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UNLOCK-CEI

Preliminary Market Scenarios & Pathways to the Future Open European CEI Ecosystem

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D2.2 - Preliminary Market Scenarios & Pathways to the Future Open European CEI Ecosystem

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0.7	13/12/2023	Gianni Dalla Torre	Consolidate Format addressing peer review comments

Glossary of terms

Item	Description
ARF	Adoption Readiness Framework
Value chain	In this document, a value chain means a group of companies that interact and cooperate with each other to provide a product, a solution, or a service
Value chain adopter group (VCA)	A value chain adopter group is an approach to engage and receive feedback from the industry constituency on requirements and demands for CEI technologies
Digital Continuum	Digital Continuum allows for seamless interaction of actors in a value chain using CEI technologies
PESTEL	A strategic framework used to analyse and understand the external factors that can impact an organisation's business environment
Porter's 5 Forces	A framework to analyse the competitive dynamics and attractiveness of an industry
Blue Ocean Strategy	A strategic framework that focuses on creating uncontested market spaces and making the competition irrelevant
SWOT	A strategic planning tool used to assess the internal strengths and weaknesses of an organisation, as well as the external opportunities and threats it faces
IoT	Internet of Things
IT	Information Technologies
Cloud	A network of remote servers that are used to store, manage, and process data and applications over the internet
Edge	A technology enabling processing and analysing data closer to the source
Use case	A specific interaction or scenario that captures how a system or product is used by actors or users to achieve a particular goal
Demand landscape	The overall characteristics, dynamics, and trends of the market demand for products or services within a specific industry or market segment
Demand sector	The market sector that represents companies that buy from suppliers.
Market adoption	The process and rate at which a new product, technology, or innovation is accepted and adopted by customers or users within a particular market
Drivers	The factors or influences that shape and stimulate demand for products or services within a particular market
Barriers	Obstacles that make it difficult for new companies or products to enter and compete in a particular market
Scenario	A scenario is a plausible and internally consistent narrative or description of a potential future situation.
Pathway	Pathways refer to potential sequences or trajectories of events and outcomes that may unfold, based on different sets of conditions, assumptions, or variables.
Market Structure	Market structure refers to the organizational and competitive characteristics of a market, including the number and size of firms, the nature of products or services offered, the degree of competition, entry and exit barriers, and the extent of pricing control.
Market scenarios	Market scenarios are dynamic situations arising from the aggregated service requirements of diverse demand constituencies. These configurations, shaped by factors like specific use cases, service needs, and adopter preferences, reflect the intricate value chains essential for delivering market solutions.

Keywords

Cloud, Edge, IoT, PESTEL, PORTER, SWOT, Blue Ocean Strategy, Demand landscape, Use case, Market adoption, and Drivers and barriers.

Disclaimer

Executive Summary

This document, titled "D2.2 - Preliminary Market Scenarios & Pathways to the Future Open European CEI Ecosystem” is a direct outcome of the UNLOCK-CEI project's work package 2 (WP2), which focuses on designing a framework to address proactively the needs and wants of demand sector about IoT-to-Edge-to-Cloud (CEI) technology as well as to identify the requirements to implement such solutions in specific products and services.

This deliverable unfolds as a strategic endeavour to comprehend the current and future market structures within the European Union, positioning itself as a valuable resource for stakeholders navigating the evolving landscape of Cloud-Edge-IoT technologies. The methodological foundation rests on a synthesis of Eurostat data and other authoritative sources, establishing a robust framework for a nuanced understanding of the unique challenges and opportunities embedded in each sector.

The journey through this deliverable offers stakeholders a holistic perspective on the service requirements essential for the successful deployment of Cloud-Edge-IoT technologies. It illuminates key insights into the factors influencing market structures, providing a roadmap to navigate the complexities of the European market. As the technological landscape evolves, this deliverable stands as a crucial guide, offering a strategic vantage point for informed decision-making and fostering a deeper understanding of the transformative potential of Cloud-Edge-IoT solutions across diverse industry sectors in the European Union.

The cross-sectoral examination underscores the importance of a common implementation patterns. Stakeholders will get information on how communalities can be leveraged to find solutions that can be implemented concentrating on a proper delivery path. Potential scenarios and pathways to reach the goals can be derived and from this analysis we can create suggestions for the stakeholders.

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1. Introduction

1.1 Purpose of this deliverable

This document aims to analyse the current European ecosystem to understand the future scenarios of different industries where solutions based on Cloud-Edge-IoT technologies will highlight and emphasise the necessity of a coordinated effort to promote innovation, competitiveness, and sustainability, the content explains the imperative for such a consortium.

This document explores Cloud-Edge-IoT solutions in the European context. It encompasses a cross-sectoral analysis, highlighting shared variables and challenges across diverse industries, laying the groundwork for collaborative approaches. The structural analysis delves into the intricacies of use cases, emphasizing the importance of granularity in developing modular and scalable solutions. A market value analysis, rooted in realistic unit costs aligned with market drivers, informs strategic investments for optimized returns. The document presents hypothetical pathways for implementation, suggesting phased approaches and targeted investments to maximize growth.

1.2 Objectives of Work Package 2 and Timelines

Within the scope of Work Package 2 (WP2) - "CEI Market Scenarios and Guidance," our strategic efforts are directed towards contributing meaningfully to the evolution of the open European Cloud-Edge-IoT (CEI) ecosystem. WP2 is dedicated to achieving a set of core objectives to help shape the future landscape of CEI technology.

The purpose of WP2 is to oversee key elements of the growth of the CEI ecosystem. Our primary objectives include identifying what are the most important service requirements, constructing comprehensive market scenarios, and assessing the pathways that may influence the CEI ecosystem's trajectory. Furthermore, our aim is to provide significant guidance to interested parties, enabling them to make well-informed decisions while taking initiatives that increase the likelihood of favourable events happening. Additionally, we are committed to developing an analytical framework and ensuring that adopter groups of value chains specific to a certain industry actively participate in the subsequent WP3 activities.

Our journey unfolds through a carefully designed timeline, marked by key deliverables:

- D.2.1, focused on the "Adoption Readiness Framework and Service Requirements," setting the groundwork in Month 12.
- D.2.2 - "Preliminary Market Scenarios & Pathways to the Future Open European CEI Ecosystem." Final version due for refinement by December 2023 (M18).
- A final position paper, D.2.3, due December 2024 (M30).

1.3 Target Audience

This deliverable is crafted to cater to a diverse array of stakeholders deeply invested in the evolution of the European technology landscape.

- The primary target audience comprises policymakers and regulatory bodies shaping the overarching framework for the CEI ecosystem. Their engagement is crucial in aligning legislative measures with the dynamic advancements in cloud-edge-IoT technologies.
- Industry leaders and decision-makers will find specific insides for sectors such as Agriculture, Energy & Utilities, Healthcare, Manufacturing, and Transport.

- Technology developers and solution providers seeking opportunities within the CEI ecosystem will find valuable market scenarios and pathways to guide their product development and innovation efforts.
- Academic researchers and analysts focusing on technology trends, safety protocols, and market dynamics constitute another pertinent audience, benefiting from the comprehensive analysis presented herein.

Collectively, this deliverable serves as a comprehensive resource, ensuring relevance and value for a broad spectrum of stakeholders involved in shaping the future of the Open European Cloud-Edge-IoT Ecosystem.

1.4 Document Structure

The document unfolds as a comprehensive exploration of the Cloud-Edge-IoT landscape, strategically designed to provide readers with a thorough understanding of the subject matter.

Section 2, **Methodology**, provides the systematic approach employed in Service Requirements Identification, Strategic Analysis, and Framework Development.

Section 3, **General Overviews of the CEI Landscape**, paints a broad picture of Cloud, EDGE, and IoT components, offering readers a foundational understanding of the key elements comprising the Cloud-Edge-IoT ecosystem.

Section 4, the **Service Requirements Analysis**, dissects the nuances of each sector: Agriculture, Energy & Utilities, Healthcare, Manufacturing, and Transportation. The sector specific analysis, the document elucidates the distinct challenges and opportunities inherent in each domain.

Section 5, **Guiding Investments: Cross-sector Strategic Insights** constitute an extensive exploration, commencing with an introduction and leading into a multifaceted analysis of gathered data. This section unravels insights into usage, growth, development, outcomes, physical scope importance, target types, and nuanced analysis of data frequency, volumes, and location. The **Implementation Challenges** section 6 takes a critical look at the hurdles associated with deploying Cloud-Edge-IoT solutions, providing a nuanced analysis of potential obstacles and outcomes.

In the concluding section 7, **Conclusions**, key findings, and insights drawn from the extensive analysis are provided, offering a conclusive perspective on the potential impact and strategic implications of Cloud-Edge-IoT technologies across diverse sectors.
Lastly section 8, **Annexes** are provided, offering supplementary information and resources to augment the main sections, providing additional context and depth to enrich the reader's understanding. In essence, the document is meticulously structured to guide readers on a logical and cohesive journey through the intricate landscape of Cloud-Edge-IoT technologies, fostering a holistic comprehension of the subject matter.

2. Methodology

2.1 Background - Service Requirements Identification

In the rapidly evolving landscape of Cloud-Edge-IoT solutions, the process of service requirements identification plays a pivotal role in shaping the efficacy and functionality of these innovative systems. Deliverable 2.1, Deliverable 3.1, and Deliverable 1.2 collectively serve as comprehensive repositories where valuable insights into the identification of service requirements for these cutting-edge solutions can be found.

We found strong structural parallels across different industries through the examination of several use cases, which lays the groundwork for a more comprehensive comprehension of Cloud-Edge-IoT solutions. Taking note of these similarities, we took a calculated risk and developed a taxonomy, as described in the chapter called Structural Framework Methodology: Mapping Market Scenarios, that classifies and codes the use cases. In accordance with the three-layered analysis methodology, this taxonomy provides an organised framework for effectively presenting and considering the similarities that have been found in later sections.

The methodology employed for gathering service requirements and understanding the market structure adopts a three-layered analysis approach. In the first layer, a meticulous examination of each use case is conducted individually. This micro-level analysis involves delving into the specific intricacies, challenges, and requirements of each scenario within the Cloud-Edge-IoT domain. Through this use case by use case analysis, a granular understanding is achieved, providing a foundation for subsequent layers.

The formulation of Service Requirements has been intricately linked to the identification of market challenges elucidated in both Work Package 1 (D1.2) and Work Package 4 (cross-portfolio analysis of Research and Innovation Actions in MetaOS HORIZON-CL4-2021-DATA-01).

As we proceed to the second layer, the analysis aggregates use cases across various dimensions to adopt a macro viewpoint. Important elements including data volume, data velocity, coverage area, and the "Lx" taxonomy are included in these dimensions. The objective is to find patterns and commonalities amongst use cases, regardless of their industry, by assembling varied clusters of aggregations. This comprehensive approach provides insights into cross-industry patterns, going beyond sector-specific categorization. Finding these patterns makes it easier to outline possible market segmentation tactics, which gives suppliers important direction for where to concentrate their efforts.

The methodology's third layer is devoted to providing insights into market scenarios, enablers, and pathways. This layer offers a forward-looking viewpoint to satisfy the requirements of both the European Commission and the project. Using the patterns and insights from the second layer, it entails creating fictitious future scenarios. These scenarios examine possible market development paths while considering several variables, including changing user preferences, regulatory changes, and technological advancements. Pathway and enabler identification provides stakeholders with a strategic roadmap and actionable intelligence to navigate the complex world of Cloud-Edge-IoT solutions.

This three-layered approach is effective enough to be used in Wave 2 workshops. The technique presents an organised and thorough framework for analysis and acts as a starting point for involving stakeholders from various industries. The approach guarantees relevance and practicality by incorporating representatives from every sector in the workshops. This validates the approach's efficacy in capturing the varied needs and expectations of stakeholders.

Essentially, this methodology provides a comprehensive and prospective viewpoint on market dynamics and service requirements in the Cloud-Edge-IoT space. It provides both a strategic roadmap for navigating future market scenarios and a detailed analysis of individual use cases, which is in line with the project's objectives and the expectations of the European Commission.

In our analysis of the identified requirements, we incorporated several key structural variables, that are described in the Table 1 - Structural Variables, to gain a comprehensive understanding of the intricacies involved in Cloud-Edge-IoT solutions. These structural variables play a crucial role in shaping the scope and characteristics of the requirements, providing a nuanced perspective on the diverse use cases within the ecosystem.

Variable	Description
Coverage	This variable explores the depth and range of coverage in a particular use case. It provides an overview of the various features and applications, illuminating the use case's overall significance and impact in relation to Cloud-Edge-IoT solutions.
Retrofitting vs OEM	Differentiating between situations in which IoT features are added to already-existing systems and those in which they are integrated into the original equipment during manufacturing. Understanding the complexity of integration and long-term viability of each use case depends on this differentiation.
Data Collection Volume	This variable evaluates how much data is created and gathered for a given use case. It offers perceptions into the volume of data that must be handled and handled, assisting in the making of decisions about the kind of infrastructure needed, its capacity for data processing, and any potential scalability issues.
Data Collection Frequency	Examining the frequency of data collection for a given use case. Understanding the temporal aspects of data requirements, event-driven architectures, real-time processing decisions, and the overall responsiveness of the Cloud-Edge-IoT solution are all influenced by this factor.
Data Storing Location	Examining the system architecture's data storage locations. This variable considers several options, such as corporate cloud storage, commercial cloud storage, on-premises edge storage, and on-device storage. The location of storage has a big impact on things like latency, accessibility, and data security.

Table 1 - Structural Variables

2.2 Strategic Analysis and Framework Development: Unravelling Market Dynamics

WP2 aims to comprehensively analyse Use Cases identified in WP1, translating them into unique solutions and evaluating market opportunities, providing a strategic roadmap for implementation, identifying ecosystem elements, utilizing morphological analysis for strategic planning, and employing PESTEL analysis to connect routes to external factors, ultimately offering a foundational framework for navigating technology solutions, fostering innovation, and ensuring market sustainability.

These result in the creation of different boxes showing different variables and outcomes that were included.

Every level of the taxonomy described in the chapter "Structural Framework Methodology: Mapping Market Scenarios" has a common implementation pattern with elements shared across different use cases. This commonality makes it possible to identify recurrent components and the expenses related to them, which helps to improve the accuracy of cost estimation. The strategic method used facilitates a thorough market value analysis, which is necessary to define market paths according to possible deviations and investment considerations. This method simplifies the cost estimation procedure as well.

A common implementation pattern has been found at every taxonomy level, exposing recurrent elements in a variety of use cases. Because of this similarity, cost estimation becomes more efficient as shared components, and their associated costs are identified. This method facilitates a thorough market value analysis, which is essential for defining market routes according to different potential and investment factors.

A uniform framework is developed for cost estimation within each taxonomy level, which includes components such as connectivity modules, software solutions, hardware, and other technological elements that are common. Location trackers, "limited area" network gear, edge gateway processors, and storage solutions are examples of components that are common to many use cases. Finding and comprehending these similarities makes it possible to determine the total market value, which represents the total expense of putting Cloud-Edge-IoT solutions into practice across a range of use cases.

For a more in-depth understanding of the market, differentiation of element types is prioritised over the overall market value. This entails classifying parts such as edge gateway processors, network equipment, and location trackers. The idea is to create a segmented market perspective by separating various element types according to their investment appeal and market potential. This method is essential for market pathways because it makes it possible to identify larger markets that might not require a large investment as well as smaller markets with enormous potential.

By avoiding needless investments in smaller markets and strategically concentrating investments where there is a high potential for returns, the analysis of segregated market values shapes market pathways. In the Cloud-Edge-IoT space, this strategic approach facilitates more effective resource allocation and informed decision-making.

2.3 Structural Framework Methodology: Mapping Market Scenarios

The structural analysis methodology for the Preliminary Market Scenarios and Pathways is systematically designed to provide a comprehensive understanding of the market landscape. This involves a meticulous annotation of use cases, where we delve into key structural details to unravel the intricate layers of the market structure.

Understanding the common factors for implementing Cloud-Edge-IoT solutions across various industries requires a cross-sector analysis. While these industries have distinct operational features, there is a notable convergence in the obstacles and demands encountered in the process of implementing Cloud-Edge-IoT technologies. A comprehensive approach to solution development can be informed by identifying patterns, similarities, and shared variables that can be found through a thorough cross-sector analysis.

By using a cross-sector approach, it is easier to identify requirements and challenges that are common across industries. Comprehending shared requirements like scalability, interoperability, and data security enables solutions to be developed that can be easily applied to different domains. As more and more industries adopt Cloud-Edge-IoT solutions, this common understanding becomes especially important.

Finding best practices and successful implementation strategies that work across industries is made possible by a cross-sector analysis. Stakeholders can mitigate potential challenges and accelerate the deployment of Cloud-Edge-IoT solutions by leveraging lessons learned from one sector and applying them to another. The dissemination of this knowledge fosters productivity and quickens the Cloud-Edge-IoT ecosystems' overall maturity.

Establishing industry-neutral standards is made possible by identifying common variables in the deployment of Cloud-Edge-IoT solutions. In the end, standardisation promotes cooperation, expedites interoperability, and increases the scalability and sustainability of these technologies.

A pivotal element of this methodology is the introduction of a taxonomy of levels as described in Table 2 - Aggregation levels, which serves as a framework for categorizing use cases based on complexity and overarching architectural elements. They represent clusters of different use cases from different industry sectors that have same variables in common.

Level	Description
L1	for location tracking
L2	for visual inspection
L3	for condition monitoring
L4	for predictive maintenance (based on condition monitoring)
L5	for asset command and control (asset on/off)
L6	for autonomous driving, process automation/optimization

Table 2 - Aggregation levels

Deployment models play a crucial role, with considerations for retrofit and OEM integration, intricately linked to the Return on Investment (ROI) of the application. The nature of the device population, data collection modes, and data reduction options are meticulously outlined, incorporating factors such as the type of sensors, data collection frequency, and reduction levels at the device, intermediate, or centralized points.

The extent and location of data analysis represent critical considerations, with proximity to the device enabling low latency and fast response times, intermediate analysis introducing increased latency, and centralized analysis potentially offering cost advantages. The exploration of a federated model training approach further enhances the depth of our structural analysis methodology, ensuring a nuanced understanding of the evolving European Cloud-Edge-IoT landscape.

In alignment with the objectives of the EU project, the proposed costing and scoping methodology for cross-sector Cloud-Edge-IoT use cases offers a robust market-driven analysis. This involves a segmentation of element types, enabling the calculation of segregated market values and the identification of significant market opportunities. Common implementation patterns are delineated within each taxonomy group, streamlining development processes for efficiency. The methodology further breaks down costs for each element type, providing a comprehensive assessment of market opportunities for various stakeholders, and sub-segmenting the market into Cloud, Edge, and IoT domains. This approach emphasizes strategic evaluation of potential processing locations, steering clear of undue reliance on cloud solutions, and quantifying opportunities for Original Equipment Manufacturers (OEMs). By guiding scenario development, the methodology ensures that strategic decisions align with market potential, scalability considerations, and the intricacies of the Cloud-Edge-IoT landscape, thereby facilitating informed investments and advancements in line with the EU project's overarching goals.

In conclusion, the proposed methodology serves as a guide for stakeholders within the EU project, offering a data-driven approach to decision-making, resource allocation, and scenario development. It fosters a nuanced understanding of market dynamics, encouraging targeted investments that contribute to the scalability and technological advancements of Cloud-Edge-IoT solutions in the project's context.

3. General Overview of the CEI Landscape

In the CEI landscape, the cloud market is the most mature and by far the most developed. However, the edge and IoT markets are seen as having a huge potential for growth and development in the long run as explained in the European Commission Strategy "The next generation Internet of Things" [1].

As described in the following, the cloud market structure is becoming more and more oligopolistic, while the current state of the edge and IoT markets can still be considered perfect competition. However, it is important to consider that, as it may be strategic for large companies to expand into this field, there is a significant risk of facing unfair competition, or being acquired, for new and successful SME companies in edge IoT.

That poses opportunities and challenges for companies entering this market. The regulator holds a significant influence in shaping the evolution of this segment in Europe; however, it remains uncertain whether there are legal boundaries that allow impactful intervention without violating market agreements.

3.1 Cloud

Few major businesses define the market structure of the cloud technology sector in the EU, which often qualifies it as an oligopoly. Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP) are a few of the top cloud service providers. Other companies with relevant market quotes outside of the EU include IBM Cloud (& RedHat), Oracle Cloud, and Alibaba Cloud.
As explained in the "D1.2 – Cloud-Edge-IoT Demand Landscape[1]", a sizable share of the global cloud market is dominated by major cloud providers and a select few others. While there are specialized and smaller cloud providers, the dominance of these major players is evident. The integration of diverse cloud services within a single provider while delivers tangible value to clients makes the competition more difficult for smaller providers. Once provider specific services are integrated in the pipelines, production, and deployment environments, recreating a comparable configuration outside of these major providers requires significant effort, fostering client loyalty. Moreover, the rapid development of cloud services by major providers poses challenges for smaller providers to keep pace, with some services potentially not being offered by the latter.

3.2 Edge

In contrast to several other industries, the market structure for edge technology was not dominated by a single monopoly or a limited number of companies. Instead, a more diverse and fragmented market landscape for edge computing was evident, with many businesses providing distinct edge solutions and services.
A wide range of hardware, software, and services together referred to as "edge technology" enable processing and data storage closer to the point of data production, usually at or near the edge of a network. This broad topic includes a variety of elements[2], such as edge data centres, edge analytics software, edge devices, and edge servers. The IoT (Internet of Things), telecommunications, healthcare, manufacturing, and other sectors are among the many industries it supports.

[1] https://zenodo.org/records/8107103
[2] https://zenodo.org/records/8107103

Key characteristics of the edge technology market structure include:

1. Diverse Player Base: The edge computing market has been entered by numerous technological firms, both big and small. This comprises well-established IT firms, telecom businesses, cloud service providers, and start-ups that focus on edge solutions.
2. Competitive Innovation: The competitive environment and innovation are ongoing forces in the edge computing market because of the changing nature of the technology landscape. Companies are always improving and developing their cutting-edge services to meet changing customer needs.
3. Specialisation: A few businesses concentrate on specialised fields of edge technology, such as edge security, real-time analytics, or the deployment of edge infrastructure. The market is more diverse because of this specialisation.
4. Alliances and Partnerships: Businesses frequently form alliances and partnerships to take advantage of one another's capabilities and produce comprehensive cutting-edge solutions. This teamwork-based methodology is typical of the edge technology ecosystem.
5. Geographical variances: There may be geographical variances in the edge computing market, with certain businesses and service providers being more prevalent in particular regions.
6. Changing Environment: The edge technology market is currently developing, and as new players, mergers, and acquisitions, as well as technological breakthroughs impact the industry, its structure may change over time.

The edge technology market does not cleanly fall under a standard market structure category like monopoly or oligopoly due to these characteristics. Instead, it is a dynamic and changing environment with a wide range of companies and plenty of potential for innovation and growth, which makes it the ideal environment for competitiveness.

3.3 IoT

The Internet of Things (IoT) market structure was characterised by a broad and fragmented environment as of my most recent knowledge update in September 2021, with several enterprises active in various IoT ecosystem segments. IoT is a complicated and multidimensional topic that includes a wide range of technologies and applications, such as sensors, connectivity options, data analytics, and IoT platforms.

Key characteristics of the IoT technology market structure include:

- Diverse Player Base: The edge computing market has been entered by numerous technological firms, both big and small. This comprises well-established IT firms, telecom businesses, cloud service providers, and start-ups that focus on edge solutions.
- Competitive Innovation: The competitive environment and innovation are ongoing forces in the edge computing market because of the changing nature of the technology landscape. Companies are always improving and developing their cutting-edge services to meet changing customer needs.
- Specialisation: A few businesses concentrate on specialised fields of edge technology, such as edge security, real-time analytics, or the deployment of edge infrastructure. The market is more diverse as a result of this specialisation.
- Partnerships and Alliances: Businesses commonly develop partnerships and alliances to build complete IoT ecosystems because of the complexity of IoT solutions and the requirement for interoperability. These partnerships seek to deliver end-to-end solutions and guarantee interoperability between different IoT platforms and devices.
- Regional Variations: Depending on local laws and consumer preferences, the IoT market may exhibit regional variations, with certain businesses and technologies being more prevalent in particular regions.

- Evolution and Development: New technology, standards, and application cases are continuously emerging in the IoT sector. This development adds to the market structure's flexibility.

The IoT technology market does not cleanly fit into a typical market structure category like monopoly or oligopoly because of its diversity, complexity, and rapidly growing nature. Instead, it can be described as perfect competition because it is characterised by competition, innovation, and many competitors meeting different industry demands[3].

[3] https://zenodo.org/records/8107103

4. Service Requirements Analysis

4.1 Introduction

Different analyses were conducted and have been the source of the service requirements to understand the various shapes and variables affecting them, from technological to cultural. Rather than being seen as isolated obstacles, these requirements are being defined as necessary preconditions for guaranteeing the success of Cloud-Edge-IoT technology implementation.

The definition of these requirements started from the use case[4] analysis from whom they were generated. Following this analysis the delivery of workshops and interviews. The facilitation of workshops and conduct of interviews has proven instrumental in gaining insights into the perspectives of diverse stakeholders. This approach has significantly enhanced our comprehension of their perspectives regarding CEI technologies, as well as provided valuable insights into the readiness of their respective organizations for the implementation of solutions based on them.

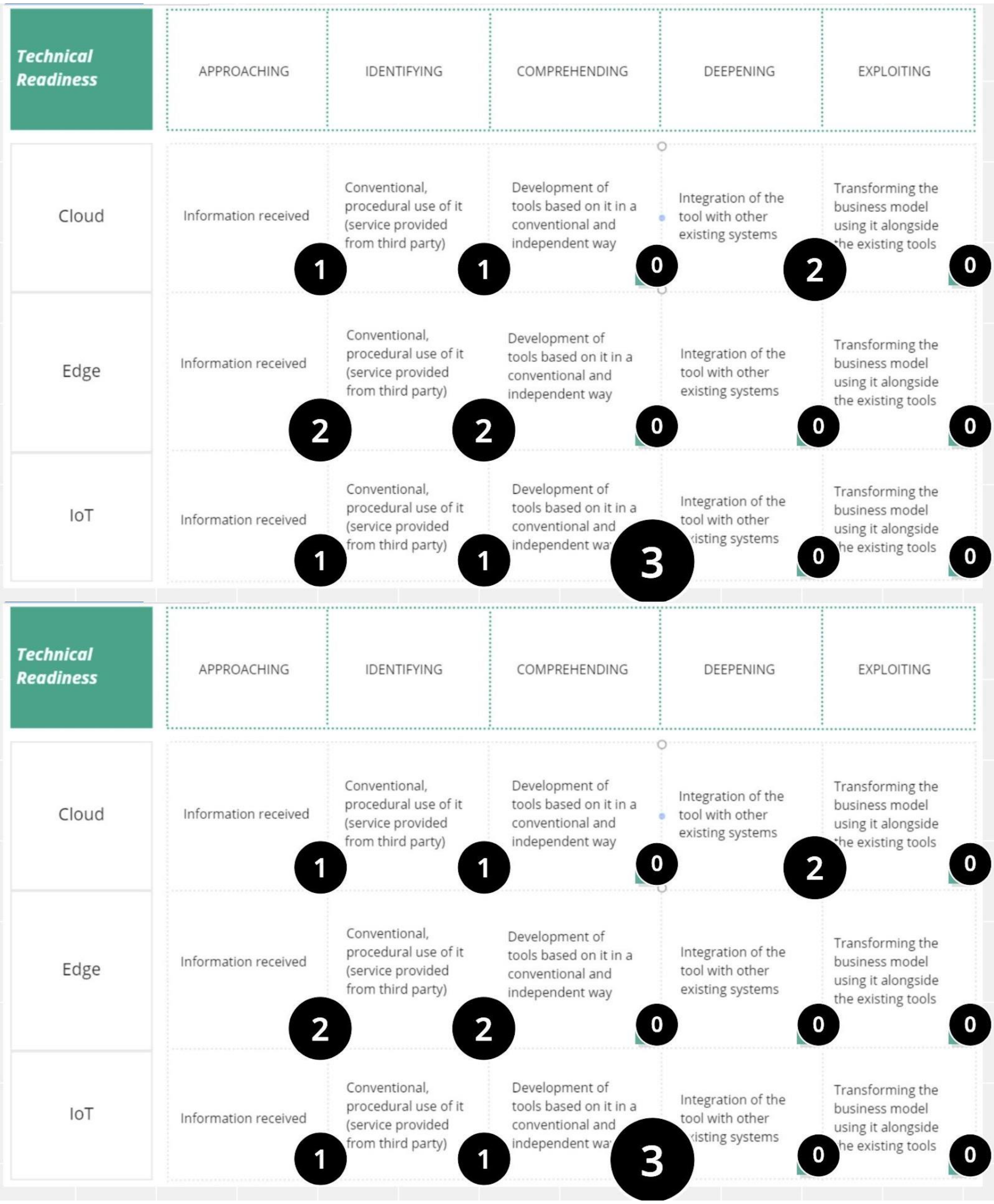
In particular, the analysis[5] was focused on different kinds of readiness as shown in Figure 1 – Example of Technical Readiness Analysis, in Figure 2 - Example of Organisational Readiness Analysis, and in Figure 3 - Example of Use Case Readiness. These obstacles stand for important issues that need to be resolved to implement and use Cloud-Edge-IoT solutions successfully. The knowledge gained from WP1 offers a thorough grasp of the market dynamics and establishes the foundation for determining Service Requirements that directly address these difficulties.

Each column represents a level of understanding/implementation from the lower/initial (left) to the (deeper/specialised) right.

Each row represents the technology in the first table; the 6 main socio-business and technical dimensions[6], and the variables taken into consideration with the Blue Ocean Strategy[7].

The circles with the number graphically represent the evaluations by the various stakeholders interviewed.

[4] https://doi.org/10.5281/zenodo.7821330
[5] https://doi.org/10.5281/zenodo.8089373
[6] https://doi.org/10.1016/j.procir.2022.02.105
[7] Chan Kim, W., & Mauborgne, R. A. (2015). Blue ocean strategy, expanded edition: How to create uncontested market space and make the competition irrelevant. Harvard Business School Press.



Technical Readiness	APPROACHING	IDENTIFYING	COMPREHENDING	DEEPENING	EXPLOITING
Cloud	Information received 1	Conventional, procedural use of it (service provided from third party) 1	Development of tools based on it in a conventional and independent way 0	Integration of the tool with other existing systems 2	Transforming the business model using it alongside the existing tools 0
Edge	Information received 2	Conventional, procedural use of it (service provided from third party) 2	Development of tools based on it in a conventional and independent way 0	Integration of the tool with other existing systems 0	Transforming the business model using it alongside the existing tools 0
IoT	Information received 1	Conventional, procedural use of it (service provided from third party) 1	Development of tools based on it in a conventional and independent way 3	Integration of the tool with other existing systems 0	Transforming the business model using it alongside the existing tools 0

Technical Readiness	APPROACHING	IDENTIFYING	COMPREHENDING	DEEPENING	EXPLOITING
Cloud	Information received 1	Conventional, procedural use of it (service provided from third party) 1	Development of tools based on it in a conventional and independent way 0	Integration of the tool with other existing systems 2	Transforming the business model using it alongside the existing tools 0
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IoT	Information received 1	Conventional, procedural use of it (service provided from third party) 1	Development of tools based on it in a conventional and independent way 3	Integration of the tool with other existing systems 0	Transforming the business model using it alongside the existing tools 0

Figure 1 - Example of Technical Readiness Analysis

Organisational Readiness	APPROACHING	IDENTIFYING	COMPREHENDING	DEEPENING	EXPLOITING
Product	The product could be defined as TRL-1 or TRL-2 (0)	The product could be defined as TRL-3 or TRL-4 (3)	The product could be defined as TRL-5 or TRL-6 (1)	The product could be defined as TRL-7 or TRL-9 (1)	The product could be defined as TRL-99 (0)
Process	The process is just in a draft version (1)	The process is developed and used without certain quality level (3)	The process is clear, managed, and maintained. (0)	The process has a certain quality and automation (1)	Everything related to the process is defined and it's working fluidly and integrated with others (0)
Platform	The platform is not yet developed but ideas are drafted (1)	The platform is created and it is managed and produces some (3)	The capability of the platform is integrated and data processed and used simulations and monitoring (1)	Computable models are developed and verified to represent the world and interact with it (0)	The platform is interoperable and used to produce future scenarios (0)
People	Use and knowledge of systems using these technologies (1)	Understanding the importance of these technologies and the transformation they can make in productivity (2)	Providing leadership guiding in designing new solutions. (2)	Understanding the market and providing insights to develop new solutions (0)	Useful strategic thinking, creating conditions for co-creation network and innovate (0)
Partnership	No partnership established to develop CEI solutions (1)	Studying the market to understand if some partnerships can be made (3)	Planning and managing activities to create partnerships (1)	Managing and driving partnerships to optimise solutions. (0)	Creating dynamic partnership with a strategic vision for products / services development (0)
Performance	Performances of current solutions are taken in consideration (1)	Measurement of different variables to be developed to assess new solutions provided with CEI technologies (2)	Measurement of performances of new solutions are taken into consideration (1)	Performance measurements are taken and compared between old and new solutions to evaluate the KPIs (1)	Prescriptive performances analysis are designed and simulated (0)

Figure 2 - Example of Organisational Readiness Analysis

Use Case Readiness	APPROACHING	IDENTIFYING	COMPREHENDING	DEEPENING	EXPLOITING
Problem / Pain Points / Goals	Yet to completely assess the problem and identify the pain points to create goals 0	Thinking about practices involved by the problem and causing pain points to address the goals 1	Have addressed some factors related to the problem but need more guidance in understanding pain points and focus on goals 1	Complete and in-depth understanding of pain points generating the problem and helping defining the goals 2	Extrapolation of additional factors deriving from pain points that are involved in the problem and respective goals definitions 0
Value Proposition / ROI / Benefits	Yet to completely assess the value proposition its benefits and the ROI of the proposed problem s solution 0	Thinking about practices to obtain the value proposition and create benefits that can help with the ROI 1	Have identified some factors related to the value proposition that create benefits, helping with the ROI but need more guidance 1	Complete and in depth understanding of them and their effects 2	Complete and in-depth understanding of them and their effects with their interconnections 0
Scalability	Yet to completely assess the scalability of the current solution 0	Thinking about scalability practices 3	Have identified some factors related to the scalability but need more guidance 1	Complete and in-depth understanding of it and its effects 0	Complete and in-depth understanding of it and its effects with their interconnections 0
Customers	Yet to completely assess the customers, their touch-points and how to reach them 1	Thinking about groups of customers, their touch-points and how to reach them 2	Have identified som specific kind of customers and their particularities but need more guidance 1	Complete and in-depth understanding of them and their particularities 0	Complete and in-depth understanding of them and their particularities with a specific focus on some 0
Collaborations	Yet to completely assess the need for collaborations to overcome obstacles 0	Thinking about practices involved in collaboration and understanding where it is needed 3	Have identified some factors related to the collaboration (co-design/co-development) but need more guidance 1	Complete and in-depth understanding of it and its effects 0	Complete and in-depth understanding of it and its effects with their interconnections in co-designing 0
Sponsorships	Yet to completely assess the need of sponsorships 0	Thinking about practices understanding where sponsorship is needed 3	Have identified some factors related to the sponsorhip but need more guidance 0	Obtained internal sponsorship from line managers 0	Obtained C-Suite level champions to sponsor the use case 1
Stakeholders (all the other entities related to the use case)	Yet to completely assess the interaction with stakeholders 0	Thinking about practices understanding where stakeholders are involved 3	Have identified some factors related to stakeholders but need more guidance 1	Complete and in-depth understanding of them and their effects 0	Complete and in-depth understanding of them and their effects with their interconnections 0

Use Case Readiness	APPROACHING	IDENTIFYING	COMPREHENDING	DEEPENING	EXPLOITING
Problem / Pain Points / Goals	Yet to completely assess the problem and identify the pain points to create goals 0	Thinking about practices involved by the problem and causing pain points to address the goal 1	Have addressed some factors related to the problem but need more guidance in understanding pain points and focus on goals 1	Complete and in-depth understanding of pain points generating the problem and helping defining the goa 2	Extrapolation of additional factors deriving from pain points that are involved in the roblem and pective goals finitions 0
Value Proposition / ROI / Benefits	Yet to completely assess the value proposition its benefits and the ROI of the proposed problem s solution 0	Thinking about practices to obtain the alue proposition and create benefits that can help with the ROI 1	Have identified some factors related to the value proposition that create benefits, helping with the ROI but need more guidance 1	Complete and in depth understanding of them and their effects 2	Complete and in-depth understanding of them and their effects with their erconnections 0
Scalability	Yet to completely assess the scalability of the current solution 0	Thinking about scalability practice 3	Have identified some factors related to the calability but need re guidance 1	Complete and in-depth understanding of it and its effects 0	Complete and in-depth understanding of it and its effects with their terconnections 0
Customers	Yet to completely assess the customers, their touch-points and how to reach them 1	Thinking about groups of customers, their touch-points and how to reach ther 2	Have identified som specific kind of customers and their particularities but eed more guidanc 1	Complete and in-depth understanding of them and their particularities 0	Complete and in-depth understanding of them and their particularities with a pecific focus on ome 0
Collaborations	Yet to completely assess the need for collaborations to overcome obstacles 0	Thinking about practices involved in collaboration and understanding where it is need 3	Have identified some factors related to the collaboration (co-sign/co-elopment) but d more guidance 1	Complete and in-depth understanding of it and its effects 0	Complete and in-depth understanding of it and its effects with their terconnections in -designing 0
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Figure 3 - Example of Use Case Readiness

The analysis expands the set of challenges by exploring the complexities of actual use cases in the context of Research and Innovation Actions. To complete this task, a thorough analysis of use cases has been conducted in order to identify challenges that are both indicative of industry complexities and essential to the success of Cloud-Edge-IoT implementations. As a result, these difficulties provide important benchmarks for developing Service Requirements, which are essential for removing barriers and guaranteeing the effectiveness of technological solutions.

It is imperative to emphasise that the challenges that have been identified are prerequisites for success, not sufficient in and of themselves. The derived Service Requirements offer a solid foundation for the

development and implementation of Cloud-Edge-IoT technologies in a way that is in line with industry dynamics and market demands. They also function as a roadmap for methodically addressing these challenges.
We identified three main service requirements that affects the implementation of Cloud-Edge-IoT solutions:

- Data frequency collection
- Data volume collection
- Data analysis location

Given the presented use cases and the subsequent analysis, the clarity of Return on Investment (ROI) remains somewhat obscured. It is apparent that a more robust baseline is necessary to bolster the structural analysis and provide a clearer understanding of the potential returns.
This section will furnish a comprehensive and detailed estimation of the market opportunity, delineating each use case individually. This estimation will be derived from our discernment of the anticipated implementation approach for each specific use case.

4.2 Agriculture

The integration of Cloud-Edge-IoT technologies is driving a revolutionary evolution in the agriculture sector, with a range of service requirements defining the modernization of the sector.

In the agriculture sector, the role of Cloud-Edge-IoT technologies is instrumental in ushering in a new era of precision farming and data-driven decision-making[8]. The frequency of data collection is of paramount importance, as it allows for continuous monitoring of various factors that directly influence crop health and agricultural productivity. Real-time data acquisition from sensors embedded in the fields provides insights into critical parameters such as soil moisture levels, temperature, and humidity.

The high frequency of data collection is particularly crucial for monitoring crop health, as it enables the detection of early signs of diseases, pests, or nutrient deficiencies. With rapid and continuous data streams, farmers can implement timely interventions, applying targeted treatments or adjusting irrigation practices to mitigate potential issues. This proactive approach not only safeguards crop health but also optimizes resource utilization, minimizing water wastage and reducing the environmental impact of agricultural activities.

Moreover, the volume of data collected in the agriculture sector extends beyond the immediate needs of crop monitoring. Information on soil conditions, weather patterns, and historical agricultural performance contributes to creating comprehensive datasets. These datasets serve as valuable resources for generating more accurate predictions and enhancing overall agricultural practices. For instance, historical weather data combined with current conditions aids in predicting optimal planting times, harvesting periods, and potential yield fluctuations.

The analysis of this extensive dataset can be performed either on the edge, directly within the farming equipment or sensor devices, or in the cloud, leveraging powerful computing resources. Edge computing allows for real-time insights directly in the field, facilitating immediate decision-making by farmers or autonomous farming machinery. On the other hand, cloud-based analysis offers the advantage of processing large volumes of historical and real-time data, providing a broader perspective on trends and patterns that can inform long-term agricultural strategies.

[8] https://doi.org/10.5281/zenodo.8107103

4.3 Energy and utilities

In the energy and utilities sector, the integration of Cloud-Edge-IoT technologies plays a pivotal role in revolutionizing the management and efficiency of energy resources. The frequency and volume of data collection become indispensable components for optimizing energy consumption, ensuring equipment health, and maintaining the stability of energy grids.

The high frequency of data collection is vital for monitoring real-time energy consumption patterns across various components of the infrastructure. Sensors embedded in smart meters, transformers, and other energy-related equipment continuously collect data on energy usage, load distribution, and equipment performance. This real-time monitoring allows utility providers to respond swiftly to changes in demand, optimize energy distribution, and prevent potential overloads or disruptions.[9]

Simultaneously, the substantial volume of data generated in the energy sector encompasses a wealth of information beyond immediate consumption patterns. This includes data on equipment conditions, temperature variations, and historical performance metrics. Analysing this extensive dataset enables predictive maintenance, as anomalies or early signs of equipment degradation can be identified before they escalate into critical failures.

Location-based data analysis emerges as a crucial aspect, particularly in identifying anomalies and potential failures within the energy infrastructure. By incorporating geographical information into the analysis, utility providers can pinpoint the exact location of equipment malfunctions or abnormalities in the grid. This geospatial insight facilitates a targeted and proactive approach to maintenance, reducing downtime and enhancing the overall reliability of energy systems.

The proactive maintenance approach, made possible by the frequency, volume, and location-based analysis of data, contributes significantly to grid stability. Predicting and preventing equipment failures before they occur not only ensures uninterrupted energy supply but also extends the lifespan of critical infrastructure components. This predictive capability is particularly valuable in mitigating the risks associated with aging infrastructure, optimizing capital investments, and fostering a more resilient and sustainable energy ecosystem.

4.4 Healthcare

Within the healthcare sector, the integration of Cloud-Edge-IoT technologies heralds a transformative era by enabling real-time monitoring of patient health, a development crucial for delivering timely interventions and personalized care. The high-frequency data collection from wearable devices and medical sensors emerges as a cornerstone, providing a continuous stream of valuable health-related information.

The frequency of data collection in healthcare is paramount, especially for patients with chronic conditions or those requiring constant monitoring. Wearable devices, such as smartwatches or health trackers, collect real-time data on vital signs, activity levels, and other relevant health metrics. This continuous monitoring allows healthcare professionals to receive immediate updates on patients' well-being, facilitating early detection of potential health issues and enabling prompt interventions.[10]

Simultaneously, the substantial volume of data collected from these wearable devices contributes to comprehensive health assessments. Beyond basic vital signs, this data encompasses trends, patterns, and deviations from the norm over time. By analysing this wealth of information, healthcare professionals gain a holistic understanding of patients' health, aiding in the creation of personalized treatment plans and interventions tailored to individual needs.

The analysis of health data can be conducted either on-premises within healthcare facilities or in the cloud, leveraging advanced computing capabilities. On-premises analysis ensures that sensitive patient information remains within the secure confines of healthcare institutions, addressing privacy concerns. Cloud-based

[9] https://doi.org/10.5281/zenodo.8107103
[10] https://doi.org/10.5281/zenodo.8107103

analysis, on the other hand, offers scalability and accessibility, allowing healthcare professionals to access patient data from various locations and make informed decisions even beyond the confines of a single facility.
This ability to analyse high-frequency, voluminous health data in real-time significantly enhances healthcare efficiency. Healthcare professionals can proactively address emerging health issues, make timely adjustments to treatment plans, and optimize patient care pathways. Moreover, the personalized insights derived from the data contribute to a more patient-centric approach, improving overall patient outcomes and satisfaction.

4.5 Manufacturing

Within the manufacturing sector, the infusion of Cloud-Edge-IoT technologies transforms production processes by emphasizing the integral role of high-frequency data collection in optimizing operations and maintaining stringent quality control standards. The frequency of data collection proves critical for real-time insights into various facets of the manufacturing environment.
The high-frequency data collection is instrumental in monitoring production lines, equipment efficiency, and product quality. Sensors embedded in machinery continuously gather data on parameters such as temperature, pressure, and speed, offering a granular view of the manufacturing process. This real-time monitoring enables swift identification of anomalies or deviations from optimal operating conditions, allowing for immediate corrective actions and ensuring that production remains efficient and within quality standards.[11]
Simultaneously, the substantial volume of data collected in manufacturing extends beyond immediate production metrics to encompass comprehensive information on equipment performance and product quality. This dataset becomes a valuable resource for predictive maintenance, as it enables the identification of patterns indicative of potential machinery failures before they occur. Predictive maintenance strategies, informed by the voluminous historical and real-time data, lead to reduced downtime, extended equipment lifespan, and cost savings.
The analysis of manufacturing data can be conducted either on the edge, directly within the machinery or production lines, or in the cloud, utilizing powerful computing resources. Edge computing facilitates real-time analysis, allowing for immediate adjustments to production processes based on the insights derived from the data. On the other hand, cloud-based analysis provides a broader perspective by processing large volumes of historical and real-time data, supporting long-term process improvement strategies and data-driven decision-making.

4.6 Transportation

In the transportation sector, the integration of Cloud-Edge-IoT technologies plays a pivotal role in reshaping the landscape of road safety, traffic management, and the advent of autonomous driving. The frequency of data collection emerges as a critical factor, particularly in the context of connected vehicles and infrastructure, serving as the backbone for ensuring a safer and more efficient transportation ecosystem.

The high-frequency data collection from connected vehicles and infrastructure is fundamental to real-time monitoring and analysis. Sensors embedded in vehicles and along roadways continuously gather data on various parameters, including vehicle speed, location, and environmental conditions. This constant stream of information allows for immediate insights into traffic patterns, potential hazards, and road conditions, forming the basis for proactive measures to enhance road safety[12].

[11] https://doi.org/10.5281/zenodo.8107103
[12] https://doi.org/10.5281/zenodo.8107103

Simultaneously, the substantial volume of data collected encompasses a diverse range of information, from individual vehicle health metrics to broader traffic conditions. This comprehensive dataset becomes the foundation for intelligent transportation systems. By analysing this wealth of data, transportation authorities and service providers can gain a holistic understanding of traffic dynamics, anticipate congestion points, and implement strategies to optimize traffic flow and reduce bottlenecks.

Real-time analysis of transportation data, whether conducted on the edge within vehicles or infrastructure or in the cloud utilizing advanced computing resources, is instrumental in enabling dynamic route planning and decision-making. This capability ensures that drivers receive up-to-the-minute information about the most efficient routes, contributing to reduced travel times, minimized congestion, and improved overall transportation efficiency.

Moreover, the frequency and volume of data collection in the transportation sector are indispensable for the successful implementation of autonomous driving technologies. Vehicles equipped with advanced sensors rely on real-time data to make split-second decisions, navigate complex traffic scenarios, and ensure a safe and seamless driving experience.

5. Guiding Investments: Cross-sector Strategic Insights

5.1 Introduction

The main objective of this document is to validate the efficacy of current use cases and investigate the possibilities of future scenarios. This twofold goal forms the basis for defining potential market channels. Our goal is to guarantee the credibility and relevance of the current use cases by thoroughly validating them. In addition, exploring the potential of future use cases enables us to create a solid base on which future market trajectories can be developed. Strategic decision-making within the Cloud-Edge-IoT landscape is informed by a credible and forward-looking perspective, which is made possible by this painstaking validation process.

As the present state and future course are examined, a crucial query emerges: in the absence of actual edge infrastructure, what does it mean to be "using" technology in the modern sense? The current environment frequently makes use of distributed computing and cloud computing solutions in tandem. These days, businesses use cloud infrastructure for centralised analytics, processing, and data storage. However, edge computing cannot reach its full potential without a strong edge infrastructure. Notwithstanding this constraint, the present situation entails the implementation of diverse applications and services on cloud platforms, permitting centralised administration and examination of data.

True edge infrastructure must be strategically integrated to expand on the current framework. This is because processing power is pushed closer to the data source, resulting in lower latency and faster decision-making. As the technology landscape changes, figuring out how businesses may move from the cloud-centric models they currently use to real edge computing becomes essential to determining how technology will be deployed in the future.

When data is analysed along multiple dimensions—target area, data collection methods, OEM vs. retrofit, market adoption speed, and whether cloud vs. local processing is required—patterns emerge that will play a major role in determining market value. This analysis shows critical service attributes by highlighting specific modalities that are expected to dominate the market. For example, the need for a specialised communication network covering a factory or farm becomes a key factor in determining service attributes.

A variety of connectivity factors, including volumes, data speeds, and the number of devices are presented. Despite being qualitative in nature, this data has a significant impact on how strategic decisions are made. Notably, the most notable segment found by this analysis serves as the focus for a more thorough examination by technical specialists. Since this is the biggest opportunity in the market, this is where focused efforts should start.

A thorough examination of the results is still pending, but in the meantime, it can be used as a starting point for creating a narrative about the expected course of market development. The use case level crafting of this narrative will be complex, but the aggregation of use cases with similar service characteristics will give an overall picture of how the market is anticipated to develop.

Our analytical focus is not confined to scrutinizing collected data; rather, it extends to the examination of data meticulously generated through a structural methodology. This methodological approach ensures the generation of data with a high degree of precision, employing consistent unit costs that are meticulously aligned with tangible market drivers, such as the numerical count of cars, cows, containers, and other pertinent factors. This strategic alignment with actual market dynamics reinforces the robustness and relevance of our analytical framework within the Cloud-Edge-IoT domain.

5.2 Analysis of the data

5.2.1 Usage and Growth

Analysing usage trends across various use cases offers insightful information about how technology adoption is changing. As shown in the table below: Table 3 - Details on Use Case and Use Case Solution Analysis, 21% of respondents support the combined category of autonomous driving and process automation/optimization (L6), making it a crucial area of attention. This use case is considered in expansion by 29% of the respondents, which suggests the adoption of automation and optimisation technologies is consistently increasing in industries. Given the significant growth in Automation (L6) and its relatively high usage, there may be a strategic opportunity to focus efforts on this segment, as it represents the most notable opportunity in the market according to the survey.

Location tracking (L1) is one of the most popular applications among the respondents to the survey (19% of them are currently using this technology) and it is expected to grow by 11% of the audience, indicating a growing understanding of its importance. With 14% of respondents both using this use case and expecting to increase in 1-year, Visual Inspection (L2), demonstrates its growing importance across various industries.

Level of aggregation	Respondents "Using"	1 year Growth
L1: Location tracking	19%	11%
L2: Visual inspection	14%	14%
L3: Condition monitoring	29%	10%
L4: Predictive maintenance	10%	10%
L5: Asset command and control	7%	15%
L6: Automation (Autonomous driving, process automation/optimization)	21%	29%
Total	100%	15%

Table 3 - Details on Use Case and Use Case Solution Analysis

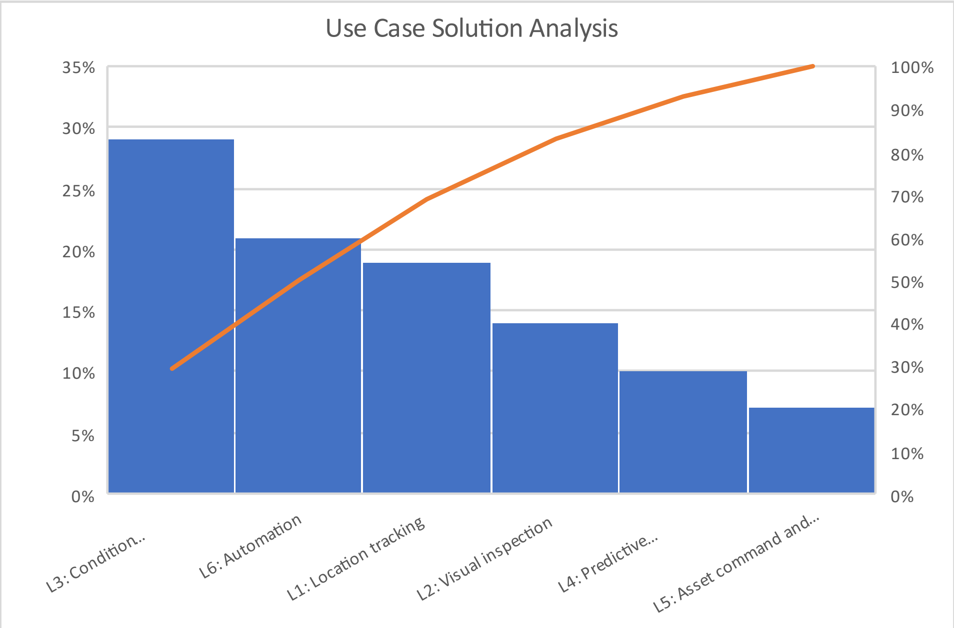

Figure 4 – Use case Analysis and Cross-Sectors Level Clusterisation

Predictive maintenance (L4) and condition monitoring (L3) are currently experiencing notable levels of adoption, standing at 10% and 29%, respectively. These figures emphasize the continued importance of these technologies in improving operational efficiency and proactively preventing equipment malfunctions. Despite their acknowledged significance, it's worth noting that both use cases are projected to see a modest growth of 10% in the coming year. While this growth indicates a positive trend, it also highlights that these Levels (L4 and L3) are among those with comparatively smaller expected expansion compared to other emerging technologies. Nevertheless, their sustained adoption underscores their enduring role in optimizing industrial processes and minimizing the risks associated with equipment failures. Despite only being used by 7% of respondents now, Asset Command and Control (L5) enjoys the trust of 15%, with an expected growth trajectory in line with other aggregation levels. This indicates that more people are becoming aware of the advantages of centralised asset management across a range of industries.
The adoption of Cloud-Edge-IoT solutions shows a commendable average growth of 15% among surveyed experts. Although this figure indicates a positive and steady trend, it does not necessarily reflect an explosive phase in business, implying that companies may approach the market with a measured pace rather than a rushed influx. This nuanced perspective suggests a strategic and thoughtful approach to the integration of Cloud-Edge-IoT solutions, highlighting a balance between growth and prudent decision-making within the business landscape.
Despite the importance of edge infrastructure for realizing the full potential of edge computing, the survey indicates current usage of cloud-centric models, which may suggest a lag in the development or adoption of true edge infrastructure.

5.2.2 Development

Strong growth rates across a range of use cases highlight a changing and dynamic environment where businesses are progressively adopting cutting-edge technologies to rethink their operational paradigms. A strategic realisation of the potential advantages that these technologies bring to the forefront is reflected in the collective shift towards innovation. Technologies like Location Tracking, Visual Inspection, Condition Monitoring, Predictive Maintenance, Asset Command and Control, and Autonomous Driving/Process Automation Optimisation are becoming more and more popular. This is indicative of a larger trend in which companies are actively looking for ways to improve productivity, increase dependability, and give them more precise operational control.

This trend reflects an industry-wide paradigm shift from reactive to proactive approaches, where the integration of these use cases is seen as a strategic imperative for sustained competitiveness rather than just technological improvements. The significant growth percentages indicate that people are becoming more and more aware of the revolutionary effects that these technologies can have on process optimisation, downtime reduction, and overall operational performance optimisation. The widespread excitement surrounding these use cases also indicates a growing dedication to utilising automation and data-driven insights, which will eventually result in more resilient and agile business operations.

This trajectory also suggests a wider understanding of the critical role technology plays in future-proofing industries. In an era of swift technological advancement, adopting these sophisticated use cases is imperative for organisations to maintain their competitive edge. The information presents a picture of a future in which innovative technologies are an essential part of many industries' operations, leading them into a new era of effectiveness, dependability, and all-encompassing operational control, in addition to showcasing the state of adoption as it stands today.

5.2.3 Outcomes

As advanced technologies continue to be adopted at a remarkable rate, it will be necessary to move from crude indicators to more accurate estimations in the future. The UNLOCK-CEI project is positioned to be a key player in this evolution by substituting more precise application cost estimates for these preliminary indicators. With a more nuanced understanding of the market size and a better understanding of the economic factors and possible returns on investment related to these transformative technologies, stakeholders should benefit from this shift.

It's critical to consider respondents' future plans in addition to their current utilisation in order to fully assess the impact and potential market size. An analysis of the proportion of respondents who indicated both current and future "use" and "plans" offers a forward-looking view of the trajectory of technology adoption. One important factor influencing the continued expansion and development of these use cases is an understanding of how companies and industries plan to incorporate these technologies into their operations going forward.

Moreover, WP2 is poised to explore finer points, like target audiences, the volume of data flowing through it, and the level of analytics that go into it. By breaking these down, a more thorough grasp of the unique requirements and difficulties in each industry can be attained. This more sophisticated method guarantees that the estimates and analyses that follow capture the nuances of various industries, enabling a customised and focused application of these technologies.

Essentially, the progression from preliminary markers to the revelations offered by WP2 signifies a development in the methodology for comprehending and utilising cutting-edge technologies. It highlights a dedication to accuracy, which is essential as sectors attempt to make sense of a world characterised by quick technical breakthroughs and use them to improve control, dependability, and operational efficiency.

5.2.4 The importance of the physical scope

Initial analysis underscores that Cloud-Edge-IoT (CEI) Use Case Applications predominantly concentrate on a "Limited Area." This spatial focus yields numerous advantages, particularly for edge infrastructure. Smaller, confined spaces lend themselves more seamlessly to deploying edge infrastructure, facilitating the implementation of targeted and localized solutions. Furthermore, the feasibility of private 5G solutions in these delimited regions emerges as a crucial enabler, acting as a technological driver for the broader integration of edge nodes.

In this small window, the idea of private 5G solutions acts as a possible "beachhead" for the larger distribution of edge nodes. A phased and scalable deployment is made possible by this strategic approach, guaranteeing that initial investments are not only feasible but also scalable through a federated model. The presumption that early investments are capable of "federation" is consistent with the notion that these solutions are intended to develop and blend in with larger ecosystems without any problems.

Furthermore, the “limited area” use cases offer a special chance for focused investment plans. Local clients can choose to pay only for the resources they really require, which encourages a customised and economical approach. In addition, more capacity to support federated users as well as more sophisticated federated capabilities may be funded concurrently to guarantee an equitable and inclusive deployment.

The “limited area” use cases also show benefits in terms of real-world application. These can be accomplished with a minimum of one edge node, removing the need for instantaneous cloud integration. This streamlined approach contributes to the efficiency and autonomy of these limited area use cases by simplifying the deployment process and highlighting their self-sufficiency. With a pragmatic and scalable approach, the strategic focus on "Limited Area" CEI Use Case Applications essentially paves the way for larger, federated deployments in the rapidly developing cloud-edge technology landscape by utilising the benefits of edge infrastructure and private 5G solutions.

5.2.5 Target Types

The Cloud-Edge-IoT (CEI) convergence of technologies offers an interesting convergence where different use case targets are present in multiple applications. Employees, movable assets (high and low value), farm equipment, logistics equipment, transport vehicles, dialysis machines, patient monitors, fixed assets (various value), machine tools, substation equipment (such as transformers), and even products are among the wide range of targets that span diverse sectors. The variety of targets demonstrates how broadly applicable CEI solutions are, extending beyond industry boundaries to meet a broad range of operational requirements.

Given the prominence of these targets in various use cases, it is reasonable to assume that market scenarios for devices associated with comparable targets will develop concurrently. For example, goals like command and control, condition monitoring, predictive maintenance, and location tracking are common themes in many different industries. These scenarios' similarities point to universality in the opportunities and challenges related to these goals, suggesting that breakthroughs or innovations in one area may have an impact on and spur development in other areas.

The coordinated expansion of use cases with comparable goals is one way in which this interconnected evolution is most obvious. For example, there may be a simultaneous increase in demand for location-tracking solutions across industries, which would result in a synchronised adoption trajectory for location-based technologies. Comparably, functionalities like condition monitoring, predictive maintenance, and targeted command and control could grow in unison and promote a synergistic evolution of CEI technologies across industries.

Essentially, the CEI framework's common goals and use cases weave a complex web of interconnected possibilities. The changing market scenarios indicate not only how flexible and scalable CEI solutions are, but also how society is moving towards a more technologically connected future in which many industries profit from the improvements and streamlined processes made possible by these game-changing technologies.

5.2.6 Analysis of Data Frequency and Volumes

In Cloud-Edge-IoT solutions, the frequency of data collection has a significant impact on how responsive and efficient these systems are. Information about the frequency classification is shown in the table below:Table 4 - Data Frequency Collection.

The three categories—fast, medium, and slow—show a varied distribution, according to the figures that are displayed. It makes up a sizeable amount in the first case, where data collection is classified as quick, ranging from 44% to 67%. Rapid data collection is common, indicating that real-time insights and fast response times should be prioritised. This is in line with applications that require instantaneous decision-making, like traffic management or healthcare monitoring.

On the other hand, adoption rates in the medium data collection category range from 11% to 56%. This category probably reflects use cases that aim to strike a compromise between resource efficiency and real-time processing, serving use cases that might not demand instantaneous answers but still need timely and pertinent data.

The percentages in the category of slow data collection range from 14% to 88%. This implies situations in which a slower pace of data collection is appropriate, possibly in applications where the conclusions drawn from the data do not necessitate quick action or where resource limitations demand a more measured approach.

The heterogeneous distribution observed among these data collection frequencies illustrates how Cloud-Edge-IoT solutions can be tailored to the unique needs of various industries and applications. The inclusion of medium and slow categories recognises the varied nature of data needs across the technological landscape, while the emphasis on rapid data collection highlights the significance of real-time decision-making in specific use cases. Because of this adaptability, Cloud-Edge-IoT solutions can be customised to fit a wide range of scenarios, increasing their usefulness and efficacy in a variety of settings.

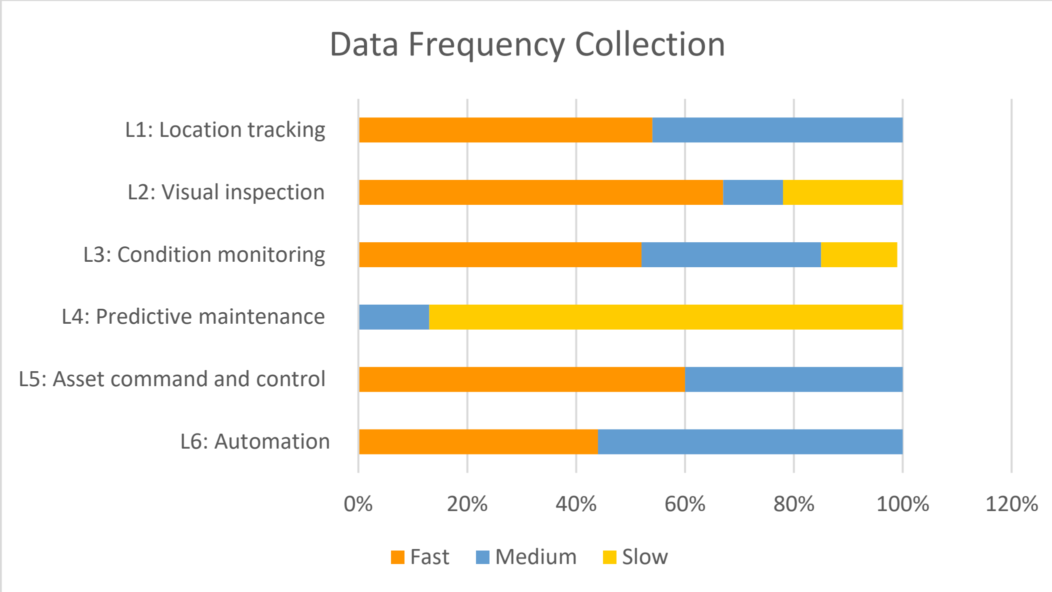

Figure 5 - Data Frequency Collection

Level	Use Case (from IDC D1.2 Section 4)	High	Medium	Low
L1: Location tracking	Agriculture Animal Tagging	0%	100%	0%
L1: Location tracking	Asset location tracking	33%	67%	0%
L1: Location tracking	Employee safety monitoring	100%	0%	0%
L1: Location tracking	Fleet tracking	50%	50%	0%
L1: Location tracking	Hospital Asset Tracking	0%	100%	0%
L1: Location tracking	Passenger traffic flow	100%	0%	0%
L1: Location tracking	**Total**	**54%**	**46%**	**0%**
L2: Visual inspection	Drone-based observation	100%	0%	0%
L2: Visual inspection	Quality of shipment conditions	0%	100%	0%
L2: Visual inspection	Vehicle and infrastructure inspection	100%	0%	0%
L2: Visual inspection	Video security and surveillance	80%	0%	20%
L2: Visual inspection	Visual inspection - quality/integrity	0%	0%	100%
L2: Visual inspection	**Total**	**67%**	**11%**	**22%**
L3: Condition monitoring	Agriculture Field Monitoring	0%	0%	100%
L3: Condition monitoring	Bedside Telemetry	100%	0%	0%
L3: Condition monitoring	Employee safety monitoring	75%	25%	0%
L3: Condition monitoring	Field service technician monitoring	100%	0%	0%
L3: Condition monitoring	Food traceability	0%	0%	100%
L3: Condition monitoring	Livestock monitoring	100%	0%	0%
L3: Condition monitoring	Regulatory compliance	25%	50%	25%
L3: Condition monitoring	Remote Health Monitoring	0%	100%	0%
L3: Condition monitoring	Remote network management	0%	100%	0%
L3: Condition monitoring	Visual Inspection	100%	0%	0%
L3: Condition monitoring	**Total**	**52%**	**33%**	**14%**
L4: Predictive maintenance	AI-enabled Diagnosis and Treatment	0%	0%	100%
L4: Predictive maintenance	Asset monitoring and maintenance	0%	0%	100%
L4: Predictive maintenance	Asset monitoring and maintenance - OEM	0%	0%	100%

L4: Predictive maintenance	Asset monitoring and maintenance - retrofit	0%	0%	100%
L4: Predictive maintenance	Robots or augmented-reality-assisted surgery	0%	0%	100%
L4: Predictive maintenance	Sensor-based diagnostics & maintenance	0%	100%	0%
L4: Predictive maintenance	**Total**	**0%**	**13%**	**87%**
L5: Asset command and control	Asset command and control	50%	50%	0%
L5: Asset command and control	Smart meters	100%	0%	0%
L5: Asset command and control	**Total**	**60%**	**40%**	**0%**
L6 Automation	Automated guided vehicles (AGVs)	100%	0%	0%
L6 Automation	Autonomous vehicles	100%	0%	0%
L6 Automation	Connected drilling and extraction	0%	100%	0%
L6 Automation	Fleet tracking	0%	100%	0%
L6 Automation	Freight monitoring	0%	100%	0%
L6 Automation	Manufacturing operations/automation	0%	100%	0%
L6 Automation	Process automation and optimization	33%	67%	0%
L6 Automation	Smart building	20%	80%	0%
L6 Automation	**Total**	44%	56%	0%
L1-L2-L3-L4-L5-L6	**Grand Total**	**47%**	**37%**	**16%**

Table 4 - Data Frequency Collection

As well as the frequency of data collection, another crucial component of Cloud-Edge-IoT solutions is the volume of data gathered, which affects system efficiency overall, processing demands, and storage needs. The data collection volume is divided into three categories in the presented figures: high, low, and medium. This reveals a subtle distribution across different scenarios. The information is shown in the table below: Table 5 - Data Collection Volume.

In cases where the volume of data collected is categorised as high, the percentages vary between 11% and 89%. This implies that there is a widespread requirement for systems to manage large volumes of data, which is indicative of applications like manufacturing processes, energy grid monitoring, and video surveillance, which generate large datasets.

On the other hand, low data collection volumes—which range from 8% to 20%—dominate in certain scenarios. These examples probably correspond to use cases—like some agricultural monitoring applications or healthcare scenarios—where the volume of data generated is constrained.

The range of adoption rates shown by the medium data collection volume is 11% to 80%. This category represents situations that require a moderate level of data processing and storage capabilities, indicating a balanced approach.

The heterogeneous distribution observed in these categories of data collection volume highlights the flexibility of Cloud-Edge-IoT solutions in meeting the data requirements of various industries and applications. While the inclusion of low and medium categories acknowledges the varied nature of data generation across diverse technological landscapes, the prevalence of high data collection volumes highlights the importance of a strong infrastructure capable of handling large datasets. Because of their adaptability, Cloud-Edge-IoT solutions can be customised to efficiently handle and use different amounts of data in various contexts.

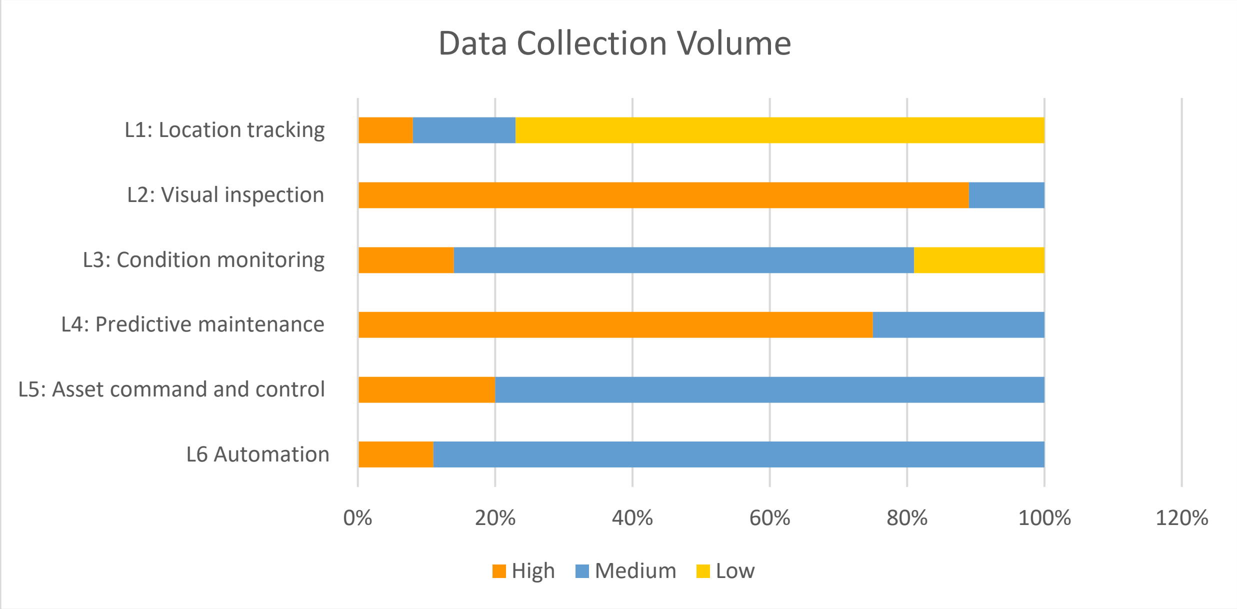

Figure 6 - Data Collection Volume

Level	Use Case (from IDC D1.2 Section 4)	High	Medium	Low
L1: Location tracking	Agriculture Animal Tagging	0%	0%	100%
L1: Location tracking	Asset location tracking	0%	33%	67%
L1: Location tracking	Employee safety monitoring	0%	0%	100%
L1: Location tracking	Fleet tracking	0%	50%	50%
L1: Location tracking	Hospital Asset Tracking	0%	0%	100%
L1: Location tracking	Passenger traffic flow	100%	0%	0%
L1: Location tracking	**Total**	**8%**	**15%**	**77%**
L2: Visual inspection	Drone-based observation	0%	100%	0%
L2: Visual inspection	Quality of shipment conditions	100%	0%	0%
L2: Visual inspection	Vehicle and infrastructure inspection	100%	0%	0%
L2: Visual inspection	Video security and surveillance	100%	0%	0%
L2: Visual inspection	Visual inspection - quality/integrity	100%	0%	0%
L2: Visual inspection	**Total**	**89%**	**11%**	**0%**
L3: Condition monitoring	Agriculture Field Monitoring	0%	0%	100%
L3: Condition monitoring	Bedside Telemetry	100%	0%	0%
L3: Condition monitoring	Employee safety monitoring	0%	87%	13%
L3: Condition monitoring	Field service technician monitoring	0%	100%	0%
L3: Condition monitoring	Food traceability	100%	0%	0%
L3: Condition monitoring	Livestock monitoring	0%	100%	0%
L3: Condition monitoring	Regulatory compliance	0%	50%	50%
L3: Condition monitoring	Remote Health Monitoring	0%	100%	0%
L3: Condition monitoring	Remote network management	0%	100%	0%
L3: Condition monitoring	Visual inspection - quality/integrity	100%	0%	0%
L3: Condition monitoring	**Total**	**14%**	**67%**	**19%**
L4: Predictive maintenance	AI-enabled Diagnosis and Treatment	100%	0%	0%
L4: Predictive maintenance	Asset monitoring and maintenance	67%	33%	0%
L4: Predictive maintenance	Asset monitoring and maintenance - OEM	100%	0%	0%
L4: Predictive maintenance	Asset monitoring and maintenance - retrofit	100%	0%	0%
L4: Predictive maintenance	Robots or augmented-reality-assisted surgery	100%	0%	0%
L4: Predictive maintenance	Sensor-based diagnostics & maintenance	0%	100%	0%

L4: Predictive maintenance	**Total**	**75%**	**25%**	**0%**
L5: Asset command and control	Asset command and control	0%	100%	0%
L5: Asset command and control	Smart meters	100%	0%	0%
L5: Asset command and control	**Total**	**20%**	**80%**	**0%**
L6 Automation	Automated guided vehicles (AGVs)	25%	75%	0%
L6 Automation	Autonomous vehicles	0%	100%	0%
L6 Automation	Connected drilling and extraction	100%	0%	0%
L6 Automation	Fleet tracking	0%	100%	0%
L6 Automation	Freight monitoring	0%	100%	0%
L6 Automation	Manufacturing operations/automation	0%	100%	0%
L6 Automation	Process automation and optimization	0%	100%	0%
L6 Automation	Smart building	0%	100%	0%
L6 Automation	**Total**	**11%**	**89%**	**0%**
L1-L2-L3-L4-L5-L6	**Grand Total**	**28%**	**53%**	**19%**

Table 5 - Data Collection Volume

5.2.7 Data Analysis Location

The information about data analysis location is shown in the Table 6 - Data Analysis Location Distribution per Level and Use Case below.

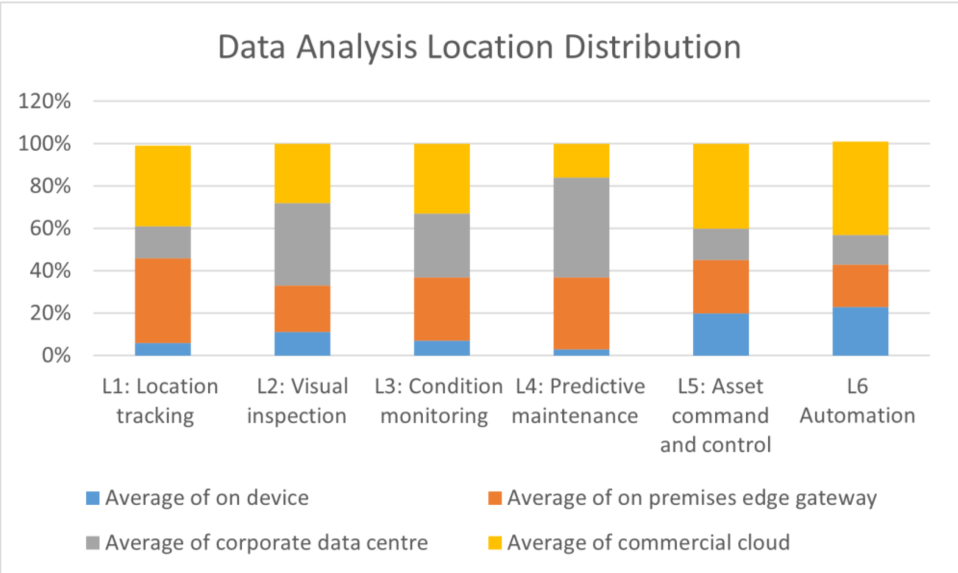

Figure 7 - Data Analysis Location Distribution

Level	*Use Case (from IDC D1.2 Section 4)*	Average of on device	Average of on premises edge gateway	Average of corporate data centre	Average of commercial cloud
L1: Location tracking	Agriculture Animal Tagging	0%	100%	0%	0%
L1: Location tracking	Asset location tracking	0%	58%	0%	42%
L1: Location tracking	Employee safety monitoring	13%	44%	19%	25%
L1: Location tracking	Fleet tracking	0%	38%	0%	63%
L1: Location tracking	Hospital Asset Tracking	0%	0%	25%	75%
L1: Location tracking	Passenger traffic flow	25%	0%	75%	0%
L1: Location tracking	**Total**	**6%**	**40%**	**15%**	**38%**
L2: Visual inspection	Drone-based observation	0%	0%	0%	100%
L2: Visual inspection	Quality of shipment conditions	0%	50%	0%	50%
L2: Visual inspection	Vehicle and infrastructure inspection	25%	0%	0%	75%
L2: Visual inspection	Video security and surveillance	15%	24%	56%	5%
L2: Visual inspection	Visual inspection - quality/integrity	0%	25%	75%	0%
L2: Visual inspection	**Total**	**11%**	**22%**	**39%**	**28%**
L3: Condition monitoring	Agriculture Field Monitoring	0%	100	0%	0%
L3: Condition monitoring	Bedside Telemetry	0%	0%	100%	0%
L3: Condition monitoring	Employee safety monitoring	19%	38%	19%	25%
L3: Condition monitoring	Field service technician monitoring	0%	0%	0%	100%
L3: Condition monitoring	Food traceability	0%	0%	0%	100%
L3: Condition monitoring	Livestock monitoring	0%	100%	0%	0%
L3: Condition monitoring	Regulatory compliance	0%	25%	25%	50%
L3: Condition monitoring	Remote Health Monitoring	0%	0%	100%	0%
L3: Condition monitoring	Remote network management	0%	0%	0%	100%
L3: Condition monitoring	Visual inspection - quality/integrity	0%	20%	80%	0%
L3: Condition monitoring	**Total**	**7%**	**30%**	**30%**	**33%**
L4: Predictive maintenance	AI-enabled Diagnosis and Treatment	0%	0%	100%	0%
L4: Predictive maintenance	Asset monitoring and maintenance	8%	33%	25%	33%
L4: Predictive maintenance	Asset monitoring and maintenance - OEM	0%	50%	50%	0%
L4: Predictive maintenance	Asset monitoring and maintenance - retrofit	0%	50%	50%	0%
L4: Predictive maintenance	Robots or augmented-reality-assisted surgery	0%	0%	100%	0%
L4: Predictive maintenance	Sensor-based diagnostics & maintenance	0%	75%	0%	25%
L4: Predictive maintenance	**Total**	**3%**	**34%**	**47%**	**16%**
L5: Asset command and control	Asset command and control	25%	31%	19%	25%
L5: Asset command and control	Smart meters	0%	0%	0%	100%
L5: Asset command and control	**Total**	**20%**	**25%**	**15%**	**40%**
L6 Automation	Automated guided vehicles (AGVs)	25%	13%	19%	44%
L6 Automation	Autonomous vehicles	42%	17%	25%	17%
L6 Automation	Connected drilling and extraction	0%	50%	0%	50%
L6 Automation	Fleet tracking	25%	25%	0%	50%
L6 Automation	Freight monitoring	25%	25%	0%	50%
L6 Automation	Manufacturing operations/automation	25%	0%	0%	75%
L6 Automation	Process automation and optimization	17%	42%	0%	42%
L6 Automation	Smart building	20%	10%	25%	45%
L6 Automation	**Total**	**23%**	**20%**	**14%**	**44%**
L1-L2-L3-L4-L5-L6	**Grand Total**	**12%**	**28%**	**25%**	**35%**

Table 6 - Data Analysis Location Distribution per Level and Use Case

5.2.7.1 *L1 for location tracking*

The data location analysis for Cloud-Edge-IoT solutions within the cross-sector L1 (location tracking) segmentation reveals varied preferences and requirements across different use cases. The average distribution of data location for each use case provides insights into the predominant choices made by industries for deploying these solutions.

In the Agriculture Animal Tagging use case, the average data location indicates a strong preference for on-premises edge gateways, with data entirely stored in this location. This choice aligns with the need for real-time tracking and monitoring of animals in remote agricultural settings, where on-device solutions might have limitations.

For Asset Location Tracking, the average data location distribution shows a balanced approach, with 58% stored on premises edge gateways and 42% in commercial cloud services. This suggests a strategic combination of local and cloud storage to ensure both immediate accessibility and scalability.

Employee Safety Monitoring exhibits a diversified data location preference, with 44% on-premises edge gateways, 25% in commercial cloud services, and 19% in corporate data centres. This distribution reflects the complex nature of ensuring employee safety, requiring a mix of local and cloud-based resources.

Fleet Tracking, on average, leans towards commercial cloud services with 63%, emphasizing the scalability and accessibility advantages offered by cloud-based solutions. The remaining 38% is distributed across on-premises edge gateways, indicating a hybrid approach to meet specific operational needs.

In Hospital Asset Tracking, the data location distribution is characterized by 75% in corporate data centres and 25% in commercial cloud services. This choice aligns with the healthcare sector's emphasis on data security and compliance, often preferring on-premises solutions.

Passenger Traffic Flow, on average, reveals a preference for corporate data centres (75%) and on-device storage (25%). This suggests a balance between immediate data processing capabilities at the edge and the storage and analysis capabilities of corporate data centres.

5.2.7.2 L2 for visual inspection

The cross-sector L2 (visual inspection) data location analysis for Cloud-Edge-IoT solutions sheds light on the diverse preferences and requirements across different use cases, emphasizing the critical role of visual inspection in various industries.

For Drone-Based Observation, the average data location indicates a strong reliance on commercial cloud services, with 100% of data stored in this location. This aligns with the need for centralized processing and storage capabilities for the vast amounts of visual data captured by drones during observation tasks.

Quality of Shipment Conditions exhibits a balanced approach to data storage, with 50% on-premises edge gateways and 50% in commercial cloud services. This distribution reflects the need for both immediate access to data during shipment inspections and the scalability offered by cloud-based solutions.

In Vehicle and Infrastructure Inspection, the average data location distribution leans heavily towards commercial cloud services (75%), emphasizing the scalability and accessibility advantages for managing the visual data generated during vehicle and infrastructure inspections.

Video Security and Surveillance present a nuanced data location preference, with 56% stored in corporate data centres, 24% in on-premises edge gateways, and 15% in commercial cloud services. This indicates a diversified approach, likely driven by the varying security and compliance requirements across different industries.

Visual Inspection - Quality/Integrity showcases a clear preference for corporate data centres, with 75% of data stored in this location. This choice aligns with the emphasis on data security and integrity in applications where visual inspection plays a crucial role in maintaining quality standards.

5.2.7.3 L3 for condition monitoring

The cross-sector L3 (condition monitoring) data location analysis for Cloud-Edge-IoT solutions underscores the nuanced choices made by industries in deploying these solutions for various use cases centred around condition monitoring.

Agriculture Field Monitoring reveals a preference for on-premises edge gateways, with 100% of data stored in this location. This choice aligns with the need for real-time monitoring and immediate access to data in agricultural field conditions, where on-device solutions might encounter limitations.

For Bedside Telemetry in the healthcare sector, the average data location shows a complete reliance on corporate data centres, with 100% of data stored in this location. This aligns with the healthcare industry's emphasis on data security and compliance, ensuring patient telemetry data is securely managed.

Employee Safety Monitoring exhibits a diversified approach to data storage, with 38% on-premises edge gateways, 25% in commercial cloud services, and 19% in corporate data centres. This distribution reflects the complex nature of ensuring employee safety, requiring a mix of local and cloud-based resources.

Field Service Technician Monitoring shows a strong reliance on commercial cloud services, with 100% of data stored in this location. This choice aligns with the need for centralized processing and storage capabilities for monitoring and maintaining equipment in diverse field service scenarios.

In Food Traceability, the average data location distribution emphasizes a complete reliance on commercial cloud services, with 100% of data stored in this location. This choice ensures the scalability and accessibility needed to trace food products across the supply chain.

Livestock Monitoring in the agriculture sector exhibits a preference for on-premises edge gateways, with 100% of data stored in this location. This choice aligns with the need for immediate access to real-time monitoring data in remote agricultural settings.

Regulatory Compliance showcases a diversified data location preference, with 50% in commercial cloud services, 25% in corporate data centres, and 25% on-premises edge gateways. This distribution reflects the need to comply with regulations across various industries, requiring a mix of storage solutions.

Remote Health Monitoring in the healthcare sector shows a complete reliance on corporate data centres, with 100% of data stored in these locations. This aligns with the healthcare industry's focus on data security and compliance, especially when dealing with sensitive health information.

Remote Network Management (e.g., fault detection) exhibits a strong reliance on commercial cloud services, with 100% of data stored in this location. This choice ensures the scalability and accessibility needed for managing and monitoring network conditions.

Visual Inspection - Quality/Integrity reveals a preference for corporate data centres, with 80% of data stored in this location. This choice aligns with the emphasis on data security and integrity in applications where visual inspection plays a crucial role in maintaining quality standards.

5.2.7.4 L4 for predictive maintenance

The cross-sector L4 (predictive maintenance) data location analysis for Cloud-Edge-IoT solutions reveals distinct preferences across various use cases where predictive maintenance is a critical component.

AI-Enabled Diagnosis and Treatment in the healthcare sector demonstrates a complete reliance on corporate data centres, with 100% of data stored in these locations. This choice aligns with the healthcare industry's emphasis on data security and compliance, ensuring patient diagnosis and treatment information is securely managed.

Asset Monitoring and Maintenance presents a diversified approach to data storage, with 33% in on-premises edge gateways, 25% in corporate data centres, and 33% in commercial cloud services. This distribution reflects the need for a mix of local and cloud-based resources to ensure real-time monitoring and maintenance of critical assets.

Asset Monitoring and Maintenance - OEM and Asset Monitoring and Maintenance - Retrofit both exhibit a balanced approach to data storage, with 50% in on-premises edge gateways and 50% in commercial cloud services. This distribution reflects the need for immediate access to data during maintenance operations and the scalability offered by cloud-based solutions.

Robots or Augmented-Reality-Assisted Surgery in the healthcare sector showcase a complete reliance on corporate data centres, with 100% of data stored in these locations. This aligns with the healthcare industry's focus on data security and compliance, especially when dealing with sensitive surgical and patient information.

Sensor-Based Diagnostics & Maintenance demonstrates a preference for on-premises edge gateways, with 75% of data stored in this location. This choice aligns with the need for real-time monitoring and diagnostics, especially in scenarios where immediate responses to equipment conditions are crucial.

5.2.7.5 L5 for asset command and control

The cross-sector L5 (asset command and control) data location analysis for Cloud-Edge-IoT solutions highlights the diverse strategies employed across industries where efficient asset command and control are crucial.

For Asset Command and Control, the average data location distribution shows a balanced approach, with 31% in on-premises edge gateways, 25% in corporate data centres, and 25% in commercial cloud services. This distribution reflects the need for a mix of local and cloud-based resources to ensure effective command and control of assets in various operational scenarios.

Smart Meters in the energy and utilities sector exhibit a complete reliance on commercial cloud services, with 100% of data stored in this location. This choice aligns with the energy industry's emphasis on scalability and accessibility, ensuring efficient management of smart meters and associated data.

5.2.7.6 L6 for autonomous driving, process automation/optimization

The cross-sector L6 (autonomous driving, process automation/optimization) data location analysis for Cloud-Edge-IoT solutions reveals diverse strategies across industries, reflecting the distinct operational requirements of each use case.

Automated Guided Vehicles (AGVs) showcase a varied approach to data storage, with 44% in commercial cloud services, 25% in on-premises edge gateways, and 19% in corporate data centres. This distribution highlights the need for a mix of local and cloud-based resources to ensure efficient command and control of AGVs.

Autonomous Vehicles demonstrate a distributed approach to data storage, with 42% in on-premises edge gateways, 25% in corporate data centres, and 17% in commercial cloud services. This strategy ensures a combination of local processing capabilities and the scalability offered by cloud services for the complex data generated by autonomous vehicles.

Connected Drilling and Extraction present an equal distribution between on-premises edge gateways and commercial cloud services, reflecting the need for a balanced approach to data storage in this sector. This approach ensures both real-time processing capabilities and the scalability required for connected drilling and extraction operations.

For Fleet Tracking and Freight Monitoring, a balanced approach is observed, with 25% in on-premises edge gateways, 25% in corporate data centres, and 50% in commercial cloud services. This distribution aligns with the dynamic nature of fleet tracking and the need for scalable solutions in freight monitoring.

Manufacturing Operations/Automation showcase a preference for on-premises edge gateways, with 75% of data stored in this location. This choice aligns with the manufacturing sector's emphasis on real-time processing and control of automated operations within the manufacturing facility.

Process Automation and Optimization exhibit a balanced approach, with 42% in on-premises edge gateways, 42% in commercial cloud services, and 17% in corporate data centres. This distribution reflects the need for both local and cloud-based resources to achieve efficient process automation and optimization.

Smart Building strategies include 45% in commercial cloud services, 25% in on-premises edge gateways, and 20% in corporate data centres. This distribution ensures the scalability and accessibility required for smart building applications.

5.3 A Cross-Sector Example - Employee Safety Monitoring

The project presents a comprehensive analysis to guide strategic resource allocation for Employee Safety Monitoring in diverse sectors, considering both reported incidents and potential risk factors, it takes into account the number of businesses and employment data in order to determine the size of the market for safety monitoring systems in various sectors. This methodical technique guarantees a comprehensive comprehension of the market environment, which finally leads to a more precise and sophisticated evaluation of market sizing. The analysis is intended as a valuable guide for strategic decision-making in the implementation of similar initiatives across diverse sectors within the Open European Cloud-Edge-IoT Ecosystem.

To assess Employee Safety Monitoring across multiple sectors, our analysis utilizes self-reported workplace accident data from Eurostat's 2020 extensive report of "accidents reported at work" for the EU 27. Key findings include:
The reported incident rate of 2.3% for employees experiencing accidents in a 12-month period provides a baseline understanding of workplace safety across the EU 27.

Several sectors exhibit incident rates above the average:

- Agriculture, Forestry, Fishing: 2.8%
- Industrial (excluding construction): 2.6%
- Construction: 4.1%
- Wholesale/Retail, Transport, Acc. & Food Services, Info & Comms: 2.3%
- All other sectors: 2.0%

Identifying "excess percentages" in sectors like Agriculture, Forestry, Fishing (0.5%), Industrial (including energy) (0.3%), and Construction (1.8%) serves as a metric for estimating potential investments in employee safety monitoring. While other sectors, such as Transport and Healthcare, show no excess accidents, a conservative factor is considered across employment, particularly in Transport, to encompass potential use cases.

Investment Sizing: The potential market size for employee safety monitoring across different sectors is estimated considering the number of employees in each sector and the number of excess accidents. This provides insights into the markets where this challenge needs to be earlier, highlighting the broader impact of workplace safety issues.

Finally, we refine the projection based on the distribution of employees by enterprise, with the following assumption: the willingness to invest in safety solutions is measured pragmatically, assuming a minimum value added per firm of 5 million euros, enterprises with this size are considered a potential market for the use case, as smaller enterprises may have less availability for investment. However, we also took into account the cases of enterprises with up to nine employees, recognizing that accidents can result in significant financial consequences (e.g., loss of income, operational disruptions), as for such small enterprises' personnel, the immediate impact on the business may be higher and replacement may be more difficult.
Within the agricultural setting, the analysis focuses on farm holdings that produce more than 100,000 euros in standard output annually. This criterion aids in focusing on large-scale agricultural activities. A sector is assumed to be a prime target for employee safety monitoring systems if it reports incidents at a rate higher than normal (for example, 0.3% of employees in agriculture), meaning that a proportionately greater number (for example, 10 times) are exposed to similar dangers.

5.4 A Cross-Sector Example - Livestock Tracking

By assessing the possible application of tracking technologies based on the most productive farms in the European Union with an annual standard output surpassing €500,000, the market sizing technique adopts a targeted approach. This criterion guarantees a focused examination of farms that possess significant financial resources, suggesting a greater inclination to allocate funds towards cutting-edge tracking equipment. The emphasis is on cattle because the most productive farms for pigs and poultry are often smaller in size, which lowers the risk of animal mishaps. Furthermore, there aren't many highly profitable farms that specialise in other grazing species like sheep and goats, and the large grazing ranges these animals graze throughout can increase the expense of tracking technology.

Eurostat offers useful information on the number of animals on EU farms, indicating that there are 77 million cows in total. Interestingly, 25,000 larger agricultural organisations categorised as Farm Types 45, 46, and 47 are in charge of 10.5 millions of these cows. This division guarantees a focused examination of farms with sizable herds of cattle that meet the chosen standards for market assessment.

Application costing considers tracking animals, which is similar to tracking employees and is connected to a local base station intended for a "limited area." Each tracker is expected to cost €25, making this an affordable option for keeping an eye on individual animals. Furthermore, for larger agricultural operations, a field installation cost of €750 is envisaged for base station installation. The methodology's cautious approach to evaluating possible expenses is highlighted by the possibly conservative assumption that each firm will have one base station, particularly for multi-site enterprises. All things considered, this extensive technique combines factors like application costing, economic capacity, and livestock population data to offer a targeted and sophisticated market sizing estimate for animal monitoring solutions in the agricultural industry.

5.5 Understanding the roles

5.5.1 Approach

In every industry, installers and system integrators play a crucial role in making sure that Cloud-Edge-IoT solutions are physically deployed and seamlessly integrated. Their knowledge covers a wide range of industries, tackling issues unique to each, like real-time patient monitoring in healthcare or energy efficiency in manufacturing.

Valuable insights for business developers and CEI technology providers regarding potential gaps in networks and value chains, as well as potential business opportunities, data, and revenue flows comes from the reports gathered by VDI. Both the researchers working on the scientific projects and the commercial CEI users and providers need to know the gathered service requirements.[13]

Communication service providers (CSPs) offer specialised solutions for effective data transmission and connectivity, navigating the various demands of each sector. Specialised network providers in the healthcare industry concentrate on strict data security, whereas general network evolution providers support the wider advancement of communication infrastructure, which benefits manufacturing and transportation.

In a cross-sectoral setting, the function of cloud service providers (CSPs) is ubiquitous but complex. Cloud services can be used for precision farming in agriculture, and they can help with the analysis and storage of private patient data in the healthcare industry. Transportation depends on cloud infrastructure for real-time traffic management, and the manufacturing sector uses cloud services to optimise processes.

Additional roles[14] have been delineated to complement and intricately integrate with the existing framework, offering a more nuanced and detailed perspective. However, for the current analysis, these roles have not been taken into consideration to concentrate efforts by focusing on a higher degree of granularity.

The cooperative synergy between OEMs, Installers, System Integrators, Cloud Service Providers, and Device Retrofit specialists becomes crucial in this cross-sectoral environment. Acknowledging the distinct requirements and obstacles of every industry guarantees the customised implementation of Cloud-Edge-IoT technologies, promoting creativity and productivity in a variety of sectors.

[13] https://doi.org/10.5281/zenodo.8089373
[14] https://doi.org/10.5281/zenodo.8283428

5.5.2 Understanding data

In the current technological landscape, the strategy for putting various solutions into practice - whether through OEM deployment or retrofitting - is crucial. The distribution of adoption across these approaches is not uniform, according to the data shown in the table below: Table 7 - OEM vs Retrofit.

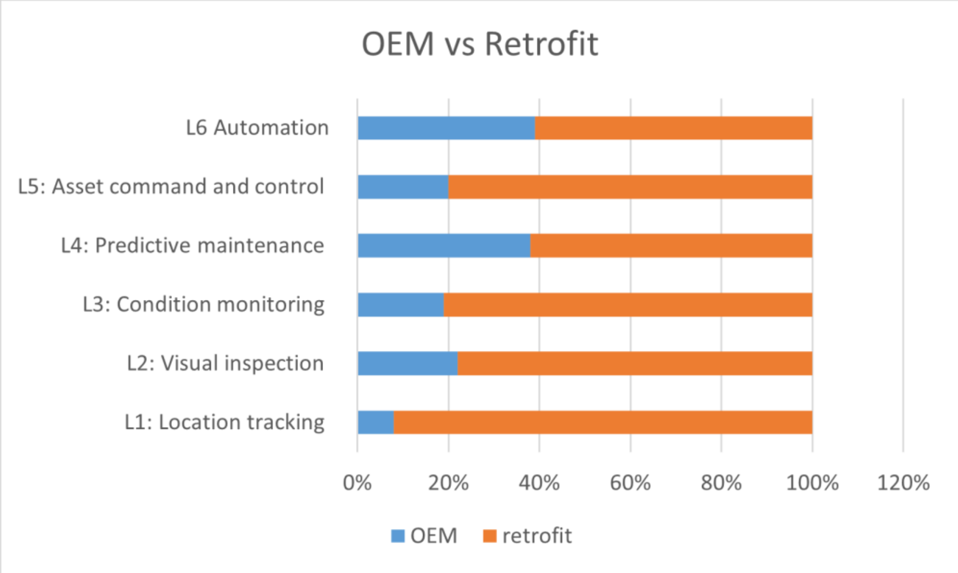

Figure 8 - OEM vs Retrofit Implementation Analysis

Level	Use Case (from IDC D1.2 Section 4)	OEM	retrofit
L1: Location tracking	Agriculture Animal Tagging	0%	100%
L1: Location tracking	Asset location tracking	0%	100%
L1: Location tracking	Employee safety monitoring	0%	100%
L1: Location tracking	Fleet tracking	0%	100%
L1: Location tracking	Hospital Asset Tracking	50%	50%
L1: Location tracking	Passenger traffic flow	0%	100%
L1: Location tracking	**Total**	**8%**	**92%**
L2: Visual inspection	Drone-based observation	100%	0%
L2: Visual inspection	Quality of shipment conditions	0%	100%
L2: Visual inspection	Vehicle and infrastructure inspection	100%	0%
L2: Visual inspection	Video security and surveillance	0%	100%
L2: Visual inspection	Visual inspection - quality/integrity	0%	100%
L2: Visual inspection	**Total**	**22%**	**78%**
L3: Condition monitoring	Agriculture Field Monitoring	0%	100%
L3: Condition monitoring	Bedside Telemetry	0%	100%
L3: Condition monitoring	Employee safety monitoring	0%	100%
L3: Condition monitoring	Field service technician monitoring	100%	0%
L3: Condition monitoring	Food traceability	0%	100%
L3: Condition monitoring	Livestock monitoring	0%	100%
L3: Condition monitoring	Regulatory compliance	50%	50%
L3: Condition monitoring	Remote Health Monitoring	50%	50%
L3: Condition monitoring	Remote network management	0%	100%
L3: Condition monitoring	Visual inspection - quality/integrity	0%	100%
L3: Condition monitoring	**Total**	**19%**	**81%**
L4: Predictive maintenance	AI-enabled Diagnosis and Treatment	100%	0%
L4: Predictive maintenance	Asset monitoring and maintenance (x3)	0%	100%
L4: Predictive maintenance	Asset monitoring and maintenance - OEM	100%	0%
L4: Predictive maintenance	Asset monitoring and maintenance - retrofit	0%	100%
L4: Predictive maintenance	Robots or augmented-reality-assisted surgery	100%	0%
L4: Predictive maintenance	Sensor-based diagnostics & maintenance	0%	100%
L4: Predictive maintenance	**Total**	**38%**	**62%**

L5: Asset command and control	Asset command and control	25%	75%
L5: Asset command and control	Smart meters	0%	100%
L5: Asset command and control	**Total**	**20%**	**80%**
L6 Automation	Automated guided vehicles (AGVs)	100%	0%
L6 Automation	Autonomous vehicles	100%	0%
L6 Automation	Connected drilling and extraction	0%	100%
L6 Automation	Fleet tracking	0%	100%
omation	Freight monitoring	0%	100%
L6 Automation	Manufacturing operations/automation	0%	100%
L6 Automation	Process automation and optimization	33%	67%
L6 Automation	Smart building	0%	100%
L6 Automation	**Total**	**39%**	**61%**
L1-L2-L3-L4-L5-L6	**Grand Total**	**24%**	**76%**

Table 7 - OEM vs Retrofit.

When OEM implementation is selected, the numbers show a comparatively lower adoption rate, ranging from 8.33% to 38.89%. This implies that, depending on their requirements, stakeholders may choose to purchase brand-new, specialised equipment with integrated Cloud-Edge-IoT capabilities.

On the other hand, retrofitting, which is defined as adding IoT capabilities to already-existing infrastructure, has become the most popular strategy, with adoption rates ranging from 61.11% to 91.67%. This preference for retrofit solutions indicates a sensible and economical approach, especially in light of the various industries involved. Through compatibility and cost-effectiveness, retrofitting enables enterprises to take advantage of Cloud-Edge-IoT technologies while utilising their current infrastructure.

The distribution of these adoption rates varies which highlights how flexible and adaptable Cloud-Edge-IoT solutions are. While OEM deployment might be preferred in certain situations requiring state-of-the-art technology, retrofitting is still a common and practical strategy that meets the various needs of various sectors and industries. This nuanced adoption strategy reflects a thoughtful assessment of cost-effectiveness, compatibility with current infrastructure, and technological advancement.

5.6 Device Cost Analysis

The chapter at hand unfolds as a meticulous exploration into the cost analysis for devices essential for the first cross-sectors within the realm of Cloud-Edge-IoT solutions as well as for the implementation at enterprise level. In our pursuit of strategic insights, we delve into diverse use cases. The financial landscape comes to life through a nuanced lens, where each use case is associated with distinct device requirements and corresponding cost estimates, providing stakeholders with a granular understanding of the financial considerations entailed in implementing Cloud-Edge-IoT solutions.

5.6.1 L1 for location tracking

The device acquisition cost analysis for the first cross-sectors level (L1) provides insights into the financial considerations associated with deploying Cloud-Edge-IoT solutions. For Agriculture Animal Tagging, the device acquisition cost is 25 Euros, reflecting the specialized nature of this application. Asset location tracking incurs costs ranging from 50 to 150 Euros, reflecting varying levels of complexity and functionality. Employee safety monitoring sees costs ranging from 50 to 100 Euros, while Fleet tracking incurs costs ranging from 25 to 250 Euros, with the latter reflecting higher capabilities. Hospital Asset Tracking and Passenger traffic flow have associated costs of 25 and 1,000 Euros, respectively. This detailed analysis equips stakeholders with a nuanced understanding of the device acquisition costs for each use case within L1, facilitating informed decision-making and strategic planning for the implementation of Cloud-Edge-IoT solutions across diverse sectors.

5.6.2 L2 for visual inspection

The device acquisition cost analysis for the second cross-sectors level (L2) unveils the financial considerations associated with implementing Cloud-Edge-IoT solutions. For Drone-based observation, the acquisition cost is 8,000 Euros, reflecting the advanced nature of this application. Quality of shipment conditions incurs a device acquisition cost of 150 Euros, offering an economical solution for monitoring shipment integrity. Vehicle and infrastructure inspection sees a cost of 2,500 Euros, indicative of the specialized requirements for this use case. Video security and surveillance, with varying levels of sophistication, has an associated cost of 750 Euros. Visual inspection focusing on quality and integrity incurs a device acquisition cost of 2,500 Euros. This detailed analysis provides stakeholders with a nuanced understanding of the device acquisition costs for each use case within L2, facilitating informed decision-making and strategic planning for the implementation of Cloud-Edge-IoT solutions across diverse sectors.

5.6.3 L3 for condition monitoring

The device acquisition cost analysis for the third cross-sectors level (L3) provides a detailed overview of the financial considerations associated with deploying Cloud-Edge-IoT solutions. Agriculture Field Monitoring incurs a device acquisition cost of 150 Euros, emphasizing its efficiency in monitoring agricultural fields. Bedside Telemetry has a cost of 50 Euros, offering an economical solution for healthcare applications. Employee safety monitoring sees costs ranging from 80 to 500 Euros, reflecting the diverse requirements of this use case. Field service technician monitoring incurs a device acquisition cost of 600 Euros, emphasizing its specialized nature. Food traceability and Livestock monitoring have associated costs of 250 and 40 Euros, respectively. Regulatory compliance and Remote Health Monitoring have costs ranging from 100 to 500 Euros. Visual inspection focusing on quality and integrity incurs a device acquisition cost of 100 Euros. This comprehensive analysis equips stakeholders with a nuanced understanding of the device acquisition costs for each use case within L3, facilitating informed decision-making for the implementation of Cloud-Edge-IoT solutions across diverse sectors.

5.6.4 L4 for predictive maintenance tracking

The device acquisition cost analysis for the fourth cross-sectors level (L4) provides detailed insights into the financial considerations associated with the deployment of advanced Cloud-Edge-IoT solutions. AI-enabled Diagnosis and Treatment, at the forefront of technological sophistication, incurs a substantial device acquisition cost of 100,000 Euros. Asset monitoring and maintenance has costs ranging from 150 to 25,000 Euros, reflecting diverse options catering to varying operational needs. The OEM solution incurs no additional device acquisition cost. The retrofit option has a cost of 50 Euros, offering a cost-effective alternative. Robots or augmented-reality-assisted surgery, representing cutting-edge medical technology, commands a device acquisition cost of 5,000 Euros. Sensor-based diagnostics & maintenance has an associated cost of 1,000 Euros. This detailed analysis empowers stakeholders with a nuanced understanding of the device acquisition costs for each use case within L4, facilitating informed decision-making for the implementation of Cloud-Edge-IoT solutions across diverse sectors.

5.6.5 L5 for asset command and control

The device acquisition cost analysis for the fifth cross-sectors level (L5) delves into the financial considerations associated with the deployment of advanced Cloud-Edge-IoT solutions. Asset command and control provides a range of options with costs ranging from 0 to 2,500 Euros, reflecting varying levels of capabilities. Smart meters, designed for efficient resource monitoring, incur a device acquisition cost of 100 Euros. This analysis equips stakeholders with a nuanced understanding of the device acquisition costs for each use case within L5, allowing for informed decision-making and strategic planning in the implementation of Cloud-Edge-IoT solutions across diverse sectors.

5.6.6 L6 for autonomous driving, process automation/optimization

The device acquisition cost analysis for the sixth cross-sectors level (L6) offers valuable insights into the financial considerations associated with deploying Cloud-Edge-IoT solutions. Automated guided vehicles (AGVs), pivotal for efficient logistics, have costs ranging from 150 to 25,000 Euros, reflecting diverse options catering to various operational needs. Autonomous vehicles, a cornerstone of advanced transportation solutions, have costs ranging from 0 to 1,000 Euros. Connected drilling and extraction incurs a device acquisition cost of 5,000 Euros, emphasizing its specialized nature. Fleet tracking and Freight monitoring have associated costs of 150 Euros each, showcasing their versatility. Manufacturing operations/automation incurs a cost of 500 Euros, while Process automation and optimization have costs ranging from 0 to 1,000 Euros. Smart building solutions provide a range of options with costs ranging from 0 to 500 Euros, reflecting diverse capabilities. This detailed analysis equips stakeholders with a nuanced understanding of the device acquisition costs for each use case within L6, facilitating informed decision-making for the implementation of Cloud-Edge-IoT solutions across diverse sectors.

Level	Use Case (from IDC D1.2 Section 4)	0	25	40	50	100	150	250	500	600	1,000	2,500	5,000	8,000	25,000	100,000
L1: Location tracking	Agriculture Animal Tagging		25													
L1: Location tracking	Asset location tracking		50				150									
L1: Location tracking	Employee safety monitoring	0	50		50											
L1: Location tracking	Fleet tracking		25					250								
L1: Location tracking	Hospital Asset Tracking	0	25													
L1: Location tracking	Passenger traffic flow										1,000					
L1: Location tracking	**Total**	**0**	**175**		**50**		**150**	**250**			**1,000**					
L2: Visual inspection	Drone-based observation													8,000		
L2: Visual inspection	Quality of shipment conditions						150									
L2: Visual inspection	Vehicle and infrastructure inspection											2,500				
L2: Visual inspection	Video security and surveillance						750									
L2: Visual inspection	Visual inspection - quality/integrity											2,500				
L2: Visual inspection	**Total**						**900**					**5,000**		**8,000**		
L3: Condition monitoring	Agriculture Field Monitoring						150									
L3: Condition monitoring	Bedside Telemetry				50											
L3: Condition monitoring	Employee safety monitoring	0		80	200				500							
L3: Condition monitoring	Field service technician monitoring									600						
L3: Condition monitoring	Food traceability							250								
L3: Condition monitoring	Livestock monitoring			40												
L3: Condition monitoring	Regulatory compliance	0														
L3: Condition monitoring	Remote Health Monitoring	0				100										

L3: Condition monitoring	Remote network mgmt (e.g. fault detection)								500							
L3: Condition monitoring	Visual inspection - quality/integrity					100										
L3: Condition monitoring	**Total**	**0**		**120**	**250**	**200**	**150**	**250**	**1,000**	**600**						
L4: Predictive maintenance	AI-enabled Diagnosis and Treatment															100,000
L4: Predictive maintenance	Asset monitoring and maintenance						150						5,000		25,000	
L4: Predictive maintenance	Asset monitoring and maintenance - OEM	0														
L4: Predictive maintenance	Asset monitoring and maintenance - retrofit				50											
L4: Predictive maintenance	Robots or augmented-reality-assisted surgery												5,000			
L4: Predictive maintenance	Sensor-based diagnostics & maintenance										1,000					
L4: Predictive maintenance	**Total**	**0**			**50**		**150**				**1,000**		**10,000**		**25,000**	**100,000**
L5: Asset command and control	Asset command and control	0						250			1,000	2,500				
L5: Asset command and control	Smart meters					100										
L5: Asset command and control	**Total**	**0**				**100**		**250**			**1,000**	**2,500**				
L6 Automation	Automated guided vehicles (AGVs)						150				1,000	2,500			25,000	
L6 Automation	Autonomous vehicles	0									1,000					
L6 Automation	Connected drilling and extraction												5,000			
L6 Automation	Fleet tracking						150									
L6 Automation	Freight monitoring						150									

L6 Automation	Manufacturing operations/automation								500							
L6 Automation	Process automation and optimization	0							1,000							
L6 Automation	Smart building	0				100	300		500							
L6 Automation	**Total**	**0**				**100**	**750**		**2,000**		**2,000**	**2,500**	**5,000**		**25,000**	
L1-L2-L3-L4-L5-L6	**Grand Total**	**0**	**175**	**120**	**350**	**400**	**2,100**	**750**	**3,000**	**600**	**5,000**	**10,000**	**15,000**	**8,000**	**50,000**	**100,000**

Table 8 - Device Acquisition Costs Analysis

5.7 Enterprise Implementation Cost Analysis

The chapter at hand unfolds as a meticulous exploration into the cost analysis for the implementation at enterprise level of the solution. In our pursuit of strategic insights, we delve into diverse use cases. The financial landscape comes to life through a nuanced lens, providing stakeholders with a granular understanding of the financial considerations entailed in implementing Cloud-Edge-IoT solutions.

5.7.1 L1 for location tracking

The cost analysis for the enterprise implementation at level (L1) is structured around various use cases, each associated with distinct cost tiers in Euro currency. For Agriculture Animal Tagging, the implementation cost is estimated at 750 Euros. Asset location tracking incurs costs ranging from 750 to 25,000 Euros, with higher expenses correlating with increased capabilities. Employee safety monitoring entails costs starting at 750 Euros, reaching 15,000 Euros for more advanced solutions. Fleet tracking, another use case under L1, sees costs varying from 750 to 5,000 Euros. Hospital Asset Tracking is estimated at 10,000 Euros. The Passenger traffic flow use case, demanding more sophisticated solutions, incurs costs escalating up to 200,000 Euros. This tiered cost analysis provides stakeholders with a nuanced understanding of the financial considerations associated with diverse use cases, allowing for informed decision-making and strategic planning in the enterprise implementation of Cloud-Edge-IoT solutions.

5.7.2 L2 for visual inspection

The cost analysis for enterprise implementation at level (L2) encompasses a diverse set of use cases, each associated with specific cost considerations in Euros. Drone-based observation incurs costs estimated at 10,000 Euros, providing stakeholders with an aerial perspective for comprehensive observation. Quality of shipment conditions is another use case under L2, with an associated cost of 10,000 Euros, ensuring meticulous monitoring and assessment during transit. Vehicle and infrastructure inspection, crucial for maintenance and safety, is also estimated at 10,000 Euros. Video security and surveillance, featuring enhanced capabilities, sees costs ranging from 2,000 to 25,000 Euros. Visual inspection focusing on quality and integrity incurs a cost of 3,000 Euros. This detailed cost breakdown equips stakeholders with a nuanced understanding of the financial considerations for each use case within L2, facilitating informed decision-making and strategic planning in the enterprise implementation of Cloud-Edge-IoT solutions.

5.7.3 L3 for condition monitoring

The cost analysis for enterprise implementation at level (L3) involves a diverse array of use cases, each associated with distinct cost considerations in Euros. Agriculture Field Monitoring incurs costs of 1,000 Euros, providing a comprehensive solution for monitoring agricultural fields. Bedside Telemetry, designed for healthcare applications, has a cost estimate of 3,000 Euros. Employee safety monitoring, with varying levels of sophistication, sees costs ranging from 2,000 to 40,000 Euros. Field service technician monitoring, a critical aspect for operational efficiency, incurs costs of 10,000 Euros. Food traceability, essential for supply chain transparency, is estimated at 5,000 Euros. Livestock monitoring and Regulatory compliance both have costs of 1,000 and 2,000 Euros, respectively. Remote Health Monitoring incurs a cost of 20,000 Euros, while Remote network management and Visual inspection - quality/integrity have associated costs of 10,000 and 2,000 Euros, respectively. This detailed cost breakdown facilitates a nuanced understanding of the financial considerations for each use case within L3, aiding stakeholders in making informed decisions for the enterprise implementation of Cloud-Edge-IoT solutions.

5.7.4 L4 for predictive maintenance tracking

The cost analysis for enterprise implementation at the level (L4) unveils a set of advanced use cases, each associated with distinct cost considerations in Euros. AI-enabled Diagnosis and Treatment, at the forefront of technological sophistication, commands a substantial cost of 100,000 Euros. Asset monitoring and maintenance, crucial for operational efficiency, incurs costs ranging from 20,000 to 25,000 Euros, while OEM and retrofit solutions within this category have associated costs of 1,500 Euros each. The implementation of Robots or augmented-reality-assisted surgery, representing cutting-edge medical technology, comes at a significant cost. Lastly, Sensor-based diagnostics & maintenance, a critical aspect of predictive maintenance, incurs costs estimated at 5,000 Euros. This detailed cost breakdown empowers stakeholders with a nuanced understanding of the financial considerations for each use case within L4, facilitating strategic decision-making for the enterprise implementation of Cloud-Edge-IoT solutions.

5.7.5 L5 for asset command and control

The cost analysis for the enterprise implementation at level (L5) encompasses use cases characterized by advanced functionalities, with specific cost considerations in Euros. Asset command and control, crucial for operational efficiency, incurs costs ranging from 2,500 to 50,000 Euros, reflecting varying levels of sophistication and capabilities. The implementation of Smart meters, designed for efficient resource monitoring, comes at a cost of 1,000 Euros. This detailed cost breakdown facilitates a comprehensive understanding of the financial considerations for each use case within L5. Stakeholders can utilize this information to make informed decisions, ensuring strategic planning and optimal resource allocation for the enterprise implementation of Cloud-Edge-IoT solutions in diverse sectors.

5.7.6 L6 for autonomous driving, process automation/optimization

The cost analysis for the enterprise implementation for level (L6) unfolds a spectrum of technologically advanced use cases, each associated with specific cost considerations in Euros. Automated guided vehicles (AGVs), integral to efficient logistics, command costs ranging from 20,000 to 50,000 Euros. Autonomous vehicles, representing cutting-edge transportation solutions, have costs ranging from 2,500 to 25,000 Euros. Connected drilling and extraction, Fleet tracking, Freight monitoring, Manufacturing operations/automation, and Process automation and optimization incur costs varying from 3,000 to 25,000 Euros. The implementation of Smart building solutions, featuring sophisticated automation and optimization features, commands costs ranging from 3,000 to 100,000 Euros. This detailed cost breakdown offers stakeholders a nuanced understanding of the financial considerations for each use case within L6, facilitating informed decision-making for the enterprise implementation of Cloud-Edge-IoT solutions across diverse sectors.

Level	Use Case (from IDC D1.2 Section 4)	0	750	1000	1500	2000	2500	3000	5000	10000	20000	25000	50000	100000	200000
L1: Location tracking	Agriculture Animal Tagging		750												
L1: Location tracking	Asset location tracking		750						5,000			25,000			
L1: Location tracking	Employee safety monitoring		750						15,000						
L1: Location tracking	Fleet tracking		750						5,000						
L1: Location tracking	Hospital Asset Tracking								10,000						
L1: Location tracking	Passenger traffic flow														200,000
L1: Location tracking	**Total**		**3,000**						**35,000**			**25,000**			**200,000**
L2: Visual inspection	Drone-based observation									10,000					
L2: Visual inspection	Quality of shipment conditions									10,000					
L2: Visual inspection	Vehicle and infrastructure inspection									10,000					
L2: Visual inspection	Video security and surveillance			2,000						20,000		25,000			
L2: Visual inspection	Visual inspection - quality/integrity							3,000							
L2: Visual inspection	**Total**			**2,000**				**3,000**		**50,000**		**25,000**			
L3: Condition monitoring	Agriculture Field Monitoring			1,000											
L3: Condition monitoring	Bedside Telemetry							3,000							

L3: Condition monitoring	Employee safety monitoring			2,000					20,000		40,000				
L3: Condition monitoring	Field service technician monitoring									10,000					
L3: Condition monitoring	Food traceability								5,000						
L3: Condition monitoring	Livestock monitoring			1,000											
L3: Condition monitoring	Regulatory compliance			2,000						20,000					
L3: Condition monitoring	Remote Health Monitoring									20,000					
L3: Condition monitoring	Remote network mgmt (e.g. fault detection)									10,000					
L3: Condition monitoring	Visual inspection - quality/integrity					2,000									
L3: Condition monitoring	**Total**			**6,000**		**2,000**		**3,000**	**25,000**	**60,000**	**40,000**				
L4: Predictive maintenance	AI-enabled Diagnosis and Treatment													100,000	
L4: Predictive maintenance	Asset monitoring and maintenance									20,000		25,000			
L4: Predictive maintenance	Asset monitoring and maintenance - OEM				1,500										
L4: Predictive maintenance	Asset monitoring and maintenance - retrofit				1,500										

L4: Predictive maintenance	Robots or augmented-reality-assisted surgery	0													
L4: Predictive maintenance	Sensor-based diagnostics & maintenance								5,000						
L4: Predictive maintenance	**Total**	**0**			**3,000**				**5,000**	**20,000**		**25,000**		**100,000**	
L5: Asset command and control	Asset command and control						2,500		5,000		20,000		50,000		
L5: Asset command and control	Smart meters			1,000											
L5: Asset command and control	**Total**			**1,000**			**2,500**		**5,000**		**20,000**		**50,000**		
L6 Automation	Automated guided vehicles (AGVs)									20,000		50,000			
L6 Automation	Autonomous vehicles						2,500					25,000			
L6 Automation	Connected drilling and extraction										20,000				
L6 Automation	Fleet tracking										20,000				
L6 Automation	Freight monitoring											25,000			
L6 Automation	Manufacturing operations/automation										20,000				
L6 Automation	Process automation and optimization							3,000	5,000		20,000				
L6 Automation	Smart building							3,000			40,000	25,000		100,000	
L6 Automation	**Total**						**2,500**	**6,000**	**5,000**	**20,000**	**120,000**	**125,000**		**100,000**	
L1-L2-L3-L4-L5-L6	**Grand Total**	**0**	**3,000**	**9,000**	**3,000**	**2,000**	**5,000**	**12,000**	**75,000**	**150,000**	**180,000**	**200,000**	**50,000**	**200,000**	**200,000**

Table 9 - Enterprise Implementation Costs Analysis

5.8 Total Addressable Market Analysis

We have carefully examined the Total Addressable Market (TAM) for each industry, including manufacturing, transportation, energy and utilities, healthcare, and agriculture, as part of our thorough study of Cloud-Edge-IoT solutions. A thorough understanding of the potential size and opportunities within a particular industry is provided by the Total Addressable Market, which is the total market demand for a given good or service. By concentrating on total addressable market (TAM), we are able to evaluate the potential revenue potential of Cloud-Edge-IoT solutions in every industry, taking into account variables like application scenarios, potential user base, and scalability.

Moreover, we focus on the Annual Market in addition to the larger TAM, which gives us a more sophisticated perspective of the yearly variations and patterns in every industry. We can identify growth areas, new opportunities, and possible obstacles that could influence the course of Cloud-Edge-IoT adoption by analysing the annual market. This thorough investigation guarantees a dynamic and adaptable approach to market dynamics, providing stakeholders with information essential for making strategic decisions in the quickly changing Cloud-Edge-IoT technology landscape.

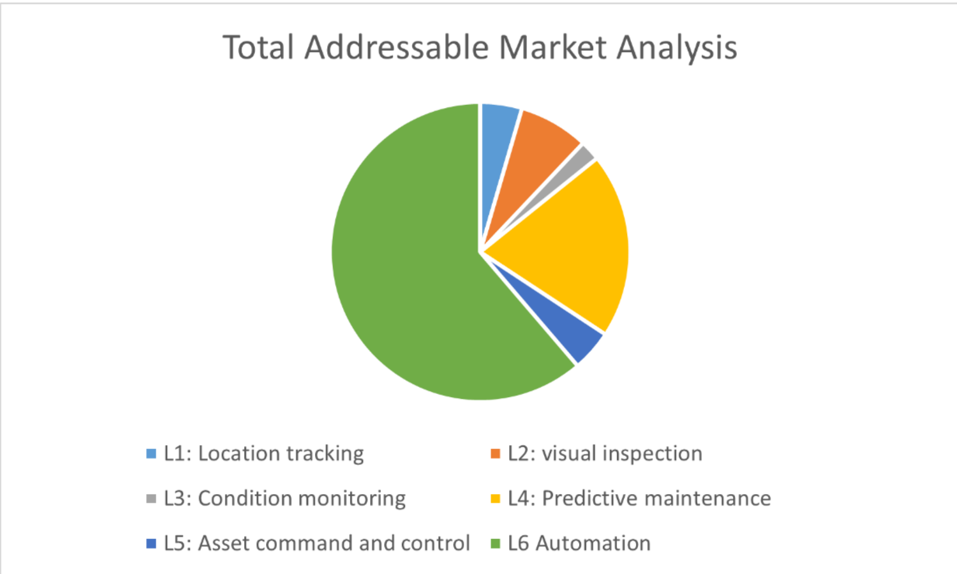

Figure 9 - Total Addressable Market Analysis

Level	Use Case (from IDC D1.2 Section 4)	SUM of TAM
L1: Location tracking	Agriculture Animal Tagging	280,105,500
L1: Location tracking	Asset location tracking	8,071,620,250
L1: Location tracking	Employee safety monitoring	604,491,700
L1: Location tracking	Fleet tracking	1,087,534,500
L1: Location tracking	Hospital Asset Tracking	329,504,865
L1: Location tracking	Passenger traffic flow	18,809,050,000
L1: Location tracking	**Total**	29,182,306,815
L2: Visual inspection	Drone-based observation	3,250,480,000
L2: Visual inspection	Quality of shipment conditions	29,896,490,000
L2: Visual inspection	Vehicle and infrastructure inspection	692,965,000
L2: Visual inspection	Video security and surveillance	12,684,898,000
L2: Visual inspection	Visual inspection - quality/integrity	2,214,408,000
L2: Visual inspection	**Total**	48,739,241,000
L3: Condition monitoring	Agriculture Field Monitoring	211,619,500
L3: Condition monitoring	Bedside Telemetry	234,092,700
L3: Condition monitoring	Employee safety monitoring	3,043,239,421
L3: Condition monitoring	Field service technician monitoring	5,709,691,040
L3: Condition monitoring	Food traceability	237,258,000
L3: Condition monitoring	Livestock monitoring	67,028,080
L3: Condition monitoring	Regulatory compliance	369,108,000
L3: Condition monitoring	Remote Health Monitoring	2,046,400,000
L3: Condition monitoring	Remote network management	2,061,280,000
L3: Condition monitoring	Visual inspection - quality/integrity	146,190,000
L3: Condition monitoring	**Total**	14,125,906,741
L4: Predictive maintenance	AI-enabled Diagnosis and Treatment	6,376,000,000
L4: Predictive maintenance	Asset monitoring and maintenance	120,193,115,000
L4: Predictive maintenance	Asset monitoring and maintenance - OEM	199,995,000
L4: Predictive maintenance	Asset monitoring and maintenance - retrofit	266,660,000
L4: Predictive maintenance	Robots or augmented-reality-assisted surgery	637,600,000
L4: Predictive maintenance	Sensor-based diagnostics & maintenance	2,021,640,000
L4: Predictive maintenance	**Total**	129,695,010,000
L5: Asset command and control	Asset command and control	15,836,246,400
L5: Asset command and control	Smart meters	13,107,928,000
L5: Asset command and control	**Total**	28,944,174,400
L6 Automation	Automated guided vehicles (AGVs)	108,848,625,000
L6 Automation	Autonomous vehicles	20,627,300,000
L6 Automation	Connected drilling and extraction	2,510,000,000
L6 Automation	Fleet tracking	3,365,830,000
L6 Automation	Freight monitoring	15,344,225,000
L6 Automation	Manufacturing operations/automation	5,536,020,000
L6 Automation	Process automation and optimization	43,454,007,000
L6 Automation	Smart building	196,649,115,000
L6 Automation	**Total**	396,335,122,000
L1-L2-L3-L4-L5-L6	**Grand Total**	**647,021,760,956**

Table 10 - Total Addressable Market Analysis

In the table above, Table 10 - Total Addressable Market Analysis, the data analysed in the following chapters.

5.8.1 L1 for location tracking

Within the context of location tracking applications, the Level 1 (L1) segment of the Total Addressable Market (TAM) for Cloud-Edge-IoT technologies unveils a diverse and promising landscape spanning various industries. In the agricultural sector, the estimated TAM is €280,105,500, encompassing applications such as Animal Tagging. This application facilitates precise tracking and observation of livestock, showcasing how Cloud-Edge-IoT solutions can enhance agricultural sector management and efficiency.

The asset location tracking market emerges as a substantial segment with a TAM of €8,071,620,250, indicating a notable demand for products streamlining the tracking and management of valuable assets in manufacturing, transportation, and healthcare sectors. Concurrently, the Employee Safety Monitoring segment, with a TAM of €604,491,700, reflects a growing emphasis on workplace safety. It suggests that Cloud-Edge-IoT technologies play a pivotal role in ensuring the welfare of workers across various industries.

Fleet Tracking presents a substantial market opportunity in the transportation industry, with a TAM of €1,087,534,500. Accurate tracking and administration of automobile fleets showcase how Cloud-Edge-IoT solutions can enhance logistics performance, optimize routes, and improve operational efficiency. In the healthcare sector, Hospital Asset Tracking demonstrates a TAM of €329,504,865, underscoring the significance of location tracking for the management and optimization of healthcare assets within medical facilities.

The Passenger Traffic Flow segment stands out with a substantial TAM of €18,809,050,000, highlighting the pivotal role that Cloud-Edge-IoT technologies can play in transforming transportation networks. This underscores the revolutionary potential of location tracking solutions in enhancing urban mobility, encompassing applications such as smart traffic management and crowd monitoring. This comprehensive exploration of the TAM in the Level 1 location tracking segment showcases the wide-ranging impact of Cloud-Edge-IoT technologies across diverse industries.

5.8.2 L2 for visual inspection

The L2 segmentation's Total Addressable Market (TAM) for Cloud-Edge-IoT technologies, with a focus on visual inspection applications, offers a sizable and varied market opportunity across multiple industries. With a total addressable market (TAM) of €3,250,480,000, drone-based observation demonstrates how Cloud-Edge-IoT solutions can transform industries through aerial visual inspection, with applications in infrastructure monitoring, construction, and agriculture.

With an outstanding TAM of €29,896,490,000, Quality of Shipment Conditions stands out and demonstrates the significant need for Cloud-Edge-IoT technologies to guarantee and optimise the quality and integrity of shipped goods. This segment highlights the transformational potential of visual inspection solutions and has wide-ranging implications for supply chain management, logistics, and quality assurance processes.

With a total addressable market (TAM) of €692,965,000, Vehicle and Infrastructure Inspection emphasises the market potential for Cloud-Edge-IoT technologies in guaranteeing the dependability and safety of industrial facilities, infrastructure assets, and transportation systems. Preventive maintenance, compliance monitoring, and general operational efficiency all depend on this application.

With a TAM of €12,684,898,000, the video security and surveillance highlight the vital role that cloud-edge-IoT solutions play in improving security measures across a variety of sectors. Applications in facility monitoring, public safety, and smart city projects are included in this, all of which enhance the general resilience and safety of urban environments.

With a TAM of €2,214,408,000, the Visual Inspection - Quality/Integrity segment highlights the market demand for accurate and automated visual inspection processes to guarantee the integrity and quality of products in the manufacturing, healthcare, and other industries. The potential for streamlining quality control and inspection workflows with Cloud-Edge-IoT technologies is demonstrated in this segment.

5.8.3 L3 for condition monitoring

In the realm of condition monitoring applications, the Level 3 (L3) segmentation within the Total Addressable Market (TAM) for Cloud-Edge-IoT technologies unfolds a diverse landscape with substantial market opportunities across various sectors.

Agriculture Field Monitoring, with a TAM of €211,619,500, showcases the potential of real-time field condition monitoring through Cloud-Edge-IoT solutions to optimize crop management and enhance agricultural productivity.

Bedside Telemetry illustrates the demand for Cloud-Edge-IoT technologies in healthcare, particularly for monitoring patients' vital signs. With a TAM of €234,092,700, this application underlines how condition monitoring significantly improves patient care and healthcare productivity.

Employee Safety Monitoring, with an astounding TAM of €3,043,239,421, underscores the vital role of Cloud-Edge-IoT solutions in ensuring worker safety across industries. Real-time monitoring proves essential in preventing accidents and enhancing workplace safety comprehensively.

Field Service Technician Monitoring, boasting a substantial TAM of €5,709,691,040, addresses the need for condition monitoring solutions in the service sector. This involves monitoring field technicians to maximize service effectiveness and ensure prompt maintenance and repairs.

Food Traceability, with a TAM of €237,258,000, highlights the market potential for Cloud-Edge-IoT technologies in ensuring food product quality and traceability throughout the supply chain. This application is essential for the food industry to meet regulatory requirements and enhance consumer confidence.

Livestock Monitoring, with a TAM of €67,028,080, emphasizes the role of Cloud-Edge-IoT solutions in monitoring the health and welfare of livestock in agriculture, optimizing farm management techniques and enhancing animal welfare.

Regulatory Compliance, with a TAM of €369,108,000, addresses the need for condition monitoring services ensuring conformity to industry rules and guidelines. This application illustrates the flexibility of Cloud-Edge-IoT technologies in meeting regulatory requirements across various industries, including manufacturing, healthcare, and energy.

Remote Health Monitoring, with a TAM of €2,046,400,000, unveils a sizable market opportunity for Cloud-Edge-IoT technologies in the healthcare industry. This application enables the remote monitoring of patients, providing medical professionals with insightful data to enhance overall patient care.

Fault Detection under Remote Network Management, boasting a TAM of €2,061,280,000, emphasizes the crucial role of condition monitoring in maintaining and enhancing network infrastructure across sectors.

Visual Inspection-Quality/Integrity, with a TAM of €146,190,000, underscores the need for Cloud-Edge-IoT technologies to automate and improve visual inspection procedures for quality control in manufacturing and other industries.

5.8.4 L4 for predictive maintenance tracking

With a focus on predictive maintenance applications, the L4 segmentation of the Total Addressable Market (TAM) for Cloud-Edge-IoT technologies reveals a landscape ripe with opportunities across multiple industries. With a TAM of €6,376,000,000, AI-enabled Diagnosis and Treatment demonstrates the significant market potential for Cloud-Edge-IoT solutions in transforming healthcare through the integration of predictive maintenance into diagnostic and treatment procedures. This application demonstrates how predictive maintenance can improve patient care and overall healthcare efficiency in a revolutionary way.

A crucial market segment, Asset Monitoring and Maintenance, has a total addressable market (TAM) of €120,193,115,000. This section includes all-inclusive predictive maintenance solutions that handle the requirement for proactive maintenance and real-time monitoring in a variety of industries, such as manufacturing, energy, and utilities.

The OEM market has a TAM of €199,995,000 in the Asset Monitoring and Maintenance category, indicating the need for OEMs to incorporate predictive maintenance features into their products. This suggests that there is a market for Cloud-Edge-IoT technologies to be directly integrated into new assets, enhancing their performance and lifecycle.

With a TAM of €266,660,000, the retrofit market for asset monitoring and maintenance shows how cloud-edge-IoT solutions can be used to retrofit existing infrastructure with predictive maintenance features. For industries looking to update their machinery and increase asset longevity through preventative maintenance, this application is essential.

With a TAM of €637,600,000, Robots or Augmented-Reality-Assisted Surgery demonstrates the revolutionary role that Cloud-Edge-IoT technologies play in predictive maintenance in the healthcare industry. Enhancing surgical precision and patient outcomes, this application boosts the dependability and efficiency of augmented reality systems and surgical robots.

With a TAM of €2,021,640,000, Sensor-based Diagnostics & Maintenance highlights the value of predictive maintenance solutions that use sensor data for proactive and diagnostic maintenance. This application is used in a variety of industries, such as transportation and manufacturing, where sensors are essential for keeping an eye on and maintaining machinery.

5.8.5 L5 for asset command and control

With a total addressable market (TAM) of €15,836,246,400 for Cloud-Edge-IoT technologies, the L5 segmentation, which focuses on asset command and control applications, offers significant opportunities across sectors. Asset command and control systems are essential for sectors looking to maximise real-time asset performance and management, which boosts operational effectiveness and streamlines procedures. The substantial need for Cloud-Edge-IoT technologies in offering reliable solutions for asset monitoring, control, and coordination is reflected in this thorough TAM.

Smart Metres are another example of the vast market potential in the asset command and control space, with a TAM of €13,107,928,000. In industries like energy and utilities, where real-time data collection and control capabilities are essential for improved resource management, accurate billing, and overall grid optimisation, smart metre adoption is critical. This application demonstrates how Cloud-Edge-IoT solutions can revolutionise infrastructure modernization and create more responsive, intelligent systems.
The TAM for asset command and control represents the increasing awareness of the need for cutting-edge solutions that can blend in with current infrastructure and provide enterprises precise asset monitoring,

command, and control. Cloud-edge-IoT technologies in this market segment can help a variety of industries, from manufacturing to energy, by promoting a more responsive and connected operational environment.

5.8.6 L6 for autonomous driving, process automation/optimization

With a combined TAM of €300,385,117,000. The Total Addressable Market (TAM) for Cloud-Edge-IoT technologies within the L6 segmentation, which focuses on autonomous driving and process automation/optimization applications, represents a dynamic and expansive landscape. This section demonstrates how the deployment of autonomous systems, automation, and optimisation of Cloud-Edge-IoT solutions can revolutionise various industries.

With a significant TAM of €108,848,625,000, Automated Guided Vehicles (AGVs) stand out and highlight the role that Cloud-Edge-IoT technologies are playing in revolutionising manufacturing and logistics. Automated guided vehicles (AGVs) are essential for optimising material handling procedures, leading to higher productivity and lower operating expenses.

With a TAM of €20,627,300,000, autonomous vehicles demonstrate the market potential for Cloud-Edge-IoT solutions in influencing the direction of transportation. This application represents the revolutionary impact of Cloud-Edge-IoT technologies in improving mobility, safety, and overall transportation efficiency, ranging from self-driving cars to autonomous delivery vehicles.

With a TAM of €2,510,000,000, Connected Drilling and Extraction meets the need for Cloud-Edge-IoT solutions to optimise and automate processes in the energy industry. Applications for intelligent oil and gas extraction are included in this, which improves resource optimisation and operational effectiveness.

With a TAM of €3,365,830,000, Fleet Tracking highlights the importance of Cloud-Edge-IoT technologies in tracking and improving the efficiency of car fleets. This application helps with fuel efficiency, route optimisation, and fleet management in sectors like transportation and logistics.

With a TAM of €15,344,225,000, freight monitoring highlights the market potential for Cloud-Edge-IoT solutions in enhancing freight shipments' tracking and monitoring. This application enhances overall logistics efficiency, security, and visibility throughout the supply chain.

With a TAM of €5,536,020,000, Manufacturing Operations/Automation highlights the revolutionary power of Cloud-Edge-IoT technologies in modernising and automating manufacturing processes. This application helps the manufacturing industry run more efficiently overall, with lower downtime and higher productivity.

With a TAM of €43,454,007,000, Process Automation and Optimisation demonstrates the significant need for Cloud-Edge-IoT solutions for automating and optimising a range of industrial processes. This programme enhances operational excellence and efficiency in a variety of industries through predictive maintenance and real-time process monitoring.

With a TAM of €196,649,115,000, the smart building market segment emerges as a crucial one, indicating the need for cloud-edge and internet of things technologies to create intelligent and energy-efficient buildings. This application helps create smart cities by spanning multiple industries, such as real estate and urban planning.

5.9 Annual Market Analysis

In the table below, Table 11 - Annual Market Analysis, the information analysed in the following chapters.

Level	Use Case (from IDC D1.2 Section 4)	SUM of EAM
L1: Location tracking	Agriculture Animal Tagging	14,005,275
L1: Location tracking	Asset location tracking	1,598,022,025
L1: Location tracking	Employee safety monitoring	68,569,065
L1: Location tracking	Fleet tracking	108,753,450
L1: Location tracking	Hospital Asset Tracking	16,475,243
L1: Location tracking	Passenger traffic flow	940,452,500
L1: Location tracking	**Total**	2,746,277,558
L2: Visual inspection	Drone-based observation	650,096,000
L2: Visual inspection	Quality of shipment conditions	4,484,473,500
L2: Visual inspection	Vehicle and infrastructure inspection	138,593,000
L2: Visual inspection	Video security and surveillance	1,228,256,600
L2: Visual inspection	Visual inspection - quality/integrity	332,161,200
L2: Visual inspection	**Total**	6,833,580,300
L3: Condition monitoring	Agriculture Field Monitoring	21,161,950
L3: Condition monitoring	Bedside Telemetry	23,409,270
L3: Condition monitoring	Employee safety monitoring	323,393,379
L3: Condition monitoring	Field service technician monitoring	856,453,656
L3: Condition monitoring	Food traceability	35,588,700
L3: Condition monitoring	Livestock monitoring	3,351,404
L3: Condition monitoring	Regulatory compliance	56,719,500
L3: Condition monitoring	Remote Health Monitoring	81,856,000
L3: Condition monitoring	Remote network management	309,192,000
L3: Condition monitoring	Visual inspection - quality/integrity	14,619,000
L3: Condition monitoring	**Total**	1,725,744,859
L4: Predictive maintenance	AI-enabled Diagnosis and Treatment	159,400,000
L4: Predictive maintenance	Asset monitoring and maintenance	10,785,569,900
L4: Predictive maintenance	Asset monitoring and maintenance - OEM	5,999,850
L4: Predictive maintenance	Asset monitoring and maintenance - retrofit	18,666,200
L4: Predictive maintenance	Robots or augmented-reality-assisted surgery	31,880,000
L4: Predictive maintenance	Sensor-based diagnostics & maintenance	202,164,000
L4: Predictive maintenance	**Total**	11,203,679,950
L5: Asset command and control	Asset command and control	2,355,538,140
L5: Asset command and control	Smart meters	524,317,120
L5: Asset command and control	**Total**	2,879,855,260
L6 Automation	Automated guided vehicles (AGVs)	11,996,818,800
L6 Automation	Autonomous vehicles	3,050,762,750
L6 Automation	Connected drilling and extraction	125,500,000
L6 Automation	Fleet tracking	336,583,000
L6 Automation	Freight monitoring	2,301,633,750
L6 Automation	Manufacturing operations/automation	830,403,000
L6 Automation	Process automation and optimization	4,345,400,700
L6 Automation	Smart building	10,285,869,100
L6 Automation	**Total**	33,272,971,100
L1-L2-L3-L4-L5-L6	**Grand Total**	**58,662,109,027**

Table 11 - Annual Market Analysis

5.9.1 L1 for location tracking

With a combined Annual Market of €2,741,273,558 for Cloud-Edge-IoT technologies under the L1 segmentation, which focuses on location tracking applications, shows a varied landscape. The importance of Cloud-Edge-IoT solutions in enabling accurate and real-time location tracking across a range of industries is highlighted in this segment.

With an annual market value of €14,005,275, Agriculture Animal Tagging is a prime example of how Cloud-Edge-IoT technologies are being used in precision agriculture. Animal welfare is ensured through the effective management of farms and livestock monitoring that comes with the integration of animal tagging.

With an annual market of €1,598,022,025 for asset location tracking, it becomes clear how widely used Cloud-Edge-IoT solutions are for asset management and tracking across industries. Applications in inventory control, supply chain management, and logistics are included in this, all of which improve operational effectiveness.

With an annual market value of €68,569,065 for employee safety monitoring, cloud-edge and internet of things technologies play a critical role in maintaining worker safety. With its real-time monitoring capabilities that help prevent accidents and improve overall occupational safety, this application is essential to all industries.

With an annual market value of €108,753,450, fleet tracking highlights the use of cloud-edge and internet of things technologies to monitor and improve fleet performance. This application helps with fuel efficiency, route optimisation, and fleet management in sectors like transportation and logistics.

Hospital Asset Tracking is a product that caters to the need for Cloud-Edge-IoT solutions in healthcare environments, with an annual market value of €16,475,243. Asset tracking integration improves the way medical equipment is managed, which benefits patients and increases operational efficiency in healthcare facilities.

With a significant Annual Market of €940,452,500, Passenger Traffic Flow highlights the revolutionary effect of Cloud-Edge-IoT technologies in streamlining traffic management systems. This application improves overall urban transportation efficiency, lowers traffic, and increases public safety.

5.9.2 L2 for visual inspection

With a combined Annual Market of €6,833,580,300, the L2 segmentation's Cloud-Edge-IoT technologies Annual Market, which focuses on visual inspection applications, reveals a strong market environment. The importance of Cloud-Edge-IoT solutions in enabling sophisticated visual inspection capabilities across a range of industries is highlighted in this segment.

With an annual market value of €650,096,000, drone-based observation represents the revolutionary impact of cloud-edge and internet of things technologies in aerial surveillance and data collection. In sectors like construction, agriculture, and environmental monitoring, drones with visual inspection capabilities are essential.

With an Annual Market of €4,484,473,500, Quality of Shipment Conditions emerges as a crucial market segment, demonstrating the substantial demand for Cloud-Edge-IoT solutions in guaranteeing the integrity and quality of shipped goods. This application is essential for supply chain management and logistics since it raises customer satisfaction and product quality.

The Vehicle and Infrastructure Inspection market, which has an annual revenue of €138,593,000, highlights the significance of Cloud-Edge-IoT technologies in streamlining vehicle and infrastructure inspection and maintenance. This application is essential for improving safety and operational efficiency in sectors like construction and transportation.

With an Annual Market of €1,228,256,600, Video Security and Surveillance highlights the broad need for Cloud-Edge-IoT solutions to improve security measures. With its real-time visual monitoring and threat detection capabilities, this application is essential for a variety of industries, including public safety and private businesses.

With an annual market value of €332,161,200, Visual Inspection-Quality/Integrity emphasises the significance of Cloud-Edge-IoT technologies in guaranteeing the integrity and quality of infrastructure and products through visual inspection. This application is essential for quality control and risk mitigation in the manufacturing and construction industries.

5.9.3 L3 for condition monitoring

With a combined Annual Market of €1,725,744,859, the L3 segmentation's Cloud-Edge-IoT technologies Annual Market, which focuses on condition monitoring applications, shows a dynamic market environment. The importance of Cloud-Edge-IoT solutions in enabling real-time monitoring and analysis of diverse conditions across industries is highlighted in this segment.

With an annual market value of €21,161,950, Agriculture Field Monitoring emphasises the use of Cloud-Edge-IoT technologies in precision agriculture. A higher level of agricultural productivity and more efficient crop management are facilitated by real-time environmental condition monitoring.

With an annual market of €23,409,270, bedside telemetry stands out as a significant market segment, highlighting the importance of cloud-edge IoT solutions in healthcare settings. Bedside telemetry makes it possible to continuously monitor patients, which improves the capacity of medical professionals to provide prompt, individualised care.

With an annual market value of €323,393,379, employee safety monitoring highlights the significance of cloud-edge and internet of things technologies in maintaining worker safety. With its real-time monitoring capabilities that help prevent accidents and improve overall occupational safety, this application is essential to all industries.

With an annual market value of €856,453,656, Field Service Technician Monitoring highlights the role that Cloud-Edge-IoT technologies play in maximising the efficiency of field service operations. Technicians under real-time observation led to higher productivity, less downtime, and better overall service quality.

With an annual market value of €35,588,700, Food Traceability meets the need for Cloud-Edge-IoT solutions to guarantee the quality and traceability of food products. In the food industry, this application is essential because it promotes consumer trust and supply chain transparency.

With an annual market value of €3,351,404, livestock monitoring demonstrates how cloud-edge and internet of things technologies are revolutionising the management of livestock. Monitoring livestock conditions in real time improves both the welfare of the animals and the general efficiency of the farm.
Regulatory Compliance highlights the importance of Cloud-Edge-IoT solutions in guaranteeing compliance with industry regulations, with an Annual Market of €56,719,500. This application is cross-sectoral and helps with regulatory compliance and risk reduction.

With an annual market value of €81,856,000, remote health monitoring caters to the expanding need for cloud-edge, Internet of Things solutions in remote healthcare. Healthcare professionals are able to provide patients with proactive and individualised care when health parameters are continuously monitored.

With an Annual Market of €309,192,000, Remote Network Management (e.g., Fault Detection) highlights the significance of Cloud-Edge-IoT technologies in optimising network performance. Improved network efficiency and reliability are facilitated by remote management and real-time fault detection.

With an annual market value of €14,619,000, Visual Inspection-Quality/Integrity emphasises the role of Cloud-Edge-IoT technologies in assuring the integrity and quality of products through visual inspection. In the processes of manufacturing and quality control, this application is essential.

5.9.4 L4 for predictive maintenance

The Annual Market for Cloud-Edge-IoT technologies within the L4 segmentation, focusing on predictive maintenance applications, showcases a robust market landscape with a combined Annual Market of €11,203,679,950. This segment highlights the pivotal role of Cloud-Edge-IoT solutions in revolutionizing maintenance practices across industries.

AI-Enabled Diagnosis and Treatment, with an Annual Market of €159,400,000, signifies the transformative impact of Cloud-Edge-IoT technologies in healthcare. The integration of AI enables advanced diagnosis and treatment planning, contributing to improved patient outcomes and healthcare efficiency.

Asset Monitoring and Maintenance emerges as a significant market segment with an Annual Market of €10,785,569,900, emphasizing the widespread demand for Cloud-Edge-IoT solutions in optimizing asset performance and reducing downtime. This application spans across industries such as manufacturing, energy, and transportation, contributing to enhanced operational efficiency.

Asset Monitoring and Maintenance - OEM, with an Annual Market of €5,999,850, addresses the specific market for original equipment manufacturers (OEMs) providing integrated solutions for predictive maintenance. This application caters to industries where OEMs play a critical role in equipment maintenance.

Asset Monitoring and Maintenance - Retrofit, with an Annual Market of €18,666,200, focuses on the market for retrofit solutions in predictive maintenance. Retrofitting existing infrastructure with Cloud-Edge-IoT technologies contributes to extending the lifespan and efficiency of equipment.

Robots or Augmented-Reality-Assisted Surgery, boasting an Annual Market of €31,880,000, underscores the transformative impact of Cloud-Edge-IoT technologies in healthcare. The integration of robotics and augmented reality enhances surgical precision and patient outcomes.

Sensor-Based Diagnostics & Maintenance, with an Annual Market of €202,164,000, emphasizes the role of Cloud-Edge-IoT technologies in leveraging sensor data for diagnostics and proactive maintenance. This application is vital across industries, contributing to enhanced equipment reliability and cost savings.

5.9.5 L5 for asset command and control

The Annual Market for Cloud-Edge-IoT technologies within the L5 segmentation, emphasizing asset command and control applications, demonstrates a substantial market with a combined Annual Market of €2,879,855,260. This segment highlights the pivotal role of Cloud-Edge-IoT solutions in providing advanced command and control capabilities for various assets across industries.

Asset Command and Control, with an Annual Market of €2,355,538,140, underscores the widespread demand for Cloud-Edge-IoT solutions in optimizing the command and control of diverse assets. This application is crucial for industries such as manufacturing, energy, and transportation, contributing to enhanced operational efficiency and real-time decision-making.
Smart Meters, boasting an Annual Market of €524,317,120, addresses the specific market for advanced metering solutions. The integration of smart meters in utility infrastructure enhances the monitoring and management of energy consumption, contributing to increased efficiency and sustainability.

5.9.6 L6 for autonomous driving, process automation

The Annual Market for Cloud-Edge-IoT technologies within the L6 segmentation, encompassing autonomous driving, process automation, and optimization applications, reveals a robust market with a combined Annual Market of €32,378,971,100. This segment underscores the transformative impact of Cloud-Edge-IoT solutions in revolutionizing mobility, manufacturing, and industrial processes across diverse industries.

Automated Guided Vehicles (AGVs), with an Annual Market of €11,996,818,800, signify the widespread demand for Cloud-Edge-IoT solutions in optimizing material handling and logistics through automation. AGVs play a crucial role in industries such as manufacturing and warehousing, contributing to increased efficiency and reduced operational costs.

Autonomous Vehicles, boasting an Annual Market of €3,050,762,750, reflects the growing prominence of Cloud-Edge-IoT technologies in the automotive industry. The integration of autonomous vehicles contributes to enhanced safety, efficiency, and sustainability in transportation and logistics.

Connected Drilling and Extraction, with an Annual Market of €125,500,000, addresses the specific market for Cloud-Edge-IoT solutions in optimizing drilling and extraction processes in the energy sector. This application contributes to increased efficiency and reduced environmental impact.

Fleet Tracking, with an Annual Market of €336,583,000, underscores the pivotal role of Cloud-Edge-IoT solutions in monitoring and optimizing fleet operations. This application is vital for industries such as transportation and logistics, contributing to improved route planning and fuel efficiency.

Freight Monitoring, boasting an Annual Market of €2,301,633,750, emphasizes the transformative impact of Cloud-Edge-IoT technologies in enhancing the monitoring and security of freight during transportation. This application contributes to supply chain visibility and risk mitigation.

Manufacturing Operations/Automation, with an Annual Market of €830,403,000, highlights the broad application of Cloud-Edge-IoT solutions in optimizing manufacturing processes. Automation and real-time data analytics contribute to increased production efficiency and quality.

Process Automation and Optimization, with an Annual Market of €4,345,400,700, underscores the widespread demand for Cloud-Edge-IoT solutions in optimizing various industrial processes. This application spans across industries, contributing to increased operational efficiency and reduced resource consumption.

Smart Building, boasting an Annual Market of €10,285,869,100, reflects the transformative impact of Cloud-Edge-IoT technologies in building automation and optimization. Smart building solutions contribute to increased energy efficiency, comfort, and sustainability in the real estate sector.

6. Implementation challenges

6.1 Introduction

During consultations and interviews, a notable trend emerged, the widespread lack of a comprehensive understanding of the entire CEI landscape. Industry professionals showcased expertise in specific silos, emphasizing the need for increased investment in harmonizing knowledge across Cloud, Edge, and IoT and underscores the necessity for strategic efforts to bridge awareness gaps.

More specifically, Task Force 5's data from Workshop 2 offered insightful information about the wide range of use cases that fall under the Cloud-Edge-IoT (CEI) umbrella. Twenty-one use cases in all, spanning important industries, were categorised. Four use cases apiece came from Agriculture and Energy, three from Manufacturing, five from Transportation (two of which were for "entertainment" in cars), two from the Environment and three from Smart Cities—two of which were not related to UNLOCK's five core sectors. This distribution remarks how widely applicable CEI technologies are, covering industries vital to manufacturing, transportation, energy, agriculture, and cutting-edge fields like the environment and smart cities.

The Task Force recognised and self-reported 181 challenges within this rich tapestry of use cases, classifying them as either "Key components missing" or "Constraints, challenges & risks." Following a methodical coding process, 158 of these challenges matched one or more of the 25 general CEI requirements. This classification highlights how fundamental these issues are, as it aligns with the fundamental specifications that establish the CEI framework. It highlights how problems are interconnected across industries, providing a foundation for innovative and focused solutions.

Interestingly, 23 challenges turned out to be use-case-specific, suggesting a degree of complexity and uniqueness in some situations that call for a customised strategy. These difficulties, which are different from the general CEI requirements, emphasise the necessity for customised solutions that meet the complex needs of specific use cases within the wide range of applications that CEI technologies cover.

In conclusion, the data from Workshop 2 sheds light on the wide range of use cases present in the CEI landscape and offers a detailed grasp of the requirements and difficulties that arise during implementation. This information forms the basis for improving tactics, creating focused solutions, and encouraging creativity in the use of Cloud-Edge-IoT technologies in a variety of industries.

6.2 Analysis

A thorough understanding of the complexities involved in deploying Cloud-Edge-IoT (CEI) technologies is made possible by the strategic grouping of the implementation challenges discovered during Workshop 2 into four overarching categories, in addition to the abundance of information supplied by Task Force 5.

Issues with IoT devices, data sources, and challenges at the "device end" of the processing flow are all included in the first category, "Data challenges." This includes issues with the acquisition, calibre, and dependability of data from the Internet of Things devices in addition to the efficient administration and application of various data sources. The complex problems in this area emphasise the fundamental role that data plays in powering CEI technologies and draw attention to the necessity of strong device-level solutions.

The second type of challenge is called continuum challenge, and it centres on how the "CEI Continuum" functions. To ensure a coherent and integrated CEI ecosystem, this category tackles issues with the smooth orchestration and coordination of edge and cloud components. It emphasises how crucial it is to design a continuum that can be adjusted to changing operational requirements across a range of use cases and industries while remaining effective.

Analytical and processing skills necessary for a successful CEI implementation are covered in detail in the third category, Processing Challenges. This includes difficulties with machine learning algorithms, data analytics, and the overall processing power needed to extract valuable information from the massive amounts of data produced by Internet of Things devices. To fully utilise CEI technologies for real-time decision-making and predictive capabilities, these issues must be resolved.

Lastly, the General category encompasses difficulties that are universal across domains and are thought to be necessary for the effective application of CEI. These difficulties cover issues like scalability, security, and interoperability and are indicative of the general rules that control the efficient application of CEI technologies in a variety of industries.

6.3 Outcomes

In our analysis, we have acknowledged the pivotal significance of the availability and affordability of local edge gateways in influencing the implementation and adoption of use cases. Acting as a vital intermediary between local devices and the cloud, an edge gateway plays a key role in enabling efficient data processing and communication.
Nevertheless, the timing and cost-effectiveness of developing an EU-based solution are crucial considerations. Should reasonably price local edge gateways meeting the specified requirements be unavailable, the consequence may be a reduced adoption rate or the implementation of use cases through Cloud Homing, involving wireless communications directly connecting to the cloud.

Essentially, a systematic framework for handling the complex issues related to the deployment of CEI technologies is provided by the classification of implementation challenges into these four extensive categories. To guarantee the smooth integration and success of CEI solutions, stakeholders can strategically navigate the complexities of data, continuum operation, processing capabilities, and general requirements by breaking down challenges into discrete domains.

It is important to note that most of the Research and Innovation Actions (RIA) Use Cases focus on Level 6, which is the most advanced and ambitious use case in the taxonomy. This indicates that CEI (Cloud-Edge-IoT) technologies are being strategically pushed to their limits. High-level use cases like driverless vehicles, process automation and optimisation, and other sophisticated applications that require state-of-the-art technologies and seamless edge-to-cloud integration are included in Level 6. This focused strategy shows a dedication to innovative solutions that not only solve present problems but also open the door for game-changing developments in a variety of industries.

Going forward, Use Case Pilots will have a rare chance to develop maturity by methodically working their way up the taxonomy's levels—basically starting from the bottom. A methodical and informed deployment of CEI technologies is ensured by this evolutionary approach, which also enables stakeholders to iteratively refine and enhance solutions based on lessons learned and successes attained at each level. This iterative process promotes the creation of reliable and scalable CEI solutions and is consistent with an attitude of continuous improvement.

In addition, the analysis gains an interesting dimension with the discovery of two Use Cases concerning "content distribution" in the automotive industry. Although not covered in detail in the earlier talks, content distribution turns out to be an important category in the automotive "edge" industry. In this context, content delivery networks, or CDNs, are important players in the edge infrastructure. Given this recognition, CDNs have a rare chance to act as possible "beachheads" for the deployment of CEI, particularly in situations where content distribution and the automotive edge interact closely. Utilising CDNs' current infrastructure and experience could make it easier to integrate and implement CEI technologies, resulting in synergies that stimulate innovation in the automotive industry.

Concurrently, we observed a multifaceted challenge with a notable trend where a few industries have recently shifted their focus away from the Edge, emphasizing the Cloud and IoT facets. This dynamic landscape, coupled with inherent ambiguity in defining the Edge's position and boundaries, presents a significant risk investing directly on it. As Cloud and IoT services, frameworks and models undergo rapid development, while their paradigms and components are evolving, expanding, and crossbreeding the original boundaries (i.e. coupling micro cloud and gateways) there is a tangible concern that the Edge layer might become overshadowed by the expansive growth of the other layers.

Over the next few years, as we navigate the changing landscape of Cloud-Edge-IoT solutions in Europe, several potential paths become apparent, based on the thorough analyses and previously described methodologies. The foundation for shared solutions and cooperative approaches has been established by the cross-sectoral analysis, which has identified common variables and challenges across industries. Making use of this knowledge, a possible course of action is to form industry alliances or consortia to promote cooperation in tackling broad issues and advancing group advances in Cloud-Edge-IoT deployments.

Moreover, a market analysis could be provided by the taxonomy and the identification of common implementation patterns. Stakeholders may use this as a guide when choosing strategic areas of emphasis. A possible solution is a phased rollout, with the sectors with the greatest promise and the greatest overlaps leading the first wave of adoption. By focusing efforts on the most promising opportunities, this phased strategy guarantees a strong start to market growth.

A speculative course entails creating scalable, modular solutions that can be adjusted to meet the demands of particular use cases. This strategy not only meets the various needs of various industries, but it also establishes Cloud-Edge-IoT solutions as flexible and future-proof, promoting steady market expansion.

A practical and quantitative foundation for market estimation is provided by the market value analysis based on unit costs in line with real market drivers. A plausible course entails making calculated strategic investments in industries with the largest market potential, directed by the evaluation of significant prospects and market value segments. This focused investment approach supports the natural growth of Cloud-Edge-IoT solutions across multiple industries while optimising returns.

In conclusion, the emphasis on Level 6 Use Cases and the tactical chance to advance maturity via Use Case Pilots demonstrate a progressive approach to the creation and application of CEI technologies. The recognition of content distribution in the automotive industry and the possible function of CDNs as "beachheads" indicates a cognizance of the infrastructures that are currently in place and can accelerate the implementation of cutting-edge CEI solutions, especially in areas as intricate and dynamic as autonomous driving and automotive edge applications.

7. Conclusion

Considering the vast array of Cloud-Edge-IoT solutions available in Europe, the information and analysis provided by this investigation paint a picture of future growth opportunities and stakeholder strategic requirements. Together, the various analyses, approaches, and potential routes shed light on a roadmap that, with careful navigation, offers both a competitive advantage and long-term market growth in this ever-changing ecosystem.

A mosaic of common factors and difficulties that cut across industry boundaries has been uncovered by the cross-sector analysis. Stakeholders have a distinct chance to promote collaboration across traditional sector silos by identifying these commonalities. The adoption of Cloud-Edge-IoT solutions can be facilitated by industry consortia and alliances, which can help to drive collective advancements, pool resources, and create a unified front. The recommendation is very clear: to fully realise this interconnected landscape's growth potential, collaboration is not only advantageous but also essential.

The structural analysis offers a sophisticated comprehension of the nuances within use cases because of its emphasis on granularity and modular solutions. This level of detail goes beyond simple analysis; for stakeholders hoping to stay competitive in this changing market, it is a strategic necessity. Stakeholders position themselves to meet a variety of industry needs and remain ahead of the competition by creating solutions that are not only sector-specific but also flexible and scalable.

The significance of targeted approaches and foresight is further highlighted by strategic investments grounded in market value analysis. Stakeholders should strategically direct resources towards industries with the largest market potential to maximise returns and establish the framework for natural growth. By directing stakeholders towards the most promising opportunities, this targeted investment strategy acts as a compass and improves their competitive position.

Stakeholders should adopt a culture of flexibility and openness to working with technical experts as the market changes. This culture of collaboration makes sure that implementations stay flexible, adaptable to new technology, and in line with end users' constantly changing needs.

The market for cloud-edge-IoT solutions is expanding in Europe, but this is a dynamic process driven by cooperation, flexibility, and strategic foresight rather than a linear one. Those stakeholders who actively use the shared variables and challenges to promote cross-sector collaboration are those who are poised to be competitive, especially when companies from the US and China are leading the market. Stakeholder engagement on an ongoing basis, targeted investments, and modular, scalable solutions are key components of this emerging ecosystem. The way forward necessitates a shared dedication to creativity, cooperation, and tactical adaptability, guaranteeing that involved parties not only capitalise on the expansionary trend but also mould the future Cloud-Edge-IoT terrain in Europe.

In conclusion there is an increasing agreement on the necessity of promoting a strong ecosystem as a result of realising the strategic significance of remaining competitive with world leaders. To do this, the creation of specialised organisations, similar to an "Airbus Consortium," is being explored. The aerospace industry saw success with this consortium model, and its adaptation to Cloud-Edge-IoT aims to empower the European ecosystem in important areas like manufacturing, transportation, energy and utilities, healthcare, and agriculture.

8. Appendixes

Sector	Use Case Code	Use Case (from IDC D1.2 Section 4)	Level	Generic Use Case	Target	Physical Scope	Using	Planning
Agriculture	A01	Employee safety monitoring	L1	Location Tracking	Employee (AWU)	Limited area (Farm)	52%	8%
Agriculture	A02	Employee safety monitoring	L3	Condition monitoring	Employee (AWU)	Limited area (Farm)	52%	8%
Agriculture	A03	Employee safety monitoring	L3	Condition monitoring	Risky Facilities	Limited area (Farm)	52%	8%
Agriculture	A04.1	Asset monitoring and maintenance - retrofit	L4	Predictive maintenance	agricultural assets (fixed, movable)	Limited area (Farm)	50%	9%
Agriculture	A04.2	Asset monitoring and maintenance - OEM	L4	Predictive maintenance	agricultural assets (fixed, movable)	Limited area (Farm)	50%	9%
Agriculture	A05	Visual inspection - quality/integrity	L3	Condition monitoring	Agricultural products (produce, livestock)	Limited area (Farm)	47%	13%
Agriculture	A06	Video security and surveillance	L2	Fixed video surveillance	All assets	Limited area (Farm)	45%	13%
Agriculture	A07	Asset command and control	L5	Asset command and control	agricultural fixed assets (milking machines?)	Limited area (Farm)	45%	14%
Agriculture	A08	Agriculture Field Monitoring	L3	Condition monitoring	Farm Fields (Ha)	Limited area (Farm)	42%	14%
Agriculture	A09	Asset location tracking	L1	Location Tracking	agricultural movable assets (tractors, harvesters)	Limited area (Farm)	41%	12%
Agriculture	A10	Process automation and optimization	L6	Process automation/optimization	Agricultural operations (farms)	Limited area (Farm)	38%	15%
Agriculture	A11	Livestock monitoring	L3	Condition monitoring	Livestock (head of cattle)	Limited area (Farm)	35%	21%
Agriculture	A12	Agriculture Animal Tagging	L1	Location Tracking	Livestock (head of cattle)	Limited area (Farm)	31%	20%
Agriculture	A13	Autonomous vehicles	L6	Autonomous vehicles	Agriculture movable assets (e.g. tractors, harvesters, etc.)	Limited area (Farm)	21%	29%
Agriculture	A14	Smart building	L6	Process automation/optimization	Building operations	Limited area (Farm)	21%	25%

Table 12 - Use Case Analysis – Agriculture

Sector	Use Case Code	Use Case (from IDC D1.2 Section 4)	Level	Generic Use Case	Target	Physical Scope	Using	Planning
Energy	E01	Employee safety monitoring	L1	Location Tracking	Employee	Service Area (distributed)	61%	6%
Energy	E02	Employee safety monitoring	L3	Condition monitoring	Employee	Service Area (distributed)	61%	6%
Energy	E03	Employee safety monitoring	L3	Condition monitoring	Facility	Limited area (substation, generation facility)	61%	6%
Energy	E04	Asset location tracking	L1	Location Tracking	Energy/utilities mobile assets (e.g. not trucks, but valuable stuff inside -- like test equipment)	Service Area (distributed)	60%	9%
Energy	E05	Asset monitoring and maintenance	L4	Predictive maintenance	Energy/utilities fixed assets (e.g. circuit breakers)	Service Area (distributed)	59%	8%
Energy	E06	Fleet tracking	L1	Location Tracking	Energy/utilities mobile assets (e.g. bucket trucks, repair trucks)	Service Area (distributed)	56%	9%
Energy	E07	Smart meters	L5	Asset Command and Control	Residential, Commerical, Industrial Meters	Service Area (distributed)	54%	11%
Energy	E08	Regulatory compliance	L3	Detailed reporting/analysis	Energy grid/infrastructure operations	Service Area (distributed)	53%	11%
Energy	E09	Remote network management	L3	Condition Monitoring	Energy infrastructure	Service Area (distributed)	53%	13%
Energy	E10	Sensor-based diagnostics & maintenance	L4	Predictive maintenance	Energy/utilities fixed assets (e.g. circuit breakers, residential service)	Service Area (distributed)	53%	13%
Energy	E11	Video security and surveillance	L2	Fixed video surveillance	All assets	Service Area (distributed)	52%	16%

Energy	E12	Asset command and control	L5	Asset command and control	Energy/utilities fixed assets (e.g. circuit breakers, residential service)	Service Area (distributed)	50%	14%
Energy	E13	Process automation and optimization	L6	Process automation/optimization	Energy grid/infrastructure operations	Service Area (distributed)	50%	16%
Energy	E14	Drone-based observation	L2	Drone-based inspection	Outdoor facilities, power lines, pipelines, substations, compressor stations	Service Area (distributed)	44%	19%
Energy	E15	Field service technician monitoring	L3	Employee monitoring	Field service technicians	Service Area (distributed)	43%	22%
Energy	E16	Connected drilling and extraction	L6	Process automation/optimization	Full oil exploration and production value chain	Limited area (Exploration area)	39%	20%
Energy	E17	Smart building	L6	Process automation/optimization	Building operations	Service Area (distributed)	38%	29%
Energy	E18	Automated guided vehicles (AGVs)	L6	Automated guided vehicles	Energy/utilities mobile assets (e.g. bucket trucks, repair trucks)	Service Area (distributed)	29%	36%

Table 13 - Use Case Analysis – Energy & Utilities

Sector	Use Case Code	Use Case (from IDC D1.2 Section 4)	Level	Generic Use Case	Target	Physical Scope	Using	Planning
Healthcare	H01.1	Remote Health Monitoring	L3	Condition Monitoring	Ill people @home, people with chronic disease @home, emergency response	Service Area (distributed)	59%	4%
Healthcare	H01.2	Remote Health Monitoring	L3	Condition Monitoring	Ill people @home, people with chronic disease @home, emergency response	Service Area (distributed)	59%	4%
Healthcare	H02.1	Hospital Asset Tracking	L1	Location Tracking	Dumb Assets (beds, wheelchairs) & Smart assets (patient monitors, larger mobile assets)	Limited area (hospital campus)	58%	8%
Healthcare	H02.2	Hospital Asset Tracking	L1	Location Tracking	Dumb Assets (beds, wheelchairs) & Smart assets (patient monitors, larger mobile assets)	Limited area (hospital campus)	58%	8%
Healthcare	H03	Video security and surveillance	L2	Fixed video surveillance	All assets	Limited area (hospital campus)	57%	8%
Healthcare	H04	Regulatory compliance	L3	Detailed reporting/analysis	Patient Healthcare operations	Limited area (hospital campus)	54%	12%
Healthcare	H05	Bedside Telemetry	L3	Condition Monitoring	Patient monitoring devices	Limited area (hospital campus)	53%	9%

Healthcare	H06	AI-enabled Diagnosis and Treatment	L4	AI analysis and recommendations	Medical Imaging and Clinical Data	Limited area (hospital campus)	49%	13%
Healthcare	H07	Robots or augmented-reality-assisted surgery	L4	Robots or AR-assisted repairs	Routine surgeries	Limited area (hospital campus)	48%	8%
Healthcare	H08	Smart building	L6	Process automation/optimization	Building operations	Limited area (hospital campus)	36%	30%
Healthcare	H09	Automated guided vehicles (AGVs)	L6	Automated guided vehicles	healthcare movable assets (e.g. dialysis machines, drug dispensaries)	Limited area (hospital campus)	24%	41%

Table 14 - Use Case Analysis – Healthcare

Sector	Use Case Code	Use Case (from IDC D1.2 Section 4)	Level	Generic Use Case	Target	Physical Scope	Using	Planning
Manufacturing	M01	Asset monitoring and maintenance	L4	Predictive maintenance	Manufacturing equipment (conveyer belts, machine tools)	Limited area (Factory and yard)	64%	8%
Manufacturing	M02	Employee safety monitoring	L1	Location Tracking	Employee	Limited area (Factory and yard)	59%	9%
Manufacturing	M03	Employee safety monitoring	L3	Condition monitoring	Employee	Limited area (Factory and yard)	59%	9%
Manufacturing	M04	Employee safety monitoring	L3	Condition monitoring	Facility	Limited area (Factory and yard)	59%	9%
Manufacturing	M05	Visual inspection - quality/integrity	L2	Visual inspection	Manufactured products	Limited area (Factory and yard)	59%	11%
Manufacturing	M06	Manufacturing operations/automation	L6	Process automation/optimization	Manufacturing operations	Limited area (Factory and yard)	58%	12%
Manufacturing	M07	Video security and surveillance	L2	Fixed video surveillance	All assets	Limited area (Factory and yard)	55%	13%
Manufacturing	M08	Food traceability	L3	Product Value Chain (product level asset tracking -- is it in the refrigerator, or on the floor)	Products	Agricultural Value Chain	53%	11%
Manufacturing	M09	Asset command and control	L5	Asset command and control	Manufacturing equipment (conveyer belts, machine tools)	Limited area (Factory and yard)	52%	15%
Manufacturing	M10	Fleet tracking	L1	Location Tracking	Manufacturing movable assets (e.g. freight trucks, forklifts?)	Limited area (Factory and yard)	52%	14%
Manufacturing	M11	Regulatory compliance	L3	Detailed reporting/analysis	Manufacturing operations	Limited area (Factory and yard)	51%	16%
Manufacturing	M12	Process automation and optimization	L6	Process automation/optimization	Manufacturing operations	Limited area (Factory and yard)	49%	19%
Manufacturing	M13	Smart building	L6	Process automation/optimization	Building operations	Limited area (Factory and yard)	45%	23%
Manufacturing	M14	Asset location tracking	L1	Location Tracking	Manufacturing movable assets (e.g. forklifts, supply pallets, crates)	Limited area (Factory and yard)	45%	19%

Manufacturing	M15	Automated guided vehicles (AGVs)	L6	Automated guided vehicles	Manufacturing movable assets (e.g. forklifts)	Limited area (Factory and yard)	29%	33%

Table 15 - Use Case Analysis – Manufacturing

Sector	Use Case Code	Use Case (from IDC D1.2 Section 4)	Level	Generic Use Case	Target	Physical Scope	Using	Planning
Transport	T01	Employee safety monitoring	L1	Location Tracking	Employee	Limited area (Transport facility)	61%	7%
Transport	T02	Employee safety monitoring	L3	Condition monitoring	Employee	Limited area (Transport facility)	61%	7%
Transport	T03	Employee safety monitoring	L3	Condition monitoring	Facility	Limited area (Transport facility)	61%	7%
Transport	T04	Fleet tracking	L6	Process automation/optimization	Transport movable assets (e.g. freight trucks, locomotives, railcars, buses?)	Limited area (Transport facility), Corridor (rights of way)	53%	11%
Transport	T05	Passenger traffic flow	L1	Location Tracking	Passengers	Limited area (Transport facility) AND/OR Corridor (rights of way)	51%	12%
Transport	T06	Video security and surveillance	L2	Fixed video surveillance	All assets	Limited area (Transport facility), Corridor (rights of way)	51%	15%
Transport	T07	Vehicle and infrastructure inspection	L2	Drone-based inspection	Movable vehicles, transport rights of way	Limited area (Transport facility), Corridor (rights of way)	51%	14%
Transport	T08	Regulatory compliance	L3	Detailed reporting/analysis	Transportation operations	Limited area (Transport facility), Corridor (rights of way)	48%	16%
Transport	T09	Freight monitoring	L6	Process automation/optimization	Containers, Pallets, Crates, Boxes	Limited area (Transport facility), Corridor (rights of way)	48%	18%

Transport	T10	Asset monitoring and maintenance	L4	Predictive maintenance	Trucks, locomotives, trailers, railcars	Limited area (Transport facility), Corridor (rights of way)	47%	20%
Transport	T11	Autonomous vehicles	L6	Autonomous vehicles	Transport movable assets (e.g. freight trucks?)	Limited area (Transport facility), Corridor (rights of way)	43%	19%
Transport	T12	Quality of shipment conditions	L2	Visual inspection	Containers, Pallets, Crates, Boxes	Limited area (Transport facility), Corridor (rights of way)	40%	23%
Transport	T13	Asset command and control	L5	Asset command and control	Trucks, locomotives, trailers, railcars	Limited area (Transport facility), Corridor (rights of way)	39%	22%
Transport	T14	Automated guided vehicles (AGVs)	L6	Automated guided vehicles	Transport movable assets (e.g. forklifts, cranes)	Limited area (Transport facility)	24%	28%
Transport	T15	Smart building	L6	Process automation/optimization	Building operations	Limited area (Transport facility), Corridor (rights of way)	24%	37%

Table 16 - Use Case Analysis - Transportation