARE built a large community on Data Management through popular Context Management platforms, such as the Orion [36], Scorpio [37], and Stellio Context Brokers [38], while Eclipse Foundation projects, such as Eclipse Arrowhead [39], Eclipse XFSC [40] and Eclipse EDC [41] emerged more recently. Europe is now converging these platforms towards a European sovereign Data Space ecosystem under the GAIA-X [42] initiative, the Common EU Data Spaces [43], and the Data Spaces Support Centre blueprint [44].

COP-PILOT leverages the synergy of two ETSI orchestrators, i.e., HypO [8] and OpenSlice [27], both under the same ETSI OpenSlice Software Development Group to manage disperse compute and network resources, while these orchestrators also interface with Data Space platforms (i.e., both from FIWARE [45] and Eclipse Foundation [46]) to cover data-related aspects for collaborative end-to-end vertical services.

4.1.2 Opportunities and challenges

Edge computing ecosystems are undergoing rapid transformation, driven by the proliferation of IoT devices, the deployment of private 5G networks, and the expansion of distributed computing infrastructures. While this evolution enables new digital capabilities, it also results in **fragmented and siloed environments**, where resources, services, and data remain distributed across heterogeneous technologies and administrative domains. As a result, the ability to coordinate and orchestrate these distributed environments is increasingly recognised as a critical enabler of value creation.

In this context, there is a growing demand for **platform solutions** capable of **integrating, orchestrating, and enabling collaboration across domains**, particularly in **cross-sector** settings. COP-PILOT directly leverages this shift by positioning itself as a horizontal orchestration layer that addresses fragmentation and enables coordinated service deployment across heterogeneous environments.

4.1.2.1 Technology and infrastructure

The continued expansion of IoT deployments and edge infrastructures, supported by advanced connectivity technologies such as 5G, is creating a strong demand for **end-to-end orchestration across the IoT–edge–core continuum**. Organisations increasingly require the ability to deploy applications seamlessly across distributed infrastructures while ensuring performance and scalability. COP-PILOT can leverage this trend by enabling coordinated orchestration across multiple domains, thereby reducing fragmentation and improving the efficiency of distributed service deployment.

At the same time, the increasing importance of **cross-domain applications**, particularly in areas such as mobility, logistics, and industrial supply chains, is driving demand for **service composition across independent infrastructures and stakeholders**. This creates a clear opportunity for COP-PILOT to facilitate such scenarios by enabling applications that span across organisational and technological boundaries, supporting the emergence of integrated digital value chains.

Another important trend is the growing need for **secure and trusted collaboration across organisations**, especially in multi-stakeholder ecosystems where data and services must be exchanged under controlled conditions. Traditional approaches based on static connectivity models are increasingly insufficient. COP-PILOT can exploit this shift by enabling secure, policy-driven interactions between domains, supporting trusted collaboration in distributed environments.

The rising complexity of distributed systems is also increasing demand for **automation and AI-driven orchestration**, particularly for managing service lifecycle, ensuring performance, and adapting to dynamic conditions. COP-PILOT can leverage this opportunity by incorporating intelligent orchestration mechanisms that support automated service onboarding, monitoring, and adaptive reconfiguration.

In parallel, the increasing importance of **data sharing across domains**, reinforced by initiatives such as the European Data Strategy and the development of sectoral data spaces, is creating demand for **federated data management approaches**. These approaches enable controlled data exchange while preserving ownership and sovereignty. COP-PILOT is well positioned to support this trend by enabling interoperable data exchange across domains, aligning with data space architectures and standards.

Finally, the need to **simplify access to complex distributed infrastructures** is becoming more pronounced, as developers and organisations seek to reduce the effort required to deploy and manage applications. COP-PILOT can capitalise on this by providing abstraction mechanisms that hide infrastructure heterogeneity and enable faster and more scalable service deployment.

Variability in network connectivity and performance, particularly in edge and remote environments and across 5G deployments, remains a significant challenge. Differences in latency, bandwidth, and reliability can directly affect service performance and consistency across domains, especially for applications requiring real-time responsiveness. This may constrain the effectiveness of COP-PILOT in scenarios requiring strict service-level guarantees and time-sensitive orchestration.

In addition, the edge computing landscape is characterised by **high technological heterogeneity**, encompassing diverse IoT devices, communication protocols, cloud platforms, and legacy systems. This diversity significantly complicates integration efforts and increases the need for adaptation across environments. As a result, it may further limit the efficiency and increase the complexity of COP-PILOT deployments in heterogeneous, real-world settings.

Although significant progress has been made in standardisation, including through initiatives such as ETSI and TM Forum, **interoperability challenges persist across heterogeneous environments**, limiting the practical applicability of existing approaches. This increases integration complexity and hinders seamless interaction across systems and domains. **COP-PILOT can mitigate these challenges by leveraging an open, standards-based platform approach that promotes interoperability through common interfaces and facilitates integration across heterogeneous infrastructures.**

Scalability also represents a key challenge, as orchestration platforms must manage **large numbers of devices, services, and domains** while maintaining performance and responsiveness. COP-PILOT must address these scalability constraints to remain effective in large-scale deployments.

Security and trust remain fundamental concerns, particularly in cross-sector and critical infrastructure contexts. Although COP-PILOT supports secure interactions, **establishing trust among stakeholders and ensuring consistent policy enforcement** remains a barrier to adoption.

Finally, the increasing use of **AI-driven orchestration** introduces challenges related to data quality, model reliability, and transparency. These factors may influence the effectiveness and acceptance of COP-PILOT's automation capabilities, particularly in environments where accountability is required.

4.1.2.2 Economic

The growing complexity of distributed infrastructures is driving demand for solutions that can **reduce operational costs through automation and orchestration**. Organisations are increasingly seeking to improve resource utilisation and minimise manual intervention. COP-PILOT can exploit this trend by enabling more efficient management of distributed infrastructures and reducing operational overhead.

At the same time, the emergence of **platform-based ecosystems** is creating new opportunities for value creation, where multiple stakeholders can exchange services, data, and resources. This creates potential for **new business models, including service marketplaces and data-driven offerings.** COP-PILOT can leverage this development by enabling multi-stakeholder ecosystems that facilitate collaboration and monetisation of digital assets.

The increasing focus on **innovation ecosystems**, particularly those involving SMEs and startups, further reinforces the need for platforms that lower barriers to entry. COP-PILOT can support this trend by providing a common environment for service development and deployment, enabling broader participation and innovation.

In addition, the possibility to **reuse solutions across multiple sectors** enhances scalability and improves return on investment. COP-PILOT can capitalise on this by enabling cross-sector deployment of applications, facilitating the transfer of solutions across domains such as energy, agriculture, and mobility.

The adoption of such platform solutions requires **significant upfront investment**, particularly for integrating existing infrastructures and onboarding stakeholders. This may act as a barrier for organisations with limited resources or digital maturity.

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A further challenge arises in defining **clear business models and value capture mechanisms** within multi-party ecosystems. The distribution of costs and benefits among stakeholders remains complex, which may create uncertainty regarding the economic viability of adopting COP-PILOT.

Additionally, platform success depends on achieving sufficient **ecosystem adoption and network effects**. Without a critical mass of users and stakeholders, the value proposition of the platform may remain limited. **This creates a "chicken-and-egg" situation, where stakeholders are reluctant to join until clear value is demonstrated, while value itself depends on broad participation.**

The targeted sectors are also characterised by **long adoption cycles and risk-averse behaviour**, which can delay the uptake of new solutions. **In particular, decision-making processes in sectors such as energy and industry often involve strict validation requirements and compliance checks, further extending time-to-market.** This may slow down the commercial exploitation of COP-PILOT.

4.1.2.3 Regulatory, legal and ethical

The European regulatory framework increasingly supports **data sharing, interoperability, and digital sovereignty**, as reflected in initiatives such as the Data Governance Act, the Data Act, and the European Data Strategy. These developments create favourable conditions for platforms that enable controlled data exchange and federated data management. COP-PILOT can leverage this alignment by supporting data sharing across domains while preserving data ownership and compliance.

Moreover, the growing emphasis on **security-by-design and privacy-by-design approaches**, particularly under GDPR and cybersecurity regulations, reinforces the need for platforms that embed security and access control mechanisms. COP-PILOT can benefit from this trend by enabling secure and policy-driven interactions across stakeholders.

The emergence of the **AI Act** further increases demand for systems supporting **trustworthy and accountable AI**. COP-PILOT can exploit this opportunity by providing controlled and transparent orchestration mechanisms that align with evolving regulatory requirements for AI systems.

The regulatory landscape remains complex, particularly due to **differences across sectors and national jurisdictions**, which can complicate deployment and scaling of cross-domain platforms such as COP-PILOT. Regulatory requirements may vary significantly between domains such as telecommunications, energy, and industry. This creates additional effort in ensuring compliance across different deployment contexts.

Data governance challenges are also significant, especially in defining **ownership, access rights, and data usage policies** across multiple stakeholders and domains, particularly in cross-border scenarios. The absence of harmonised governance frameworks can limit data sharing between organisations. This may affect the ability of COP-PILOT to fully enable data-driven services across domains.

Compliance with **cybersecurity requirements**, especially in critical sectors such as energy and industry, increases both technical complexity and operational costs. Organisations must adhere to strict security standards and certification requirements. This may create additional barriers for deploying and scaling COP-PILOT solutions.

Trust-related concerns may further limit participation in shared ecosystems, as organisations may be reluctant to **share data or rely on external infrastructure** without strong guarantees. Concerns related to data misuse, loss of control, or dependency on external systems remain prevalent. This can slow down the adoption of collaborative platform approaches such as COP-PILOT.

Finally, the increasing adoption of **AI-driven decision-making systems** introduces challenges related to accountability, transparency, and liability. Regulatory frameworks such as the AI Act impose requirements on explainability and risk management. COP-PILOT must ensure that its automation mechanisms comply with these evolving constraints.

4.2 CLUSTER 1

Cluster 1 focuses on the integration of advanced digital mining applications into secure, interoperable and scalable edge-to-cloud infrastructures. It addresses four complementary use cases: UC1.1 distributed seismic monitoring and processing, UC1.2 underground asset tracking and smart ground support, UC1.3 conveyor condition monitoring and predictive maintenance, and UC1.4 orchestration of digital mining services across heterogeneous industrial environments.

Together, these scenarios demonstrate how COP-PILOT can reduce deployment barriers, improve interoperability, and enable more resilient, data-driven mining operations.

4.2.1 Market Overview

4.2.1.1 Market Trends

The global mining industry is undergoing a broad digital transformation driven by safety, productivity, cost efficiency, and environmental performance. A clear trend is the increasing use of Industrial IoT, connected sensors and data-driven decision support across mining operations. Sensors are increasingly deployed on equipment, vehicles, infrastructure, ventilation systems and personnel to monitor vibration, temperature, pressure, location, and safety-related conditions. This enables continuous monitoring of both production assets and the underground working environment.

Predictive maintenance is becoming an important application area for digital mining. Sensor data from machinery and infrastructure is increasingly analyzed using AI and analytics tools to identify anomalies, predict failures and support planned maintenance. This trend is particularly relevant for mission-critical mining systems where unplanned downtime can cause significant production losses, safety risks, and operational disruption.

Another strong trend is the shift from purely centralized cloud architectures towards hybrid edge-to-cloud models. Mining operations often face constrained connectivity, limited bandwidth, latency-sensitive applications, and strict requirements on data governance. As a result, more processing is being moved closer to the data source, while cloud resources are used selectively for heavier analytics, long-term storage, model training, or batch processing. This creates a growing need for architectures that can distribute processing intelligently across edge, on-premise and cloud environments.

Edge computing is also increasingly linked to safety-critical use cases. Local processing of video, sensor, and operational data can support faster warnings and automated responses in situations such as gas leaks, roof-fall risks, vehicle interactions, or equipment failures. This is especially important in remote or underground environments where network interruptions may prevent reliable cloud-based processing.

Interoperability and openness are becoming increasingly important market drivers. Mining companies often operate heterogeneous technology environments with multiple OEMs, sensor suppliers, and specialized application providers. External market observations point to growing interest in open standards and supplier-agnostic solutions, for example in autonomous mining systems and fleet management. The underlying driver is to reduce vendor lock-in, enable multi-vendor integration, and allow mining operators to select the most suitable technology for each operational need.

At the same time, the trend towards openness must be balanced against cybersecurity, data governance, and protection of intellectual property. Mining companies handle sensitive operational data and often maintain strict control over infrastructure access, credentials, and data flows. This means that open interfaces and interoperable architectures must be combined with robust security, access control, auditability, and clear data-sharing rules.

A further trend is the increasing need for automated management and orchestration of distributed digital infrastructure. As mines adopt more sensors, edge nodes, AI models and cloud-connected services, manual deployment and lifecycle management become difficult to scale. Market analysis highlights the growing relevance of edge management and orchestration platforms that can support provisioning, configuration, monitoring, security, performance optimization, and lifecycle management across distributed environments.

However, the market is not uniform. Digital maturity differs significantly between mining companies and regions. Some operators are already deploying advanced autonomous systems, edge analytics and hybrid cloud strategies, while others are still working with fragmented data architectures, legacy systems, and siloed decision-making. This means that market uptake of advanced IoT-edge-cloud solutions will depend not only on technical performance, but also on integration effort, organizational readiness, cybersecurity confidence, change management and the availability of trusted partners.

For Cluster 1, these trends confirm a market need for secure, interoperable, and scalable digital mining solutions that can operate across constrained and heterogeneous infrastructures. The most relevant market direction is not a single monolithic platform, but an ecosystem approach where mining operators can adopt specialized services for seismic monitoring, asset tracking and predictive maintenance, while relying on common principles for secure data exchange, edge-to-cloud processing, automated deployment and multi-vendor interoperability.

4.2.1.2 Competitive Landscape

The competitive landscape for digital mining is shaped by a combination of large established industrial suppliers, specialized technology providers, emerging open platforms, and ongoing standardization initiatives. Digital tools are no longer limited to isolated pilot projects, but are increasingly embedded in day-to-day mining operations, including condition monitoring, autonomous haulage, drilling, predictive maintenance, logistics, and remote operations.

Large OEMs and established industrial technology providers remain dominant in many operational domains. These actors typically offer mature, vertically integrated systems for specific mining functions such as autonomous haulage, drilling, fleet management, process monitoring, and machine control. Their solutions are often reliable and proven at industrial scale, but they are commonly built around closed ecosystems that work best when the mine standardizes around one supplier or one technology stack. This can create significant barriers for mining companies that operate mixed fleets or rely on multiple technology providers.

A central competitive issue is therefore the trade-off between maturity and openness. Closed, vertically integrated solutions can reduce technical risk within a single supplier ecosystem, but they may also increase vendor lock-in, limit flexibility and make it more difficult to integrate third-party systems. In autonomous mining, for example, closed ecosystems may require mines to standardize fleets on one supplier, while open autonomy approaches allow mixed fleets but introduce higher integration complexity.

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Alongside the large OEMs, a growing number of SMEs, niche suppliers and start-ups are developing specialized digital solutions for mining-specific problems. These include seismic monitoring, IoT-based logistics, underground asset tracking, conveyor belt condition monitoring, predictive maintenance, and AI-based decision support. Such actors often provide highly innovative and domain-specific solutions, but they frequently face barriers when scaling into operational mining environments, particularly around integration, deployment, data governance, cybersecurity, connectivity and lifecycle management.

The market is also characterized by a high degree of fragmentation. Mines often operate several independent systems from different suppliers, resulting in siloed data, limited version control, manual data handling, and weak interoperability between workflows. External sources highlight that interoperability is not achieved simply by exposing APIs; even when interfaces exist, adaptation, authentication, legacy systems and site-specific workflows still require significant engineering effort.

Standardization initiatives and open architectures are emerging as a response to this fragmentation. Industry initiatives around interoperable protocols, open autonomy, and standards such as ISO 23725 indicate that the market is gradually moving towards more supplier-agnostic and collaborative ecosystems. However, standardization is still evolving and does not remove the need for practical integration work, cybersecurity assurance and adaptation to each mine's operational environment.

Advanced analytics, AI and IoT solutions also face specific adoption barriers. Mining companies must consider the cost of implementation, hardware, software, training, and ongoing technical support. Trust in AI-based recommendations remains an important issue, particularly for mission-critical decisions, and hybrid models with human oversight are often preferred. In addition, limited network capacity and intermittent connectivity in mines mean that real-time or high-volume data applications must be carefully designed around actual use cases and available infrastructure.

Within this landscape, COP-PILOT and Cluster 1 are positioned not as direct competitors to specialized mining applications or OEM systems, but as an enabling layer for interoperability, secure data exchange, edge-to-cloud orchestration and scalable deployment. The project addresses a gap between specialized digital applications and the complex infrastructure reality of mining operations: niche solutions can create strong domain value, but often need open, secure and orchestrated environments to scale reliably across heterogeneous mine infrastructures.

For Cluster 1, the competitive opportunity lies in supporting an ecosystem model rather than a single-vendor model. Mining operators can continue to procure specialized solutions for seismic monitoring, asset tracking and predictive maintenance from domain experts, while benefiting from common mechanisms for secure integration, distributed processing, automated deployment and interoperability. This positioning is aligned with the market's gradual shift from closed stacks towards more open, collaborative and standards-based digital mining ecosystems.

4.2.1.3 Target Groups

The primary target group for Cluster 1 solutions is mining operators, particularly those with complex underground operations where safety, reliability, and operational efficiency are critical. These organizations require advanced monitoring, analytics, and decision support systems to manage seismic risks, optimize logistics, and ensure continuous production.

A secondary target group consists of technology providers and application developers, including SMEs and specialized vendors offering analytics, IoT solutions, and digital services. These actors benefit from a platform that simplifies deployment, integration, and scaling of their applications across different mining environments.

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Another important target group is IT/OT service providers and system integrators, who are responsible for deploying, managing, and maintaining digital infrastructure within mining companies. These actors play a key role in enabling the adoption of edge-to-cloud platforms and managed services, particularly for mining operators with limited in-house IT capabilities.

Finally, infrastructure owners and industrial enterprises beyond mining represent a broader target group, as the solutions developed in Cluster 1 are transferable to other domains with similar requirements, such as heavy industry, logistics, and energy.

4.2.2 Opportunities and challenges

Cluster 1 addresses a clear market need in the mining industry: enabling advanced digital services to operate reliably across highly constrained, security-sensitive and heterogeneous mine infrastructures. The main opportunity lies in combining domain-specific vertical applications — seismic monitoring, underground asset tracking, and conveyor condition monitoring — with an interoperable edge-to-cloud platform that reduces deployment friction, improves scalability, and supports secure data exchange across distributed industrial environments. This creates value both for mining operators, who need better safety, productivity and resilience, and for specialized suppliers, who need more efficient ways to deploy and operate digital services in customer environments.

At the same time, the cluster operates in a market characterized by fragmented infrastructures, strict data governance, legacy systems, and significant operational constraints. Mines often rely on siloed vendor-specific solutions, manual deployment practices, and infrastructures that are not designed for modern service-oriented integration. These constraints slow adoption, increase cost, and make scaling difficult. Cluster 1 therefore has a strong opportunity to position its results as an enabling layer for digital mine operations, but it must do so in a way that addresses infrastructure heterogeneity, real-world deployment complexity, and the conservative risk profile of mining operators.

4.2.2.1 Technology and infrastructure

The main technological opportunity for Cluster 1 is to enable secure and interoperable operation of digital mining services across heterogeneous infrastructures. In UC1.1, the ability to consolidate multi-technology and multi-vendor seismic sensing into one processing and visualization workflow represents a significant step beyond today's siloed seismic systems. In UC1.2, the integration of smart rock bolts, asset tracking, AI-enabled data processing and Arrowhead/ColonyOS-based interoperability creates opportunities for smarter underground logistics and safety applications. In UC1.3, the combination of IoT-based sensing, analytics and scalable onboarding creates a path toward more dependable conveyor monitoring and predictive maintenance. UC1.4 strengthens all three use cases by providing a validated edge-to-cloud continuum with secure service discovery, orchestration, autoscaling and automated deployment across distributed mining environments.

The corresponding technology and infrastructure challenges are substantial. Mining environments are characterized by limited bandwidth, high data volumes, strict network segmentation, and heterogeneous on-prem, edge and cloud systems. Cluster 1 documents repeatedly identify interoperability gaps, fragmented software deployment, lack of automated lifecycle management, diverse customer infrastructures, and legacy systems that do not support modern communication protocols or cybersecurity mechanisms. In addition, some applications require low-latency edge processing while others benefit from cloud bursting or distributed execution, which means the platform must support both real-time and non-real-time workloads without assuming a single deployment model. These conditions raise the technical bar for integration, observability, resilience, and maintainability.

4.2.2.2 Economic

Economically, Cluster 1 targets value pools that are highly relevant for mining operators: reduced downtime, improved safety, lower deployment effort, and more efficient use of compute and maintenance resources. In UC1.1, improved seismic processing and distributed compute flexibility can reduce production disruptions and enable better mine planning. In UC1.2, high-accuracy asset tracking and scalable ground-support monitoring can reduce time spent locating equipment and personnel, lower inspection effort, and reduce lost-asset costs. In UC1.3, predictive conveyor monitoring addresses one of the most critical economic risks in continuous operations: unplanned conveyor downtime and associated production losses. Across the cluster, UC1.4 provides an opportunity to reduce IT-related costs by automating deployment, provisioning and scaling, while also improving the business case for advanced digital services in mines with constrained infrastructure.

The business requirements in the use cases point to concrete economic benefits. UC1.2 explicitly targets reductions in physical installation time and configuration time for rock-bolt-based systems, lower costs associated with lost assets, and reduced manual inspection effort. UC1.3 is motivated by the need to avoid costly unplanned downtime and to scale deployment efficiently across multiple units and customers. UC1.4 identifies reduced IT-related costs as a direct market requirement, while the broader COP-PILOT material links the platform approach to reduced OPEX and faster onboarding of services. This indicates that the economic opportunity is not only in selling individual vertical applications, but also in lowering the cost-to-serve and time-to-value for each deployment.

However, the economic challenges should not be underestimated. Mining customers typically face long procurement cycles, site-specific deployment conditions, and high requirements for reliability and validation before adoption. On-prem deployments can be expensive to install and maintain, sensor hardware must often be ruggedized for harsh environments, and integration projects can become costly when multiple legacy systems are involved. In addition, value realization may depend on customer maturity: some mines have strong internal IT/OT capabilities, while others will require external integration and operational support. This means that commercialization will likely require flexible business models, including direct product sales, solution engineering, onboarding support, and potentially managed operational roles around the reference stack.

4.2.2.3 Regulatory, legal and ethical

From a regulatory and legal perspective, the most important factor in Cluster 1 is that mining operators impose strict controls on data access, data location, system connectivity and operational security. Several use cases explicitly state that handled data must comply with mining companies' data restriction demands. This makes compliance with data governance and industrial cybersecurity requirements central to market adoption. In practice, any deployable solution must support secure authentication, controlled service exposure, encrypted communications, auditability and deployment models compatible with restricted on-prem environments.

The project's legal framework reinforces this. The Grant Agreement explicitly includes obligations around confidentiality and security, data protection, IPR, dissemination, and record-keeping, while the project documentation also refers to GDPR compliance, privacy-by-design, data protection impact assessments where needed, and consideration of the Data Act, Data Governance Act, Digital Services Act, Cyber Resilience Act and AI Act in project activities. For Cluster 1, these obligations are especially relevant where digital mine services involve cross-domain data sharing, user access management, worker-related data, or AI-supported decision-making.

Ethically, Cluster 1 solutions are strongly linked to worker safety and responsible operational decision support, but they also introduce considerations related to surveillance, access rights and acceptable use of data. This is particularly relevant in UC1.2, where personnel tracking may be used for safety and emergency response, and in UC1.1 and UC1.3, where operational decisions may increasingly rely on automated analytics and predictive insights. The opportunity is therefore to position Cluster 1 as enabling safer and more transparent industrial operations, while the challenge is to ensure that such solutions are proportionate, privacy-aware, explainable where relevant, and aligned with both legal obligations and workforce trust.

Finally, legal and commercial clarity around IPR and exploitation will be important because Cluster 1 combines proprietary vertical applications with open-source and standards-based platform components. The Grant Agreement states that beneficiaries own their results, while project materials show a mixed ecosystem of proprietary applications, open-source platform components and open-source contributions. This creates a positive basis for exploitation, but it also requires clear partner agreements on ownership, licensing, access rights, and the boundary between open reusable infrastructure and partner-specific commercial offerings.

4.2.3 Hourglass model

Figure 10 illustrates the Cluster 1 ecosystem through an hourglass model, mapping the relationships between stakeholders and technical capabilities across the cluster's architecture. The left side of the hourglass identifies the key stakeholder categories involved — ranging from Solution Engineers and Product Builders at the top, through Tools and Integration Platforms and Platform and Tool Providers, down to Cloud and Core Service Orchestration and Physical and Network Infrastructure at the base. The right side mirrors this structure by mapping the corresponding technical capability layers, from User Interfaces and AI and Data Services, through the Platform layer, to Orchestration, Federation and Digital Twin, and Cloud-Edge Compute Infrastructure. The narrow waist of the hourglass represents the integration and orchestration core of the platform, where components such as HypO, OpenSlice, OpenZiti, ColonyOS and Kubernetes converge to federate the diverse upper and lower layers. The model highlights how Cluster 1 partners — including UBITECH, TATA, RISE, LTU, RockSigma, ThingWave, HOSCH, and Predge, among others — contribute components and services at different layers of the stack, collectively enabling secure, interoperable, and scalable Cloud-Edge-IoT service delivery across the cluster.

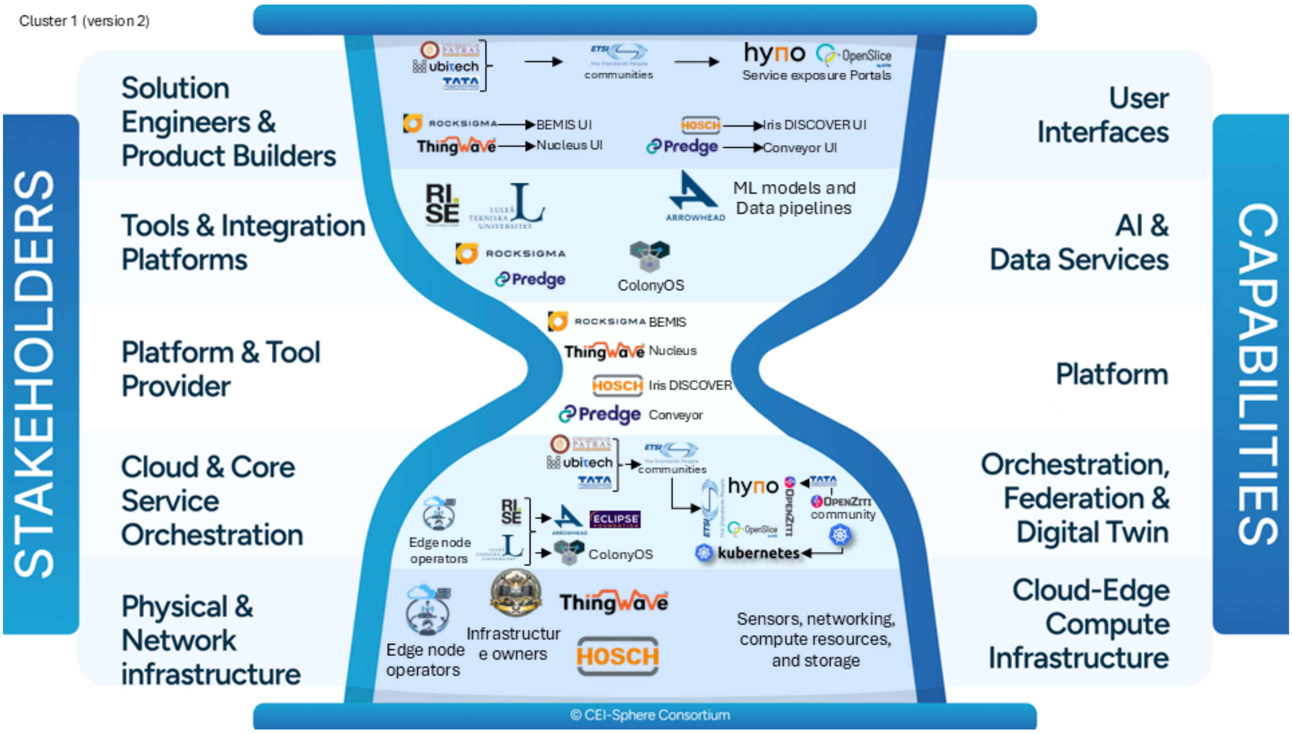

Figure 10: Hourglass model for Cluster 1

4.3 CLUSTER 2

Cluster 2 focuses on the integration of advanced smart city applications into secure, interoperable and scalable edge-to-cloud infrastructures. It addresses four complementary use cases: UC2.1 urban traffic management and flooding monitoring, UC2.2 smart campus sustainability optimisation, UC2.3 intelligent maritime traffic management, and UC2.4 IoT-driven smart building management. Together, these scenarios demonstrate how COP-PILOT can reduce deployment barriers, improve interoperability, and enable more resilient, data-driven urban and port operations.

4.3.1 Market Overview

The global smart city market is estimated at USD 1.68 trillion in 2025, with a forecast of USD 4.76 trillion by 2030 – a CAGR of roughly 23% [47]. Focusing on Europe, the sector was valued at USD 317.2 billion in 2025 and is expected to reach USD 1.77 trillion by 2034 (around 22% CAGR [48]). The IoT segment alone, which is central to the cluster, accounts for 32.7% of the European market [48]. It is expected to grow from USD 126.7 billion in 2025 to USD 462.7 billion by 2032 [49], representing a CAGR of 19%, driven by advances in 5G, edge computing, and AI.

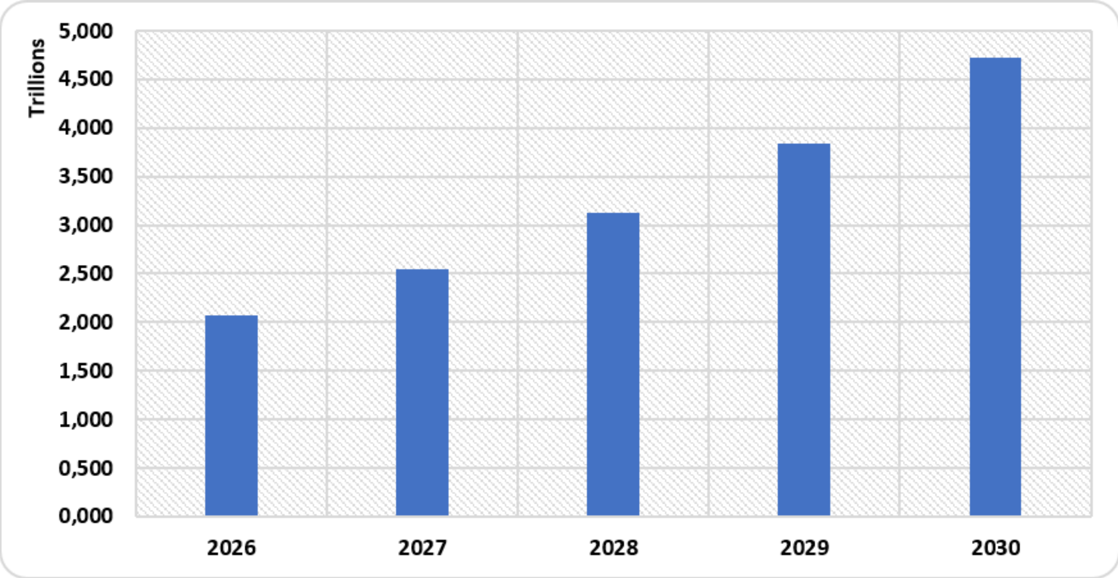

Figure 11: Global smart city market

The growth of the market can be attributed to different factors. Cities are investing in digital infrastructure, IoT connectivity, and artificial intelligence to manage more effectively urban challenges that are facing. Real-time data collection and analytics help improve traffic flow, reduce energy consumption, optimise waste collection, and enhance public safety. At the same time, citizen engagement platforms and integrated operation centres are becoming more common, supporting collaborative governance and new public services.

Government policies play a major role. Many cities see smart technologies as a practical answer to congestion, high energy bills, waste management problems, and safety concerns. International climate commitments – such as the Paris Agreement and the EU Green Deal – are pushing cities to adopt low-carbon solutions. Favorable regulations and public-private partnerships further accelerate deployment.

Municipalities and transport authorities are becoming more demanding. Concerns over data privacy, vendor lock-in, and governance mean that cities increasingly ask for privacy-by-design, open standards, and full transparency on possible risks. Budget constraints lead them to prefer phased rollouts, outcome-based contracts, and managed services. AI and edge analytics must be explainable, low-latency, and well validated. Cybersecurity and supply-chain security are also becoming priorities.

Actual deployment data confirms the trend. More than half of smart cities now use connected devices for traffic, lighting, and environmental monitoring, and about four in ten have adopted AI-driven analytics for congestion control and predictive maintenance. In Europe [50], which holds 26% of the global smart cities market, smart infrastructure and smart energy dominate (36% and 24% respectively), followed by smart mobility at 19%. Data privacy and cybersecurity requirements now influence over 60% of technology procurement decisions, and nearly six out of ten European projects include sustainability performance monitoring as a core metric.

Three overarching trends are particularly relevant:

- **Integrated Data Platforms & Digital Twins**

Cities are moving away from isolated systems towards unified digital ecosystems. This allows real-time, cross-domain operations and avoids data silos.

- **Sustainability & Net-zero Goals**

  Strong EU mandates, including the Green Deal, continue to push digitalisation as a means to lower emissions and manage resources more efficiently.

- **Widespread IoT & AI Adoption**

  The combination of IoT and AI is now the backbone of smart city management, enabling real-time decisions for traffic, utilities, public safety, and environmental monitoring.

In summary, the market is both large and fast-growing, with clear demand for the types of integrated, sustainability-focused IoT solutions that Cluster 2 is examining in Valencia.

4.3.1.1 Competitive Landscape

The smart city platform market is quite crowded and competitive. A handful of large players hold most of the market, though no single company dominates entirely.

Among the big names, Siemens [51](Germany) leads with an estimated 6–7% market share. Cisco (US) follows closely with around 5.5–6%, and IBM (US) is also a top contender, especially strong in AI, hybrid cloud, and digital transformation for cities and ports. Other come global tech giants are following Microsoft, Huawei (with about 4–5% share), and AWS – all major providers of cloud infrastructure and IoT services.

In the area of port automation, ABB and GE Vernova stand out, alongside IBM, Accenture, and Siemens, offering deep expertise in automation and energy management for ports.

Beyond these established names, several innovative startups are gaining attention. dataMatters from Cologne has launched "urbanOS", a municipal operating system. Kentyou in Grenoble focuses on digital twins and open-source IoT solutions. VizioSense from Lille works on edge AI for urban mobility.

Cluster 2 aims to aggregate and integrate solutions from multiple providers – including some of the above – into a single, cohesive real-world pilot. The city of Valencia has a strong sustainability mission, backed by Valencia's status as European Green Capital 2024, that gives a clear and credible focus on sustainability related aspects.

The primary target group for Cluster 2 solutions are infrastructure owners (public sector authorities, particularly city governments, port authorities, and transport agencies) responsible for urban mobility, public safety, environmental monitoring, and infrastructure management. These organisations require advanced monitoring, analytics, and decision support systems to manage traffic congestion, reduce emissions, optimise waste collection, and improve public safety.

A secondary target group consists of technology providers and application developers, including SMEs and specialised vendors offering IoT solutions, data analytics, and digital services providers and system integrators, who are responsible for deploying, managing, and maintaining digital infrastructure within municipalities, ports, and public buildings. These actors benefit from a platform like COP-PILOT that simplifies deployment, integration, and scaling of their applications across different environments.

Another important target group is infrastructure owners and industrial enterprises beyond smart cities that represent a broader target group, as the solutions developed in Cluster 2 are transferable to other domains with similar requirements, such as industrial parks, logistics hubs, airports, and large-scale campuses.

Finally, citizens who benefit from improved air quality, reduced noise and emissions, better public transport or driving through the city, visitors to buildings.

4.3.2 Opportunities and challenges

The smart city sector offers significant business potential. With the global market reaching almost $2 trillion, fuelled by rapid urban growth and the rise of AI, cities are actively looking for flexible, software-driven solutions that help them run infrastructure more efficiently, cut costs, and deliver better services to their residents.

4.3.2.1 Technology and infrastructure

Advances in 5G, edge computing and AI are opening up real possibilities that were hard to imagine just a few years ago. As the IoT in smart cities market is growing cities are actively using new technologies to run services more smoothly and make daily life better for residents. A key enabler of this shift is 5G connectivity, which brings three critical improvements over previous generations: significantly lower power consumption, highly reliable low-latency connectivity, and the capacity to support massive volumes of simultaneously connected devices and data streams. Together, these characteristics make it practical — for the first time at scale — to deploy dense sensor networks across entire urban areas. The most established applications currently span traffic and mobility, energy management, and water utilities. COP-PILOT is well positioned to take advantage of this shift: by integrating the growing ecosystem of connected devices, the project can orchestrate data-driven services that directly address persistent urban inefficiencies.

A major technological challenge for smart city deployment is the integration of advanced technologies such as IoT, AI, edge computing, and 5G into existing infrastructure that was not originally designed for digital connectivity. Many cities and industrial environments still rely on legacy systems, including older traffic controllers, utility networks, and industrial monitoring platforms that use proprietary protocols and lack interoperability with modern smart solutions. This creates significant integration complexity, particularly when processing and managing real-time data at scale across multiple vendors and platforms.

4.3.2.2 Economic

The smart city market continues to experience strong growth, driven by increasing investments in digital infrastructure, sustainability, urban resilience, and data-driven public services. The rapid adoption of IoT technologies, artificial intelligence, cloud platforms, and advanced connectivity is creating new opportunities across sectors such as intelligent transport, smart buildings, port operations, energy management, and environmental monitoring. Industry forecasts indicate sustained double-digit growth over the coming years, reflecting both public-sector investment priorities and growing demand for digital solutions that improve efficiency and sustainability. For projects such as COP-PILOT, this expanding market creates favorable conditions for technology adoption, commercialization, and long-term scalability, while also attracting continued investment from public funding programmes, private stakeholders, and infrastructure operators.

Beyond broad investments in smart cities, several sector-specific policies and regulations are creating new opportunities for digital solutions. In urban mobility, initiatives promoting sustainable transport and intelligent traffic management are encouraging cities to adopt advanced monitoring, analytics, and traffic optimization systems. In the maritime sector, the ongoing digitalization of ports, combined with stricter environmental and operational requirements, is increasing demand for solutions that support vessel tracking, berth management, and more efficient port operations. Similarly, energy-efficiency requirements for buildings are driving the uptake of smart building management systems that help optimize energy consumption and operational performance. At the same time, circular economy and waste-reduction objectives are encouraging the deployment of smart waste management solutions, particularly in campuses and urban environments where resource efficiency and sustainability have become key priorities. Collectively, these trends create a favorable regulatory and economic environment for the adoption and scaling of smart-city technologies.

Beyond regulatory requirements and public funding, organizations are increasingly investing in smart city technologies to improve operational efficiency and reduce costs. Public authorities, port operators, facility managers, and infrastructure providers face growing pressure to deliver better services while operating within constrained budgets. Digital solutions based on IoT, data analytics, artificial intelligence, and real-time monitoring enable more efficient use of resources, assets, and infrastructure. In transport and logistics environments, reducing traffic congestion, vessel turnaround times, and truck queuing can generate substantial economic benefits while improving service quality and environmental performance. Similarly, smart building management systems help reduce energy consumption and maintenance costs, while intelligent waste management solutions optimize collection routes and resource utilization. As a result, the business case for smart city technologies is increasingly driven not only by sustainability objectives but also by the need to achieve measurable operational and financial gains.

One of the main economic challenges for smart city adoption is the high upfront investment required for deploying digital infrastructure, IoT networks, smart sensors, connectivity platforms, and integrated urban systems. Many projects involve long return-on-investment (ROI) cycles, making them difficult to justify within short-term public budgeting frameworks. In addition to deployment costs, ongoing operating, maintenance, cybersecurity, and upgrade expenses increase the total cost of ownership over the full lifecycle of the solution. Furthermore, many of the key benefits of smart cities — such as improved public safety, reduced emissions, better quality of life, and environmental sustainability — generate strong social value but are often difficult to monetize or quantify financially in the short term.

4.3.2.3 Regulatory, legal and ethical

The European Union has established one of the world's most comprehensive regulatory frameworks for digital infrastructure, creating a predictable and trusted environment for smart city investments. Regulations such as the GDPR, AI Act, Data Act, NIS2 Directive, Energy Performance of Buildings Directive (EPBD), Intelligent Transport Systems (ITS) Directive, and Waste Framework Directive define clear requirements for data governance, cybersecurity, interoperability, building automation, transport data sharing, and environmental monitoring. While compliance introduces obligations, these regulations also create non-discretionary demand for digital solutions and provide public authorities and investors with a stable framework for procurement and deployment. For initiatives such as COP-PILOT, regulatory alignment becomes a competitive advantage, enabling solutions to scale more easily across European markets while addressing mandatory operational and reporting requirements.

European sustainability policies are increasingly translating climate ambitions into legally binding targets, creating sustained demand for smart city technologies. Through the European Climate Law [52], the European Green Deal [53], and related sector-specific regulations, Member States and local authorities are required to reduce emissions, improve energy efficiency, monitor environmental performance, and support the transition to climate-neutral economies. These obligations are driving investment in environmental monitoring, smart energy management, digital twins, intelligent mobility systems, and resource optimization platforms. For technology providers, sustainability mandates represent more than a policy trend; they create long-term procurement pipelines and recurring market opportunities, as cities and public organizations must continuously demonstrate progress toward regulatory and climate objectives.

Rapid urbanisation continues to increase pressure on transportation networks, energy systems, public services, and environmental resources, making smarter and more efficient urban management a necessity rather than a choice. As cities grow, authorities face increasing challenges related to traffic congestion, air pollution, energy consumption, waste management, and citizen well-being. Smart city technologies provide practical tools to address these challenges through data-driven decision-making, automation, and real-time monitoring. This creates sustained demand for solutions across mobility, energy, lighting, environmental monitoring, public safety, and digital government services, making urbanisation one of the most significant long-term drivers of smart city market growth globally.

The increasing deployment of connected sensors, digital platforms, and AI-driven services in smart cities raises important challenges related to data protection, governance, and ethical use of information. Applications such as traffic management, smart buildings, port operations, and waste management generate large volumes of data from diverse sources, some of which may contain personal or identifiable information. Ensuring compliance with data protection regulations, including GDPR, requires careful management of data collection, processing, storage, sharing, and retention practices. At the same time, the growing use of advanced analytics and artificial intelligence introduces additional concerns regarding transparency, accountability, fairness, and potential bias in automated decision-making processes. Establishing clear governance frameworks, promoting responsible data use, and maintaining citizen trust are therefore essential prerequisites for the successful adoption and long-term sustainability of smart city solutions.

Smart city ecosystems typically involve multiple stakeholders, including municipalities, transport authorities, port operators, utility providers, technology vendors, and facility managers, each operating under different cybersecurity policies, technical standards, and operational procedures. This diversity creates a complex security environment in which vulnerabilities, inconsistent security practices, or legacy systems within one organization can affect the resilience of the broader ecosystem. The challenge is particularly relevant for interconnected use cases such as intelligent transport systems, smart buildings, port monitoring platforms, and IoT-enabled waste management networks, where data and services must be exchanged across organizational boundaries. Emerging regulatory frameworks, such as the NIS2 Directive and the Cyber Resilience Act, further increase expectations regarding risk management, incident reporting, supply-chain security, and the protection of critical infrastructure. Ensuring a consistent and interoperable security posture across all participating stakeholders therefore remains a key challenge for the deployment and operation of large-scale smart city solutions.

The successful deployment of smart city technologies depends not only on technical performance but also on public trust and societal acceptance. Solutions based on sensors, connected devices, data analytics, and artificial intelligence can generate concerns regarding privacy, transparency, data ownership, and the potential for excessive monitoring of public spaces and daily activities. These concerns may arise even when systems are designed to comply fully with legal and regulatory requirements. For applications such as intelligent traffic management, smart buildings, port operations, and other digitally enabled public services, citizens and stakeholders increasingly expect clear information about what data is collected, how it is used, who has access to it, and what benefits are delivered in return. Failure to address these expectations can reduce user acceptance, limit participation, and create barriers to large-scale deployment. Building trust through transparency, stakeholder engagement, responsible governance, and demonstrable public value therefore remains a critical challenge for smart city initiatives.

4.3.3 Hourglass model

Figure 12 presents the hourglass model for Cluster 2, structured around the Valencia urban innovation ecosystem and its smart city use cases. As with Cluster 1, the left side identifies the stakeholder categories contributing to the cluster, while the right side maps the corresponding capability layers. At the upper levels, UBITECH and TATA, and UoP, feed into the HypO and OpenSlice service exposure portals, while Telefónica contributes directly to the Valencia Smart City Portal. The middle layers capture the diversity of Cluster 2's use cases, including air quality monitoring, flood monitoring, traffic and radar monitoring, smart building management, waste collection, maritime traffic monitoring, and berthing assistance — with contributions from Universitat Politècnica de València, Valenciaport, and the Smart City Notification Engine. At the platform level, IoT platform providers including Nespra and FIWARE components interface with Telefónica's Private 5G Slice Manager and SmartCity's platform layer. The orchestration core at the waist of the hourglass brings together HypO, OpenSlice, OpenZiti, and Kubernetes, underpinned by Proxmox-based compute infrastructure. At the base, physical and network infrastructure is provided by Telefónica's public NB-IoT network, private 5G networks, and sensor deployments from Nespra and Fivecomm, covering field-level air quality, smart buildings, 5G traffic and maritime radars, and flood sensors, with stakeholder anchors including the Ajuntament d'Almussafes, UPV, and Valenciaport.

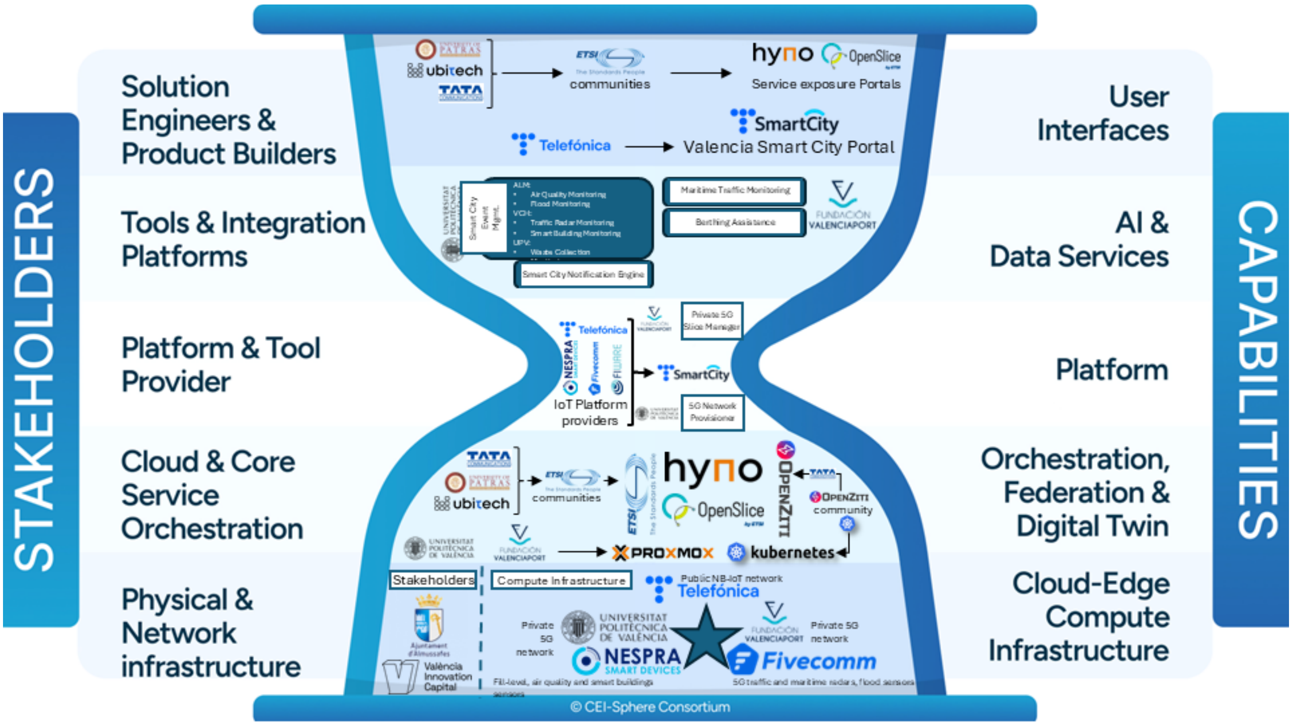

Figure 12: Hourglass model for Cluster 2

4.4 CLUSTER 3A

Cluster 3A, entitled ATSI — AgriTech Transformation and Sustainability Initiative, focuses on the integration of advanced digital agriculture services into a secure, interoperable and scalable edge-to-cloud infrastructure deployed across active spinach cultivation operations in the Kilkis region of Central Macedonia, Greece. The cluster addresses four complementary scenarios: precision agriculture and crop monitoring, AI-enabled AgriRobotics, secure data management and supply-chain traceability, and smart logistics and supply-chain optimisation. Together, these scenarios demonstrate how COP-PILOT can reduce operational fragmentation in contract farming networks, improve evidence-based crop management, and enable end-to-end digital traceability from field to consumer. The cluster is structured around a multidisciplinary team of seven partners whose contributions span field sensing, AI inference, autonomous robotics, farm management, blockchain, logistics, and private 5G connectivity. The operational testbed is provided by Barba Stathis, a market leader in the Greek food production and distribution sector specialising in frozen vegetables, plant-based meals and fresh salads, whose contract farming network in Kilkis constitutes the real-world environment in which all cluster scenarios are validated.

4.4.1 Market Overview

The European smart agriculture sector is experiencing sustained growth, driven by the convergence of digital technologies with the operational and regulatory pressures facing the agri-food industry. Industry forecasts consistently signal a strong growth trajectory for the European market: one estimate values the European smart agriculture market at EUR 5.2 billion in 2024 and projects it to reach EUR 11.4 billion by 2033, representing a compound annual growth rate of 9.05%; a parallel forecast covering a slightly earlier window projects growth from EUR 3.7 billion in 2022 to EUR 7.8 billion in 2027 at 16.09% CAGR [54]. While these figures reflect vendor and industry forecast sources rather than peer-reviewed estimates, the directional signal is consistent: the European market for integrated smart farming solutions is expanding rapidly and represents a commercially significant opportunity for the components demonstrated in Cluster 3A.

Precision agriculture is rapidly maturing from isolated pilot deployments into operational practice. The adoption of IoT sensors, UAV-based imagery, satellite data, and AI-driven advisory tools is accelerating across both large-scale and smallholder farming environments. Farm Management Information Systems are increasingly serving as operational hubs that aggregate these data streams and deliver evidence-based guidance to farmers and agronomists. This convergence of hardware sensing, edge processing and cloud-based analytics is creating demand for platforms that can orchestrate heterogeneous data streams across geographically distributed farm networks, precisely the integration gap that COP-PILOT addresses.

A particularly strong market driver is the regulatory and commercial pressure to reduce agrochemical inputs. The European Green Deal, adopted in 2019, established the overarching policy framework for the EU's transition to sustainable food systems. The Farm to Fork Strategy that followed set a specific target to reduce the use of and risk from chemical pesticides by 50% by 2030 [55]. Although the Commission's proposed Sustainable Use Regulation did not advance through the full legislative process, the policy direction it embodied remains firmly anchored in the Green Deal agenda and continues to shape national action plans under the existing Sustainable Use Directive. For contract farming networks and food processors operating in the EU market, this regulatory trajectory creates a direct and growing need for integrated digital farm management platforms that can support real-time advisory on treatment intensity, automate cultivation activity recording, and generate audit-ready evidence of sustainable practice. The ability to compute and report treatment frequency at farm and network level in real time is no longer a technical aspiration but a commercial and regulatory necessity for agri-food operators seeking to demonstrate sustainability credentials to retailers, certification bodies, and public procurement authorities.

Agricultural robotics represents a further growth area with significant market momentum [56]. Autonomous and semi-autonomous UAVs and UGVs are increasingly deployed for crop scouting, targeted plant protection, and precision inspection [57]. The combination of aerial and ground-based robotics for complementary sensing and actuation is emerging as a preferred operational model in precision horticulture [58], [59]. AI-driven pest and disease detection, coupled with robotic ground verification, addresses one of the most persistent inefficiencies in conventional crop protection: the lag between problem identification and targeted intervention [60], [61]. While regulatory constraints on full autonomy remain a factor in several member states, the market trajectory is clearly towards greater automation, and demand for validated robotic inspection platforms in operational agricultural environments is expanding [62], [56].

Supply-chain traceability is becoming both a competitive differentiator and, increasingly, a regulatory requirement [62], [63]. Consumer demand for verified provenance, retailer sustainability documentation requirements, and the EU's Digital Product Passport initiative under the Ecodesign for Sustainable Products Regulation are driving agri-food producers towards the systematic digitalisation of cultivation records and chain-of-custody data [64], [65]. Blockchain-based traceability solutions are gaining traction as the preferred mechanism for creating tamper-evident, auditable lot histories in fresh produce supply chains, where short shelf lives and complex multi-party logistics make rapid, verifiable traceability both a food safety necessity and a commercial asset [66], [67].

Private 5G and edge connectivity for agriculture is an emerging but fast-growing segment [68]. The deployment of private mobile networks in rural and semi-rural environments enables reliable, low-latency connectivity for UAV telemetry, UGV coordination, and continuous IoT sensor streaming in conditions where public broadband infrastructure is insufficient [69], [70]. Network operators are increasingly targeting precision agriculture as a primary use case for private 5G deployments, supported by the European Commission's agricultural connectivity objectives under the Digital Decade policy programme and the Common Agricultural Policy's digital transition priorities [62], [71].

The Kilkis deployment in Cluster 3A, combining an OTE private 5G Mobile Private Network with public 5G as a resilience failsafe, provides a validated reference architecture for this emerging connectivity market [72], [73]. The digitisation of agri-food logistics is advancing in parallel, with growing market interest in closed-loop, data-driven harvest scheduling and fleet coordination platforms that integrate crop readiness signals from field management systems with dispatch and routing tools serving contract farming networks [72], [63].

The Competitive landscape of Cluster 3A Outputs/Solutions

The competitive landscape for digital precision agriculture is shaped by a combination of large global agri-tech platforms, specialised vertical solution providers, open-source communities, and emerging start-ups [74]. The overall market is characterised by significant fragmentation, and the absence of integrated, orchestrated solutions that span field sensing, AI crop management, blockchain traceability and logistics coordination represents a structural gap that Cluster 3A directly addresses. Global agri-tech platforms from major equipment and seed companies (including John Deere Operations Centre, Trimble Agriculture, the Climate Corporation, and Bayer's digital farming portfolio etc.) offer broad farm management functionality encompassing mapping, yield monitoring, agronomic advisory and input management. These platforms are mature and widely adopted in large-scale arable farming but are primarily designed for mechanised row-crop environments and large farm units. Their applicability to smallholder contract farming networks in Southern European horticultural contexts is limited, and their integration with third-party AI robotics, blockchain traceability and logistics platforms is constrained by proprietary data architectures.

Specialised providers in adjacent domains occupy distinct market segments without connecting them [75]. In agricultural robotics, companies such as Naïo Technologies, Small Robot Company and SwarmFarm are developing ground-based robotic platforms for precision horticulture, but these typically operate as standalone products rather than as components in an orchestrated multi-domain system [59]. In blockchain-based traceability, platforms such as IBM Food Trust and TE-FOOD are commercially active but are rarely integrated with real-time field sensing or AI crop management. In agricultural logistics, fleet management tools for farm equipment exist in the market but their integration with crop readiness data from FMIS platforms is limited. This fragmentation across domains is the central competitive gap that the ATSI cluster addresses.

Open-source and standards-based communities provide relevant infrastructure context [76]. FIWARE and its NGSI-LD context management standard have been adopted by a range of smart agri-food initiatives across Europe. The Hyperledger Fabric permissioned blockchain framework, hosted under the Linux Foundation Decentralized Trust, is an established open-source basis for supply-chain traceability. However, as the ATSI cluster directly demonstrates, combining these components into a working operational system that spans field IoT, AI inference, blockchain and logistics requires substantial integration engineering, the gap that COP-PILOT's orchestration platform is specifically designed to address. Within this landscape, the cluster is positioned not as a direct competitor to any single vertical application but as a demonstration and enabling layer for secure, interoperable, multi-domain precision agriculture.

Cluster 3A Target Groups

To optimise the positioning of the AgriTech Transformation and Sustainability Initiative (ATSI) within the COP-PILOT platform ecosystem, the following strategic layout categorizes and breaks down the core stakeholders. The primary market participants and technological adopters benefiting from these orchestrated solutions are organized into five distinct pillars:

a. Agri-Food Processors and Distributors
b. Farmers and Farming Cooperatives
c. Agricultural Advisory Services, Agronomists, and Consultants
d. Retailers, Certification Bodies, and Food Service Companies
e. Agri-Tech Developers and Technology Providers

a) Agri-Food Processors and Distributors

The primary target group for ATSI cluster solutions is agri-food processors and distributors operating contract farming models, particularly in the fresh and processed vegetable sector. Organisations that coordinate cultivation across networks of independent farmers and operate centralised processing facilities face exactly the fragmentation challenges the cluster addresses: the need for live visibility of network-wide cultivation status, evidence-based crop protection advisory, digital traceability from field to gate, and optimised logistics coordination for owned harvester fleets. The market for integrated digital management platforms serving this model is underserved relative to the scale of the operational need.

b) Farmers and Farming Cooperatives

Farmers and farming cooperatives, particularly those participating in contract farming or sustainability certification schemes, represent a second important target group. The obligation to demonstrate compliance with sustainable use targets, organic certification requirements or retailer sustainability standards creates growing demand for FMIS platforms that automate footprint computation and generate audit-ready activity records. In Greece and across the Mediterranean, where smallholder horticultural farming is widespread and cooperative structures are common, the addressable market for accessible, integrated digital farm management tools is substantial.

c) Agricultural Advisory Services, Agronomists, and Consultants

Agricultural advisory services, agronomists, and crop protection consultants form a third target group. Real-time sensing data, AI-driven pest detection alerts, and aggregated crop status dashboards enhance the quality and efficiency of advisory services and enable agronomists to serve larger farm networks without proportional increases in physical scouting effort.

d) Retailers, Certification Bodies, and Food Service Companies

Retailers, certification bodies and food service companies represent a further commercial audience: the ability to provide verifiable, blockchain-attested supply-chain documentation at lot level directly supports the traceability, sustainability and provenance claims that premium retail and certification channels increasingly require.

e) Agri-Tech Developers and Technology Providers

Finally, agri-tech developers and technology providers are a strategic target group for the platform layer, since the open, validated, standards-based integration infrastructure of COP-PILOT reduces the cost of entry for specialised solution providers developing domain-specific agricultural applications.

4.4.2 Opportunities and challenges

Cluster 3A addresses a clear and growing market need in the agri-food sector: enabling contract farming networks to move from fragmented, manual operational practices to integrated, data-driven management of crop production, supply-chain traceability, and logistics coordination. The main opportunity lies in demonstrating how IoT sensing, AI-enabled robotics, farm management software, blockchain, and private 5G connectivity can be combined into a single orchestrated platform that reduces operational fragmentation, supports regulatory compliance, and extends verified traceability from the field to the final consumer while reducing the environmental footprint of primary production.

A key cross-cutting challenge across these environments is limited system observability, where incomplete or delayed data reduces visibility into real-time crop conditions, field operations, and logistics status across distributed farm networks. This is reinforced by restricted data access from proprietary platforms and vendor-specific systems, which limits interoperability and increases integration complexity.

Cluster 3A operates in a sector characterised by digital heterogeneity, significant hardware and integration complexity, conservative adoption culture among smallholder farmers, and an evolving regulatory framework for autonomous agricultural technology. Realising the market opportunity requires addressing both the technical integration challenges but also the economic, organisational, regulatory conditions and stakeholders perception, that altogether govern adoption at scale.

4.4.2.1 Technology and infrastructure

The primary technological opportunity for Cluster 3A is the demonstration of a working, validated architecture that integrates field-level sensing, AI inference, autonomous robotics, digital farm management, blockchain traceability, and logistics coordination across a geographically distributed operational environment. The UAV-to-AI-to-UGV detection and verification pipeline, combined with real-time activity recording in AgroApps 360 and blockchain-attested chain-of-custody records, creates an end-to-end digital thread from crop phenology to supply-chain handover. This architecture addresses a structural gap in the current agri-tech market, where powerful vertical tools exist in isolation and the integration infrastructure needed to connect them is absent. The Kilkis deployment provides a validated reference model for this integrated approach that is directly replicable across other contract farming environments in Southern Europe and beyond.

The deployment of TOR plant wearable sensors for continuous antinutrient monitoring represents a particularly novel technological contribution. Inline sensing of antinutrient proxies at canopy level, feeding structured data streams into a shared FMIS platform, is a capability that sits at the frontier of precision crop quality management and has clear commercial relevance for food processors and retailers operating in premium or health-focused market segments. Combined with the AI pest detection and UGV inspection capabilities, this gives the ATSI cluster a multi-layered, complementary sensing architecture that goes considerably beyond single-parameter precision agricu re deployments.

The technical challenges are substantial, and several are directly encountered in the Kilkis deployment. Hyperledger Fabric, the blockchain framework selected for supply-chain traceability, and FIWARE NGSI-LD, the COP-PILOT standard for cross-domain IoT data federation, operate as decoupled data planes in the Cluster 3A architecture. Rather than attempting a direct integration between the two, the PowerFleet logistics platform acts as the authorised bridge actor: it ingests FMIS harvest events from Orion-LD and writes the corresponding traceability records to the Fabric channel. This pattern avoids the structural tension common to permissioned-blockchain + IoT-context-broker integrations and keeps each data plane optimised for its own purpose — context distribution for FIWARE, immutable provenance for Fabric.

Regulatory constraints on autonomous agricultural robotics currently limit the UGV to a two-scenario operational model, requiring a mandatory confirmation step before advisory actions are issued following independent inspections. This is a market-wide constraint rather than a project-specific limitation, and the regulatory trajectory is towards greater autonomy as safety frameworks mature. The current design nevertheless provides a validated operational model that functions within existing legal boundaries while preserving the technical readiness to scale towards higher automation levels as regulations evolve. Connectivity remains a further infrastructure consideration: the semi-rural environment of the Kilkis testbed requires the private 5G MPN as the primary connectivity layer, with public 5G as a failsafe, and the replication of this architecture to other farming environments will depend on the pace of rural 5G infrastructure rollout across target markets. Finally, scaling from pilot to a full contract farming network deployment introduces integration complexity, data volume, and multi-tenancy requirements that the current pilot phase is designed to fully resolve.

An additional challenge arises from coordinating processes operating at different temporal scales, ranging from real-time sensing and intervention to crop development cycles and logistics planning activities. Synchronising these heterogeneous data flows and decision layers adds complexity to system design and operation.

4.4.2.2 Economic

The economic opportunity for ATSI cluster solutions is grounded in concrete value pools that are directly relevant to its primary stakeholders. For agri-food processors operating contract farming networks, the platform creates value through multiple complementary mechanisms: reduced crop protection costs through evidence-based, timely intervention rather than calendar-based or precautionary treatment; labour efficiency gains for agronomists whose field visit burden is substantially reduced by automated UAV and AI detection; optimised harvester fleet dispatch and routing, reducing idle vehicle time and improving processing facility throughput predictability; and systematic digital recording of cultivation activities, which reduces the administrative burden of compliance documentation across the network. The market access and premium pricing opportunity is equally significant. Blockchain-attested, consumer-accessible traceability records directly support the sustainability and provenance claims that premium retail channels, organic certification schemes, and public food procurement authorities increasingly require as conditions of market entry. For a processor such as Barba Stathis, the ability to provide verified, product-level documentation of cultivation practices to downstream buyers and ultimately to consumers represents a meaningful competitive differentiator in a market where food transparency is a growing purchasing criterion. The EU Digital Product Passport initiative, which is expected to extend to food products over time, will further expand the commercial value of the digital lot record that the ATSI blockchain traceability component generates.

Common Agricultural Policy funding provides a further economic dimension. CAP Strategic Plans across EU member states increasingly link agri-environment payments and eco-scheme eligibility to the use of digital farm management tools and the ability to document sustainable practice through electronic records. Farmers and farming networks that have invested in integrated FMIS platforms are better positioned to access these payments, creating a direct financial incentive for digital adoption that runs alongside the operational efficiency case. For AgroApps, this policy linkage creates a structural demand pull in the market that is independent of the purely agronomic value proposition.

The economic challenges should not be underestimated; smallholder farming networks present a structurally difficult commercialisation environment. Individual farms in the Kilkis network operate at scales where upfront sensor hardware, connectivity infrastructure, and integration costs are not easily recovered without the aggregating economic logic of the contract farming operator. This means the primary commercial model for ATSI solutions is likely to be business-to-business, with the processing company or cooperative as the procuring entity, rather than direct-to-farmer. Business model design must therefore reflect this organisational reality, with per-farm costs aggregated at the network level and value realisation expressed in terms of network-wide operational efficiency, compliance, and market access rather than farm-level ROI alone. In addition, value realisation from some components, particularly the consumer-facing traceability extension and the flexibility market participation enabled by digital records, is contingent on complementary market developments and retailer adoption of digital product documentation that are not fully in place across all target markets.

In addition, value capture is unevenly distributed across actors, creating a challenge in aligning incentives for adoption. While processors and downstream stakeholders benefit from improved coordination and traceability, the costs of data generation and system deployment are often borne at farm level, requiring business models that clearly articulate and distribute value across the network.

4.4.2.3 Regulatory, legal and ethical

From a regulatory perspective, the most significant enabling condition for Cluster 3A's broader market impact is the continued development of EU policy frameworks that reward (e.g. Paying Environmental schemes) and eventually require digital documentation of sustainable farming practice. The European Green Deal and Farm to Fork Strategy provide the overarching regulatory direction, and the CAP digitalisation agenda creates institutional demand for FMIS integration and electronic record-keeping. As member states progressively tighten their national pesticide reduction targets and link agri-environment payments to documented compliance, the market for platforms that automate treatment frequency tracking and generate audit-ready cultivation records will expand. The ATSI deployment provides a validated operational model that is directly aligned with this regulatory trajectory.

The ATSI solution as a whole, addresses data governance requirements through design rather than retrospective compliance. AgroApps 360 is built on privacy-by-design principles: cultivation records, parcel location data, and activity logs are processed under clearly defined data processing agreements that establish the respective roles of the farmer, the contract farming operator, and the platform provider in line with GDPR obligations. Farmers retain ownership of their farm-level data, and access rights are structured so that aggregated network-level insights are available to Barba Stathis agronomists while individual farm records remain under farmer-controlled permissions. The EU Data Act (Regulation 2023/2854), which governs access to data generated by IoT-connected products and services, is directly relevant to the sensor and robotics components of the cluster. The ATSI architecture ensures that machine-generated data from UAV flights, UGV inspections, and field IoT sensors is handled within the data sharing and portability framework the Data Act establishes, giving farmers the right to access and share data generated on their own parcels. This positions the platform as a compliant and trustworthy data infrastructure for contract farming environments across the EU.

Lastly, human oversight is a foundational operational principle of the AI-assisted and autonomous components of the ATSI cluster. The UGV operates under a mandatory confirmation requirement: whether triggered by a UAV detection or conducting an independent field inspection, recommendations are issued only after a human agronomist reviews and confirms the finding. AI pest-detection alerts generated by AUA's inference infrastructure are delivered to AgroApps 360 as inputs to the agronomist's decision-making process, not as automated directives. This human-in-the-loop architecture ensures that precision sensing and AI inference enhance rather than replace agronomic judgement. It also directly aligns with the principles of the EU AI Act for advisory systems operating in economically significant contexts, and with the current regulatory framework for autonomous agricultural robotics. The design choice is therefore simultaneously an operational safeguard, a regulatory compliance posture, and a foundation of farmer trust.

4.4.3 Hourglass model

Figure 13 presents the hourglass model for Cluster 3A, which focuses on the AgriTech Transformation and Sustainability Initiative (ATSI) and its precision agriculture use cases centred on the Barba Stathis contract farming network in the Kilkis region. At the upper user interface level, UBITECH and TATA feed into the HypO and OpenSlice service exposure portals, while iLINK contributes the PowerFleet Logistics and Fleet Management interface, and AgroApps provides both a consumer-facing interface and the AgroApps360 Farm Management Information System. The AI and Data Services layer captures the cluster's rich set of agronomic intelligence capabilities, including crop monitoring, fertilisation and irrigation management, environmental footprint calculation, pest and disease AI forecasting, logistics environmental footprint tracking, just-in-time logistics optimisation, and AI-based weed detection. At the platform level, AgroApps and iLINK interface with the FIWARE community's Orion IoT Platform and a Hyperledger Fabric blockchain platform, enabling both operational data management and end-to-end supply chain traceability. The orchestration core at the waist brings together HypO, OpenSlice, OpenZiti, and Kubernetes on Proxmox compute infrastructure, with UBITECH, TATA, iLINK, and AgroApps contributing at this layer. At the base, the physical and network infrastructure layer encompasses private 5G connectivity, drones, weather stations, detection and spraying robots, IoT-coupled logistics trucks and harvesters, and plant wearable sensors, collectively providing the field-level data acquisition foundation that feeds the entire cluster stack.

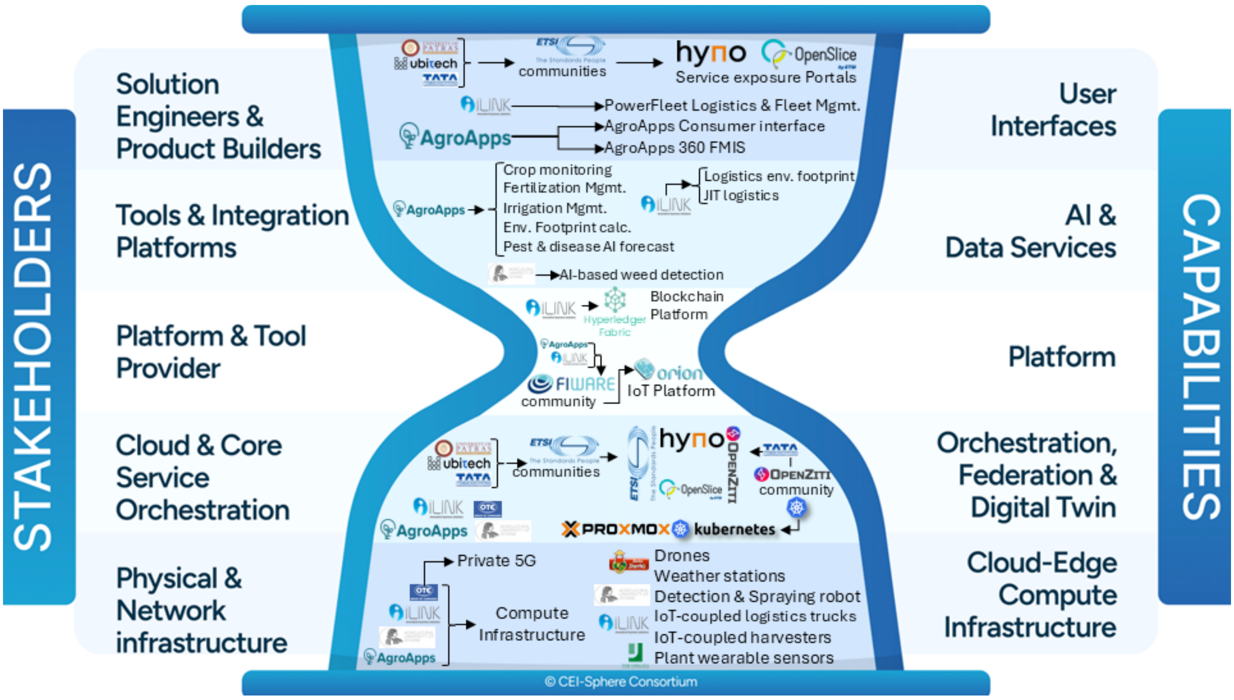

Figure 13: Hourglass model for Cluster 3A

4.5 CLUSTER 3E

Cluster 3E focuses on the integration of advanced digital energy services into secure, interoperable and scalable edge-to-cloud infrastructures deployed across active electricity distribution networks in Western Greece. It addresses three complementary use cases: UC3E.1 grid flexibility management through distributed energy resources (DERs), UC3E.2 predictive maintenance and demand forecasting for highway electric vehicle (EV) charging infrastructure, and UC3E.3 real-time monitoring and anaerobic digestion forecasting for a biogas plant.

Together, these scenarios demonstrate how COP-PILOT can reduce the operational silos between energy domains, improve cross-domain interoperability, and enable more resilient, data-driven management of decentralised energy systems with high renewable penetration.

4.5.1 Market Overview

4.5.1.1 Market Trends

The global energy sector is undergoing a fundamental structural transformation driven by the large-scale integration of renewable energy sources, the electrification of transport and heating, and the growing imperative to operate distribution grids more flexibly, efficiently and safely. Several converging trends define the current market environment and directly shape the relevance and opportunity for Cluster 3E solutions.

The accelerating deployment of distributed energy resources is perhaps the most defining trend. Photovoltaic installations, wind turbines, biogas generation units, battery storage systems and EV charging infrastructure are being added to distribution networks at a pace that was not anticipated in the original design of those grids. This creates new operational challenges: grid congestion, overvoltage events, thermal limit violations and highly stochastic supply variations that are difficult to manage with the centralised, manual tools that most distribution system operators (DSOs) currently rely on. The need for smarter, real-time grid management is therefore not a future aspiration but a present operational necessity in regions with high DER penetration, such as Western Greece.

A closely related trend is the shift from passive to active distribution networks. Historically, power flowed in one direction — from large central generation plants down to consumers. The proliferation of DERs has reversed this logic, requiring distribution networks to manage two-way power flows, coordinate flexible loads, and integrate generation assets that are geographically dispersed and individually unpredictable. This transition is creating strong demand for advanced distribution management systems (ADMS), real-time monitoring, and flexibility harvesting platforms that can aggregate and coordinate distributed assets in support of grid stability.

The electrification of transport is generating a particularly significant wave of demand-side complexity. The rapid growth of EV charging infrastructure introduces new, high-power loads that are both geographically distributed and highly variable in their usage patterns. For grid operators, uncoordinated EV charging can create local congestion and voltage problems, while coordinated smart charging represents an opportunity for demand-side flexibility. For infrastructure operators, the ability to forecast charging demand, detect equipment anomalies early, and plan maintenance proactively is becoming a critical operational capability. These requirements are driving growing interest in IoT-enabled EV monitoring, edge analytics, and predictive maintenance solutions specifically designed for highway and public charging networks.

In parallel, the role of biogas and biomethane production in the energy transition is expanding. Biogas plants represent a form of dispatchable renewable generation — unlike solar or wind, they can in principle be scheduled to produce when the grid needs it. However, realising this flexibility potential requires accurate real-time monitoring of the anaerobic digestion process, forecasting of production capacity, and integration with grid management systems. Today, most biogas plants operate largely in isolation from the grid coordination layer, creating inefficiencies and missed opportunities for grid services. The wider adoption of IoT sensing, edge-based analytics, and interoperable data exchange could unlock significant value in this domain.

Across all these DER domains, a critical and underserved trend is the demand for real-time visibility and structured data exchange between asset owners and grid operators. DSOs today have very limited insight into the operational state, availability and flexibility potential of the DERs connected to their networks. The data that would enable smarter grid decisions — current generation, predicted output, available flexibility, equipment health — is either locked inside proprietary systems, not flowing through standardised interfaces, or simply not being collected at all. This information gap is a major barrier to efficient grid operation, and addressing it requires both technical solutions for secure cross-domain data exchange and the development of operational processes and market mechanisms to act on that data.

The Internet of Things and edge computing are increasingly recognised as enabling technologies for this transformation. Moving data processing closer to the source reduces latency, limits bandwidth requirements, and enables faster automated responses — all of which are essential in time-critical grid management scenarios. Edge intelligence is becoming particularly relevant for applications such as real-time health monitoring of EV chargers, anaerobic digestion process control at biogas plants, and sub-second control decisions that cannot tolerate the round-trip delays of cloud-only architectures. The market for edge AI hardware and software in the energy sector is growing rapidly, with demand concentrated in applications that combine high data frequency, tight latency requirements and the need for local resilience.

Interoperability and open standards are emerging as strategic priorities as the complexity of the DER ecosystem increases. Energy systems today are characterised by fragmentation: proprietary communication protocols, closed vendor ecosystems, incompatible data formats and siloed operational domains. Standards such as IEC 61850 for substation communication, OCPP for EV charging, DLMS/COSEM for smart metering, and FIWARE NGSI-LD for context data management represent the industry's gradual convergence towards more open and interoperable architectures. However, as the Cluster 3E experience directly confirms, the existence of a standard on paper does not guarantee its operational adoption. The gap between nominal standardisation and actual interoperability in deployed systems remains large, and bridging it requires significant integration effort alongside the standards themselves.

Finally, the regulatory environment is evolving in ways that are expected to accelerate market adoption. The European Commission's energy digitalisation agenda, the Clean Energy Package, the Electricity Market Directive, and emerging regulations around flexibility markets and demand response are creating pressure on TSOs and DSOs to open their interfaces, adopt digital operational models, and develop structured mechanisms for procuring flexibility from distributed assets. While the pace of regulatory change is uneven across member states, the direction is clear: the energy system of the future will depend on real-time data exchange, automated coordination and interoperable digital infrastructure. Cluster 3E is directly aligned with this regulatory trajectory.

4.5.1.2 Competitive Landscape

The competitive landscape for digital energy management solutions is shaped by a diverse mix of large industrial technology providers, specialised IoT and analytics vendors, open-source platform communities, and emerging start-ups. Each segment occupies a different part of the value chain, and the overall landscape is characterised by both significant fragmentation and increasing convergence pressure driven by the interoperability demands described above.

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Large established players in the energy technology sector — including major grid equipment manufacturers, SCADA system providers, and automation vendors — typically offer mature, vertically integrated solutions for grid monitoring, ADMS, and substation automation. These solutions are often reliable and proven at utility scale, but they tend to be built around proprietary architectures that work best within a single-vendor ecosystem. They are generally designed for transmission and high-voltage distribution contexts, and their applicability to the low-voltage, DER-rich distribution edge is more limited. Their offerings can also be costly and complex to deploy in the heterogeneous, resource-constrained environments that characterise many real-world DER deployments.

In the EV charging domain, the market is dominated by a growing number of charging network operators and hardware manufacturers, most of whom offer their own proprietary management platforms. These platforms provide useful functionality within their own ecosystem but present significant integration barriers when operators or grid managers need to aggregate data across multiple charging networks or share operational signals with grid management systems. The commercial EV chargers used in the Cluster 3E deployment are a direct illustration of this problem: they do not provide open API access to their full data pool, requiring workarounds such as externally installed inductive sensors to capture current and voltage measurements. This limitation is common across the industry and represents a clear market gap for open, interoperable monitoring and analytics solutions.

The biogas sector has its own set of technology providers, including plant control system vendors, process analytics companies, and agricultural technology suppliers. Predictive analytics and AI-based forecasting for anaerobic digestion are a relatively nascent segment, with most existing solutions either custom-built for individual plants or offered as part of broader process control packages that are not designed for integration with energy management and grid flexibility systems. The combination of real-time IoT sensing, edge-based ML forecasting, and structured data exchange with grid operators that Cluster 3E demonstrates is genuinely novel in this space.

Open-source platforms and community-driven initiatives are playing an increasingly important role in the competitive landscape. FIWARE and its NGSI-LD Context Broker represent a widely adopted open standard for context data management in smart city and energy applications, providing a vendor-neutral integration layer that reduces dependence on proprietary APIs. LF Energy and its suite of open-source energy tools, including the RTDIP real-time data ingestion framework, are building a commons of reusable infrastructure for energy data management. These communities provide a strong foundation for interoperable solutions but do not in themselves resolve the deployment complexity, operational integration work, and domain-specific application development that real-world energy deployments require.

Within this landscape, COP-PILOT and Cluster 3E are positioned not as competitors to any specific vertical application or grid management platform, but as a demonstration and enabling layer for secure, interoperable, cross-domain energy data exchange and edge intelligence. The cluster addresses a clear gap between the specialised domain applications that exist — biogas process analytics, EV fleet management, ADMS — and the shared digital infrastructure needed to connect them and make their data useful to the grid operator. This positioning is differentiated from both the large proprietary vendors, who prioritise integration within their own stack, and from the open-source communities, which provide standards and tools but not deployed, validated solutions.

4.5.1.3 Target Groups

The primary target group for Cluster 3E solutions is distribution system operators (DSOs) and electricity aggregators, particularly those operating in regions with high penetration of distributed energy resources. These organisations face growing operational complexity as DERs expand and are actively seeking tools that provide better real-time visibility, structured flexibility data, and automated coordination capabilities across their networks. The solutions demonstrated in Cluster 3E — including the ADMS integration, DER flexibility harvesting, and cross-domain data exchange architecture — directly address the operational needs of this group.

A second important target group is DER asset owners and operators, including biogas plant operators and EV charging infrastructure providers. These actors stand to benefit from improved operational efficiency, predictive maintenance, and the ability to participate in grid flexibility markets. For biogas operators, edge-based monitoring and forecasting of the anaerobic digestion process can improve production reliability and enable more active participation in energy market services. For EV charging operators, predictive maintenance and demand forecasting reduce downtime and support more efficient network planning. Both groups also have a potential commercial interest in monetising their flexibility through grid services, once the market mechanisms and data interfaces to support this are in place.

Technology providers and application developers, including SMEs and specialised analytics companies, represent a third target group. These actors can leverage the COP-PILOT open infrastructure — the FIWARE-based data platform, the Secure Integration Fabric, the edge compute environment, and the available sensor data streams — to develop and validate domain-specific applications without needing to build and deploy the underlying integration architecture themselves. The open call structure of COP-PILOT is directly designed to engage this group.

Finally, policymakers, regulators and standardisation bodies represent an indirect but important audience. Cluster 3E generates concrete evidence about the technical feasibility, operational requirements, and regulatory preconditions for cross-domain energy data exchange and distributed flexibility management. This evidence is directly relevant to ongoing EU policy processes around energy system digitalisation, flexibility markets, and the operationalisation of open interfaces for TSOs and DSOs.

4.5.2 Opportunities and challenges

Cluster 3E addresses a clear and growing market need in the energy sector: enabling the real-time, secure exchange of operational data across distributed energy domains — biogas generation, EV charging, and grid management — to support smarter, more flexible and more resilient distribution grid operation. The main opportunity lies in demonstrating how IoT-enabled sensing, edge intelligence and interoperable data exchange can bridge the silos between DER asset owners and grid operators, and in doing so reduce inefficiencies, improve safety, and unlock new flexibility services that the grid urgently needs as renewable penetration increases.

A common challenge across use cases is limited system observability, where fragmented and incomplete data reduces real-time visibility into operational conditions across distributed assets. This is compounded by restricted access to operational data from proprietary platforms and infrastructure components, requiring workarounds such as additional sensing or intermediate data processing layers. The need to coordinate multiple independent stakeholders with different systems, roles, and operational priorities further increases system complexity and constrains integration. In addition, the maturity of flexibility markets and the availability of operational interfaces for integrating distributed energy resources remain limited, restricting the immediate exploitation of data-driven coordination capabilities.

At the same time, Cluster 3E operates in a sector characterised by conservative adoption culture, proprietary ecosystems, regulatory lag, and critical infrastructure constraints. Realising the market opportunity will require overcoming not only technical barriers but also organisational, commercial and regulatory ones.

Co-funded by the European Union

4.5.2.1 Technology and infrastructure

The main technological opportunity for Cluster 3E is to demonstrate a working, validated architecture for secure cross-domain energy data exchange, built on open standards and capable of supporting real-time grid management decisions. In UC3E.1, the integration of simulated DERs, a private cloud infrastructure, and an advanced distribution management system creates a validated environment for testing grid flexibility algorithms and demonstrating the value of structured DER data to grid operators. In UC3E.2, the combination of IoT sensing, NVIDIA Jetson-based edge analytics, OCPP-compliant communication, and power consumption forecasting creates a path towards more intelligent, proactive management of highway EV charging infrastructure. In UC3E.3, the deployment of gas analyser and pH sensor data streams through a FIWARE-based edge processing pipeline, coupled with ML-based forecasting of the anaerobic digestion process, demonstrates how biogas plant operators can move from reactive to predictive operational models while contributing structured data to the grid coordination layer.

The technical challenges are substantial and directly confirmed by the Cluster 3E deployment experience. Commercial EV chargers represent closed systems that do not expose full data access through open APIs, requiring workaround sensor installations that provide useful but incomplete data. Protocol fragmentation between energy domains — different communication standards for EV chargers, smart meters, substations, and IoT sensors — requires significant adaptation work even where nominal standards exist. The synchronisation of data streams with different formats, frequencies and latency characteristics adds further complexity. At the infrastructure level, the deployment of private 5G connectivity and edge compute devices in operational energy environments introduces configuration, maintenance and cybersecurity requirements that raise the integration bar considerably. The architecture must also support a range of workload profiles — sub-second edge control decisions, near-real-time analytics, and longer-horizon ML-based forecasting — without assuming a uniform deployment model across all domains.

4.5.2.2 Economic

Cluster 3E targets value pools that are directly relevant to its primary stakeholders. For DSOs and aggregators, the economic case centres on improved grid visibility and the ability to act on structured flexibility signals from DERs, reducing the cost of grid management and enabling more efficient use of existing network capacity. The alternative — continued reliance on manual processes, limited real-time data, and reactive rather than predictive operational models — carries increasing cost as DER penetration grows and grid complexity increases. The Cluster 3E documentation directly references the current state of play: DSO curtailments of DERs have historically been managed by personnel physically driving to sites, and the digital infrastructure to act on richer real-time signals simply has not been built out in many distribution network contexts.

For biogas plant operators, the economic case includes improved production reliability through early anomaly detection and process forecasting, reduced environmental costs from avoided methane releases during grid curtailment events, and the potential to participate in grid flexibility markets as dispatchable generation assets. For EV charging operators, predictive maintenance reduces unplanned downtime and associated service disruption costs, while demand forecasting enables more efficient capacity planning and energy procurement.

The economic opportunity also extends to the broader ecosystem of technology providers and application developers who can build on the Cluster 3E infrastructure. By providing open, validated, and standards-based integration infrastructure, the platform reduces the cost of entry for specialised solution providers who would otherwise need to build bespoke integration stacks for each customer deployment.

However, the economic challenges are real. The energy sector is characterised by long procurement cycles, high requirements for reliability and validation, and significant caution about introducing new digital systems into critical infrastructure. The business case for DER owners to open their data and participate in grid services depends on clear commercial incentives that are not yet fully established in most European markets. Flexible capacity markets at the distribution level are still nascent in most member states, and the revenue streams that could reward DER owners for providing grid services are either absent or insufficiently developed to drive commercial adoption without project support. This means that the economic opportunity demonstrated by Cluster 3E is real but contingent on complementary developments in market design and regulatory frameworks.

In addition, significant upfront investment in sensing infrastructure, connectivity, and system integration can act as a barrier to adoption across all use cases. The deployment of IoT sensors, edge computing devices, and communication infrastructure requires not only capital expenditure but also substantial installation, configuration, and maintenance effort. In practice, fragmented system environments and proprietary technologies further increase integration costs, as additional sensing or custom interfaces may be required to access operational data. In distributed energy contexts, such as low-voltage grids and biogas facilities, these investments are often difficult to justify upfront due to uncertainty in return and the absence of mature market mechanisms to monetise system flexibility. As a result, even where the technical and operational benefits of digitalisation are clear, the initial cost and integration burden can slow adoption across stakeholders, particularly for smaller asset owners and operators.

4.5.2.3 Regulatory, legal and ethical

From a regulatory perspective, the most important enabling condition for Cluster 3E's market impact is the development of standardised mechanisms for DSOs to procure and act on flexibility from distributed assets at the distribution level. Currently, most European DSOs lack both the digital interfaces and the market frameworks to systematically integrate DER flexibility into their operational processes. The data that Cluster 3E demonstrates can be collected, processed and shared — real-time generation data from a biogas plant, power consumption forecasts from EV charging stations, aggregated DER flexibility signals — has limited operational value if the receiving party has no structured way to act on it. Regulatory mandates requiring TSOs and DSOs to open their interfaces, adopt digital operational models, and develop flexibility procurement mechanisms would directly accelerate the transition from pilot demonstrations to operational deployment.

Data governance and cybersecurity are central to adoption in this domain. Energy infrastructure is classified as critical infrastructure in most jurisdictions, and operators apply strict controls over system access, data flows and connectivity. Any deployable solution must support secure authentication, encrypted communications, controlled service exposure, auditability and deployment models compatible with operational technology environments. The Cluster 3E architecture addresses these requirements through the Secure Integration Fabric and the FIWARE-based data domain separation, which ensures that cross-domain data exchange is limited to the specific signals that each party actually needs, rather than exposing full data pools across domain boundaries. This design principle — right data, right level — is directly relevant to the regulatory and security requirements of energy system operators.

The project's legal framework includes obligations consistent with the broader COP-PILOT grant structure: GDPR compliance, privacy-by-design principles, data protection impact assessments where relevant, and alignment with the Data Act, Data Governance Act, Cyber Resilience Act and AI Act. For Cluster 3E, these obligations are most directly relevant in the context of smart metering data, personnel-related data from EV charging usage patterns, and AI-supported decision-making in grid management contexts. The explainability and auditability of AI-based forecasting and anomaly detection models are particularly important where their outputs inform operational decisions in critical infrastructure.

Commercially, the mixed ecosystem of open-source platform components, proprietary application layers and partner-specific data streams requires clear agreements on data ownership, access rights, licensing and the boundary between shared infrastructure and commercial offerings. Cluster 3E combines open standards and communities — FIWARE, LF Energy, OCPP, IEC 61850 — with proprietary analytics developed by consortium partners, and this combination must be managed carefully to ensure that the openness of the platform does not inadvertently undermine the commercial interests of the application providers who build on top of it.

4.5.3 Hourglass model

Figure 14 presents the hourglass model for Cluster 3E, which focuses on energy management and sustainability use cases spanning biogas production and EV charging infrastructure in Western Greece. At the upper user interface level, UBITECH and TATA feed into the HypO and OpenSlice service exposure portals, while ENAKRONIK contributes dedicated monitoring interfaces for biogas plant operations and EV charger fleet management. The University of Patras provides the Advanced Distribution Management System (ADMS) as a key tool at the integration platform level. The AI and Data Services layer captures the cluster's energy intelligence capabilities, including biogas plant predictive maintenance, forecasting of anaerobic digestion processes, EV charger demand forecasting, and EV charger predictive maintenance, all contributed by enakroniC. At the platform level, enakroniC interfaces with the FIWARE community's Orion IoT Platform, enabling standardised data ingestion and context management across the cluster's heterogeneous energy assets. The orchestration core at the waist brings together HypO, OpenSlice, OpenZiti, and Kubernetes on OpenStack infrastructure, with UBITECH, TATA, ENAKRONIK, and the University of Patra contributing at this layer. At the base, the physical and network infrastructure layer encompasses private 5G connectivity, gas analysers, pH sensors, EV charging stations, and smart energy meters, provided by the University of Patras, P-NET, and DEI, collectively forming the field-level sensing and actuation foundation that underpins the entire cluster stack.

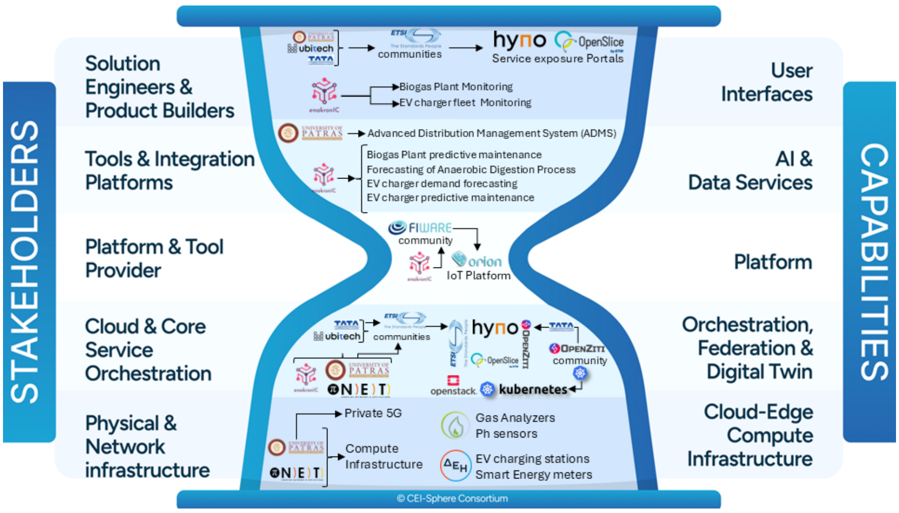

Figure 14: Hourglass model for Cluster 3E

4.6 CLUSTER 4

Cluster 4 operates at the intersection of agriculture, manufacturing and environmental sustainability. Its market relevance comes from the growing demand for IoT, AI and trusted data-sharing solutions that can improve efficiency, reduce waste and support better decision-making across vineyards, wineries and related industrial environments.

The cluster brings together use cases focused on circular sensor lifecycle management, precision viticulture and irrigation support, winery monitoring and optimisation, and broader sustainable operational practices. Together, these scenarios position Cluster 4 as a cross-domain demonstration of how COP-PILOT can support both sector-specific digitalisation and transferable sustainability-oriented innovation.

4.6.1 Market Overview

4.6.1.1 Market Trends

Cluster 4 operates at the intersection of agriculture, manufacturing, and environmental sustainability. Each of these sectors is undergoing rapid digital transformation, creating a strong market pull for the IoT, AI, and data sovereignty solutions.

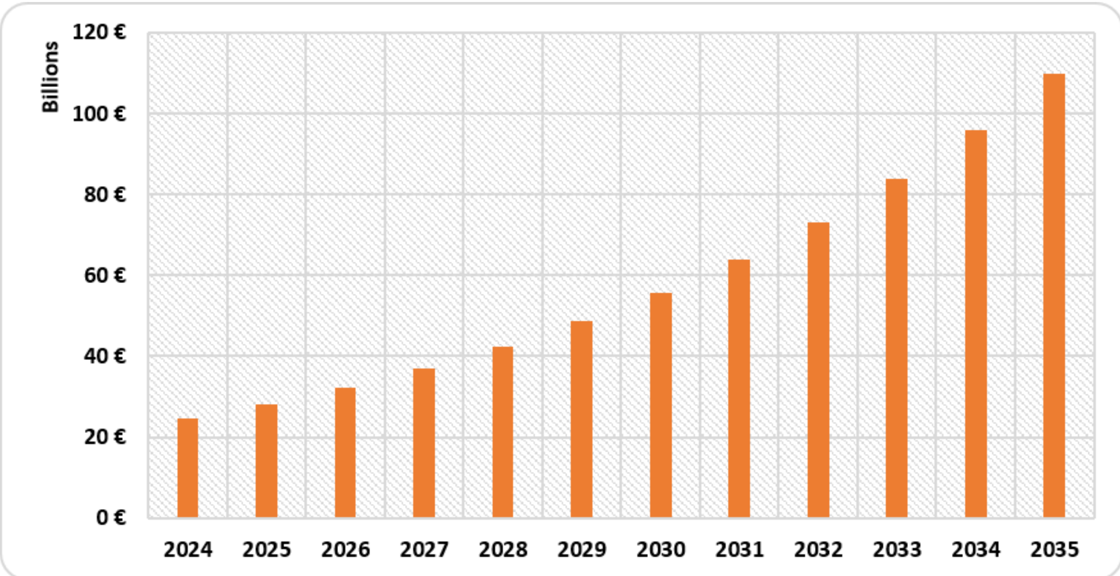

Figure 15: Global smart agriculture market

According to Grand View Research [77], the global smart agriculture market is estimated to reach approximately 83.7 billion by 2033, registering a compound annual growth rate (CAGR) of 14.6%. The Food and Agriculture Organization (FAO) of the United Nations has also been actively promoting digital water management solutions: its WaPOR tool tracks crop water use via satellite imagery [78], providing near real-time data to help countries monitor agricultural water productivity and identify water productivity gaps. Beyond the United Nations, within precision viticulture, the market is expanding as vineyards increasingly rely on data-driven decision-making and automated systems, with demand for tailored precision solutions rising globally.

The global wine industry is undergoing a profound transformation. While production and consumption volumes in some regions are stabilising or slightly decreasing, the market is shifting towards higher value, driven by consumer preference for premium products and operational efficiency. To remain competitive and profitable, wineries are increasingly adopting digital technologies. A key trend is the integration of the entire value chain, from vineyard to bottle, moving towards "smart factories" to improve traceability, quality, and reduce waste. The global wine industry is valued at over USD 360 billion in 2025 and is projected to grow at a CAGR of **3.37%** [79] through 2031, highlighting a stable, large addressable market where efficiency gains translate directly to profitability.

Looking at the manufacturing side, the global smart factory market – a core component of Industry 4.0 – is anticipated to grow from 104.42 billion in 2025 to 169.73 billion by 2030, at a CAGR of 10.2% [80]. Advances in industrial IoT, AI, robotics and digital twin technologies are boosting productivity, facilitating predictive maintenance and optimising manufacturing processes across industries such as automotive, electronics and pharmaceuticals. A separate analysis of the wider Industry 4.0 technologies market – which includes AI, big data analytics, cloud computing, IIoT, robotics and digital twins – reached a value of 551.7 billion in 2024 and is estimated to 1.6 trillion by 2030, achieving a CAGR of 19.4% [81] from 2025 through 2030.

The predictive maintenance subsegment is particularly relevant to Cluster 4. The AI-based predictive maintenance market was valued at 806.72 million in 2024 and is projected to reach 1,92 billion by 2030, representing a CAGR of 15.59% [82]. By integrating real-time sensor inputs with advanced analytics, organisations are moving beyond reactive and preventive approaches toward a proactive maintenance paradigm, with significant improvements in overall equipment effectiveness and decision-making agility.

4.6.1.2 Competitive Landscape

The competitive field for Cluster 4's solutions is broad and fragmented, spanning from established automation giants to specialised IoT and analytics firms. The players can be divided across three interconnected sectors: Smart Agriculture, Smart Manufacturing, and Circular Economy & Waste Management.

Smart Agriculture

The global agritech market is seeing major industrial firms lead the way. For the specific precision viticulture segment, the key technology providers include established equipment manufacturers, precision farming specialists, and newer digital-native startups.

- **Equipment & Technology Leaders**

  Industrial giants John Deere leads with an estimated 15–18% [83] market share, followed by **Trimble** for GPS and field analytics, **Bayer Crop Science (Climate FieldView)** holding **8–10%**, **AGCO Corporation** with **7–9%**, and **CNH Industrial**. Core viticulture technology vendors include **Topcon Positioning Systems**, **TeeJet Technologies**, and **Raven Industries**.

- **Specialised Platforms & Startups**

  Vineyard-specific platforms like **Terraview's TerraviewOS** focus on integrating satellite and field data. Meanwhile, there are many alternative platforms offering a range of solutions, from general vineyard analytics to highly specialized technologies like robotics and AI-driven vision systems.

Smart Manufacturing

The smart factory is a core component of the Industry 4.0 market, which is estimated to grow to USD 1.2 trillion by 2035. The predictive maintenance market is also increasing, with GII placing its value at about 80 billion in 2024 [84] and projecting it to exceed nearly 266 billion by 2031. This environment is dominated by a small group of very large industrial conglomerates.

Siemens leads in Industry 4.0 with over 4% market share [85], while **Emerson**, **GE**, **Bosch**, and **Honeywell** collectively hold about 16%. **Rockwell Automation**, **Schneider Electric**, **ABB**, and **Mitsubishi Electric** are also major global players. These companies supply everything from controllers (PLCs) to full manufacturing execution systems.

For data-focused solutions like JIG's OEE platform, the field includes SAP, IBM, and Microsoft [84] which offer large-scale analytics platforms. A growing number of software start-ups are providing more flexible and specialised SaaS models, though they typically lack the deep hardware integration of the large conglomerates.

Circular Economy & IoT Waste Management

The market for digital waste management is growing rapidly. The **digital smart waste management solution market** is projected to grow from USD 740.33 million in 2025 to USD 2.60 billion by 2032 at a 19.64% CAGR [86].

Major multinationals like Veolia, Suez, and Republic Services [87] are the primary integrators, offering services that increasingly use IoT for tracking and logistics efficiency within traditional frameworks. Start-ups are leading the development of specialized IoT-driven systems. Providers like Sensoneo, Ecube Labs, Evreka, Enevo, and Compology [86] use smart bins and analytics to optimise collection routes and container capacity.

4.6.2 Opportunities and challenges

4.6.2.1 Technology and infrastructure

The growing sophistication of IoT sensors, incorporating advanced electronics, embedded intelligence, rechargeable batteries, and critical raw materials, is increasing the economic value of recovering, refurbishing, and recycling devices at end-of-life. As sensor deployments expand across agriculture and industry, organisations are seeking more efficient lifecycle management approaches that reduce waste, recover valuable components, and support circular economy objectives, creating favourable conditions for sensor tracking and recycling solutions (UC4.1). The EU's Right to Repair legislation and the revised WEEE Directive create policy-level pressure on manufacturers and operators alike to extend product lifetimes and ensure proper end-of-life processing. These obligations make the business case for sensor tracking and recycling solutions more compelling and more urgent.

Industrial equipment manufacturers are increasingly adopting open communication standards APIs. This trend simplifies the integration of production assets into digital monitoring platforms, reducing deployment costs and accelerating the implementation of real-time Overall Equipment Effectiveness (OEE) monitoring, predictive maintenance, and production optimisation solutions within winery operations (UC4.3). It is important to acknowledge that adoption remains uneven: larger, more modernised wineries are embracing open standards, while smaller and family-run operations may still rely heavily on proprietary or legacy interfaces. This gradient of readiness is precisely the market gap that COP-PILOT is positioned to bridge, by abstracting heterogeneous equipment behind a unified monitoring layer that works regardless of protocol.

The continuous availability of free Copernicus Sentinel satellite data provides frequent, large-scale observations of vegetation status, soil conditions, and environmental variables. Combined with AI-based analytics, these datasets enable cost-effective monitoring of vineyard conditions and support precision irrigation strategies without requiring dense deployments of field sensors. This significantly lowers adoption barriers for data-driven viticulture and sustainable water management (UC4.2).

The increasing availability of public and commercial meteorological data services provides reliable environmental information that can be integrated into irrigation and crop management models. By combining local weather observations with satellite imagery and vineyard-specific data, precision agriculture solutions can improve forecasting accuracy and water-use efficiency while reducing the need for additional sensing infrastructure (UC4.2).

The increasing adoption of European data-space initiatives such as GAIA-X is making it easier for organisations to share operational and lifecycle data while keeping that data under their own control. For Cluster 4, this is a genuine opportunity because lack of trust in data sharing is currently a major barrier – vineyard owners, wineries, and hospitals are often reluctant to share data if they fear losing control over it. Sovereign data frameworks remove that barrier by allowing each participant to decide exactly who can access their data, for what purpose, and for how long. As more sectors adopt these standards, the cost and complexity of trusted data sharing decreases, opening the door for Cluster 4 to offer compliant, cross-domain solutions that partners are willing to join.

IoT sensors from different manufacturers often use proprietary formats and maintenance procedures, making it difficult to automate tracking, testing, refurbishment, and recycling processes. The absence of standardised lifecycle information and interoperability mechanisms increases integration complexity and limits the scalability of circular sensor management solutions across heterogeneous device fleets (UC4.1).

Vineyards are frequently located in rural or geographically challenging areas where cellular, LPWAN, or broadband coverage may be limited or unreliable. Connectivity constraints can hinder real-time data collection, edge-cloud synchronisation, and remote system management, requiring adaptive architectures capable of operating under intermittent network conditions (UC4.2).

Many wineries operate bottling lines that combine equipment from different generations and multiple vendors – ranging from modern connected assets with open interfaces to legacy machinery lacking any digital connectivity. This heterogeneity complicates every step of data acquisition, monitoring, and automation. Old machines may require additional sensors and gateways to capture basic operational data, while newer machines from different brands often use incompatible communication protocols, proprietary data models, and vendor-specific control interfaces. Achieving seamless integration across the entire line for unified monitoring, OEE analytics, and predictive maintenance remains a significant technical hurdle (UC4.3).

UC4.4 extends Cluster 4 to rural environments where advanced sensing, edge processing, and remote operations must function under constrained infrastructure conditions. The Matanza de Soria site combines green-powered 5G connectivity, IoT devices, cameras, near-edge AI support, and remotely operated agricultural assets, creating a strong opportunity to validate resilient edge-to-cloud services in settings with variable energy availability and uneven connectivity. At the same time, the use case highlights technical challenges related to service continuity, remote maintenance, and orchestration across heterogeneous components (UC4.4).

Many vineyards and wineries rely on existing management platforms, production systems, and operational databases that were not designed for real-time IoT integration. Limited interoperability and the absence of modern APIs can complicate data exchange, increase deployment effort, and restrict the seamless integration of smart monitoring and analytics solutions across the value chain.

Distributing data processing and AI workloads across IoT devices, edge nodes, and cloud infrastructures requires efficient orchestration mechanisms that balance latency, bandwidth consumption, computational resources, and operational reliability. Managing this continuum becomes particularly challenging when deployments span multiple locations and heterogeneous technologies.

Environmental conditions, sensor ageing, calibration drift, and hardware failures can reduce data quality and affect the reliability of AI-driven analytics. Ensuring trustworthy decision support requires mechanisms for continuous validation, anomaly detection, and quality assessment across diverse sensing infrastructures.

4.6.2.2 Economic

Consumers, retailers, and export markets are increasingly favouring wines produced under sustainable and environmentally responsible practices, with certifications covering organic production, biodiversity, carbon footprint, and water stewardship becoming meaningful market differentiators. This shift creates direct economic incentives for wineries to invest in digital monitoring and traceability solutions — such as those provided by COP-PILOT — that generate the verifiable, audit-ready evidence of sustainability performance required to access premium market segments, satisfy retailer due diligence requirements, and strengthen brand equity in both domestic and international markets.

Tightening regulatory restrictions on agricultural water abstraction and steadily rising water tariffs across European wine regions are converting precision irrigation from a competitive advantage into a financial necessity. As drought conditions intensify under climate change, the ROI case for data-driven water management solutions strengthens considerably: COP-PILOT's UC4.2 approach directly targets the operational cost reduction and regulatory compliance outcomes that vineyard operators increasingly cannot afford to ignore.

Agriculture and food processing are facing structural workforce pressures across the EU, with rising labour costs and persistent difficulties in recruiting skilled workers creating strong economic incentives for automation and AI-assisted decision support. For Cluster 4, this translates into a pull for technologies that reduce manual inspection requirements in the vineyard (UC4.2) and minimise operator intervention on winery production lines through predictive maintenance and automated monitoring (UC4.3).

UC4.4 demonstrates how rural agricultural operations can benefit from advanced connectivity, remote monitoring, and edge-supported intelligence without relying on conventional infrastructure. This can improve asset utilisation, reduce manual intervention, and support more efficient service deployment in remote areas. However, its business case depends on balancing these gains against the cost of specialised connectivity, edge infrastructure, and resilience measures required for energy- and connectivity-constrained environments (UC4.4).

Sustained expansion of public and private investment in digital agriculture — through Horizon Europe, national AgriTech programmes, EIC Accelerator funding, and venture capital — is accelerating market readiness for AI- and IoT-driven farm management solutions. This investment climate lowers the cost of technology components, expands the ecosystem of compatible services, and creates co-funding opportunities that reduce the upfront financial burden on individual vineyard operators, making adoption of COP-PILOT-style precision viticulture solutions more economically accessible and commercially viable.

Unplanned equipment downtime and inefficient production processes represent significant costs for wineries. Advances in predictive maintenance and operational analytics enable earlier detection of equipment issues, improved asset utilisation, and reduced maintenance expenses. These economic benefits are increasing industry interest in digital solutions that improve effectiveness and efficiency.

Co-funded by the European Union

Many digitalisation initiatives in agriculture and food production rely on public grants, regional development programmes, or co-funded innovation schemes. Lengthy evaluation, approval, and reimbursement processes can delay investments and slow the adoption of new technologies, particularly for smaller organisations with limited financial flexibility.

The collection, transport, inspection, and refurbishment of IoT sensors can generate significant logistical costs, particularly when devices are geographically dispersed and individually have relatively low residual value. Achieving economically sustainable reverse logistics models requires efficient coordination and sufficient volumes to offset operational expenses (UC4.1).

Recurring subscription costs for cloud-based monitoring and analytics platforms represent a meaningful financial commitment for SME wineries and small vineyards, particularly when the magnitude of expected savings — in water, energy, labour, or maintenance — remains uncertain at the point of adoption decision. This ROI uncertainty is one of the primary brakes on digital technology uptake in the sector.

The European vineyard sector is characterised by a large number of small and micro producers with highly diverse operational practices, limited purchasing power, and often strong attachment to traditional methods — a structure that raises customer acquisition costs, reduces economies of scale for shared digital services, and complicates the standardisation of deployment models.

Vineyards and wineries are simultaneously absorbing cost inflation across water, energy, packaging, and transport — creating competing pressures on constrained operational budgets that may cause decision-makers to defer technology investment in favour of immediate cost management. While digital solutions ultimately address these same cost pressures, the investment horizon mismatch — upfront costs now versus savings realised over months or years — remains a genuine adoption barrier that is amplified in periods of acute input cost stress.

4.6.2.3 Regulatory, legal and ethical

The WEEE Directive, Circular Economy Action Plan, and Critical Raw Materials Regulation are collectively tightening requirements for the traceability, reuse, refurbishment, and recycling of electronic equipment — including the IoT sensors central to UC4.1. These regulatory developments create favourable conditions for solutions that support lifecycle monitoring, recovery, and responsible end-of-life management of IoT devices and sensors (UC4.1).

European and national authorities are introducing stricter requirements for water efficiency, drought resilience, and sustainable resource management in agriculture. Water scarcity concerns, climate adaptation policies, and environmental reporting obligations are encouraging vineyards to adopt data-driven irrigation management practices that improve water utilisation while supporting compliance with sustainability objectives (UC4.2).

The Common Agricultural Policy increasingly promotes sustainable farming practices through eco-schemes and environmental incentives that reward efficient resource management and climate-resilient agriculture. These programmes encourage the adoption of precision irrigation, digital monitoring, and data-driven decision support tools, creating favourable conditions for smart viticulture solutions that improve environmental performance while supporting compliance with agricultural policy objectives (UC4.2).

European energy efficiency legislation and sustainability reporting frameworks are increasing the need for industrial facilities to monitor, optimise, and document resource consumption and operational performance. These requirements create incentives for wineries to deploy digital monitoring, analytics, and predictive maintenance solutions that improve production efficiency while supporting energy management and sustainability reporting obligations (UC4.3).

UC4.4 also raises regulatory, legal, and ethical considerations linked to rural connectivity, operational data governance, and remote or semi-autonomous operations. Because the use case combines sensing, video capture, AI-enabled processing, and remote asset control, adoption will depend on compliance with data protection, cybersecurity, and safety requirements, as well as clear rules for data access and use. Appropriate safeguards for privacy, accountability, and human oversight are therefore essential (UC4.4).

The Corporate Sustainability Reporting Directive (CSRD)— which extends mandatory sustainability reporting to a significantly wider range of EU companies from 2025 onwards, including many mid-sized food and beverage producers — creates substantial demand for reliable, granular environmental and operational performance data. Digital monitoring platforms that continuously capture measurable indicators on water consumption, energy use, equipment utilisation, and production efficiency provide precisely the data infrastructure that organisations need to satisfy CSRD's double materiality reporting requirements, reducing compliance burden while generating business intelligence as a co-benefit.

The refurbishment, reuse, and recycling of IoT devices must comply with environmental, waste management, and product safety regulations. Ensuring that recovered sensors meet applicable technical and legal requirements before redeployment can increase operational complexity and create additional compliance obligations for organisations implementing circular lifecycle management processes (UC4.1).

Many advanced agricultural analytics and soil moisture estimation models are developed as proprietary solutions, limiting transparency, independent validation, and interoperability. Balancing intellectual property protection with the need for explainability, trust, and scientific validation remains an important challenge for AI-driven precision agriculture solutions (UC4.2).

Wineries may be hesitant to share production performance indicators, equipment utilisation metrics, or OEE-related information due to concerns that sensitive operational data could reveal competitive weaknesses or commercially valuable insights. These concerns can limit participation in collaborative analytics and benchmarking initiatives (UC4.3).

Deploying cameras, motion sensors, and production monitoring technologies within the COP-PILOT pilot environment winery facilities may involve the incidental or systematic collection of personal data relating to employees — triggering GDPR obligations around data minimisation, purpose limitation, transparency, and the rights of data subjects. National labour regulations in several member states impose additional requirements, including works council consultation or collective agreement obligations before introducing monitoring technologies.

Agricultural and industrial stakeholders increasingly require assurance that operational data remains under their control and is processed according to agreed governance policies. Ensuring compliance with evolving European data-sharing frameworks while maintaining interoperability across multiple organisations and platforms remains a significant challenge.

4.6.3 Hourglass model

Figure 16 presents the hourglass model for Cluster 4, which focuses on smart viticulture and winery operations, combining precision agriculture, IoT-enhanced production optimisation, and AI-driven energy and resource management across vineyard and winery environments. At the upper user interface level, UBITECH and TATA feed into the HypO and OpenSlice service exposure portals, while RedZinc, terraviewos, JIG , and NOKIA contribute dedicated application interfaces —

respectively the RMLIoT application for recycling, maintenance and logistics of IoT sensors, the GAMAYA application for smart vineyard irrigation and water use optimisation, the TheTorre application for IoT-enhanced winery production optimisation, and the AIDGE application for AI-driven green energy vineyard management. These four applications collectively constitute the AI and Data Services layer, further complemented by a Smart Wine Value Chain Management capability. At the platform level, IoT platform providers including NOKIA, FIWARE, JIG , RedZinc, and terraviewos provide the data ingestion and context management foundation through the Orion IoT Platform. The orchestration core at the waist brings together HypO, OpenSlice, OpenZiti, and Kubernetes on Proxmox infrastructure, with UBITECH, TATA, RedZinc, JIG , terraviewos, and OneSource contributing at this layer. At the base, the physical and network infrastructure layer encompasses AWS and Advantech compute infrastructure, OneSource and RedZinc edge nodes, Nokia's Green 5G Site providing 5G connectivity, Raspberry Pi sensors, QAMPO devices, and vineyard-specific sensors provided by NOKIA, collectively forming the field-level sensing and connectivity foundation that underpins the entire cluster stack.

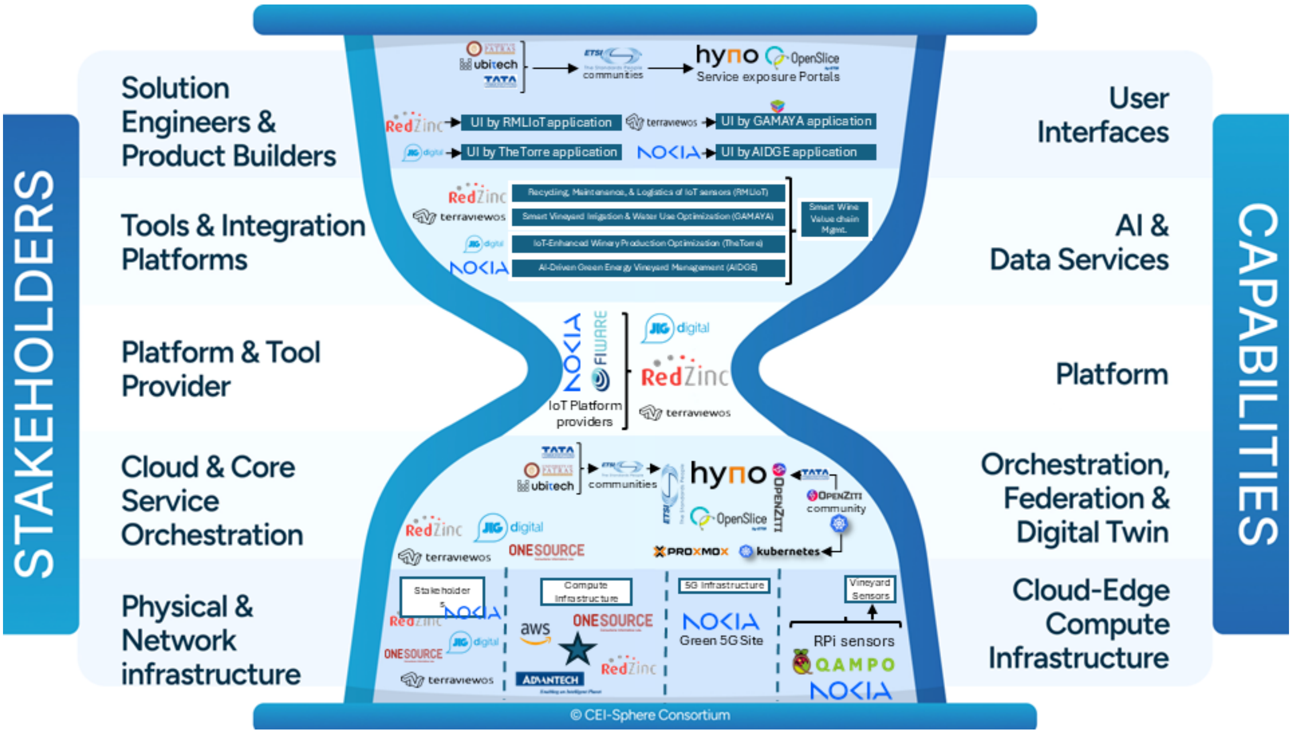

Figure 16: Hourglass model for Cluster 4

5 EXPLOITATION PLANS

The consortium adopted a flexible and adaptive exploitation strategy from the outset, recognising that technical results, market conditions, and partnership dynamics would evolve over time. Currently with tangible results achieved, the partners have revisited and updated their exploitation plans. The following pages present these individual exploitation plans, reflecting progress made to date, adjustments driven by technical developments, IPR considerations, or market intelligence, and revised pathways to ensure that exploitation remains aligned with both partner intentions and project deliverables.

5.1 INTRA - Netcompany-Intrasoft SA

INTRA's exploitation strategy is centered on its role as an integrator of the project results into operational digital solutions. INTRA will exploit its role in the project by turning the developed platform capabilities into integration-ready solutions that can be deployed in complex, multi-stakeholder environments. Its main value lies in combining technical integration, interoperability, and system orchestration skills with the project's reusable components, so that they can be introduced efficiently in new customer settings.

INTRA's exploitation focus will be on:

- Integration and customization services for complex digital platforms.
- Reuse of interoperability patterns, deployment methodologies, and orchestration know-how.
- Pilot-to-production transfer of project results into scalable client solutions.
- Future reuse of the acquired expertise in follow-up EU projects and innovation activities.

Building on the technical knowledge, integration patterns, and deployment experience gained through the project, INTRA will strengthen its service portfolio in system integration, interoperability, and platform orchestration. The company will reuse the project outcomes in future client engagements, particularly in cases where secure, scalable, and heterogeneous digital environments require tailored integration support and adaptation of reusable components to specific operational needs. In parallel, INTRA will assess opportunities to embed relevant results into its broader innovation roadmap and to leverage the acquired know-how in future collaborative and EU-funded initiatives, thereby ensuring both immediate and longer-term exploitation value.

5.2 NOVA - NOVA Telecommunications & Media Single Member SA

NOVA participates in COP-PILOT as a telecommunications and media operator and as an infrastructure/service provider, rather than as the owner of a discrete software component or Key Exploitable Result. Accordingly, NOVA's exploitation strategy is centred on the knowledge, methodologies, operational experience and market intelligence acquired through the project, and on how these strengthen NOVA's commercial connectivity, edge and enterprise service portfolio as well as its positioning in future European and national R&I initiatives. NOVA's roles as WP5 leader (Pilots' validation and evaluation), as leader of Task 2.2 (Piloting Use Cases' definitions and requirements) and Task 5.3 (Platform and pilot use cases assessment), and as a connectivity/infrastructure provider, give it a privileged, cross-cluster vantage point that is itself a primary exploitable asset.

NOVA's exploitation focus will be on:

- **Validation, evaluation and impact-assessment methodology.** The requirements-engineering, testing-case design and KPI-to-KVI assessment know-how developed in leading WP5, T2.2 and T5.3, including the statistical analysis of multi-cluster pilot data and the cross-cluster synthesis of consolidated feedback, constitutes a reusable methodological capability that NOVA can apply to its internal service-validation activities and to future collaborative projects.
- **Standardisation and ecosystem positioning.** NOVA will reinforce its presence in European edge/data ecosystems and standardisation fora.

In parallel, NOVA will embed the methodological and technical know-how gained in COP-PILOT into its R&I roadmap, using it as background and as demonstrated capability in follow-up Horizon Europe, Digital Europe and national initiatives addressing edge computing, 5G/6G, trustworthy AI-assisted service management and cross-sector data spaces. NOVA will also continue to contribute to project dissemination and showcasing activities, using these channels to raise the visibility of its role in advanced digital-infrastructure innovation.

From an IPR perspective, NOVA does not currently foresee the generation of foreground intellectual property requiring dedicated protection. Its exploitation relies primarily on accumulated know-how, operational experience and background assets (network infrastructure and services). NOVA will exploit jointly generated results in accordance with the access-rights and joint-ownership arrangements set out in the Consortium Agreement, and will support open-source releases and open dissemination of results where this is strategically beneficial and consistent with its commercial interests.

5.3 OTE - Organismos Tilepikoinonion Tis Ellados Ote AE

OTE will exploit its participation in COP-PILOT to validate the deployment and operation of 5G network infrastructures in agricultural environments, supporting advanced precision farming applications. Through the project, OTE will provide the communication backbone enabling the connectivity of drones, IoT sensors and robotic systems operating in the field, while assessing the performance, reliability and scalability of 5G technologies under real farming conditions. The project will allow OTE to strengthen its expertise in rural connectivity deployments and explore new business opportunities in the smart agriculture sector.

The key exploitation areas for OTE include:

- **5G deployment models for agriculture**: OTE will gain valuable know-how in planning, deploying and optimizing 5G coverage in open-field and rural environments, creating reusable deployment blueprints for future agricultural or remote-area use cases.
- **Advanced connectivity services for autonomous systems**: The project will validate the capability of 5G to support heterogeneous connected devices, including drones, sensors and robotic platforms, enabling differentiated service models with guaranteed performance levels.
- **Private 5G and managed service offerings**: Based on the project outcomes, OTE will explore the commercialization of private 5G infrastructures and connectivity-as-a-service solutions targeting large farms, agricultural cooperatives and agritech providers.

- **Expansion to adjacent vertical markets**: The operational experience and technical assets generated in COP-PILOT can be transferred to other sectors requiring rural or industrial-grade connectivity, such as logistics, energy and environmental monitoring.

5.4 TATA - TATA Communications (UK) LTD

TATA's exploitation strategy in COP-PILOT is centred on the technical and commercial valorisation of the Secure Integration Fabric (SIF), implemented using OpenZiti, and the extension of this identity-first connectivity model into secure AI and agentic communication. Through COP-PILOT, TATA will validate OpenZiti as a secure integration layer for Cloud-Edge-IoT environments where multiple organisations, domains, services, data platforms and AI components need to collaborate without creating broad network-level trust.

Exploitable item 1: OpenZiti-based Secure Integration Fabric (SIF)

Short description:

The NetFoundry/OpenZiti-based SIF provides identity-first, zero-trust service connectivity across COP-PILOT platform components, domains, data services, vertical applications and authorised external collaborators. It enables services to be exposed by identity and policy rather than by network location, reducing dependence on VPNs, inbound firewall rules, static IP allowlists and shared underlay networks. The SIF includes OpenZiti controllers, routers, identities, services, policies, client/gateway deployment patterns and supporting integration artefacts such as Helm charts and deployment documentation.

Target users/stakeholders:

The target users and stakeholders include Cloud-Edge-IoT platform operators, infrastructure providers, system integrators, industrial and smart-city service providers, energy and logistics platform operators, data-space participants, and organisations requiring secure multi-domain service connectivity across heterogeneous environments. Within COP-PILOT, relevant stakeholders include platform operators, domain operators, vertical service providers, service developers and external collaborators accessing selected platform services.

Exploitation plan:

TATA will exploit the SIF results by using COP-PILOT as a large-scale validation and reference environment for OpenZiti-based secure service connectivity in distributed Cloud-Edge-IoT systems. The knowledge and integration patterns developed in the project will be reused to strengthen NetFoundry/OpenZiti commercial offerings and open-source community assets, particularly around secure customer/partner access, service exposure, multi-domain connectivity, and deployment automation. TATA will use the COP-PILOT experience to refine product packaging, documentation, reusable templates, deployment patterns and integration guidance for organisations that need secure connectivity across sites, clouds, edge environments and partner ecosystems. TATA will also use COP-PILOT as evidence in future commercial engagements and R&I activities where customers need to replace VPN-centric or firewall-centric integration with identity-defined service reachability.

Exploitable item 2: Secure agentic communication using OpenZiti LLM Gateway and OpenZiti MCP Gateway

Short description:

TATA will also exploit the extension of OpenZiti into secure AI and agentic workflows, including OpenZiti LLM Gateway and OpenZiti MCP Gateway. These components apply the same identity-first, policy-driven security model to AI-to-model and AI-to-tool communication. The LLM Gateway can provide controlled access to LLM providers and self-hosted model backends, while the MCP Gateway can enable AI assistants and agents to access internal tools, APIs and data services without exposing those systems directly to the public network.

Target users/stakeholders:

The target stakeholders include platform teams deploying AI assistants, enterprises adopting LLM and MCP-based workflows, operators of private or sovereign AI environments, organisations exposing internal tools to AI agents, and COP-PILOT stakeholders using the Business Management Portal and LLM-assisted service workflows. This is particularly relevant for sectors where AI adoption must be combined with strong access control, auditability, cost visibility, model-routing control and protection of internal APIs or data services.

Exploitation plan:

TATA will exploit these results by integrating the OpenZiti LLM Gateway and MCP Gateway patterns into the NetFoundry/OpenZiti roadmap for secure AI infrastructure. COP-PILOT will provide a reference context for validating how governed AI access can be combined with secure service connectivity, observability and policy enforcement. The results will support future commercial positioning around secure AI-to-model, AI-to-tool and, where relevant, agent-to-agent communication. TATA will also explore how telemetry from these gateways can complement COP-PILOT observability components, including the LLM Observability Dashboard, by providing evidence on identity, model/provider access, routing decisions, policy blocks, latency, usage and cost.

Knowledge, methodologies and follow-up exploitation

In addition to the software components themselves, TATA will exploit the technical knowledge gained through COP-PILOT in areas such as multi-domain secure connectivity, service exposure across organisational boundaries, open-source integration, Cloud-Edge-IoT deployment patterns, secure AI access, and operationalisation of zero-trust networking in complex platform-of-platform environments. This knowledge will be reused in NetFoundry/OpenZiti product development, customer engagements, technical documentation, open-source community activity, standards-related discussions and future EU or national R&I projects. The main exploitation objective is to translate COP-PILOT's SIF validation into reusable commercial and open-source assets that can support secure, interoperable and scalable service collaboration beyond the project lifetime.

5.5 UBI - Gioumpitek Meleti Schediasmos Ylopoiisi Kai Polisi Ergon Pliroforikis Etaireia Periorismenis Efthynis

Exploitable item: ETSI Hyper Orchestrator (HypO)

Description: An open-source multi-domain service orchestrator designed to deliver complex orchestration workflows for services that span multiple administrative domains, while ensuring built-in security and trust. HypO implements popular TMForum standards both at the service and resource levels to ensure interoperability with market solutions.

Target users / markets: Vertical business stakeholders (service providers/developers, end users), Mobile Network Operators (MNOs), system integrators, and researchers requiring a seamless, unified and standardized way to manage heterogeneous end-to-end services.

Exploitation strategy: For UBITECH, COP-PILOT is strategic in many ways. First, at the end of the successful ACROSS project and though COP-PILOT, UBITECH transitioned its former Maestro service orchestration platform from a proprietary software platform to an open-source project titled Hyper Orchestrator (HypO) under the umbrella of ETSI as a Module Development Group (MDG) of the ETSI Software Development Group (SDG) OpenSlice. This is a huge step forward for HypO to create a community and substantially improve its visibility, impact, and strategic position in the European open-source software landscape. In parallel, COP-PILOT's large-scale pilots and high Technology Readiness Level (TRL) provides UBITECH a unique opportunity to stress test HypO at scale. This is because even at the early stages of the project HypO has peered with almost a dozen of ETSI OpenSlice domain orchestrators across 5 COP-PILOT Clusters dispersed from north Sweden to the entire range of South Europe in Greece, Spain, and Portugal. All this is done via the COP-PILOT SIF, where another popular open-source software titled OpenZiti provides solid and secure integration. The joint synergy among HypO, OpenSlice, and OpenZiti creates a unique opportunity for individual component development through integration, but most importantly joint exploitation of the entire COP-PILOT core platform as a mature solution for heterogeneous vertical sectors that wish to see their services being securely orchestrated across collaborative Cloud-Edge-IoT domains in Europe. UBITECH will pursue an exploitation pathway that will combine both commercial outreach of HypO to UBI's customers around Europe, but also through big standardization events (e.g., ETSI SNS4SNS, participation in Proof-of-Concept activities in various ETSI SDGs and/or ISGs) where HypO will advertise its interoperability capabilities with other relevant systems.

5.6 ONE - One Source Consultoria Informatica LDA

ONE's exploitation strategy in COP-PILOT is centred on the technical and commercial valorisation of software components, architectural know-how, and integration capabilities related to multi-domain orchestration and AI-assisted business interaction. Through its work in COP-PILOT, ONE is consolidating exploitable assets at two complementary levels: (i) domain orchestration capabilities through the MIRO platform, and (ii) AI-assisted business interaction through the Business Management Portal LLM component.

Main exploitable results

<u>**Exploitable Item 1: MIRO platform (MIRO portal and MIRO backend)**</u>

Description: MIRO is ONE's domain orchestration platform for managing Kubernetes clusters, applications, components, providers, monitoring, and lifecycle operations across edge-to-cloud environments. It consists of a web portal offering management views and workflows, together with a FastAPI-based backend exposing APIs for orchestration-related functions, including services and infrastructure monitoring, deployment, scaling, and TMF-aligned integrations.

Target users / markets: Platform operators, system integrators, private network operators, edge/cloud infrastructure providers, and organisations requiring orchestration and lifecycle management of distributed applications and resources.

How ONE plans to exploit it: ONE will exploit MIRO by evolving it into a reusable orchestration product and service offering for organisations operating distributed digital infrastructures. The knowledge, software assets, and integration patterns developed in COP-PILOT will be reused in future commercial projects involving automated multi-cluster management and edge-to-cloud service deployment and observability. ONE will also exploit MIRO internally as a foundation for future orchestration-related R&D, prototypes, and customer-specific platform integrations.

<u>**Exploitable Item 2: Business Management Portal – LLM component**</u>

Description: The COP-PILOT AI Assistant is the LLM-based component of the Business Management Portal, enabling natural-language interaction with the platform for product and service exploration, guided order preparation, and AI-assisted access to platform capabilities. It is designed to support business and operational stakeholders by simplifying interaction with orchestration and service management functions through conversational interfaces.

Target users / markets: Business users, operations teams, platform administrators, service managers, and organisations seeking AI-assisted access to orchestration, catalog, and ordering services workflows.

How ONE plans to exploit it: ONE plans to exploit the COP-PILOT AI Assistant by reusing its conversational interaction patterns, integration architecture, and AI-assisted workflow capabilities in future intelligent platform solutions. This includes the incorporation of LLM-based assistants into orchestration portals, business support systems, and TMF-aligned service management environments. The experience gained in combining AI assistance with orchestration workflows and TMF-based APIs will strengthen ONE's service portfolio in intelligent platforms, human-friendly management interfaces, and AI-assisted interaction for complex digital infrastructure services.

5.7 SUITE5 - SUITE5 DATA INTELLIGENCE SOLUTIONS LIMITED

Exploitable Item 1: LLM Observability & Explainability Dashboard

Description: A real-time monitoring dashboard for LLM usage within AI-driven platforms, providing metrics on model performance, response quality (AI-judged), token consumption, latency, and explainability indicators. Developed within COP-PILOT and intended for integration into the main COP-PILOT Business Portal, aligned with Component C#4 (LLM/Agent Layer) and C#10 (Security Add-ons / Explainable LLM).

Live deployment: https://llm-observability.cop-pilot.s5projects.eu/

Target users / markets: Platform administrators and LLM operators in enterprise or public-sector deployments; AI product teams needing auditability and transparency tooling; organisations subject to EU AI Act transparency/explainability obligations.

How SUITE5 plans to exploit it:

- Open-source release with commercial support tier: Publish the dashboard under an open licence towards build community traction, while offering hosted/managed deployment and customisation as a commercial service.
- Commercialisation as a standalone SaaS module: Package the dashboard as a reusable, configurable monitoring layer that can be plugged into any LLM-based platform, beyond COP-PILOT project. Target markets include EU-funded AI platforms (given regulatory pressure on explainability), enterprise AI deployments, and AI solution integrators, since the dashboard's explainability features directly address EU AI Act's transparency and compliance needs
- Integration into SUITE5's existing AI/data intelligence service portfolio; place the dashboard as an add-on service offered alongside SUITE5's data intelligence and AI analytics services.

Exploitable Item 2: Context Broker Data Observability Dashboard

Description: A real-time data quality and health monitoring dashboard for FIWARE NGSI-LD Context Brokers, tracking data latency, schema compliance, entity update rates, and anomaly indicators. Designed for deployment at each COP-PILOT cluster where a Context Broker is deployed; intended for integration into domain-specific portals developed under T3.4.

Live deployment: https://data-observability.cop-pilot.s5projects.eu/

Target users / markets: FIWARE ecosystem adopters (smart cities, energy, mobility, agri); platform/data engineers managing distributed context broker deployments and requiring data quality assurance; public authorities deploying FIWARE-based digital services.

How SUITE5 plans to exploit it:
Engage FIWARE Foundation and iHub network, to promote the dashboard to adopter communities across Europe, particularly in domains where COP-PILOT operates.

Exploitation actions already performed
None yet

5.8 AGE - Agentscape AG

Exploitable Item: COP-PILOT Business Management Portal

Description*:* The COP-PILOT Business Management Portal is a role-based web platform that provides a unified interface for managing multi-domain services, infrastructure resources, orchestration workflows, and operational monitoring across the COP-PILOT ecosystem. The portal integrates TMF-compliant service and resource management APIs, RBAC capabilities, dashboards, and AI-assisted operations.

Target Users / Stakeholders: Infrastructure operators, Domain operators, Service providers, Industrial platform operators, Energy, mobility, smart city and manufacturing operators, Open-source orchestration communities (ETSI OSL, OpenSlice), Future customers of Agentscape AG

Exploitation Plan: Agentscape AG will exploit the Business Management Portal as a reusable commercial software asset and reference implementation for AI-enabled infrastructure and service management. The portal architecture, UI framework, RBAC model, and orchestration integrations will be incorporated into the Agentscape product portfolio and offered to customers operating distributed cloud-edge infrastructures.

The project will enable Agentscape to:

- Develop commercial offerings for cloud-edge management and service orchestration.
- Provide customized portal deployments for industrial customers.
- Offer consulting and integration services around TMF-compliant service management.
- Reuse portal components in future Horizon Europe and industrial projects.
- Contribute selected components and interfaces to open-source initiatives where strategically beneficial.

- Demonstrate the platform as a reference implementation for multi-domain AI-assisted operations and orchestration.

Expected exploitation channels include software licensing, managed services, consulting engagements, and integration projects in cloud, edge, telecommunications, and critical infrastructure domains.

5.9 AXON - Axon Logic Idiotiki Kefalaiouxiki Etaireia

Within COP-PILOT, AXON contributes to the project's shared CI/CD platform (led by INTRA, released under MIT), the common automation backbone through which platform and cluster components are built, tested and deployed across the platform and its managed Clusters.

AXON's specific contribution to this platform is the COP-PILOT CD Plugin, the continuous-deployment stage of the CI/CD process (WP3/TF#4). Although custom-developed by AXON, it is not a separate exploitable item but an integral part of the shared CI/CD platform. While the earlier CI pipelines build, test, and publish a new release, the CD Plugin pushes that updated version into COP-PILOT. Once a new release is published to the Service Repository, the plugin runs it through specific preflight checks. If everything passes and the release is confirmed as healthy, it places a new service order with HypO to deploy the new version. If anything fails, the rollout stops and the developer receives a clear report. In effect, it is the gate that ensures only validated and compliant versions reach the platform.

AXON's exploitation is therefore based on the knowledge, methodologies and engineering capabilities gained through this work, rather than on a standalone product. The CI/CD and continuous deployment know-how strengthens AXON's platform engineering and integration services and provides a demonstrated capability to build on in future Horizon Europe and national R&I initiatives. AXON will support the open-source release of the shared CI/CD platform within the cop-pilot-eu organisation. From an IPR perspective, AXON does not foresee any separate foreground IP that would require dedicated protection. Its contribution is part of the shared CI/CD platform and is released under that platform's MIT license. AXON will exploit jointly generated results in line with the access rights and joint ownership arrangements set out in the Consortium Agreement.

5.10 KON - Konnekt Able Technologies Limited

Konnektable's exploitation activities in COP-PILOT will focus on the technical and commercial uptake of the data management and intelligent interaction capabilities developed within the project. In particular, Konnektable will exploit its contribution to the definition and use of ETSI NGSI-LD data models and its participation in the Scorpio NGSI-LD context broker activities, as part of the COP-PILOT Data Management layer. Konnektable will also exploit its contribution to the LLM-based logic and translation mechanisms that support the transformation of high-level user intents into technical specifications, policies and service-related artefacts.

The main exploitable items for Konnektable are:

1. NGSI-LD data modelling know-how and integration patterns for interoperable IoT, edge and data-space environments.
2. Experience and technical assets related to Scorpio NGSI-LD integration, supporting context information management and interoperability across heterogeneous IoT platforms and vertical domains.

3. LLM-based intent translation and automation capabilities, enabling more user-friendly onboarding, configuration and lifecycle management of services in edge/cloud environments.

4. Reusable integration methodologies and technical expertise gained from the COP-PILOT platform architecture, especially in relation to data management, semantic interoperability and intelligent service management.

Konnektable plans to exploit these results by integrating the acquired knowledge, methodologies and software components into its service portfolio for IoT, edge computing, data management and AI-enabled digital platforms. The project outcomes will strengthen the entity's capacity to offer consulting, integration and software development services to public and private organisations that require interoperable data infrastructures, NGSI-LD-based context management, data-space readiness, and intelligent automation of service deployment and operation.

Konnektable will also use COP-PILOT results to enhance its internal technical capabilities and future R&D roadmap. The experience gained from the project will support the development of new offerings around semantic data interoperability, FIWARE-compatible solutions, context broker deployment, and AI-assisted user interaction for complex digital ecosystems. In addition, Konnektable will explore commercial opportunities in sectors addressed by COP-PILOT, including smart cities, energy, agriculture, logistics and industrial environments, where interoperable IoT data management and edge-enabled automation are increasingly needed.

Exploitation will be pursued through a combination of commercial, technical and knowledge-based actions. Commercially, Konnektable will assess how the project results can be packaged as part of its existing and future service offerings. Technically, Konnektable will further develop its expertise in NGSI-LD, Scorpio, FIWARE-compatible architectures and LLM-based automation. From a knowledge-exploitation perspective, Konnektable will reuse the know-how gained in COP-PILOT in future European projects, client-oriented innovation activities, demonstrations, and potential collaborations with technology providers and end-user organisations.

Exploitation actions initiated so far include the identification of Konnektable's relevant exploitable assets within the COP-PILOT platform and the preliminary alignment of these assets with Konnektable's broader portfolio in IoT, data management, AI-enabled services and digital transformation solutions.

5.11 INC - Incites Consulting SA

INCITES Consulting SA will leverage its participation in the COP-PILOT project to strengthen its expertise and market positioning in the fields of edge computing, AI-enabled service orchestration, IoT-to-edge-to-cloud ecosystems, and cross-sector digital transformation. Building on the project's focus on collaborative open platforms, intelligent automation, and secure orchestration across heterogeneous infrastructures, INCITES will enhance its market intelligence activities by developing targeted market studies, business reports, and stakeholder seminars that explore emerging opportunities related to edge intelligence, AI-driven network and service management, and trusted data-sharing ecosystems. These activities will support the identification of new value chains and commercial opportunities stemming from the convergence of IoT, AI, cloud-edge computing, and advanced connectivity technologies.

Through its involvement in COP-PILOT, the company will deepen its understanding of innovative service delivery models, ecosystem-based business approaches, and evolving European policy and standardisation frameworks related to open digital platforms, edge computing, and trustworthy AI. This knowledge will enable INCITES to better support public authorities, infrastructure operators, technology providers, and industrial stakeholders in the adoption and deployment of advanced digital solutions that enhance operational efficiency, resilience, and sustainability across sectors such as energy, smart cities, agriculture, manufacturing, mobility, and logistics.

At the same time, INCITES will expand its consulting portfolio by offering specialised advisory services on the deployment, and market uptake of AI-enabled orchestration platforms, distributed edge infrastructures, and secure cross-domain data ecosystems. The company will strengthen its capacity to perform techno-economic and socio-economic analyses of investments related to edge computing infrastructures, AI-driven automation services, and collaborative digital platforms, assessing their feasibility, scalability, market potential, and long-term business value. Particular emphasis will be placed on evaluating the sustainability, and societal impacts of cross-sector digital ecosystems and supporting the development of viable exploitation and commercialisation strategies for innovative platform-based services.

Overall, participation in COP-PILOT will reinforce INCITES Consulting SA's role as a leading international advisory firm operating at the intersection of digital innovation, artificial intelligence, edge computing, and the data economy. The project will further enhance the company's ability to contribute to European initiatives that promote open digital platforms, trustworthy AI, strategic digital autonomy, and the green and digital transitions, while supporting the market adoption of next-generation computing and data infrastructures.

5.12 ARTHUR - Arthur's Legal BV

Arthur's Legal is an independent, global strategic legal advisory and knowledge partner. It focuses on the combination of technology, strategy, impact, ethics and law focusing on (inter)national, regional and global strategy and policy aspects in this Digital Age. ARTHUR is involved in several European co-founded projects regarding Fit for the Digital Age and Digital Decade 2030 and is a member of European alliances and expert groups regarding data, cloud and digital transformation. These include the European Alliance for Industrial Data, Edge and Cloud, leading the Cloud-Edge Working Group, the Expert Group on B2B Data Sharing and Cloud Computing Contracts and several institutes such as the Institute for Future of Living.

Arthur's Legal will exploit the results of the COP-PILOT project by leveraging its extensive European network, policy expertise, and leadership roles in digital sovereignty, data governance, and trustworthy digital transformation. Efforts will focus on transforming project knowledge, methodologies, governance frameworks, policy recommendations, and best practices into sustainable assets that can be adopted by policymakers, industry stakeholders, public authorities, and digital ecosystem actors. The knowledge generated within COP-PILOT will also be integrated into ARTHUR's ongoing activities supporting public authorities, industrial stakeholders and European initiatives.

No specific commercial pathways are defined at this stage as opportunities are primarily indirect and relate to strengthening and extending the firm's expertise, enhancing the quality of advisory services, and supporting participation in ongoing and future projects and policy initiatives as explained above. Potential opportunities may arise in further research or innovation projects building on project outcomes, development of guidelines, best practices or policy-oriented outputs and collaboration in future EU-funded initiatives.

5.13 ICCS - Erevnitiko Panepistimiako Institouto Systimaton Epikoinonion Kai Ypologiston

Exploitable item: HPA+ / AI-based Cluster Scaling service.

Short description: A Kubernetes-based autoscaling service extending horizontal pod autoscaling capabilities for COP-PILOT platform services. It supports zero-touch resource scaling based on workload and infrastructure metrics, improving resource efficiency and service reliability across cloud/edge environments.

Target users/stakeholders: COP-PILOT platform operators, Kubernetes/edge-cloud infrastructure providers, DevOps teams, researchers, and vertical application providers needing automated scaling of services.

Exploitation plan: ICCS will exploit HPA+ mainly through open-source release, research exploitation, integration in COP-PILOT pilots, reuse in future EU/R&D projects, publications/demonstrations, and potential technology transfer or integration support for Kubernetes-based cloud-edge platforms.

5.14 UBRAD - University Of Bradford

Name of Exploitable Item: KPI-to-KVI Policy Translation & Business Governance Toolkit for Industry 5.0

Short description: Developed by UBRAD, this exploitable asset operationalizes the overarching KVI conceptual framework into an actionable toolkit for stakeholders outside of academia. While KUL provides the scientific modelling, UBRAD's toolkit focuses on the **business feasibility and policy alignment** dimensions. It provides structured frameworks, audit guidelines, and business models that translate technical achievements into socio-economic value. This allows non-technical stakeholders to justify public and private investments in Cloud-Edge-IoT infrastructures, ensuring technological advancements are aligned with regional economic goals and EU regulatory standards.

Target users/ stakeholders:

- **Policymakers & Public Authorities:** EU evaluators, regional funding bodies, and municipal planners who need structured, non-technical governance frameworks to audit, justify, and monitor public investments in digital infrastructure.
- **Business & Innovation Managers:** Business developers and exploitation managers who require tools to translate Edge-IoT capabilities into viable, marketable business models.
- **Use-Case & Exploitation Leads (Internal Consortium):** Partners looking to map their cluster's technical success directly to market readiness and business sustainability.

Exploitation plan: UBRAD will exploit this toolkit through policy influence, institutional capacity building, and ecosystem advisory:

- **Policy & Institutional Integration:** UBRAD will synthesize the framework's findings into accessible, high-impact policy briefs and white papers. These will be targeted at public authorities and EU bodies to demonstrate how to bridge the gap between deep-tech performance and tangible socio-economic value, potentially influencing future regulatory frameworks.

- **Institutional Knowledge Building & Advisory:** UBRAD will leverage the toolkit to enhance its own institutional advisory capacity. The business feasibility blueprints will be used in workshops and training sessions for industry stakeholders, transferring the knowledge from COP-PILOT into practical guidelines for European SMEs and tech integrators looking to adopt Cloud-Edge-IoT solutions sustainably.

5.15 IPN - INSTITUTO PEDRO NUNES ASSOCIACAO PARA A INOVACAO E DESENVOLVIMENTO EM CIENCIA E TECNOLOGIA

IPN's exploitation strategy in COP-PILOT is centred on security assurance for LLM-assisted TM Forum API management. Its main exploitation asset is a **AI Security Guardrails Gateway** that validates how natural-language requests are transformed into structured API actions within Business Portal workflows.

IPN will use COP-PILOT results to support future R&D, proposals, dissemination, and potential standardization activities on trustworthy AI for telecom service management. The work will focus on reusable guardrail mechanisms for safe LLM-to-tool and LLM-to-backend execution, covering validation, authorization, confirmation, sensitive-data protection, and policy enforcement.

The target context includes AI-assisted product discovery, ordering, status queries, and orchestration-triggering operations based on TM Forum APIs. IPN will promote these results through its regional innovation network, including startups, SMEs, research groups, and technology stakeholders.

For valorization and standardization, IPN will explore reusable security patterns and governance models for LLM-assisted TM Forum API interactions, including possible collaboration with COP-PILOT partners on ETSI ZSM Proofs of Concept for secure, AI-assisted zero-touch service management. IPN will also scout national and European funding opportunities to support follow-up R&D and innovation activities.

5.16 LTU - LULEA TEKNISKA UNIVERSITET

LTU will primarily exploit COP-PILOT results through education, research, and innovation activities. Emphasis will be placed on the outcomes of Cluster 1, including AI-enabled orchestration, distributed IoT–Edge–Cloud infrastructures, and intelligent operational management.

The main exploitation route will be the integration of project results into LTU's educational portfolio. Methods, architecture, software assets, and lessons learned from COP-PILOT will be incorporated into Computer Science and Engineering programmes through lectures, laboratory exercises, student projects, and master's theses. The results will also be used in stand-alone and professional education courses targeting engineers and practitioners in industry, contributing to workforce upskilling in AI, edge-cloud systems, and digital transformation.

LTU will further exploit project outcomes through future national and international research projects, building on the knowledge and technologies developed within Cluster 1, aligned with the project as a whole. The university will actively pursue new collaborations with industrial partners from the COP-PILOT ecosystem to extend and validate project results in real-world industrial settings.

In addition, LTU will facilitate technology transfer through industrial collaboration, contract research, and innovation activities. Where appropriate, technologies and intellectual assets generated within

COP-PILOT may form the basis for startups, spin-offs, or licensing activities, in collaboration with LTU Business AB and relevant industrial partners. Through education, research, industrial collaboration, and entrepreneurship, LTU will contribute to the long-term sustainability, dissemination, and adoption of COP-PILOT results, strengthening both academic excellence and industrial competitiveness.

5.17 RISE - RISE Research Institutes of Sweden AB

RISE's exploitation centres on the knowledge and competence it has gained in COP-PILOT from designing, integrating, and operating an edge-to-cloud compute continuum for Cluster 1. The continuum uses the ColonyOS metaOS to run workloads across edge, on-premises, and cloud resources, and RISE operates the ETSI OpenSlice orchestrator for the cluster. Developed through the project's demanding mining use cases, this competence applies equally well to other domains and applications. As a research institute, RISE is well placed to take it into future research and innovation projects, in EU and national programmes and in direct collaboration with industry.

A central part of RISE's exploitation is its continued engagement with ColonyOS. RISE intends to remain an active contributor to the ColonyOS open-source community and to draw on it in its own projects beyond COP-PILOT. Because this work is open source, the results stay available and maintainable after the project, and RISE can build on a shared codebase with LTU and other partners. Questions such as workload placement, scaling, and trustworthy automation of the continuum can be taken forward directly on this shared foundation, which lowers the cost and risk of starting new projects and helps turn results into capabilities that others can adopt.

The compute infrastructure that RISE hosts at its ICE data center, now set up to run the full software stack, remains available as a testbed for later projects and for partners wishing to experiment with edge-to-cloud orchestration. With this testbed, alongside the continuum and competence and the relationships built with the Cluster 1 use-case partners, RISE has a strong basis for new and continued collaborations once COP-PILOT ends.

5.18 HOSCH - Hosch Fordertechnik Recklinghausen GMBH

HOSCH will integrate certain COP-PILOT outcomes into future product and service offerings to enhance exploitation. It is anticipated that features enabled by COP-PILOT technologies will strengthen HOSCH's competitive positioning in the conveyor technology market, delivering distinctive benefits to clients. Our target markets and segmentation remain unchanged as a result of COP-PILOT.

HOSCH primarily operates as an independent vendor of belt conveyor components and maintenance solutions, working directly with mining and bulk material handling operators across multiple continents. The core strategy involves continuously developing a pipeline of prospects, converting them into qualified leads, and conducting targeted outreach through sales presentations and product demonstrations.

Product innovation will extend beyond the scope of the COP-PILOT project. Building upon the platform technologies and condition monitoring capabilities established within COP-PILOT, HOSCH anticipates accelerating the development of value-creating features for predictive maintenance of conveyor belt systems.

At the time of writing, there are no active plans to apply for additional grants. Future innovation and exploitation will proceed on a commercial basis.

The HOSCH IPR strategy is founded on the following pillars:

- Safeguarding proprietary source code for strategically significant features, such as the HOSCHiris platform and its IoT-based conveyor belt condition monitoring capabilities.
- Diligent management of know-how and trade secrets to preserve domain expertise in relation to conveyor system performance and data-driven maintenance methodologies.
- Utilization of open-source releases and publications for certain aspects of our products, both to ensure freedom to operate (FTO) and to promote awareness of our core competencies in conveyor technology.

5.19 TAB - ThingWave AB

In order to enhance exploitation, ThingWave will integrate the COP-PILOT outcome into our products and services developed within the project. The anticipated outcome is that support from COP-PILOT technologies will help solidify ThingWaves market leading position by its distinctive benefits. ThingWaves market and segmentation remain unchanged because of COP-PILOT.

ThingWaves primary operation is as an independent vendor of sensor and SaaS solutions. The focus is primarily rock bolt monitoring, with target customers in the mining industry across the world. The core business is to continuously develop a pipeline of prospects, convert them into qualified leads and use outreach methods such as sales presentations and product demonstrations. There is also engagement from our side in commercial pilot projects, with the long-term goal of securing future long-term contracts to deliver hardware and subscription based software deals.

ThingWaves product innovation extends beyond the scope of the COP-PILOT project. We anticipate accelerated development of value-creating features by building on the platform technologies established within the project.

ThingWave has plans to pursue additional grants if the calls and consortiums are available. There will be future innovation and exploitation on a commercial basis within ThingWave.

ThingWave's IPR strategy is founded on the following pillars:

- Safeguarding proprietary source code for strategically significant features, such as embedded sensor code or IoT platform source.
- Diligent management of know-how and trade secrets to preserve domain expertise in relation to our data-driven methodologies.
- Utilization of open-source releases and publications for certain aspects of our products, both to ensure freedom to operate (FTO) and to promote awareness of our core competencies.

5.20 PAB - Predge AB

Predge will integrate COP-PILOT outcomes into forthcoming product and service offerings to enhance exploitation. It is anticipated that features derived with the support of COP-PILOT technologies will reinforce Predge's competitive position in the marketplace by delivering distinctive benefits to clients. Our target markets and segmentation remain unchanged because of COP-PILOT.

Predge primarily operates as an independent vendor of SaaS solutions focused on condition-based and predictive maintenance, targeting directly mining and railway customers across multiple continents. The core strategy involves continuously developing a pipeline of prospects, converting them into qualified leads, and conducting targeted outreach through sales presentations and product demonstrations. Subsequently, we engage in commercial pilot projects, with the long-term objective of securing subscription-based contracts with mine and railway operators.

Product innovation will extend beyond the scope of the COP-PILOT project. Building upon the platform technologies established with COP-PILOT, Predge anticipates accelerating the development of value-creating features.

Currently, there are no active plans to pursue additional grants; future innovation and exploitation will proceed exclusively on a commercial basis.

The Predge IPR strategy is founded on the following pillars:

- Safeguarding proprietary source code for strategically significant features, such as predictive algorithms for component degradation.
- Diligent management of know-how and trade secrets to preserve domain expertise in relation to our data-driven methodologies.
- Utilization of open-source releases and publications for certain aspects of our products, both to ensure freedom to operate (FTO) and to promote awareness of our core competencies.

5.21 ROC - Rocksigma AB

For exploitation, RockSigma will embed COP-PILOT results in future product and service offerings. It is envisioned that the features enabled by COP-PILOT results will contribute to RockSigmas competitive positioning in the market, with unique client benefits delivered. Our target markets and segmentation remain unaffected by COP-PILOT.

RockSigma is primarily going to market as an independent vendor of seismic processing solutions, working directly with mine operator clients on multiple continents. The strategy is essentially to continuously develop our pipeline of prospects, convert them to qualified leads and then engage with outreach to perform sales presentations and product demonstrations. After that, we work with commercial pilot projects and the ultimate commercial goal is to enter into long term subscription style contracts with mine operators.

Product innovation will be continued beyond the COP-PILOT project. With the platform foundation achieved through COP-PILOT, it is assumed that RockSigma will be able to innovate value creating features, service end-user benefits, at a higher pace than without.

At the time of writing, there are no active plans to apply for other grants. Continued innovation and exploitation will be on a commercial basis.

The RockSigma IPR strategy relies on the following pillars

- Protected, proprietary source code for strategically important features, such as our core seismic processing methods.

- Careful management of know how and trade secrets, especially when it comes to how seismic processing is applied and how its outputs are interpreted.
- Open Source and publications for aspects of the products where broader engagement is deemed valuable, for example in the case of generic platform components (open source) or uniquely high performance of seismic processing (publications).

5.22 LTUB - LTU Business AB

LTU Business does not generate a standalone technical exploitable result in COP-PILOT. Instead, LTU Business will exploit the project outcomes by strengthening its internal business development and innovation support methodology for industrial digitalisation projects. This includes reusable knowledge, templates and advisory practices related to exploitable asset identification, market positioning, stakeholder mapping, exploitation pathways, open call design and business model development for IoT-edge-cloud solutions in complex industrial environments.

The main route for exploitation is internal capability building and reuse in future innovation projects, research commercialisation support and regional ecosystem activities. LTU Business may use the insights from COP-PILOT to support researchers, SMEs and industrial partners in assessing market potential, defining exploitation strategies and preparing future collaborative projects, but does not intend to commercialise a proprietary COP-PILOT technical component.

5.23 UPV - Universitat Politecnica De Valencia

UPV's exploitation strategy in COP-PILOT is focused on leveraging the knowledge, methodologies and operational experience acquired through the deployment and validation of the Smart Waste Management use case on its campus. By acting as a real-life testbed, UPV has gained valuable experience in the implementation and evaluation of IoT-based monitoring solutions, data-driven resource management approaches and the integration of digital technologies into complex operational environments.

The UPV campus provides a controlled yet highly representative environment that shares many characteristics with a small urban area, including a diverse population, distributed infrastructure and multiple service management processes. This makes it an ideal setting for the testing and validation of innovative Smart City solutions before their deployment in larger and more complex urban environments.

The experience gained during COP-PILOT will be exploited by applying the methodologies and lessons learned to future Smart Campus initiatives and research activities related to sustainability, IoT and urban digitalisation. Furthermore, the validation of the waste management use case contributes to demonstrating the feasibility and scalability of data-driven waste monitoring solutions, supporting their potential adoption in municipalities and other public environments. The project also reinforces UPV's role as a living laboratory for the experimentation and validation of emerging digital technologies, creating opportunities for future collaborations with cities, public administrations, technology providers and research organisations.

5.24 VPF - Fundacion De La Comunidad Valenciana Para La Investigacion, Promocion Y Estudios Comerciales De Valenciaport

The FVP's exploitation strategy focuses on providing new services related to the arrival and management of ships docking at ports. The system that the FVP is designing for a terminal in the Port of Valencia is entirely new and could prove very useful in many Spanish and European ports.

The technology we are using is already mature but is not yet in use in ports. Its usefulness is also being recognised, not only in the use cases proposed in the project but also in other scenarios that could improve all operations related to ship berthing, whilst also taking into account aspects such as safety.

The proposed development involves improvements to port entry operations, approach to the terminal and ship berthing, making it of interest to all stakeholders involved in these operations, such as pilots, tugboats, mooring crews, terminals, maritime traffic control services and port authorities. The solution tested in the project could be proposed to Spanish ports, to the European ports with which we collaborate on other projects, and to the Latin American ports with which we have significant trade links.

5.25 TID - TELEFONICA INNOVACION DIGITAL SL

Telefónica Innovación Digital (TID) participates in the COP-PILOT project with the objective of acquiring, consolidating and exploiting technical and business capabilities related to multidomain observability, event management and AI-driven interaction over complex digital platforms. The exploitation strategy of TID is aligned with its role as a technology provider and system integrator for advanced digital platforms, with a strong focus on Smart City environments and cross-domain data management.

The exploitation activities planned by TID cover both technical exploitation (reuse of software components, architectural patterns and know-how) and commercial exploitation (integration of project results into Telefónica's service portfolio and future business offerings).

TID activities are structured at two levels: (i) the COP-PILOT cluster level, as a multidomain observability and event management platform, and (ii) the Smart City domain, where TID focuses on the deployment, configuration and validation of concrete use cases.

Main exploitable results: The main exploitable assets generated or consolidated by TID within COP-PILOT are related to the design, integration and operation of a modular platform for data ingestion, event management, visualization and AI-based interaction.

At the core of the platform, TID has worked on the integration and configuration of a lightweight content broker based on the Scorpio NGSI-LD component, enabling the ingestion, normalisation and management of data coming from heterogeneous sensors and systems. Data persistence is handled through a PostgreSQL database, using the open-source component Draco. User access and identity management are provided through an IDM component based on Keyrock, while basic monitoring of the platform components is also included.

On top of the core platform, two components represent key exploitable results:

Event Management component: In addition to the standard Perseo capabilities, TID has developed an application-level event management component that translates configured event triggers into TM

Forum–compliant service orders. This component enables the connection of any city event to a specific and automated action, depending on the selected use case, thus bridging operational events with service management processes.

Visualisation Portal: A web-based portal providing dashboards adapted to each use case, implemented using open-source Grafana software. This component allows different stakeholders to visualise relevant operational and contextual data in a clear and configurable way.

Finally, the exploitation layer of the platform is completed with:

Open Data APIs, providing secure access to stored data for external applications and third parties.

AI Agent, enabling access to platform information not only through the web portal or APIs, but also via natural language interaction.

At a higher level, TID is also specifying and developing a Business Portal, which will support the orchestration and request of product and service orders, as well as the integration of a platform-level Large Language Model (LLM) or AI agent, applicable across products and domains.

Exploitation strategy: TID's exploitation strategy is based on the progressive integration of COP-PILOT results into its existing technological capabilities and future commercial offerings.

From a technical perspective, TID will exploit the software components, reference architectures and integration patterns developed in COP-PILOT by reusing them in internal innovation activities, customer pilots and future R&D projects. The experience gained in deploying a multidomain observability and event management platform, combined with AI-based interaction, strengthens TID's expertise in NGSI-LD–based data management, Smart City platforms and service orchestration.

From a commercial perspective, the results of COP-PILOT will be incorporated into Telefónica's portfolio of digital platform services. In particular, the event management capabilities, the Open Data APIs and the AI agent will be exploitable as value-added features for Smart City solutions, operational intelligence platforms and cross-domain digital services offered to public administrations and large enterprises.

Target markets and users: The primary target market for TID's exploitation activities is the Smart City domain, including city councils, public authorities and urban service operators seeking advanced observability, event-driven automation and data-driven decision support.

Additional target markets include other verticals addressed by COP-PILOT, such as mobility, energy and large-scale digital infrastructures, where multidomain data integration and AI-assisted operation are increasingly required.

Target users include platform operators, city service managers, technical integrators, and, at a higher level, business and operational decision-makers who benefit from unified visibility and intelligent interaction with complex systems.

Exploitation actions and sustainability: During the project, TID will continue identifying exploitable assets and aligning them with its internal roadmap. After the end of COP-PILOT, the results will be sustained through their reuse in commercial projects, further evolution of the Business Portal and AI agent, and participation in new European initiatives building the same technological foundations.

Overall, COP-PILOT represents a strategic opportunity for TID to reinforce its position as a key player in the development and exploitation of interoperable, AI-enabled digital platforms for Smart Cities and beyond.

5.26 NES - Nespra SL

COP-PILOT has enabled Nespra to deploy and validate heterogeneous IoT sensor networks in real operational environments across Cluster 2, covering three distinct use cases: smart waste management at UPV campus, smart building management at La Harinera, and environmental quality monitoring at the industrial park of Almussafes. Each deployment involved sensors of different nature — waste level, people counting and gas detection — operating over different communication protocols including NB-IoT and LoRaWAN, which has provided Nespra with valuable cross-domain experience in multi-protocol IoT deployments.

Nespra's participation in COP-PILOT has served a dual purpose. On one hand, it has allowed the company to validate the integration of commercially available sensors into the COP-PILOT platform architecture, demonstrating that market-ready devices can be successfully onboarded into NGSI-LD-based data platforms with the required reliability and data quality standards. On the other hand, and of greater strategic value, the project has been an opportunity to advance Nespra's work on standardisation of the interface between the device layer and the data layer. This includes the development and refinement of methodologies, data models and integration patterns that guarantee interoperability between heterogeneous IoT devices and FIWARE-compliant data platforms, improving the reliability, robustness and quality of the information flowing from field devices to operational systems.

The results generated during the project will be exploited through the consolidation and enhancement of Nespra's IoT product portfolio, incorporating the integration patterns and device management capabilities validated in COP-PILOT into its commercial offerings. The experience gained across multiple sensor types, communication technologies and real-world deployment environments will support the optimisation of hardware configuration processes, remote monitoring capabilities and device lifecycle management. Furthermore, the standardisation work carried out during the project contributes to building a replicable and scalable approach to IoT deployments that can be offered to new clients in sectors beyond those covered by the project.

The successful deployments carried out within COP-PILOT provide Nespra with concrete reference cases demonstrating the company's ability to deliver end-to-end IoT solutions — from hardware selection and lab testing to field deployment and platform integration — in demanding operational environments. These references will support future commercial activities with municipalities, building operators, industrial clients and public administrations. In the long term, COP-PILOT reinforces Nespra's positioning as a reliable IoT provider capable of bridging the gap between the physical world of sensors and the data platforms that power smart city and smart industry applications.

5.27 FIVE - 5G Communications for Future Industry Verticals SL

COP-PILOT has enabled FIVE to deploy and validate its IoT sensing infrastructure in a real operational environment, and test the reliability, scalability and interoperability. The deployment has allowed the collection of valuable operational insights while validating the performance of the devices representing an opportunity to refine deployment methodologies and strengthen the company's expertise in IoT implementations.

The results generated during the project will be exploited through the enhancement of the company's existing products and services, as well as the implementation of new data-driven solutions that will complement current designs. The experience acquired during deployment and operation will support the optimization of hardware configuration, analytics tools, and remote monitoring capabilities. In addition, the datasets and operational knowledge obtained throughout the project will contribute to the improvement of maintenance strategies and decision-support functionalities that can be integrated will be integrated into future commercial offerings.

The successful execution of the project is expected to expand the company's opportunities in both existing and emerging markets. Demonstrating the effectiveness of the deployed solution in a real-world environment will provide strong reference cases that will support future commercial activities with municipalities, infrastructure operators, industrial clients, and other potential stakeholders. The project outcomes will also strengthen the company's positioning as a reliable technology provider capable of delivering scalable IoT solutions adapted to different operational contexts and customer requirements, in important sectors such as smart mobility, smart infrastructure and public safety.

In the long term, the project will contribute to the company's strategic growth by increasing visibility within the innovation ecosystem and creating opportunities for future collaborations, pilots, and larger-scale deployments. The knowledge and technical assets generated during the project will serve as a foundation for continued research and product evolution. Overall, the project represents an important step toward expanding the company's portfolio, reinforcing its market presence, and supporting sustainable business development in the IoT sector.

5.28 VCH - FUNDACION DE LA COMUNITAT VALENCIANA PARA LA PROMOCION ESTRATEGICA EL DESARROLLO Y LA INNOVACION URBANA

VCH's exploitation strategy in COP-PILOT is focused on fostering urban innovation ecosystems, facilitating collaboration among public and private stakeholders, and supporting the adoption and replication of innovative smart city solutions. Through its role in Cluster 2 and within the Valencia innovation ecosystem, VCH contributes to connecting departments from the municipality, technology providers and local communities around digital transformation and sustainable urban development activities.

The main exploitable outcomes for VCH are the experience and know-how acquired in facilitating multi-stakeholder collaboration in smart city environments, the methodologies and good practices for coordinating and validating urban innovation pilots, and the strengthened positioning of VCH within European smart city and urban innovation ecosystems. The project also provides valuable knowledge related to cross-domain urban services and data-driven innovation approaches in areas such as mobility, public safety and smart buildings.

VCH plans to exploit the results of COP-PILOT by reinforcing its role as an urban innovation facilitator and by supporting the transfer and replication of project outcomes in Valencia and other European city ecosystems. The knowledge and experience gained through the project will support future innovation activities, stakeholder engagement processes, urban experimentation initiatives and participation in European projects related to smart cities, sustainable urban development and digital transformation. VCH will also leverage the project outcomes to strengthen collaboration with municipalities, innovation hubs, SMEs, universities and technology communities working on interoperable and citizen-oriented digital services.

Co-funded by the European Union

Exploitation actions already performed include participation in the coordination and validation of Cluster 2 urban use cases and innovation activities, engagement with local stakeholders and technology partners within the Valencia innovation ecosystem, contribution to dissemination and ecosystem-building activities related to smart city innovation, and the initial identification of opportunities for future collaboration and replication of COP-PILOT outcomes in urban innovation initiatives and European projects.

5.29 ALM - Ayuntamiento De Almussafes

The exploitation strategy of the project focuses on the deployment and validation of an innovative monitoring solution aimed at improving safety, environmental management and risk prevention in urban and industrial environments. The project combines two complementary use cases: the monitoring of flood-prone areas through vertical distance radar technology and the continuous assessment of air quality through toxic substance sensors, with a specific focus on formaldehyde detection.

The solution developed within the project will demonstrate the value of real-time sensing technologies for supporting preventive decision-making, enabling early detection of critical situations and improving the resilience of industrial areas and surrounding urban environments.

The first use case, based on the deployment of five radar-based monitoring devices in urban flood-prone areas and in the Juan Carlos I industrial estate, will provide a continuous assessment of water level variations and potential flooding risks. The generated information would support emergency management services, infrastructure operators and local authorities by improving situational awareness and reducing response times during extreme weather events.

The second use case will focus on environmental quality monitoring within the industrial estate through a network of five sensors capable of detecting the presence of hazardous substances, particularly formaldehyde. This deployment will enable the validation of continuous air quality monitoring capabilities in real operational conditions, providing valuable information for improving occupational safety, environmental compliance and industrial risk management.

The technologies involved in the project are already available and mature, but their integration into a combined monitoring solution adapted to industrial and urban risk management represents an opportunity to create new services and operational capabilities. The project will demonstrate how IoT-based sensing infrastructures can be effectively applied to improve safety, sustainability and resilience in industrial environments.

The results generated during the project will be exploited through the enhancement of existing monitoring solutions and the development of new data-driven services. The knowledge acquired during the deployment phase, including sensor performance, data collection processes and operational requirements, will support the optimization of future solutions, improving scalability, reliability and integration capabilities.

The project outcomes are expected to create opportunities in several markets, including smart cities, industrial parks, environmental monitoring, emergency management and critical infrastructure protection. The validated solution could be replicated in other industrial areas, municipalities and regions facing similar challenges related to flooding risks and air quality control.

The project will also provide a valuable reference case demonstrating the applicability of sensor-based monitoring technologies in real environments. This experience will strengthen the capacity of technology providers and stakeholders involved to offer scalable solutions adapted to the needs of municipalities, industrial operators and environmental agencies.

Overall, the project represents an important step towards the deployment of smarter, safer and more sustainable urban and industrial environments, creating a foundation for future commercial applications, collaborations and larger-scale deployments.

5.30 UoP - Panepistimio Patron

Exploitable Item 1: ETSI SDG OpenSlice

Description: An open-source, service-based Operations Support System (OSS) designed to deliver Network-as-a-Service (NaaS). OpenSlice is applicable to all project Use Cases and serves as the core of the resource orchestrator, also incorporating the policy engine. It adheres to TMF standards and is fully customizable, as well as open source.

Target users / markets: Mobile Network Operators (MNOs), system integrators, and researchers requiring a seamless, unified and standardized way to manage heterogeneous computational and network resources and services; organizations seeking highly interoperable OSS solutions compatible with controllers and drivers across different domains.

How UoP plans to exploit it:

Community promotion through ETSI's SDG OSL: Leverage UoP's leading role in the ETSI Software Development Group for OpenSlice to promote the tool within the standardisation community and related ecosystems, driving adoption among MNOs and integrators at a global scale.

Further R&D and research funding: Pursue additional funded research projects to continue development of OpenSlice and expand its capabilities as a reference implementation for network slicing and resource orchestration.

Open-source ecosystem engagement: Maintain and grow the open-source community around OpenSlice, positioning it as the go-to TMF-compliant OSS for network slicing, competing against OSM, ONAP, and Contrail through its openness and standards-based interoperability.

5.31 AUA - Geoponiko Panepistimion Athinon

Exploitable Item 1: AI-driven crop pest detection service

Description: An AI-driven service for the detection of crop pests using image-based analysis and machine learning methods. The service is intended to support earlier and more consistent identification of pest presence in agricultural settings and can be integrated into advisory, monitoring, or precision farming workflows. The current maturity level is TRL 7, indicating that the service has been demonstrated in an operationally relevant environment.

Target users / markets: Agricultural research institutions, agri-tech companies, crop protection advisors, precision farming service providers, and organizations developing digital agriculture or decision-support tools for crop monitoring.

How AUA plans to exploit it

Research exploitation and further validation: Use the service in ongoing and future research activities related to crop monitoring, pest management, and digital agriculture, while continuing validation under different crop, pest, and environmental conditions.

Licensing to relevant stakeholders: Explore licensing opportunities with agri-tech companies, crop protection service providers, and precision farming solution providers that may integrate the pest detection capability into their own platforms or advisory services.

Academic and open-source dissemination where appro*priate:* Make selected components, models, documentation, or research outputs available under an open-source or academic licence, where this is compatible with project obligations, data constraints, and protection of exploitable knowledge.

Exploitable Item 2: Autonomous UGV inspection platform

Description: An autonomous unmanned ground vehicle platform for agricultural inspection tasks. The platform is designed to support field-level monitoring and data collection in agricultural environments, contributing to precision farming and agricultural robotics applications. The current maturity level is TRL 6, indicating that the platform has been demonstrated in a relevant environment.

Target users / markets: Agricultural robotics companies, precision farming service providers, agricultural research institutions, and organizations developing autonomous systems or robotic inspection solutions for farming applications.

How AUA plans to exploit it

Research exploitation and technical improvement: Use the platform as a basis for further research in agricultural robotics, autonomous inspection, field monitoring, and precision agriculture, with further testing and refinement under realistic operating conditions.

Licensing to agricultural robotics and precision farming companies: Explore licensing or technology-transfer opportunities with companies active in agricultural robotics, autonomous field platforms, and precision farming services.

Collaboration with research and industry partners: Pursue collaborations with research institutions and industry actors to adapt the platform to specific inspection use cases, improve robustness, and assess potential integration with sensing, analytics, or farm management systems.

5.32 TOR - Universita Degli Studi Di Roma Tor Vergata

Tor Vergata's exploitation activity in COP-PILOT centres on its contribution to Cluster 3A (ATSI — AgriTech Transformation and Sustainability Initiative). Its primary technical contribution is the development of a miniaturised electrochemical sensor system for the continuous determination of oxalate — a key antinutrient in spinach — directly in the field. TOR's contribution addresses a gap in commercial precision agriculture that existing platforms do not cover: the real-time, field-level assessment of crop compositional quality as a complement to yield and phytosanitary monitoring.

Exploitable Item: Electrochemical Plant Wearable Sensor System for Oxalate Monitoring in Spinach Vegetables

Description: The TOR sensor system integrates two fit-for-purpose-built components. The first is a miniaturised screen-printed electrochemical sensor whose working electrode is functionalised with oxalate oxidase, an enzyme that catalyses the selective oxidation of oxalic acid, enabling highly specific, quantitative determination of oxalate concentration without the need for laboratory sample preparation. The second is a 3D-printed microneedle-based sampler coupled with a functionalised paper substrate engineered for minimally invasive extraction of spinach interstitial fluid directly from the plant tissue, providing a continuous and localised source of sample with minimal disruption to the crop. Together, the two components constitute a wearable, plant-attachable sensing unit capable of operating in field conditions and transmitting oxalate concentration data via the COP-PILOT IoT integration layer to the shared FMIS platform.

Target users / markets: The primary target market is the agri-food farming sector, particularly operators of leafy vegetable supply chains where oxalate content is relevant to nutritional labelling, and dietary health claims. In this regard, the most immediate targets are food processors and distributors with premium quality or health-positioning strategies.

Exploitation strategy

TOR's exploitation strategy operates along three complementary pathways.

The primary pathway is research exploitation and dissemination*.* TOR has already published three peer-reviewed papers establishing the scientific basis of the electrochemical sensing and microneedle sampling technology, and has presented the work at one international conference. These publications provide the scientific foundations needed to anchor subsequent transfer activities, and TOR will continue its dissemination activity order to build awareness and generate interest among both the research community and potential industrial partners.

The second pathway is device development. The core of TOR's exploitation vision is the development of a standalone analytical device integrating the 3D-printed microneedle-based paper sampler and the electrochemical sensor into a single, field-deployable unit. This device would allow direct, on-plant oxalate determination without laboratory infrastructure, making the technology accessible to agri-food operators, quality control services, and field agronomists.

The third pathway is validation analyses and AgroApps integration. The validated field deployment at Barba Stathis testbed constitutes the reference performance evidence needed to support the applicability of the developed analytical tool. AgroApps360 will be further integrated with the sensor analytical tool.

Exploitation actions already performed: During the first phase of the project, TOR's exploitation-related activities include: the development and full characterisation of the 3D-printed microneedle-based paper sampling device; the characterisation of the screen-printed electrochemical sensors and the initiation of measurements with the oxalate oxidase enzyme; preliminary on-site trials conducted directly at the Barba Stathis testbed, providing the first field-level evidence of system performance in an operationally representative agricultural environment; the publication of three peer-reviewed scientific papers establishing the technological and scientific basis of the sensing system; the presentation of results at one international conference.

5.33 DEI - DIMOSIA EPICHEIRISI ILEKTRISMOU ANONYMI ETAIREIA

DEI participates in COP-PILOT within Cluster 3E both as Aggregator and Retail Energy provider and as operator of fast EV charging stations in the Preveza area and along the local highways, contributing primarily to the use case on uninterruptible power supply and predictive maintenance for fast EV chargers, while remaining attentive to the broader cluster context related to active distribution grids and Distributed Energy Resources. From this participation, DEI expects two main exploitable items: (i) operational know-how on the application of edge intelligence and the COP-PILOT IoT-to-edge-to-cloud orchestration platform to EV charging infrastructure, with possible relevance, in a longer perspective, to other aggregation-related activities; and (ii) preliminary capabilities related to charger availability, predictive maintenance and charging-demand forecasting. Exploitation is envisaged along two complementary, non-binding directions. The internal direction explores how these capabilities could inform the gradual digitalisation of DEI's EV charging operations, supporting operational efficiency and the planning of field-maintenance activities, and could in the future feed into the wider digitalisation of DEI's aggregation-related processes. The external direction considers, subject to further analysis of the maturity of the technology and of market conditions, the possibility of leveraging these capabilities in value-added offerings addressed to e-mobility stakeholders, potentially aligned with Business Model #3 (Collaborative vertical sector services). Service-layer elements specific to DEI's operational context are expected to remain as proprietary know-how. All elements of this plan are preliminary and indicative, and may evolve in line with the maturity of the COP-PILOT results and with DEI's broader strategic priorities.

During the first half of the project, DEI's exploitation-related activities have remained at an exploratory level, consistent with the early stage of the work. They have included: contribution to the consortium-level discussions on exploitable assets and business models in the framework of WP7; internal mapping of the relevance of the EV-related use case to DEI's e-mobility activities and identification of the business unit acting as natural internal reference for follow-up; participation in the requirements and pilot-design activities) with attention to aspects that may later support exploitation, such as integration points with DEI's existing EV charging infrastructure; and informal monitoring of the regulatory and market context for e-mobility services in Greece. No commercial agreements, IPR filings or formal commitments have been undertaken at this stage. Exploitation considerations will be revisited as the project progresses and as the COP-PILOT results reach higher maturity.

5.34 BAR - Barmpa Stathis Monoprosopi Anonymi Viomichaniki Kai Emporiki Etairia

Barba Stathis' exploitable asset in COP-PILOT is the validated end-to-end digital integration of contract farming operations, combining Farm Management Information Systems (AgroApps360), AI-driven crop monitoring, blockchain-based traceability, and logistics orchestration within a real industrial environment in the Kilkis region. The system enables continuous monitoring of crop development, automated recording of cultivation practices, optimisation of harvest logistics, and the generation of auditable, tamper-proof traceability records from field to processing and distribution.

This integrated approach transforms traditional contract farming into a data-driven, transparent, and optimised supply chain, improving operational efficiency, compliance, and product differentiation.

Exploitable Item: Integrated Digital Contract Farming & Traceability Ecosystem

Target Users / Stakeholders

- Agri-food processors operating contract farming models
- Retailers and food service companies requiring traceability and sustainability verification
- Certification bodies and regulatory authorities

- Farming cooperatives and contract farmers
- Supply chain partners (logistics operators, distributors)
- Consumers (through enhanced transparency and provenance information)

Exploitation Plan: Barba Stathis will exploit COP-PILOT results through a combined operational, commercial, and strategic pathway, focusing on scaling and valorising the validated digital ecosystem across its production and supply chain activities.

At operational level, the company will integrate COP-PILOT technologies into its existing contract farming model, extending the Kilkis pilot deployment to additional crops, geographies, and farmer networks. This includes the systematic use of digital cultivation records, AI-assisted crop monitoring, and logistics optimisation tools to improve planning accuracy, reduce inefficiencies, and enhance coordination between farmers and processing facilities.

At commercial level, Barba Stathis will leverage the blockchain-enabled traceability and digital monitoring capabilities to strengthen its market positioning. The ability to provide verifiable, audit-ready data on cultivation practices, sustainability performance, and product provenance will support differentiation in retail markets, particularly in segments focused on quality, transparency, and sustainability. This may enable premium positioning, improved retailer partnerships, and alignment with emerging requirements such as digital product passports and traceability standards.

At compliance and regulatory level, the platform will be used to facilitate adherence to EU policies and market requirements, including CAP-linked sustainability practices, environmental footprint monitoring, and traceability obligations. Automated data collection and reporting will reduce administrative burden while ensuring readiness for audits and certifications.

At strategic and innovation level, Barba Stathis will use the knowledge and experience acquired through COP-PILOT to support future digital transformation initiatives and participation in European R&D projects. The company will explore opportunities to further develop advanced capabilities such as predictive agronomy, sustainability analytics, and supply-chain optimisation, while strengthening partnerships with technology providers (e.g., AgroApps, iLINK) to build a scalable digital ecosystem.

Finally, Barba Stathis will assess the potential to act as a reference case and early adopter for integrated agri-food digitalisation solutions, contributing to knowledge transfer, dissemination, and replication of the model in similar agri-food value chains across Europe.

5.35 BPO - Vioaerio Prevezas 1 Ike

Exploitable Item: Digitalised Biogas Plant Operations – Edge-Based Predictive Maintenance and Production Forecasting

Description: Through UC#3E.3, BPO's 2 MWe Preveza Biogas Plant in Western Greece, which turns organic waste into renewable electricity via anaerobic digestion, is upgraded with edge intelligence, predictive maintenance and digital-twin analytics. BPO uses the Edge EMS platform provided by ENIC and acts as the industrial host for the pilot, contributing its operational expertise to help customise the platform for the monitoring of its internal anaerobic digestion processes and putting the resulting insights and early-warning alerts to use in its day-to-day operations. The exploitable outcomes are twofold: improved internal plant operations enabled by edge-based predictive maintenance, and an electricity-generation forecasting capability that can support BPO's engagement with energy markets.

Target users / markets: Primarily BPO's own plant operations; secondarily, in a longer perspective and subject to market conditions, the wider community of biogas operators for know-how sharing, and energy market operators with whom BPO could engage as a more predictable renewable producer.

How BPO plans to exploit it: Exploitation is envisaged primarily along an internal direction focused on the gradual digitalisation of BPO's own operations, working on two levels. First, the capabilities can support the plant itself, helping to reduce unplanned downtime, stabilise biogas yield and improve cogeneration efficiency, and thereby strengthen the plant's profitability and reliability as a renewable asset. Second, the same capabilities can be used to produce more accurate electricity-generation forecasts. BPO will explore how through this forecasting capability it could interact with energy market operators and how it could better monetise this improved forecasting capability, subject to analysis of technology maturity and market conditions. Beyond its own operations, BPO will also investigate collaboration with other biogas operators for the sharing of operational know-how, with the aim of strengthening the biogas domain as a whole. BPO's own plant-specific operational practices are expected to remain proprietary.

Exploitation actions already performed: On the internal side, BPO has taken the first steps towards the digitalisation of its processes through the integration of the new sensors and ENIC's platform, and is now collecting valuable data that will feed the forecasting capabilities. On the collaboration side, BPO has already engaged other biogas owners for knowledge sharing through the 1st pilot of Cluster 3E, promoting knowledge sharing and the adoption of the proposed solution across the biogas industry.

5.36 AGA - Agricultural Applications Ike

AgroApps exploitation strategy in COP-PILOT is centred on the commercial development of AgroApps360, the company's Farm Management Information System, substantially enhanced through the integrations developed and validated within the ATSI cluster. COP-PILOT provides AgroApps with the operational environment to extend AgroApps360 beyond its current capabilities as a standalone FMIS and validate it as the hub of a fully integrated precision agriculture platform, connecting field sensing, AI-driven crop monitoring, blockchain-based traceability, and logistics coordination in a single orchestrated environment. The Barba Stathis contract farming network in Kilkis serves as the reference deployment, providing real-world validation at operational scale in a commercially representative contract farming context.

Exploitable Item: AgroApps 360 — Integrated Precision Agriculture FMIS

Description: AgroApps360 is a cloud-native Farm Management Information System deployed on Kubernetes infrastructure, serving as the operational hub through which agronomists and farmers manage the full cultivation cycle. Within COP-PILOT, the platform has been extended with four significant new capabilities: real-time computation of environmental footprint indicators including the Treatment Frequency Index, aggregated at farm and network level; integration with AI-driven pest detection alerts generated by UAV imagery analysis, delivered as structured advisory inputs to the platform's decision-support layer; connectivity with a Hyperledger Fabric permissioned blockchain for automated recording of cultivation events as part of an end-to-end supply-chain traceability chain; and integration with PowerFleet logistics signals for harvest dispatch coordination. Together, these integrations transform AgroApps360 from a farm-level recording tool into a network-level management and compliance platform.

Target users / markets: The primary target market is agri-food processors and distributors operating contract farming models, with a focus on the fresh and processed vegetable sector in Greece and across EU markets, including Cyprus, Bulgaria, Italy, and Spain. Secondary target groups include farming cooperatives seeking integrated digital management and CAP digital compliance tools, agricultural advisory organisations requiring network-level crop monitoring and advisory platforms, and certification and traceability service providers looking for FMIS platforms with native blockchain connectivity.

Exploitation strategy: AgroApps will pursue a commercial SaaS exploitation pathway, offering the enhanced AgroApps360 platform under a subscription licensing model to agri-food businesses and cooperative networks. The Barba Stathis deployment provides the reference case that anchors the commercial proposition: a validated, operational integration of precision crop monitoring, digital activity recording, environmental footprint computation, and blockchain traceability across a contract farming network of meaningful commercial scale. This reference case will be the primary instrument for market development, supporting direct outreach to comparable agri-food processors across Greece and EU member states.

The regulatory environment actively supports this strategy with CAP Strategic Plans across EU member states increasingly link agri-environment payments and eco-scheme eligibility to the use of digital farm management tools and the generation of electronic cultivation records. AgroApps360, as validated in the ATSI cluster, provides exactly the capability these frameworks require: automated recording of cultivation activities, real-time treatment frequency tracking, and audit-ready compliance documentation. AgroApps will engage directly with CAP managing authorities, agronomist networks, and farmer advisory services to position the platform as a practical instrument for digital compliance under the current and forthcoming CAP programming periods.

Beyond direct commercial exploitation, AgroApps will pursue a partnership development strategy with the complementary technology providers validated within the ATSI cluster. The integration architecture developed with AUA for AI pest detection alerts, with iLink for blockchain traceability connectivity, and with the COP-PILOT orchestration infrastructure provides reusable integration patterns that AgroApps will package as a certified partner ecosystem for precision agriculture deployments. This ecosystem model reduces the integration cost for new customers and positions AgroApps360 as the management layer in a broader multi-vendor precision agriculture stack rather than a standalone tool competing against larger proprietary platforms.

AgroApps will also leverage COP-PILOT results to strengthen its position in follow-on EU-funded research and innovation projects. The validated operational architecture, the reference deployment at Barba Stathis, and the integration know-how developed across the ATSI consortium provide a strong foundation for participation in Horizon Europe calls addressing precision agriculture, agri-food supply chain digitalisation, and sustainable farming practice. These future project activities will serve both to extend the platform's technical capabilities and to develop new market partnerships across European agri-food ecosystems beyond the current cluster geography.

Exploitation actions already initiated: As a commercial entity AgroApps has already put into place a number of actions aiming to prepare the ground for post-project commercial exploitation:

- AgroApps360 is an operational commercial product with an existing customer base in Greece, providing a market-ready foundation for the enhanced version validated through COP-PILOT.
- The ATSI cluster deployment at Barba Stathis is actively serving as a live validation environment for the enhanced platform capabilities, generating operational evidence and reference material for commercial outreach.

- Preliminary alignment of the COP-PILOT integration architecture with AgroApps commercial product roadmap has been initiated, identifying the specific enhanced features to be packaged for the post-project commercial release.
- Engagement with Barba Stathis on the potential continuation of the integrated platform deployment beyond the project period is under discussion, with the objective of establishing the first post-project reference customer relationship.

5.37 PNET - P-NET ANADYOMENA DIKTYA NEAS GENIAS & EFARMOGES IDIOTIKI KEFALAIOUCHIKI ETAIREIA

P-NET is a Competence Centre for Emerging Smart Networks and Services, incorporated in the region of western Greece. It is a public-private partnership and involves 21 shareholders representing industrial and business sectors, research and academia, public authorities, consulting and entrepreneurship support companies. The mandate of P-NET is to prepare the business and civic worlds for the introduction and wide uptake of emerging innovations in Smart Networks and Services (SNS). P-NET aims to empower selected sectors of the Greek economy, through a) the provision of specialized and innovative services and solutions and b) technology transfer and capacity building to businesses, especially SMEs.

Exploitable Item: PNET pre-commercial testbed. P-NET's operations and services are centered around knowledge and technology transfer and include research and development of business solutions, experimentation and pilot testing in advanced lab infrastructure and experimental facilities, upskilling and reskilling training on topics relevant to telecoms and the element of smartness in networks and services. The Centre also aims to create awareness and offer consulting services to public authorities and businesses and mentoring start-ups.

Within this context, P-NET's exploitation plans for COP-PILOT domain components integrated in the testbed, focus around: 1) extending the Centre's know-how and experimental capabilities in Beyond 5G and 6G systems including IoT and data exposure, 2) extending R&I activity on multiple 5G/6G and IoT aspects and raise additional R&I funding, 3) creating and delivering relevant capacity building programs, 4) implementing awareness building activities to strengthen P-NET's visibility and 5) developing collaborations and partnerships and possibly new business models to facilitate exploitation of technology innovations in real commercial environments.

5.38 ILINK - Ilink Nees Texnologies OE

Exploitable Item: PowerFleet for Agri-food — Logistics and Fleet Dispatch Platform

Description: PowerFleet for Agri-food is iLINK's commercial logistics and fleet-dispatch platform, deployed in Cluster 3A as a Kubernetes-orchestrated service. The platform combines a Java backend, a meta-heuristic Vehicle Routing Problem (VRP) solver inspired by the Jsprit library, and OpenAPI 2.0 service interfaces with a web and mobile driver UI. Within COP-PILOT, PowerFleet has been extended in three significant ways: (i) **Orion-LD-triggered auto-dispatch**, where the platform pulls FMIS harvest events from the FIWARE Orion-LD context broker and automatically generates and dispatches a vehicle assignment to the field; (ii) **continuous freshness-aware re-routing**, where once the vehicle is en route, PowerFleet continuously re-optimises the active route as new context (additional pickups, traffic, delivery-window changes) becomes available; and (iii) **blockchain-authorised provenance writing**, where PowerFleet acts as the authorised writer to the Hyperledger Fabric traceability channel, recording chain-of-custody events for each leg of the supply chain. For the post-processing distribution leg — from the Barba Stathis IQF facility to retail points of sale, where the spinach has already been processed and packaged for the end consumer — Raspberry Pi 5 nodes mounted inside refrigerated trucks transmit in-cabin temperature readings over public 5G directly to the PowerFleet platform. PowerFleet consolidates these readings with the rest of the operational context to verify cold-chain integrity all the way to the end consumer. The PowerFleet platform itself runs behind an OpenZiti zero-trust overlay on the server side.

Target users / markets: Agricultural cooperatives and contract-farming networks coordinating multi-vehicle harvest operations; food processors operating in-house distribution fleets between processing facility and retail (such as Barba Stathis distributing chilled, packaged spinach products to the Greek and export markets); third-party logistics operators specialising in agri-food perishables and cold-chain distribution to retail; regulated freight operators needing eFTI-aligned electronic chain-of-custody records.

How iLINK plans to exploit it:

- **Commercial Routing-as-a-Service (RaaS) licensing:** Offer PowerFleet for Agri-food as a per-vehicle SaaS subscription with two tiers — a standard tier (routing and tracking) and a premium tier that adds Orion-LD context integration, in-truck temperature telemetry for chilled distribution, and blockchain-attested chain-of-custody. Validated KPI evidence from the Kilkis-to-Sindos and Sindos-to-retail pilots will support direct B2B sales to agri-food cooperatives and processors in Greece and Southern Europe.

- **eFTI-ready positioning:** Position PowerFleet as a first-mover Greek platform able to bridge national digital freight tracking (myDATA e-Delivery / eMARK) with the EU eFTI common data set ahead of the 9 July 2027 mandatory acceptance deadline.

- **Standards engagement:** Engage with ITS Hellas (where iLINK's CEO holds the Vice President role) and with ETSI TC DATA to align PowerFleet's freshness-aware routing API with emerging cross-modal logistics interoperability standards.

Exploitation actions already performed: iLINK has deployed the platform on a production Kubernetes cluster with full ArgoCD GitOps automation, OpenSlice service orchestration, and OpenZiti zero-trust networking on the server side, and has executed the first end-to-end logistics trigger during the Autumn/Winter Spinach Season 2025–2026 Farm Pilot. The Orion-LD-triggered auto-dispatch and continuous re-routing pipeline is operational across the Sindos pilot area, and the in-truck temperature telemetry pipeline for the distribution leg is feeding live data into PowerFleet. iLINK has secured a dissemination engagement at the CEI-Sphere Deep-dive AgriTech Workshop on Interoperability (26 May 2026) and is preparing further presentations at ITS Hellas (UC3A.4 angle) and Linux Foundation Decentralized Trust events (UC3A.3 angle) during Period 2.

Exploitable Item: Blockchain-based Agri-food Traceability

Description: iLINK's blockchain-based traceability solution is built on a Hyperledger Fabric permissioned network deployed on Kubernetes with an Istio service mesh for data-plane isolation. The deployment uses Raft consensus for ordering and the Chaincode-as-a-Service (CCaaS) pattern, with the AssetContract chaincode implemented in Go using the official fabric-contract-api-go library and exposed over gRPC. A single shared channel hosts the traceability ledger across the participating organisations (AgroApps, Barba Stathis and iLINK). The architectural choice to keep Fabric **decoupled** from FIWARE NGSI-LD — with PowerFleet acting as the authorised writer — avoids the structural integration tension common to blockchain-plus-IoT-broker deployments and keeps each data plane optimised for its purpose. The chaincode application is currently under active implementation, with full functional completion targeted for September 2026 (M21).

Target users / markets: Food producers and processors operating in premium, organic, or PDO/PGI market segments where verifiable chain-of-custody supports market access; retailers and food-service operators implementing supplier-side traceability requirements; certification bodies and auditors needing tamper-resistant evidence of cultivation and handling events; regulators and consumer-facing platforms preparing for the EU Digital Product Passport rollout in agri-food.

How iLINK plans to exploit it:

- **Commercial licensing to food producers and retailers:** Offer the traceability service on a per-supply-chain subscription basis, with bundled options for cultivation-event recording, cold-chain attestation, and consumer-facing QR-linked records.
- **Integration with certification schemes:** Package the solution as a back-end attestation layer for existing food certification schemes (organic, PDO/PGI, sustainability labels), reducing the cost and friction of audit evidence collection.
- **Digital Product Passport readiness:** Position the platform as a DPP-ready provenance back-end aligned with the EU Digital Product Passport initiative as it extends to agri-food.
- **Standards engagement:** Contribute the multi-org deployment pattern to the Linux Foundation Decentralized Trust community as a reference implementation for agri-food consortia, where appropriate co-authored with Barba Stathis and AgroApps.

Exploitation actions already performed: iLINK has deployed and operates the full Hyperledger Fabric infrastructure (peers, orderers, certificate authorities) across two active organisations, with onboarding of the third organisation planned for M21. The CCaaS chaincode pattern has been finalised and the blockchain application is in active implementation. iLINK has contributed traceability-specific exploitable items to the Cluster 3A Blueprint (D3.1), MS4.1, the D7.1 events table, and the project-wide Exploitation Strategy, and will present the architecture pattern at Linux Foundation Decentralized Trust events during Period 2.

5.39 ENIC - Enakronik Katanemimenes Lyseis Technitis Effyias IKE

Exploitable Item: ENIC Edge EMS – Multi-Domain Energy Management System

Description: A commercial edge computing platform that provides end-to-end energy asset management across heterogeneous DER domains. Within COP-PILOT Cluster 3E, the Edge EMS has been extended with two domain-specific application modules/features — a Biogas Management App and an EV Charger Management App, both running on a shared FIWARE NGSI-LD data fabric orchestrated via OpenSlice/Maestro. The platform additionally integrates a structured signal ingestion system for receiving and executing control signals from aggregators and DSOs, enabling connected DER assets to participate in flexibility markets.

Target users / markets: Biogas plant operators and EV charging network operators seeking to transition from manual or SCADA-based operations to AI-driven, edge-resident predictive management; energy aggregators and DSOs requiring standardised, auditable DER participation interfaces for local flexibility markets; multi-asset prosumer communities and energy service companies managing heterogeneous DER portfolios.

How ENIC plans to exploit it:

- **Commercial product licensing:** Offer the Biogas and EV Charger application modules as licensable add-ons to the core Edge EMS on a per-site SaaS subscription basis, leveraging validated KPI evidence from the Cluster 3E pilots to support direct B2B sales to energy asset operators in Greece and Southern Europe.

Exploitation actions already performed: ENIC has already established strategic partnerships with facility owners operating multiple energy assets outside the scope of the project, including biogas production sites and EV charging infrastructure operators. These partnerships provide a pre-qualified pipeline of deployment targets for the Edge EMS platform upon project completion, significantly reducing time-to-market for the first commercial rollout.

5.40 RZ - Redzinc Services Limited

Exploitation item: Circular IoT sensor lifecycle and EU wallet traceability platform

Short description: A circular IoT lifecycle management solution for monitoring, maintaining, reusing and recycling IoT sensors deployed in vineyard, agri-food and other distributed operational environments. The solution combines an IoT Sensor Platform for lifecycle monitoring and recycling workflow management with an EU wallet-based traceability layer, enabling sensor identity, operational status, maintenance history, reuse events and recycling outcomes to be securely recorded. It is designed to integrate with COP-PILOT components such as FIWARE/NGSI-LD data models, Secure Integration Fabric, DataOrch and Kubernetes-based deployment mechanisms.

Target users / stakeholders: Vineyard and winery operators, agri-food companies deploying IoT sensor networks, IoT device manufacturers, sensor maintenance and calibration providers, recycling and refurbishment companies, logistics operators, healthcare and industrial organisations managing reusable IoT equipment, and public or private actors interested in circular economy, e-waste reduction and trusted device traceability.

Exploitation plan: RedZinc will exploit this solution as a configurable service offering for organisations that need to manage fleets of reusable IoT sensors and demonstrate traceability across the device lifecycle. Planned exploitation actions include:

- Repackaging the IoT recycling platform and EU wallet concept as a modular lifecycle-management service, adaptable to vineyards, healthcare, industrial IoT and other sensor-intensive environments.
- Offering integration and deployment services for clients requiring sensor monitoring, maintenance workflows, replacement triggers, refurbishment tracking, or recycling traceability.
- Using the UC4.1 pilot results as a demonstrable reference case for circular IoT management, highlighting benefits such as reduced electronic waste, extended sensor lifetime, improved logistics coordination and stronger compliance/auditability.
- Exploring commercial collaboration with IoT manufacturers, recycling companies and logistics providers to create end-to-end service models for sensor recovery, reuse and responsible disposal.
- Leveraging COP-PILOT outcomes, especially FIWARE interoperability, EU wallet traceability and secure data exchange, to position the solution for future European innovation projects, agri-food digitalisation programmes and sustainability-focused funding opportunities.

5.41 JIG - J.I.G. Internet Consulting SL

Exploitation item: Smart production line monitoring solution

Short description: A real-time monitoring solution for industrial production lines, built on a FIWARE architecture (IoTAgent, Orion Context Broker, QuantumLeap, CrateDB) with NGSI-LD data normalisation. It integrates physical IoT sensors on production machines (ABB robots, labellers, capsulers, sealers), ERP/MES APIs, and manual operator inputs for OEE tracking, deployed as a unified Helm chart via OpenSlice on the JIG server.

Target users / stakeholders: Industrial production line operators (food & beverage, manufacturing), IoT system integrators, organisations requiring OEE monitoring and predictive maintenance capabilities, SMEs in the European agri-food sector.

Exploitation plan: JIG will exploit this solution as a replicable product and service offering industrial environments beyond the wine sector. Planned exploitation actions include:

- Repackaging the solution as a configurable commercial offering for different types of production lines (food & beverage, light manufacturing), reusing the FIWARE architecture and integration patterns validated in UC4.3.
- Offering integration and deployment services to industrial clients requiring OEE monitoring, production traceability or integration with existing ERP/MES systems.
- Using the UC4.3 pilot results as a demonstrable reference case (operational cost reduction, energy savings, monitoring automation) in commercial and marketing activities targeting European industrial customers.

Exploring opportunities in future European and national innovation programmes where the solution can be validated in new vertical sectors or extended with predictive maintenance capabilities.

5.42 KUL - Kingston University

Name of Exploitable Item: Multi-Dimensional KPI-to-KVI Evaluation Methodology for Sustainable Cloud-Edge-IoT

Short description: Developed by KUL, this conceptual evaluation methodology provides the rigorous scientific "engine" to assess the multi-dimensional impact of the COP-PILOT platform. The methodology defines the formal mapping mechanisms required to translate raw, technical Key Performance Indicators (KPIs) into broader Key Value Indicators (KVIs). KUL's specific focus within this framework is on modelling the **societal impact and environmental sustainability** dimensions. By creating a standardized, scientifically validated approach to measuring deep-tech deployments, this methodology directly supports Europe's Industry 5.0 objectives and the Twin Transition (digital and green).

Target users/stakeholders:

- **The Academic & R&I Community:** Researchers in sustainable computing, distributed systems, and data-driven impact assessment who require a validated, peer-reviewed methodology for evaluating decentralized computing environments.

- **Scientific & Technical Pilot Leads (Internal Consortium):** Technical leads across the Smart Cities, Energy, Agriculture, and Mining clusters who need structured models to scientifically measure their environmental and societal baselines and improvements.

Exploitation plan: KUL will exploit this methodology primarily through scientific advancement, open science, and further R&D funding:

- **Academic Dissemination (Conferences & Journals):** The primary pathway is establishing peer visibility and scientific consensus. KUL will present the foundational methodology and empirical validation data from the COP-PILOT pilots at prominent international conferences (e.g., ECIS, ICIS) and publish in high-impact, open-access journals (e.g., JIQ, EurOMA).
- **Further Academic Research & Grant Capitalization:** The methodology will serve as a core intellectual asset for KUL's future grant pipeline. It will be used to anchor subsequent proposals for national funding and Horizon Europe R&I calls (e.g., Cluster 4: Digital, Industry and Space), specifically positioning KUL as a leader in sustainable digital transition metrics.

5.43 D4P - Digital For Planet-D4P

Short description: Open Call and Cascade Funding Management Framework, including methodologies, procedures, evaluation processes, stakeholder engagement practices, and tools for the design and implementation of innovation support programmes targeting SMEs and start-ups.

Target users/stakeholders: European projects implementing cascade funding schemes, public authorities, innovation agencies, Digital Innovation Hubs, SMEs, start-ups, research organisations, and funding bodies.

Exploitation plan: D4P will leverage the expertise and methodologies developed during the project to strengthen its position as a key expert in cascade funding and innovation management. The knowledge acquired will be integrated into D4P's consulting portfolio and offered as a service to future European and national projects requiring the design and management of open calls. The developed methodologies and best practices will be transformed into reusable frameworks and operational toolkits, enabling D4P to support innovation ecosystems and maximise the impact of funding programmes beyond the project's lifetime.

Exploitable Item 2

Short description: Innovation management methodologies and stakeholder engagement approaches supporting the adoption of secure, energy-efficient, and cognitive computing infrastructures across cloud, edge, and IoT environments.

Target users/stakeholders: Technology providers, SMEs, start-ups, public administrations, research organisations, digital innovation ecosystems, and future collaborative research initiatives.

Exploitation plan: D4P will incorporate the knowledge and methodologies generated by the project into its innovation management and business development services. The project outcomes will be used to expand D4P's expertise in digital technologies, AI, cloud-edge computing, and data ecosystem processing, supporting future consulting activities and participation in European and international innovation initiatives. The acquired know-how will strengthen D4P's capacity to facilitate technology uptake and collaboration among stakeholders in emerging digital markets.

Co-funded by the European Union

Exploitable Item 3

Short description: Dissemination, communication, and community-building methodologies, including digital media strategies, public outreach approaches, liaison activities with sister projects, and stakeholder engagement practices.

Target users/stakeholders: European projects, research organisations, innovation communities, public authorities, industry stakeholders, and communication professionals.

Exploitation plan: D4P will exploit the dissemination and communication experience gained through the project to enhance its media, outreach, and stakeholder engagement services. The approaches developed for digital communication, community building, and collaboration with sister projects and Coordination and Support Actions (CSAs) will be integrated into future projects and consulting activities. These capabilities will support the creation of new business opportunities in communication and innovation promotion while increasing D4P's visibility as a trusted partner in European research and innovation ecosystems. Exploitation of Knowledge and Skills Acquired Beyond the specific exploitable items, D4P will exploit the knowledge, skills, and networks acquired throughout the project to strengthen its leadership in data ecosystem processing and digital innovation management. The project will enable D4P to expand its service portfolio with new consulting offerings related to innovation management, cascade funding, stakeholder engagement, and digital transformation. Furthermore, the collaborations established with project partners, sister projects, and wider stakeholder communities will be leveraged to develop future research and business opportunities, ensuring the long-term sustainability and valorisation of the project's results.

5.44 TER - Terraview GMBH

Exploitable item: Aquaview soil moisture estimation map to manage irrigation

Short description: Aquaview is an AI-powered soil moisture monitoring platform developed by Terraview that combines satellite Earth Observation data, weather information, soil characteristics, and machine learning models to generate high-resolution soil moisture maps and forecasts. Physical soil moisture sensors are incorporated as calibration and validation inputs to further improve accuracy. This solution helps farmers to manage their irrigation plan and reduce waste of water.

Target users/stakeholders: Commercial vineyard managers, estate winemakers, large grape cooperatives, agricultural consultants, and wine industry supply chain managers.

Exploitation plan: The developed tool will be exploted as a scalable B2B Software-as-a-Service (SaaS) subscription model with tiered subscription fees calculated as a fixed rate in $/ha per year based on monitored vineyard acreage. Custom API access is available under an enterprise license for seamless integration into winery resource planning (ERP) systems used by large-scale wine conglomerates.

We'll target as early adopters large-scale commercial grape growers, multi-estate wine producers, and progressive agricultural cooperatives in major European wine regions who want to improve irrigation planning thanks to data-driven tools. They will be reached through pilot demonstrations, regional viticulture showcases, and the COP-PILOT project's dissemination networks.

Terraview (TERRA) will act as the primary owner and lead commercializing partner for the market roll-out. Cross-KER commercial packaging opportunities will be explored with consortium technology and platform partners.

5.45 NOKIA

NOKIA's exploitation strategy in COP-PILOT is focused on the technical and commercial expoitation of 5G private network capabilities, network-exposed APIs like NAC, and AI-enabled service innovation for agriculture and green energy environments. Through its work in COP-PILOT, NOKIA is consolidating exploitable assets at three complementary levels: (i) 5G infrastructure management for agricultural deployments, (ii) energy management for green energy sites, and (iii) AI-driven energy saving through smart agro applications.

Main exploitable results

Exploitable Item 1: 5G Infra Management API for Agriculture

Description: The 5G Infra Management API for Agriculture enables the monitoring, management, and integration of 5G private network infrastructure deployed in agricultural environments. It provides access to network-related capabilities that can support the supervision of connectivity assets, operational status, service availability, and infrastructure conditions across IoT connected farms and rural deployments. The API is designed to help expose relevant 5G network functions to agricultural platforms, allowing them to interact with the underlying private network as part of broader digital farming and automation workflows.

Target users / markets: Agricultural technology providers, farm operators, private 5G network operators, system integrators, rural connectivity providers, precision agriculture platforms, and organisations deploying digital infrastructure in farming environments.

How NOKIA plans to exploit it: NOKIA will exploit the 5G Infra Management API for Agriculture by positioning it as a reusable network-exposure capability for private 5G deployments in the agricultural sector. The API and related integration know-how developed in COP-PILOT will support future commercial and R&D activities involving smart farming, connected machinery, sensor networks, remote operations, and edge-enabled agricultural services. NOKIA will also use the experience gained in the project to strengthen its portfolio of private wireless solutions for vertical industries, demonstrating how 5G infrastructure can become an active enabler of agricultural digitalisation rather than only a connectivity layer.

Exploitable Item 2: 5G Energy Management API for green energy sites

Description: The 5G Energy Management API for green energy sites enables the exposure and use of network-enabled capabilities to support the monitoring and optimisation of energy-related operations in renewable energy environments with 5G infrastructure private networks. It can facilitate the integration of 5G private networks with energy management platforms, allowing operational data, connectivity status, and site-level information to contribute to more efficient supervision of green energy assets. The API is intended to support digital services for sites such as solar farms, wind farms, hybrid energy facilities, or remote energy installations where reliable private connectivity and operational intelligence are required. The system supports also functions to switch on or off infrastructure and devices for saving energy.

Target users / markets: Renewable energy operators, green energy site managers, energy technology providers, utilities, private network operators, system integrators, infrastructure managers, and organisations seeking to digitalise distributed energy assets.

How NOKIA plans to exploit it: NOKIA plans to exploit the 5G Energy Management API for green energy sites by reusing the API concepts, integration patterns, and network-exposure mechanisms developed in COP-PILOT in future solutions for renewable energy and industrial private networks. This exploitable asset will support NOKIA's ability to offer 5G-enabled management capabilities for energy sites, helping customers improve operational visibility, automate monitoring, and integrate connectivity data into energy optimisation workflows. The results will also contribute to NOKIA's broader strategy of enabling sustainable digital infrastructure through private wireless, edge computing, and API-based service innovation.

Exploitable Item 3: 5G Smart Agro API for AI driven energy saving

Description: The 5G Smart Agro API for AI driven energy saving combines 5G network capabilities, agricultural data, and AI-based optimisation mechanisms to support energy-efficient operations in smart farming environments. The API is designed to enable AI-driven recommendations, predictions, or control actions that can reduce energy consumption associated with agricultural processes, connected devices, sensors, irrigation systems, edge applications, or private network operations. By connecting agro-operational data with 5G-enabled service capabilities, the API supports more sustainable and intelligent management of agricultural resources.

Target users / markets: Smart agriculture platforms, precision farming providers, farm operators, agri-food companies, energy optimisation solution providers, private 5G network operators, system integrators, and organisations focused on reducing energy consumption in digital farming environments.

How NOKIA plans to exploit it: NOKIA will exploit the 5G Smart Agro API for AI driven energy saving by using it as a foundation for future AI-enabled services that combine private 5G connectivity, edge intelligence, and sustainability-oriented optimisation. The asset will help NOKIA demonstrate how 5G networks can support not only connectivity and automation, but also energy-aware decision-making in agricultural environments. The knowledge generated in COP-PILOT will be reused in future commercial projects, pilots, and vertical solutions where AI, 5G network exposure, and operational data are combined to reduce energy consumption, improve efficiency, and support greener digital transformation in agriculture.

6 CONCLUSIONS

This interim exploitation deliverable (D7.2) reflect work curried out within the Agreement Phase of the COP-PILOT exploitation strategy. It documents the consortium's progress from preliminary asset identification to evidence-based exploitation planning and establishes the baseline from which the final exploitation phase will proceed towards D7.4 at Month 36.

SUMMARY OF KEY OUTPUTS

The Agreement Phase has produced the following primary outputs, that has been reported in this deliverable.

A validated and updated catalogue of exploitable results, comprising platform-level open-source components and cluster-level vertical application assets across five industry domains, each characterised by ownership, licensing, TRL trajectory, exploitation type, and target market.

A comprehensive market analysis for the COP-PILOT platform and for each of the five vertical clusters, providing evidence-based grounding for commercialisation decisions and confirming the existence of substantial and growing addressable markets across all domains.

Opportunities and challenges were identified for COP-PILOT platform and the five clusters to help define viable exploitation pathways and shape strategies that can make use of strengths while reducing risks. This activity will provide owners of exploitable results a clearer basis for deciding what to pursue, what to delay, and what needs mitigation before resources are committed.

An IPR management framework that maps the relevant European regulatory instruments — including the Horizon Europe Regulation, Software Directive, Database Directive, Data Act, AI Act, and GDPR — to the specific outputs generated within COP-PILOT, providing partners with a structured basis for IP protection and exploitation decisions.

Individual exploitation plans for all 44 consortium partners, covering both industrial commercialisation routes and academic/research exploitation pathways, and reflecting the diverse business profiles and strategic priorities within the consortium.

Application of the Hourglass Model across all five clusters, providing a consistent framework for visualising stakeholder and capability layer interactions and for positioning COP-PILOT outputs within their respective market ecosystems.

At the mid-point of the project, exploitation activities are at different stages of maturity across the consortium. Industrial partners with commercial products already on the market — including AgroApps, iLINK, HOSCH, ThingWave, Predge, RockSigma, ENIC, and JIG — have the most advanced individual exploitation plans, with early commercial deployments, reference customers, and defined go-to-market strategies. Research and academic partners — including LTU, RISE, AUA, TOR, ICCS, UBRAD/KUL, and UoP — are actively exploiting results through publications, open-source contributions, and follow-on research funding.

Platform-level component owners — particularly UBITECH (HypO), UoP (OpenSlice), TATA (OpenZiti SIF), and AGE (Business Management Portal) — are pursuing a combined open-source community building and commercial outreach strategy, leveraging COP-PILOT's large-scale, multi-cluster validation as a reference environment for their solutions.

Several partners are already engaged in dissemination and standards activities that support exploitation, including ETSI standardisation contributions (UoP, UBITECH), community engagement with Linux Foundation Decentralized Trust (iLINK), ITS Hellas engagement (iLINK), and participation in sector-specific ecosystems (AgroApps, Barba Stathis, OTE, TID).

The market analyses confirm that COP-PILOT's outputs are well positioned within growing and strategically important markets. European regulatory tailwinds — the AI Act, Data Act, CSRD, CAP digitalisation agenda, and the EU's energy and sustainability frameworks — reinforce demand for exactly the types of interoperable, trustworthy, and open digital infrastructure that COP-PILOT provides. The project's alignment with ETSI standards, FIWARE, Linux Foundation, and European data space initiatives positions it strongly within the broader European open-source and standards ecosystem.

OUTLOOK TOWARDS D7.4

The final exploitation deliverable, D7.4, will be produced at Month 36 following the completion of the project's piloting and validation activities. It will contain the outputs of the Final Exploitation Phase, including:

- Finalised individual exploitation plans for all partners, incorporating lessons learned from piloting and validation activities.
- Detailed joint exploitation plans for partner clusters with shared exploitation interests in specific results or market segments.
- SWOT analyses and gap analyses for the COP-PILOT platform and each cluster, benchmarked against competing and complementary solutions.
- Business Model Canvases for key exploitable results, with defined value propositions, revenue streams, and go-to-market strategies.
- Long-term sustainability projections (up to five years post-project) for each identified exploitation pathway.
- A consolidated go-to-market strategy for the COP-PILOT open platform.

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