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D3.3 – Report on Business and Service Requirements, Preferred Market Structures and Pathways for the CEI Ecosystem

Work Package	WP3 | Dialogue with Industry Constituency
Task	T2.2 | Analysis of CEI service requirements and market scenarios
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Glossary of terms

Item	Description
AGV	Automated Guided Vehicle
AI	Artificial Intelligence
AR/VR	Augmented Reality/Virtual Reality
CAGR	Compound Annual Growth Rate
CDN	Content Delivery Networks
CEE	Central and Eastern Europe
CEI	Cloud-Edge-IoT
CRM	Customer Relationship Management
DSL	Digital Subscriber Line
ERP	Enterprise Resource Planning
EU	European Union
GEO	Geostationary Equatorial Orbit
IaaS	Infrastructure as a Service
IED	Intelligent Electronic Devices
IoT	Internet of Things
IPA	Intelligent Process Automation
IT	Information Technology
LED	Light-Emitting Diode
LEO	Low Earth Orbit
LTE	Long-Term Evolution
LPWAN	Low-Power Wide-Area Networks
MEC	Multi-access Edge Computing
MPLS	Multiprotocol Label Switching
MVNO	Mobile Virtual Network Operator
NB-IoT	Narrowband IoT
PaaS	Platform as a Service
RFID	Radio-Frequency Identification
ROI	Return on Investment
RPA	Robotic Process Automation
RTU	Remote Terminal Unit
SaaS	Software as a Service
SD-WAN	Software-Defined Wide Area Network
SIM	Subscriber Identity Module
TF	Task Force
VNF	Virtual Network Functions
VPN	Virtual Private Network
WAN	Wide Area Network
WLAN	Wireless Local Area Network
WP	Work Package

Keywords

Cloud, Edge, IoT, Demand landscape, Use case, Market segment, go-to-market, requirements, scenarios

Disclaimer

Executive Summary

This report identifies key business and service requirements, key market segments and likely market pathways for the Cloud-Edge-IoT (CEI) Ecosystem in Europe. This information has been partially validated by industry participants in the "Wave 2" workshops and will be further validated through upcoming "Wave 3" interviews.

In this document, the following definitions apply:

Market Segment: a subset of a total market based on demographics, needs, priorities, common interests, and other psychographic or behavioural criteria used to better understand the target audience.

Market Pathway: a subset of a market segment expected to develop and evolve in a certain way, based on the changing needs of customers, the changing capabilities of suppliers, as well as the dynamics of different suppliers entering and existing the market over time.

Market Scenario: alternative Market Pathways that might be expected to develop. Different Market Scenarios would reflect different development pathways that might be possible depending on future actions by market participants.

Key Market Segments

The UNLOCK-CEI project has estimated market opportunities total over €26 billion per year, based on an analysis of 79 Considered Use Cases (use cases initially presented in [D1.2] and augmented with market estimates in [D2.2]). Of the five sectors examined by the UNLOCK-CEI project, the Transportation sector represents the largest total market opportunity, estimated at almost €12 billion per year (45% of the total). Energy/Utilities and Manufacturing are each estimated at roughly 25% of the total, with €6.8 and €6.4 billion per year respectively. Agriculture and Healthcare make up the balance, with €0.8 and €0.4 billion per year respectively (3% and 1% of the total, respectively).

This market is not homogeneous, with significant differences in both size and characteristics among the 79 Considered Use Cases. For example, the largest 24% of the use cases (19 use cases) account for over 90% of the total annual market estimate. Suppliers are likely to enter the European CEI market by focusing on these larger use cases, but it will be the characteristics of the different use cases that will determine how the market is segmented.

Section 2 develops preliminary market segmentation based on three main characteristics: industrial sector, architectural pattern employed in implementing the use case, and the technologies and target objects required by the use case. Using these characteristics, six key market segments are identified, representing over 95% of the total annual market estimate. (See Table 1 and Figure 1.)

Table 1: Key Characteristics of Market Segments (all figures annual)

Market Segment	Sectors	Use Cases	Total Market (€M)	Gateway Market (€M)	Device Market (€M)	Total Gateways (000s)	Total Devices (millions)
1: Autonomous Vehicle	5	6	8,411	3,611	4,799	66	11
2a: Optimization	4	5	2,357	837	1,520	40	59
2b: Image Processing	5	10	3,734	829	2,905	68	131
3: Smart Meters	1	1*	4,222	34	4,187	1	557
4: Location of Movable Assets	5	8	4,451	193	4,258	37	788
5: Smart Building	4	4	1,209	183	1,026	42	40
6: Location of Mobile Assets	4	6	626	57	568	32	156
None	5	39	1,084	518	566	101	40
Grand Total			**26,092**	**6,262**	**19,830**	**388**	**1,783**

* Also EV charging, a new use case identified in the Wave 2 workshops.

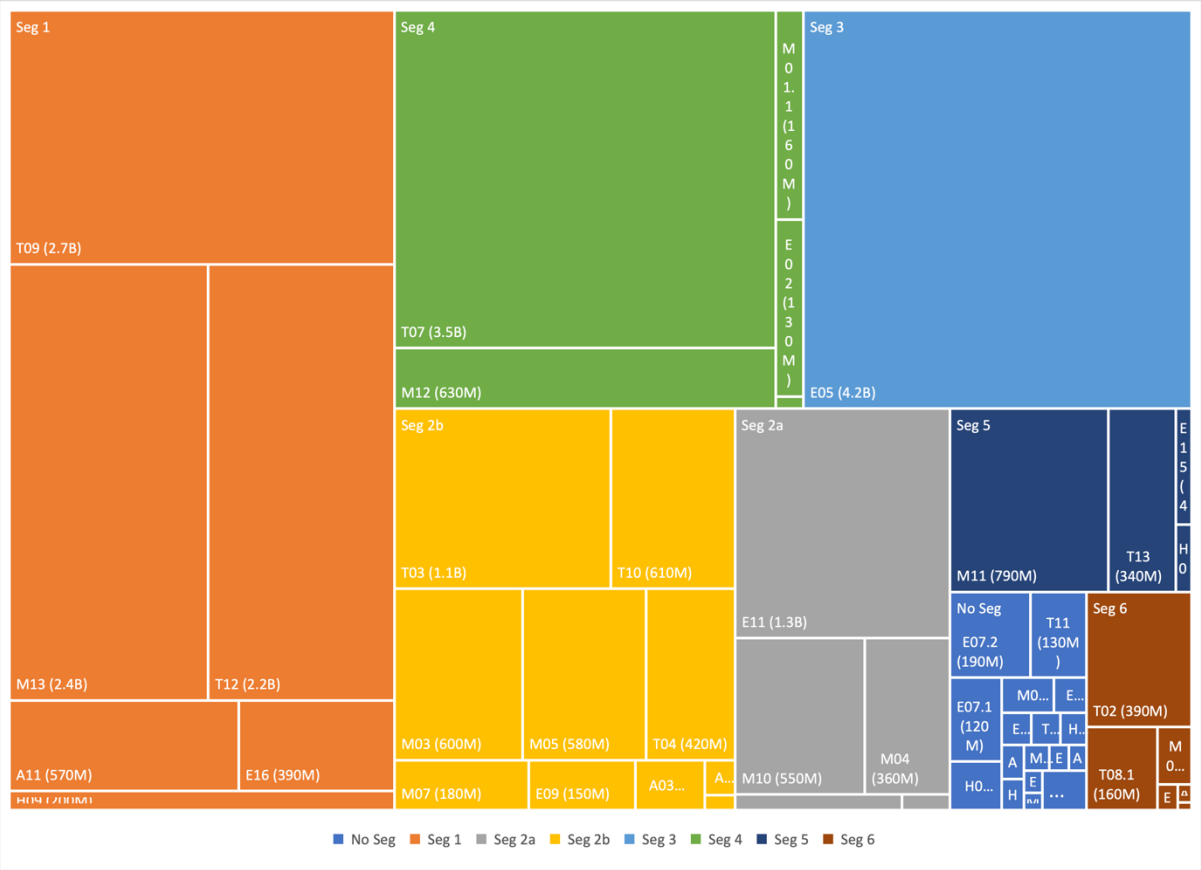

Figure 1: Illustrating Annual Value of Key Market Segments

All the proposed market segments concentrate on specific categories of use case or application, such as Segment 5, “smart building”. This commonality of application and common technical components make the full segment easier to serve by potential suppliers. While Segments 2a and 2b address different applications, they share many technical aspects, making them easier to address by a given supplier, which is why they are linked together.

Different Service Requirements or Go-To-Market Factors That Might Alter Market Segmentation

All the preliminary market segments presented in Section 2, aside from Segment 3 (“smart meters”), address use cases that span four or five different sectors. This raises the question of whether those sectors have significantly different expectations regarding the service requirements that are important to them, or their preferred go-to-market strategies and business models.

Sections 3 and 4 consider whether the preliminary market segments presented in Section 2 should be modified to reflect important differences between sectors. They rely on Appendices A and B, which address priority service requirements by sector, and preferred go-to-market strategies and business models by sector, respectively.

Section 3 concludes that, while there are differences between sectors in the prioritization of service requirements, similar service requirements are important to almost all sectors. Any supplier would need to address all the important service requirements, regardless of sector. Individual suppliers might customize their approach to

different sectors (for example, applying the differentiation techniques described in Blue Ocean Strategy), but similar technologies and operating methods would be needed across the full segment.

Section 4 arrives at the same conclusion regarding preferred go-to-market strategies and business models. Specific customers might have different preferences, but no distinct sectoral preferences were identified in the Wave 2 workshops. Suppliers would need to align their approaches to each customer's preferences.

Based on this analysis, no adjustment to the market segments presented in Section 2 is needed.

Key Service Requirements

Key service requirements have been identified in three UNLOCK-CEI analyses:

- D1.2 "Updated Report of CEI Demand Landscape" [D1.2]
- "EUCEI Task Force 5: Markets and Sectors - Workshop 2 outcomes: Technology mapping of MetaOS use cases" [TF5].
- D3.2 "Sector-specific service requirements, data flows and revenue streams in Cloud-Edge-IoT value networks" [D3.2].

This extensive information about service requirements has been consolidated into a list of 29 requirements (see Appendix A), presented in Table 2, along with indicators of their relative importance.

Table 2: Consolidated Service Requirements

ID	Requirement	Importance		
		D1.2	**TF5**	D3.2
D1.2 Tech 9	Reduces volumes of data sent across networks	37.6%		
D1.2 Tech 6	Overcomes unreliable connectivity	36.9%	56%	1
D1.2 Tech 5	Very low latency /high computational requirements	35.9%	38%	4
D1.2 Tech 4	Improved Security, Data Protection, Privacy	34.5%	69%	8
D1.2 Tech 8	Allows deployment of AI analytics models close to the device	33.4%	44%	1
D1.2 Econ 1	Costs need to be low & ROI clear	29.5%	31%	1
D1.2 Tech 7	Allows deployment of resource-constrained IoT devices	27.0%	13%	
D1.2 Econ 2	Enables Business Improvements	26.7%	50%	5
D1.2 Org 3	Need support to close Skills gaps	24.5%	6%	2
D1.2 Org 2	Need supports for improving readiness of Existing IT infrastructure	23.8%	25%	1
D1.2 Econ 3	Reducing energy consumption	23.5%	6%	1
D1.2 Tech 1	Complete solutions, end-to-end, easy deployment	23.0%	13%	26
D1.2 Econ 5	Improved safety (of customers or employees)	21.2%	31%	1
D1.2 Econ 4	Improved physical security	20.9%	6%	
D1.2 Org 1	Need Help with management Buy-in/overcoming Organization resistance	20.8%		
D1.2 Net 1	Need mature 5G networks and devices	20.1%		
D1.2 Org 4	Improve Regulatory/Legal Compliance	19.5%	13%	6
D1.2 Tech 3	Standards-based, Interoperable	19.2%	19%	4
D1.2 Org 5	Ease-of-use, Solution easy to adapt to my business processes	19.0%	6%	10
D1.2 Tech 2	Technical stability, capabilities, mature offerings, confidence in suppliers	18.0%		1
TF5 Tech 1	Orchestration of workloads across different parts of continuum and different providers		50%	1
TF5 Org 1	Support for improving quality and currency of source data		31%	2
TF5 Tech 3	Configurability/Smart Infrastructure		31%	5
TF5 Tech 7	Works with diverse devices		31%	
TF5 Tech 8	Deliver new capabilities		25%	
TF5 Tech 2	Scalability		19%	4
TF5 Tech 4	High source data rates		13%	5
TF5 Tech 5	Ability to work in a range of weather conditions		6%	1
TF5 Tech 6	Enable data sharing and value-added services		6%	12

Of the twenty-nine common requirements:

- Seventeen (17) – more than half – relate to technical requirements
- Five (5) relate to economic expectations
- Five (5) address organizational readiness
- One (1) relates to network readiness.

Table 2 indicates minimal correlation between the three sources of data. This reflects the very different methodologies of the three sources, rather than disagreement about the comparative importance of the different requirements. This list of 29 common service requirements collectively represents key requirements from a broad sample of CEI ecosystem players.

Market Pathways and Scenarios

To determine likely market pathways, the market segments presented in Table 1 are examined along the following dimensions:

- Use case specialization and use of key technologies
- Use case size and concentration
- Physical scope
- Extent of data sharing and the role of the cloud
- Algorithm readiness and data completeness.

Based on this examination, the market segments are modified slightly to yield market pathways that reflect the likely evolution of each market, as summarized in Table 3.

Table 3: Key Characteristics of Proposed Market Pathways (all figures annual)

Market Segment	Sectors	Use Cases	Total Market (€M)	Gateway Market (€M)	Device Market (€M)	Total Gateways (000s)	Total Devices (millions)
1a: Automatically Guided Vehicles	4	4	5,354	3,079	2,275	57	4
1b: Autonomous Vehicle	2	2	3,056	532	2,524	10	7
2a: Optimization	3	4	1,009	796	213	39	7
2b: Video Surveillance	5	7	2,429	295	2,134	45	120
2b: Product Inspection	3	3	1,305	533	772	24	10
3: Smart Meters, Smart Grid	1	2*	5,569	75	5,494	3	609
4a: Fleet Tracking, Freight Monitoring	2	4	4,053	99	3,954	11	540
4b: Asset Tracking in Limited Areas	4	10	1,024	151	873	57	404
5: Smart Building	4	4	1,209	183	1,026	42	40
None	5	39	1,084	518	566	101	40
Grand Total	**5**	**79**	**26,092**	**6,262**	**19,830**	**388**	**1,783**

* Also EV charging, a new use case

These nine pathways respect the similarities described in Section 2, while also respecting the different evolutionary paths that are likely, given factors including coverage over a larger service area, sharing of data across ecosystems and technical requirements such as image processing algorithms for product inspection.

No alternative market scenarios are identified.

Conclusions

Several preliminary conclusions can be offered based on this analysis:

- Estimated market opportunities were heavily concentrated in a small number of use cases, each of which featured large numbers of IoT devices of a single type. This suggests investment should target

optimization of these high-volume IoT devices, rather than the design of versatile gateways and related orchestration mechanisms.

- Based on estimated market opportunities, very few use cases for condition monitoring or predictive maintenance were in the list of high-value use cases, nor were these use cases aggregated into larger market segments based on their similarities. This highlights the diversity of requirements for these use cases (e.g. needing to support diverse IoT devices and their distinct protocols) as well as the relatively small market opportunities available in each sector. This suggests that these use cases may not be attractive targets for investment in development and research.
- High device volumes represent significant opportunities for European economy but will also attract considerable foreign interest.
- The EU has established a useful regulatory regime (e.g. GDPR, Data Act) relevant to these IoT devices (including surveillance and product inspection), but appropriate enforcement mechanisms should be implemented.
- The segmentation analysis yielded market segments that were organized according to the types of application, rather than the sector, of each use case. This suggests that investment, for example through EC-funded development projects, as well as through large scale pilots and/or competence centres, should target single applications implemented in multiple sectors, rather than versatile gateways addressing multiple applications within a single sector.
- Most of the use cases representing the biggest market opportunities do not need edge roaming or workload orchestration.
- Where this is needed, the biggest drivers for expanded network coverage as well as edge-roaming might come from freight and fleet tracking. Ideally incentives should be put in place to support the transportation sector to drive this expansion, not only for their own benefit, but also to support broader network and edge-roaming coverage, which would enable other important use cases across the CEI ecosystem.
- Even implementations of CEI use cases using private networking to serve limited area coverage requirements should also be encouraged to support federated edge networks.

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1. Introduction

This report identifies key business and service requirements, key market segments and likely market pathways for the Cloud-Edge-IoT (CEI) Ecosystem in Europe. This information has been partially validated by industry participants in the "Wave 2" workshops and will be further validated through upcoming "Wave 3" interviews.

In this document, the following definitions apply:

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Market Scenario: alternative Market Pathways that might be expected to develop. Different Market Scenarios would reflect different development pathways that might be possible depending on future actions by market participants.

1.1 Motivation

This report is intended to guide supply-side actors in the CEI Ecosystem in forming effective go-to-market strategies in their approach to this nascent and evolving market. These strategies must reflect the likely size and composition of important market segments, critical business and service requirements found in each segment, customer preferences in terms of their own implementation strategies, and dependencies/competition among potential supply-side players.

Developing a clear view of the size and composition of important CEI market segments requires an understanding of the technical and economic structure underlying the European CEI market. This information is critical to understand the current and future state of the market from the perspective of potential suppliers, potential architectures and business relationships in delivering CEI services to customers, and possible alternative service requirements and market scenarios that may develop as this market grows. Unfortunately, given the CEI market's evolving nature, understanding the market at this level of detail is difficult.

- UNLOCK-CEI's own D1.1[1] ("Cloud-Edge-IoT Demand Landscape" [D1.1]) and D1.2[2] ("Updated report of CEI demand landscape" [D1.2]) present high-level market estimates for the respective cloud, edge and IoT segments of the overall market, and explore various structural aspects of the market, without quantifying them in detail.
- A recent study by DECISIONS Etudes et Conseils[3] has explored the underlying technologies in detail, as well as selected sectoral requirements, offering glimpses into how, overall, the markets for different services and technologies may evolve over time. Aside from selected sectoral requirements, this report did not address the architectural choices that may be possible, or the service requirements that will limit the architectures that might feasibly be used to implement each use case.

To develop a more detailed understanding of the possible segmentation of the CEI market in Europe, the UNLOCK-CEI team analysed a large set (63) of use cases, in five major industry sectors, that appear promising for the Cloud-

[1] https://zenodo.org/records/7821330
[2] https://zenodo.org/records/8107103
[3] https://op.europa.eu/en/publication-detail/-/publication/ff35c457-8f3b-11ee-8aa6-01aa75ed71a1

Edge-IoT market in Europe. This set of use cases (the "Considered Use Cases", see Table 4 below) was initially explored through a survey of 700 industry respondents, the results of which can be found in [D1.2].

This report synthesizes the work of several work packages of the UNLOCK-CEI project to identify preliminary market segments for the CEI ecosystem in Europe, and corresponding service requirements that must be addressed by market players, promising business models that might be adopted by those players, and factors in each market segment that might enhance or challenge the sovereignty and autonomy of the EU and EU-based market players as the ecosystem develops.

This report analyses results from workshops held with Value Chain Adopter Groups. These workshops are designed to identify and validate 25 key service requirements needed for effective Cloud-Edge-IoT (CEI) solutions across various fields. The report gathers feedback from different stakeholders, making sure the service requirements are both technically sound and highly relevant to users' real-world needs. By doing so, we aim to develop CEI services that meet market demands and boost their adoption and success.

The report details cross-domain similarities, unique requirements for each domain, and key factors affecting user preferences. It will also offer initial insights into the frameworks and conditions needed to encourage the creation of preferred service requirements. This comprehensive analysis ensures the CEI service requirements are practical and impactful, driving innovation and efficiency in CEI solutions deployment.

Table 4: Considered Use Cases

Use Case Code	**Use Case (from D1.2 Section 4)**	**Explanatory title**
Agriculture		
A01.1	Employee safety monitoring	Track Employees in Hazardous Environments
A01.2	Employee safety monitoring	Monitor Employee "Vitals" in Hazardous Environments
A01.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations
A02.1	Asset condition monitoring	Monitor the Condition of Key Fixed Equipment
A02.2	Asset monitoring & maintenance	Predictive Maintenance for Key Fixed Equipment
A02.3	Asset condition monitoring	Monitor the Condition of Key Mobile Equipment (e.g. tractors, trucks, harvesters)
A02.4	Asset monitoring & maintenance	Predictive Maintenance for Key Mobile Equipment (e.g. tractors, harvesters)
A03	Visual inspection - quality/integrity	Inspect agricultural products (e.g. at harvesters, and grading stations) for quality control
A04	Video security & surveillance	Visual monitoring of fields and buildings
A05	Asset command & control	Command & Control of Key Assets (e.g. processing machines)
A06	Agriculture Field Monitoring	Monitor the Condition of Farm Fields, Paddocks and Pasture areas
A07	Asset location tracking	Track and Optimise Key Mobile Assets (e.g. tractors, harvesters)
A08	Process automation & optimization	Manage & Optimise precision agriculture systems
A09	Livestock monitoring	Collect Livestock health Data from "wearable" devices
A10	Agriculture Animal Tagging	Track Livestock locations from "wearable" devices
A11	Autonomous Vehicles	Enhancing and optimising the production
A12	Smart building	Smart Building Management
Energy		
E01.1	Employee safety monitoring	Track Employees in Hazardous Environments
E01.2	Employee safety monitoring	Monitor Employee "Vitals" in Hazardous Environments
E01.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations
E02	Asset location tracking	Track the Location of Key Movable (portable) Assets (e.g. high-value test equipment and tools
E03	Asset monitoring & maintenance	Monitor the Condition of Key Fixed Equipment
E04	Fleet tracking	Track and Optimise Key Mobile Assets (e.g. repair trucks)
E05	Smart meters	Smart Meters: Load Management, Theft Prevention
E06	Regulatory compliance	Operational Reporting for Regulatory Compliance
E07.1	Remote network mgmt (e.g. fault detection)	Enhanced Grid Monitoring
E07.2	Remote network mgmt (e.g. fault detection)	Diagnostics, Incident detection from Enhanced Grid Monitoring

Use Case Code	Use Case (from D1.2 Section 4)	Explanatory title
E08	Sensor-based diagnostics & maintenance	Predictive Maintenance for Key Fixed Equipment (e.g. transformers, circuit breakers)
E09	Video security & surveillance	Intrusion Detection & Access Control
E10	Asset command & control	Asset Dispatch of Generation Assets, Command & Control of Key Assets
E11	Process automation & optimization	Smart Grid: Real-Time Analytics and Dynamic Grids Optimisation
E12	Drone-based observation	Drone-based Inspection (e.g. remote generation, transmission assets)
E13	Field service technician monitoring	Technician Performance and Work Order Optimisation
E14	Connected drilling & extraction	Optimised Gas & Petroleum Exploration and Production
E15	Smart building	Smart Building Management
E16	Automated guided vehicles (AGVs)	Automated Guided Vehicles in Special Environments (switchyards, substations)
Healthcare		
H01	Remote Health Monitoring	Collect Patent Health Data from remote devices (e.g. in patients' homes)
H02.1	Hospital Asset Tracking - dumb assets	Track Location of portable Assets (e.g. wheelchairs, hospital beds)
H02.2	Hospital Asset Tracking - patient monitors	Track Location of smart Assets (e.g. bedside monitors)
H02.3	Hospital Asset Tracking - other high-value assets	Track Location of other high-value portable Assets (e.g. dialysis machines, imaging machines)
H03	Video security & surveillance	Intrusion Detection & Access Control
H04	Regulatory compliance	Operational Reporting for Regulatory Compliance
H05	Bedside Telemetry	Collect Patent Health Data from distributed devices in the hospital
H06	AI-enabled Diagnosis & Treatment	Collect data about pathologies and symptoms to analyse and leverage cures.
H07	Robots or augmented-reality-assisted surgery	Routine surgical procedures are assisted by robots and/or AR tools for surgeons
H08	Smart building	Smart Building Management
H09	Automated guided vehicles (AGVs)	Automated Guided Vehicles (medical supplies, specimens) in hospitals
Manufacturing		
M01.1	Asset monitoring & maintenance	Monitor Condition of Key Fixed Equipment
M01.2	Asset monitoring & maintenance	Predictive Maintenance for Key Fixed Equipment
M02.1	Employee safety monitoring	Track Employees in Hazardous Environment
M02.2	Employee safety monitoring	Monitor Employee “Vitals” in Hazardous Environments
M02.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations
M03	Visual inspection - quality/ integrity	Inspect manufactured products at various stages of production for quality control
M04	Manufacturing operations/ automation	Manage & Optimise Smart manufacturing at a single facility
M05	Video security & surveillance	Intrusion Detection & Access Control
M06	Food traceability	Track flow of food products through the agricultural food chain
M07	Asset command & control	Command & Control of Key Assets (e.g. conveyor belts)
M08	Fleet tracking	Track and Optimise Key Mobile Assets (e.g. forklifts)
M09	Regulatory compliance	Operational Reporting for Regulatory Compliance
M10	Process automation & optimization	Manage & Optimise Smart manufacturing across the enterprise
M11	Smart building	Smart Building Management
M12	Asset location tracking	Track Location of Key Movable (portable) Assets (e.g. Pallets, Crates, Boxes, high value test or calibration equipment)
M13	Automated guided vehicles (AGVs)	Automated Guided Vehicles in Factories, Warehouses
Transportation		
T01.1	Employee safety monitoring	Track Employees in Hazardous Environment
T01.2	Employee safety monitoring	Monitor Employee “Vitals” in Hazardous Environments
T01.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations
T02	Fleet tracking	Track and Optimise Key Mobile Assets (e.g. trucks, containers, ships, railroad cars)
T03	Passenger traffic flow	Track passenger flow across the transport network to manage capacity and congestion
T04	Video security & surveillance	Intrusion Detection & Access Control
T05	Vehicle & infrastructure inspection	Drone-based Inspection (e.g. railroad rights of way, switchyards)
T06	Regulatory compliance	Operational Reporting for Regulatory Compliance
T07	Freight monitoring	Track Location of Key Movable (portable) Assets (e.g. Containers, Pallets, Crates, Boxes)
T08.1	Asset monitoring & maintenance	Monitor Condition of Key Mobile Equipment (e.g. trucks, containers, ships, railroad cars)

Use Case Code	Use Case (from D1.2 Section 4)	Explanatory title
T08.2	Asset monitoring & maintenance	Predictive Maintenance for Key Mobile Equipment (e.g. trucks, containers, ships, railroad cars)
T09	Autonomous Vehicles	Autonomous vehicles leveraging security in a controlled system
T10	Quality of shipment conditions	Inspect shipping units (containers, pallets, crates, boxes) to detect damage and ensure proper routing
T11	Asset command & control	Command & Control of Key Assets (e.g. close/open doors to warehouses for truck access)
T12	Automated guided vehicles (AGVs)	Automated Guided Vehicles in railyards, ports, warehouses
T13	Smart building	Smart Building Management

This deliverable builds on the work presented in the following documents:

- D1.1 "Cloud-Edge-IoT Demand Landscape" [D1.1]
- D1.2 "Updated report of CEI demand landscape" [D1.2]
- D2.2 "Preliminary Market Scenarios & Pathways to the Future Open European CEI Ecosystem" (revision forthcoming) [D2.2]
- "Technology Implementation Model and Architectural Patterns for CEI Use Cases" [WP-ArchPatterns]
- D3.2 "Sector-specific service requirements, data flows and revenue streams in Cloud-Edge-IoT value networks"[4] [D3.2]
- "EUCEI Task Force 5: Markets and Sectors - Workshop 2 outcomes: Technology mapping of MetaOS use cases"[5] [TF5]

This deliverable also presents three new analyses:

- Appendix A: Consolidated Service Requirements
- Appendix B: Analysis of Survey Results from Four Sectoral Workshops on CEI Opportunities ("Wave 2 Workshops")

1.2 Methodology

A key assumption in this analysis is that CEI markets will initially develop through the exploitation of a relatively small number of priority use cases or "applications". The Wave 2 workshops with market experts (full results presented in Appendix B) highlighted several factors that support this assumption:

- Adopting organizations rank economic challenges, or return on investment ("ROI"), as a key challenge for CEI use cases. The payback from the investment must be clear and high, and/or the investment cost must be low. This suggests that use cases that represent larger revenue opportunities for suppliers are more likely to justify those suppliers developing a complete and compelling solution and more likely to enable development of lower cost components that could serve these larger markets.
- Adopting organizations also rank "technology readiness" as an important challenge for CEI use cases. This also favours larger market opportunities that encourage suppliers to offer more mature solutions.
- Some adopting organizations identify their own organizational readiness as a challenge to adopting CEI applications. This again favours larger market opportunities where suppliers can offer more mature solutions that can be directly implemented by clients.

[4] https://zenodo.org/records/8089373
[5] https://zenodo.org/records/8272707

Estimating the scale of potential payback for each use case is complex and outside of the scope of this project. It is possible that some use cases, representing smaller market opportunities, may experience accelerated adoption because they offer very high ROI – even in the face of lower technical readiness and/or limited economies of scale. Despite this gap, the results of this analysis should provide a good view of likely market segments in the coming few years.

Figure 2 below illustrates the methodology used in this analysis.

Section 2 will start by summarizing the annual market opportunity estimates presented in [D2.2]. Feedback gathered from market experts in four[6] sectoral feedback sessions will be used to adjust these estimates. In addition, important use cases identified by these experts, outside of the list of Considered Use Cases, will be included in the overall analysis.

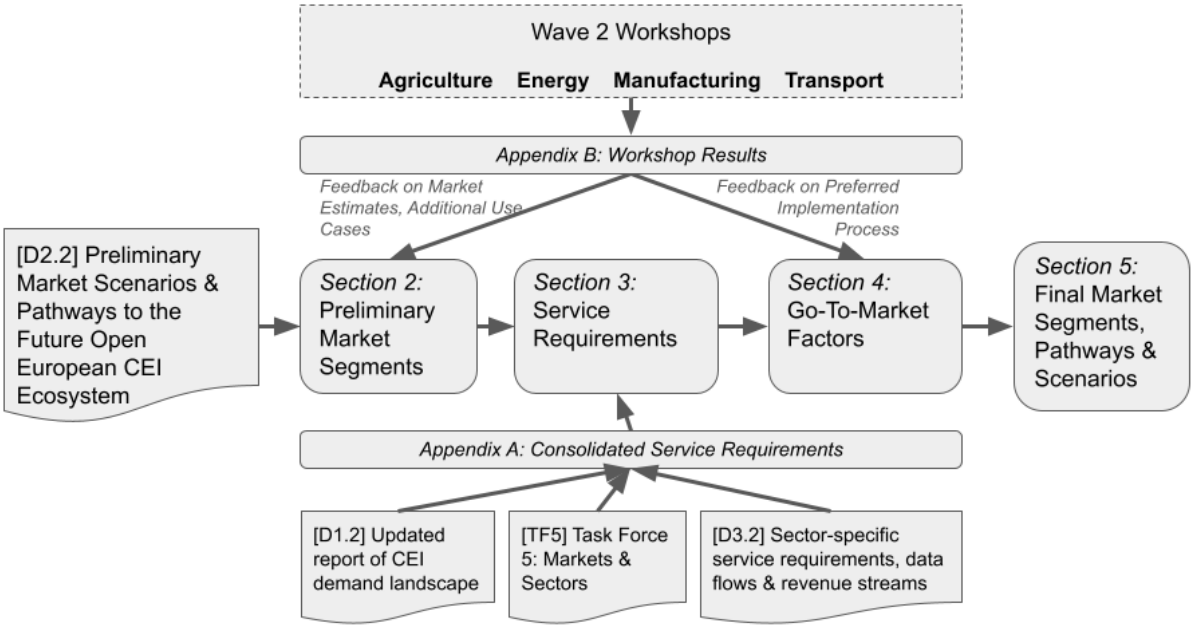

Figure 2: Methodology Used in this Analysis

Section 2 will merge these market opportunities into proposed market segments where the respective use cases share characteristics that should make it possible for suppliers to target the use cases in an integrated manner. [D2.2] has already explored such synergies and adjacencies based on industrial sector and architectural patterns, respectively. This section will identify additional dimensions of similarity. Common characteristics will guide the aggregation of market opportunities into market segments. For example, two use cases with many common characteristics could be merged in a single market segment, while two use cases with no common characteristics would be kept in separate segments. since there would be little or few synergies or economies for any supplier to address the opportunities together. The largest market segments after this consolidation will be examined more closely in section 3 and beyond.

[6] Four "Wave 2" Workshops were organised by WP3 for all the sectors of interest in UNLOCK-CEI, except Healthcare. Appendix B provides details on timing and participation of each workshop.

Section 3 presents the full set of service requirements identified by the UNLOCK-CEI project, based on the analysis detailed in Appendix A. This analysis harmonizes the different presentations and styles from different sources, yielding a consolidated presentation that is prioritized based on survey results (from [D1.2]) and analysis of Task Force 5 reports (from [TF5]), allowing key service requirements to be identified. 29 service requirements are presented, exceeding the KPI of 25 services requirements established at the beginning of the UNLOCK-CEI project.

Section 3 continues by considering service requirements relevant to each of the larger market segments (each of which represents a set of merged use cases, serving multiple sectors). Where market segments span multiple sectors, sectoral differences in service requirements are considered, to determine whether requirements are different enough to argue for adjustment or "splitting" of the segment.

Section 4 explores the business and market factors relevant to each market segment, as captured in the workshops. The methodology is like that in Section 3, where common business models/go-to-market approaches will make a segment easier to address, while differences between use cases in a single market segment will make the segment harder to address and slower to develop. Note that since the workshops only capture results according to sector, this section will only identify similarities and differences that will affect the development of market segments that span multiple sectors.

Section 5 presents the final market segments resulting from this analysis. Each market segment comprises a set of market opportunities for individual use cases, with combined annual market estimates. Each market segment is then assessed against several factors affecting its possible evolution. This assessment translates into modifications to the market segments to respect these evolutionary factors, resulting in a proposed set of market pathways for the development of the CEI ecosystem in Europe.

Section 6 presents key conclusions and outlines next steps for this part of the project.

2. Preliminary Market Segments

This section presents the initial estimates of annual market opportunity for each of the 79 Considered Use Cases, explores common characteristics of these opportunities that might contribute to synergy and merger into larger market segments, considers other use cases suggested by workshop participants, as well as adjustments to market sizing based on expert feedback.

2.1 Annual Market Estimates by Use Case

Deliverable D2.2 (revision forthcoming) examined the "Considered Use Cases" identified by WP1 and presented in D1.2 and applied a structural analysis methodology[7] to develop estimated annual market opportunities in the EU for each use case, listed for reference here in Table 5 (sorted by Use Case Code, with high-value use cases highlighted in green).

The estimated market opportunities total over €26 billion per year. Of the five sectors examined by the UNLOCK-CEI project, the Transportation sector represents the largest total market opportunity, estimated at almost €12 billion per year (45% of the total). Energy/Utilities and Manufacturing are each estimated at roughly 25% of the total, with €6.8 and €6.4 billion per year respectively. Agriculture and Healthcare make up the balance, with €0.8 and €0.4 billion per year respectively (3% and 1% of the total, respectively). Figure 3 compares the total annual market opportunity by sector.

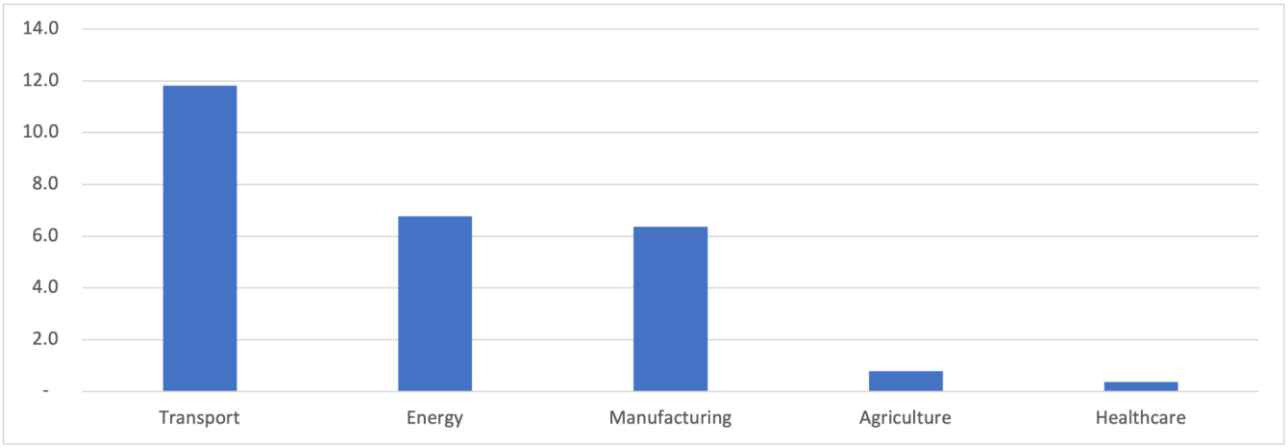

Figure 3: Total Annual Market Estimates for 5 sectors of interest (€ billions)

These market opportunities are very concentrated. The largest 24% of the 79 use cases (19 use cases) account for over 90% of the total annual market estimate. The largest 16.5% of the 79 use cases (13 use cases) account for over 80% of the total annual market. As explained in section 1.2 above, addressing these top applications represents the most attractive way for suppliers to enter the European CEI market. The top 19 use cases are highlighted in Table 5. Note that 18 of the 19 highest value use cases appear in the Energy/Utilities, Manufacturing and Transportation sectors, with only one appearing in the Agriculture sector.

[7] Detailed methodology and assumptions presented in "Technology Implementation Model and Architectural Patterns for CEI Use Cases" [WP-ArchPatterns].

Table 5: Annual Market Estimates for 79 Considered Use Cases (€ millions: high-value use cases highlighted in green)

Use Case Code	Use Case (from [D1.2] Section 4)	Explanatory title	Annual Market (€)
Agriculture			
A01.1	Employee safety monitoring	Track Employees in Hazardous Environments	0.2
A01.2	Employee safety monitoring	Monitor Employee "Vitals" in Hazardous Environments	0.1
A01.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations	0.03
A02.1	Asset condition monitoring	Monitor the Condition of Key Fixed Equipment	3.1
A02.2	Asset monitoring & maintenance	Predictive Maintenance for Key Fixed Equipment	4.2
A02.3	Asset condition monitoring	Monitor the Condition of Key Mobile Equipment (e.g. tractors, trucks, harvesters)	4.7
A02.4	Asset monitoring & maintenance	Predictive Maintenance for Key Mobile Equipment (e.g. tractors, harvesters)	5.6
A03	Visual inspection - quality/integrity	Inspect agricultural products (e.g. at harvesters, and grading stations) for quality control	94.3
A04	Video security & surveillance	Visual monitoring of fields and buildings	28.8
A05	Asset command & control	Command & Control of Key Assets (e.g. processing machines)	20.7
A06	Agriculture Field Monitoring	Monitor the Condition of Farm Fields, Paddocks and Pasture areas	6.2
A07	Asset location tracking	Track and Optimize Key Mobile Assets (e.g. tractors, harvesters)	6.7
A08	Process automation & optimization	Manage & Optimize precision agriculture systems	20.4
A09	Livestock monitoring	Collect Livestock health Data from "wearable" devices	0.9
A10	Agriculture Animal Tagging	Track Livestock locations from "wearable" devices	4.3
A11	Process automation & optimization	Enhancing and optimizing the production	566.9
A12	Smart building	Smart Building Management	12.2
Energy			
E01.1	Employee safety monitoring	Track Employees in Hazardous Environments	0.8
E01.2	Employee safety monitoring	Monitor Employee "Vitals" in Hazardous Environments	0.2
E01.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations	0.1
E02	Asset location tracking	Track the Location of Key Movable (portable) Assets (e.g. high-value test equipment and tools	134.7
E03	Asset monitoring & maintenance	Monitor the Condition of Key Fixed Equipment	11.3
E04	Fleet tracking	Track and Optimise Key Mobile Assets (e.g. repair trucks)	14.4
E05	Smart meters	Smart Meters: Load Management, Theft Prevention	4,221.7
E06	Regulatory compliance	Operational Reporting for Regulatory Compliance	0.6
E07.1	Remote network mgmt (e.g. fault detection)	Enhanced Grid Monitoring	118.5
E07.2	Remote network mgmt (e.g. fault detection)	Diagnostics, Incident detection from Enhanced Grid Monitoring	188.2
E08	Sensor-based diagnostics & maintenance	Predictive Maintenance for Key Fixed Equipment (e.g. transformers, circuit breakers)	7.5
E09	Video security & surveillance	Intrusion Detection & Access Control	145.4
E10	Asset command & control	Asset Dispatch of Generation Assets, Command & Control of Key Assets	13.4
E11	Process automation & optimization	Smart Grid: Real-Time Analytics and Dynamic Grids Optimisation	1,347.3
E12	Drone-based observation	Drone-based Inspection (e.g. remote generation, transmission assets)	31.1
E13	Field service technician monitoring	Technician Performance and Work Order Optimisation	26.4
E14	Connected drilling & extraction	Optimised Gas & Petroleum Exploration and Production	71.2
E15	Smart building	Smart Building Management	49.2
E16	Automated guided vehicles (AGVs)	Automated Guided Vehicles in Special Environments (switchyards, substations)	385.2
Healthcare			
H01	Remote Health Monitoring	Collect Patent Health Data from remote devices (e.g. in patients' homes)	68.2
H02.1	Hospital Asset Tracking - dumb assets	Track Location of portable Assets (e.g. wheelchairs, hospital beds)	4.0

Use Case Code	Use Case (from [D1.2] Section 4)	Explanatory title	Annual Market (€)
H02.2	Hospital Asset Tracking - patient monitors	Track Location of smart Assets (e.g. bedside monitors)	3.1
H02.3	Hospital Asset Tracking - other high-value assets	Track Location of other high-value portable Assets (e.g. dialysis machines, imaging machines)	0.8
H03	Video security & surveillance	Intrusion Detection & Access Control	12.4
H04	Regulatory compliance	Operational Reporting for Regulatory Compliance	0.2
H05	Bedside Telemetry	Collect Patent Health Data from distributed devices in the hospital	23.0
H06	AI-enabled Diagnosis & Treatment	Collect data about pathologies and symptoms to analyse and leverage cures.	0.4
H07	Robots or augmented-reality-assisted surgery	Routine surgical procedures are assisted by robots and/or AR tools for surgeons	18.7
H08	Smart building	Smart Building Management	28.6
H09	Automated guided vehicles (AGVs)	Automated Guided Vehicles (medical supplies, specimens) in hospitals	200.9
Manufacturing			
M01.1	Asset monitoring & maintenance	Monitor Condition of Key Fixed Equipment	159.4
M01.2	Asset monitoring & maintenance	Predictive Maintenance for Key Fixed Equipment	50.2
M02.1	Employee safety monitoring	Track Employees in Hazardous Environment	17.8
M02.2	Employee safety monitoring	Monitor Employee “Vitals” in Hazardous Environments	3.2
M02.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations	1.7
M03	Visual inspection - quality/ integrity	Inspect manufactured products at various stages of production for quality control	600.3
M04	Manufacturing operations/ automation	Manage & Optimize Smart manufacturing at a single facility	363.3
M05	Video security & surveillance	Intrusion Detection & Access Control	578.8
M06	Food traceability	Track flow of food products through the agricultural food chain	1.4
M07	Asset command & control	Command & Control of Key Assets (e.g. conveyor belts)	182.7
M08	Fleet tracking	Track and Optimise Key Mobile Assets (e.g. forklifts)	53.6
M09	Regulatory compliance	Operational Reporting for Regulatory Compliance	8.6
M10	Process automation & optimization	Manage & Optimise Smart manufacturing across the enterprise	554.5
M11	Smart building	Smart Building Management	792.7
M12	Asset location tracking	Track Location of Key Movable (portable) Assets (e.g. Pallets, Crates, Boxes, high value test or calibration equipment)	631.9
M13	Automated guided vehicles (AGVs)	Automated Guided Vehicle10s in Factories, Warehouses	2,369.2
Transportation			
T01.1	Employee safety monitoring	Track Employees in Hazardous Environment	2.8
T01.2	Employee safety monitoring	Monitor Employee “Vitals” in Hazardous Environments	0.5
T01.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations	0.3
T02	Fleet tracking	Track and Optimise Key Mobile Assets (e.g. trucks, containers, ships, railroad cars)	387.7
T03	Passenger traffic flow	Track passenger flow across the transport network to manage capacity and congestion	1,064.1
T04	Video security & surveillance	Intrusion Detection & Access Control	416.9
T05	Vehicle & infrastructure inspection	Drone-based Inspection (e.g. railroad rights of way, switchyards)	270.8
T06	Regulatory compliance	Operational Reporting for Regulatory Compliance	2.9
T07	Freight monitoring	Track Location of Key Movable (portable) Assets (e.g. Containers, Pallets, Crates, Boxes)	3,515.9
T08.1	Asset monitoring & maintenance	Monitor Condition of Key Mobile Equipment (e.g. trucks, containers, ships, railroad cars)	160.7
T08.2	Asset monitoring & maintenance	Predictive Maintenance for Key Mobile Equipment (e.g. trucks, containers, ships, railroad cars)	25.9
T09	Autonomous Vehicles	Autonomous vehicles leveraging security in a controlled system	2,670.9
T10	Quality of shipment conditions	Inspect shipping units (containers, pallets, crates, boxes) to detect damage and ensure proper routing	610.1
T11	Asset command & control	Command & Control of Key Assets (e.g. close/open doors to warehouses for truck access)	131.2
T12	Automated guided vehicles (AGVs)	Automated Guided Vehicles in railyards, ports, warehouses	2,217.5

Use Case Code	Use Case (from [D1.2] Section 4)	Explanatory title	Annual Market (€)
T13	Smart building	Smart Building Management	338.2

Figure 4 illustrates the range of estimated annual market sizes as a bar chart sorted in reverse order of market size.

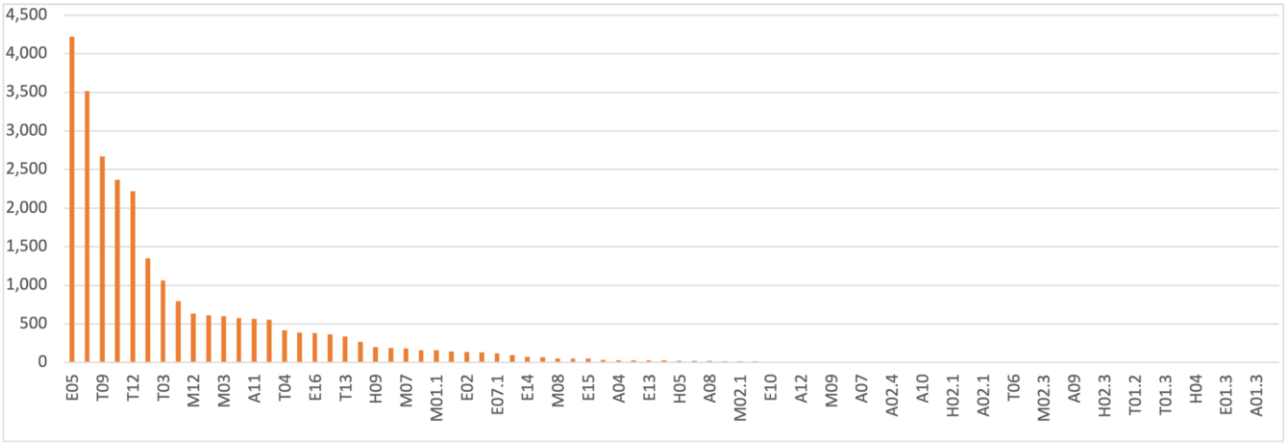

Figure 4: Annual Market Estimates for 79 Considered Use Cases (€ millions)

Table 5 highlights how 18 significant market opportunities (in terms of potential annual market size) fall in the Transportation (8 opportunities), Manufacturing (7) and Energy & Utilities (3) sectors, plus one opportunity in Agriculture. These high-value opportunities are summarized here:

Agriculture: A single €560 million opportunity (A11) for autonomous vehicles supporting farming, such as autonomous tractors operating on fields.

Energy & Utilities: Three opportunities totaling almost €6 billion:

- Smart meters (E05): €4.2 billion
- Smart Grid (E11): €1.3 billion
- Automated guided vehicles (E16): €390 million, autonomous vehicles supporting utility operations, such as transmission line repair trucks operating along utility rights of way, or repair vehicles in substations or power generation facilities.

Manufacturing: Seven opportunities totaling almost €6 billion:

- Automated guided vehicles (M13): €2.4 billion, vehicles in Factories, Warehouses
- Smart building (M11): €800 million, Smart Building Management
- Asset location tracking (M12): €630 million, Track Location of Key Movable (portable) Assets (e.g. Pallets, Crates, Boxes, high value test or calibration equipment)
- Visual inspection - quality/ integrity (M03): €600 million, Inspect manufactured products at various stages of production for quality control
- Video security & surveillance (M05): €580 million, Intrusion Detection & Access Control
- Process automation & optimization (M10): €550 million, Manage & Optimize Smart manufacturing across the enterprise
- Manufacturing operations/ automation (M04): €360 million, Manage & Optimize Smart manufacturing at a single facility.

Transportation: Eight opportunities totaling €11.2 billion:

- Freight monitoring (T07): €3.5 billion, Track Location of Key Movable (portable) Assets (e.g. Containers, Pallets, Crates, Boxes)
- Autonomous Vehicles (T09): €2.7 billion, Autonomous vehicles leveraging security in a controlled system
- Automated guided vehicles (T12): €2.2 billion, Vehicles in railyards, ports, warehouses
- Passenger traffic flow (T03): €1.1 billion, Track passenger flow across the transport network to manage capacity and congestion
- Quality of shipment conditions (T10): €610 million, Inspect shipping units (containers, pallets, crates, boxes) to detect damage and insure proper routing
- Video security & surveillance (T04): €420 million, Intrusion Detection & Access Control
- Fleet tracking (T02): €390 million, Track and Optimize Key Mobile Assets (e.g. trucks, containers, ships, railroad cars)
- Smart building (T13): €340 million, Smart Building Management.

2.2 Adjustments From Workshop Feedback

Before constructing possible market segments from these use case opportunities, it is important to consider feedback from market experts gathered in the Wave 2 workshops. Appendix B summarizes feedback on three sets of information presented in four sector workshops:

Projected adoption rates by use case: Estimated annual market opportunities are based on adoption rates from the survey of 700 companies conducted by the project and presented in [D1.2]. Wave 2 workshop participants provided a range of feedback to these adoption rates, indicating that their own expectations were about the same (expectation is 100% of the presented rates), lower than presented rates (expectation is less than 100% of the presented rates), or higher than presented rates (expectation is more than 100% of the presented rates).

Project system level pricing by use case: Average system costs for each use case are based on estimates presented in [D2.2]. Wave 2 workshop participants indicated that their own expectations were about the same (expectation is 100% of the presented costs) or lower than presented costs (expectation is less than 100% of the presented costs).

Respondents' own plans for investment: Wave 2 workshop participants further qualified their intent to invest at the levels presented, indicating that their intents were about the same (intent to invest at 100% of the levels presented) or lower than expected (intent to invest at less than 100% of the levels presented).

For each sector, the corresponding answers to the questions above were combined to yield an overall expectation factor, ranging from 63% (i.e. market opportunities would be 37% below the amounts presented) to 111% (market opportunities would be 11% higher than the amounts presented). (See Table 6.) Despite the wide range of expectations, when applied to the respective estimates by sector, the total annual estimate was roughly the same (96%, or 4 % less) as the original market estimate. (Note that these four sectors are representative of the total market considered by UNLOCK-CEI, leaving out only the Healthcare sector, which is estimated to account for only 1% of this market.)

Table 6: Adjusted Market Estimates for Four sectors, based on Wave 2 Workshop Expectations

Sector	Wave 2 Workshop Expectations			Overall Expectation	Annual Market (€ B)	
	Adoption Rate	System Pricing	Investment Levels		From [D2.2]	Adjusted
Energy & Utilities	100%	100%	100%	100%	6.8	6.8
Agriculture	90%	100%	70%	63%	0.8	0.5
Transportation	185%	60%	100%	111%	11.8	13.1

Manufacturing	100%	97%	70%	68%	6.4	4.3
				Total	**25.8**	**24.7**
				Adjusted Value / Original Estimate		**96%**

This analysis helps validate the methodology used to generate the market estimates presented in [D2.2]. Given the low number of participants in the Wave 2 workshops, and the small overall adjustment that might be applied, the estimates from [D2.2] will continue to form the basis for the rest of this market analysis, while highlighting their inherent uncertainty, which should be kept in mind in subsequent discussions.

2.3 Use Case Characteristics Used for Clustering into Larger Market Segments

The list of high-value use cases reveals that many use cases have important similarities. These common characteristics can be used to cluster similar use cases into market segments. A single supplier might then be able to efficiently target all or most of the use cases within the segment. Sections 3 and 4 will identify additional similarities or differences in service requirements and business factors, respectively, that may require further differentiation of the preliminary Market Segments.

2.3.1 Characteristics

From a supplier's perspective, use cases exhibit several characteristics that may make it possible to efficiently offer common or similar solutions to distinct use cases, promoting the possible clustering of those use cases into market segments. Each characteristic is assigned a numerical weighting to allow the "similarity" between use cases to be calculated.

2.3.1.1 *Sector*

Offering to implement a range of use cases within a single sector is efficient for several reasons:

- Common marketing and sales costs.
- Understanding the structure of the market, typical organizational structures found in customers, common challenges, "jargon" and any regulatory requirements.
- Experience integration solutions with sector-specific IT and OT systems.
- Increased reputational value of project success within the sector – customers want to do business with suppliers that have worked with other customers in the sector.

There is also the possibility that a customer for one use case might become a customer for another use case in the same sector within some period. Every high value use case implemented by a supplier at a given customer represents a "beachhead" that might be exploited by the same supplier to address other Cloud-Edge-IoT use cases at that customer.

Sector is one of the most important characteristics that might be used to cluster use cases and is assigned a weighting of 5.

2.3.1.2 *Technology Models and Architectural Patterns*

Suppliers with experience implementing use cases with a given technology pattern should have greater success implementing the same technical solution for a different use case, even in a different industrial sector. This experience may include offering customers support in implementing business processes associated with such use cases, such as integrating improved location tracking information, or product inspection data, into a customer's digital operations and business processes. Figure 5 illustrates key architectural patterns found in the Considered Use Cases.

Architectural Patterns for each use case are presented in more detail in [WP-ArchPatterns].

Architectural Pattern is an important characteristic that might be used to cluster use cases and is also assigned a weighting of 5.

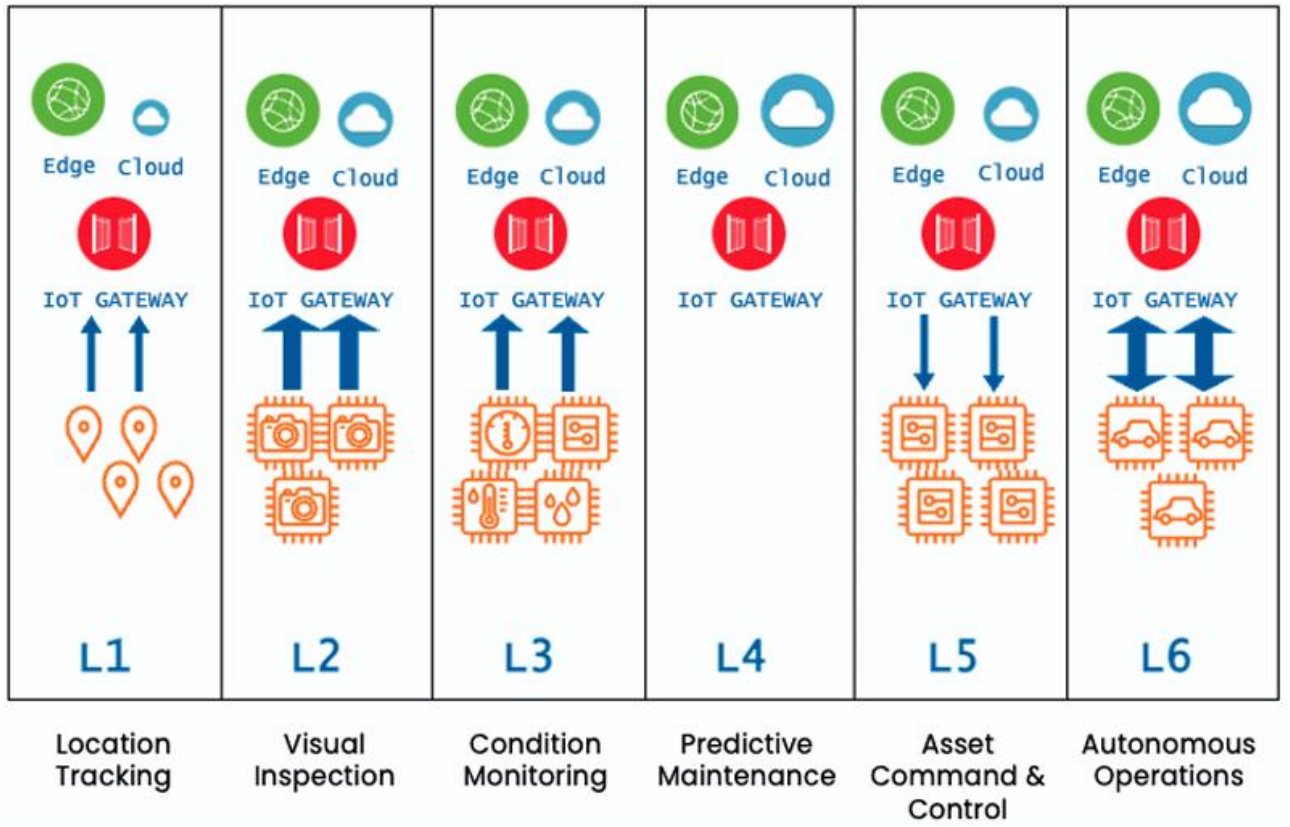

Figure 5: Schematic illustration of architectural patterns

2.3.1.3 *Common Technologies and Similar Target Objects*

Beyond similar technology models, if use cases require the same kinds of technology (communications protocols, processing capabilities, cloud interfaces, etc.), this increases the synergies in addressing compatible use cases.

Quite different use cases may nonetheless have some technology components in common. For example, any use case monitoring medical conditions (whether of people or livestock) may need some devices that are similar. Similarly, any use cases tracking mobile equipment might need similar tracking devices. Suppliers with access to the right kinds of IoT devices, especially those available in quantity with proven reliability, are well placed to service different use cases (even in different industries) when they rely on the same kinds of IoT devices.

- Note that most of the high-value use cases identified in this analysis involve a large proportion of investment in specific kinds of IoT devices. This factor alone may point to specific market pathways where the IoT device manufacturer (or distributor) takes the lead in approaching the market to deploy relevant use case solutions. This idea will be explored later in this report.

[WP-ArchPatterns] analyzed the technical components, as well as the IoT device characteristics, required to implement each use case, and presents an abstracted list of these technical components that would be configured as part of the solution (see Appendix 1 of [WP-ArchPatterns] for details). There are fourteen distinct component types required to construct a use case solution (some are mandatory, some are optional).

Where the same component is employed to implement two different use cases, a weighting of 1 is included in the similarity score between them. Since up to fourteen component types can be combined into a solution, exactly matching configurations would add 14 to the similarity score between them.

2.4 Forming Market Segments Based on Similar Characteristics

Using the logic presented above, a similarity score can be calculated between any two use cases. Starting with the 19 high value use cases, similarity scores can be used to group these high-value use cases into seven (7) clusters, as follows, listed by total market value in descending order (totaling only the value of the high value use cases):

Segment 1 ("Autonomous Vehicles"): €8.2 billion value.

- Autonomous vehicles (T09): €2.7 billion, leveraging security in a controlled system
- Automated guided vehicles (T12): €2.2 billion, vehicles in railyards, ports, warehouses
- Automated guided vehicles (M13): €2.4 billion, vehicles in Factories, Warehouses
- Autonomous vehicles (A11): €560 million, farming applications, such as autonomous tractors operating on fields.
- Automated guided vehicles (E16): €390 million, vehicles supporting utility operations, such as transmission line repair trucks operating along utility rights of way, or repair vehicles in substations or power generation facilities.

Segment 2a ("optimization"): €2.3 billion

- Smart Grid (E11): €1.3 billion
- Process automation & optimization (M10): €550 million, Manage & Optimize Smart manufacturing across the enterprise
- Manufacturing operations/ automation (M04): €360 million, Manage & Optimize Smart manufacturing at a single facility.

Segment 2b ("image processing"): €3.3 billion

- Passenger traffic flow (T03): €1.1 billion, Track passenger flow across the transport network to manage capacity and congestion
- Quality of shipment conditions (T10): €610 million, Inspect shipping units (containers, pallets, crates, boxes) to detect damage and insure proper routing
- Visual inspection - quality/ integrity (M03): €600 million, Inspect manufactured products at various stages of production for quality control
- Video security & surveillance (M05): €580 million, Intrusion Detection & Access Control
- Video security & surveillance (T04): €420 million, Intrusion Detection & Access Control

Segment 3 ("smart meters"): Smart meters (E05): €4.2 billion value.

Segment 4 ("location of movable assets"): €4.1 billion value.

- Freight monitoring (T07): €3.5 billion, Track Location of Key Movable (portable) Assets (e.g. Containers, Pallets, Crates, Boxes)
- Asset location tracking (M12): €630 million, Track Location of Key Movable (portable) Assets (e.g. Pallets, Crates, Boxes, high value test or calibration equipment)

Segment 5 ("smart building"): €1.1 billion

- Smart building (M11): €800 million, Smart Building Management
- Smart building (T13): €340 million, Smart Building Management.

Segment 6 ("location of mobile assets"): €390 million

- Fleet tracking (T02): €390 million, Track and Optimize Key Mobile Assets (e.g. trucks, containers, ships, railroad cars)

Segments 2a and 2b are combined because, despite the different architectural patterns of the two subsegments, they share almost identical technical configurations.

Based on the calculated similarity scores, some of the lower-value use cases can be added to these segments as follows:

Segment 1 ("autonomous vehicles"): add €200 million → €8.4 billion

- Automated guided vehicles (H09): €200 million, Automated Guided Vehicles (medical supplies, specimens) in hospitals

Segment 2a ("optimization"): add €100 million → €2.4 billion

- Connected drilling & extraction (E14): €71 million, Optimized Gas & Petroleum Exploration and Production
- Process automation & optimization (A08): €20 million, Manage & Optimize precision agriculture systems

Segment 2b ("image processing"): add €500 million → €3.7 billion

- Visual inspection - quality/ integrity (A03): €94 million, Inspect agricultural products (e.g. at harvesters, grading stations) for quality control
- Asset command & control (M07): €180 million, Command & Control of Key Assets (e.g. conveyor belts). While involving a different architectural pattern than the other image processing use cases, there are strong similarities in the technologies required and a common need for low latency operation.
- Video security & surveillance (E09): €150 million, Intrusion Detection & Access Control
- Video security & surveillance (A04): €29 million, Visual monitoring of fields and buildings
- Video security & surveillance (H03): €12 million, Intrusion Detection & Access Control

Segment 3 ("smart meters"): no similar use cases

Segment 4 ("Location of movable assets"): add €300 million → €4.5 billion

- Asset monitoring & maintenance (M01.1): €160 million, Monitor Condition of Key Fixed Equipment
- Asset location tracking (E02): €130 million, Track Location of Key Movable (portable) Assets (e.g. high-value test equipment and tools
- Hospital Asset Tracking - dumb assets (H02.1): €4 million, Track Location of portable Assets (e.g. wheelchairs, hospital beds)
- Hospital Asset Tracking - patient monitors (H02.2): €3 million, Track Location of smart Assets (e.g. bedside monitors)
- Hospital Asset Tracking - other high value assets (H02.3): €0.8 million, Track Location of other high-value portable Assets (e.g. dialysis machines, imaging machines)
- Food traceability (M06): €1 million, Track flow of food products through the agricultural food chain

Segment 5 ("smart building"): add €100 million → €1.2 billion

- Smart building (E15): €49 million, Smart Building Management
- Smart building (H08): €29 million, Smart Building Management

Segment 6 ("location of mobile assets"): add €200 million → €600 million

- Asset monitoring & maintenance (T08.1): €160 million, Monitor Condition of Key Mobile Equipment (e.g. trucks, containers, ships, railroad cars)
- Fleet tracking (M08): €54 million, Track and Optimize Key Mobile Assets (e.g. forklifts)
- Asset location tracking (A07): €7 million, Track and Optimize Key Mobile Assets (e.g. tractors, harvesters)
- Employee safety monitoring (T01.1): €3 million, Track Employees in Hazardous Environment

- Fleet tracking (E04): €14 million, Track and Optimize Key Mobile Assets (e.g. repair trucks)

Collectively these six segments account for 95% of the annual market value estimated for the Considered Use Cases. Thirty-nine (39) use cases remain unconnected with any segment, but these represent a total market value of only €1.1 billion per year (less than 5% of the total estimated market).

Figure 6 illustrates these preliminary market segments, showing the different segments by color, with boxes inside proportionally illustrating the size of each market opportunity. This diagram highlights the highest value opportunities. (Figure 6 is the same as Figure 1 in the Executive Summary.)

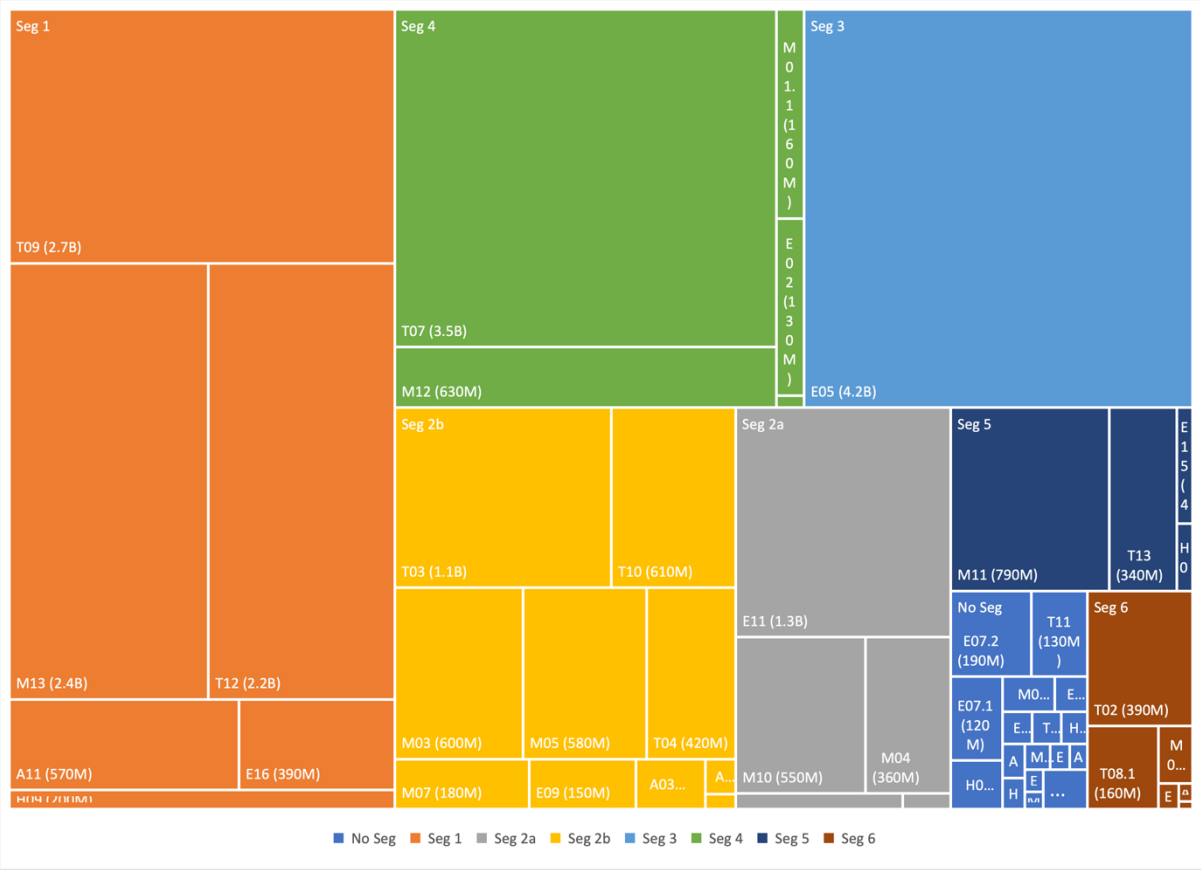

Figure 6: Illustrating Annual Value of Key Market Segments

2.5 Additional Market Opportunities

Several additional use cases were mentioned in sector expert workshops, specifically:

Energy & Utility Sector:

- Electric vehicle (EV) charging: emphasizing Vehicle-to-Everything (V2X) integration. This use case is like the "Smart Meter" use case (E05), but with EV chargers (both public and private) as the target object in the technology model. This could be a substantial opportunity.
- Smart-Grid Sub-Use Cases: Highlighting the numerous potential sub-use cases within smart grid technology. These extend the existing "Smart Grid" use case (E11).
- Integration of Renewable Energy Sources (RES) into smart grids. RES are a special case of the general use case of Smart Grid, so this is included in the existing "Smart Grid" use case (E11).

- Indoor Environment Quality Monitoring: Focusing on monitoring and improving indoor air quality.

Agriculture Sector:

- Digital Twin of the Farm: Creating a digital replica of farm operations for better management and optimization. This aligns with the Precision Agriculture use case (A08).
- Solutions for Animal Breeding: Implementing advanced solutions to improve animal breeding processes.

No additional use cases were mentioned in the Transport or Manufacturing Sector workshops.

The EV charging use case should be considered as part of Segment 3, and this opportunity would grow with increased adoption of electric vehicles, potentially becoming comparable to use case E05, with more than €1 billion in annual revenues (not including the prices charged for actual charging services).

3. Consolidated Service Requirements, Influence on Market Segmentation

The market segments presented in Section 2 were assembled based on various characteristics, notably similar sectors and similar technical architectures and components. However, these segments may mix use cases with very different service requirements, making it difficult for suppliers to address this diversity in their service/product offerings. This may suggest that the segments need to be subdivided so that suppliers can differentiate their offers so that they will be more effective and meaningful to potential customers.

This section presents the priority service requirements consolidated from three sources:

- D1.2 "Updated Report of CEI Demand Landscape" [D1.2]: based on a survey of 700 industry participants, asking specifically about drivers and barriers to adoption of IoT and Edge technologies, which provides insights into the requirements needed for success in these markets, based on a relatively large survey sample.
- "EUCEI Task Force 5: Markets and Sectors - Workshop 2 outcomes: Technology mapping of MetaOS use cases" [TF5]: which identified specific technical gaps and challenges experienced by each of 21 use cases in development by the MetaOS coordination and support action.
- D3.2 "Sector-specific service requirements, data flows and revenue streams in Cloud-Edge-IoT value networks" [D3.2]: which collects service requirements mentioned in five market workshops ("Wave 1"). Participation in these workshops was limited (less than 10 participants were actively commenting in each workshop when questions were asked about service requirements), so these service requirements should be seen as illustrative, rather than providing guidance about the relative importance of different requirements.

Appendix A analyses the broad range of information about service requirements presented in these sources and develops a consolidated list of requirements, along with indicators of their relative importance. The next two subsections summarize this information overall, and then assess the extent to which any differences in importance between sectors would need to be reflected in adjustments to the market segmentation presented in Section 2.

3.1 Consolidated Service Requirements

Table 7 presents the consolidated list of service requirements resulting from this analysis. Twenty (20) requirements were derived from [D1.2]. Requirements from [TF5] were then reviewed and where appropriate could be mapped to one of the 20 requirements from [D1.2]. However, nine (9) requirements did not match any requirement derived from [D1.2] and were added as additional requirements. Finally, the requirements recorded in the Wave 1 workshops and captured in [D3.2] were themselves mapped to one of the 29 requirements derived from [D1.2] or [TF5]. The resulting unified list provides a holistic view of the requirements to be met in implementing cloud, edge and IoT solutions across different sectors.

Figure 7 below illustrates the comparative importance (and mentions) attached to each service requirement, based on the respective data. The 20 service requirements from [D1.2] are sorted in descending order of their importance from [D1.2]. The 9 service requirements identified in [TF5] do not have this data, so they are presented as if their importance (in [D1.2]) were zero, placing them at the right side of the diagram. (Relative importance is shown on the left axis. Mentions from [D3.2] are plotted based on the right axis.)

Table 7: Consolidated Service Requirements

ID	Requirement	Overall		
		D1.2	**TF5**	D3.2
D1.2 Tech 9	Reduces volumes of data sent across networks	37.6%		
D1.2 Tech 6	Overcomes unreliable connectivity	36.9%	56%	1
D1.2 Tech 5	Very low latency /high computational requirements	35.9%	38%	4
D1.2 Tech 4	Improved Security, Data Protection, Privacy	34.5%	69%	8
D1.2 Tech 8	Allows deployment of AI analytics models close to the device	33.4%	44%	1
D1.2 Econ 1	Costs need to be low & ROI clear	29.5%	31%	1
D1.2 Tech 7	Allows deployment of resource-constrained IoT devices	27.0%	13%	
D1.2 Econ 2	Enables Business Improvements	26.7%	50%	5
D1.2 Org 3	Need support to close Skills gaps	24.5%	6%	2
D1.2 Org 2	Need supports for improving readiness of Existing IT infrastructure	23.8%	25%	1
D1.2 Econ 3	Reducing energy consumption	23.5%	6%	1
D1.2 Tech 1	Complete solutions, end-to-end, easy deployment	23.0%	13%	26
D1.2 Econ 5	Improved safety (of customers or employees)	21.2%	31%	1
D1.2 Econ 4	Improved physical security	20.9%	6%	
D1.2 Org 1	Need Help with management Buy-in/overcoming Organization resistance	20.8%		
D1.2 Net 1	Need mature 5G networks and devices	20.1%		
D1.2 Org 4	Improve Regulatory/Legal Compliance	19.5%	13%	6
D1.2 Tech 3	Standards-based, Interoperable	19.2%	19%	4
D1.2 Org 5	Ease-of-use, Solution easy to adapt to my business processes	19.0%	6%	10
D1.2 Tech 2	Technical stability, capabilities, mature offerings, confidence in suppliers	18.0%		1
TF5 Tech 1	Orchestration of workloads across different parts of continuum and different providers		50%	1
TF5 Org 1	Support for improving quality and currency of source data		31%	2
TF5 Tech 3	Configurability/Smart Infrastructure		31%	5
TF5 Tech 7	Works with diverse devices		31%	
TF5 Tech 8	Deliver new capabilities		25%	
TF5 Tech 2	Scalability		19%	4
TF5 Tech 4	High source data rates		13%	5
TF5 Tech 5	Ability to work in a range of weather conditions		6%	1
TF5 Tech 6	Enable data sharing and value-added services		6%	12

Figure 7 indicates minimal correlation between the three sources of data. This reflects the very different methodologies of the three sources, rather than disagreement about the comparative importance of the different requirements. Instead, Table 7 and Figure 7 illustrate that this list of 29 common service requirements seems to represent the key requirements from a broad sample of CEI ecosystem players.

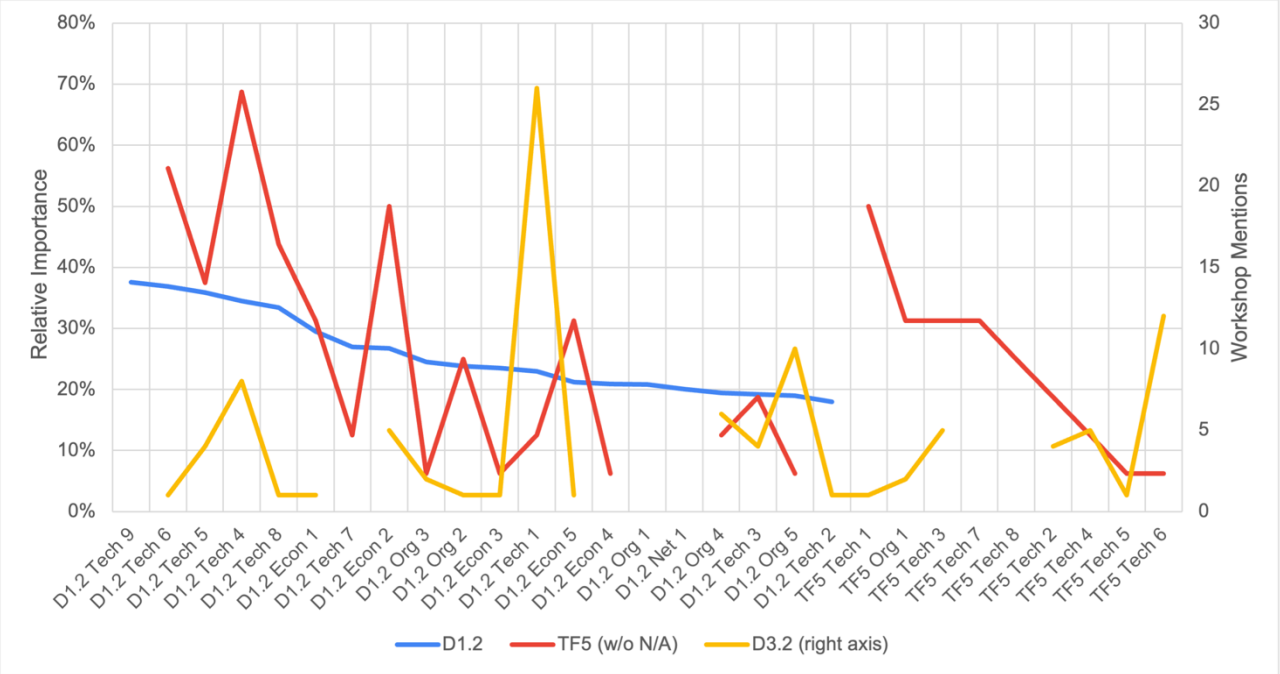

Figure 7: Comparative Importance and Mentions Attached to each of 29 Common Service Requirements

In addition to the common service requirements identified from [D1.2]. [TF5] and [D3.2], Appendix B's analysis of go-to-market strategies and business models preferred by market participants (summarized in Section 4), identified several additional requirements that suppliers may want to address in their go-to-market strategies:

- Suppliers can test their use case implementations through pilots and/or proofs of concept
- Suppliers are prepared to share some risks with their customers
- Suppliers work to improve trust in their organization and in their solutions, through guarantees, references, testimonials and other mechanisms.
- Suppliers develop awareness of the architecture of their solutions so that customers are more prepared to adopt those solutions than to specify customized solutions.

These are not included in the master list and cannot be ranked since no comparable ranking information is available, but these business requirements may be important for supplier success.

3.2 Impact on Market Segmentation

Table 8 adds the sectoral perspective to the list of consolidated service requirement from Table 7. The order of requirements is the same as Table 7, so requirements at the top of the table are rated more highly overall.

The respective indicators of importance from the three sources ([D1.2], [TF5], and [D3.2]) are color-coded to indicate comparative importance – with green highlight indicating most important, and red highlight indicating least important. Each source is coded (coloured) separately, since the methodologies of each source are different.

Table 8: Common Service Requirements, with Importance Indicators for each Sector

ID	Requirement	D1.2					TF5				D3.2				
		Ag	En	Mfg	H	Tr	Ag	En	Mfg	Tr	Ag	En	Mfg	H	Tr
D1.2 Tech 9	Reduces volumes of data sent across networks	47.1%	34.4%	38.2%	38.2%	33.3%									
D1.2 Tech 6	Overcomes unreliable connectivity	48.6%	36.7%	35.8%	34.6%	34.5%	75%	67%	33%	33%					1
D1.2 Tech 5	Very low latency /high computational requirements	47.0%	26.4%	37.4%	36.4%	35.7%	50%	33%	33%	33%	1			2	1
D1.2 Tech 4	Improved Security, Data Protection, Privacy	29.2%	32.3%	39.8%	29.6%	28.2%	50%	83%	67%	67%		3		1	4
D1.2 Tech 8	Allows deployment of AI analytics models close to the device	22.6%	32.2%	28.5%	38.7%	34.9%	25%	67%	0%	67%		1			
D1.2 Econ 1	Costs need to be low & ROI clear	32.6%	29.5%	37.0%	24.5%	31.3%	0%	50%	0%	67%					1
D1.2 Tech 7	Allows deployment of resource-constrained IoT devices	28.2%	35.6%	17.8%	23.5%	29.9%	25%	17%	0%	0%					
D1.2 Econ 2	Enables Business Improvements	25.1%	21.7%	18.7%	19.2%	19.9%	0%	67%	67%	67%	1			4	
D1.2 Org 3	Need support to close Skills gaps	25.7%	25.1%	18.8%	25.8%	24.3%	25%	0%	0%	0%				2	
D1.2 Org 2	Need supports for improving readiness of Existing IT infrastructure	22.4%	21.5%	23.6%	25.1%	25.1%	25%	17%	33%	33%					1
D1.2 Econ 3	Reducing energy consumption	23.9%	23.1%	17.6%	26.4%	21.7%	0%	0%	33%	0%		1			
D1.2 Tech 1	Complete solutions, end-to-end, easy deployment	27.3%	24.1%	14.7%	22.7%	23.5%	0%	17%	33%	0%	7	8	1	6	4
D1.2 Econ 5	Improved safety (of customers or employees)	15.4%	26.0%	24.1%	20.3%	21.6%	0%	33%	33%	67%				1	
D1.2 Econ 4	Improved physical security	22.3%	23.9%	12.7%	18.3%	26.1%	25%	0%	0%	0%					
D1.2 Org 1	Need Help with management Buy-in/overcoming Organization resistance	17.8%	20.3%	23.6%	23.5%	17.8%									
D1.2 Net 1	Need mature 5G networks and devices	24.8%	22.8%	18.9%	18.1%	17.7%									
D1.2 Org 4	Improve Regulatory/Legal Compliance	17.2%	20.9%	28.3%	18.0%	17.6%	0%	33%	0%	0%	2	1	1	1	1
D1.2 Tech 3	Standards-based, Interoperable	17.4%	24.2%	18.5%	19.3%	13.6%	0%	33%	0%	33%	1	2	2		
D1.2 Org 5	Ease-of-use, Solution easy to adapt to my business processes	15.5%	19.0%	20.7%	20.9%	17.5%	0%	0%	33%	0%	3		1	3	3

ID	Requirement	D1.2					TF5				D3.2				
		Ag	En	Mfg	H	Tr	Ag	En	Mfg	Tr	Ag	En	Mfg	H	Tr
D1.2 Tech 2	Technical stability, capabilities, mature offerings, confidence in suppliers	15.1%	20.3%	12.7%	19.5%	18.3%					1				
TF5 Tech 1	Orchestration of workloads across different parts of continuum and different providers						25%	50%	67%	67%	1				
TF5 Org 1	Support for improving quality and currency of source data						25%	33%	67%	0%				2	
TF5 Tech 3	Configurability/Smart Infrastructure						0%	50%	33%	33%	2	1		2	
TF5 Tech 7	Works with diverse devices						25%	33%	0%	67%					
TF5 Tech 8	Deliver new capabilities						50%	0%	33%	33%					
TF5 Tech 2	Scalability						0%	33%	33%	0%				2	2
TF5 Tech 4	High source data rates						0%	17%	33%	0%	2	1	1		1
TF5 Tech 5	Ability to work in a range of weather conditions						25%	0%	0%	0%	1				
TF5 Tech 6	Enable data sharing and value-added services						0%	17%	0%	0%	6	2		3	1

Based on the coding of comparative importance for each source, there are ten (10) requirements that appear generally important across sectors. These are highlighted in light green. Eight (8) of these requirements were identified in [D1.2], along with one each from [TF5] and [D3.2]. Many of these requirements are highly ranked overall, supporting the idea that suppliers who address the most important service requirements overall, will also be addressing the most important requirements as seen within each of the five sectors.

There are six (6) requirements, highlighted in tan, that seem important to only a few sectors:

- D1.2 Econ 5: Improved safety (of customers or employee (Transportation)
- TF5 Org 1: Support for improving quality and currency of source data (Manufacturing)
- TF5 Tech 3: Configurability/Smart Infrastructure (Energy & Utilities)
- TF5 Tech 7: Works with diverse devices (Transportation)
- TF5 Tech 8: Deliver new capabilities (Agriculture)
- TF5 Tech 6: Enable data sharing and value-added services (Agriculture).

These requirements are also important to some other sectors, so addressing these requirements would not reduce a supplier's competitiveness in those other sectors. At most these differences might argue for different marketing approaches to different customers within a given market segment, rather than requiring different technology solutions or go-to-market strategies.

Note that the technology model introduced in the White Paper "Technology Implementation Model and Architectural Patterns for CEI Use Cases" [WP-ArchPatterns] can be used to align solutions across different use cases and sectors. This technology model embodies fourteen (14) technical service requirements, such as "Gateways can be configured to handle a wide range of communication demands (total bytes/second) appropriate to the use case requirement".

If suppliers organize their go-to-market efforts to take advantage of the proposed clustering across use cases, this will improve interoperability across use cases and technology solutions, and exploit economies of scale, thereby contributing to solution stability and maturity.

This analysis of common service requirements confirms that there do not appear to be significant differences in service requirements between sectors. This suggests that the segments identified in section 2 can be addressed by individual suppliers without developing different solutions and offers for different sectors.

4. Go-To-Market Factors Influencing Market Segmentation

Section 3 considered the possibility that differences in service requirements between sectors would affect the market segmentation that can be expected to develop in the CEI ecosystem. This section goes on to consider differences by sector in the expected business models and "go-to-market" strategies to be adopted by suppliers targeting the various clusters that have been identified.

Questions of "business model" and "go-to-market" strategies were addressed in the Wave 2 workshops conducted with experts from four of the five sectors of interest to the UNLOCK-CEI project. These experts participated in a survey on these and related topics, and detailed results can be found in Appendix B: Analysis of Survey Results from Four Sectoral Workshops on CEI Opportunities ("Wave 2 Workshops"). In this section we focus on responses to the following questions:

- Preferred "go-to" partner for implementation
- In-house champion for implementation
- Top reasons for implementing Edge-IoT projects
- Preferred way of working on projects.

Note that only a few workshop attendees answered these survey questions, so no definitive guidance or "best practice" recommendation can be offered.

Preferred "go to" partner for implementation:

Answer	Energy & Utilities	Manufacturing
In-house capabilities	1st	1st
A mix of partners	3rd	5th
New specialists in Edge/IoT	4th	4th
Existing IT vendors, system integrators we work with	6th	2nd
New specialists from our sector	2nd	7th
Our current cloud partners	7th	3rd
Our current telco partners	5th	6th
Not sure	8th	8th

Workshop participants showed a clear preference for working with "in-house capabilities" for implementation. However, this preference is at odds with the many requirements for edge/IoT implementation discussed in section 3. These requirements are both technical and organizational – with concerns about lack of skills or adequate infrastructure introducing a contradiction, if experts' preferred implementation "partner" is in-house.

Willingness to work with other players varied widely. Incumbents (especially current cloud and telco partners) were not favoured. Overall, the finding from this question is that "new specialists in edge/IoT" as well as "existing IT vendors, system integrators we work with" may be in the best position to work closely with use case adopters to implement new use cases.

In-house champion for implementation:

Answer	Agriculture	Energy & Utilities	Manufacturing
Our tech people	1st	1st (tie)	1st

Our operations people	–	1st (tie)	3rd
Top management	–	3rd	2nd

The preference above for working with in-house capabilities for implementation makes this question even more important. Internal technology people were the preferred champions for all three sectors, followed by operations people and then top management. Note that most Agricultural enterprises are small and may not have dedicated technical staff. In all cases, concerns about "management buy-in" (see Section 3) should be kept in mind when suppliers develop their go-to-market strategy.

Top reasons for implementing Edge-IoT projects:

Answer	Agriculture	Energy & Utilities	Manufacturing
Clear ROI	1st (tie)	1st	1st
Regulatory Compliance	1st (tie)	2nd	3rd
Keep up with competition	3rd	3rd	2nd

Having a clear ROI was the primary motivation for all three sectors, followed by regulatory compliance and keeping up with the competition. "Regulatory/Legal Compliance" was also ranked as an important requirement for edge adoption by the Energy & Utilities sector, so suppliers need to address such requirements, particularly in this sector.

Preferred way of working on projects.

Answer	Agriculture	Energy & Utilities	Manufacturing
Pilots, proof of concept	2nd	1st	1st
Drive to our specifications	–	2nd	2nd (tie)
Partner with Trusted Supplier	–	3rd	2nd (tie)
Shared risk model	1st	4th	4th

Pilots and proofs of concept were the preferred way of working for Energy & Utilities and Manufacturing, but a shared risk model was preferred by Agriculture. Developing solutions specifically to each customer's specifications was the 2nd choice for both Energy & Utilities and Manufacturing, followed by partnering with a trusted supplier.

Overall, no specific go-to-market strategy was preferred by the Wave 2 workshop participants. Instead, respondents (collectively) highlighted that each customer will have their own preferred approach, and that suppliers must be prepared to work in the way that makes the most sense for each customer. In some cases, this will mean starting with smaller scale pilots and proofs of concept and, even when those pilots are successful, continuing to work collaboratively with customers, including sharing some of the risks involved in implementation.

Note that implementations driven by "in-house capabilities" and to "our specifications" may not deliver the proven, end-to-end, complete solutions that were reported as desirable (in [D1.2]). This in turn argues that suppliers should work closely with customers, well in advance of implementation, to socialize their solutions and architectures so that, when customers are ready to move forward, they can support the approach of their chosen supplier without pushing for customized solutions that may not be sustainable. Note that this can be challenging in some of the sectors of interest in this project since many customers in these sectors are likely to be larger organizations that will want things done their way.

These insights translate into requirements for the suppliers' go-to-market strategies:

- Suppliers can test their use case implementations through pilots and/or proofs of concept
- Suppliers are prepared to share some risks with their customers

- Suppliers work to improve trust in their organization and in their solutions, through guarantees, references, testimonials and other mechanisms.
- Suppliers develop awareness of the architecture of their solutions so that customers are more prepared to adopt those solutions than to specify customized solutions.

These four requirements are included in the presentation of common service requirements in section 3.1 above.

This analysis of business models and go-to-market strategies confirms that there do not appear to be significant differences in these factors between sectors. This suggests that the market segments identified in section 2 can be addressed by individual suppliers without developing different business models for different sectors.

At the same time, the ability to work with in-house teams will be critical. Go-to-market strategies will favour suppliers that have these relationships already, which in turn might suggest that edge/IoT specialists need to partner with existing IT vendors and system integrators for success.

5. Market Segments and Evolution through Market Pathways and Scenarios

Sections 3 and 4 confirm that the market segments proposed in Section 2 do not need to be modified or "split" to reflect differences in service requirements, business models or go-to-market strategies. In this section, the sequencing and prioritization of use cases within each segment is discussed as a "market pathway", and possible alternative market approaches to each segment can be identified as possible "market scenarios" for each segment.

Table 9 below summarizes key characteristics about each segment, including statistics on annual gateway and device sales (both estimated revenues and quantities). (Table 9 is the same as Table 1 in the Executive Summary.)

Table 9: Key Characteristics of Market Segments (all figures annual)

Market Segment	Sectors	Use Cases	Total Market (€M)	Gateway Market (€M)	Device Market (€M)	Total Gateways (000s)	Total Devices (millions)
1: Autonomous Vehicle	5	6	8,411	3,611	4,799	66	11
2a: Optimization	4	5	2,357	837	1,520	40	59
2b: Image Processing	5	10	3,734	829	2,905	68	131
3: Smart Meters	1	1*	4,222	34	4,187	1	557
4: Location of Movable Assets	5	8	4,451	193	4,258	37	788
5: Smart Building	4	4	1,209	183	1,026	42	40
6: Location of Mobile Assets	4	6	626	57	568	32	156
None	5	39	1,084	518	566	101	40
Grand Total	**5**	**79**	**26,092**	**6,262**	**19,830**	**388**	**1,783**

* Also EV charging, a new use case

5.1 Factors Influencing Potential Market Pathways

Market pathways, namely the evolution of a market segment over time, can be influenced by multiple factors.

5.1.1 Use Case Specialization and Use of Key Technologies

Except for one segment (Segment 3: smart meters), each segment groups use cases by major use case type or architectural pattern, and then addresses similar use cases across multiple sectors. (Segment 3, the smart meter segment, focusses on a single use case in a single sector.) This segmentation, combined with preferences for implementation partners presented in section 4, suggests that suppliers should specialize in a particular architectural pattern (such as "location of mobile assets") and then partner with relevant incumbents in each sector. This allows the specialist edge/IoT firm to establish a stable, end-to-end technology offering, which can then be adapted to the particular needs of the sector, led by the sector specialist partner.

Table 9 highlights the distinct relationships between gateways and devices in each segment.

- In Segment 1, autonomous vehicles, gateways require significant capabilities to manage each autonomous vehicle, reflected a low ratio of devices to gateways, and device revenues to gateway revenues.
- In Segments 2a and 2b, optimization and image processing, respectively, these ratios are higher than for segment 1 but lower than for other clusters.

- In Segment 3 (smart meters), these ratios are the highest of all the clusters. Device revenue dominates the market segment, and over 500 million devices are projected to be deployed each year. At the same time, only 1,000 gateways are deployed per year, reflecting a concentrated market segment (mostly distribution system operators, DSOs), compared to other segments, which by contrast are expected to deploy 30,000-70,000 gateways per year.
- Segments 4 and 6 (location of movable and mobile assets, respectively) also exhibit high ratios of devices to gateways, although not as high as for smart meters. Device revenues are also significant.

As noted earlier in this section, this market segmentation favours edge/IoT specialist suppliers who can optimize technology offerings (and customer support) for particular use case types. Where device counts and revenues per system are high (such as for Segments 3 and 4, and to a lesser extent, 5 and 6), device manufacturers may be involved directly, either as the specialist edge/IoT supplier, or driving the market through channel arrangements to such suppliers.

5.1.2 Use Case Size and Concentration

The bulk of revenues in each segment are associated with one or more of the 19 high-value use cases identified in Section 2. This is likely to attract multiple competitors given the size of each market segment. Initial market entrants are likely to focus on different use cases but will soon find themselves in competition with suppliers targeting similar use cases from the same segment. This should allow market entrants to establish a competitive advantage and offer good value to customers through healthy competition.

By contrast, revenues from secondary use cases (the non-high-value use cases that are included in each segment) may take some time to develop since market actors are likely to compete intensively in their primary market segments, before moving into secondary segments. Since these segments are significantly smaller than the primary segments, these secondary moves will come more slowly.

5.1.3 Physical Scope of Use Cases

Most segments group use cases of the same type as well those using as similar technologies, but use cases within a segment could be implemented across different physical scopes. For example, use cases in Segment 1 ("Autonomous Vehicles") target two different physical scopes:

- Limited areas, such as factory premises (M13), farm holdings (A11), health care facilities (H09) or defined transportation areas such as railyards, port areas (T12)
- Broader service areas, particularly for transportation corridors (T09) and vehicles operated by energy companies throughout their service territory (E16).

This distinction is important where the "target object" of a use case is itself mobile, must be tracked across a wide area, and must maintain at least intermittent connectivity with gateway devices through some form of "edge roaming" mechanisms. Providing this capability makes implementation of such use cases dependent on both network coverage and presence of a network of edge gateways capable of edge roaming, slowing the adoption of such use cases.

5.1.4 Extent of Data Sharing and the Role of the Cloud

Although these two factors are slightly different, there are interactions between them, so they are discussed together.

The extent of data sharing can vary between the use cases grouped together in a single market segment. This ranges across:

- No data sharing is needed between use case implementations.
- No data is shared, but "best practices" in the form of local processing algorithms, etc. may be provided from a central source or provider (usually from the cloud).

- Some data is sent to the cloud to enable fusion with other data sources, such as the integration of locally acquired farm condition data with earth observation/remote sensing data sources.
- Data is shared with specific partners in a supply chain (e.g. the food traceability use case (M06), freight monitoring (T07), etc.)
- Data is potentially shared more broadly through sector ecosystems, notably in energy (e.g. smart meters (E05) and smart grid (E11)).

Similarly, use case dependence on the cloud can vary:

- Many use cases can be fully implemented using a combination of gateways and processing on local edge computing hardware.
- Where use cases depend on algorithms that might be downloaded from the cloud, processing might instead move to the cloud to reduce local hardware costs.
- Data fusion, especially with larger data sets, is often performed on the cloud.
- Data can be shared with partners in a point-to-point fashion, but increasingly "data space" solutions operate in public cloud environments.
- Data sharing across ecosystems is increasingly operated in a public cloud environment.

The "cloud" could refer to a private cloud operated by a customer (such as a larger transportation company), public cloud services provided by European service providers, or public cloud services provided by one of the major "hyperscalers" – including AWS and Azure. Even when cloud-based platforms are not required by a use case, many edge platform providers base their platforms on public cloud (European or hyperscalers) since this is a cost-effective option for small and growing enterprises.

5.1.5 Algorithm Readiness and Data Completeness

As a specific part of the technical solution to any use case, some use cases place higher demands on the algorithms required to achieve the use case's objective. Moreover, the effectiveness of these algorithms often depends on the availability of sufficient data, not only about the direct target of the CEI use case, but also the related conditions.

- In Segment 2a ("Optimisation"), included use cases all intend to improve the efficiency of a business activity using optimisation algorithms. This is not a general problem, although the concept of "digital twins" helps to frame possible solutions. Specific algorithms are needed for each type of business activity. The effectiveness of these algorithms will determine the ROI of the related use cases. These algorithms also require more "complete" knowledge about the state of the activity being optimised, and much of this information may have to be provided by other systems in the enterprise.
- Segment 3 ("Smart Meters") is a special case of optimisation, involving the optimal control of energy-consuming devices in homes and businesses in response to local and general conditions. Although most smart meter applications are justified by labour savings associated with "meter reading" activities, the full benefits depend on more complicated demand side load management and optimisation, which require the use of optimisation algorithms. As with optimisation, effective load management needs to take both local and general conditions into account.
- In Segment 1 ("Autonomous Vehicles"), included use cases have similar requirements. However, for the general case of autonomous vehicles, operating on public roads in a wide variety of conditions, the required "algorithms" are still in development. In the narrower case of "autonomously guided vehicles", which operate in more controlled environments (e.g., within a warehouse, port or railyard switchyard), the required algorithms have shown greater reliability. Whether fully autonomous or AGV, these algorithms also require situational awareness to be safe and effective.

- In Segment 5, "Smart Building" optimisation algorithms have been more successful, benefitting from their lower risk profile. However, integration with relevant data about the general condition of the building in question (local weather, occupancy, etc.) is required for effective performance.
- In Segment 2b ("Image Processing"), several use cases are intended to inspect various objects (agricultural products, manufactured products, shipping containers, etc.) for defects, sometimes in real time as the items are being processed. In most cases this requires local image processing and effective detection of any quality issues of the item being inspected. As with optimisation, the effectiveness of these image processing algorithms will determine the ROI of the related use cases. For Segment 2b, having complete data is less challenging than the ability to adapt the image processing algorithms to respond to new conditions.

5.2 Likely Market Pathways Expected in Each Market Segment

Considering the factors outlined in Section 5.1, this section presents the likely pathways expected in each segment. Some consideration is also given to opportunities to maintain European sovereignty and autonomy in each market segment.

5.2.1 Segment 1: Autonomous Vehicles

Suppliers in this €8.4 billion/year market segment must address one key issue: the physical scope of each use case. Roughly €3.1 billion/year of this segment requires fully autonomous vehicle operation in public roads (in the transportation and energy sectors). Most of the organisations in these sectors are economically significant and are likely to be conservative in adopting this technology, both for liability issues and because the required network and "edge roaming" infrastructure is not fully deployed. The balance of the segment (€5.3 billion) targets more limited "autonomously guided vehicles", generally on private property, and could be expected to develop quickly. This would be supported by privately operated networking infrastructure (such as private 5G), which could be a significant market opportunity on its own.

Although there are challenges with algorithm and data readiness (as discussed above), these challenges are not unique to Europe, and the European CEI market should benefit from global developments. At the same time, this introduces concerns about Europe's autonomy and sovereignty in this market segment.

Development of the AGV market subsegment can be expected to develop more rapidly than the more general autonomous vehicle subsegment. Despite the important role of key autonomous vehicle vendors (e.g. Tesla), this more "captive" market, with key European customers, might be guided toward EU-based solutions if they are competitive.

5.2.2 Segment 2a: Optimization

The development of this €2.4 billion/year market segment will be gated by the successful development of optimisation algorithms suited to each customer's requirements and objectives, as well as effective mechanisms for giving those algorithms access, not only to the data collected by the CEI implementation, but also to the other operational and situational data required.

The largest opportunity in this segment is the "Smart Grid" use case (E11), alone worth €1.3 billion/year, where national interests are likely to ensure that EU actors and sector specialists take important roles in this opportunity.

For the balance of this segment (€1.1 billion/year), existing software vendors (e.g. ERP vendors such as SAP from Germany and Oracle from the US), operating in relevant sectors, already control such algorithms and data flows and are likely to drive the development of this market segment. A growing number of AI-based offerings are also likely to be both disruptive of this market structure and successful. Suppliers and operators of local CEI data collection infrastructure are not likely to be able to change the market dynamic in this segment. The role of data sharing and data fusion in this segment, both relying on existing enterprise systems and/or the public cloud, will

further limit opportunities for European leadership in this segment. The €1.1 billion/year opportunity will continue to develop, with players taking the role of supplier or "input" to broader initiatives of enterprise optimisation and data sharing.

5.2.3 Segment 2b: Image Processing

This €3.7 billion/year market segment will be dominated by revenues for powerful on-site camera and image processing systems, with quantities projected at over 100 million devices installed per year. (Note that this is not a new market – sophisticated video surveillance products have been available for decades.) Most of the applications will be generic video surveillance use cases. The size the market and the opportunities for economies of scale should make it very interesting for European suppliers, and device vendors will drive development of the market, rather than suppliers of any "gateway" devices.

This market will also be targeted by significant international vendors, notably from China. Given the "connected" nature of this market, as well as China's adoption of intrusive video surveillance technology, the EU must strictly enforce its privacy controls to ensure that personal data is properly protected.

As noted above, for those use cases requiring inspection of products, performance expectations are higher, so suppliers might be able to create competitive advantage by specializing in certain kinds of video inspection. At the same time, no personal data is involved, so sophisticated products from non-EU suppliers might be successful in the market. The EU might consider applying the requirements of the Data Act, treating the inspection systems as "connected devices", to minimize undesirable export of data about food products, manufacturing or logistics.

5.2.4 Segment 3: Smart Meters

This segment comprises a single use case from the 79 Considered Use Cases, namely "smart meters", valued at €4.2 billion/year. It is joined by another growing opportunity related to "EV charging". While smart meters (as well as EV charging) are not new applications, rollouts are continuing, and the market is evolving from "meter reading" to "load management", so continued investment is expected. (EV charging must include optimisation functions to prevent overloading local power distribution networks.) Revenues come almost entirely from metering devices, with over 500 million devices estimated to be installed annually (reflecting the diversity of buildings and "economic units" to be metered – residential, commercial and industrial – as well as the need for replacement and upgrades in functionality).

Given the close relationship between national markets and national actors in the electric power sector, there is a natural focus on supporting EU-based suppliers, and the EU market is sufficiently large to allow EU suppliers to achieve the economies of scale required to allow thus use case to generate a return on investment.

Smart meters, and the data they generate, represent an important component in the planned democratization of the energy grid, creating market-based opportunities for both consumers and new entrants to the energy market. This will require smart meter suppliers to support data sharing through the energy market ecosystem, as well as using cloud-technologies in a way that respects the data sovereignty of the many actors participating in this system.

5.2.5 Segment 4: Location of Movable Assets

This €4.5 billion/year market segment address location tracking for billions of movable assets (from hospital beds, to parcels, to high value test equipment), with an estimate 800 million low-cost tracking devices (roughly €5 each) installed each year. As with "smart meters" the market will be dominated by the vendors of location tracking devices, which may enter the market directly, or work through distribution partners. Give the volumes involved, high volume manufacturers (China, India) can be expected to participate, and, as with Segment 2b ("Image Processing"), the connected nature of this market should trigger vigilant enforcement of EU laws around data generated by these devices.

The largest single opportunity in this segment (worth €3.5 billion/year) is freight monitoring (use case T07), which is likely to develop differently since it requires broader network coverage (to allow packages to be monitored on their full journey), edge roaming (to allow those packages to be tracked as they move) as well as sharing of data with the logistics ecosystem (since many parties are involved from start to finish). While these requirements are more demanding, the size the market opportunity is sufficient to drive creation of seamless, yet cost-effective, solutions. The shared nature of this challenge will drive cooperation among key players to find a re-usable solution.

5.2.6 Segment 5: Smart Building

The €1.2 billion/year market segment should continue to develop as an extension of the existing building automation market, which is dominated by a small number of players, including some from Europe.

5.2.7 Segment 6: Location of Mobile Assets

This €625 million/year market segment is dominated by the existing "fleet tracking" use case (T02) in the transportation sector. This application must address the same requirements as "freight monitoring" (T07) above, namely broader network coverage, edge roaming, as well as sharing of data across the transportation ecosystem. Other use cases in this segment will benefit from progress with the fleet tracking use case.

5.3 Preliminary Market Pathways

Given the discussion in section 5.2, the market segments presented earlier are adjusted slightly to reflect the synergies that are likely to develop, as follows:

- Segment 1 is divided into two pathways: AGVs and autonomous vehicles
- In Segment 2a, the Smart Grid use case is linked to Segment 3, Smart Meters.
- Segment 2b is split into Video Surveillance and Product Inspection (2c).
- Segment 3 now includes the Smart Grid use case.
- Segments 4 and 6 are merged, and then split into Segment 4a (Fleet Tracking and Freight Monitoring), and Segment 4b (Asset Tracking in Limited Areas)
- Segment 5 (Smart Building) is unchanged.

The nine (9) proposed market pathways are summarized in Table 10. Appendix C summarizes the market pathways presented here.

Table 10: Key Characteristics of Proposed Market Pathways (all figures annual)

Market Segment	Sectors	Use Cases	Total Market (€M)	Gateway Market (€M)	Device Market (€M)	Total Gateways (000s)	Total Devices (millions)
1a: Automatically Guided Vehicles	4	4	5,354	3,079	2,275	57	4
1b: Autonomous Vehicle	2	2	3,056	532	2,524	10	7
2a: Optimization	3	4	1,009	796	213	39	7
2b: Video Surveillance	5	7	2,429	295	2,134	45	120
2b: Product Inspection	3	3	1,305	533	772	24	10
3: Smart Meters, Smart Grid	1	2*	5,569	75	5,494	3	609
4a: Fleet Tracking, Freight Monitoring	2	4	4,053	99	3,954	11	540
4b: Asset Tracking in Limited Areas	4	10	1,024	151	873	57	404
5: Smart Building	4	4	1,209	183	1,026	42	40
None	5	39	1,084	518	566	101	40
Grand Total	**5**	**79**	**26,092**	**6,262**	**19,830**	**388**	**1,783**

* Also EV charging, a new use case

These nine market pathways respect the similarities described in Section 2, while also respecting the different evolutionary paths that are likely, given factors including coverage over a larger service area, sharing of data across ecosystems and technical requirements such as image processing algorithms for product inspection.

6. Conclusions and Next Steps

This report has described the Cloud-Edge-IoT (CEI) Ecosystem in Europe along several dimensions:

- Six (6) key market segments,
- Nine (9) proposed market pathways for the development of that ecosystem (no alternative scenarios are identified), and
- Twenty-nine (29) key business and service requirements that will be critical for successful suppliers to the CEI ecosystem.

Several preliminary conclusions can be offered based on this analysis:

- Estimated market opportunities were heavily concentrated in a small number of use cases, each of which featured large numbers of IoT devices of a single type. This suggests investment should target optimization of these high-volume IoT devices, rather than the design of versatile gateways and related orchestration mechanisms.
- Based on estimated market opportunities, very few use cases for condition monitoring or predictive maintenance were in the list of high-value use cases, nor were these use cases aggregated into larger market segments based on their similarities. This highlights the diversity of requirements for these use cases (e.g. needing to support diverse IoT devices and their distinct protocols) as well as the relatively small market opportunities available in each sector. This suggests that these use cases may not be attractive targets for investment in development and research.
- High device volumes represent significant opportunities for European economy but will also attract considerable foreign interest.
- The EU has established a useful regulatory regime (e.g. GDPR, Data Act) relevant to these IoT devices (including surveillance and product inspection), but appropriate enforcement mechanisms should be implemented.
- The segmentation analysis yielded market segments that were organized according to the types of application, rather than the sector, of each use case. This suggests that investment, for example through EC-funded development projects, as well as through large scale pilots and/or competence centres, should target single applications implemented in multiple sectors, rather than versatile gateways addressing multiple applications within a single sector.
- Most of the use cases representing the biggest market opportunities do not need edge roaming or workload orchestration.
- Where this is needed, the biggest drivers for expanded network coverage as well as edge-roaming might come from freight and fleet tracking. Ideally incentives should be put in place to support the transportation sector to drive this expansion, not only for their own benefit, but also to support broader network and edge-roaming coverage, which would enable other important use cases across the CEI ecosystem.
- Even implementations of CEI use cases using private networking to serve limited area coverage requirements should also be encouraged to support federated edge networks.

The market segments, pathways and service requirements, as well as the preliminary conclusions above, will be further validated through upcoming “Wave 3” interviews.

7. Appendix A: Consolidated Service Requirements

7.1 Overview

To conduct a comprehensive analysis of the various requirements for IoT and Edge Computing across different sectors, we compared data from multiple documents developed in course of the UNLOCK-CEI project:

- D1.2 "Cloud-Edge-IoT Demand Landscape" [D1.2] provided a detailed list of benefits and challenges associated with IoT and Edge Computing solutions across the sectors of interest to the project: Agriculture, Energy, Healthcare, Manufacturing, and Transport. It is important to note that [D1.2] offers a larger sample set but considers fewer, more general challenges, which are presented here as service requirements.
- EUCloudEdgeIoT's Task Force 5 "Market & Sectors" [TF5], discusses specific use cases from different sectors. focused on specific use cases within these sectors, offering practical insights into how IoT and Edge Computing technologies are being implemented to address particular needs and scenarios. [TF5] utilized a smaller sample set but was more technically focused. The information in [TF5] was presented as percentages of projects reporting each requirement, allowing for direct comparison with the broader data from [D1.2].
- D3.2 "Sector-specific service requirements, data flows and revenue streams in Cloud-Edge-IoT value networks" [D3.2], which captures sector-specific needs. [D3.2] highlights sector-specific needs, detailing the unique requirements and constraints of each industry when adopting IoT and Edge Computing solutions. However, [D3.2] only provided mentions of these requirements without the ability to measure their relative importance. We mapped these mentions to the challenges and service requirements identified in [D1.2] and [TF5], using them to validate the analysis rather than mathematically including them.

By synthesizing these documents, a unified list of service requirements is created that can assist suppliers develop effective strategies for participating in the European Cloud-Edge-IoT ecosystem.

Recurring themes and requirements were identified across the three sources. This involved recognizing common benefits such as improved efficiency, better customer experiences, and enhanced security, as well as challenges like high costs, deployment complexity, and the need for skilled personnel. To facilitate a meaningful comparison, we generated a new, consolidated list of requirements. This list aimed to encompass all the identified benefits and challenges to be addressed from the three documents, ensuring that it covered both the general and sector-specific aspects of IoT and Edge Computing implementations.

7.2 Requirements Identified in [D1.2]: "Cloud-Edge-IoT Demand Landscape"

The data presented below are derived from [D1.2], which outlines the benefits and challenges associated with the implementation of IoT (Internet of Things) and edge computing solutions.

The analysis involved a detailed comparison of the benefits and challenges of implementing IoT (Internet of Things) and Edge Computing solutions across various sectors, starting by identifying common requirements across the benefits and barriers and across the two technologies. After collecting benefits and challenges according to their common requirements, the survey results (from [D1.2]) are combined as an average of the individual percentages of respondents that selected each benefit or challenge as one of their top 3 concerns. This composite importance

figure approximates the results of an analysis that might be possible with direct access to the survey data – this analysis will be discussed with UNLOCK-CEI partners in a possible update.

Table 11 below details how the original barriers and benefits (listed under "Barrier/Benefit from [D1.2]") are grouped by common service requirement and presents the original survey results as well as the composite importance calculated for each common service requirement. Table 12 summarizes the results of this analysis by presenting the common service requirements that enable the benefits of and address the challenges to CEI adoption, along with composite importance of each requirement overall and by sector.

Twenty (20) common service requirements are identified from the survey results presented in [D1.2]. Of these:

- Nine (9) relate to technical requirements, of which five (5) have the highest composite importance indicator.
- Five (5) requirements relate to economic expectations, two (2) of which rank just below the top five technical requirements.
- Another five (5) requirements address the readiness of the adopting organisation.
- One final requirement relates to addressing readiness of communications networks.

These rankings should be taken as illustrative, rather than definitive, since they result from the combination of survey responses for individual factors, and there is some variability in rated importance among each group of original benefits/barriers that has been consolidated into each common requirement.

Similarly, there is important variation in rated importance of a given requirement across the five sectors. For example, the top 3 rated requirements (reducing data volumes, overcoming unreliable connectivity and very low latency) are rated much more highly by the Agriculture sector than the other four. Similar variation is seen across all the common service requirements, but overall, based on this data, there do not appear to be radically different service requirements across the five sectors. Figure 8 illustrates this variation by charting composite importance for the survey overall, and for the four sectors individually.

Table 11: Common Service Requirements Identified in [D1.2] – detailed presentation

Barrier/Benefit from [D1.2]	Barrier/ Benefit	Technology	Common Service Requirement	ID	Overall	Agri-culture	Energy & Utilities	Health-care	Manu-facturing	Transport
Reduces volumes of data sent across networks --> kept on its own	Benefit	Edge	Reduces volumes of data sent across networks	D1.2 Tech 9	37.6%	47.1%	34.4%	38.2%	38.2%	33.3%
Overcomes unreliable connectivity --> kept on its own	Benefit	Edge	Overcomes unreliable connectivity	D1.2 Tech 6	36.9%	48.6%	36.7%	35.8%	34.6%	34.5%
Very low latency --> kept on its own	Benefit	Edge	Very low latency / High computational requirements	D1.2 Tech 5	35.9%	47.0%	26.4%	37.4%	36.4%	35.7%
Improves security and compliance, as data is not travelling	Benefit	Edge	Improved Security, Data Protection, Privacy		41.6%	37.9%	46.2%	37.3%	39.5%	45.8%
Security concerns	Barrier	IoT	Improved Security, Data Protection, Privacy		34.1%	29.3%	39.6%	42.5%	32.1%	31.6%
Security concerns	Barrier	Edge	Improved Security, Data Protection, Privacy		27.7%	29.1%	24.9%	37.2%	27.1%	24.8%
Average of above 3			Improved Security, Data Protection, Privacy	D1.2 Tech 4	34.5%	29.2%	32.3%	39.8%	29.6%	28.2%
Allows deployment of AI analytics models close to the device --> kept on its own	Benefit	Edge	Allows deployment of AI analytics models close to the device	D1.2 Tech 8	33.4%	22.6%	32.2%	28.5%	38.7%	34.9%
Overall cost of deployment	Barrier	IoT	Costs need to be low & ROI clear		39.9%	41.8%	39.6%	55.3%	29.5%	47.2%
High costs and unclear ROI	Barrier	Edge	Costs need to be low & ROI clear		27.7%	33.1%	29.0%	32.2%	24.2%	25.8%
Unclear return on investment (ROI)	Barrier	IoT	Costs need to be low & ROI clear		20.9%	23.1%	19.9%	23.4%	19.7%	21.0%
Average of above 3			Costs need to be low & ROI clear	D1.2 Econ 1	29.5%	32.6%	29.5%	37.0%	24.5%	31.3%
Allows deployment of resource-constrained IoT devices --> kept on its own	Benefit	Edge	Allows deployment of resource-constrained IoT devices	D1.2 Tech 7	27.0%	28.2%	35.6%	17.8%	23.5%	29.9%
Efficiency and productivity	Benefit	IoT	Enables Business Improvements		40.8%	38.4%	34.0%	38.6%	43.2%	45.3%
Better customer experience	Benefit	IoT	Enables Business Improvements		34.4%	38.1%	38.6%	36.7%	31.2%	32.4%

Barrier/Benefit from [D1.2]	Barrier/ Benefit	Technology	Common Service Requirement	ID	Overall	Agri-culture	Energy & Utilities	Health-care	Manu-facturing	Transport
Reduces costs (including of network connectivity)	Benefit	Edge	Enables Business Improvements		28.4%	25.2%	32.9%	36.2%	24.5%	28.6%
Better decision-making	Benefit	IoT	Enables Business Improvements		26.9%	17.6%	25.8%	37.2%	23.9%	35.4%
Reach new customer segments	Benefit	IoT	Enables Business Improvements		23.4%	26.8%	21.8%	24.7%	22.2%	23.9%
Digital transformation	Benefit	IoT	Enables Business Improvements		23.3%	26.7%	29.5%	10.4%	25.1%	18.2%
Improved product quality	Benefit	IoT	Enables Business Improvements		22.1%	27.4%	23.6%	14.0%	25.3%	15.3%
Launch new products or services	Benefit	IoT	Enables Business Improvements		21.6%	24.3%	20.6%	22.1%	18.6%	25.6%
Faster time-to-market	Benefit	IoT	Enables Business Improvements		19.7%	26.0%	22.9%	15.3%	19.8%	14.2%
Average of *above* 9			Enables Business Improvements	D1.2 Econ 2	26.7%	25.1%	21.7%	18.7%	19.2%	19.9%
Lack of skills/qualified workforce	Barrier	Edge	Need support to close Skills gaps		26.6%	29.5%	29.2%	20.5%	25.9%	26.6%
Lack the needed skills	Barrier	IoT	Need support to close Skills gaps		22.5%	21.9%	21.0%	17.2%	25.7%	22.0%
Average of above 2	Barrier		Need support to close Skills gaps	D1.2 Org 3	24.5%	25.7%	25.1%	18.8%	25.8%	24.3%
Lack of adequate IT infrastructure	Barrier	Edge	Need supports for improving readiness of Existing IT infrastructure		26.7%	25.4%	22.6%	27.8%	28.1%	28.4%
Limitations of existing infrastructure	Barrier	IoT	Need supports for improving readiness of Existing IT infrastructure		21.0%	19.4%	20.4%	19.5%	22.0%	21.7%
Average of above 2			Need supports for improving readiness of Existing IT infrastructure	D1.2 Org 2	23.8%	22.4%	21.5%	23.6%	25.1%	25.1%
Reduce energy usage and meet sustainability goals	Benefit	Edge	Reducing energy consumption		32.8%	33.7%	32.9%	26.8%	37.4%	27.7%

Barrier/Benefit from [D1.2]	Barrier/ Benefit	Technology	Common Service Requirement	ID	Overall	Agri-culture	Energy & Utilities	Health-care	Manu-facturing	Transport
Reduces energy usage	Benefit	IoT	Reducing energy consumption		14.2%	14.1%	13.4%	8.4%	15.4%	15.7%
Average of *above* 2			Reducing energy consumption	D1.2 Econ 3	23.5%	23.9%	23.1%	17.6%	26.4%	21.7%
Deployment complexity	Barrier	IoT	Complete solutions, end-to-end, easy deployment		28.4%	37.0%	26.8%	19.0%	25.4%	33.5%
Lack of end-to-end solutions	Barrier	IoT	Complete solutions, end-to-end, easy deployment		22.7%	31.4%	27.1%	10.4%	22.9%	18.3%
Lack of complete solutions available	Barrier	Edge	Complete solutions, end-to-end, easy deployment		17.8%	13.6%	18.5%	14.6%	19.8%	18.7%
Average of above 3			Complete solutions, end-to-end, easy deployment	D1.2 Tech 1	23.0%	27.3%	24.1%	14.7%	22.7%	23.5%
Improved safety (of customers or employees) --> kept on its own	Benefit	IoT	Improved safety (of customers or employees)	D1.2 Econ 5	21.2%	15.4%	26.0%	24.1%	20.3%	21.6%
Improved physical security --> kept on its own	Benefit	IoT	Improved physical security	D1.2 Econ 4	20.9%	22.3%	23.9%	12.7%	18.3%	26.1%
Management buy-in	Barrier	IoT	Need Help with management Buy-in/overcoming Organization resistance		21.3%	22.4%	19.4%	23.5%	22.9%	18.2%
Organizational resistance	Barrier	Edge	Need Help with management Buy-in/overcoming Organization resistance		20.4%	13.3%	21.3%	23.7%	24.0%	17.3%
Average of above 2	Barrier		Need Help with management Buy-in/overcoming Organization resistance	D1.2 Org 1	20.8%	17.8%	20.3%	23.6%	23.5%	17.8%
Need mature 5G networks and devices --> kept on its own	Barrier	Edge	Need mature 5G networks and devices	D1.2 Net 1	20.1%	24.8%	22.8%	18.9%	18.1%	17.7%
Regulatory and legal compliance	Benefit	IoT	Improve Regulatory/Legal Compliance		19.9%	11.9%	17.2%	37.5%	21.3%	17.0%
Regulation/legal risks	Barrier	Edge	Improve Regulatory/Legal Compliance		19.0%	22.4%	24.6%	19.0%	14.7%	18.2%

Barrier/Benefit from [D1.2]	Barrier/ Benefit	Technology	Common Service Requirement	ID	Overall	Agri-culture	Energy & Utilities	Health-care	Manu-facturing	Transport
Average of above 2			Improve Regulatory/Legal Compliance	D1.2 Org 4	19.5%	17.2%	20.9%	28.3%	18.0%	17.6%
Incompatible components -- Interoperability	Barrier	Edge	Standards-based, Interoperable		20.4%	21.0%	16.9%	16.6%	18.1%	28.9%
Insufficient interoperability or standards	Barrier	IoT	Standards-based, Interoperable		19.7%	21.9%	21.7%	20.4%	20.4%	14.9%
Lack of standards (or too many conflicting standards)	Barrier	Edge	Standards-based, Interoperable		17.6%	13.0%	26.8%	16.7%	18.3%	12.3%
Average of above 3			Standards-based, Interoperable	D1.2 Tech 3	19.2%	17.4%	24.2%	18.5%	19.3%	13.6%
Complexity of business process change	Barrier	IoT	Ease-of-use, Solution easy to adapt to my business processes		18.9%	16.4%	16.1%	23.5%	24.5%	11.8%
Difficulties modifying established processes	Barrier	Edge	Ease-of-use, Solution easy to adapt to my business processes		19.0%	14.6%	22.0%	17.9%	17.3%	23.1%
Average of above 2			Ease-of-use, Solution easy to adapt to my business processes	D1.2 Org 5	19.0%	15.5%	19.0%	20.7%	20.9%	17.5%
Concern about technology stability/capabilities	Barrier	IoT	Technical stability, capabilities, mature offerings, confidence in suppliers		21.1%	12.6%	29.6%	9.3%	22.2%	24.2%
Offerings from vendors are not yet mature	Barrier	Edge	Technical stability, capabilities, mature offerings, confidence in suppliers		16.9%	9.6%	17.3%	16.0%	20.6%	16.4%
Lack of confidence in existing suppliers	Barrier	Edge	Technical stability, capabilities, mature offerings, confidence in suppliers		15.9%	23.0%	14.1%	12.6%	15.7%	14.3%
Average of above 3			Technical stability, capabilities, mature	D1.2 Tech 2	18.0%	15.1%	20.3%	12.7%	19.5%	18.3%

Barrier/Benefit from [D1.2]	Barrier/ Benefit	Technology	Common Service Requirement	ID	Overall	Agri-culture	Energy & Utilities	Health-care	Manu-facturing	Transport
			offerings, confidence in suppliers							

Table 12: Common Service Requirements Identified in [D1.2] – summary presentation

Common Service Requirement	ID	Overall	Agri-culture	Energy & Utilities	Health-care	Manu-facturing	Transport
Reduces volumes of data sent across networks	D1.2 Tech 9	37.6%	47.1%	34.4%	38.2%	38.2%	33.3%
Overcomes unreliable connectivity	D1.2 Tech 6	36.9%	48.6%	36.7%	35.8%	34.6%	34.5%
Very low latency / High computational requirements	D1.2 Tech 5	35.9%	47.0%	26.4%	37.4%	36.4%	35.7%
Improved Security, Data Protection, Privacy	D1.2 Tech 4	34.5%	29.2%	32.3%	39.8%	29.6%	28.2%
Allows deployment of AI analytics models close to the device	D1.2 Tech 8	33.4%	22.6%	32.2%	28.5%	38.7%	34.9%
Costs need to be low & ROI clear	D1.2 Econ 1	29.5%	32.6%	29.5%	37.0%	24.5%	31.3%
Allows deployment of resource-constrained IoT devices	D1.2 Tech 7	27.0%	28.2%	35.6%	17.8%	23.5%	29.9%
Enables Business Improvements	D1.2 Econ 2	26.7%	25.1%	21.7%	18.7%	19.2%	19.9%
Need support to close Skills gaps	D1.2 Org 3	24.5%	25.7%	25.1%	18.8%	25.8%	24.3%
Need supports for improving readiness of Existing IT infrastructure	D1.2 Org 2	23.8%	22.4%	21.5%	23.6%	25.1%	25.1%
Reducing energy consumption	D1.2 Econ 3	23.5%	23.9%	23.1%	17.6%	26.4%	21.7%
Complete solutions, end-to-end, easy deployment	D1.2 Tech 1	23.0%	27.3%	24.1%	14.7%	22.7%	23.5%
Improved safety (of customers or employees)	D1.2 Econ 5	21.2%	15.4%	26.0%	24.1%	20.3%	21.6%
Improved physical security	D1.2 Econ 4	20.9%	22.3%	23.9%	12.7%	18.3%	26.1%
Need Help with management Buy-in/overcoming Organization resistance	D1.2 Org 1	20.8%	17.8%	20.3%	23.6%	23.5%	17.8%
Need mature 5G networks and devices	D1.2 Net 1	20.1%	24.8%	22.8%	18.9%	18.1%	17.7%
Improve Regulatory/Legal Compliance	D1.2 Org 4	19.5%	17.2%	20.9%	28.3%	18.0%	17.6%
Standards-based, Interoperable	D1.2 Tech 3	19.2%	17.4%	24.2%	18.5%	19.3%	13.6%
Ease-of-use, Solution easy to adapt to my business processes	D1.2 Org 5	19.0%	15.5%	19.0%	20.7%	20.9%	17.5%
Technical stability, capabilities, mature offerings, confidence in suppliers	D1.2 Tech 2	18.0%	15.1%	20.3%	12.7%	19.5%	18.3%

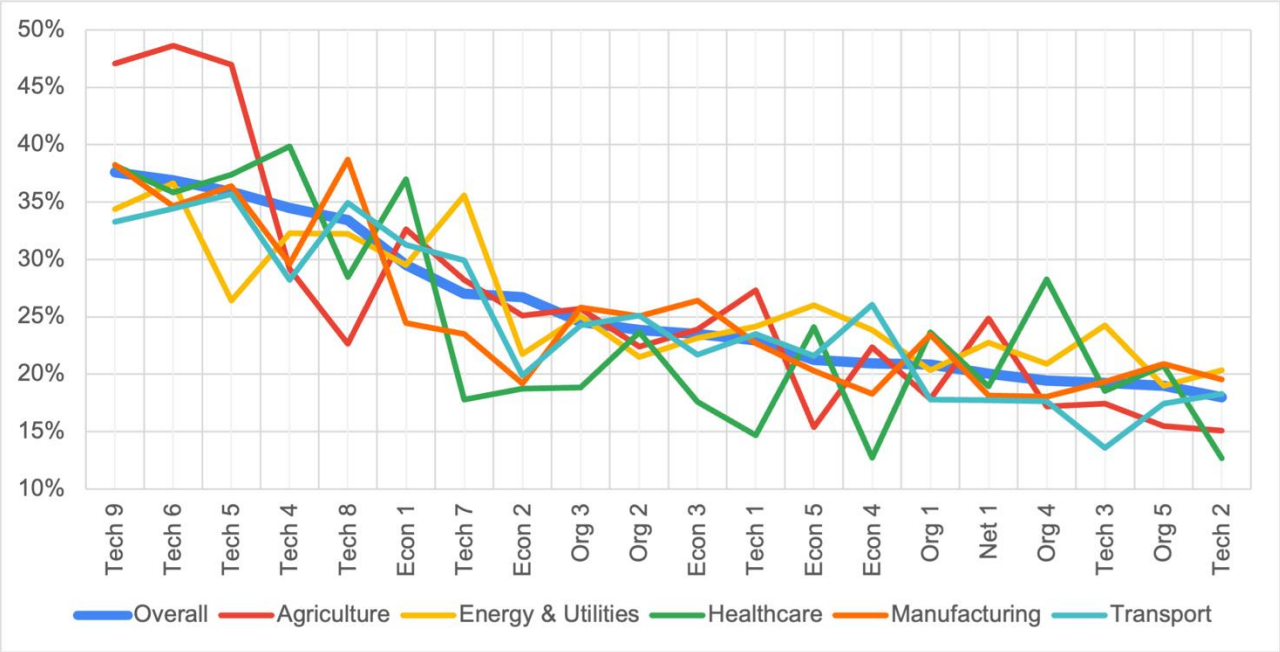

Figure 8: Composite Importance of Service Requirements from [D1.2], overall and by sector

7.3 Requirements Identified in [TF5]: "Task Force 5: Markets and Sectors"

The EUCEI Task Force 5: "Markets and Sectors" worked with twenty-one (21) use cases participating in the MetaOS project cluster, asking them to present key categories of information about each use case, which were summarized in [TF5]. Two categories of information offered insights into service requirements that would need to be met to enable implementation and successful adoption of the use case: "Constraints, challenges & risks" and "Key missing components".

Across the 21 projects participating, 181 aspects were reported in these categories. 117 of these aspects could be mapped to one of the common service requirements derived from [D1.2] and presented in the previous section. Sixty-four (64) aspects could not be mapped accurately to one of those requirements, so an additional nine (9) requirements were identified to complete the mapping, as follows:

- TF5 Org 1: Support for improving quality and currency of source data
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
- TF5 Tech 2: Scalability
- TF5 Tech 3: Configurability/Smart Infrastructure
- TF5 Tech 4: High source data rates
- TF5 Tech 5: Ability to work in a range of weather conditions
- TF5 Tech 6: Enable data sharing and value-added services
- TF5 Tech 7: Works with diverse devices
- TF5 Tech 8: Deliver new capabilities

Adding these nine common service requirements brings the total to twenty-nine (29).

Since the "sample" used by Task Force 5 was the 21 use cases, if one use case mentioned multiple aspects that could be mapped to one of the 29 common service requirements, these were only counted once, and the percent of use cases reporting this common requirement (in any form) is presented as the relevant importance rating for that requirement.

Table 13 below details how aspects reported by each use case in the "Constraints, challenges & risks" or "Key missing components" categories are grouped by common service requirement.

Table 13: Requirements reported by MetaOS use cases, mapped to Common Service Requirements

AerOS: High Performance Computing Platform for Connected & Cooperative agricultural Mobile Machinery (Agriculture)

- D1.2 Tech 5: Very low latency / High computational requirements
  - (semi) Real-time data transfer
  - Synchronizing machine work
  - Time-critical machinery tasks
  - Timely data analysis
- TF5 Tech 7: Works with diverse devices
  - Compatibility and integration of the provided HW from Tech provider

AerOS: Containerised Edge Computing Near Renewable Energy Sources (Energy & Utilities)

- D1.2 Econ 2: Enables Business Improvements
  - Decentralised and distributed configuration of Renewable Energy structure in the local area
  - Difficulties in monitoring the grid at large scale
  - Trustworthy intelligence in a critical sector
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Privacy restrictions for data sharing
- D1.2 Tech 6: Overcomes unreliable connectivity
  - Connection challenges
- D1.2 Tech 8: Allows deployment of AI analytics models close to the device
  - Advanced intelligence decision support
  - Usage of AI for intelligent forecasting
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - Considering far edge
  - Heterogeneous sources of information for orchestrating and scheduling optimisation
  - Possible rapid changes in task distribution due to available energy, network throughput etc.
- TF5 Tech 3: Configurability/Smart Infrastructure
  - Infrastructure's autonomy in terms of management

aerOS: Port Continuum (Logistics & mobility, Transportation)

- D1.2 Econ 1: Costs need to be low & ROI clear: average of above
  - Costly (money-wise) OCR solutions
- D1.2 Econ 2: Enables Business Improvements
  - Digitalization across the terminal with IoT
- D1.2 Econ 5: Improved safety (of customers or employees)
  - Worker's safety
- D1.2 Org 2: Need supports for improving readiness of Existing IT infrastructure
  - Old infrastructure
- D1.2 Tech 3: Standards-based, Interoperable: avg (slightly more for IoT)
  - Proprietary maintenance solutions
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Security risks sending to cloud
- D1.2 Tech 5: Very low latency / High computational requirements
  - Computational demanding CV solutions
  - Reactive -> Not proactive
- D1.2 Tech 8: Allows deployment of AI analytics models close to the device

- AI-based services
- TF5 Tech 7: Works with diverse devices
  - Heterogeneous manufacturers
- TF5 Tech 8: Deliver new capabilities
  - Cargo handling quality check
  - Preventive maintenance solutions

AerOS: Data-driven Cognitive Production Lines (Manufacturing)

- D1.2 Econ 2: Enables Business Improvements
  - Fully automated quality control
- D1.2 Econ 3: Reducing energy consumption
  - CO2 footprint prediction
- D1.2 Org 2: Need supports for improving readiness of Existing IT infrastructure
  - Obsolete IT infrastructures
  - Obsolete machinery
- D1.2 Org 5: Solution easy to adapt to my business processes
  - Complexity and variety of production processes
  - Manual processes
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Send information securely to the cloud
- D1.2 Tech 5: Very low latency / High computational requirements
  - High latency response
- TF5 Org 1: Support for improving quality and currency of source data
  - Data sources variety
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - Cloud's computing resources
- TF5 Tech 3: Configurability/Smart Infrastructure
  - Adaptation to all production lines
  - Mass customization needs
  - Self-diagnosis and recovery
- TF5 Tech 4: High source data rates
  - Big data volumes to process

aerOS: Energy Efficient, Health Safe and Sustainable Smart Buildings (Smart City & Buildings, Energy & Utilities)

- D1.2 Econ 1: Costs need to be low & ROI clear
  - Transform existing buildings to smart buildings with minimum investment.
- D1.2 Econ 5: Improved safety (of customers or employees)
  - The employee is seated in the most health safe Station, and according to his/her preferences
- D1.2 Tech 1: Complete solutions, end-to-end, easy deployment
  - Mobile or Web App
- D1.2 Tech 3: Standards-based, Interoperable: avg (slightly more for IoT)
  - Various IoT protocols
- D1.2 Tech 5: Very low latency / High computational requirements
  - The appropriate placement of the employee should be instantly decided upon his/her entering the building
- D1.2 Tech 8: Allows deployment of AI analytics models close to the device
  - AI-based health-safe/energy efficient prediction and recommendation engine
- TF5 Tech 3: Configurability/Smart Infrastructure
  - Each building has its own characteristics and employee's placement conditions (open space etc.)
- TF5 Tech 7: Works with diverse devices
  - Heterogeneous devices, technologies

FluiDOS: Smart Viticulture (Agriculture)

- D1.2 Org 3: Need support to close Skills gaps
- Education on digitalisation to realise its value/potential
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Data privacy

- D1.2 Tech 6: Overcomes unreliable connectivity
  - Connectivity availability
  - Reliability and accuracy
- D1.2 Tech 7: Allows deployment of resource-constrained IoT devices
  - Partial set of services at the edge, the rest in core
  - Resource constraints at the edge
- TF5 Tech 8: Deliver new capabilities
  - Hyperspectral imaging

FluiDOS: Energy grid resilience (Energy & Utilities)

- D1.2 Econ 1: Costs need to be low & ROI clear
  - Low-cost infrastructure
  - Low-cost PMU
- D1.2 Econ 2: Enables Business Improvements
  - Resilience
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Cybersecurity
- D1.2 Tech 5: Very low latency / High computational requirements
  - Latency
  - Time synchronization
- D1.2 Tech 6: Overcomes unreliable connectivity
  - Reliability
- TF5 Tech 2: Scalability
  - Scalability
- TF5 Tech 3: Configurability/Smart Infrastructure
  - Microservices Architecture
- TF5 Tech 4: High source data rates
  - Data Congestions
  - High sampling rate

FluiDOS: Robotic Logistics (Manufacturing)

- D1.2 Tech 1: Complete solutions, end-to-end, easy deployment
  - Robotic Kubernetes deployment
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Security of the data
- D1.2 Tech 6: Overcomes unreliable connectivity
  - Network delays
  - Network interruptions
- TF5 Org 1: Support for improving quality and currency of source data
  - Limited robot resources
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - ROS architecture
  - Seamless switch among robot/edge/cloud
- TF5 Tech 2: Scalability
  - Scalability
- TF5 Tech 8: Deliver new capabilities
  - Offloading
  - Robotic task

ICOS: Agriculture Operational Robotic Platform (AORP)(Agriculture)

- D1.2 Tech 5: Very low latency / High computational requirements
  - Latency of Service
- D1.2 Tech 6: Overcomes unreliable connectivity
  - Connectivity of Service
- D1.2 Tech 8: Allows deployment of AI analytics models close to the device
  - Use of ML and AI to obtain satisfactory solutions at edge

- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - Coexistence of real-time processing and coordination with cloud services
  - Intelligent Cloud-Edge Orchestration

ICOS: Energy Management and Decision Support system (EMDS) (Energy & Utilities)

- D1.2 Econ 2: Enables Business Improvements
  - Flatten demand/ supply curve
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Data security and data privacy
- D1.2 Tech 8: Allows deployment of AI analytics models close to the device
  - Use of ML and AI to obtain solutions at edge level to share knowledge from home to home
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - IoT, Cloud, Edge orchestration
- TF5 Tech 2: Scalability
  - Connectivity of service (especially in rural areas) scalability (from 5 to 5000 to 500000 customers)
  - Scalability
- TF5 Tech 6: Enable data sharing and value-added services
  - Complete data flow for different phases of the validation process in ICOS

ICOS: In-car Advanced Infotainment and Multimedia Management system (IAIMM) (Entertainment, N/A)

- D1.2 Tech 6: Overcomes unreliable connectivity
  - Interruptions of Wireless or Internet Connection
- D1.2 Tech 9: Reduces volumes of data sent across networks
  - Minimizing exchange of data
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - Intelligent Cloud-Edge Orchestration
- TF5 Tech 2: Scalability
  - Scalability issues in case of high request of the service

ICOS: Railway Structural Alert Monitoring system (RSAM) (Logistics & mobility, Transportation)

- D1.2 Tech 6: Overcomes unreliable connectivity
  - Failure recovery management when losing the connectivity
  - Interruptions of Wireless or Internet Connection
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - Cloud-edge orchestration
  - Coexistence of real-time processing and coordination with cloud services
  - Edge to Cloud Orchestration of several applications according to complexity, processing, or time requirements

Nebulous: International Disaster Response (Environment, N/A)

- D1.2 Tech 5: Very low latency / High computational requirements
  - On field data processing
- D1.2 Tech 6: Overcomes unreliable connectivity
  - Communication Possibilities
  - Connectivity between Nodes/Edge to Cloud
  - Internet connectivity
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - Different Cloud provider
  - Orchestration of between edge point and designated cloud
- TF5 Tech 7: Works with diverse devices
  - Data acquisition

NebulOus: Computer Vision for City Maintenance (Smart City & Buildings, N/A)

- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Privacy in edge <-> cloud
  - Privacy/security aspects on data between edge nodes and cloud
- D1.2 Tech 5: Very low latency / High computational requirements

- Latency issues on critical messages from cloud to edge
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - Orchestration between fully edge / partially edge + cloud / fully cloud
  - Orchestration edge / cloud
- TF5 Tech 2: Scalability
  - Auto scaling edge / cloud
  - Automatic scaling of workloads throughout the edge and cloud continuum

NEMO: Smart farming- precision bio spraying (Agriculture)

- D1.2 Econ 4: Improved physical security
  - Physical Security of Network and devices
- D1.2 Org 2: Need supports for improving readiness of Existing IT infrastructure
  - Plethora of diverge devices and architectures (legacy systems)
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Dataset security
  - Security in M2M interactions
- D1.2 Tech 6: Overcomes unreliable connectivity
  - Rural areas and limited availability of high-end infrastructure (5G nets)
- TF5 Org 1: Support for improving quality and currency of source data
  - Limited datasets
- TF5 Tech 5: Ability to work in a range of weather conditions
  - Weather conditions
- TF5 Tech 8: Deliver new capabilities
  - Hyperspectral imaging

NEMO: Smart Grid Flexibility, Smart Mobility (Energy & Utilities)

- D1.2 Econ 2: Enables Business Improvements
  - Digitalisation across the energy infrastructure
  - Improvement of grid observability
- D1.2 Org 2: Need supports for improving readiness of Existing IT infrastructure
  - Old electrical infrastructure
- D1.2 Org 4: Improve Regulatory/Legal Compliance
  - Regularity constraints
- D1.2 Tech 3: Standards-based, Interoperable: avg (slightly more for IoT)
  - Increase the integration of RES in the grid
  - IoT device interoperability
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Cybersecurity of IoT Devices
  - Physical security of the network
  - Security in M2M interactions
- D1.2 Tech 6: Overcomes unreliable connectivity
  - Reliability of the networks
- TF5 Org 1: Support for improving quality and currency of source data
  - Sensors within the energy grid

NEMO: Smart Media / City & XR Use Cases (Entertainment, N/A)

- D1.2 Tech 1: Complete solutions, end-to-end, easy deployment
  - Service migration
- D1.2 Tech 3: Standards-based, Interoperable: avg (slightly more for IoT)
  - Interoperability with existing infrastructure
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Network security
- D1.2 Tech 5: Very low latency / High computational requirements
  - Real time data analysis
- TF5 Tech 7: Works with diverse devices
  - Heterogenous IoT devices

- TF5 Tech 8: Deliver new capabilities
  - Biofeedback analysis as a service of HMD shows
  - Gesture, Voice recognition as a service

NEMO: Smart Manufacturing & Industry 4.0 (Manufacturing)

- D1.2 Econ 2: Enables Business Improvements
  - Automized component recognition
  - Automized picking process
  - Automized transfer to AGV
- D1.2 Econ 5: Improved safety (of customers or employees)
  - Collision-free driving of AGV

Nephele: Disaster/Emergency Recovery (Environment, N/A)

- D1.2 Econ 1: Costs need to be low & ROI clear
  - Economic risks
- D1.2 Econ 2: Enables Business Improvements
  - Monitoring situation
- D1.2 Econ 5: Improved safety (of customers or employees)
  - Physical security of humans reaching
  - Reaching dangerous areas
- D1.2 Org 4: Improve Regulatory/Legal Compliance
  - Regulatory restrictions
- D1.2 Tech 5: Very low latency / High computational requirements
  - Fast response
  - High computational needs
- D1.2 Tech 6: Overcomes unreliable connectivity
  - No network infrastructure
  - Reliability of the network
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - Cloud-to-Edge-to-IoT orchestration
- TF5 Tech 7: Works with diverse devices
  - Heterogeneous devices
  - Heterogenous IoT devices communication

Nephele: AI-assisted Logistics Operations in the Port of Koper (Logistics & mobility, Transportation)

- D1.2 Econ 1: Costs need to be low & ROI clear
  - Economic risk
- D1.2 Econ 2: Enables Business Improvements
  - Container localization accuracy
  - Devices status update
  - Forklifts (trucks) availability and location
  - Route (roads) status update
- D1.2 Econ 5: Improved safety (of customers or employees)
  - Human safety risks
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Cyber security risks
- D1.2 Tech 8: Allows deployment of AI analytics models close to the device
  - Decentralized ML techniques
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - Cloud-to-Edge-to-IoT orchestration framework
  - Real-time resources allocation
- TF5 Tech 3: Configurability/Smart Infrastructure
  - Policies and KPIs definition
- TF5 Tech 7: Works with diverse devices
  - VO Stack (heterogenous IoT devices communication)

Nephele: Energy management in smart buildings/cities (Smart City & Buildings, Energy & Utilities)

- D1.2 Econ 1: Costs need to be low & ROI clear
  - Economic risks
- D1.2 Econ 5: Improved safety (of customers or employees)
  - Physical security of humans
- D1.2 Org 4: Improve Regulatory/Legal Compliance
  - Regulatory limitations
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Privacy risk
  - User data security
- D1.2 Tech 6: Overcomes unreliable connectivity
  - No network infrastructure
  - Reliability of the network
- D1.2 Tech 7: Allows deployment of resource-constrained IoT devices
  - Constrained IoT devices
- D1.2 Tech 8: Allows deployment of AI analytics models close to the device
  - Decentralized ML techniques
- TF5 Org 1: Support for improving quality and currency of source data
  - Trust
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - Cloud-to-Edge-to-IoT orchestration framework
  - Real-time execution
- TF5 Tech 7: Works with diverse devices
  - Heterogeneous devices
  - VO Stack (heterogenous IoT devices communication)

Table 14 summarizes this mapping by presenting the common service requirements that would address the reported aspects, along with importance rating of each requirement overall and by sector. Use cases that do not fall into one of the five sectors of interest (noted as "N/A") in the UNLOCK-CEI project are not included in the sectoral statistics.

Table 14: Common Service Requirements Identified by [TF5]

ID	Requirement	Overall (w/o N/A)	Agri-culture	Energy & Utilities	Manu-facturing	Trans-portation	Overall
	(Number of use cases in sample)	16	4	6	3	3	21
D1.2 Tech 4	Improved Security, Data Protection and Privacy	69%	50%	83%	67%	67%	62%
D1.2 Tech 6	Overcomes unreliable connectivity	56%	75%	67%	33%	33%	57%
D1.2 Econ 2	Enables Business Improvements	50%	0%	67%	67%	67%	43%
TF5 Tech 1	Orchestration of workloads across different parts of continuum and different providers	50%	25%	50%	67%	67%	57%
D1.2 Tech 8	Allows deployment of AI analytics models close to the device	44%	25%	67%	0%	67%	33%
D1.2 Tech 5	Very low latency / High computational requirements	38%	50%	33%	33%	33%	48%
D1.2 Econ 1	Costs need to be low & ROI clear	31%	0%	50%	0%	67%	29%
D1.2 Econ 5	Improved safety (of customers or employees)	31%	0%	33%	33%	67%	29%
TF5 Org 1	Support for improving quality and currency of source data	31%	25%	33%	67%	0%	24%
TF5 Tech 3	Configurability/Smart Infrastructure	31%	0%	50%	33%	33%	24%
TF5 Tech 7	Works with diverse devices	31%	25%	33%	0%	67%	38%
D1.2 Org 2	Need supports for improving readiness of Existing IT infrastructure	25%	25%	17%	33%	33%	19%
TF5 Tech 8	Deliver new capabilities	25%	50%	0%	33%	33%	24%

D1.2 Tech 3	Standards-based, Interoperable	19%	0%	33%	0%	33%	19%
TF5 Tech 2	Scalability	19%	0%	33%	33%	0%	24%
D1.2 Org 4	Improve Regulatory/Legal Compliance	13%	0%	33%	0%	0%	14%
D1.2 Tech 1	Complete solutions, end-to-end, easy deployment	13%	0%	17%	33%	0%	14%
D1.2 Tech 7	Allows deployment of resource-constrained IoT devices	13%	25%	17%	0%	0%	10%
TF5 Tech 4	High source data rates	13%	0%	17%	33%	0%	10%
D1.2 Econ 3	Reducing energy consumption	6%	0%	0%	33%	0%	5%
D1.2 Econ 4	Improved physical security	6%	25%	0%	0%	0%	5%
D1.2 Org 3	Need support to close Skills gaps	6%	25%	0%	0%	0%	5%
D1.2 Org 5	Solution easy to adapt to my business processes	6%	0%	0%	33%	0%	5%
TF5 Tech 5	Ability to work in a range of weather conditions	6%	25%	0%	0%	0%	5%
TF5 Tech 6	Enable data sharing and value-added services	6%	0%	17%	0%	0%	5%
D1.2 Tech 9	Reduces volumes of data sent across networks	0%	0%	0%	0%	0%	5%

The nine (9) service requirements added to those identified by [D1.2] are identified by IDs that start with “TF5”. They are also highlighted in green.

Of the twenty (20) service requirements identified in [D1.2], only seventeen (17) are also identified in [TF5].

Of the twenty-nine service requirements listed in Table 14, 16 relate to technical concerns, 5 economic and 4 to organizational readiness, consistent with the focus of the MetaOS use cases on the technical challenges the face.

As with [D1.2], these rankings should be taken as illustrative, rather than definitive, given the relatively small sample of use cases asked for their opinion.

Figure 9 illustrates considerable variation in rated importance of a given requirement across the four sectors, charting importance for all the use cases, and for the four sectors individually. This variation is as much a function of small sample size as true variation between sectors.

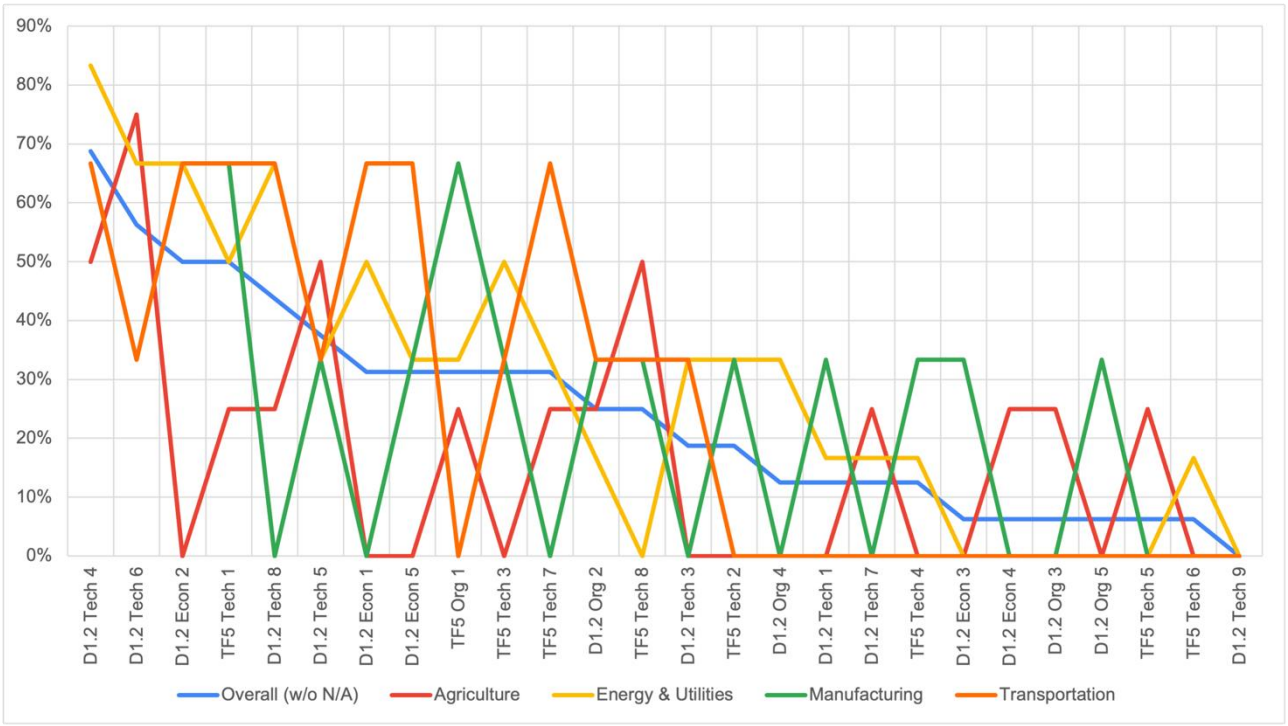

Figure 9: Prevalence of Mentions of Service Requirements from [TF5], overall and by sector

7.4 Requirements Identified in [D3.2]: "Sector-specific service requirements, data flows and revenue streams in Cloud-Edge-IoT value networks "

Value Chain Adopter Workshops ("Wave 1" workshops) were held with all five sectors of interest to the UNLOCK-CEI project. During those workshops, participants were asked identify service requirements of importance to them. 103 reported requirements were catalogued in [D3.2]. All these aspects could be mapped to one of the common service requirements derived from [D1.2] and [TF5} and presented in the previous sections. Table 15 details this mapping for each of the five sectors.

Table 15: Requirements reported in Wave 1 Workshops, mapped to Common Service Requirements

Agriculture

- D1.2 Econ 2: Enables Business Improvements
  - real-time decision-making
- D1.2 Org 4: Improve Regulatory/Legal Compliance
  - Legal compliance
  - upgrades for operability and compliance with changing regulations
- D1.2 Org 5: Easy-to-use, solution easy to adapt to my business processes
  - Farmer's local situation.
  - High usability
  - Integration with the producing environment
- D1.2 Tech 1: Complete solutions, end-to-end, easy deployment
  - 24/7 availability
  - Continuous retrofitting of hardware
  - Disposal handled by providers
  - Done on-site by service personnel
  - High usability and support for mechanics, control units, sensors, and software
  - improving software functions, adding new features, or further training AI algorithms
  - Offline operation
- D1.2 Tech 2: Tech stability, capabilities, mature offerings, confidence in suppliers
  - Regular replacement of the control unit or other hardware
- D1.2 Tech 5: Very low latency /high computational requirements
  - Low latency
- TF5 Tech 1: Orchestration of workloads across different parts of continuum and different providers
  - CEI-part operation is outsourced to manufacturers and suppliers
- TF5 Tech 3: Configurability/Smart Infrastructure
  - Storing data in software decided by the farmers
  - Versioning software
- TF5 Tech 3: Standards-based, Interoperable
  - Interoperability
- TF5 Tech 4: Capable of handling High source data rates
  - High data flow
  - Seamless Data Flow
- TF5 Tech 5: Ability to work in a range of weather conditions
  - robustness against environmental influences
- TF5 Tech 6: Enable data sharing and value-added services
  - automated data exchange and standardized formats
  - broader access is required for external service providers
  - Collected and pre-processed data can be used for value-added services
  - Increasing data streams in the supply chain

- International access
- Seamless and standardized exchange of agronomic and telemetric data

Energy & Utilities

- D1.2 Econ 3: Reducing energy consumption
  - Edge intelligence can enhance energy efficiency, especially in smart home solutions.
- D1.2 Org 4: Improve Regulatory/Legal Compliance
  - compliance with regulations
- D1.2 Tech 1: Complete solutions, end-to-end, easy deployment
  - Additional devices enable bidirectional integration of electricity and information.
  - Easy integration into existing systems
  - Hardware basis is needed for grid flexibility, observability, controllability, and automation.
  - Management of degradation
  - observability, controllability, and automation for active network management
  - Open Source instead of SCADA
  - Smart meters are needed for flexible tariffs on the consumer/prosumer side.
  - The secondary substation level requires sensors, real-time monitoring, and load prediction.
- D1.2 Tech 3: Standards-based, Interoperable
  - Interoperability
  - Standards
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
  - Cybersecurity and security compliance
  - Cybersecurity compliance
  - Data privacy
- D1.2 Tech 8: Allows deployment of AI analytics models close to the device
  - AI Integration
- TF5 Tech 3: Configurability/Smart Infrastructure
  - Infrastructure installation at various points
- TF5 Tech 4: Capable of handling High source data rates
  - Large data volume
- TF5 Tech 6: Enable data sharing and value-added services
  - Data exchange adaptation to new technologies
  - Value chain collaboration

Healthcare

- D1.2 Org 4: Improve Regulatory/Legal Compliance
  - compliance with regulations
- D1.2 Org 5: Easy-to-use, solution easy to adapt to my business processes
  - Usability
- D1.2 Tech 1: Complete solutions, end-to-end, easy deployment
  - Upgradability
- D1.2 Tech 3: Standards-based, Interoperable
  - Integration
  - Interoperability
- TF5 Tech 4: Capable of handling High source data rates
  - Performance (bandwidth, frequency, volume)

Manufacturing

- D1.2 Econ 2: Enables Business Improvements
  - Cost-effective
  - Efficiency in production
  - Optimisation
  - Quality in production
- D1.2 Econ 5: Improved safety (of customers or employees)
  - Safety and better working conditions
- D1.2 Org 3: Need support to close Skills gaps

    - Smooth training
    - Training and upgrades included
- D1.2 Org 4: Improve Regulatory/Legal Compliance
    - compliance with regulations
- D1.2 Org 5: Easy-to-use, solution easy to adapt to my business processes
    - Attention to customer service
    - minimize extra tasks for skilled laborers
    - User friendly interface
- D1.2 Tech 1: Complete solutions, end-to-end, easy deployment
    - Easy adaptability for future updates
    - Long lifetime
    - Off-line processing
    - Robust deployment
    - Upgrades done without downtime
    - Usability for maintenance
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
    - Cybersecurity
- D1.2 Tech 5: Very low latency /high computational requirements
    - No latency
    - Real-time
- TF5 Org 1: Support for improving quality and currency of source data
    - compliance with quality requirements
    - Quality assurance
- TF5 Tech 2: Scalability
    - Scalability
    - Transferability
- TF5 Tech 3: Configurability/Smart Infrastructure
    - Customisation
    - Tailored solution for on-site activities
- TF5 Tech 6: Enable data sharing and value-added services
    - Data transfer for new services
    - Prioritisation on data flow transparency
    - Prioritisation on user control

Transportation

- D1.2 Econ 1: Costs need to be low & ROI clear
    - Installation costs management
- D1.2 Org 2: Need supports for improving readiness of Existing IT infrastructure
    - Strategy for upgrading current legacy systems
- D1.2 Org 4: Improve Regulatory/Legal Compliance
    - compliance with regulations
- D1.2 Org 5: Easy-to-use, solution easy to adapt to my business processes
    - Consider different layers of road users
    - Maintenance processes could have issues with upgradability
    - Robust and clear communication between departments
- D1.2 Tech 1: Complete solutions, end-to-end, easy deployment
    - Data collection from various area in the city
    - Full-duplex communication in the infrastructure
    - Maintenance-friendly design
    - Precise and right positioning of sensors
- D1.2 Tech 4: Improved Security, Data Protection and Privacy
    - Certifications, rights management and data quality
    - Cybersecurity
    - Data protection
    - Privacy

- D1.2 Tech 5: Very low latency /high computational requirements
  - Real-time
- D1.2 Tech 6: Overcomes unreliable connectivity
  - Interconnection
- TF5 Tech 2: Scalability
  - Computational power
  - Coping with dynamic changes of traffic volumes
- TF5 Tech 4: Capable of handling High source data rates
  - Large data volume
- TF5 Tech 6: Enable data sharing and value-added services
  - Open and Free Data

Unlike the data presented in [D1.2] and [TF5], these reported requirements were only mentioned in each workshop, and no voting or assessment of their relative importance was performed. Therefore the "importance" of each common service requirement can only be estimated based on the number of reported requirements that map to each common service requirement. These counts, overall and for each of the five sectors, are presented in Table 16 below.

Requirements from [D3.2] mapped to only 23 of the 29 common service requirements identified in [D1.2] and [TF5], comprised of 15 of the 20 common services requirements identified in [D1.2] and 8 of the 9 common service requirements identified in [TF5]. Like other mappings, 14 of the common service requirements mapped from [D3.2] relate to technical requirements, 5 to organizational issues, and 4 to economic requirements.

Table 16: Common Service Requirements Identified by [D3.2]

ID	Common Service Requirement	Overall	Agri-culture	Energy & Utilities	Health-care	Manu-facturing	Trans-portation
D1.2 Tech 1	Complete solutions, end-to-end, easy deployment	26	7	8	1	6	4
TF5 Tech 6	Enable data sharing and value-added services	12	6	2		3	1
D1.2 Org 5	Easy-to-use, solution easy to adapt to my business processes	10	3		1	3	3
D1.2 Tech 4	Improved Security, Data Protection and Privacy	8		3		1	4
D1.2 Org 4	Improve Regulatory/Legal Compliance	6	2	1	1	1	1
D1.2 Econ 2	Enables Business Improvements	5	1			4	
TF5 Tech 3	Configurability/Smart Infrastructure	5	2	1		2	
TF5 Tech 4	Capable of handling High source data rates	5	2	1	1		1
D1.2 Tech 3	Standards-based, Interoperable	4		2	2		
D1.2 Tech 5	Very low latency /high computational requirements	4	1			2	1
TF5 Tech 2	Scalability	4				2	2
D1.2 Org 3	Need support to close Skills gaps	2				2	
TF5 Org 1	Support for improving quality and currency of source data	2				2	
D1.2 Econ 1	Costs need to be low & ROI clear	1					1
D1.2 Econ 3	Reducing energy consumption	1		1			
D1.2 Econ 5	Improved safety (of customers or employees)	1				1	

D1.2 Org 2	Need supports for improving readiness of Existing IT infrastructure	1					1
D1.2 Tech 2	Tech stability, capabilities, mature offerings, confidence in suppliers	1	1				
D1.2 Tech 6	Overcomes unreliable connectivity	1					1
D1.2 Tech 8	Allows deployment of AI analytics models close to the device	1		1			
TF5 Tech 1	Orchestration of workloads across different parts of continuum and different providers	1	1				
TF5 Tech 3	Standards-based, Interoperable	1	1				
TF5 Tech 5	Ability to work in a range of weather conditions	1	1				

Unlike the data from [D1.2] and [TF5], where a measure of importance is presented as a percentage of a sample, the data from [D3.2] cannot be normalized in this way, even between the different sectors and overall, so a graphical illustration is not provided.

7.5 Consolidation of Requirements from [D1.2], [TF5], and [D3.2]

Table 17 consolidates the importance measures (for [D1.2] and [TF5}) and mentions (for [D3.2]) presented in the previous sections, offering an overall view of the relative importance of the 29 common service requirements that have been identified.

Figure 10 illustrates the comparative importance (and mentions) attached to each service requirement, based on the respective data. The 20 service requirements from [D1.2] are sorted in descending order of their importance from [D1.2]. The 9 service requirements identified in [TF5] do not have this data, so they are presented as if their importance (in [D1.2]) were zero, placing them at the right side of the diagram. (Relative importance is shown on the left axis. Mentions from [D3.2] are plotted based on the right axis.)

Figure 10 indicates minimal correlation between the three sources of data. This reflects the very different methodologies of the three sources, rather than disagreement about the comparative importance of the different requirements. Instead, Table 17 and Figure 10 illustrate that this list of 29 common service requirements seems to represent the key requirements from a broad sample of CEI ecosystem players. Further conclusions are presented in Section 3.

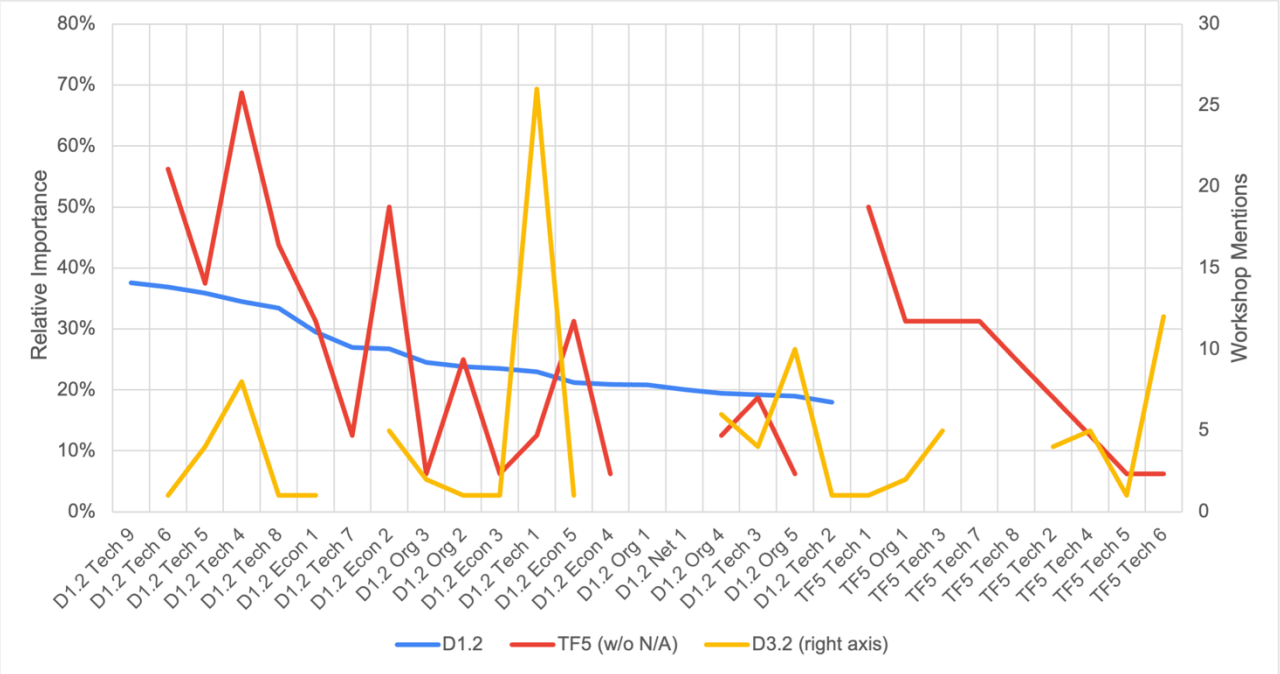

Figure 10: Comparative Importance and Mentions Attached to each of 29 Common Service Requirements

Table 17: Consolidated Service Requirements

ID	Requirement	Overall			Agriculture			Energy & Utilities			Healthcare		Manufacturing			Transportation		
		D1.2	TF5	D3.2	D1.2	TF5	D3.2	D1.2	TF5	D3.2	D1.2	D3.2	D1.2	TF5	D3.2	D1.2	TF5	D3.2
D1.2 Tech 9	Reduces volumes of data sent across networks	37.6%			47.1%			34.4%			38.2%		38.2%			33.3%		
D1.2 Tech 6	Overcomes unreliable connectivity	36.9%	56%	1	48.6%	75%		36.7%	67%		35.8%		34.6%	33%		34.5%	33%	1
D1.2 Tech 5	Very low latency /high computational requirements	35.9%	38%	4	47.0%	50%	1	26.4%	33%		37.4%		36.4%	33%	2	35.7%	33%	1
D1.2 Tech 4	Improved Security, Data Protection, Privacy	34.5%	69%	8	29.2%	50%		32.3%	83%	3	39.8%		29.6%	67%	1	28.2%	67%	4
D1.2 Tech 8	Allows deployment of AI analytics models close to the device	33.4%	44%	1	22.6%	25%		32.2%	67%	1	28.5%		38.7%	0%		34.9%	67%	
D1.2 Econ 1	Costs need to be low & ROI clear	29.5%	31%	1	32.6%	0%		29.5%	50%		37.0%		24.5%	0%		31.3%	67%	1
D1.2 Tech 7	Allows deployment of resource-constrained IoT devices	27.0%	13%		28.2%	25%		35.6%	17%		17.8%		23.5%	0%		29.9%	0%	
D1.2 Econ 2	Enables Business Improvements	26.7%	50%	5	25.1%	0%	1	21.7%	67%		18.7%		19.2%	67%	4	19.9%	67%	
D1.2 Org 3	Need support to close Skills gaps	24.5%	6%	2	25.7%	25%		25.1%	0%		18.8%		25.8%	0%	2	24.3%	0%	
D1.2 Org 2	Need supports for improving readiness of Existing IT infrastructure	23.8%	25%	1	22.4%	25%		21.5%	17%		23.6%		25.1%	33%		25.1%	33%	1
D1.2 Econ 3	Reducing energy consumption	23.5%	6%	1	23.9%	0%		23.1%	0%	1	17.6%		26.4%	33%		21.7%	0%	
D1.2 Tech 1	Complete solutions, end-to-end, easy deployment	23.0%	13%	26	27.3%	0%	7	24.1%	17%	8	14.7%	1	22.7%	33%	6	23.5%	0%	4
D1.2 Econ 5	Improved safety (of customers or employees)	21.2%	31%	1	15.4%	0%		26.0%	33%		24.1%		20.3%	33%	1	21.6%	67%	
D1.2 Econ 4	Improved physical security	20.9%	6%		22.3%	25%		23.9%	0%		12.7%		18.3%	0%		26.1%	0%	
D1.2 Org 1	Need Help with management Buy-in/overcoming Organization resistance	20.8%			17.8%			20.3%			23.6%		23.5%			17.8%		
D1.2 Net 1	Need mature 5G networks and devices	20.1%			24.8%			22.8%			18.9%		18.1%			17.7%		
D1.2 Org 4	Improve Regulatory/Legal Compliance	19.5%	13%	6	17.2%	0%	2	20.9%	33%	1	28.3%	1	18.0%	0%	1	17.6%	0%	1
D1.2 Tech 3	Standards-based, Interoperable	19.2%	19%	4	17.4%	0%	1	24.2%	33%	2	18.5%	2	19.3%	0%		13.6%	33%	

ID	Requirement	Overall			Agriculture			Energy & Utilities			Healthcare		Manufacturing			Transportation		
		D1.2	TF5	D3.2	D1.2	TF5	D3.2	D1.2	TF5	D3.2	D1.2	D3.2	D1.2	TF5	D3.2	D1.2	TF5	D3.2
D1.2 Org 5	Ease-of-use, Solution easy to adapt to my business processes	19.0%	6%	10	15.5%	0%	3	19.0%	0%		20.7%	1	20.9%	33%	3	17.5%	0%	3
D1.2 Tech 2	Technical stability, capabilities, mature offerings, confidence in suppliers	18.0%		1	15.1%		1	20.3%			12.7%		19.5%			18.3%		
TF5 Tech 1	Orchestration of workloads across different parts of continuum and different providers		50%	1		25%	1		50%					67%			67%	
TF5 Org 1	Support for improving quality and currency of source data		31%	2		25%			33%					67%	2		0%	
TF5 Tech 3	Configurability/Smart Infrastructure		31%	5		0%	2		50%	1				33%	2		33%	
TF5 Tech 7	Works with diverse devices		31%			25%			33%					0%			67%	
TF5 Tech 8	Deliver new capabilities		25%			50%			0%					33%			33%	
TF5 Tech 2	Scalability		19%	4		0%			33%					33%	2		0%	2
TF5 Tech 4	High source data rates		13%	5		0%	2		17%	1		1		33%			0%	1
TF5 Tech 5	Ability to work in a range of weather conditions		6%	1		25%	1		0%					0%			0%	
TF5 Tech 6	Enable data sharing and value-added services		6%	12		0%	6		17%	2				0%	3		0%	1

8. Appendix B: Analysis of Survey Results from Four Sectoral Workshops on CEI Opportunities ("Wave 2 Workshops")

8.1 Who participated in each workshop survey?

The webinars attracted a diverse group of participants across the different sectors, each bringing unique perspectives and expertise. The. The Energy & Utility workshop had the most varied audience, including multiple university representatives, IT market players, and energy sector professionals. The agriculture workshop focused more on research and innovation, while the Transport workshop included logistics, manufacturing, and planning professionals. The Manufacturing workshop had a balanced mix of SME manufacturers and research entities. This diverse participation reflects the interdisciplinary interest and involvement in Edge-IoT use cases and implementations.

Energy & Utility: The survey includes respondents from diverse sectors, with the highest representation from the IT market players and academic/research sectors, each having 4 representatives. Both TSO and system integration sectors have 2 representatives each. Energy suppliers are also represented by 2 individuals, while energy aggregators have the least representation with only 1 respondent.

Agriculture: The survey includes respondents from a focused range of profiles, with 5 respondents gathering insights from specific fields, such as data analytics and AI, research, Agri-Tech services, and innovation management with technology transfer. Each of these areas is likely to provide specialized knowledge and perspectives relevant to the agriculture sector, especially in the context of cloud, edge, and IoT technologies.

Manufacturing: The survey includes respondents from different types of profiles. SME manufacturers have the highest representation with 2 representatives. The research category, which includes both research institutes and research groups, also has 2 representatives. The "Other" category is represented by 1 respondent.

Transport: The survey includes respondents from various profiles with diverse backgrounds. Each of the categories—system manufacturer, vehicle supplier, private logistics, and transport planner—has one representative each. The "Other" category is represented by two respondents, indicating additional perspectives that might not fit into the specific categories listed.

8.2 Estimate of facilities currently using CEI technologies

Survey respondents were asked whether the estimated potential for adopting Edge-IoT facilities in their respective sectors was accurate. Based on their feedback, the average correction factors suggested were as follows:

Energy & Utility:	-3%
Agriculture:	+11%
Transport:	+7%
Manufacturing:	-19%

8.2.1 Notes on the Methodology

The methodology used for calculating the averages involved converting qualitative responses to numerical values, multiplying each response by its corresponding weight, and then dividing by the total number of responses. The same methodology had been used for the other questions in the survey utilising the same type of answers framework.

Table 18: Response Conversion Value and Impact

Response Conversion Values	Impact
More than 30% Less	0.5

30% Less	0.7
15% Less	0.85
It seems accurate	1
30% More	1.3
100% More	2
More than 100% More	3

8.3 The responses indicate that while the current use Are we missing any important use cases

cases are comprehensive, there are specific areas in the Energy & Utility and Agriculture sectors that could be further explored and included to address industry-specific needs and advancements. The Manufacturing sector respondents, however, seem satisfied with the existing use case coverage.

Energy & Utility Sector: Respondents provided a variety of insights regarding additional important use cases. While some indicated that no significant use cases were missing, others highlighted specific areas of interest. These included:

- EV Charging: Emphasizing Vehicle-to-Everything (V2X) integration.
- Smart-Grid Sub-Use Cases: Highlighting the numerous potential sub-use cases within smart grid technology.
- Categories and Waterfall Approach: Suggesting the need for categorization and a waterfall approach to use cases.
- Indoor Environment Quality Monitoring: Focusing on monitoring and improving indoor air quality.
- Battery Swapping: Proposing the inclusion of battery swapping technologies.

Agriculture Sector: respondents pointed out several key areas that could be considered:

- Digital Twin of the Farm: Creating a digital replica of farm operations for better management and optimization.
- Solutions for Animal Breeding: Implementing advanced solutions to improve animal breeding processes.
- ICT Education: Stressing the need for education on the basic use of Information and Communication Technology (ICT) for farmers and agricultural workers.

Transport: The question was skipped due to time constraints during the workshop.

Manufacturing Sector: Responses were straightforward, with respondents indicating that no important use cases were missing.

8.4 Are you considering/implementing use cases not on this list?

The survey responses suggest that while some sectors, particularly Energy & Utility, are actively exploring or implementing new use cases, others like Manufacturing are more settled with their current implementations. The Agriculture sector is poised to adopt AI-powered solutions in the future, indicating a readiness to innovate as technology advances. The Transport sector's input on this question was not available, due to time constraints. Overall, there is a blend of stability and innovation across different sectors regarding the adoption of new use cases.

Energy & Utility Sector: Respondents provided mixed responses, indicating both confirmation and expansion of current use cases, one respondent specifically mentioned the integration of Renewable Energy Sources (RES) into smart grids.

Agriculture Sector: provided forward-looking insights, suggesting that additional use cases are on the horizon:

- AI-Powered Solutions: A respondent mentioned that AI-powered solutions are expected to be implemented in the future, although they are not currently in place.

Manufacturing Sector: Most respondents indicated that they are not considering or implementing additional use cases beyond those already listed, with one noteworthy exception:

- One respondent noted that they have implemented augmented reality (AR) based training and guidance for employees in previous projects.

After consulting with sector stakeholders, the use case of Electric Vehicles was identified as an important area that had not been previously considered. Therefore, for the **Energy & Utility Sector**, an additional question was posed to further investigate this use case.

8.4.1 "How many of you have other use cases related to EV charging (billing, management, optimisation)?"

The respondents provided a variety of additional use cases related to EV charging, indicating an active interest and engagement in this area.
Multiple respondents confirmed that they have additional use cases related to EV charging. One respondent specifically mentioned the optimisation of EV charging processes. Another respondent mentioned a specific use case focused on the management of EV energy for a project named Elliot Clo.

8.5 Sector Perception and Alignment Assessment: Usage, Adoption, Investment, and Market Opportunity Evaluation

With the following 5 questions, we explore the perceptions and alignment of reported usage rates, adoption projections, investment levels, organizational considerations, and market opportunity estimates across various sectors.

Our first survey (for Energy & Utility sector) relied on qualitative responses, such as "Strongly Agree" or "Strongly Disagree," providing valuable but somewhat limited perspectives. Recognizing the need for more nuanced and actionable data, we revised the approach. This new format required respondents to quantify their feedback using percentage adjustments, offering a more structured and detailed understanding of their sentiments.

Notably, the Transport sector exhibited the most variability, showcasing high optimism regarding future adoption rates but caution regarding current investment levels and market opportunities. On the other hand, the Manufacturing sector, while generally aligned with reported figures, leaned slightly towards conservatism in current usage rates and investment considerations. Similarly, the Agriculture sector trended towards conservatism across the board, with lower adoption rates and investment considerations. While the Energy & Utility sectors largely aligned with reported figures, there was some disagreement regarding investment levels.

Overall, these insights underscore the importance of tailoring strategies to sector-specific dynamics and perceptions in Cloud-Edge-IoT implementations. Despite variations, there was one notable exception where alignment was high, indicating positive feedback on the elaborated estimates. Notably, the Transport sector reported an 85% higher adoption rate for future implementations, while the lowest adjustment was observed in the same sector, with a 40% lower investment level than typical planning. In the end this suggests slightly lower market opportunity sizing (1.85 x 0.4 = 0.74), although this contrasts with the specific feedback about the size of the market opportunity (which suggested that the total opportunity would be roughly 7% greater than presented).

8.5.1 Do these reported usage rates seem right to you? ("Using %")

The Transport sector is notably more optimistic, indicating higher current usage rates (+7.5%), By contrast, the Manufacturing sector shows the highest discrepancy, suggesting much lower current usage rates (-19%).

- **Energy & Utility Sector**: Agreed with the reported usage rates.
- **Agriculture Sector:** Suggested a 10% lower usage rate than reported.
- **Transport Sector:** Suggested a 7.5% higher usage rate than reported.
- **Manufacturing Sector:** Suggested a 19% lower usage rate than reported.

8.5.2 *Do these reported usage rates seem right to you? ("Adopting %")*

The Transport sector stands out with a significantly higher future adoption rate (+85%), while the agriculture sector is more conservative, suggesting a slight decrease (-10%).

- **Energy & Utility Sector:** Neutral response.
- **Agriculture Sector:** Suggested a 10% lower adoption rate for future implementations.
- **Transport Sector:** Indicated an 85% higher adoption rate for future implementations.
- **Manufacturing Sector:** Agreed with the reported adoption rates.

8.5.3 *Do these typical investment levels match the system costs you have seen in your own planning?*

The Transport sector shows the largest discrepancy, with much lower investment levels (-40%).

The Manufacturing sector suggests a relatively minor adjustment (-3%).

- **Energy & Utility Sector:** Responded that the estimated investment levels did not match their planning.
- **Agriculture Sector:** Neutral response.
- **Transport Sector:** Suggested a 40% lower investment level than typical planning.
- **Manufacturing Sector:** Suggested a 3% lower investment level than typical planning.

8.5.4 *Would your organisation consider investments at this level to implement the use cases in which it is interested?*

Both the Agriculture and Manufacturing sectors show significant reluctance, indicating a 30% lower investment consideration.

- **Energy & Utility Sector:** Neutral response.
- **Agriculture Sector:** Suggested a 30% lower investment consideration.
- **Transport Sector:** Data not available.
- **Manufacturing Sector:** Suggested a 30% lower investment consideration.

8.5.5 *Are these estimates of total EU market opportunity consistent with what you have seen?*

The Transport sector sees a significantly smaller market opportunity (-30%). The Manufacturing sector is slightly more optimistic, suggesting a slightly higher market opportunity (+7.5%).

- **Energy & Utility Sector:** Agreed with the estimates.
- **Agriculture Sector:** Suggested a 7.5% lower market opportunity estimate.
- **Transport Sector:** Suggested a 30% lower market opportunity estimate.
- **Manufacturing Sector:** Suggested a 7.5% higher market opportunity estimate.

8.6 Readiness Factors Across Sectors

The analysis highlights the multifaceted nature of readiness factors across sectors. While economic challenges universally dominate as a top concern, the importance of other factors such as technology readiness, network readiness, and internal organisational challenges varies across industries.

Economic Challenges: Economic challenges emerge as the principal concern across sectors, garnering the highest number of 1st place rankings overall.

All sectors recognise economic challenges as a critical factor. This indicates a shared recognition of the importance of financial sustainability and cost-effectiveness.

Technology Readiness: Variable Importance: Technology readiness is ranked lower across sectors, with fewer 1st place rankings compared to economic challenges. This suggests that while technological advancement is essential, it may not be the primary obstacle or priority for organizations.

Particularly notable is the Energy & Utility sector's lower emphasis on technology readiness, with multiple votes for 4th and 5th place. This sector may perceive technology readiness as less urgent compared to other factors.

Network Readiness: Sector-specific Concerns: Network readiness receives varied attention across sectors. While it ranks higher in the Agriculture sector, it is of less concern in the Energy & Utility and Manufacturing sectors.

Agriculture Sector: The Agriculture sector's focus on network readiness underscores the importance of connectivity and infrastructure in agricultural operations, which are in lower-density areas with poor connectivity.

Customer's Internal Challenges and Data Challenges: Moderate Importance: These factors are considered moderately important across sectors, with fewer 1st place rankings compared to economic challenges.

Transport and Manufacturing Sectors: These sectors show a consistent concern for customers' internal challenges, reflecting the importance of addressing internal organizational barriers to innovation and implementation.

Data Challenges: While recognized, data challenges do not emerge as a top priority in any sector, indicating a relatively lower level of concern compared to economic and operational factors.

8.7 Factors Accelerating Adoption of Edge-IoT Use Cases Across Sectors

The analysis underscores the sector-specific nuances in factors accelerating the adoption of Edge-IoT use cases. While certain suggested accelerators like video processing enjoy broad recognition, others like digital twins and network readiness incentives exhibit variability in importance across sectors.

Centre of Excellence in Video Processing Significant Importance: Identified as a top accelerator across all sectors, particularly in the Energy & Utility and Transport sectors. Energy & Utility and Transport Sectors: Considered a critical enabler, indicating the importance of video processing in applications like inspection and autonomous vehicles. Manufacturing Sector: this factor ranks high as well, highlighting its relevance beyond traditional sectors like energy and transport.

Centre of Excellence in Location Tracking Moderate Importance: While not as universally significant as video processing, location tracking still emerges as an accelerator in the Energy & Utility and Agriculture sectors. Energy & Utility Sector: Recognizes the potential impact of location tracking in enhancing operational efficiency and asset management. Agriculture Sector: Views location tracking as a valuable tool for optimizing processes and resource allocation.

Digital Twins and Related Capabilities Variable Importance: Considered a top accelerator in the Agriculture and Manufacturing sectors, highlighting its potential for process optimization. Energy & Utility Sector: This factor ranks lower, indicating potential differences in perceived value or applicability.

Agriculture and Manufacturing Sectors: Recognize the transformative potential of digital twins in enhancing productivity and efficiency.

Possible Incentives for Network Readiness Sector-specific Focus: Incentives for network readiness receive varied attention across sectors, with a focus on interoperable edge node design. Transport Sector: Places significant importance on network readiness incentives, emphasizing the critical role of robust connectivity in transportation systems. Energy & Utility Sector: Also recognizes the importance but to a lesser extent, suggesting differences in priority compared to other factors.

8.8 Preferred Implementation Partners Across Sectors

Energy & Utility and Manufacturing sectors show a strong preference for utilizing in-house capabilities, indicating a high level of confidence in their own teams' ability to manage and implement these technologies. This internal trust is particularly evident in the Energy & Utility sector, where in-house capabilities received the most first-place rankings. Similarly, the Manufacturing sector also prioritizes in-house resources but leans heavily on existing IT vendors, reflecting a reliance on established relationships and vendor expertise.

New specialists and current cloud partners are considered but do not rank as high as internal capabilities and existing IT vendors. Notably, current telco partners are less critical for Edge-IoT projects in both sectors, and there is minimal uncertainty in partner preferences, suggesting that respondents have a clear strategic direction.

While the Energy & Utility sector shows more openness to diverse external partners, the Manufacturing sector tends to stick with traditional, reliable IT vendors. This highlights a key difference in how each sector approaches Edge-IoT implementation, with the Energy & Utility sector adopting a more varied strategy and the Manufacturing sector favoring established partnerships. Overall, these insights underscore the importance of both in-house capabilities and trusted external relationships in driving Edge-IoT adoption.

8.9 Please rank the importance of these people as internal champions for Edge-IoT projects

The analysis highlights the diverse preferences for implementation partners across sectors. While internal technical teams are universally valued, the level of reliance on top management and operations people varies. Understanding these sector-specific dynamics is crucial for organisations to effectively engage the right stakeholders and drive the successful implementation of projects and initiatives. Due to time constraints, data from the Transport sector is unavailable, limiting insights into its preferred implementation partners.

Our Tech People: High Importance: Identified as a top partner across all sectors, emphasising the critical role of internal technical expertise in driving implementation.

Agriculture and Manufacturing Sectors: Show a particularly strong preference for leveraging internal tech teams, indicating confidence in their capabilities.

Top Management: Moderate Importance: While not consistently ranked as the top choice across all sectors, top management emerges as a preferred partner in the Agriculture and Manufacturing sectors. Energy & Utility Sector: Receives moderate ranking, suggesting a balanced approach to leadership involvement in implementation initiatives.

Our Operations People: Variable Importance: While operations people are valued partners in the Manufacturing sector, they receive lower rankings in other sectors.

Manufacturing Sector: Recognizes the importance of operational stakeholders in implementation, likely due to their direct involvement in process optimisation and efficiency.

Sector-specific Dynamics:

Energy & Utility Sector: Demonstrates a balanced preference across internal teams and top management, reflecting a collaborative approach to implementation.

Agriculture and Manufacturing Sectors: Exhibit a stronger reliance on internal technical expertise, suggesting a strategic focus on leveraging in-house capabilities for implementation initiatives.

8.10 Top Reasons for Implementing Edge-IoT Projects Across Sectors

The rankings of top reasons for implementing Edge-IoT projects provide insights into the driving forces behind adoption within the Energy & Utility, Agriculture, and Manufacturing sectors. The analysis underscores the varied motivations for implementing Edge-IoT projects across sectors. While ROI is universally recognised as a significant driver, the importance of other factors like regulatory compliance and competitive pressures differs based on sector-specific priorities and objectives. Understanding these dynamics is essential for organisations to tailor their strategies and initiatives effectively and drive successful implementation of Edge-IoT projects. However, data from the Transport sector is unavailable, limiting insights into its top reasons for project implementation.

Clear ROI: High Importance: Identified as a top reason across all sectors, highlighting the significance of tangible returns on investment in driving project adoption.

Energy & Utility and Manufacturing Sectors: Show a particularly strong emphasis on ROI, indicating a strategic focus on projects with clear financial benefits.

Need to Keep Up: Moderate Importance: While not universally ranked as the top reason, the need to keep up emerges as a significant driver in the Agriculture and Manufacturing sectors, highlighting the importance of staying competitive and relevant in rapidly evolving landscapes.

Compliance with Regulations: Variable Importance: Compliance with regulations ranks higher in the Energy & Utility sector compared to the Agriculture and Manufacturing sectors. Energy & Utility Sector: Recognizes the regulatory landscape as a key driver for Cloud-Edge-IoT projects, likely due to the stringent requirements in the utilities sector.

Sector-specific Dynamics:

Energy & Utility Sector: Prioritizes projects with clear ROI and compliance with regulations, reflecting a strategic alignment with industry requirements and financial objectives. Agriculture and Manufacturing Sectors: Share a similar emphasis on ROI but place less importance on regulatory compliance, suggesting a stronger focus on market competitiveness and operational efficiency.

8.11 Preferred Ways of Working on Edge-IoT Projects Across Sectors

The rankings of preferred ways of working on Edge-IoT projects provide insights into the collaborative strategies favoured by organisations within the Energy & Utility, Agriculture, and Manufacturing sectors. The analysis underscores the diverse approaches to working on Cloud-Edge-IoT projects across sectors. While piloting and proof of concepts are universally recognised as valuable strategies, the importance of partnering with external suppliers, driving projects internally, and exploring risk-sharing models varies based on sector-specific priorities and objectives. Understanding these dynamics is essential for organizations to effectively plan and execute Edge-IoT projects aligned with their strategic goals and operational requirements.

Pilots, Proof of Concepts: Moderate Importance: Identified as a top choice across all sectors, highlighting the value of iterative testing and validation in project implementation. Energy & Utility, Agriculture, and Manufacturing Sectors: Show a consistent preference for piloting and proof of concepts, indicating a strategic approach to minimising risk and validating project feasibility.

Partner with a Trusted Supplier: Variable Importance: While recognised as a viable option in the Agriculture and Manufacturing sectors, partnering with a trusted supplier receives lower rankings in the Energy & Utility sector. Agriculture and Manufacturing Sectors: Acknowledge the potential benefits of collaborating with external partners, particularly trusted suppliers, to leverage specialised expertise and resources.

Driving Projects to Specifications: High Importance: Identified as a top choice in the Energy & Utility sector and Agriculture sector, indicating a strong preference for internal project ownership and control. Energy & Utility and Agriculture Sectors: Demonstrate a desire to maintain control over project direction and outcomes, aligning with organisational goals and priorities.

Risk-sharing Models: Moderate Importance: While recognised as a viable option in the Agriculture and Manufacturing sectors, risk-sharing models receive lower rankings in the Energy & Utility sector. Agriculture and Manufacturing Sectors: Express a willingness to explore collaborative models where risks and rewards are shared among stakeholders, highlighting a pragmatic approach to project implementation.

Sector-specific Dynamics: Energy & Utility Sector: Emphasizes piloting and proof of concepts, reflecting a cautious approach to project implementation to ensure alignment with sector-specific requirements and objectives. Agriculture and Manufacturing Sectors: Share a preference for piloting and proof of concepts but also show a willingness to collaborate with external partners and explore risk-sharing models.

Table 19: Table: Aggregated answers for the surveys.

Sector	Energy & Utility	Agriculture	Transport	Manufacturing
Question				
With which of the following groups do you associate?	TSO University Scientific Consultant Other IT market player Small generation initiati Other IT market player dso it market player Research Energy supplier System integration University Forecasting University It market software player Energy aggregator Other IT Dso System integrator	Researchers Data Analytics and AI Agtech service provider Innovation Management Technology Transfer	Other Sys manufacturer Vehicle supplier Private logistics Transport planner Other	Other SME manufacturer Research Institute SME manufacturer Research group
Is our estimate of potentially adopting facilities about right?	-2.86%	11.25%	7.50%	-19.00%
Are we missing any important uses cases?	No EV charging: V2X Smart-Grid use case has so many sub use cases No Categories of use cases/ waterfall is needed Indoor environment quality monitoring Battery swapping	Digital Twin of the Farm Solutions for animal breeding... No. Education on the basic ICT use is needed		No No
Are you considering/implementing use cases not on this list?	no yes Yes RES integration into smart grids	Just a matter of time... AI-powered solutions will come!		No No No Have implemented in previous projects AR based training and guidance of employees
How many of you have other use cases related to EV charging (billing, management, optimisation)?	Yes Optimisation no Yes Security of EV charge Management for Elliot clo Ev energy			
Are you implementing any of the following additional use cases?				
Do these reported usage rates seem right to you? What about the "Using %" – organisations in your sector who have already implemented each use case?	Agree	-10.00%	7.50%	-19.00%
Do these reported usage rates seem right to you? What about the "Adopting %" – organisations in your sector planning to implement these use cases in the next year?	Neutral	-10.00%	85.00%	0.00%

Do these typical investment levels match system costs you have seen in your own planning?	Disagree	0.00%	-40.00%	-3.00%
Would your organisation consider investments at this level to implement the use cases in which it is interested?	Neutral	-30.00%		-30.00%
Are these estimates of total EU market opportunity consistent with what you have seen?	Agree	-7.50%	-30.00%	7.50%
Which other opportunities would you have estimated to be bigger?	Cybersecurity related... Resilience and climate change adaptation	New activities: online services (selling local products)		
Readiness factors in this sector	1st - 2nd - 3rd - 4th - 5th place	1st - 2nd - 3rd - 4th - 5th place	1st - 2nd - 3rd - 4th - 5th place	1st - 2nd - 3rd - 4th - 5th place
Technology readiness	0 0 0 1 3	1 0 0 1 0	0 0 1 0 2	1 0 1 1 0
Customer's internal challenges	0 3 0 1 1	1 0 0 0 2	0 2 1 0 0	0 2 1 0 0
Economic challenges	6 0 0 0 0	0 0 3 0 0	3 0 0 0 0	2 1 0 0 0
Network Readiness	0 0 2 2 0	0 3 0 0 0	0 1 0 1 1	0 0 0 1 1
Data challenges	1 3 3 0 0	1 0 0 1 0	0 0 1 2 0	0 0 1 0 1
Please rank the actions that would most accelerate adoption of Edge-IoT use cases:	1st - 2nd - 3rd - 4th - 5th place	1st - 2nd - 3rd - 4th - 5th place	1st - 2nd - 3rd - 4th - 5th place	1st - 2nd - 3rd - 4th - 5th place
Centre of Excellence in Video Processing applied to CEI use cases (inspection, autonomous vehicles)	1 1 1 0 2	0 0 1 0 1	0 1 0 1 1	0 0 0 1 0
Centre of Excellence in Location Tracking applied to CEI use cases	1 2 0 2 0	0 0 0 1 0	0 0 2 1 0	0 0 1 0 0
Digital Twins and related capabilities, applied to Process Management & Optimisation	1 1 3 0 1	0 0 1 0 0	3 0 0 0 0	3 0 0 0 0
Possible Incentives to Expand Network Readiness - Interoperable Edge node design	3 2 0 0 1	2 0 0 0 0	0 0 1 0 1	0 1 0 0 0
Possible Incentives to Expand Network Readiness - Federation/Edge roaming services	1 1 3 2 0	0 2 0 0 0	0 2 0 0 0	0 0 0 0 1
Can you suggest other actions that might be more important for adoption in your sector?		Support from Government		Remanufacturing! Explaining tangible business models to make industries trust investments
Please rank your preferred "go to" partner for implementation	1st - 2nd - 3rd place	1st - 2nd - 3rd place	1st - 2nd - 3rd place	1st - 2nd - 3rd place
Top management	0 1 1	0 0 0		1 2 0
Our tech people	1 1 1	1 0 0		2 1 0
Our operations people	2 0 0	0 0 0		0 0 3
Please rank your top reasons for implementing Edge-IoT projects:	1st - 2nd - 3rd place	1st - 2nd - 3rd place	1st - 2nd - 3rd place	1st - 2nd - 3rd place
We can see a clear ROI for these projects	3 1 0	0 2 0		2 1 0
We feel we need to do this to keep up	0 2 1	1 0 0		1 1 0
We feel we have to do this to comply with regulations	1 1 2	1 0 1		0 0 2
Rank your preferred way of working on projects like this:	1st - 2nd - 3rd - 4th place	1st - 2nd - 3rd - 4th place	1st - 2nd - 3rd - 4th place	1st - 2nd - 3rd - 4th place
Pilots, proof of concepts	3 0 1 0	0 1 0 0		1 1 1 0
Partner with a trusted supplier	0 2 0 1	0 0 0 0		1 0 2 0
We drive the project to our specifications	1 2 1 0	0 0 0 0		1 1 0 1
We need a model where we share the risk	0 0 1 2	1 0 0 0		0 1 0 2

9. Appendix C: Final Market Pathways

Consolidated Market Pathways are presented here.

Pathway 1a ("Automated guided vehicles (AGVs)"): €5.4 billion (4 use cases, 4 sectors)

- Initial Use Cases
  - Transport: Automated guided vehicles (T12): €2.2 billion, vehicles in railyards, ports, warehouses
  - Manufacturing: Automated guided vehicles (M13): €2.4 billion, vehicles in Factories, Warehouses
  - Agriculture: Autonomous vehicles (A11): €560 million, farming applications, such as autonomous tractors operating on fields.
- Clustered Use Cases
  - Healthcare: Automated guided vehicles (H09): €200 million, Automated Guided Vehicles (medical supplies, specimens) in hospitals

Pathway 1b ("autonomous vehicles"): €3.1 billion (2 use cases, 2 sectors)

- Initial Use Cases
  - Transport: Autonomous vehicles (T09): €2.7 billion, leveraging security in a controlled system
  - Energy & Utilities: Automated guided vehicles (E16): €390 million, vehicles supporting utility operations, such as transmission line repair trucks operating along utility rights of way, or repair vehicles in substations or power generation facilities.

Pathway 2a ("optimisation"): €1.0 billion (4 use cases, 3 sectors)

- Priority Use Cases:
  - Manufacturing
    - Process automation & optimization (M10): €550 million, Manage & Optimise Smart manufacturing across the enterprise
    - Manufacturing operations/ automation (M04): €360 million, Manage & Optimise Smart manufacturing at a single facility.
  - Clustered Use Cases
    - Energy & Utilities: Connected drilling & extraction (E14): €71 million, Optimised Gas & Petroleum Exploration and Production
    - Agriculture: Process automation & optimization (A08): €20 million, Manage & Optimise precision agriculture systems

Pathway 2b ("Video surveillance): €2.4 billion (6 use cases, 5 sectors)

- Priority Use Cases:
  - Transport:
    - Passenger traffic flow (T03): €1.1 billion, Track passenger flow across the transport network to manage capacity and congestion
    - Video security & surveillance (T04): €420 million, Intrusion Detection & Access Control
  - Manufacturing: Video security & surveillance (M05): €580 million, Intrusion Detection & Access Control
- Clustered Use Cases
  - Agriculture: Video security & surv. (A04): €29 million, Visual monitoring of fields and buildings
  - Manufacturing: Asset command & control (M07): €180 million, Command & Control of Key Assets (e.g. conveyor belts). While involving a different architectural pattern than the other image processing use cases, there are strong similarities in the technologies required and a common need for low latency operation.
  - Energy & Utilities: Video security & surv. (E09): €150 million, Intrusion Detection & Access Control
  - Healthcare: Video security & surv. (H03): €12 million, Intrusion Detection & Access Control

Pathway 2c ("Product Inspection"): €1.3 billion (3 use cases, 3 sectors)

- Priority Use Cases:
  - Transport: Quality of shipment conditions (T10): €610 million, Inspect shipping units (containers, pallets, crates, boxes) to detect damage and insure proper routing
  - Manufacturing: Visual inspection - quality/ integrity (M03): €600 million, Inspect manufactured products at various stages of production for quality control
- Clustered Use Cases
  - Agriculture: Visual inspection - quality/ integrity (A03): €94 million, Inspect agricultural products (e.g. at harvesters, grading stations) for quality control

Pathway 3 ("smart meters"): €5.6 billion value ++ (3 use cases, 1 sector: Energy & Utilities)

- Priority Use Cases
  - Smart meters (E05): €4.2 billion
  - Smart Grid (E11): €1.3 billion
  - Additional Use Case to be assessed
  - Electric Vehicle Charging (new)

Pathway 4a ("Fleet/Freight Tracking"): €4.1 billion value (4 use cases, 2 sectors)

- Priority Use Case
  - Transport:
    - Freight monitoring (T07): €3.5 billion, Track Location of Key Movable (portable) Assets (e.g. Containers, Pallets, Crates, Boxes)
    - Fleet tracking (T02): €390 million, Track and Optimise Key Mobile Assets (e.g. trucks, containers, ships, railroad cars)
- Clustered Use Cases:
  - Energy & Utilities: Fleet tracking (E04): €14 million, Track and Optimise Key Mobile Assets (e.g. repair trucks)
  - Energy & Utilities: Asset location tracking (E02): €130 million, Track Location of Key Movable (portable) Assets (e.g. high value test equipment and tools

Pathway 4b ("Asset Tracking"): €1.0 billion (10 use cases, 5 sectors)

- Priority Use Cases:
  - Manufacturing: Asset location tracking (M12): €630 million, Track Location of Key Movable (portable) Assets (e.g. Pallets, Crates, Boxes, high value test or calibration equipment)
- Clustered Use Cases:
  - Transport:
    - Asset monitoring & maint. (T08.1): €160 million, Monitor Condition of Key Mobile Equipment (e.g. trucks, containers, ships, railroad cars)
    - Employee safety monitoring (T01.1): €3 million, Track Employees in Hazardous Environment
  - Manufacturing:
    - Asset tracking (M08): €54 million, Track and Optimise Key Mobile Assets (e.g. forklifts)
    - Asset monitoring & maint. (M01.1): €160 million, Monitor Condition of Key Fixed Equipment
    - Food traceability (M06): €1 million, Track flow of food products through the agricultural food chain
  - Agriculture: Asset location tracking (A07): €7 million, Track and Optimise Key Mobile Assets (e.g. tractors, harvesters)
  - Healthcare:
    - Hospital Asset Tracking - dumb assets (H02.1): €4 million, Track Location of portable Assets (e.g. wheelchairs, hospital beds)
    - Hospital Asset Tracking - patient monitors (H02.2): €3 million, Track Location of smart Assets (e.g. bedside monitors)
    - Hospital Asset Tracking - other high value assets (H02.3): €0.8 million, Track Location of other high value portable Assets (e.g. dialysis machines, imaging machines)

Segment 5 ("smart building"): €1.2 billion (4 use cases, 4 sectors)

- Priority Use Cases:
  - Manufacturing: Smart building (M11): €800 million, Smart Building Management
  - Transport: Smart building (T13): €340 million, Smart Building Management.
- Clustered Use Cases
  - Energy & Utilities: Smart building (E15): €49 million, Smart Building Management
  - Healthcare: Smart building (H08): €29 million, Smart Building Management