



D2.2: COP-PILOT ARCHITECTURE AND FUNCTIONALITIES

ANNEX 1: COP-PILOT SERVICE MODEL ECOSYSTEM AND COP-PILOT SERVICE MODEL ECOSYSTEM AND REQUIREMENTS

This annex explores how value and engineering dimensions drive EU industry adoption, outlining supplier and customer roles alongside the technical foundations for sustainable impact, with detailed service requirements available in D2.1 ANNEX 8.

D2.2: COP-PILOT Architecture and Functionalities

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Authors	NETCOMPANY-INTRASOFT SA (INTRA) NOVA TELECOMMUNICATIONS & MEDIA SINGLE MEMBER SA (NOVA) ORGANISMOS TILEPIKOINONION TIS ELLADOS OTE AE (OTE) TATA COMMUNICATIONS (UK) LTD (TATA) GIOUMPITEK MELETI SCHEDIASMOS YLOPOIISI KAI POLISI ERGON PLIROFORIKIS ETAIREIA PERIORISMENIS EFTHYNIS (UBI) ONE SOURCE CONSULTORIA INFORMATICA LDA (ONE) SUITE5 DATA INTELLIGENCE SOLUTIONS LIMITED (SUITE5) AGENTScape AG (AGE) AXON LOGIC IDIOTIKI KEFALAIOUXIKI ETAIREIA (AXON) KONNEKT ABLE TECHNOLOGIES LIMITED (KON) INCITES CONSULTING SA (INC) ARTHUR'S LEGAL BV (ARTHUR) EREVNITIKO PANEPISTIMIAKO INSTITOUTO SYSTIMATON EPIKOINONION KAI YPOLOGISTON (ICCS) UNIVERSITY OF BRADFORD (UBRAD) INSTITUTO PEDRO NUNES ASSOCIACAO PARA A INOVACAO E DESENVOLVIMENTO EM CIENCIA E TECNOLOGIA (IPN) FIWARE FOUNDATION EV (FIWARE) DIGITAL FOR PLANET-D4P (D4P) LULEA UNIVERSITY OF TECHNOLOGY (LTU) RISE RESEARCH INSTITUTES OF SWEDEN AB (RISE) HOSCH FÖRDERTECHNIK RECKLINGHAUSEN GmbH (HOSCH) THINGWAVE AB (TAB) PREEDGE AB (PAB) ROCKSIGMA (ROC) LTU BUSINESS AB (LTUB) UNIVERSITAT POLITECNICA DE VALENCIA (UPV) FUNDACION DE LA COMUNIDAD VALENCIANA PARA LA INVESTIGACION, PROMOCION Y ESTUDIOS COMERCIALES DE VALENCIAPORT (VPF) TELEFONICA INNOVACION DIGITAL SL (TID) NESPRA (NES) 5G COMMUNICATIONS FOR FUTURE INDUSTRY VERTICALS SL (FIVE) FUNDACION DE LA COMUNITAT VALENCIANA PARA LA PROMOCION ESTRATEGICA EL DESARROLLO Y LA INNOVACION URBANA (VCH) AYUNTAMIENTO DE ALMUSSAFES (ALM) PANEPISTIMIO PATRON (UoP) AGRICULTURAL UNIVERSITY OF ATHENS (AUA) UNIVERSITA DI ROMA "TOR VERGATA" (TOR) DIMOSIA EPICHEIRISI ILEKTRISMOU ANONYMI ETAIREIA (DEI) MPARMPA STATHIS ANONYMI VIOMICHANIKIKAI EMPORIKI ETAIRIA (BAR) BIOGAS PREVEZA ONE PC (BPO) AGRICULTURAL APPLICATIONS IKE (AGA) P-NET NEW GENERATION EMERGING NETWORKS & VERTICALS PRIVATE COMPANY (PNET) ILINK NEES TEXNOLOGIES OE (ILINK)

ENAKRONIK- KATANEMIMENES LYSEIS TECHNITIS EFFYIAS P.C.
(ENIC)
REDZINC SERVICES Ltd (RZ)
J.I.G. INTERNET CONSULTING SL (JIG)
TERRAVIEW GMBH (TER)

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* R: Document, report (excluding the periodic and final reports)
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COP-PILOT SERVICE VALUE MODEL ECOSYSTEM AND COP-PILOT SERVICE MODEL ECOSYSTEM REQUIREMENTS

INTRODUCTION TO COP-PILOT SERVICE VALUE MODEL

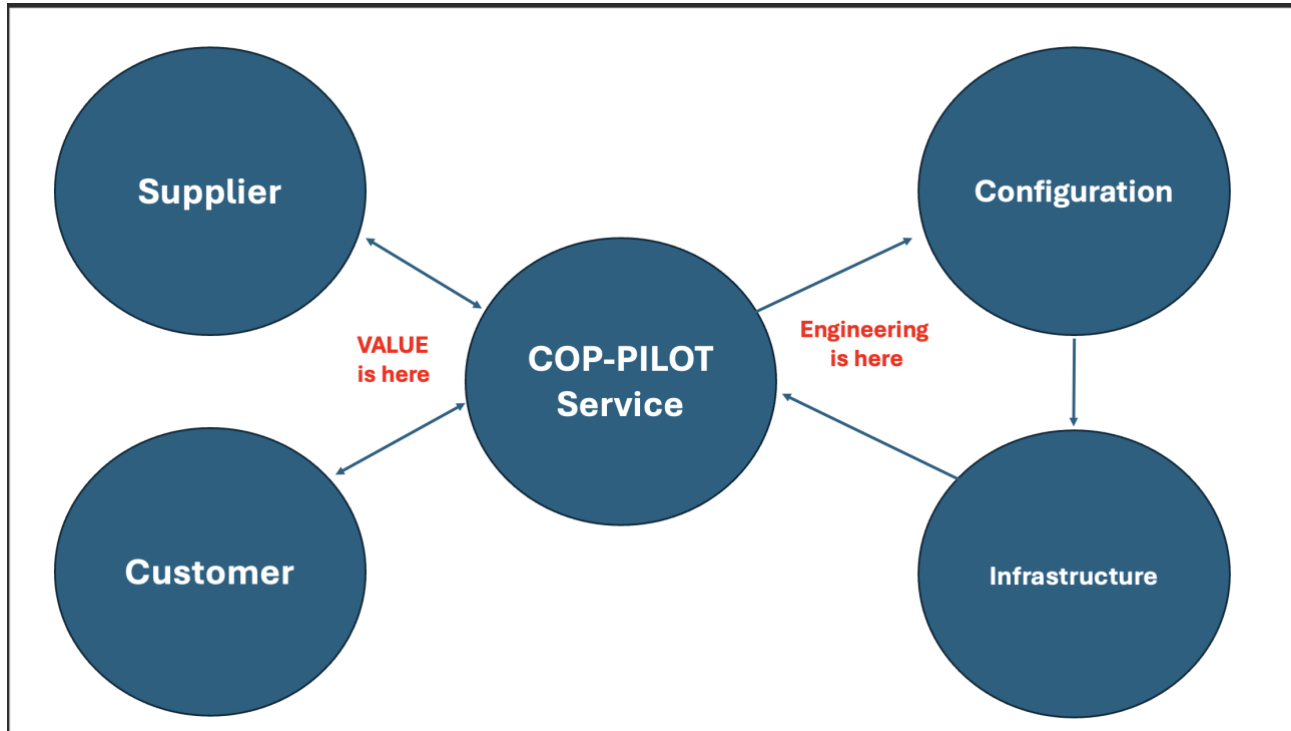


Figure 1 COP-PILOT Service Model – Business and Configuration view

To deepen the understanding of how the integration of COP-PILOT will influence industries and businesses within the European Union, the COP-PILOT service model illustrated in Figure 1 is applied. This model embodies a balanced integration of two critical dimensions central to COP-PILOT's commercialization in the EU: Value and Engineering. The service model outlines the essential components that enable COP-PILOT to function effectively and to generate tangible benefits for both society and the economy. It acknowledges the pivotal roles of Suppliers and Customers as the two interconnected ends that facilitate COP-PILOT's adoption and utilization within the broader ecosystem. Furthermore, it emphasizes that successful implementation requires a deliberate and competent establishment of robust technical configurations and advanced information technology systems, thereby providing a strong foundation for sustainable impact.

This section presents service models corresponding to each use case within their respective clusters, providing a comprehensive visualization and conceptual understanding of how the integration of the COP-PILOT service contributes to value creation within the industrial ecosystem.

To delve into further details of the service requirements required for successfully integrating COP-PILOT into the clusters, please refer to ANNEX 8: Detailed Service requirements per use case.

Sample Application for COP-PILOT Service Model

To further enhance our understanding of the service model, two illustrative examples are considered. The first involves a factory operating multiple robots equipped with approximately 1,000 IoT sensors connected to a European Data Space (EDS). The second example focuses on an AI-driven process that analyzes data from these IoT sensors to identify and signal anomalies, triggering alerts in response to detected or anticipated operational errors in robotic systems.

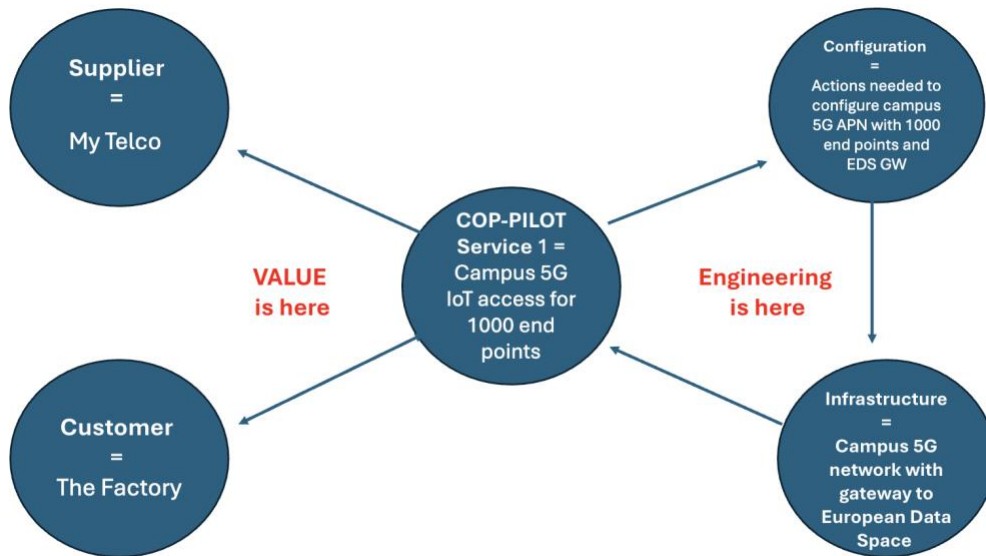


Figure 2 Sample COP-PILOT Service Model - Campus 5G IoT Access For 1000 End Points

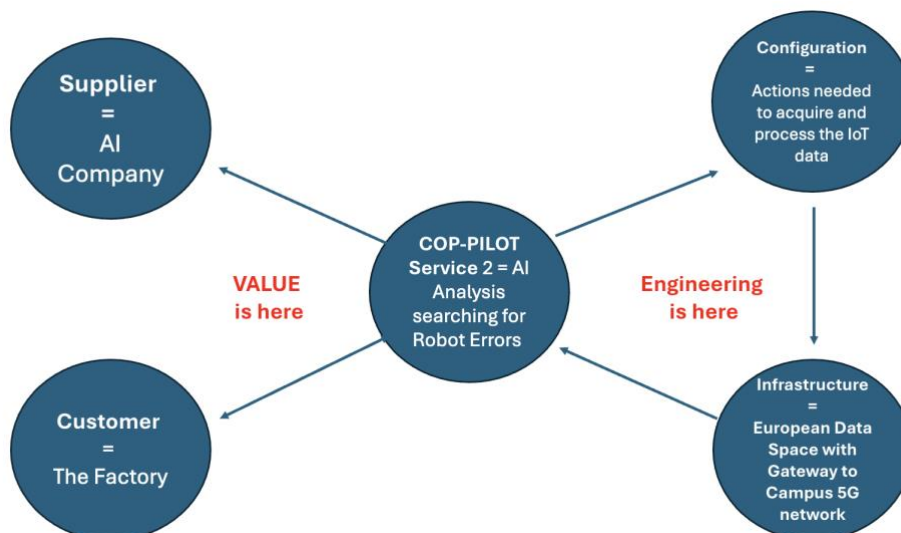


Figure 3 Sample COP-PILOT Service Model - AI Analysis Searching For Robot Errors

CLUSTER 1 (BUSINESS INTEGRATION IN MINING) SERVICE AND VALUE MODEL

The integration of the COP-PILOT system in industrial applications, particularly within the mining, manufacturing, and recycling sectors, facilitates the orchestration of an advanced edge-to-edge (E2C) continuum aimed at transforming industrial performance. This system enables real-time process monitoring, exemplified in agricultural contexts such as crop management, through the deployment of advanced Internet of Things (IoT) technologies. The implementation of COP-Pilot is projected to reduce intervention response times by 40-60% and minimize chemical input inefficiencies by enabling targeted applications through IoT-enabled units such as Unmanned Ground Vehicles (UGVs). Moreover, the incorporation of blockchain technology enhances end-to-end traceability and supports intelligent logistics planning.

The anticipated outcomes from the deployment of COP-PILOT within Cluster 1 include the optimization of resource allocation through dynamic provisioning and autoscaling. Furthermore, organizations are expected to achieve up to a 30% reduction in operational costs, supported by a system architecture that promotes real-time data exchange. In addition, COP-PILOT contributes to the development of early-warning mechanisms for seismic activity, thereby enhancing industrial safety, resilience, and sustainability.

CLUSTER 1 SERVICE MODEL ENGINEERING VIEW

The Arrowhead Local Cloud Deployment service automates the provisioning and configuration of an Arrowhead Framework instance within closed-edge-cloud environments. It handles the full deployment lifecycle, standing up the core systems (Service Registry, Orchestrator, and Authorization), configuring network parameters within an industrial subnet, enforcing version compliance, and allocating the necessary compute resources via Kubernetes or Docker. The service is designed to be repeatable and consistent, enabling the same deployment template to be instantiated across edge devices, on-premises datacenters, and protected cloud environments without manual reconfiguration each time.

The key inputs, framework version, core systems selection, network configuration, and resource requirements, are parameterized, making the service adaptable to different factory and industrial environments while maintaining standardized API behavior. Once deployed, it produces a fully operational Local Cloud instance with a network-accessible Service Registry endpoint, mutually authenticated core systems, and lifecycle management metadata to support ongoing operations such as scaling and updates. The primary intended use cases are industrial IoT applications requiring secure service discovery, multi-site edge-cloud automation, and production environments where reproducible, infrastructure-independent deployments are essential.

Use Case 1.1: IoT Mining Seismics

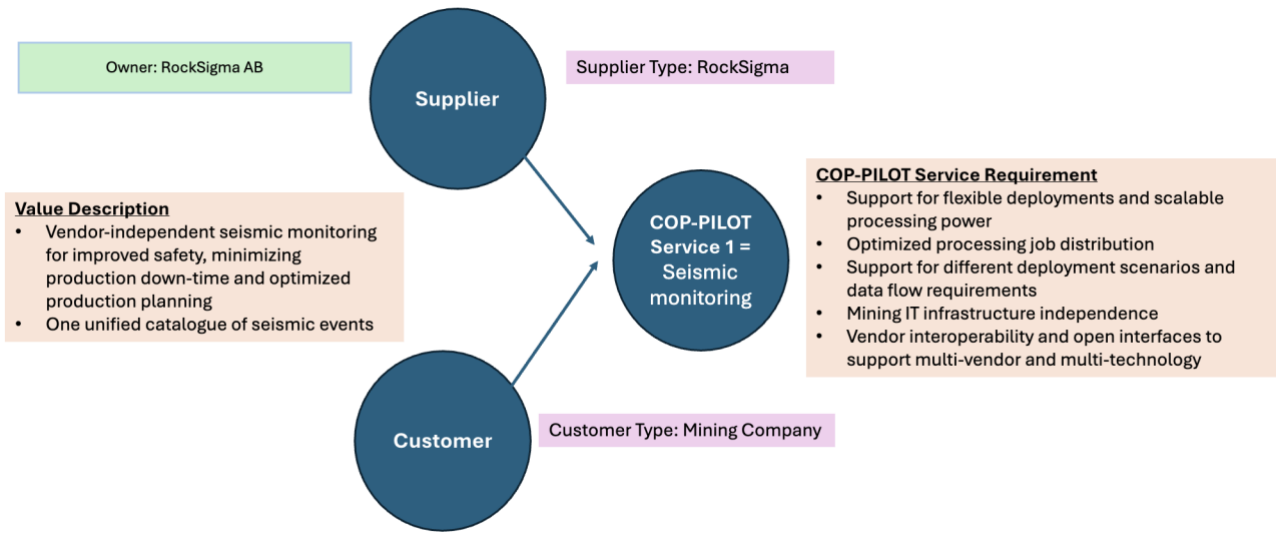


Figure 4 Service Model for Use Case 1.1 - IoT Mining Seismics

Cluster 1 Use Case 1.1

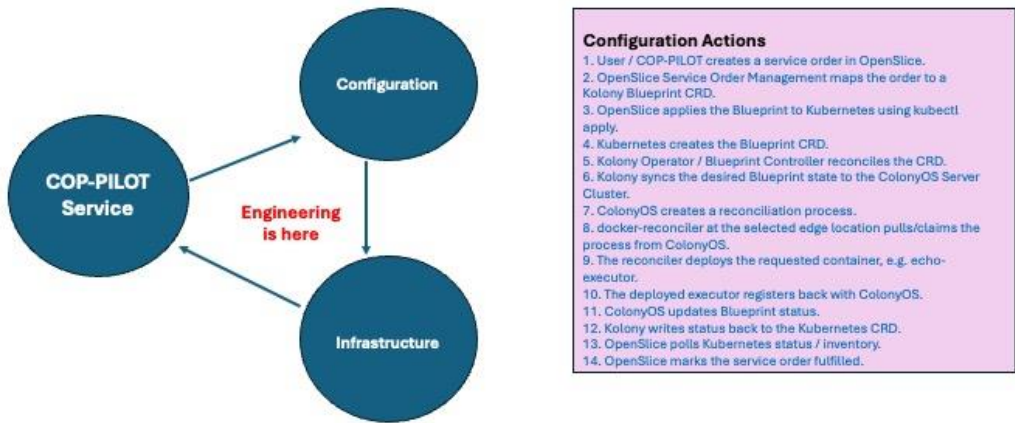


Figure 5 Engineering Model for Use Case 1.1 - IoT Mining Seismics

Cluster 1 Use Case 1.1

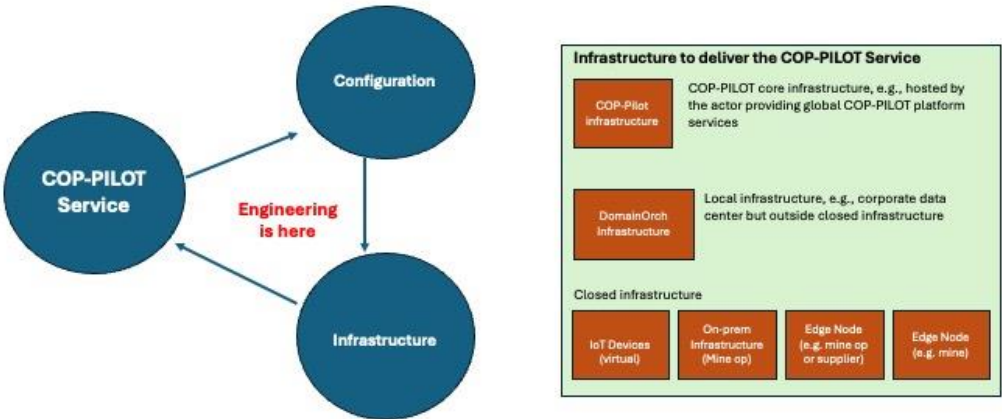


Figure 6 Engineering Model for Use Case 1.1 - IoT Mining Seismics

Use case 1.2: Logistics of IoT

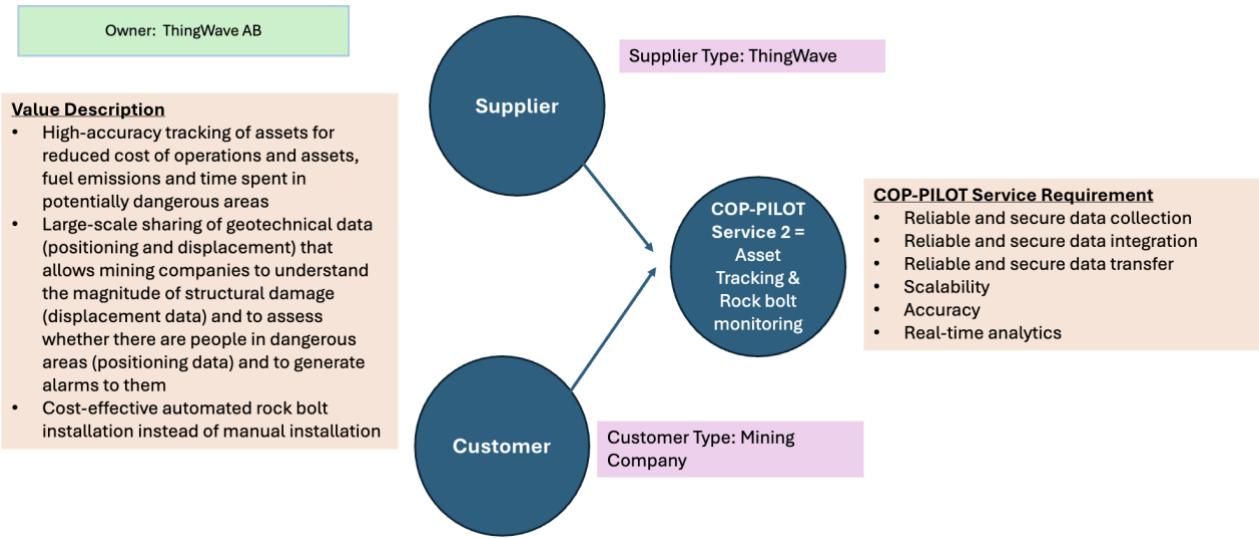


Figure 7 Service Model for Use Case 1.2 - Logistics of IoT

Cluster 1 Use Case 1.2 Service model for use case 1.2 – Logistics of IoT

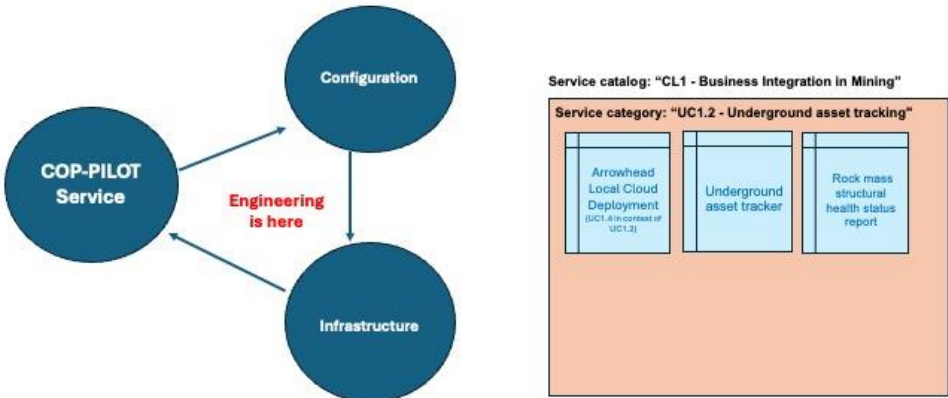


Figure 8 Engineering Model for Use Case 1.2 - Logistics of IoT

Use case 1.3: Condition Monitoring and Predictive Maintenance in Mining

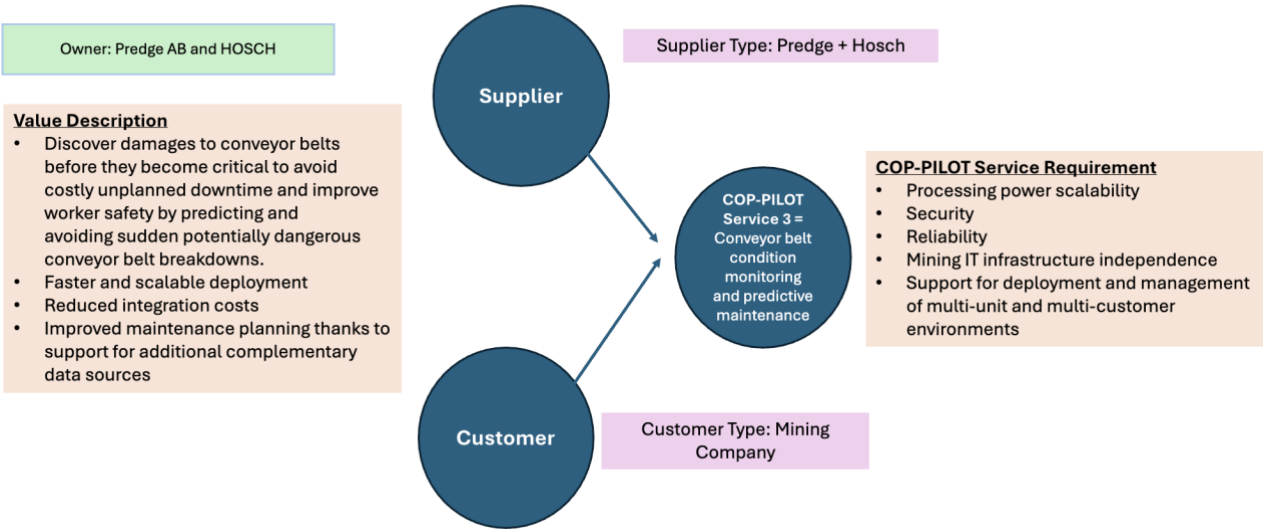


Figure 9 Service Model for Use Case 1.3 - Condition Monitoring and Predictive Maintenance in Mining

Cluster 1 Use Case 1.3 Service model for use case 1.3 – Condition Monitoring and Predictive Maintenance in Mining

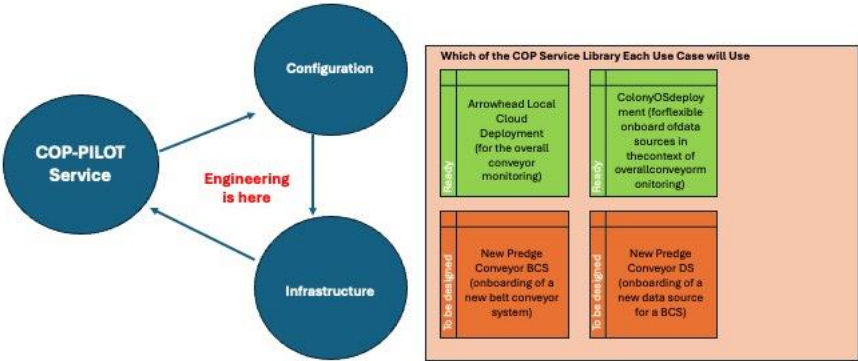


Figure 10 Engineering Model for Use Case 1.3 - Condition Monitoring and Predictive Maintenance in Mining

Use Case 1.4: IoT Edge Cloud Continuum For Digital Mines

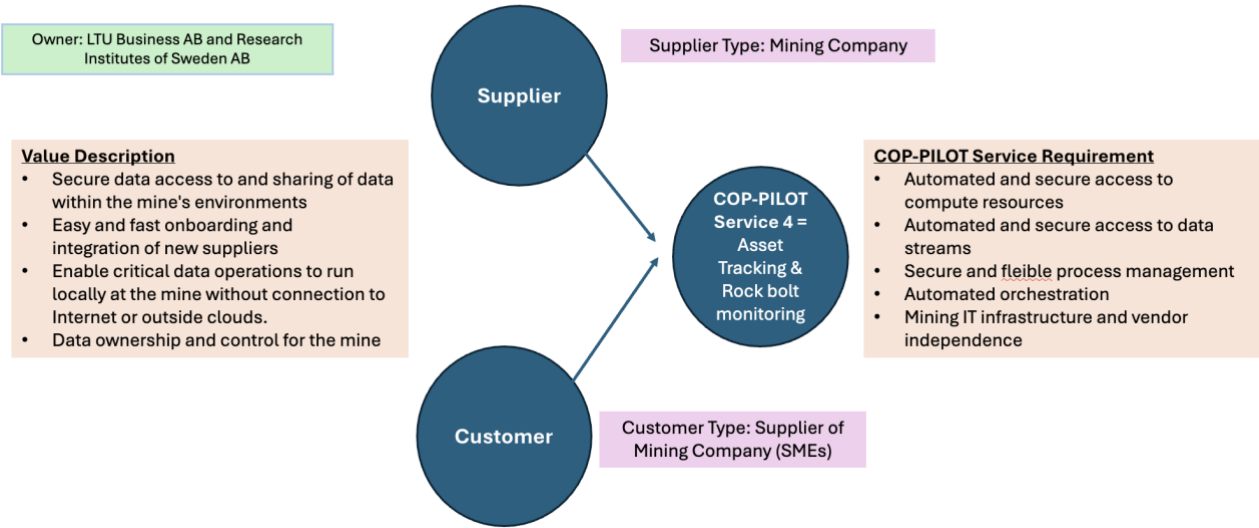
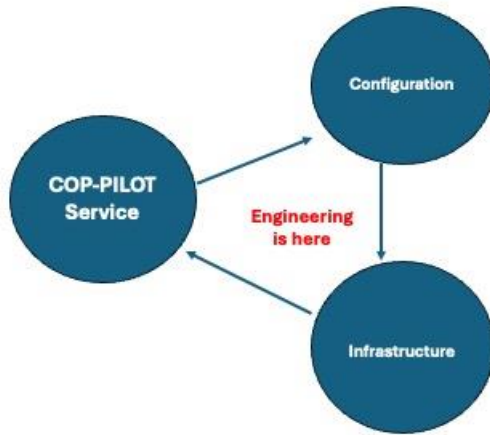


Figure 11 Service Model for Use Case 1.4 - IoT Edge Cloud Continuum For Digital Mines

Cluster 1 Use Case 1.4 Edge-Cloud Continuum Platform



Architecture team will provide list of available service library in COP-PILOT marketplace

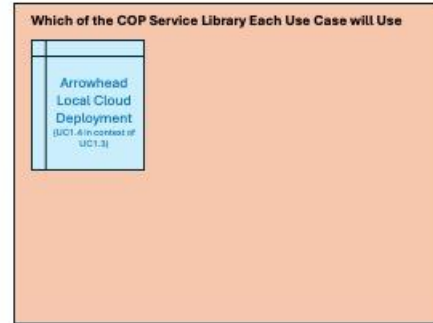


Figure 12 Engineering Model for Use Case 1.4 - IoT Edge Cloud Continuum For Digital Mines

Cluster 1 Use Case 1.4 Edge-Cloud Continuum Platform

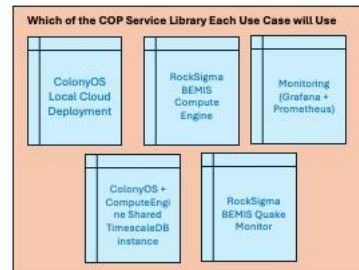
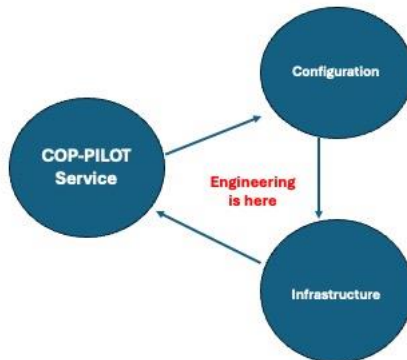


Figure 13 Engineering Model for Use Case 1.4 - IoT Edge Cloud Continuum For Digital Mines

Cluster 1 Conclusion

Cluster 1's Arrowhead Local Cloud Deployment service represents a foundational building block within the COP-PILOT ecosystem, bridging the gap between abstract service configuration and concrete infrastructure execution. As illustrated in the architecture diagrams, the engineering scope spans the full stack, from the Configuration and Infrastructure nodes of the COP-PILOT Service, through to the layered physical and virtual infrastructure tiers that include IoT devices, on-premises mine operations, edge nodes, and DomainOrch-managed local infrastructure. This range reflects the inherent complexity of industrial edge-cloud deployments, where standardization must coexist with environment-specific constraints.

The configuration action sequence, from blueprint parameter discovery through GitOps-driven deployment, Kubernetes or Docker reconciliation, and DomainOrch orchestration, demonstrates that the service is not merely a provisioning tool but a repeatable, self-correcting deployment pipeline. Taken together with the COP-PILOT service library model, where use cases such as UC1.1 through UC1.4 will draw on this deployment service as a shared foundation, the Arrowhead Local Cloud

Deployment establishes the operational baseline upon which higher-level industrial automation and secure service discovery capabilities are built. Its successful implementation during the workshop phase will be critical to validating the broader COP-PILOT architecture across diverse deployment targets.

CLUSTER 2 (SMART SUSTAINABLE IOT SOLUTIONS IN VALENCIA) SERVICE AND VALUE MODEL

The introduction of the COP-PILOT service within Cluster 2, which explores smart and sustainable IoT solutions, presents a powerful advancement toward attaining urban sustainability and systemic efficiency across interconnected infrastructures. By deploying a multi-layer and open orchestration framework that leverages IoT, AI-based extensions, and edge-to-cloud computing, COP-PILOT encourages seamless interoperability among various urban domains. This enables city planners and governments to derive enhanced, data-driven insights for sustainable planning, emission reduction, and congestion mitigation, ultimately improving urban lifestyles.

For citizens, the platform translates into tangible societal gains, including improved mobility, optimized public service delivery, and cleaner air. Academic campuses benefit through energy and water optimization, accelerating progress toward carbon-neutral targets. Additionally, port authorities and logistics operators gain from enhanced safety, resource efficiency, and improved scheduling, while third-party developers and startups are empowered through open APIs and data ecosystems that foster innovation.

By providing a real-world demonstration of scalable IoT and edge-cloud infrastructures, COP-PILOT not only amplifies cross-sectoral collaboration but also establishes a blueprint for sustainable, data-intelligent urban ecosystems, enhancing both environmental resilience and socio-economic value creation.

CLUSTER 2 SERVICE MODEL ENGINEERING VIEW

COP-PILOT's Cluster 2 focuses on Smart City and Smart Resources Management use cases centred primarily around the Universitat Politècnica de València (UPV) campus and the broader Valencia urban environment. The cluster spans six modelled services, from 5G-connected traffic radars and flood warning systems to smart waste management, water efficiency, maritime port monitoring, and IoT-driven smart building management. With value definitions and service requirements already established in D2.1 Chapter 8, this session moves into the engineering phase of the COP-PILOT service model, addressing the Infrastructure and Configuration layer for each use case. The primary focus for this workshop is Use Case 2.2A, Smart Resources Management at the UPV Campus, selected as the most technically mature service in the cluster. Currently at sensor-testing phase, with 26 fill-level sensors delivering data into Telefónica's Thinking Cities Platform, this use case provides a well-scoped starting point for defining HELM deployment strategies, infrastructure blocks (Orion CB, OpenSlice, K8S cluster, Open Ziti SIF), and the configuration actions needed to stand the service up end-to-end.

Use Case 2.1: Smart City Data Monitoring and Sustainable Mobility

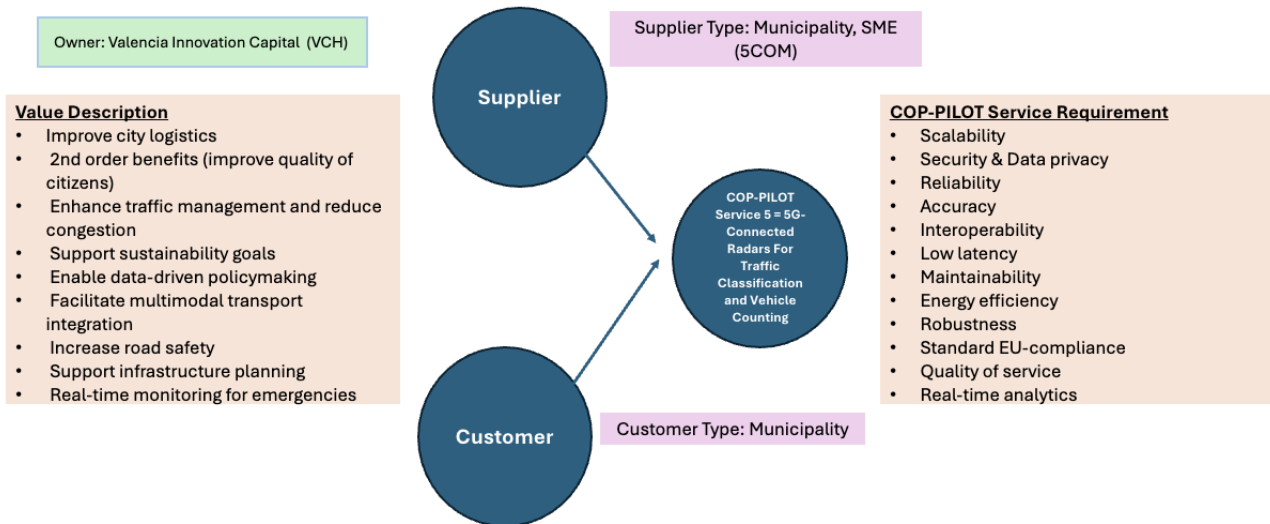


Figure 14 Service model for use case 2.1A – 5G-Connected Radars for Traffic Classification and Vehicle Counting

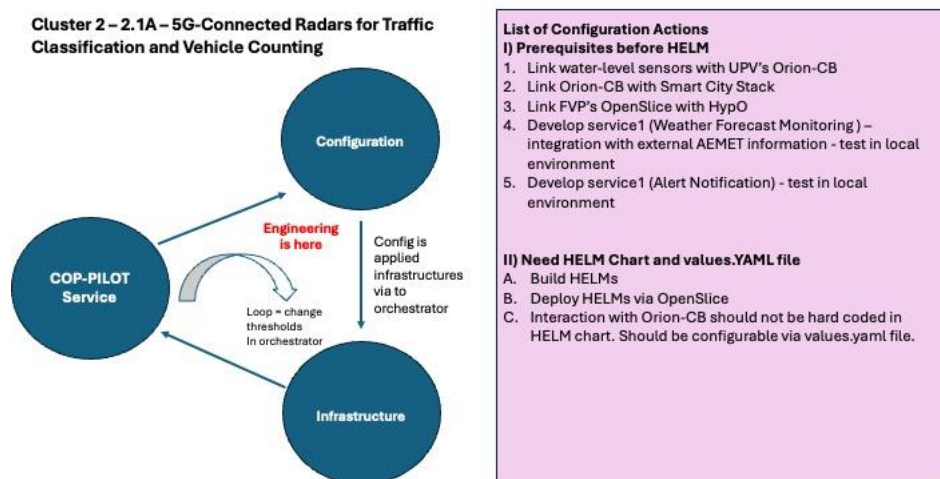


Figure 15 Engineering model for use case 2.1A – 5G-Connected Radars for Traffic Classification and Vehicle Counting

Cluster 2 – 2.1A – 5G-Connected Radars for Traffic Classification and Vehicle Counting

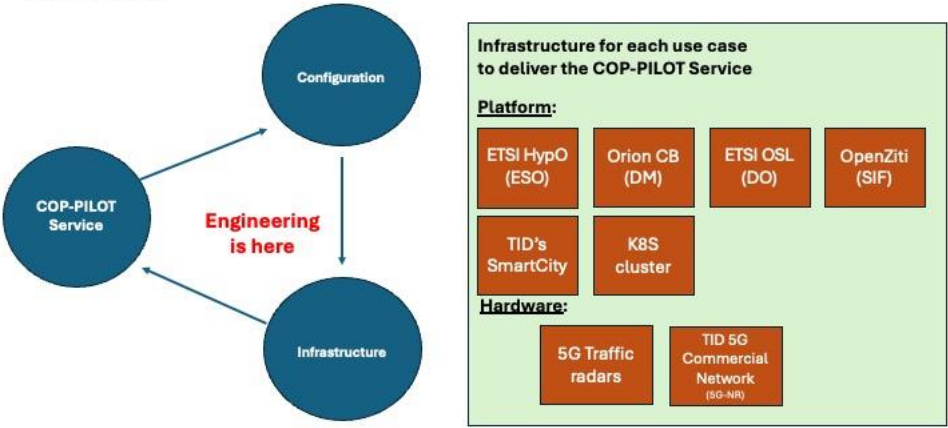


Figure 16 Engineering model for use case 2.1A – 5G-Connected Radars for Traffic Classification and Vehicle Counting

Cluster 2 – 2.1A – 5G-Connected Radars for Traffic Classification and Vehicle Counting

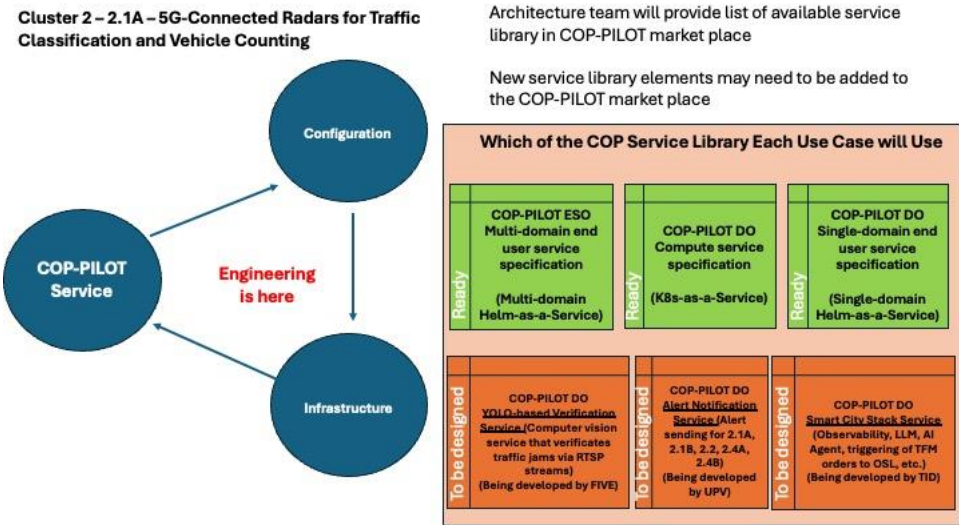


Figure 17 Engineering model for use case 2.1A – 5G-Connected Radars for Traffic Classification and Vehicle Counting

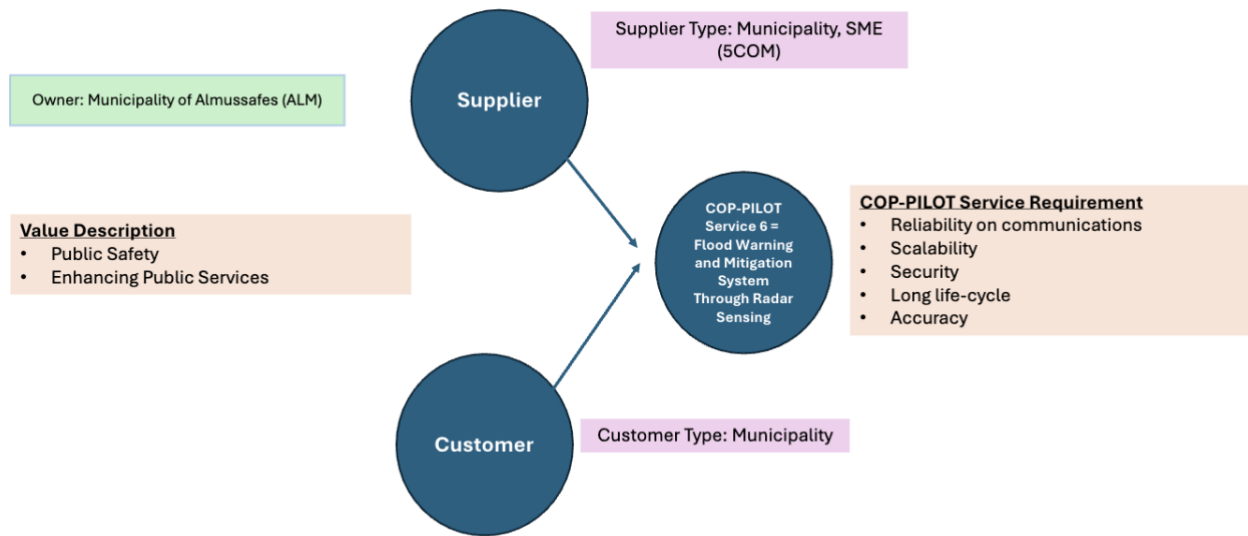


Figure 18 Service model for use case 2.1B – Flood Warning and Mitigation System Through Radar Sensing

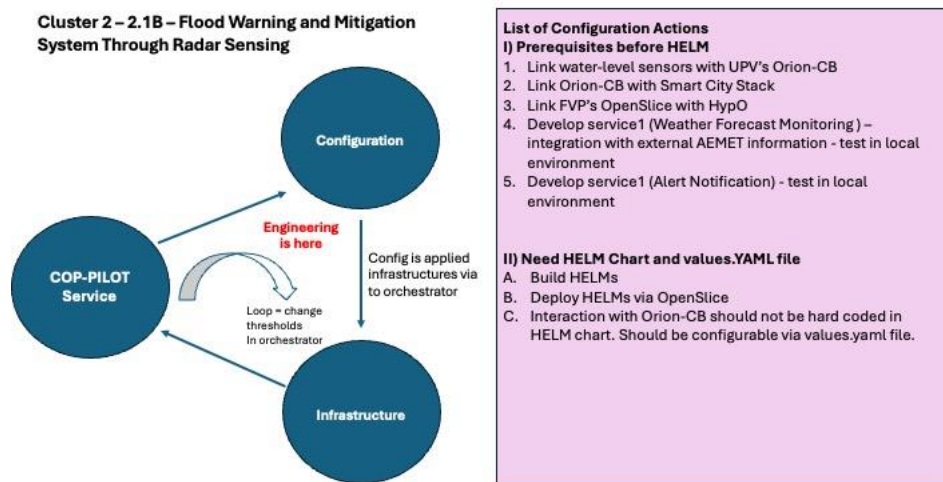


Figure 19 Engineering model for use case 2.1B – Flood Warning and Mitigation System Through Radar Sensing

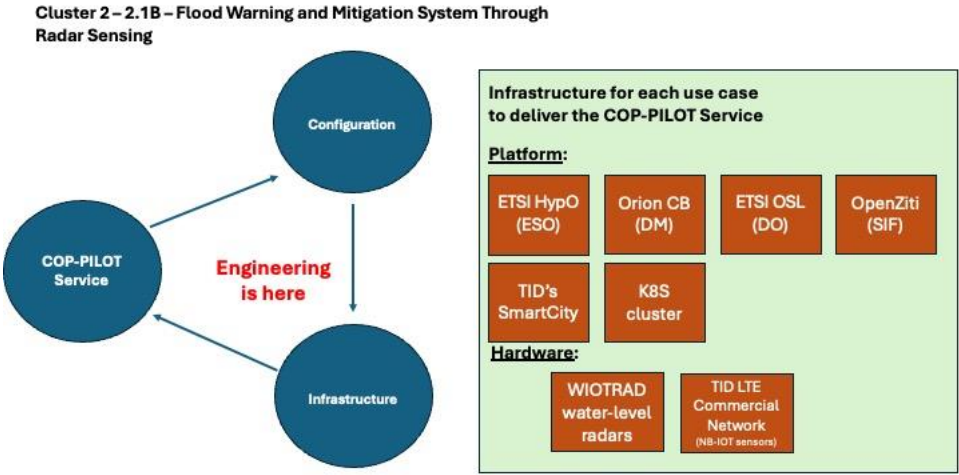


Figure 20 Engineering model for use case 2.1B – Flood Warning and Mitigation System Through Radar Sensing

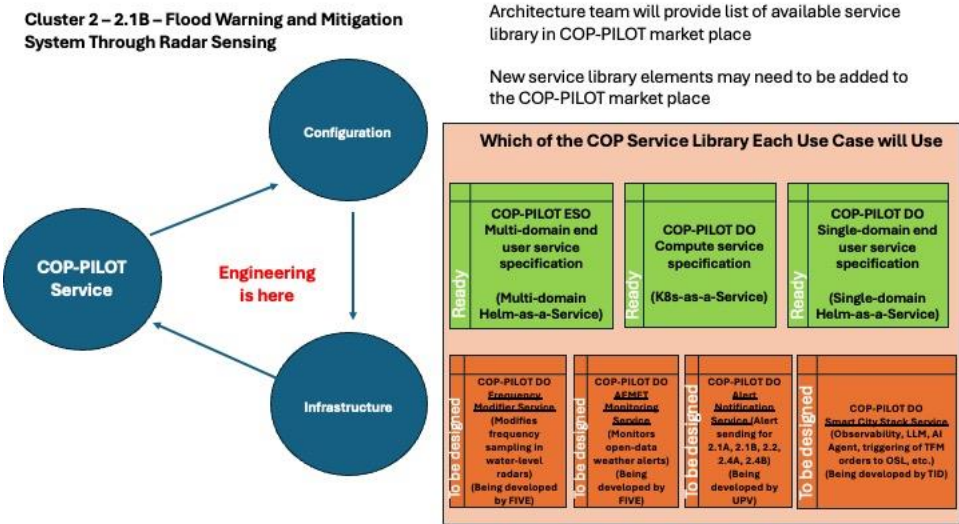


Figure 21 Engineering model for use case 2.1B – Flood Warning and Mitigation System Through Radar Sensing

Use case 2.2: Smart Resources Management in The UPV Campus

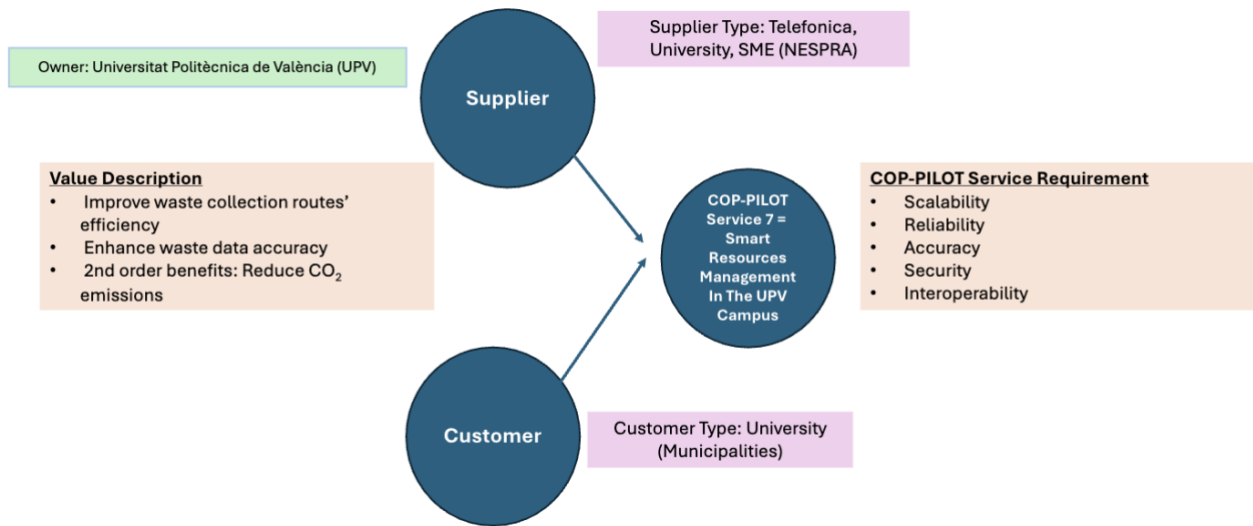


Figure 22 Service model for use case 2.2A – Smart Resources Management in the UPV Campus

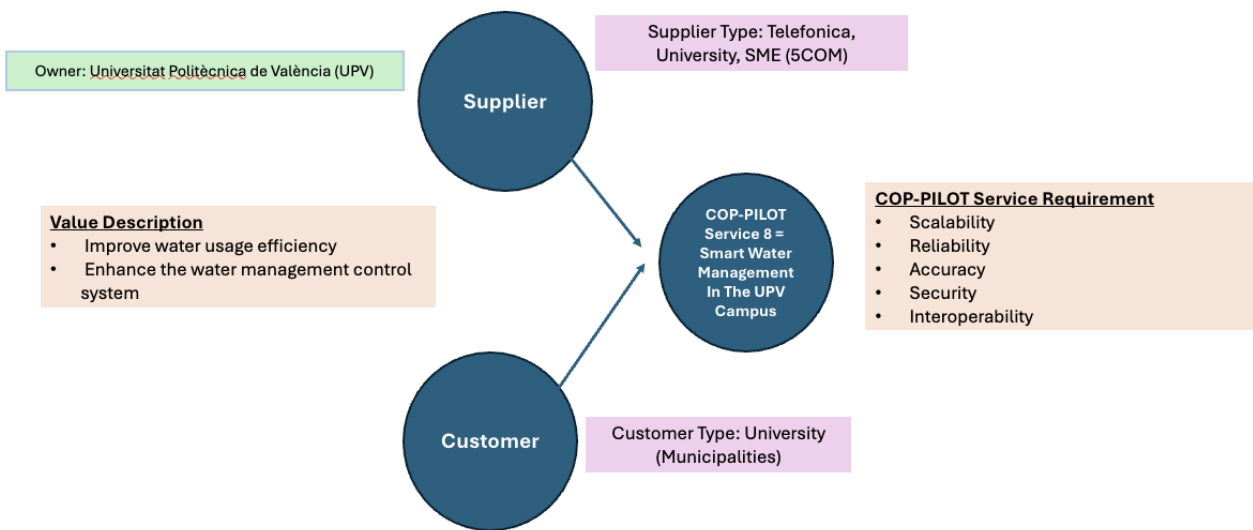


Figure 23 Service model for use case 2.2B – Smart Water Management In The UPV Campus

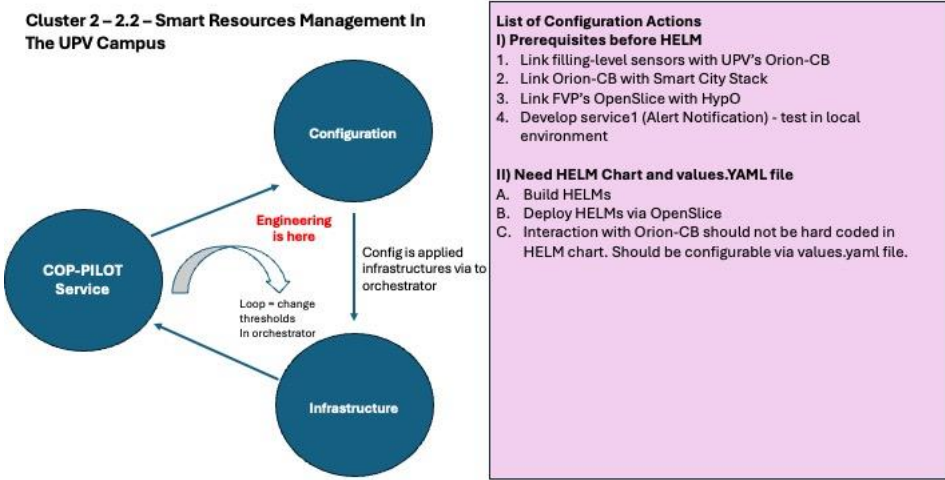


Figure 24 Engineering model for use case 2.2B – Smart Water Management In The UPV Campus

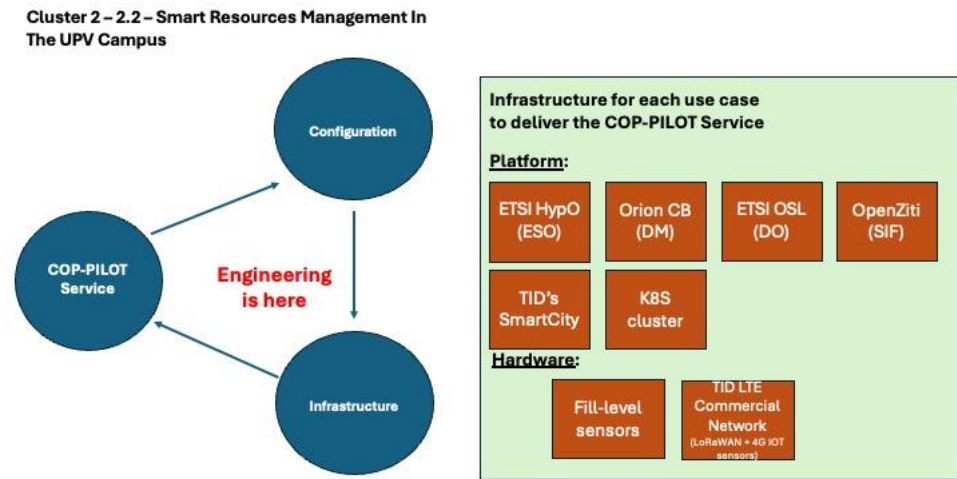


Figure 25 Engineering model for use case 2.2B – Smart Water Management In The UPV Campus

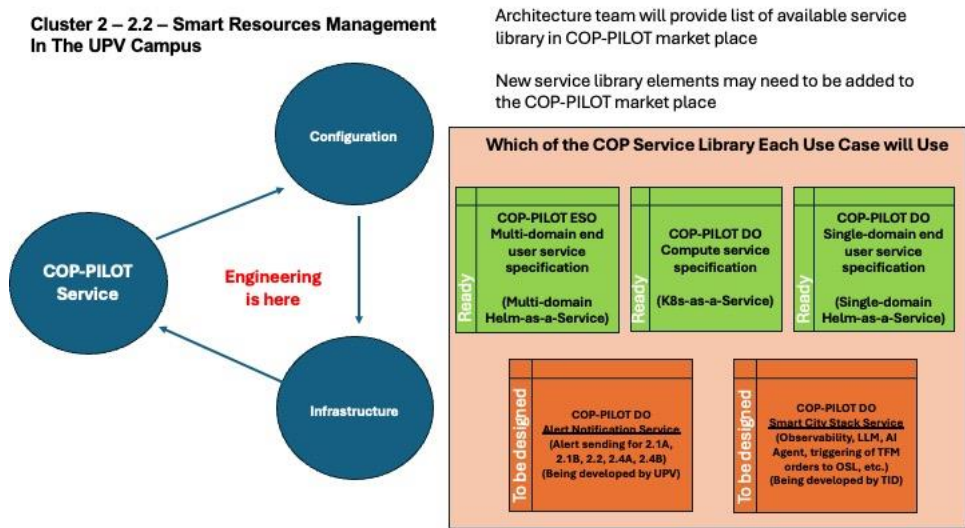


Figure 26 Engineering model for use case 2.2B – Smart Water Management In The UPV Campus

Use case 2.3: Maritime Traffic Monitoring and Berthing Assistance

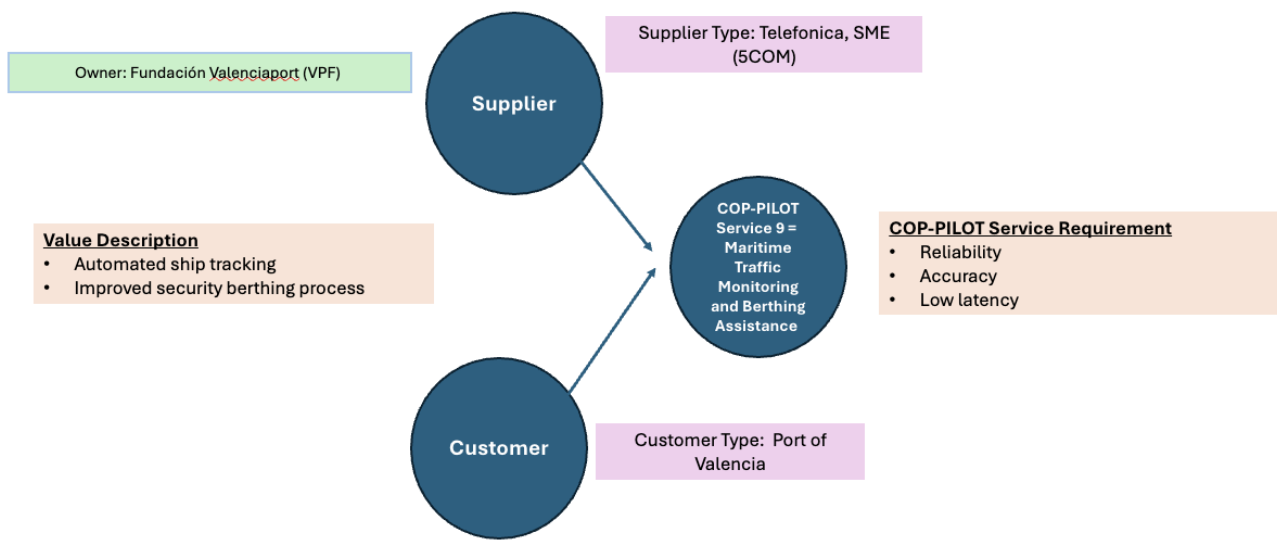


Figure 27 Service model for use case 2.3 – Maritime Traffic Monitoring and Berthing Assistance

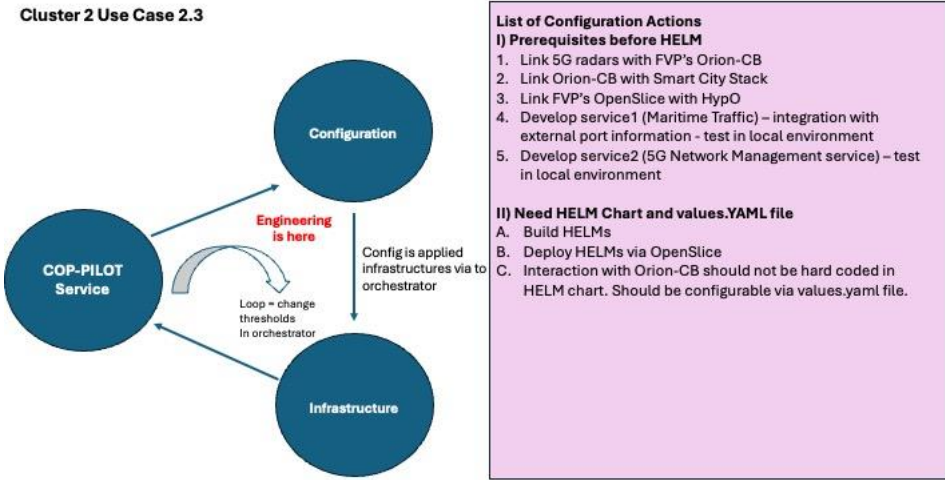


Figure 1.0: Engineering model for use case 2.3 – Maritime Traffic Monitoring and Berthing Assistance

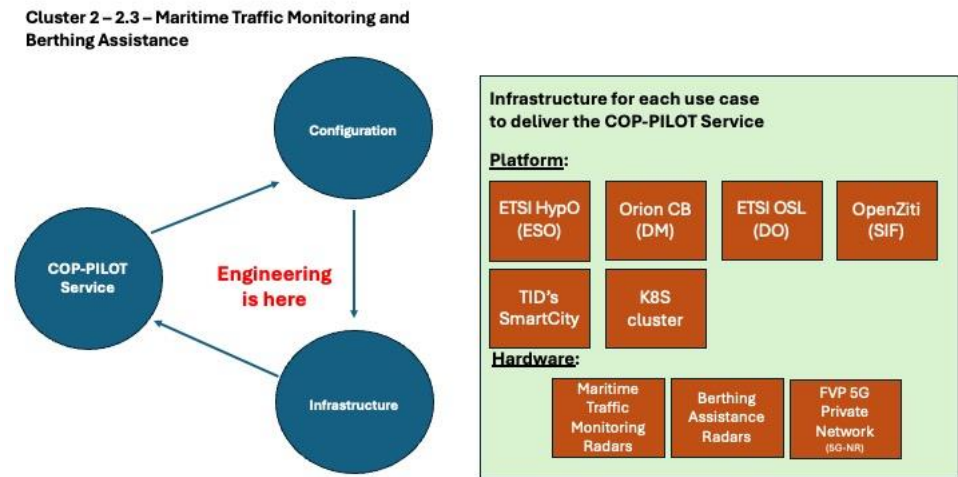


Figure 28 Engineering model for use case 2.3 – Maritime Traffic Monitoring and Berthing Assistance

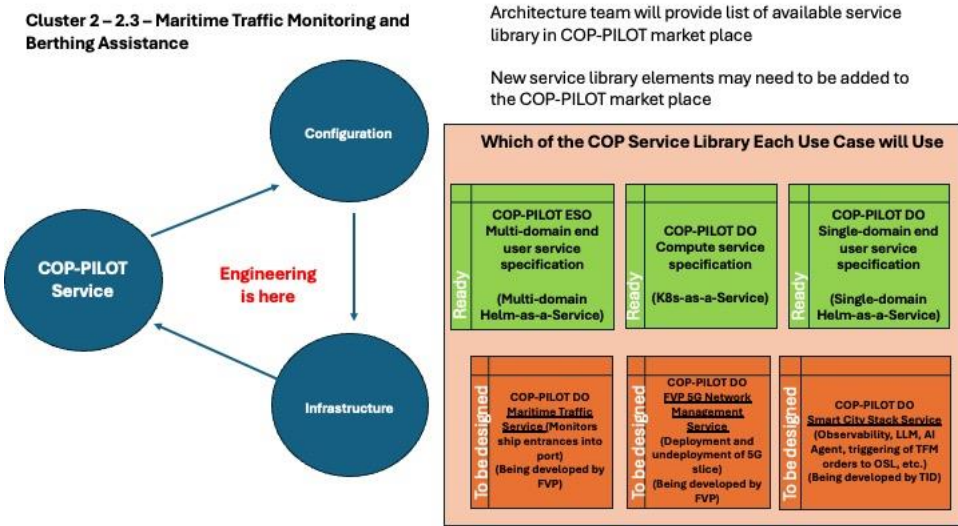


Figure 29 Engineering model for use case 2.3 – Maritime Traffic Monitoring and Berthing Assistance

Use case 2.4: IoT – Driven Smart Building Management at La Harinera

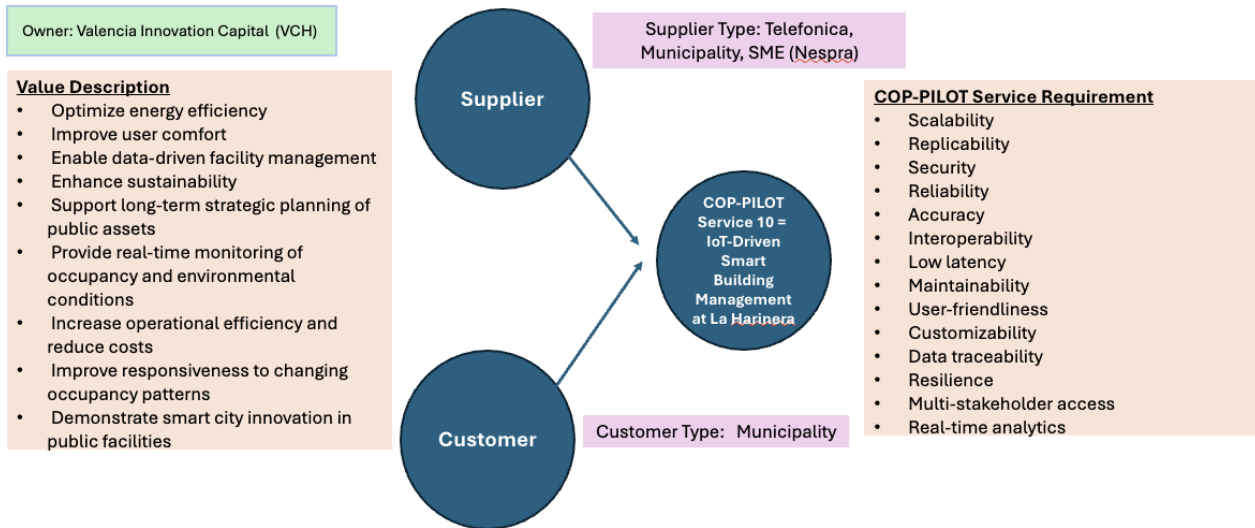


Figure 1.0:Service model for use case 2.4A – IoT-Driven Smart Building Management at La Harinera

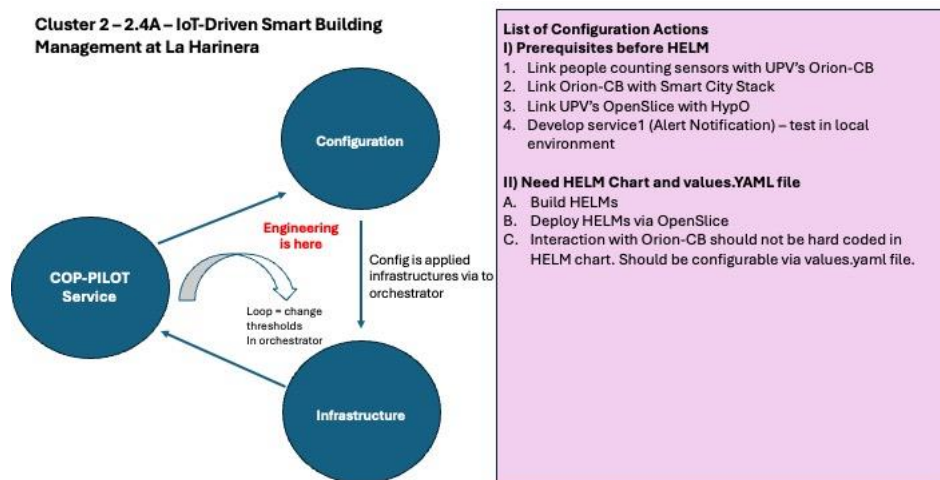


Figure 30 Engineering model for use case 2.4A – IoT-Driven Smart Building Management at La Harinera

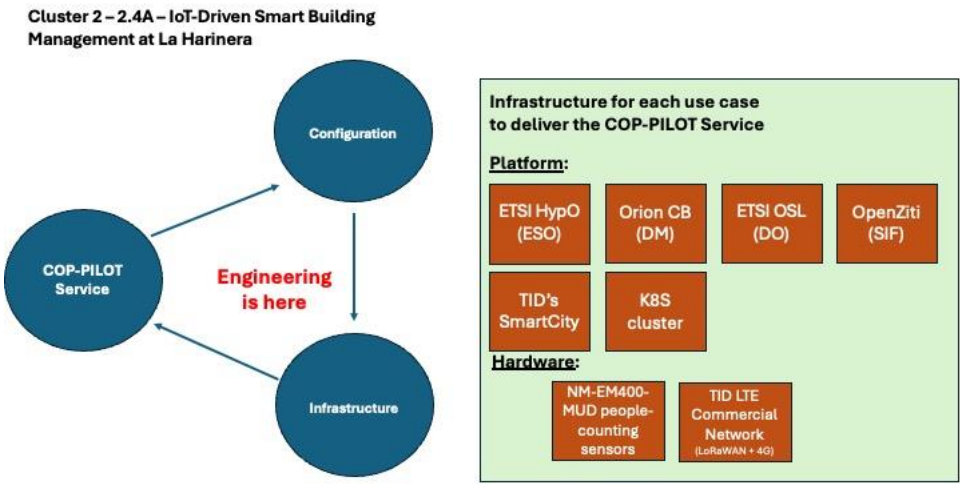


Figure 31 Engineering model for use case 2.4A – IoT-Driven Smart Building Management at La Harinera

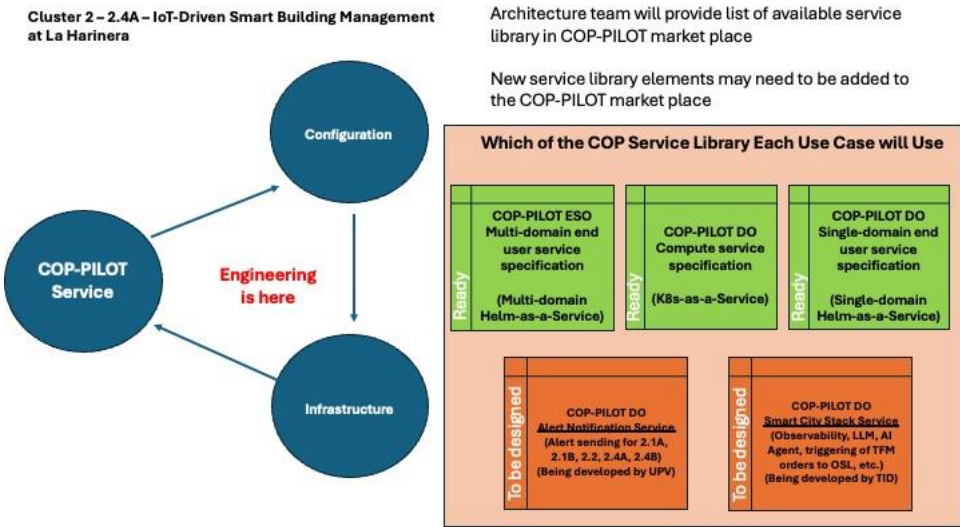


Figure 32 Engineering model for use case 2.4A – IoT-Driven Smart Building Management at La Harinera

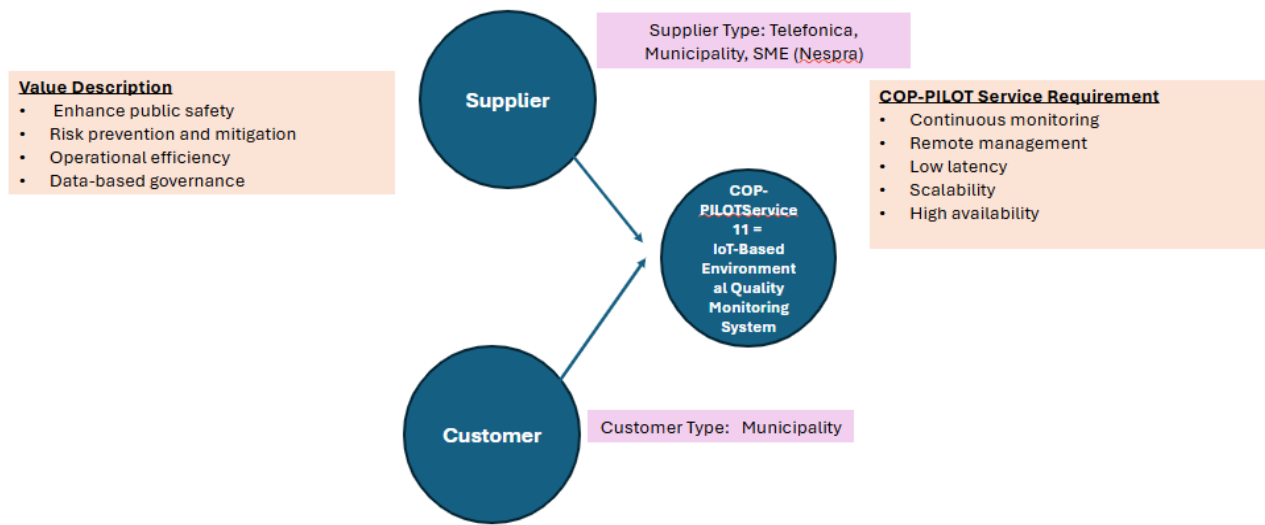


Figure 33 Service model for use case 2.4B - IoT Based Environmental Quality Monitoring System

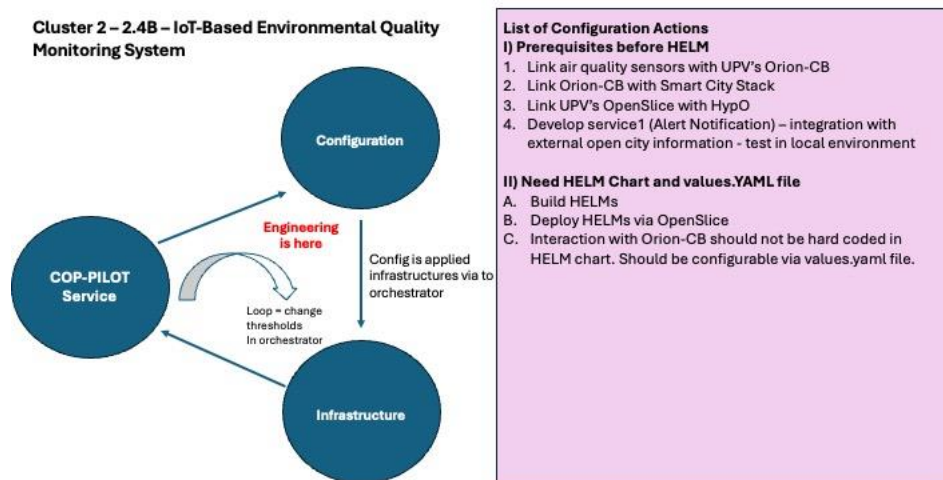


Figure 34 Engineering model for use case 2.4B - IoT Based Environmental Quality Monitoring System

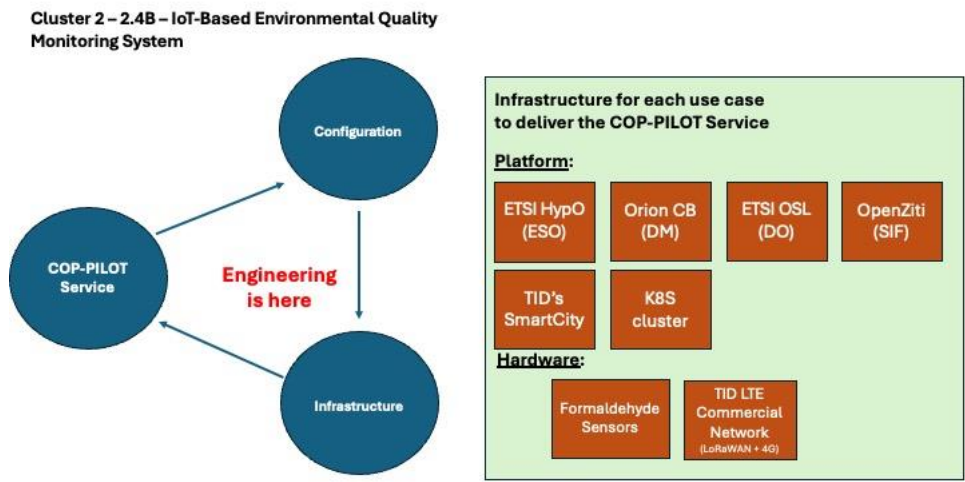


Figure 35 Engineering model for use case 2.4B - IoT Based Environmental Quality Monitoring System

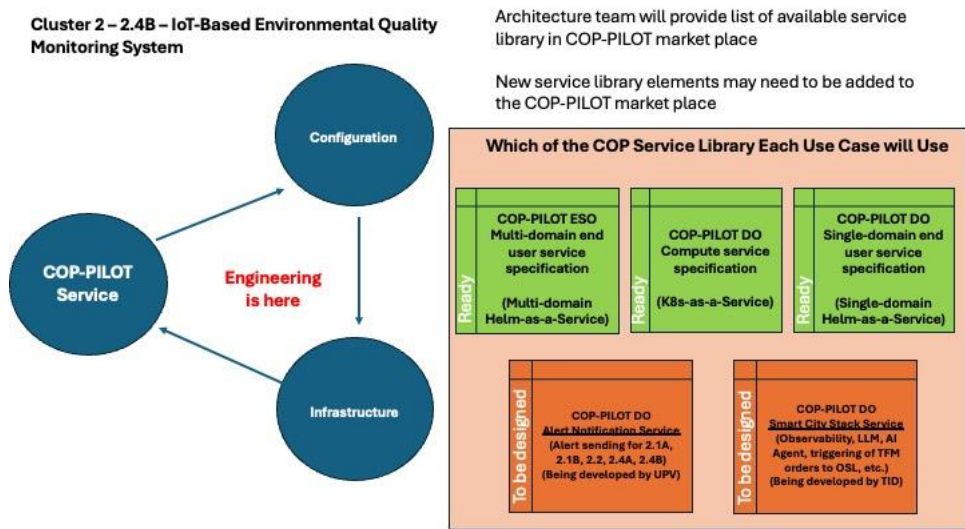


Figure 36 Engineering model for use case 2.4B - IoT Based Environmental Quality Monitoring System

Cluster 2 Conclusion

Cluster 2's engineering analysis for the Smart Resources Management use case reveals a relatively straightforward single-domain deployment path. The infrastructure stack is well-defined, Orion CB, OpenSlice, K8S cluster, Open Ziti SIF, and Telefónica's Thinking Cities Platform on the platform side, with fill-level sensors and TID's LTE Commercial Network on the hardware side, and the configuration sequence is structured around five pre-HELM prerequisites, followed by HELM build and deployment via OpenSlice, with FIWARE interaction kept configurable.

CLUSTER 3A (AGRITECH TRANSFORMATION AND SUSTAINABILITY INITIATIVE) SERVICE AND VALUE MODEL

The introduction of COP-PILOT within Cluster 3A promotes the transformation of the agri-food ecosystem through data interoperability, intelligent orchestration, and real-time optimization. Leveraging comprehensive IoT installations and smart metering infrastructures, COP-PILOT allows the continuous collection of environmental, energy, and operational data, seamlessly incorporated with external datasets such as transport logistics, market prices, and weather conditions. Through edge-residing analytics, the platform improves decision-making by facilitating adaptive demand response (DR), optimizing distributed energy resource (DER) production and consumption, and maintaining grid stability across agricultural operations.

For farmers and growers, this helps to achieve predictive control over resources, higher yields, and reduced input use. Agritech providers attain access to a unified data platform supporting validated use cases and broader tool adoption. Supply chain actors benefit from predictive routing and traceability, minimizing waste and ensuring food integrity. Consumers experience the sustainability of produce and enhanced quality, while data and platform providers establish interoperable, secure exchanges via multi-cloud architectures and blockchain.

In essence, COP-PILOT in Cluster 3A establishes a data-driven and intelligent agricultural infrastructure that improves our efforts as an ecosystem to achieve sustainability, operational efficiency, and resilience across the entire agri-value chain.

Cluster 3A Engineering Summary

Cluster 3A addresses the move from fragmented, manual, and siloed farm operations toward a fully integrated, data-driven agricultural ecosystem. The four use cases that constitute this cluster, Integrated Precision Agriculture and Crop Monitoring (UC3A.1), Advanced AgriRobotics for Autonomous Intervention (UC3A.2), Secure Data Management and Interoperability (UC3A.3), and Smart Logistics and Supply Chain Optimisation (UC3A.4), are not independent services but a layered stack in which each use case creates the conditions for the next. Together, they span the full agricultural value chain, from the field sensor and the drone above it, through the robot acting on its data, to the blockchain record that follows the crop all the way to the point of sale.

As the architecture diagrams make clear, all four use cases operate at the intersection of the COP-PILOT Service's Configuration and Infrastructure nodes, the precise layer where engineering decisions translate into deployed, running systems. Each service is packaged using HELM for Kubernetes, drawing on shared connectivity layer built around OTE's 5G public access network and private core, and routes data through Orion Context Brokers exposed via OpenZiti. The COP-PILOT service library elements underpinning all four use cases, the Multi-domain and Single-domain Helms-as-a-Service specifications and the K8s-as-a-Service Compute specification, are already marked as ready, with the OTE 5G Slice Manager configuration as the one remaining element to be designed. This shared architectural foundation indicates that what is validated in UC3A.1 directly reduces integration risk for UC3A.2, UC3A.3, and UC3A.4, and that the cluster as a whole is designed to be coherent from day one.

Use Case 3A.1: Integrated Precision Agriculture and Crop Monitoring

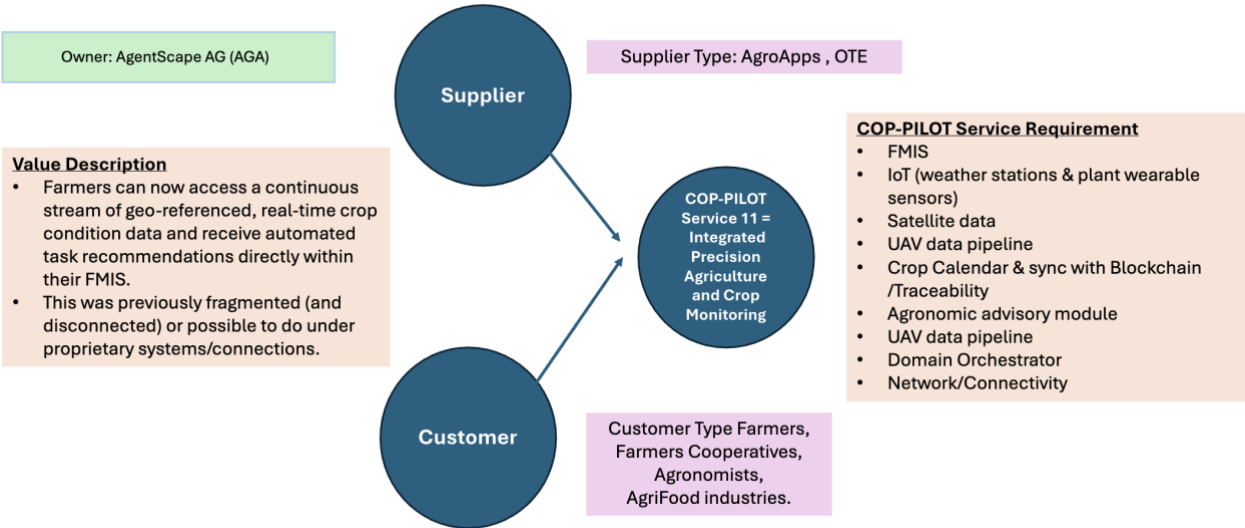


Figure 37 Service Model for Use Case 3A.1 - Integrated Precision Agriculture and Crop Monitoring

Cluster 3A Use Case 3A.1 : Integrated Precision Agriculture and Crop Monitoring

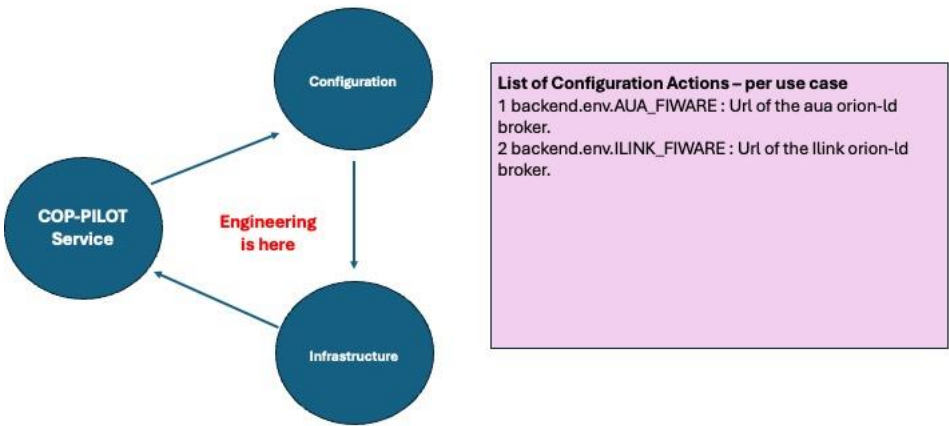


Figure 38 Engineering Model for Use Case 3A.1 - Integrated Precision Agriculture and Crop Monitoring

Cluster 3A Use Case 3A.1 : Integrated Precision Agriculture and Crop Monitoring

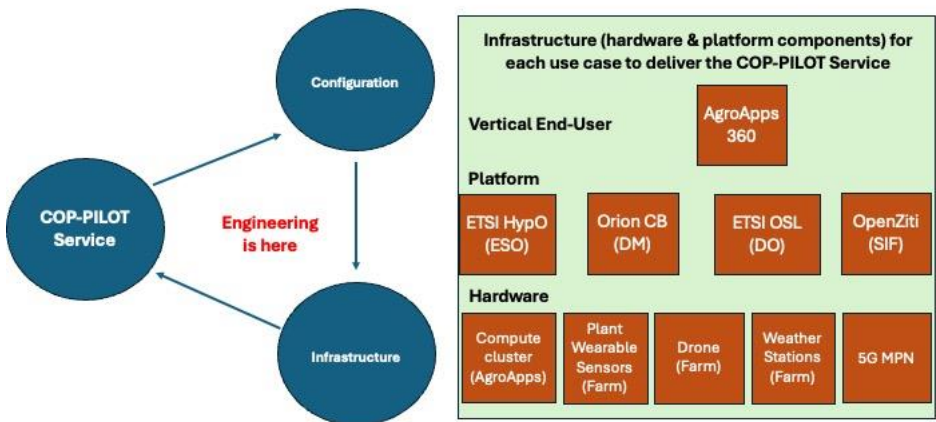


Figure 39 Engineering Model for Use Case 3A.1 - Integrated Precision Agriculture and Crop Monitoring

Cluster 3A Use Case 3A.1 :
Integrated Precision Agriculture
and Crop Monitoring

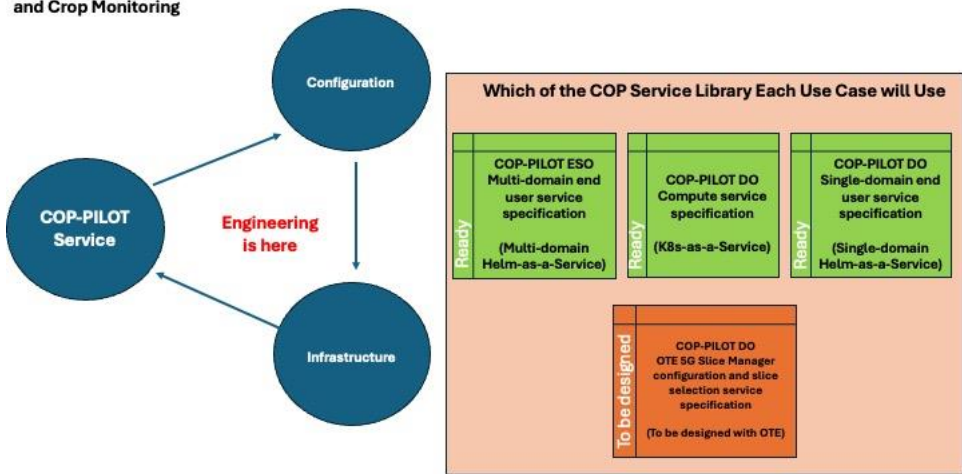


Figure 40 Engineering Model for Use Case 3A.1 - Integrated Precision Agriculture and Crop Monitoring

Use case 3A.2: Advanced AgriRobotics For Autonomous Intervention

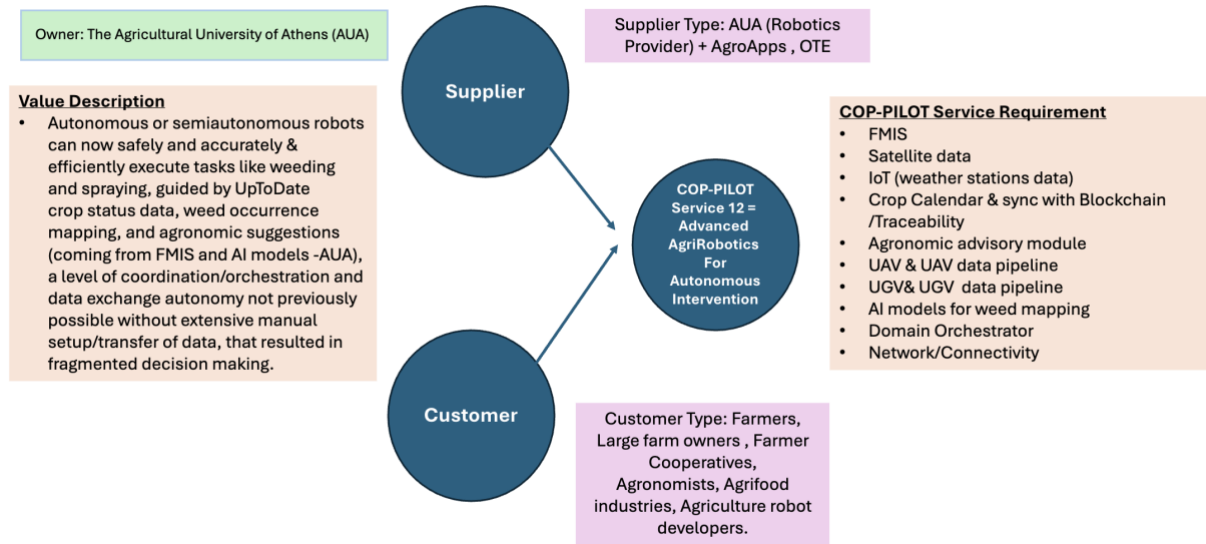


Figure 41 Service model for use case 3A.2 – Advanced AgriRobotics for Autonomous Intervention

Cluster 3A Use Case 3A.2 Advanced AgriRobotics for Autonomous Intervention

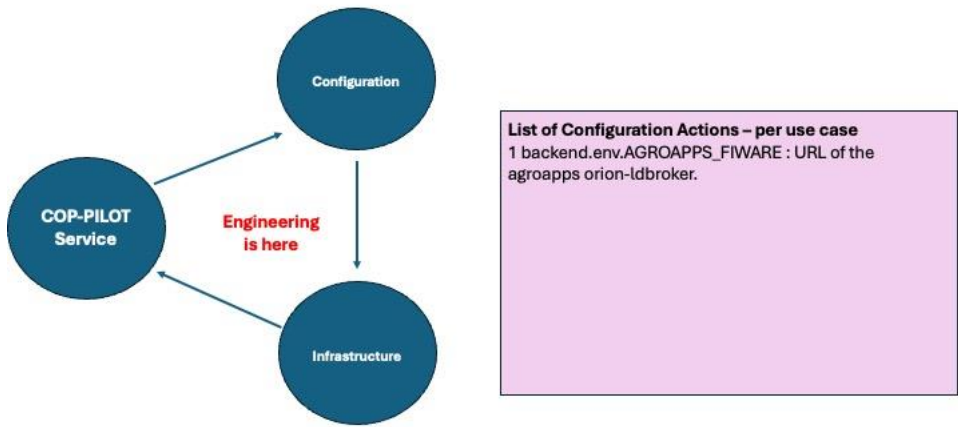


Figure 42 Engineering model for use case 3A.2 – Advanced AgriRobotics for Autonomous Intervention

Cluster 3A Use Case 3A.2 Advanced AgriRobotics for Autonomous Intervention

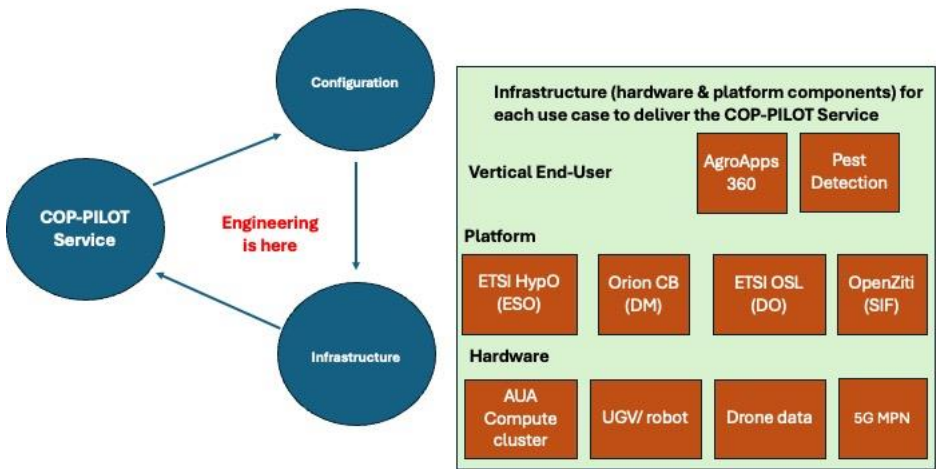


Figure 43 Engineering model for use case 3A.2 – Advanced AgriRobotics for Autonomous Intervention

Cluster 3A Use Case 3A.2 Advanced AgriRobotics for Autonomous Intervention

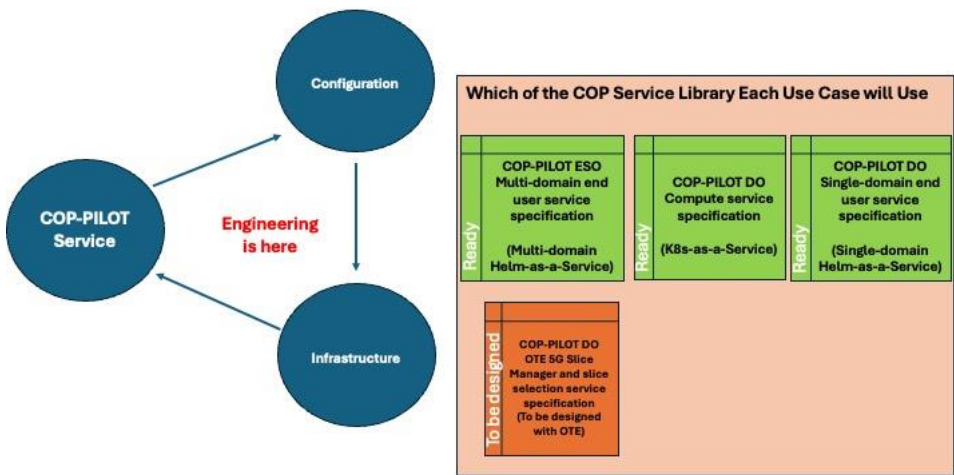


Figure 44 Engineering model for use case 3A.2 – Advanced AgriRobotics for Autonomous Intervention

Use case 3A.3: Secure Data Management and interoperability

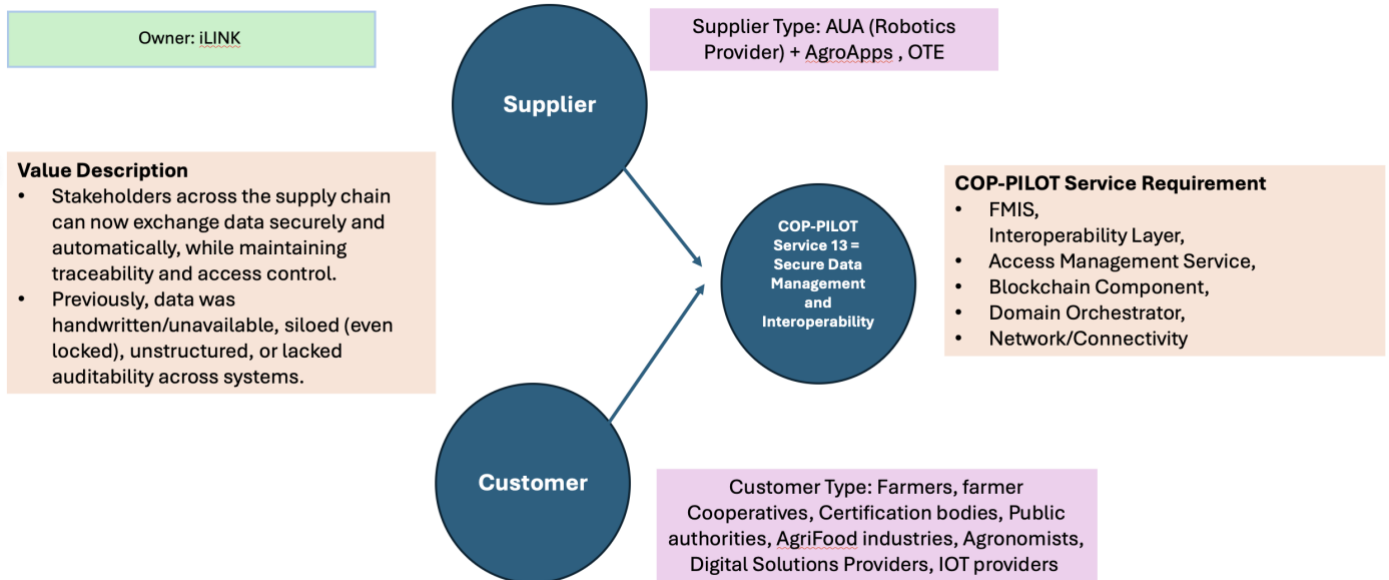


Figure 45 Service model for use case 3A.3 – Secure Data Management and Interoperability

Cluster 3A Use Case 3: Secure Data Management and Interoperability

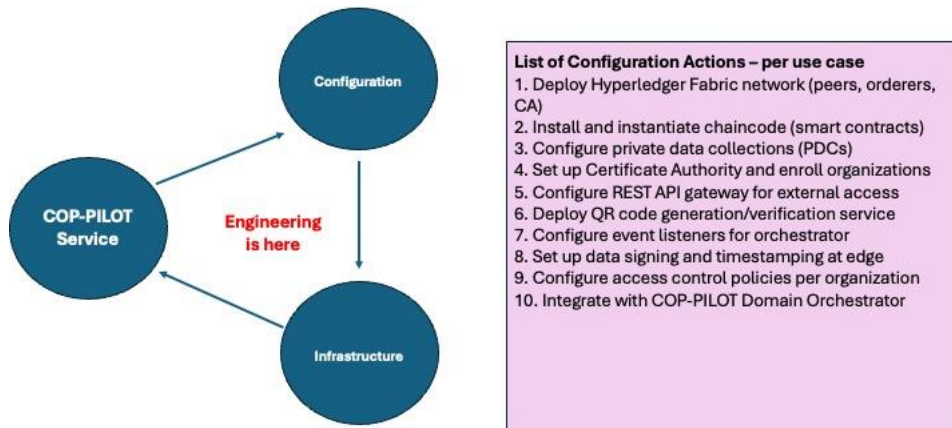


Figure 46 Engineering model for use case 3A.3 – Secure Data Management and Interoperability

Cluster 3A Use Case 3: Secure Data Management and Interoperability

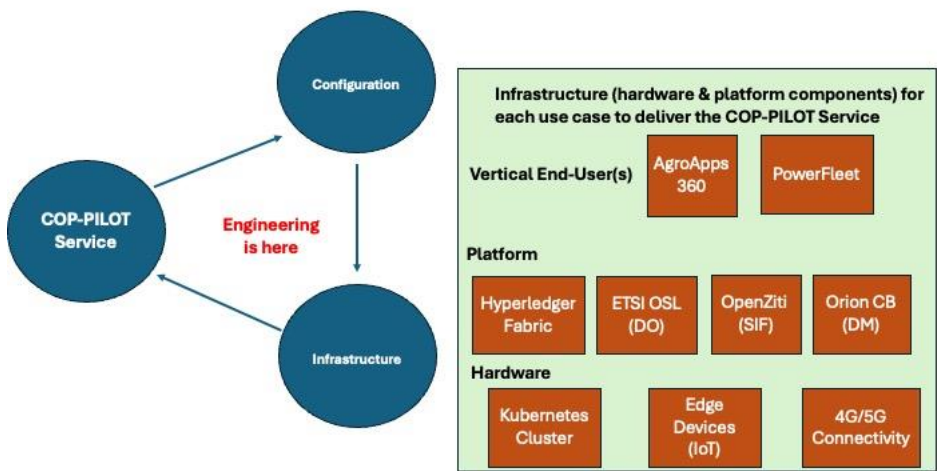


Figure 47 Engineering model for use case 3A.3 – Secure Data Management and Interoperability

Cluster 3A Use Case 3: Secure Data Management and Interoperability

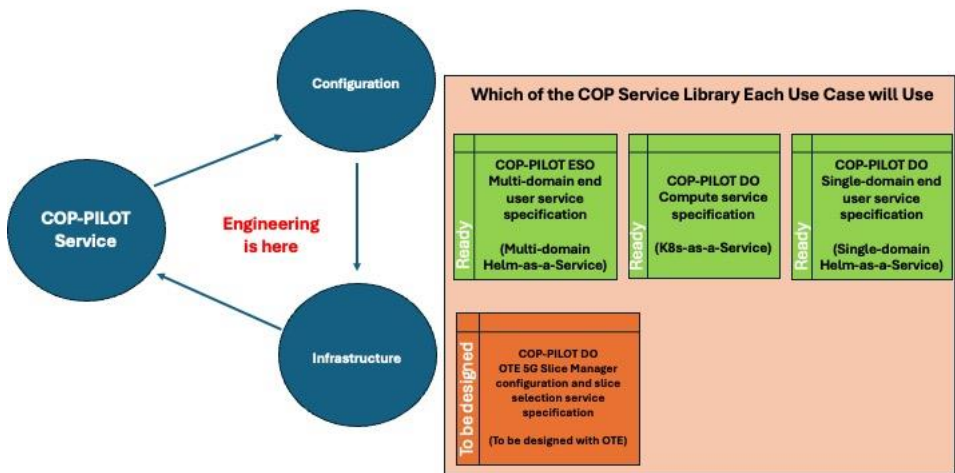


Figure 48 Engineering model for use case 3A.3 – Secure Data Management and Interoperability

Use Case 3A.4: Smart Logistics and Supply Chain Optimisation

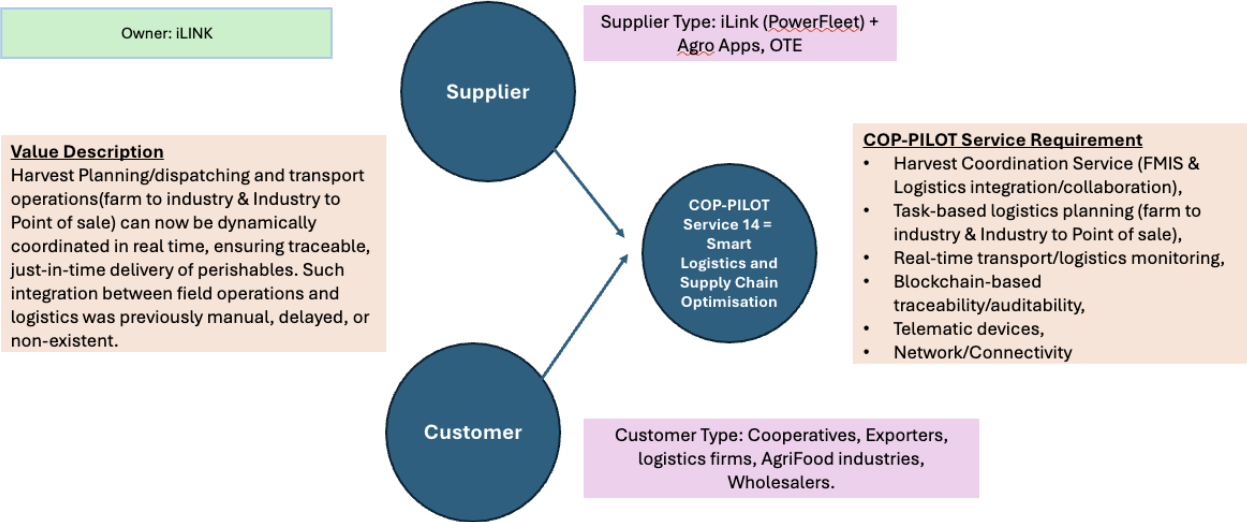


Figure 49 Service model for use case 3A.4 – Smart Logistics and Supply Chain Optimization

Cluster 3A Use Case 3: Smart Logistics and Supply Chain Optimization

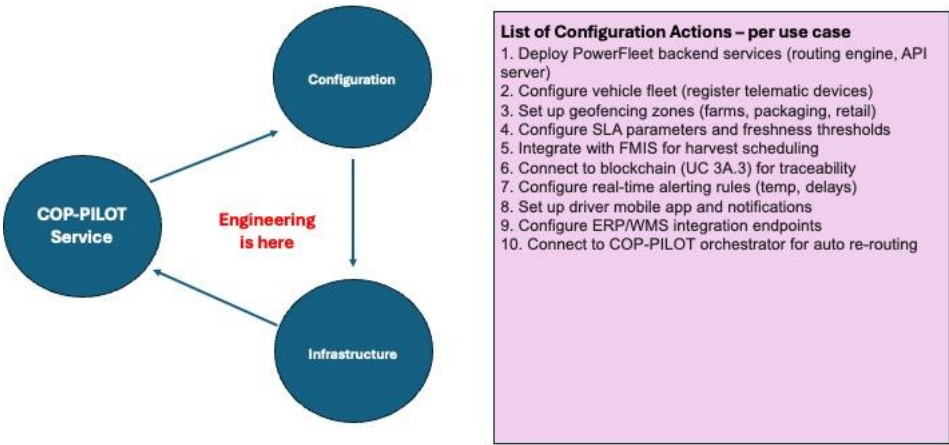


Figure 50 Engineering model for use case 3A.4 – Smart Logistics and Supply Chain Optimization

Cluster 3A Use Case 3: Smart Logistics and Supply Chain Optimization

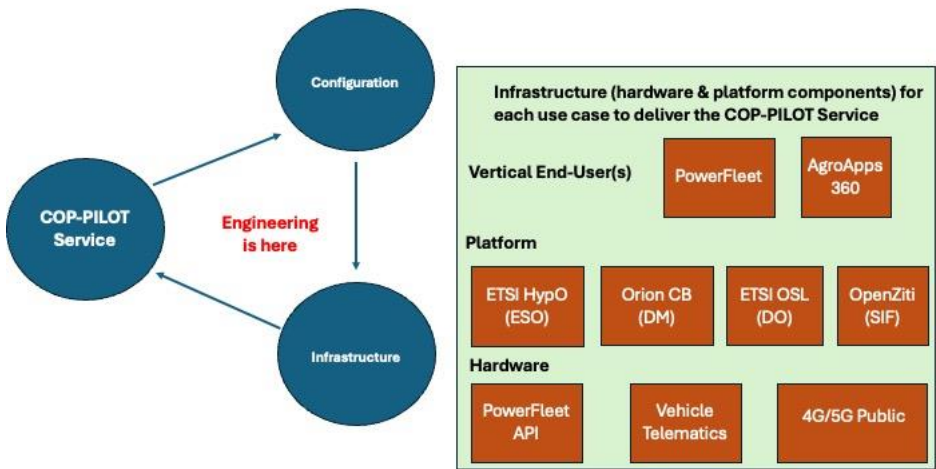


Figure 51 Engineering model for use case 3A.4 – Smart Logistics and Supply Chain Optimization

Cluster 3A Use Case 3: Smart Logistics and Supply Chain Optimization

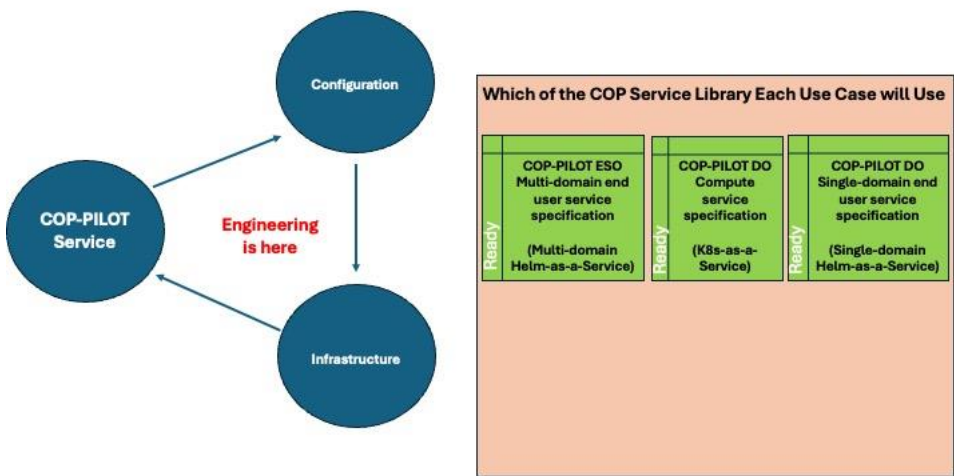


Figure 1.0: Engineering model for use case 3A.4 – Smart Logistics and Supply Chain Optimization

Cluster 3A Conclusion

The four use cases of Cluster 3A collectively demonstrate that the COP-PILOT engineering model, applied to precision agriculture, is far more than a deployment exercise, it is a systemic redesign of how agricultural data flows, acts, and is trusted. UC3A.1 establishes the real-time observational foundation, aggregating geo-referenced crop data from weather stations, plant wearables, satellite feeds, and UAVs into a continuously updated FMIS picture that was previously either fragmented across proprietary systems or simply unavailable. UC3A.2 builds directly on that foundation, enabling autonomous and semi-autonomous robots to act on up-to-date crop status and weed occurrence maps generated by AUA's AI models, a level of field-to-robot data coordination that previously required extensive manual data transfer and resulted in delayed, disconnected decision-making.

UC3A.3 then provides the trust and accountability layer that makes cross-stakeholder data exchange viable at scale. By deploying a Hyperledger Fabric network with private data collections, certificate authority management, and QR-based verification, the service transforms data that was previously handwritten, siloed, or unauditable into a tamper-evident, access-controlled record that certification bodies, public authorities, and agrifood industries can rely on. UC3A.4 closes the loop, using PowerFleet's routing and telematics infrastructure, integrated with the FMIS, the blockchain traceability chain from UC3A.3, and real-time SLA and freshness thresholds, to dynamically coordinate harvest dispatch and transport from farm to industry to point of sale in a way that was previously either manual or non-existent. Taken together, the ten configuration actions of UC3A.4 and the infrastructure they sit upon represent the culmination of everything the cluster builds: a fully traceable, real-time, orchestrator-connected agricultural supply chain, delivered through the COP-PILOT platform.

CLUSTER 3E (EDGE INTELLIGENCE FOR ENHANCING GRID RELIABILITY) SERVICE AND VALUE MODEL

The integration of COP-PILOT within Cluster 3E fortifies the shift toward data-intelligent, low-carbon, and resilient energy systems. It proves to respond to the complexities of decentralized electricity networks, described by high Distributed Energy Resource (DER) penetration. COP-PILOT's edge-based analytics and open orchestration framework deliver adaptive control, interoperability, and real-time monitoring across grid domains. By deploying smart metering data, IoT installations, and external datasets such as weather conditions and market signals, the platform allows for demand response (DR) and predictive flexibility management, stabilizing grids in Renewable Energy Source (RES)-rich regions such as Preveza.

For distribution system operators, COP-PILOT reduces maintenance interventions, mitigates line congestion and overvoltage, and improves grid reliability. EV charging operators and customers experience improved charger availability and optimized load balancing. Biogas and generation plant operators gain from reduced operational costs, smoother grid integration, and predictive fault detection. Energy market aggregators benefit from improved forecasting accuracy and monetization opportunities through flexibility services. Meanwhile, consumers and society profit from a more stable, renewable-integrated energy supply with reduced blackout risks.

Therefore, COP-PILOT in Cluster 3E exhibits a scalable model for climate-resilient and intelligent grid orchestration, advancing Europe's digital energy transition and sustainability goals through real-time optimization and federated data.

Cluster 3E Engineering Summary

Cluster 3E addresses a challenge that sits at the heart of the modern energy transition: the need to move from rigid, manually monitored energy infrastructure toward intelligent, data-driven systems capable of operating reliably in the face of growing complexity, distributed generation, accelerating EV adoption, and the increasing pressure on industrial energy producers to operate with minimal waste. The three use cases that constitute this cluster, Harvesting Real-Time Flexibility from Active Electricity Distribution (UC1/Distribution Grid), Ensuring Uninterruptible Power Supply for Fast EV Chargers (UC2/EV Chargers), and Predictive Maintenance and Monitoring of Anaerobic Digestion in a Biogas Plant (UC3/Biogas Plant), are not parallel and independent services but a coherent set of energy intelligence capabilities that share a common edge-to-cloud architecture and collectively demonstrate COP-PILOT's ability to operate across the full energy value chain: from grid simulation and DER control, through EV charging infrastructure health, to the biological processes of on-site energy production.

As the architecture diagrams make clear, all three use cases operate at the intersection of the COP-PILOT Service's Configuration and Infrastructure nodes, precisely where engineering intent must be translated into deployed, running systems. Each service is built on containerized workloads moving toward HELM-packaged Kubernetes deployments, spans a layered infrastructure stack of sensor, application, computation, and COP-PILOT layers, and relies on a shared connectivity pattern of edge Jetson devices connected via 4G and VPN tunnels to enterprise K8s clusters, which in turn connect to the COP-PILOT cloud layer through the Secure Interconnection Framework. The COP-PILOT service library elements required across all three use cases, K3s-as-a-Service, K8s-as-a-Service, and Single-domain and Multi-domain Helm-as-a-Service, form a consistent technical baseline, meaning the engineering work validated in the most mature use case, the Biogas Plant, directly de-

risks the infrastructure path for EV Chargers and Distribution Grid as they reach deployment readiness

Use Case 3E.1 Ensuring Uninterruptible Power Supply For Fast EV Chargers

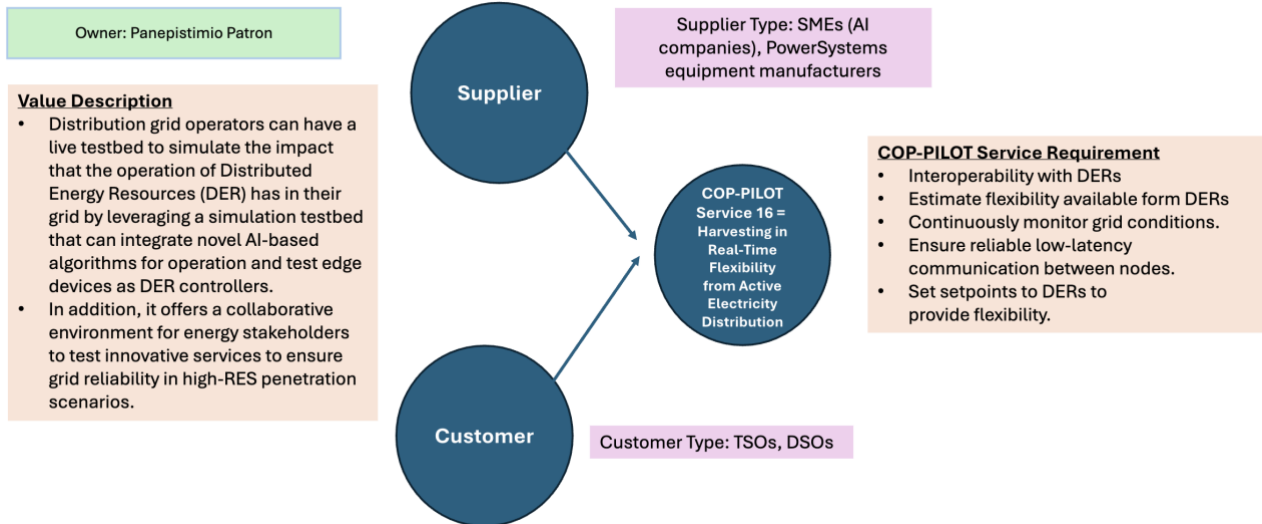


Figure 52 Service model for use case 3E.1 – Ensuring Uninterruptible Power Supply For Fast EV Chargers

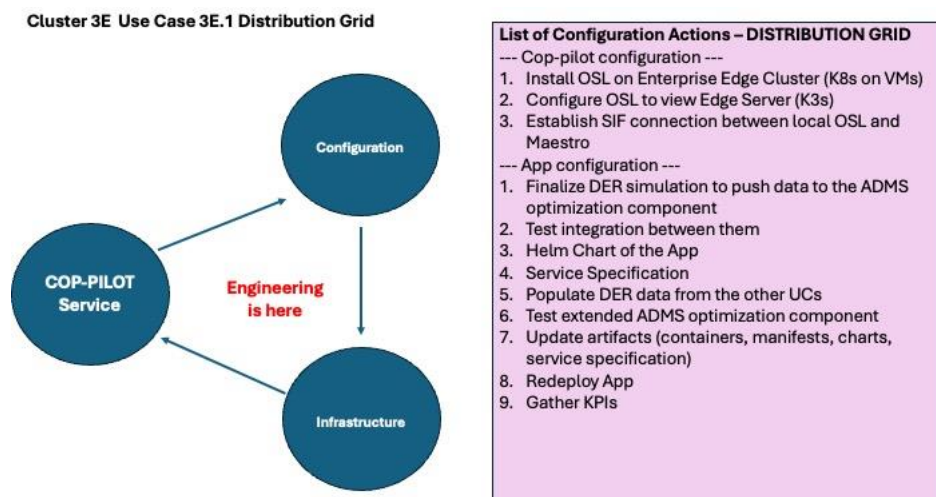


Figure 53 Engineering model for use case 3E.1 – Ensuring Uninterruptible Power Supply For Fast EV Chargers

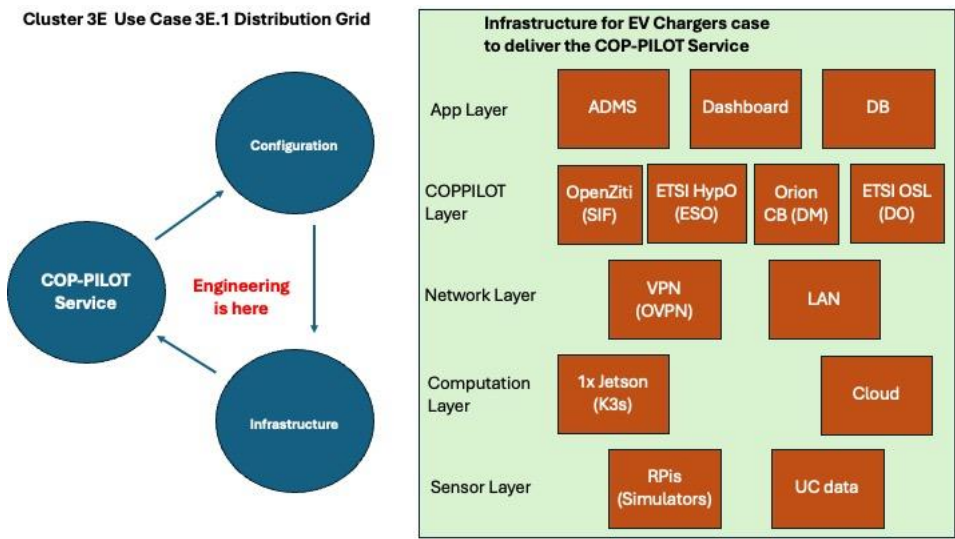


Figure 54 Engineering model for use case 3E.1 – Ensuring Uninterruptible Power Supply For Fast EV Chargers

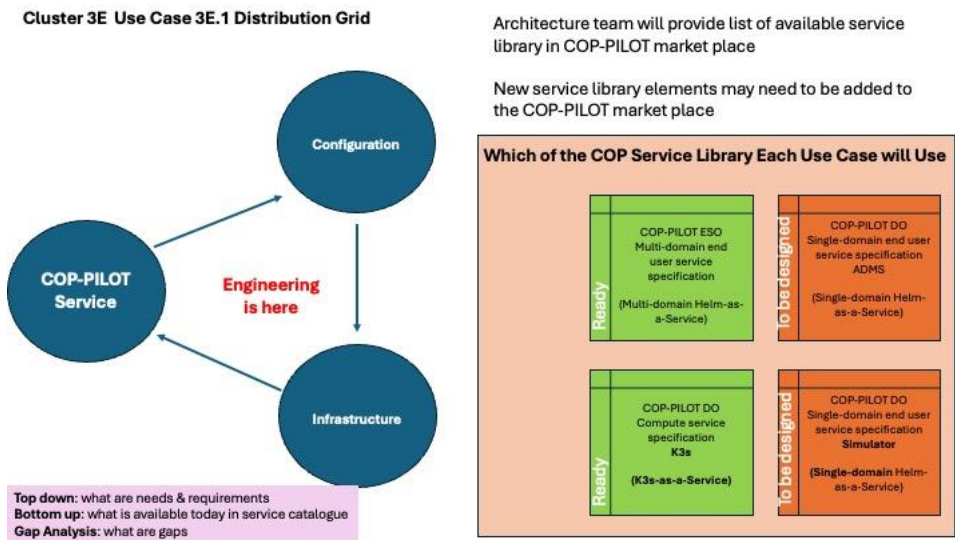


Figure 55 Engineering model for use case 3E.1 – Ensuring Uninterruptible Power Supply For Fast EV Chargers

Use case 3E.2: Ensuring Uninterruptible Power Supply for Fast EV Chargers

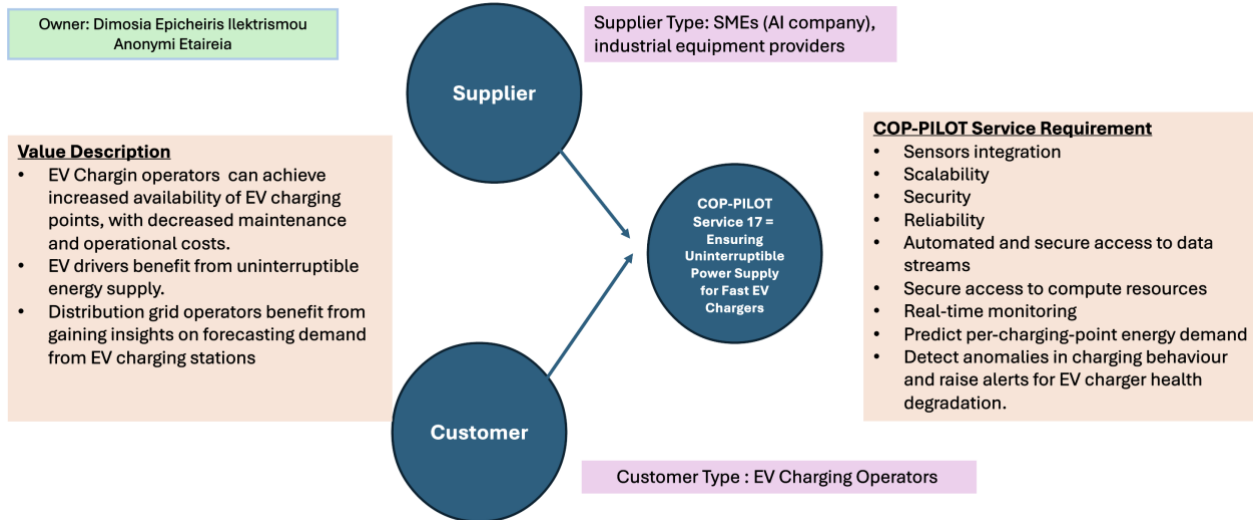


Figure 56 Service model for use case 3E.2 - Ensuring Uninterruptible Power Supply for Fast EV Chargers

Cluster 3E Use Case 3E.1 EV Chargers

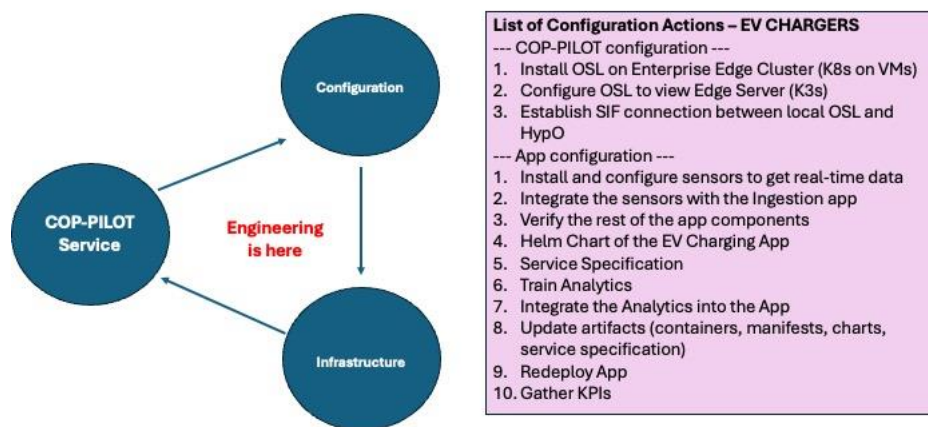


Figure 57 Engineering model for use case 3E.2 - Ensuring Uninterruptible Power Supply for Fast EV Chargers

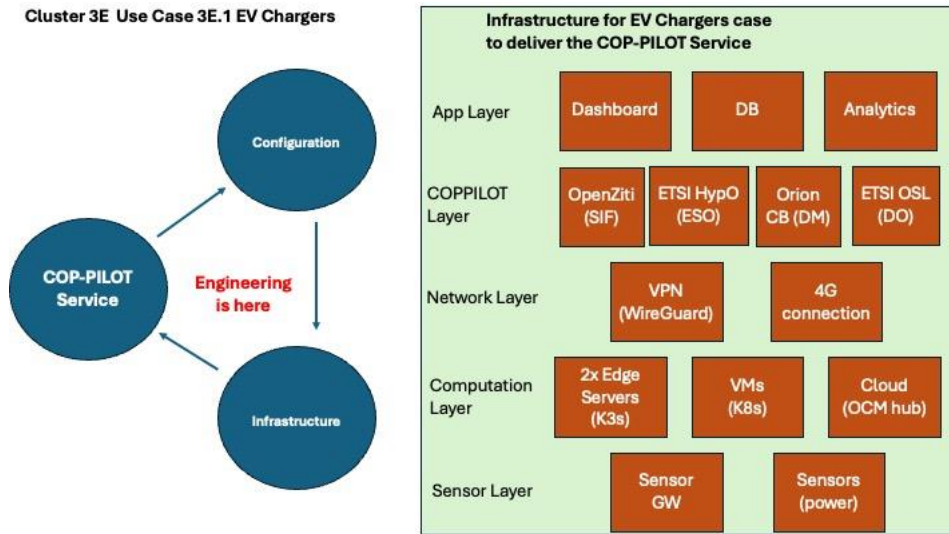


Figure 58 Engineering model for use case 3E.2 - Ensuring Uninterruptible Power Supply for Fast EV Chargers

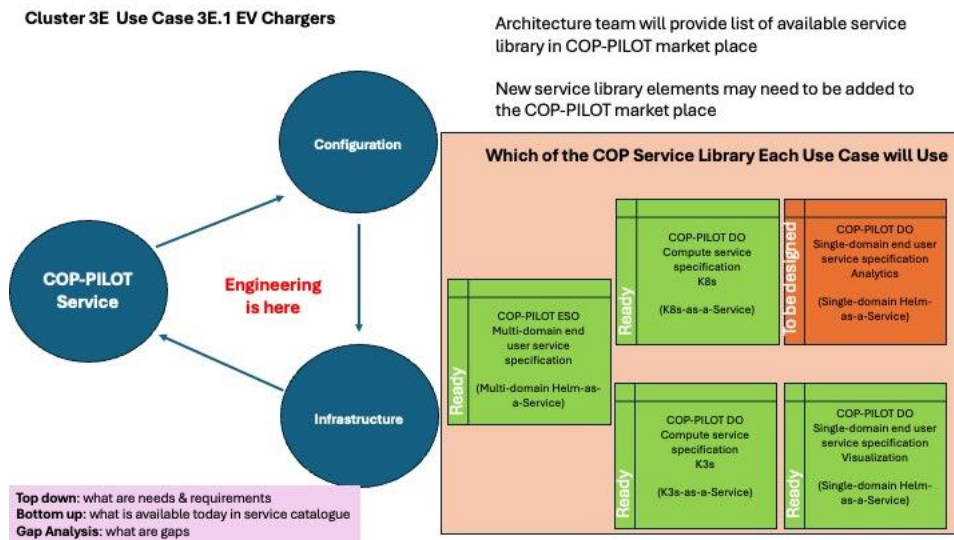


Figure 59 Engineering model for use case 3E.2 - Ensuring Uninterruptible Power Supply for Fast EV Chargers

Use case 3E.3: Predictive Maintenance and Monitoring of Anaerobic Digestion In A Biogas Plant

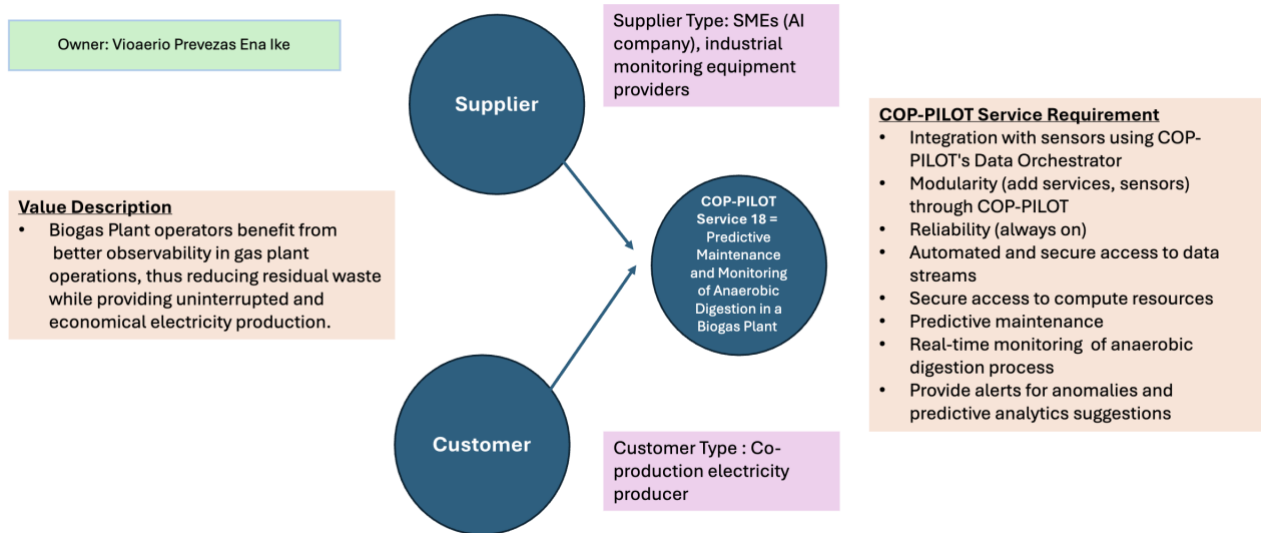


Figure 60 Service model for use case 3E.3 – Predictive Maintenance and Monitoring of Anaerobic Digestion in a Biogas Plant

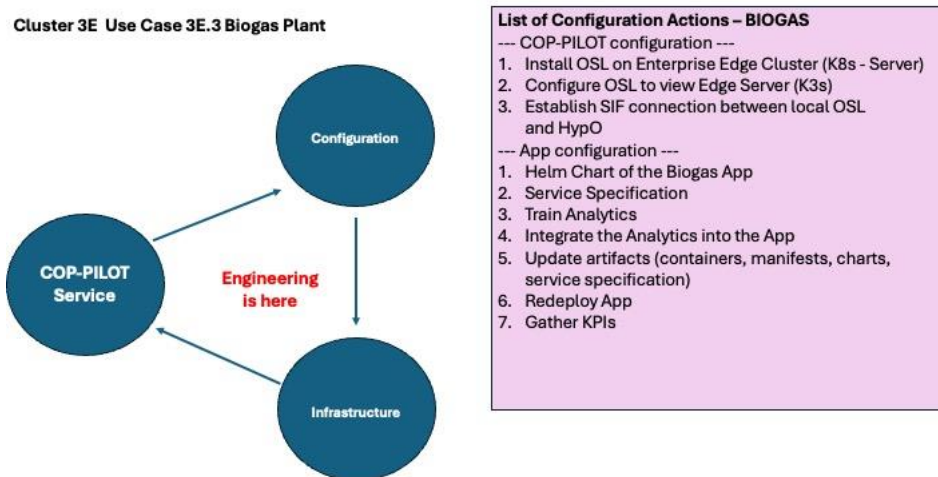


Figure 61 Engineering model for use case 3E.3 – Predictive Maintenance and Monitoring of Anaerobic Digestion in a Biogas Plant

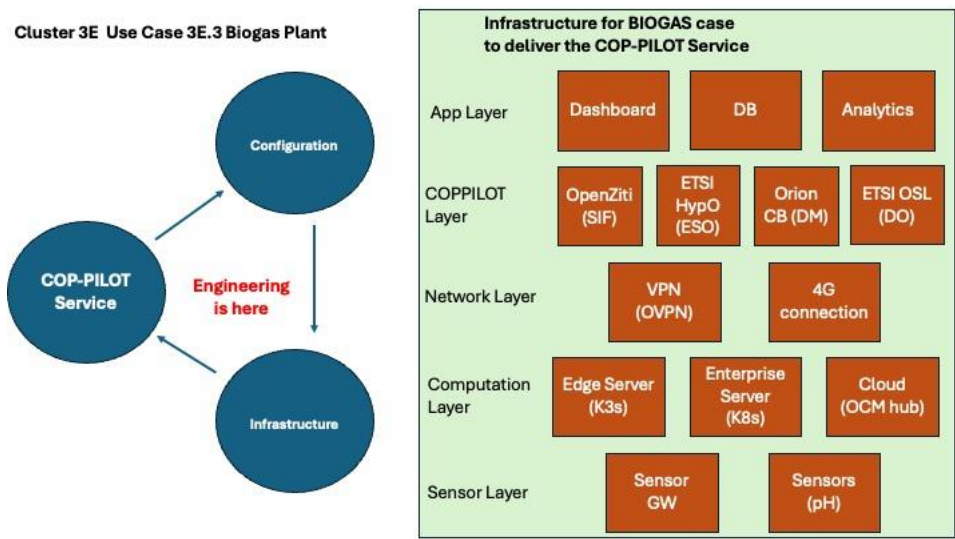


Figure 62 Engineering model for use case 3E.3 – Predictive Maintenance and Monitoring of Anaerobic Digestion in a Biogas Plant

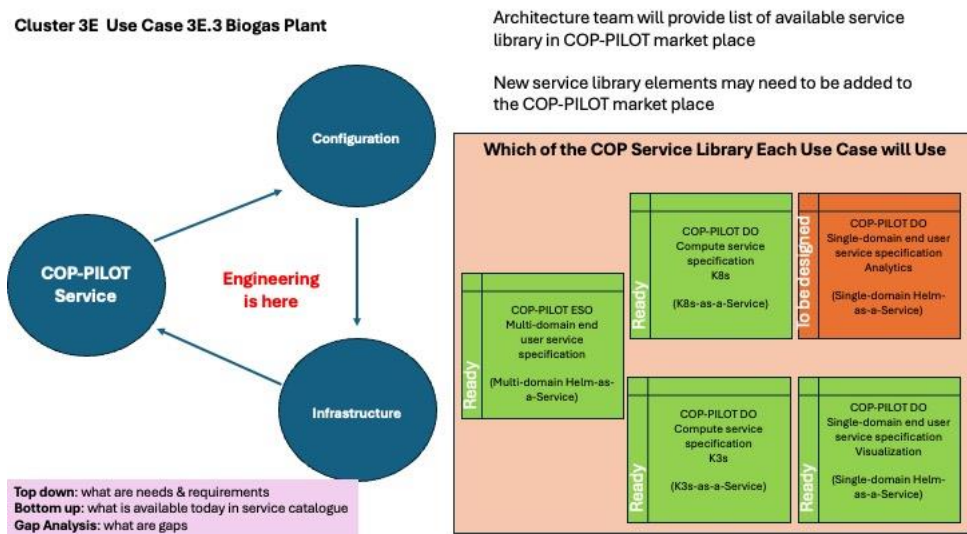


Figure 63 Engineering model for use case 3E.3 – Predictive Maintenance and Monitoring of Anaerobic Digestion in a Biogas Plant

Cluster 3E Conclusion

The three configuration action sequences for Cluster 3E, spanning OSL installation and SIF connection establishment on the COP-PILOT side, and Helm chart preparation, analytics training, artifact updates, and KPI gathering on the application side, reveal a deliberate two-layer engineering discipline that applies consistently across all three use cases. The COP-PILOT platform configuration steps are nearly identical across Biogas, EV Chargers, and Distribution Grid, confirming that the cluster shares a common integration backbone. What differs, and what gives each use case its distinct engineering character, is the application configuration: Biogas requires training ML algorithms against sensor data acquired via Modbus TCP; EV Chargers requires physical sensor installation and integration before the analytics pipeline can even begin; and Distribution Grid, the least mature of the three, must first validate its DER simulators on Raspberry Pi hardware and

complete ADMS integration before it can replicate the same deployment pattern the other two use cases are already following.

This maturity gradient, from Biogas Plant as the most ready, through EV Chargers with historical data in hand, to Distribution Grid still in simulation, is not a weakness of the cluster but a feature of how the COP-PILOT engineering model handles parallel development across use cases at different stages. The shared infrastructure stack means that as each use case progresses, it inherits proven configuration patterns rather than building from scratch. The open discussion points that remain across all three, around FIWARE-as-a-Service, ORION context broker integration, IoT adapters, Quantum Leap, and east-west connectivity, represent the cluster's genuine frontier: the questions whose resolution during the workshop phase will determine how tightly the three energy use cases can share data and operational context, and how far Cluster 3E can go toward becoming not just three deployed services, but a genuinely integrated energy intelligence platform on COP-PILOT.

CLUSTER 4 (SMART VINEYARDS & SUSTAINABLE WINERY ECOSYSTEMS) SERVICE AND VALUE MODEL

The implementation of COP-PILOT within Cluster 4 represents a critical advancement in data-driven, federated innovation across multiple fields, blending IoT, artificial intelligence, machine learning, and within a sovereign computing continuum. By utilizing advanced data management and governance frameworks aligned with GAIA-X principles and the Network-as-Code approach, COP-PILOT assures compliant, interoperable, and secure data exchange across multifarious use cases without exposure to transatlantic GDPR challenges (SCHREMS II).

The cluster's comprehensive applications contain smart water management in agriculture, healthcare waste optimization, winery process enhancement, and energy-aware agricultural scheduling. For farmers and winery operators, COP-PILOT enables predictive maintenance, improved yields, and data-guided irrigation. Process owners and manufacturers profit from reduced downtime, AI-driven efficiency gains, and optimized equipment utilization. Healthcare and supply chain stakeholders achieve better cost reductions and sensor fleet management through IoT recycling and reuse. Environmental regulators benefit from tangible sustainability metrics, including lower resource consumption and reduced waste.

Finally, COP-PILOT in Cluster 4 exhibits how sovereign data governance and federated intelligence can together facilitate digital sovereignty, socio-economic value creation, and sustainability, and set a benchmark for cross-domain and responsible technological ecosystems.

Cluster 4 Engineering View

COP-PILOT's Cluster 4 focuses on sustainable resource management across three distinct domains: Water Usage Efficiency (Terraview), IoT Lifecycle and Recycling (RedZinc), and Sustainable Winery Production Line Optimization (JIG Digital). The engineering phase of the COP-PILOT service model, covering Infrastructure and Configuration, now takes centre stage, building on the value definitions and service requirements already established in D2.1. For Cluster 4, this means translating 20 modelled use cases into concrete, deployable services by mapping each use case to its underlying infrastructure components, defining HELM-based deployment strategies, and specifying configuration actions. The three Cluster 4 use cases represent varied technical maturity levels and deployment architectures, from a single-domain edge IoT platform to multi-domain Kubernetes deployments integrating FIWARE, EU Digital Identity Wallets, and public cloud endpoints. This session documents the pre-workshop and in-workshop findings for each use case and identifies gaps against the COP-PILOT service marketplace.

Use Case 4.1: Recycling, Maintenance and Logistics of IoT Sensors

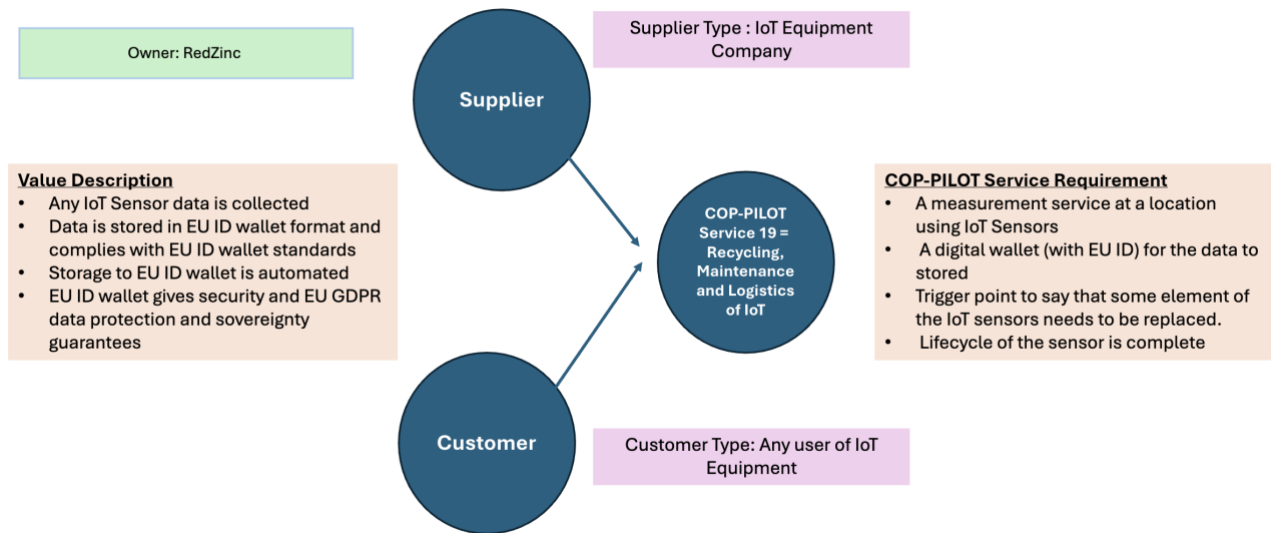


Figure 64 Service model for use case 4.1 (Service A) – Recycling, Maintenance and Logistics of IoT

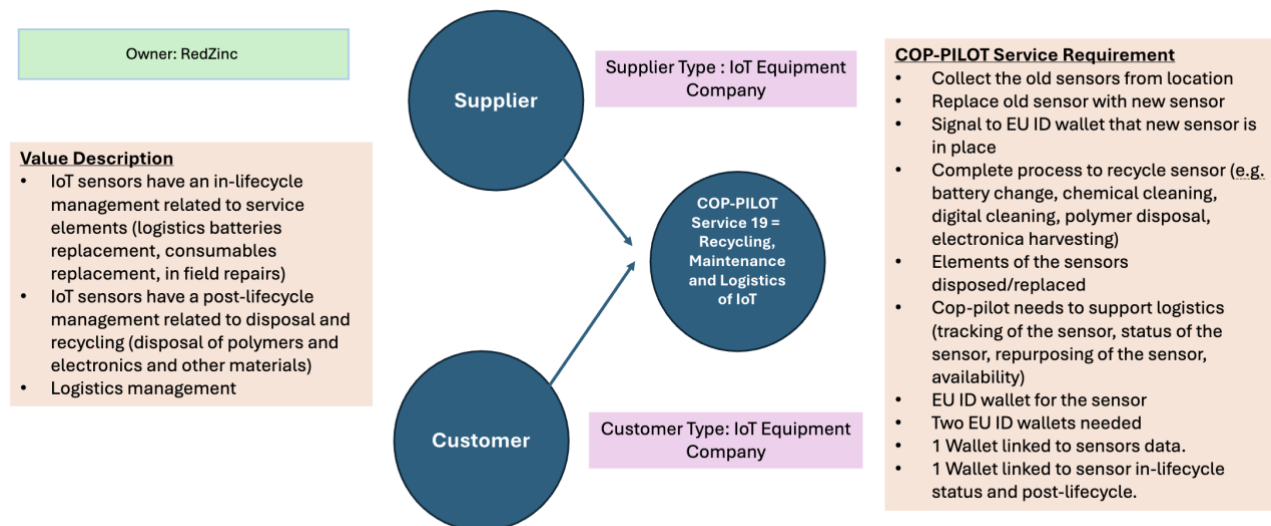


Figure 65 Service model for use case 4.1 (Service B) – Recycling, Maintenance and Logistics of IoT

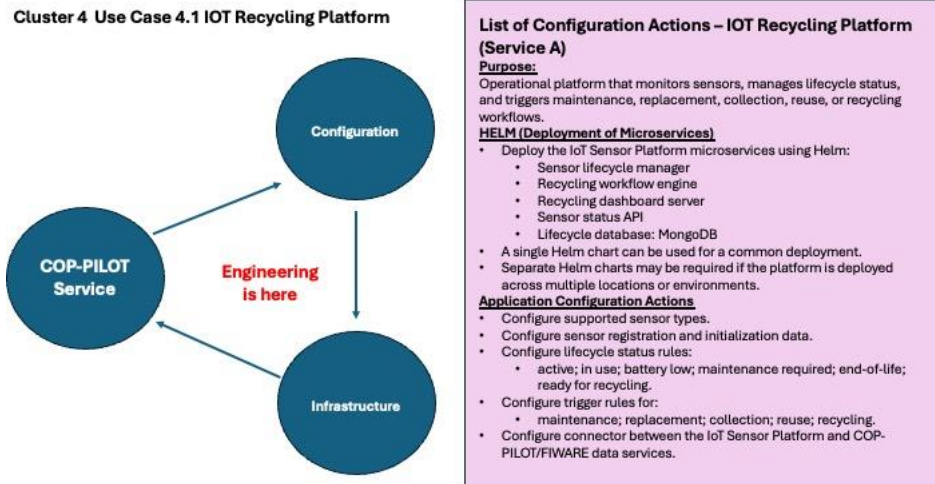


Figure 66 Engineering model for use case 4.1 – Recycling, Maintenance and Logistics of IoT

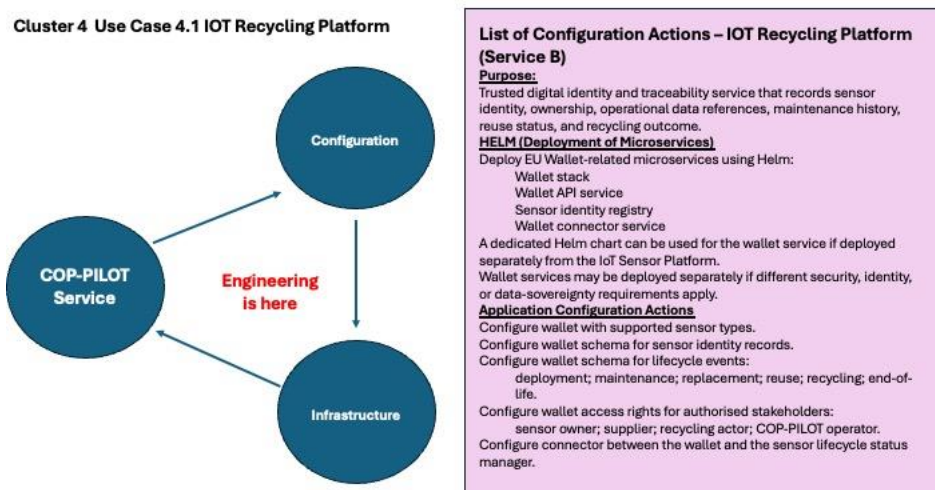


Figure 1.0: Engineering model for use case 4.1 – Recycling, Maintenance and Logistics of IoT

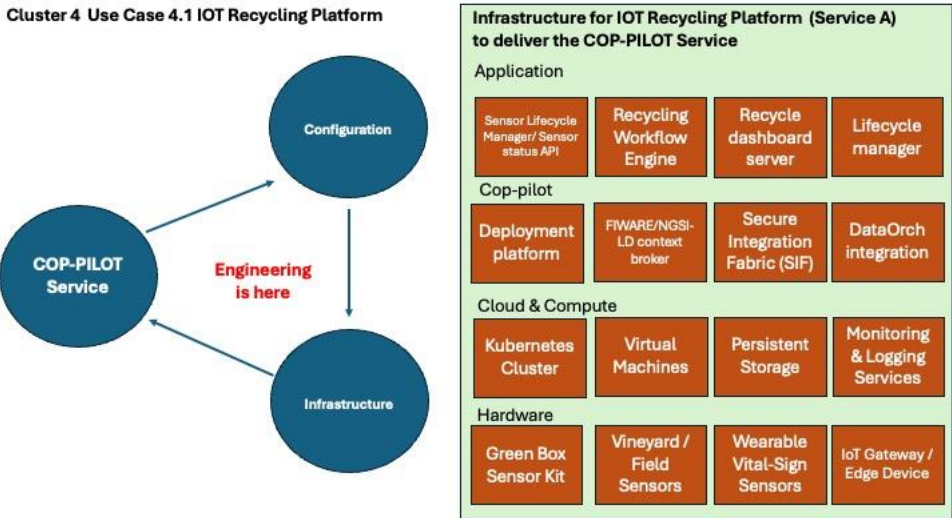


Figure 67 Engineering model for use case 4.1 – Recycling, Maintenance and Logistics of IoT

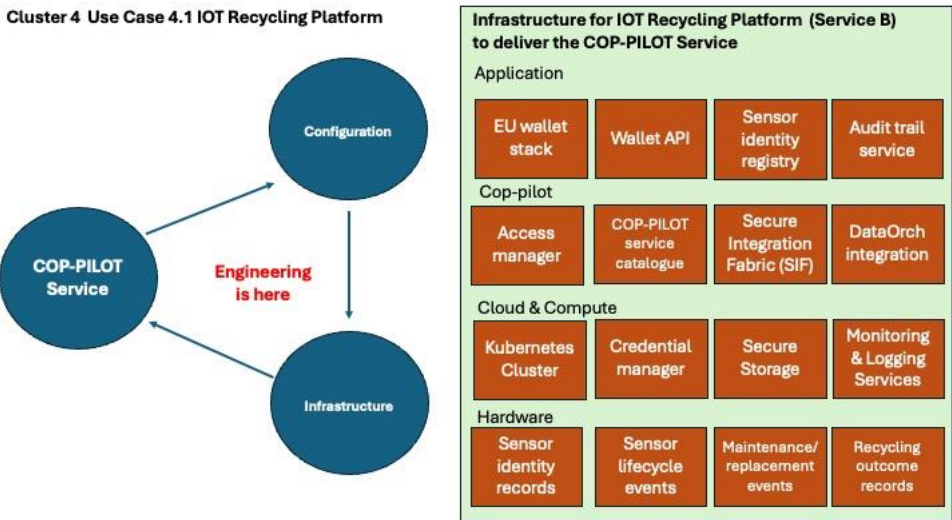


Figure 68 Engineering model for use case 4.1 – Recycling, Maintenance and Logistics of IoT

Cluster 4 Use Case 4.1 IOT Recycling Platform

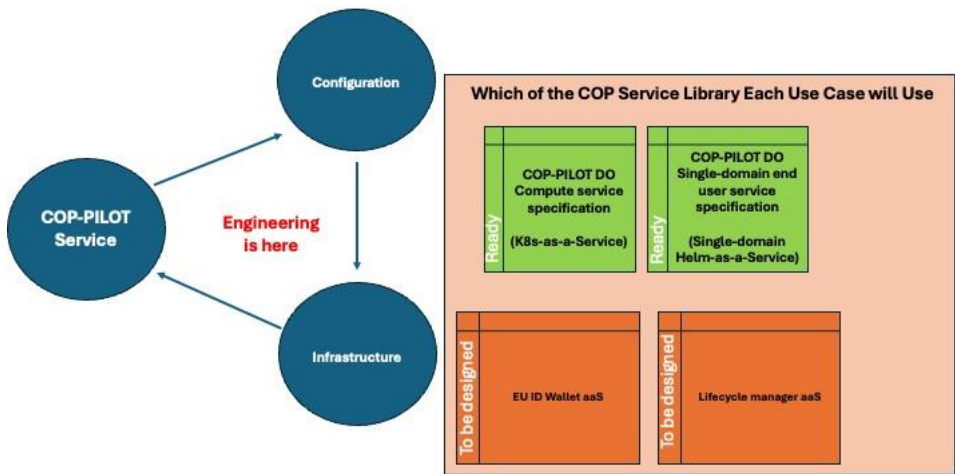


Figure 69 Engineering model for use case 4.1 – Recycling, Maintenance and Logistics of IoT

Use case 4.2: Water Utilisation Efficiency

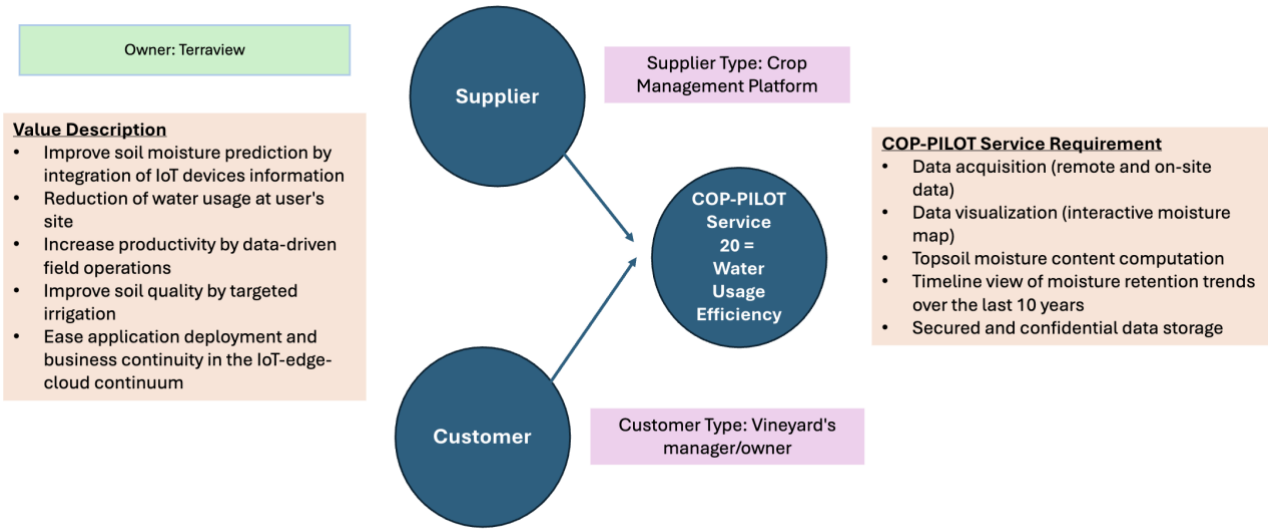


Figure 1.0: Service model for use case 4.2 – Water Utilisation Efficiency

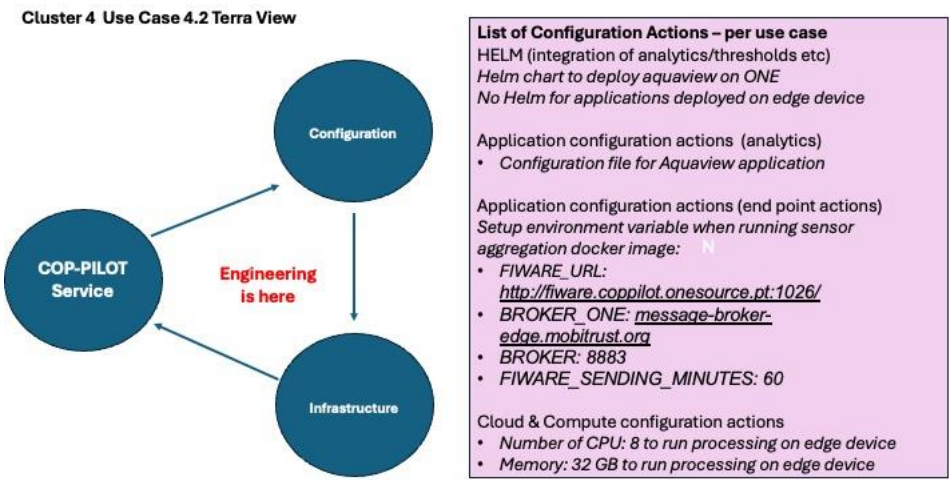


Figure 70 Engineering model for use case 4.2 – Water Utilisation Efficiency

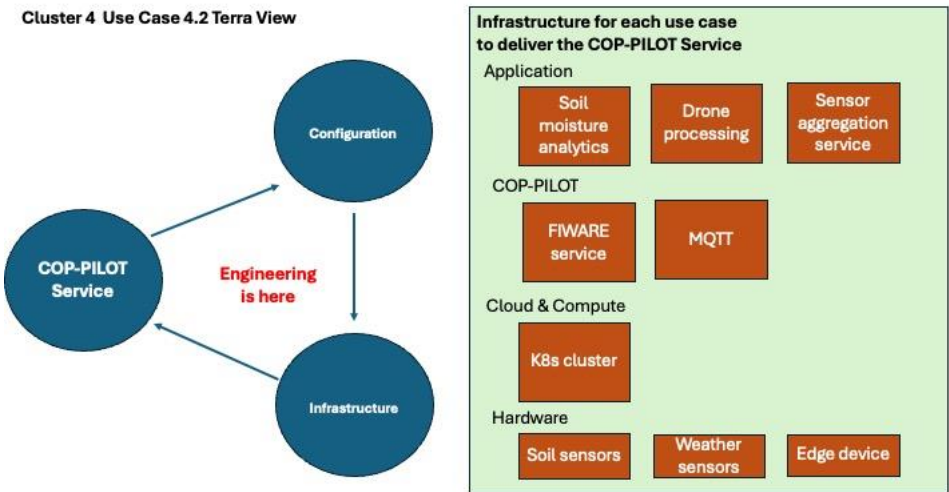


Figure 1.0: Engineering model for use case 4.2 – Water Utilisation Efficiency

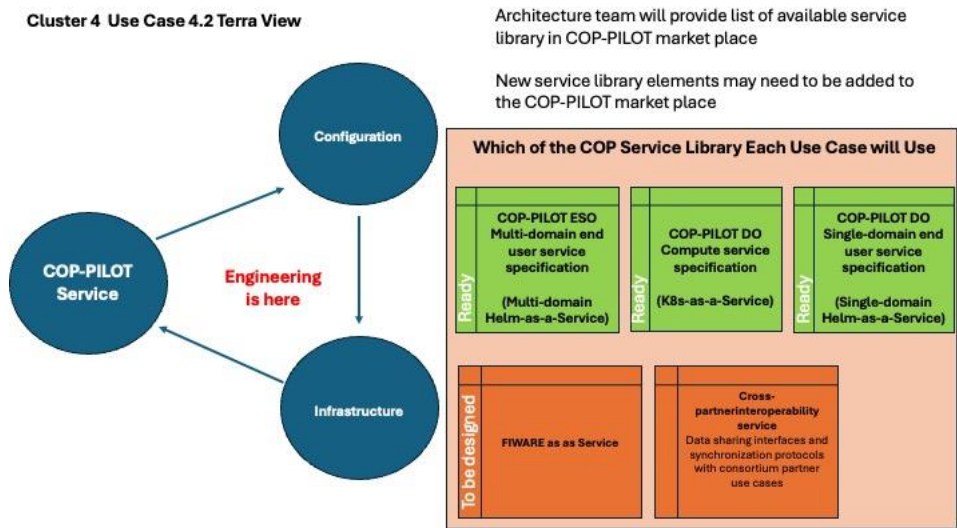


Figure 71 Engineering model for use case 4.2 – Water Utilisation Efficiency

Use case 4.3: Sustainable Optimised Winery Production Lines

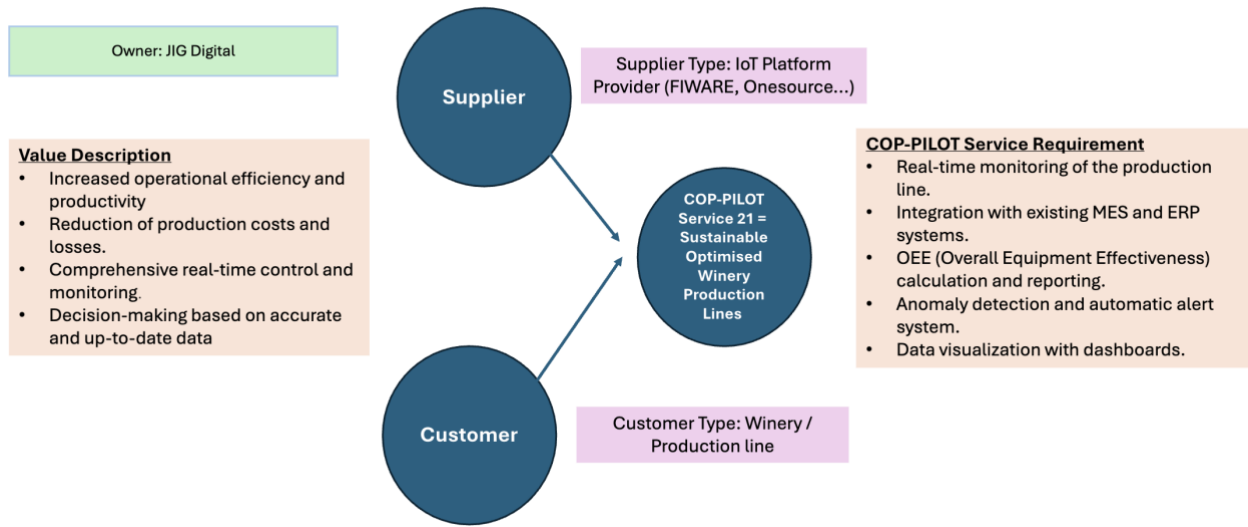


Figure 72 Service model for use case 4.3 – Sustainable Optimized Winery Production Lines

Cluster 4 Use Case 4.3

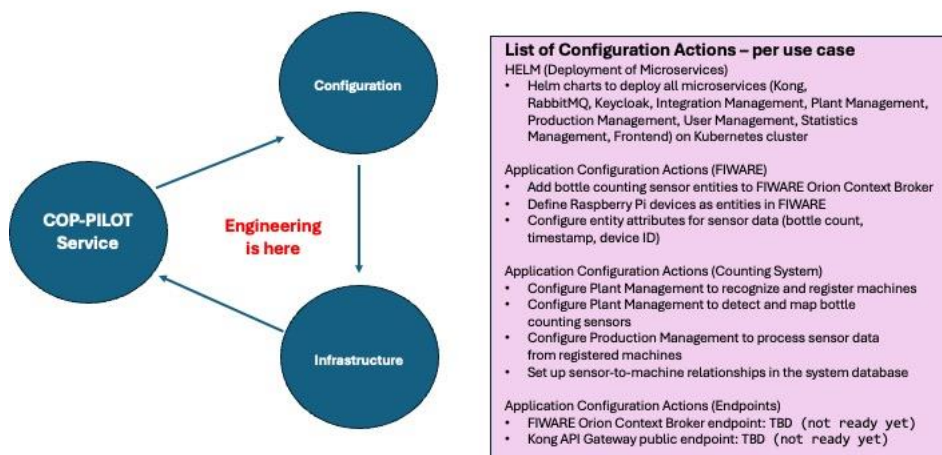


Figure 73 Engineering model for use case 4.3 – Sustainable Optimized Winery Production Lines

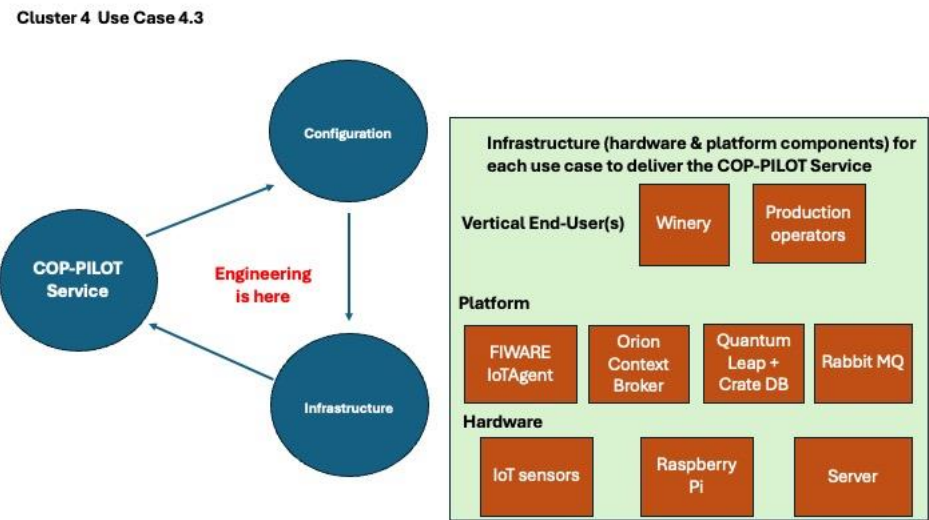


Figure 74 Engineering model for use case 4.3 – Sustainable Optimized Winery Production Lines

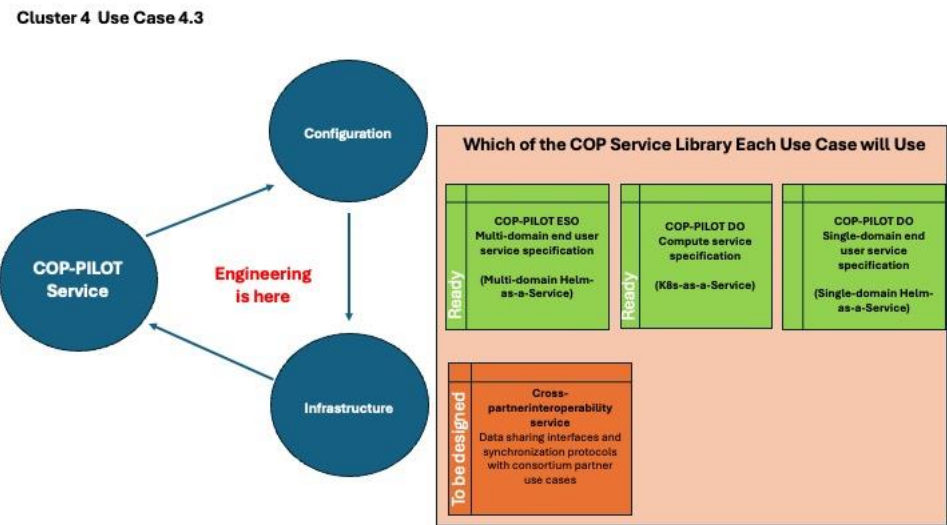


Figure 75 Engineering model for use case 4.3 – Sustainable Optimized Winery Production Lines

Use case 4.4: AI Driven Green Energy Vineyard Management

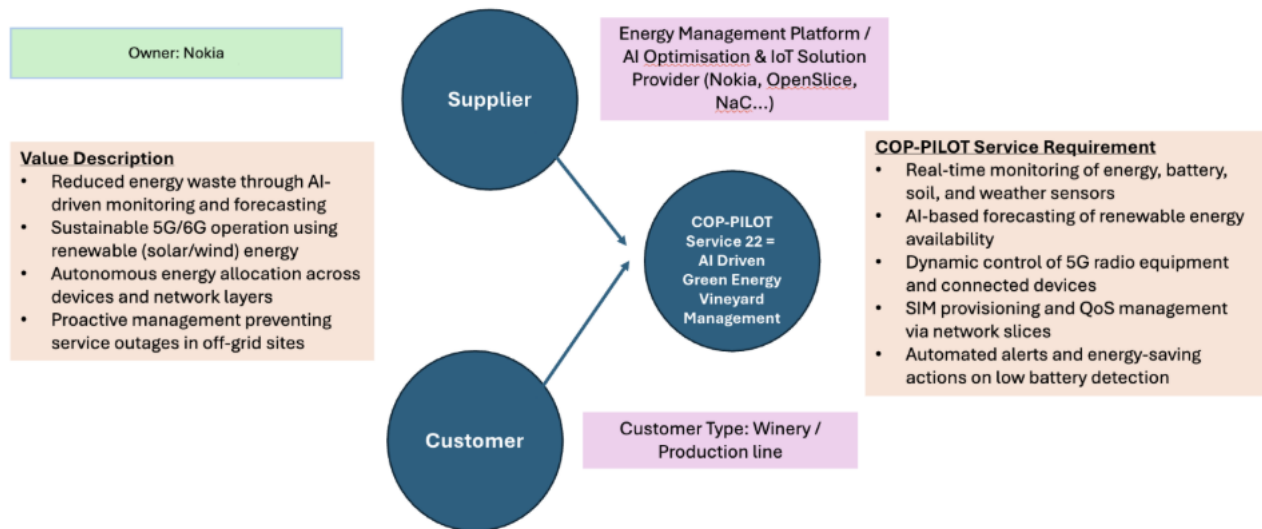


Figure 76 Service model for use case 4.4 – Sustainable Optimized Winery Production Lines

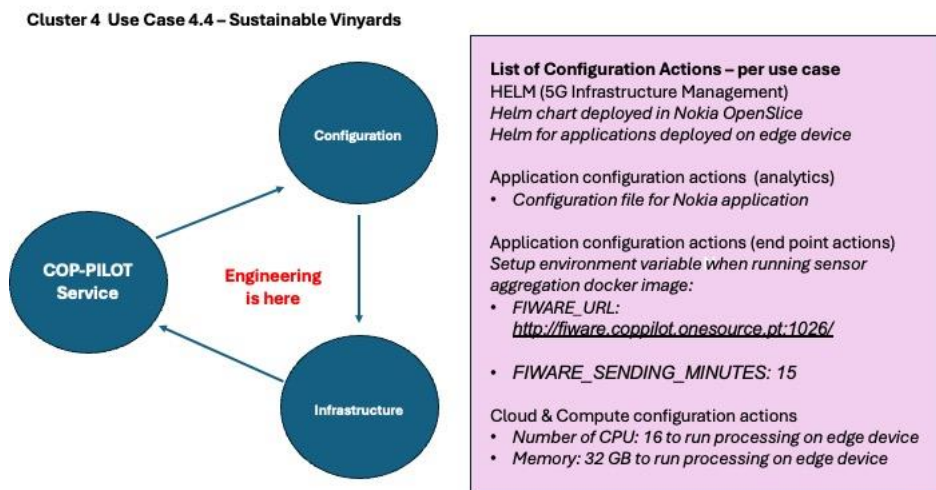


Figure 77 Engineering model for use case 4.4 – Sustainable Optimized Winery Production Lines

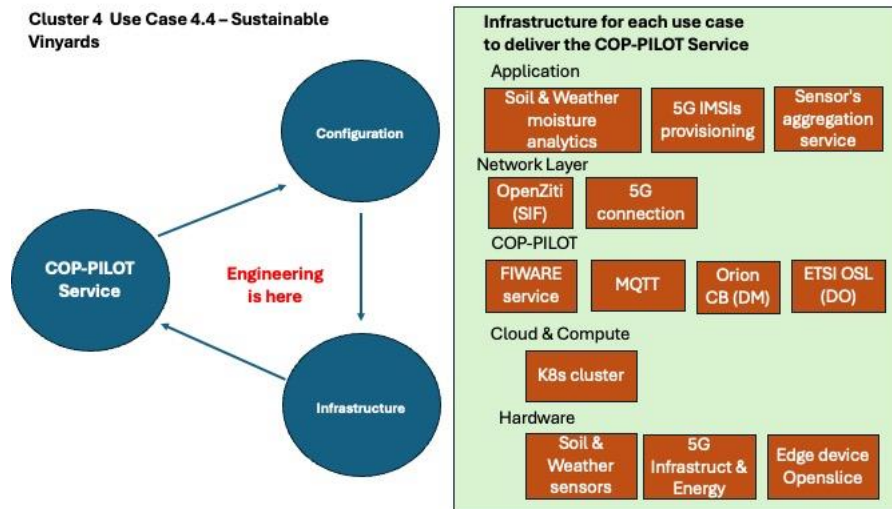


Figure 78 Engineering model for use case 4.4 – Sustainable Optimized Winery Production Lines

Cluster 4 Conclusion

Across Cluster 4's three use cases, a clear engineering picture is beginning to emerge. The RedZinc IoT Recycling Platform is the most infrastructure-defined, with a MongoDB-Wallet Stack architecture deployable via HELM on Kubernetes and a well-scoped set of configuration actions tied to EU Digital Identity Wallet integration. The Terraview Water Usage Efficiency use case introduces multi-domain complexity, requiring FIWARE and SIF connectivity between edge devices at the vineyard and analytics running on ONE's domain, with compute and endpoint configurations still being refined. The JIG Winery Production Line use case is the most component-rich, with nine microservices (including Kong, RabbitMQ, and Keycloak) and configuration actions spanning FIWARE entity registration, sensor-to-machine mapping, and Kubernetes-hosted deployment. Key open items for Cluster 4 include finalising the lower-level FIWARE and VM location diagrams with the RedZinc team, confirming Kubernetes cluster topology (single vs. multi-cluster) for the IoT Recycling Platform, and aligning on SIF client and FIWARE availability in the COP-PILOT marketplace, both of which may prove quasi-mandatory across use cases. The next step is completing these gap analyses and scheduling follow-up CL4 calls to advance each use case toward service readiness.