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ADVANCED DIGITAL SKILLS

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ON THE EDGE: MARKING THE IMPACT OF THE CEI CONTINUUM ON SKILLS DEMANDS

IDENTIFYING FUTURE BARRIERS TO MARKET ADOPTION FROM LEADING USE CASES

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AUTHOR

Sam Jones, BluSpecs, LEADS

EDITORS

Brendan Rowan, BluSpecs, LEADS
Golboo Pourabdollahian, IDC, UNLOCK-CEI

USE CASE PROVIDERS

NEBulOUS
- Amir Azimian, @fire

NEPHELE
- Elena Torrogloso, ODINS

aerOS
- Eduardo Garro, ProDevelop

NEMO
- Sonja Waechter, Continental Corporation
- Hüseyin Erdogan, Continental Corporation
- Harry Skianis, Synelexis
- Konstantinos Psychogios, Synelexis
- Michail Karadimos, Synelexis

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INTRODUCTION

1.1 Context

The convergence of Cloud and IoT within a computing continuum results from advancements in enabling technologies, such as the development of more intelligent and capable devices, federated AI architectures, and intelligent and programmable networks. The resulting computing continuum is rapidly emerging and demonstrates the convergence and dependencies among different technologies. To this end, LEADS and the EU Cloud-Edge-IoT Initiative (through the UNLOCK-CEI project) joined forces to investigate the link between CEI use cases and the required digital skills for the exploitation of those use cases.

Europe is struggling to generate the skills demanded by different sectors of the EU economy. Advanced Digital Technologies are central to the success and growth of our economy and the functioning of society, but only if we have skilled people to use them. That is why addressing skills challenges and needs in exploitation plans beyond other technology and business elements is a crucial step to support the adoption of use cases developed by teams producing the next generation of advanced technologies.

LEADS has analysed the demand for ADS skills and forecasted its growth over the next five years. This was done by projecting the future demand for ADS skills in three different scenarios, leading to a refinement/validation of the forecast model enriched by new primary research-based data. The resulting findings highlighted the critical need for investment in skills development to meet the demand for advanced digital skills, particularly in the areas of AI and Data Science.

Another critical outcome from LEADS has been the identification of education and training opportunities in the field of Advanced Digital Skills. In this regard, interim results from HEIs courses analysis indicated that, in the sample selected, almost 28.5% of the courses reviewed fell into the 'Advanced Digital Skills' category, demonstrating that, while progress has been made, much more needs to be done at a policy level to address gaps between the supply and demand of ADS, enabling more significant employment and the overall growth and success of the European digital economy.

However, quantitative analysis is based on well-defined technology areas that do not account for the convergence we are going through. For example, integrating IoT and AI in specific sectors such as manufacturing or utilities is driving significant spending in Edge Computing (worldwide spending on edge computing is expected to be $208 billion in 2023, an increase of 13.1% over 2022[1]). For this reason, it is necessary to explore the impact of this shift in paradigm from the defined IoT and Cloud environments towards the Computing Continuum and the emergence of edge computing within this on future skills and talent.

1.2 Objectives

- To identify key roles in the deployment of leading CEI Use Cases within the Meta OS as leading examples.
- To jointly develop the skills profiles of those roles within the existing teams.
- To identify the skills required by eventual industry adopters of the use cases.

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[1] LEADS Deliverable D1.2

- To support the business modelling and commercialisation of projects through the provision of insights for required skills.

1.3 About LEADS

LEADS (Leading Europe's Advanced Digital Skills) Coordination and Support Action (CSA) is a consortium funded by the Digital Europe Programme under the Advanced Digital Skills (ADS) Strategic Objective.

LEADS coordinates a current portfolio of specialised projects that will support excellence in higher education institutions, making them world leaders in training for digital specialists and increase capacity of the training offer for advanced technologies. This is done via a funding of over 80M € of master's programs, interdisciplinary programmes, and conversion programmes. The current portfolio is composed by eight projects that cover the following technology areas: AI, Cybersecurity, Data Analytics, Robotics, IoT, Quantum, Cloud Computing. Among all projects, there is representation of 22 countries, 52 High Education Institutions, 17 research organisations, 31 SMEs and 4 Corporations. The group of masters are expected to provide ADS skills training to at least 133,600 students in the next four years.

Within the Advanced Digital Skills, it is established to provide the workforce in both the private and public sector, in particular ICT professionals and the need to reduce the gender divide in order to secure Europe's long-term growth and sustained prosperity. Under the Specific Objective, the EU is seeking to stimulate the investment in sustainable consortia of education institutes, training providers, and industry to tackle both short-form and long-form skilling, reskilling, and upskilling programmes. This includes bootcamps, alliances, master's programmes, among others.

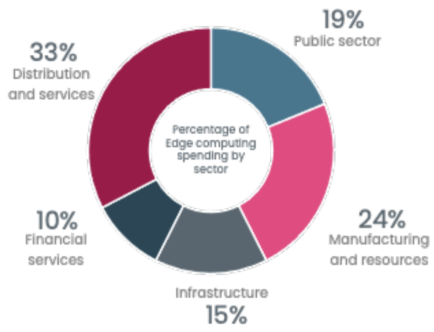
1.4 About the EU Cloud Edge IoT

EUCloudEdgeIoT.eu is an umbrella initiative that provides strategic guidance and tech development for the European Cloud, Edge, and IoT Continuum. It links tech developers with markets, where on one hand it coordinates across clusters of Research and Innovation Actions that will develop and demonstrate the missing components of the technology stack. On the other hand, it provides market forecasting, service-level requirements, go-to-market strategies, open-source community engagement, common architectures, and interoperability standards. Together, EUCloudEdgeIoT.eu supports the European digital economy, European SMEs, and world-class tech development.

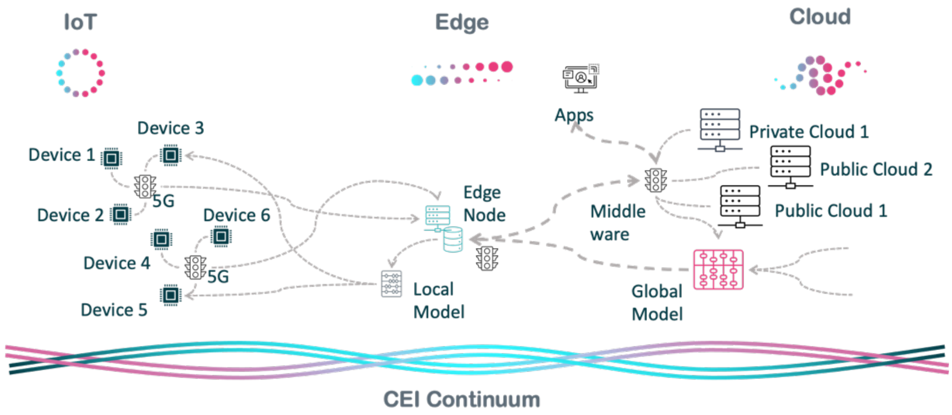
2 USE CASES AS A CONTEXT FOR EXPLORING SKILLS DEMANDS

2.1 Definition of the Cloud Edge IoT continuum

With increasing computing and processing needs, edge computing will join cloud computing as the next important part of digital infrastructures and the convergence of Cloud and Edge will serve as an enabler of future developments. The growing need for edge computing solutions and building CEI networks is reflected in the analysis of expected spending on enterprise edge, estimated to double, from €18bn to €39.6bn, between 2020 and 2025 and outpace the average growth within the ICT market[2].



In Europe, Edge computing is expected to increase at an annual growth rate of 26,5%, from €815m in 2020 to €2.6bn in 2025[3]. Also, Edge is expanding across industries as it allows advances in many forms, from simplifying production and automatizing equipment, increased safety, and reliability, to full digital integration of all resources enabled by the developments in IoT (*see left*). The developments in IIoT and AIoT are especially crucial in distribution and services, and manufacturing and resources which show the highest spending per sector, according to IDC's report.



This convergence of the Cloud and IoT within a computing continuum results from the changing technological landscape. Recent advances have seen the development of more intelligence devices, capable of applying on-device processing combined with the production of federated AI architectures across devices. This is combined with intelligent and programmable networks, development of cognitive cloud systems and advances in orchestration across different cloud environments which has resulted in the device to cloud continuum.

2.2 The role of use cases

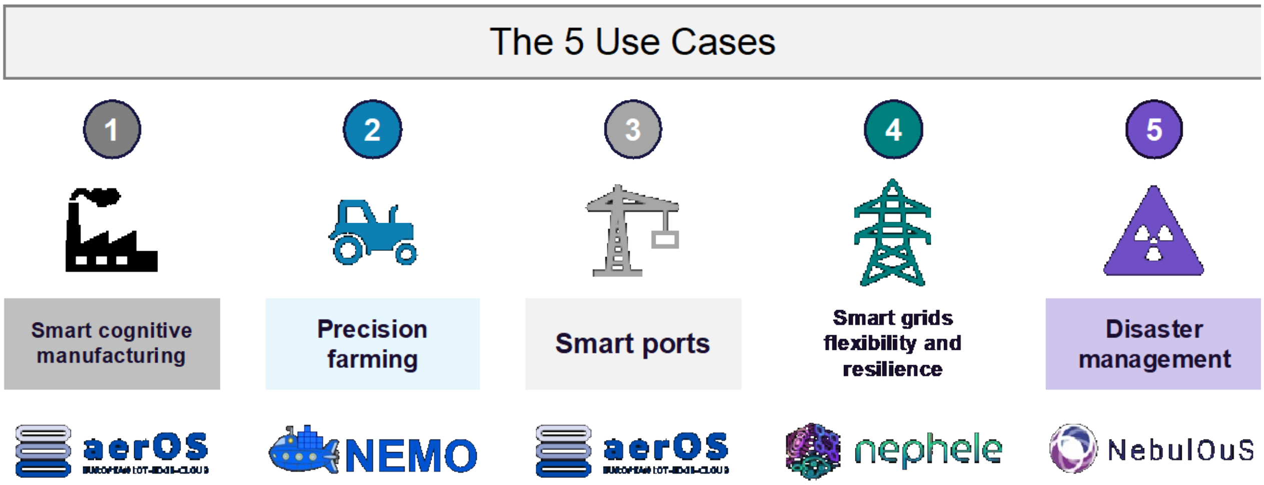
The EU CEI initiative supports the development of technological solutions which will enable the convergence of Cloud-Edge-IoT. One of the component Research and Innovation project clusters, MetaOS, aims to develop next generation of higher-level meta operating systems connecting smart IoT devices, edge-level systems embedded in the computing continuum. Within this cluster are present

[2] Europe Edge Computing Market 2020-2030 (2021) GMD Research

[3] Worldwide Edge Spending Guide (2021) IDC

a set defined use cases which seek to demonstrate the value of and provide a context for the leading technologies and systems that form part of the federated cloud-edge-IoT continuum. The use cases address specific challenges or achieve desired outcomes in selected industries and applications.

5 use cases from the total of 11 present in this cluster served as the basis for the definition of skills demands and mapping of the convergence across roles present within the existing teams. They represented the 5 domains of manufacturing, agriculture, logistics, energy, and environment/disaster management, and the respective value chains within each.[4]



The table below provides a brief overview of the selected use cases - further details can be found in the Annex 3.

Name	Sector	Description
1. **Smart Cognitive Manufacturing**	Manufacturing	The use case involves the evolution of current modular manufacturing systems to cater to mass customization requirements for a diverse range of products. It introduces the world's first autonomous production line at Level 4, utilizing an open modular edge orchestration approach and operating system built upon the IoT, Big Data, and ROS2 communities. The focus is on ensuring quality, circularity, zero environmental footprint, and incorporating AI testing and validation.
2. Precision Farming	Agriculture	The use case involves a precision farming solution that integrates various ground micro-climate, soil, and leaf information stations, agri-drones, semi-autonomous mobile robots, and wearable devices. The objectives are to reduce crop spraying and facilitate organic olive harvesting while validating the NEMO OS (operating system) in a diverse and rapidly changing environment. The solution has undergone a successful pilot in organic olive plantations in Greece, and the already implemented technologies will be further supported.
3. Smart Edge Services for the Port Continuum	Logistics	The use case involves the utilization of aerOS to orchestrate smart services at the edge, enabling maritime companies to respond quickly without relying heavily on high-performance cloud processing. The logistics pilot will be led by the industrial partner EUROGATE and will

[4] EUCloudEdgeIoT.eu. (2023). Meta-operating systems projects: Key solutions, open calls and use cases.

		be deployed and validated at the container terminal in the Port of Limassol
4. Smart Grids - Flexibility and Resilience	Energy	Energy management in smart buildings and cities involves the utilization of smart applications and services to control building equipment. This is achieved through an automation scheme that collects real-time data from various IoT devices, facilitated by Edge nodes that instantiate Virtual Objects (VOs). By implementing these strategies, smart buildings and cities can optimize energy usage, enhance security, and improve overall operational efficiency.
5. Disaster Management	Logistics	NebulOuS platform enhances crisis response by improving communication and computing capabilities. It combines LPWAN technologies and AI algorithms to enhance situational awareness for response teams. BIBA and @fire test the platform during disasters, integrating it with mobile coordination points and collecting data from various sources. This enables efficient resource deployment in affected areas.

2.3 Approach to applying data on skills to market entry.

In terms of identifying skills demands, the LEADS framework outlines a clear methodology, which consists of 4 key elements, as outlined in figure 1 below:

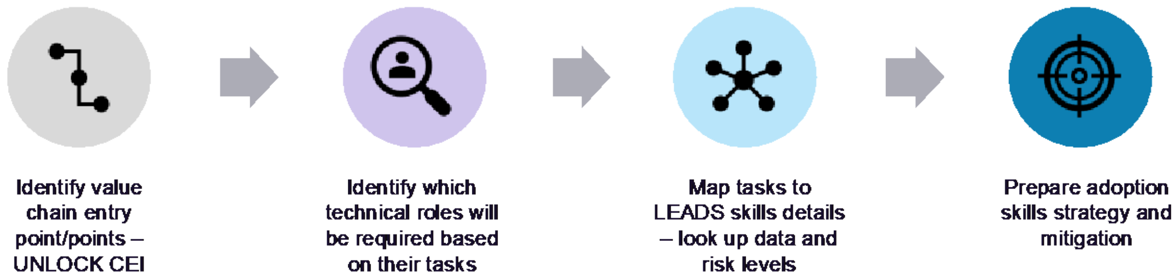


Figure 1. LEADS approach to identifying skills demands

The first step, as covered in the workshop, involves identifying the value chain entry point(s) for the technologies. This consists of assessing the current actors in the value chain (or foreseen value chain) and understanding where the technologies could be applied to the greatest benefit in the operations of each actor.

The second step involves selection of the key technical roles which will be of importance in each use case, and for each, a handful of the most prevalent tasks which would be involved in their job on a daily basis.

The third step brings together the new data and the existing LEADS data, using the tasks and roles identified and applying the pre-defined list of skills in LEADS to each task - 2-3 skills per task – to get an idea of the skills areas from which each use case/sector draw from most, and combining this with the LEADS data, identifying which roles and sectors are most at risk of not matching demand with supply.

The fourth and final step in the process involves preparing an adoption skills strategy which addresses the mitigation of particularly high-demand and low supply skills as per the findings from previous steps.

Strategies to be explored may be the development of a lower skilled user interface, greater tooling, planning for training and skilling partners, pivoting on entry point to value chain, etc.

2.4 Methodology for identifying skills with the CEI

The results provided here within have been collected through a close collaboration with the MetaOS use cases and their respective owners, acting as the model environments for future deployment of CEI solutions.

The identification of the skills was based on roles through the following exercise:

1. Use case owners provided a list of partners currently participating the development and pilot deployment within the use cases.
2. The three main partners were selected and within that three team members were identified by their current roles.
3. Within each role, key tasks were described and skills from the LEADS taxonomy and database were assigned. These skills and tasks were collaboratively defined with other members of the MetaOS and digital skills communities. The main questions addressed included:
   - **(a)** The evolution of the supply of skills for projects
   - **(b)** The differences between skills needed during the research phase and the application stage
   - **(c)** If the skills required for edge are new or a variation on existing skills from other domains
4. The roles and skills were then collected and analysed for their source tech area and level of future demand.
5. Further information was collected through semi structured outcome presentations for each use case and open discussion on challenges experienced by the teams involved.

3 SUMMARY OBSERVATIONS AND INSIGHTS

3.1 The source of edge skills

- The scoping of edge computing skills is not yet mature as the evolution of the CEI continues and takes form. It is assumed to be a mix between that observed in IoT and Cloud. It has been found, however, that the likely emergence of Edge computing roles will emerge more from cloud experts extending down the continuum rather than IoT specialists moving up from platforms. This is evident that roles which included Cloud and both Cloud and IoT, accounted for over 76% of roles while only 16% of roles required IoT skills alone.
- Edge computing demands a hybrid approach, incorporating both existing and novel skills; albeit that the specific requirements might vary depending on the sector and use case in question. Some participants suggested that existing skills can indeed be leveraged for edge computing, provided they are accompanied by the integration of domain-specific knowledge.
- Amalgamating Cloud DevOps and Embedded engineering skills. They argued that professionals well-versed in cloud technologies, such as Kubernetes (K8s), along with a profound understanding of embedded systems, possess a formidable skillset to effectively navigate the intricacies of edge computing.
- Provision of skills for edge computing demands a hybrid approach, incorporating both existing and novel skills. It was suggested that existing skills can indeed be leveraged for edge computing, provided they are accompanied by the integration of domain-specific knowledge.

3.2 A cross-disciplinary engagement

- The CEI is the largest demonstration of the convergence of the advanced digital technologies. Within the roles responsible for the execution of applications across multiple locations and through the incorporation of various data sources and models it had been reinforced the interdisciplinary skillset requiring Cyber, Data and AI capacities beyond just Cloud or IoT. It can be seen that the three combined skills of Cyber, Data, and AI are more present across roles compared to the direct Cloud or IoT skills.
- The development of these ground-breaking and leading use case solutions requires the participation of a multitude of diverse actors, each with their own roles but working collaboratively to ensure that the expected results are achieved. The active participation of the end users and domain experts is particularly notable in their contribution to the design and functioning of the system. This ensures that solutions are fit-for-purpose and establish a close link between the outputs of models, advanced interfaces and tools are correct.
- The need for the combination of roles depends largely on the domain in which the solution is being developed. It has been observed that for example in manufacturing, cloud is less demanded compared to IoT and Cyber, while in crisis management it is still cloud centric for the moment.

3.3 Shifting roles

- As orchestration become more cognitive and automation of systems occurs, the role of application developer will become more central as the *back-office* functions, including network and device configuration will become more redundant and likely specialised. Similar expectations may occur for cybersecurity.

- It is apparent that the demand within the use cases is for flexible teams and roles that can adapt to all the needs. This is especially prevalent given the nature of the research rather than production or execution. The mix of skills and competences is growing, and there is a need for all engineers and developers to be well versed in other areas such as Data, AI and Cyber to be proficient in their activities.

3.4 Challenges for demand and supply

- There are significant differences in the challenges of sourcing talent within a research context; specialised professionals can be more inclined towards production roles in the industry rather than engaging in research activities, additionally their skillsets, through use of specific standardise software tools, from industry are further limited creating barriers to return to research from industry application.
- SMEs and large organisations address meeting the needs of diverse skills within CEI applications; within large organisations, the combination of the necessary skills mix is done at a team level, managing specialist sets or groups, e.g., ML Engineers, which are brought together by a product or project manager. In the case of smaller, tech development companies, this mix is held by an individual e.g., IoT hardware engineer with advanced cybersecurity in cloud applications, until there is a business case, i.e., sufficient volume of activity, to transform into a specialist or hire a dedicated role.

3.5 Impact on market adoption

- The lack of standardisation in edge computing infrastructure poses a challenge, making it difficult to find professionals well-versed in the specific requirements of edge computing environments.
- Across all sectors, there exists a high level of risk to market adoption, i.e., a lack of available advanced skills on the market. This does not vary hugely based on sector, with all 5 use cases demonstrating between a 2x-2.5x increase in skills demand for their respective activities
- Within roles themselves, there is a greater variance based on the demand growth for constituent skills – while some roles, such as developer, or software engineer, are forecasted to experience relatively low growth, it was observed that some of the more specific roles, in cybersecurity and cloud, for example, exhibit a much higher level of market risk.
- Universities face a shortage of practical experiences with cutting-edge technologies, highlighting the need for hands-on training and exposure to emerging technologies to bridge the skills gap.

4 EXISTING ROLES AND THE SKILLS MIX

4.1 The Skills Mix/Convergence

In general, it can be observed that digital skills follow the technology. As new technologies are developed the skills are centralised on a small group of individuals who are highly specialised, which then diffuses to wider groups as training and tools gather pace. This has meant that, to date, it has been relatively possible to delineate neatly between skills for Cloud and IoT as the technology areas have matured over the previous decade.

The shift is now, however, in rapid flux. The emergence of the continuum and the natural overlaps with core skills and linked competencies is the hallmark of the individual engaged in the development and deployment of advanced solutions across both IoT and Cloud. This convergence, centred here illustratively on the Edge, can be seen as the emerging skills mix required for ICT professionals of the near future. Cloud and IoT skills are somewhat distinct from Data, Cybersecurity and AI, as the latter 3 span across the entire spectrum of these advanced digital skills, underpinning the work done in all areas. This is illustrated by Figure 2 below.

As 'Edge Skills' per se do not exist as part of the classification, section 4.2.3 will examine the idea that at least some of these skills already exist, on a continuum between cloud and IoT skills, taking some skills from both, while also considering that there are some 'new' skills, that do not currently exist in one of the other disciplines.

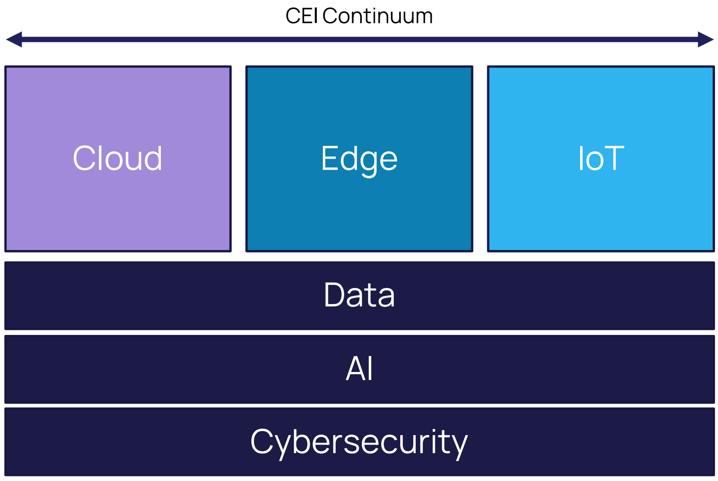


Figure 2. Skills areas in the CEI continuum

As per Figure 2, skills can be categorised into two types: foundational skills and specific skills. Foundational skills are those that are applicable across all domains, including Data, AI, and Cybersecurity. On the other hand, specific skills, such as Cloud and IoT, are more specialized and specific to certain areas. The rationale behind this classification is that foundational skills serve as the building blocks for roles in the 'Cloud' or 'IoT' domains. For instance, having some level of proficiency in Data skills is essential for almost any technical role in today's professional landscape. Similarly, AI skills are rapidly becoming a prerequisite core skillset for Even within roles of the same name, variations can be observed – for example, if we take the 'Data Manager' profile, which appeared across 3 separate use cases (denoted Data Manager 1, 2,3), there is a huge distinction between the roles, with one featuring all 5 skill areas, while the others featured 3 and 4, in both cases not including IoT. These discrepancies could be potentially explained by different definitions across organisations as to what a 'data manager' is, or increased responsibility in a certain use case due to a lack of experts in other fields, like AI and IoT as mentioned previously.

4.2 Roles Identified Across Use Cases

4.2.1 Definition of 'Role', 'Task' and 'Skill'

The LEADS project established a taxonomy of different ICT-related job **Roles** that are likely to have advanced digital skills as part of their capabilities. Roles are included in the LeADS framework to link the advanced digital skills to several job roles widely used and that are reasonably common in the labour market.

Tasks, on the other hand, refer to the day-to-day activities carried out by a person in each of the respective **Roles**. Each of the tasks, in the context of this workshop, is composed of 3-4 **Skills**, each of which come from the skills areas of AI, BI/Data, Cybersecurity, IoT or Cloud.

4.2.2 Existing roles explored

Each of the 3 to 4 organisations involved in each of the use cases was examined in terms of the roles within each one that were involved in each respective use case.

Across the 5 sessions, 19 'Roles' were identified, each consisting of 2-3 'Tasks'. As can be seen below, there are several roles which appear across multiple use cases. Project manager, for example, is a role seen across 3 of the 5 use cases, due to the common nature of the work carried out by this type of profile in the context of an R&I project.

Table 1. Distribution of roles by job type and industry

	Research	Industry	Academia
Manager	- Production manager/engineer - Quality Control Manager - Network Manager/IT Manager - Cloud Manager - Data Manager	- Technical Manager - Project Manager - Project Manager (HSSE Manager) - Technical Manager - IT/Process Manager (Maritime shipping specialist/TOS Manager	- Project Manager
Operator	- Machine operator - Line operator		
Engineer	- Data scientist/engineer - Cloud Engineer	- AI Research Engineer - Software Engineer - Integration Engineer - Network Engineer - Planning & Optimisation Engineer	
Developer	- Cloud Developer	- Developer - IoT DevOps	
Research		- Cybersecurity researcher - IoT/Edge Researcher - Edge/cloud researcher/developer - IoT Researcher - Machine Learning researcher - AI researcher	- ML Researcher - Security Researcher - Researcher - Professor - Post Doc - PhD student
Other	- Tech Dev - Technician - Tech/Admin	- Image Processing - Data Scientist - SW Architect	- IoT expert

In terms of other sector-agnostic roles, i.e., those that exist across the spectrum of use cases, profiles involving Data/AI/ML can be seen across several of the use cases.

In the manufacturing use case, the need for specific operational capabilities was also apparent, with 3 of the 4 organisations counting on a production manager, while QC, Cloud and Data managers also featured. Alongside this, the manufacturing case also necessitated the services of practically skilled users, i.e., line operators or machine operators, while also calling upon the skills of higher-tech profiles such as data scientists and engineers.

This contrasted somewhat with the precision farming use case, where the focus leaned more towards engineering skills, with Software, Technical and Integration Engineers all forming part of the team, as well as an AI Research Engineer. Another variance can be seen when looking at the Smart Grids use case, where there were numerous profiles dedicated to IoT, Edge and Cloud themselves, which, as mentioned prior, are not foundational skillsets like AI, Data and Cybersecurity.

Interestingly, it was noted that only 2 profiles mentioned Cybersecurity, in Precision Farming and Smart Grids. While this seems particularly low for such a crucial, foundational skills area, there is an additional factor to consider – within some roles, there can be a wide range of skills involved in the day-to-day activities of the job, which can span across all 5 of the skills areas and beyond. In fact, within the 17 roles named, 34 cybersecurity skills were identified as part of the tasks (i.e., the component parts of the roles).

4.2.3 Skill types across roles

As per figure 8, we can see there is variety in the type, quantity, and combination of skills across the different profiles examined. While some of the profiles featured skills from all 5 areas, some only drew from 1 or 2 of the areas, suggesting these are more specialised, or niche, roles.

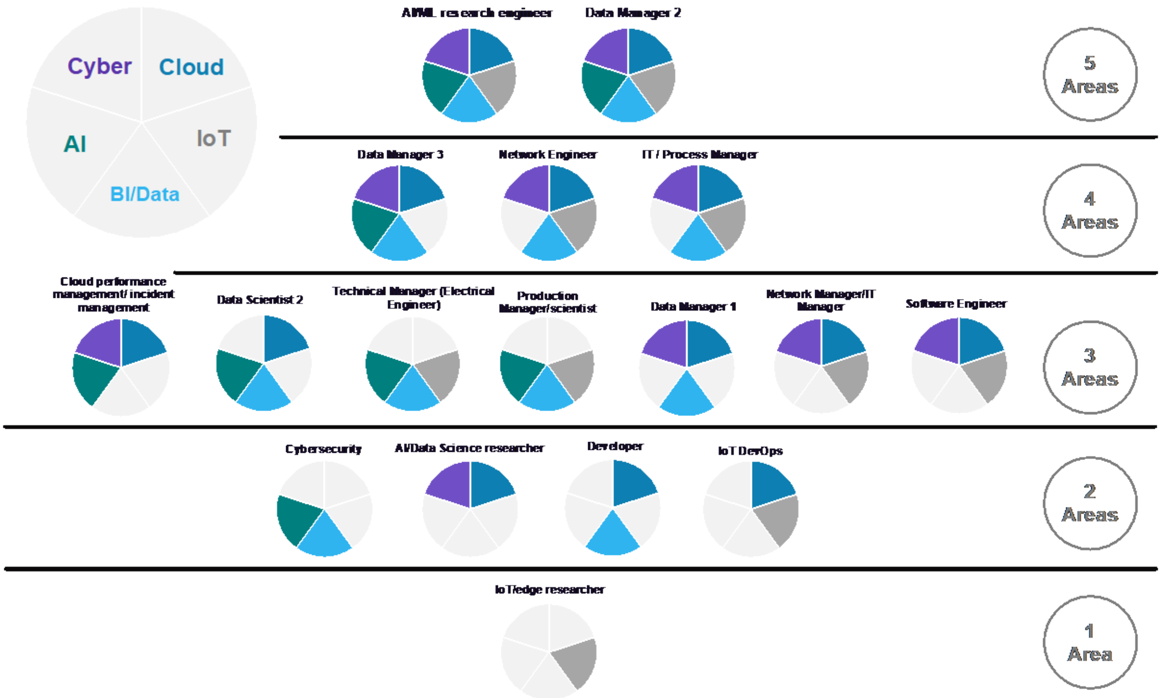


Figure 3. Skills areas which constitute each profile

Another notable presence is the 'AI/ML Research Engineer', which encompasses all five technology areas. The role may include responsibilities like integrating AI capabilities with IoT devices, analysing large volumes of data for BI/Data purposes, leveraging cloud computing resources for AI development, and contributing to cybersecurity by applying AI-based solutions, explaining the wider scope of the role.

On the opposite end of the spectrum, we can see that the 'IoT/Edge Researcher' profile only draws upon 1 of the 5 profiles, IoT. This suggests that the role is far more niche, and does not require expertise in wider fields, with a much more specific and narrow scope. Interestingly, if we contrast the AI/ML Research Engineer profile mentioned above with the IoT/Edge Researcher profile, this holds true to the idea of the foundational skills (AI/ML/Data) vs. the specialist skills (IoT/Edge/Cloud) as outlined in section 4.1.

4.3 Evolution of the skills demand

4.3.1 IoT/Cloud Overlap

Within this exercise, it was sought to understand where the skills for the edge are emerging, is from the IoT or from Cloud. From the results, and observations from practitioners, it appears that the Cloud skills remain the dominant force, with IoT becoming more niche. This correlates to the federated nature of the systems and virtualisation of the hardware which allows the applications to be run across diverse devices already deployed.

Out of the 19 identified roles, a significant portion, 37%, combined both IoT and Cloud Skills. This indicates that employers are increasingly recognising the value of individuals who possess expertise in both areas, reflecting the growing importance of these technologies in the workforce.

Although the overall **percentage of tasks combining IoT and Cloud Skills was relatively low at 7%,** it is noteworthy that each role consists of multiple tasks. This suggests that while not all tasks require both skill sets, there are roles where their combination is essential, highlighting the connection between both skillsets.

Overall, the findings demonstrate that in the early deployments of the continuum, there is a demand for professionals who possess a blend of IoT and Cloud Skills with an equal amount of Cloud skills remaining independently required for deployment. This highlights the need for individuals to acquire or enhance their competencies in these domains to stay relevant and seize opportunities in the evolving landscape of technology-driven industries.

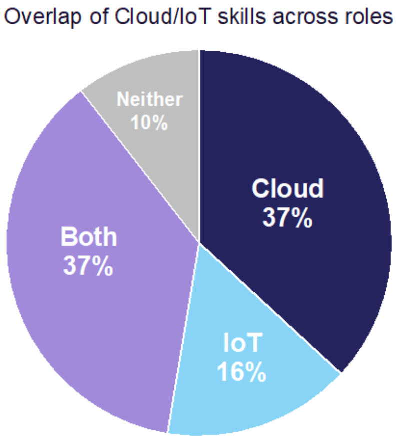


Figure 4.. Breakdown of roles which contain IoT and/or Cloud skills

As such, while the number of specific tasks which require both skills is quite low, the data shows that within the roles themselves, there is a significant overlap between the skills required for both Cloud and IoT. This indicates a divergence in terms of the core skillsets but does suggest that across the range of use cases represented, both skill sets are necessary for a significant share of the key roles.

4.3.2 Forecasted Future Roles

In terms of the forecasted future roles, i.e., the roles foreseen to be part of the implementation of the use case on a wider scale in future, there was a variance from the existing roles and skills necessary.

The list of current roles primarily consists of roles related to data science, analytics, AI/ML research, network management, software development, and cloud engineering. These skills align with the current demand for data-driven decision-making, AI implementation, and managing IT infrastructure. The inclusion of roles like IoT DevOps, Cybersecurity, and Cloud Performance Management reflects the need for specialised expertise in emerging technologies and the growing importance of security and performance in the digital landscape.

	Current	Future
Manufacturing	- Data scientist - Network/IT manager - Production Mgr./scientist - Data Manager	- Not Mapped
Agriculture	- Data Manager - AI/ML research engineer - Network Engineer - Software Engineer	- Crop Specialist - Integrator - Security engineer/analyst - AI engineer - IoT Engineer/ implementer - Data analyst - Compliance Manager
Shipping	- IT / Process Manager IoT DevOps - Data Scientist - Technical Manager (Electrical Engineer)	- Electrical Engineer - Maintenance / TOS Manager - IoT DevOps - Maintenance developer - Data Scientist - Electrical Engineer / IoT Expert - Software / Network / Cloud Engineer - Data Analytics / AI expert
Energy	- IoT/edge researcher - Cybersecurity - Developer - AI/Data researcher	- Cybersecurity developer - IA/ML developer - Business intelligence developer
Crisis Management	- Cloud performance/ incident Manager - Data Manager - Cloud Engineer	- Network operator - Data centre operator - Coordination Stake holders - Logistics manager - Recovery coordination - Decision maker (dynamic data) - Professional rescuers

Table 2. Variation between current roles and forecasted future roles by sector (mapping of future operational scenario for manufacturing remains).

On the other hand, the forecasted future roles include crop specialists, integrators, AI engineers, compliance managers, maintenance developers, and professionals in energy management and logistics. This suggests an **increasing emphasis on specific industry domains**, such as agriculture, energy, and logistics, where technology integration and data analysis will play significant roles in optimizing operations, improving efficiency, and addressing industry-specific challenges.

Additionally, the forecasted roles highlight the importance of data analytics, AI expertise, and cybersecurity. This indicates **the growing recognition of the value of data-driven insights, the expanding scope of AI technologies, and the need for robust security measures** to protect sensitive information.

Overall, the differences between current and future roles suggest a shift in focus towards industry-specific applications, emerging technologies, and the integration of data analysis and AI capabilities into various domains. The projected future skills reflect the evolving needs of industries as they adapt to technological advancements and strive for innovation and efficiency in their operations.

5 EMERGING SKILLS MAPS FOR THE CEI

5.1 The Skills Mix/Convergence

The definition of the skills mix whereby AI, Data and Cyber are horizontal skills requirements is evident when we look at the interdependence of the 5 skills areas across the 19 roles, as displayed in Tables 1 below. The table denotes the percentage of total tasks of each skills group which contain the other skill, **i.e., for all tasks that contain IoT skills, 9.5% of those contain BI/Data skills**. From this analysis, we can see that AI and Cybersecurity, at 25.7%, have the highest average overlap of all the skills, indicating that they are the most applicable to all profiles, closely followed by BI/Data at 23.2%. In contrast, Cloud and IoT only score around 15% for the same metric.

	IoT	BI/Data	AI	Cyber	Cloud
IoT		9.5%	10.8%	11.8%	14.3%
BI/Data	17.9%		59.5%	8.8%	18.4%
AI	15.4%	64.3%		8.8%	8.2%
Cybersecurity	7.7%	9.5%	16.2%		20.4%
Cloud	17.9%	9.5%	16.2%	73.5%	
Average	***14.7%***	***23.2%***	***25.7%***	***25.7%***	***15.3%***

Table 3. Interdependence of Skills Areas within Tasks

5.2 Skills Areas within the LEADS framework

The LEADS framework includes three major elements or layers: a) technologies, b) skills and c) (job) roles.[5]

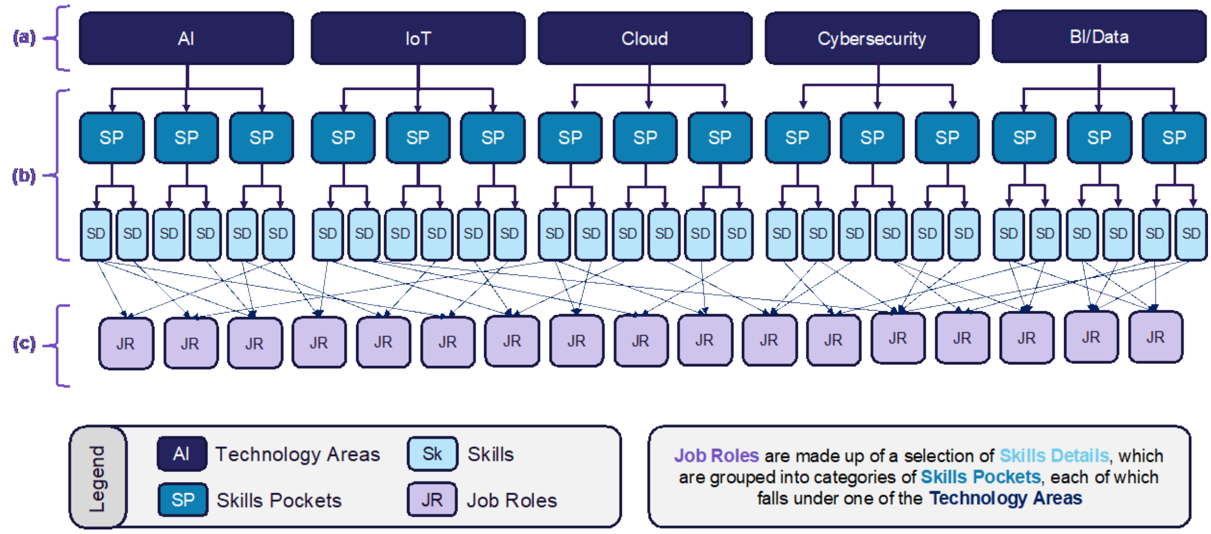


Figure 5. Level structure of LEADS elements

[5] LEADS D1.1 Demand Assessment Framework

a) Technologies

The identification of technologies is based on a high number of data sources, including external data sources and especially a wide range of works and taxonomies previously developed by partners. The result of this work includes the following technologies: Cloud, Business Intelligence / Data Science, Security, Artificial Intelligence (AI) and Internet of Things (IoT). Definitions for all the technologies are provided as part of the framework.

b) Skills

For (b) the first step has been the identification of skills and skills grouping. Guiding principles of the methodology include: the need for consensus, usability, ability for further depth and variety, and technology driven approach (i.e., while we acknowledge the demand for soft skills, they are not part of the LEADS scope). As a result of this work, the framework provides identification and definition of relevant skills within each of the technologies selected in layer a).

c) Job roles

This layer of the framework defines job roles enabling us to link the advanced digital skills to a number of job roles widely used and that are reasonably common in the labour market. Itis also defined in layers: i) a base layer with unique definitions of non-overlapping roles. This base layer needs to be consistent and stable over time; ii) a reference layer linking the unique definitions to other existing frameworks and iii) additional layers with relevant job roles and descriptions overlapping the base layer, but commonly used.

The 5 technologies (layer A) of focus are as follows:

1. Cloud
Cloud solutions/technologies refer to servers that are accessed over the Internet, and the software and databases that run on those servers. Cloud servers are located in data centres all over the world.

2. Business Intelligence/Data
Business intelligence/data support a broad range of analytic techniques across the descriptive, diagnostic, predictive, and prescriptive spectrum. Products in this category are mostly used by information consumers, business analysts, and data scientists rather than by professional programmers.

3. Cybersecurity
Security technologies and services involve a holistic view of all activities necessary to plan, design, build, and manage information security across the enterprise information technology infrastructure.

4. Artificial Intelligence (AI)
Artificial intelligence (AI) is the study and research of providing software and hardware that attempts to emulate the processing capacity of humans. The AI taxonomy is split into three main segments: AI Hardware (server and storage), AI Software (platforms, application development, applications and system infrastructure software and AI Services (Business services and IT services)

5. Internet of Things (IoT)
IoT is defined as a network of uniquely identifiable endpoints (or "things") that autonomously connect bidirectionally using IP connectivity (the IoT ecosystem encompasses a complex mix of technologies

and services including, but not limited to, modules/devices, connectivity, IoT platforms, storage, servers, security, analytics, IT services, and security).

Within each of these technology areas, there are 10-20 skills (layer b), which make up the total spectrum of skills which exist around each respective technology. As per the chart below, the number of skills present from each technology area are reasonably equal, ranging from 34 in Cybersecurity to 49 in Cloud.

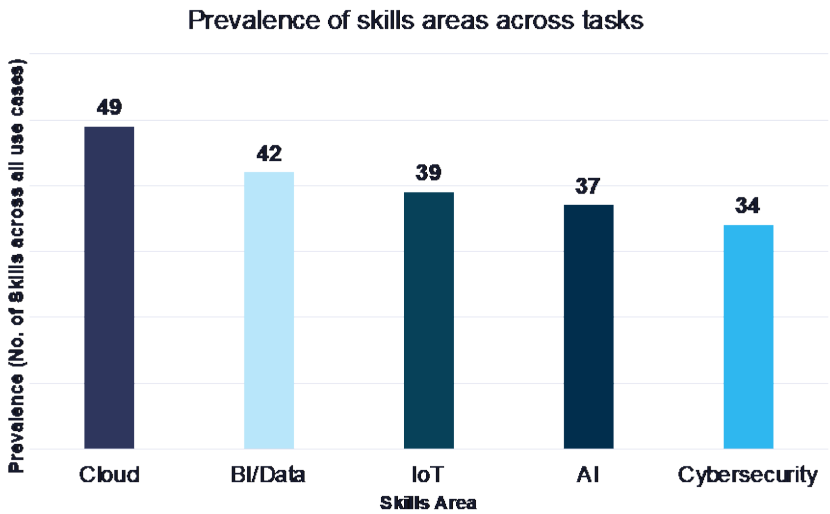


Table 4. Prevalence of skills areas across tasks from all 5 use cases

5.2.1 Breakdown by Vertical/Use Case

As illustrated in the diagram below, it becomes evident that skill areas cannot be solely attributed to specific sectors. Instead, there exists a vast network of interconnected skill areas spanning across all sectors. Consequently, it is essential to consider nearly all skill areas within each sector under examination, while also acknowledging their varying degrees of relevance.

Cloud is the skills area that has the highest number (49) of related tasks in the different sectors, whereas Cyber has the lowest number (34). In general Crisis Management is the sector that has the smallest number of tasks related to the aforementioned skills areas and the shipping sector is the one that shows the highest number of tasks related to these skills areas.

It was found that the Energy, Manufacturing, and Shipping sectors demonstrated a notable presence of AI skills. Similarly, high relevance was observed for BI/Data in Agriculture, Manufacturing, and Shipping sectors. The analysis indicated that Cyber skills played a significant role in Agriculture, Energy, and Manufacturing. However, the number of identified Cyber-related tasks was relatively lower compared to other skill areas, resulting in a correspondingly lower number of tasks across sectors. A notable observation was the relatively even distribution of tasks associated with the IoT skill area across various sectors. Furthermore, Cloud technology emerged as highly important in the Energy, Agriculture, Crisis Management, and Shipping sectors, establishing itself as the dominant skill area across multiple sectors.

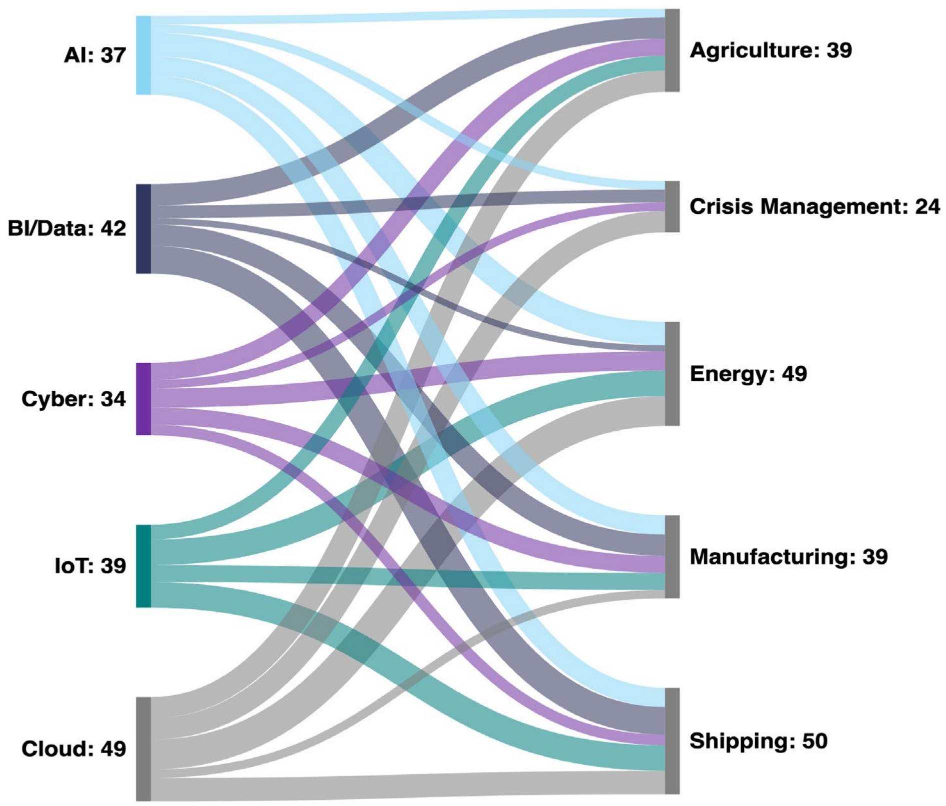


Table 5. Sankey diagram showing the skills from each area dedicated to each use case

The radar charts facilitate a clearer visualization of the significance of various skill areas within each sector.

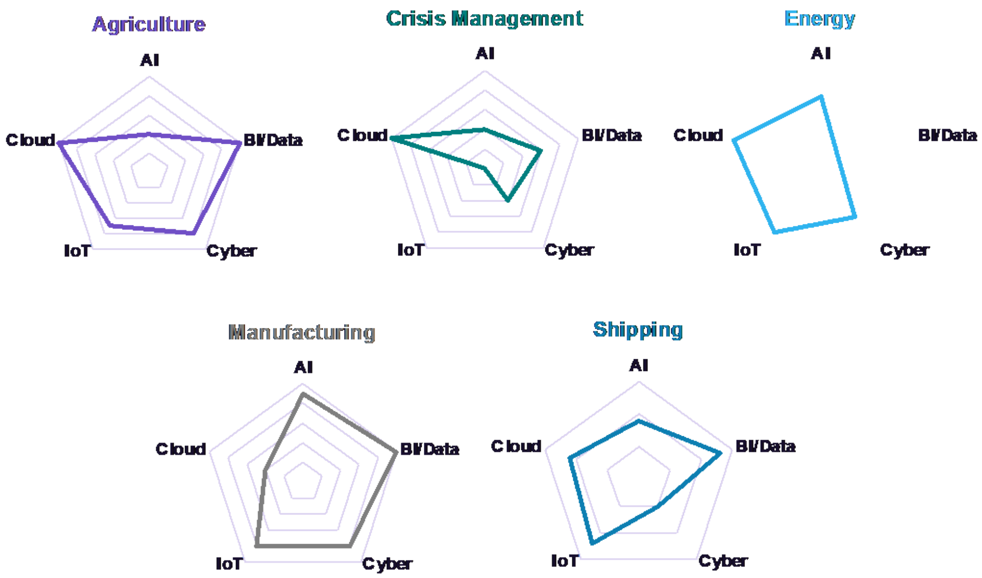


Table 6. Radar charts which represent skills areas of tasks for each sector

In the Agriculture sector, the skill areas that exhibit the highest frequency of tasks are Cloud and BI/Data, while Cyber and IoT demonstrate a moderate to high level of presence. Conversely, the occurrence of tasks aligned with the skills area of AI is notably limited.

In the realm of Crisis Management, Cloud emerges as the predominant skill area, encompassing the highest number of associated tasks. Conversely, the domains of BI/Data, AI, and Cyber exhibit relatively limited relevance in this context. Notably, there is an absence of tasks pertaining to the skill area of IoT. Crisis Management stands out significantly compared to other sectors due to the presence of a single dominant skill area with a substantial number of related tasks.

Within the Energy sector, a substantial volume of tasks aligns with the skill areas of Cloud, IoT, and AI, signifying their importance in this domain. Cyber, holds a moderate to high level of relevance. Conversely, the skill area of BI/Data demonstrates a relatively minor relevance concerning tasks associated with it.

In the Manufacturing sector, the skill areas of BI/Data and AI exhibit significant relevance concerning the number of tasks associated with it. Cyber and IoT, demonstrate a medium to high level of relevance. Cloud, while still pertinent, holds a smaller to medium level of relevance.

Within the Shipping sector, the skill areas of BI/Data, IoT, and Cloud demonstrate a notable degree of relevance in concern with the number of tasks associated with these areas. The skill area of AI also holds considerable relevance, albeit slightly less pronounced. In contrast, Cyber exhibits a relatively modest degree of relevance in this context.

We can see from the charts that there is a stark contrast in the skills mix between different sectors. If we take manufacturing, for example, we can see that all skill areas are relatively equal in terms of share, with the exception of cloud – one possible reason for this is the security concerns associated with cloud processing in a manufacturing context.

In crisis management, on the other hand, we can see that cloud is pivotal, which highlights the difference in priorities across use cases and sectors. Another stark contrast is how IoT does not feature at all in crisis management, whereas it is dominant in manufacturing.

Other noticeable data points from the radar graphs included the lack of cyber skills present in the shipping use case, as well as the lack of AI skills present in the agriculture use case.

5.2.2 Skills for Edge Computing

Edge computing skills have been shown to be more challenging to obtain relative to other skills areas - according to a previous UNLOCK-CEI survey, when it comes to Edge lack of skills is ranked as a more relevant challenge compared to IoT and Cloud (29% vs 21%).

A central theme explored during this workshop revolved around the question of these skills required for edge computing: specifically, whether new skill sets are necessary, or if it involves a combination of existing skills from other domains. In analysing this topic, a diverse range of insights and perspectives were shared by the participants.

Amongst the attendees it was identified that **edge computing demands a hybrid approach, incorporating both existing and novel skills**; albeit that the specific requirements might vary depending on the sector and use case in question. Some participants suggested that **existing skills can indeed be leveraged for edge computing, provided they are accompanied by the integration of domain-specific knowledge.** This suggests that individuals possessing expertise in relevant fields have the capacity to adapt their existing skills to address the distinct challenges presented by edge computing.

One attendee also emphasised the significance of amalgamating Cloud DevOps and Embedded engineering skills. They argued that professionals well-versed in cloud technologies, such as Kubernetes (K8s), along with a profound understanding of embedded systems, possess a formidable skillset to effectively navigate the intricacies of edge computing tasks.

Additionally, some participants advocated for the acquisition of new skills specific to edge computing. This includes expertise in IoT deployment and the critical aspect of securing edge devices, among other pertinent domains. With edge computing involving the deployment of numerous IoT devices, the ability to adeptly manage and safeguard these devices were identified as indispensable.

In summary, based on the collective insights of the expert participants, it can be concluded that the challenge of addressing skills gaps in edge computing necessitates a mixed approach. This entails leveraging existing skills, fostering upskilling endeavours, and assimilating new skill sets, all while integrating domain-specific knowledge at every stage. The multifaceted skill requirements span proficiency in cloud technologies and embedded systems, continuous skill enhancement, and the acquisition of expertise in areas such as IoT deployment and edge device security.

5.3 Skills demand evolution within the projects

Attendees offered valuable insights when assessing the current difficulty of finding the required skills for projects and how this has evolved over the past two years. The **consensus suggested that there are challenges associated with acquiring specialised skills for specific projects, and this situation has evolved to a degree in the last number of years.**

One significant observation is **that specialised professionals are often more inclined towards production roles in the industry rather than engaging in research activities**. This inclination can make finding individuals with the precise skill sets needed for certain projects more challenging.

Additionally, as intelligence is positioned closer to the data through the implementation of edge computing, the demand for engineers and specialists in this domain escalates. This growing demand necessitates finding qualified professionals with expertise in edge computing, which can prove to be a challenge due to the limited availability of such candidates. The overall need for edge computing knowledge amongst relevant professionals was also cited as a challenge, highlighting the importance of fostering a better understanding of edge computing concepts and practices to meet the skill requirements of projects in this field.

Further on the topic of edge, it was put forth that the lack of standardisation in infrastructure poses a challenge, i.e., that the absence of standardised frameworks and practices for edge computing can make it more difficult to find professionals who are well-versed in the specific infrastructure requirements of edge computing environments.

Education was identified as a defining factor. Participants **noted a shortage of practical experiences with cutting-edge technologies at the university level,** further highlighting the need for third-level institutions to address the gap in providing hands-on training and exposure to emerging technologies.

In addition, the use of **software tools for manufacturing applications, which may be outside the traditional scope of industrial engineers, has made it increasingly challenging to find candidates with relevant expertise**. This raises the issue of the need for professionals to adapt and acquire knowledge of these novel software tools.

Lastly, some respondents expressed uncertainty about the skills needed and the best sources to acquire them. However, it was noted that compared to two years ago, there now exists a far greater amount of information and accessible learning opportunities online, such as recognised certifications to help individuals acquire the necessary skills across the domains.

5.4 Risks towards market adoption of use cases

In the current difficulty in finding the required skills for projects has evolved over the past two years, according to these insights. Challenges include the inclination of specialised professionals towards production roles rather than research, limiting the availability of precise skill sets.

The demand for experts in edge computing has grown, but qualified candidates are limited, indicating a need for better understanding and education in this domain. The lack of standardisation in edge infrastructure further complicates finding professionals with relevant expertise. Universities were identified as lacking practical experiences with emerging technologies, emphasising the need for hands-on training. Adaptation to novel software tools and uncertainty about needed skills were also mentioned, although online resources and certifications have increased accessibility to learning opportunities.

5.4.1 Definition of market entry risk

If we combine these findings with the existing data from LEADS, in Figure 5, i.e., the skills forecasted to experience the highest growth in demand in the coming five years (2022-2027) [6], we can see some interesting results. In this context, the percentage is based on the increase in current demand, i.e., 250% equals 2 and a half times more demand for a given skill in 2027 compared to the same skill in 2022.

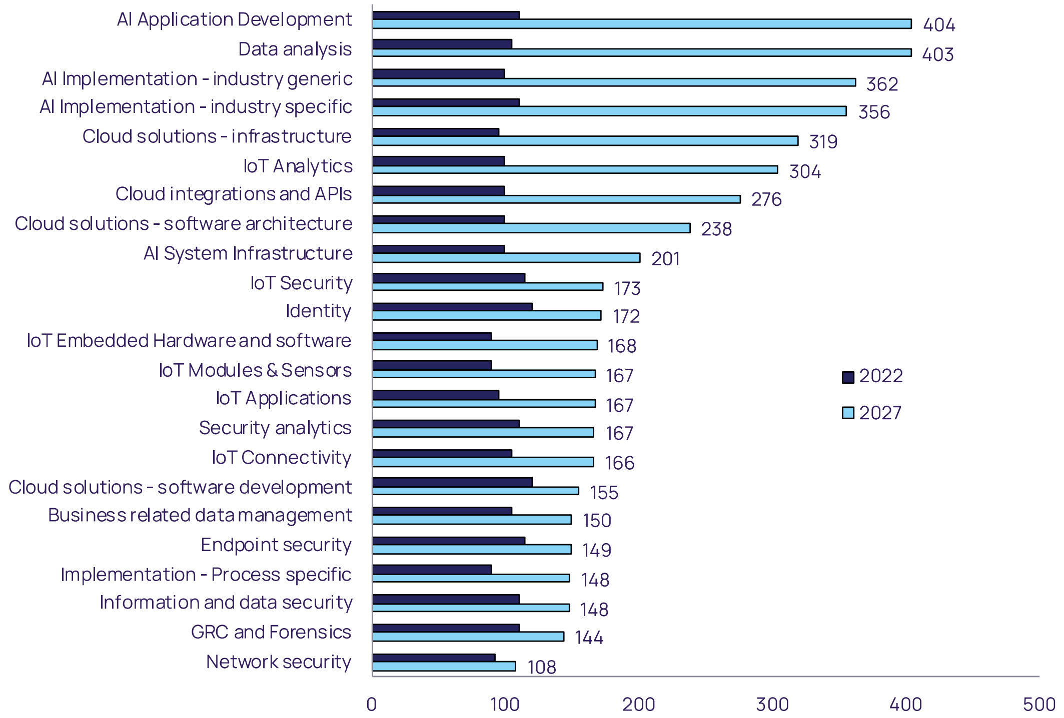


Figure 6. Example of LEADS projected demand growth data

Looking first at Figure 7, we examine the breakdown based on job role. We can see four distinct clusters emerge from this juxtaposition:

[6] LEADS D1.2 First Draft of ADS Demand and Forecast Report

- Very High Risk (>280%)
- High Risk (>220%)
- Medium Risk (>180%)
- Low Risk (>150%)

As technology advances, so does the threat landscape. Cybersecurity Managers, projected to experience a growth rate of 307% and being at the top of the list of risk profiles, as well as Network Engineers/Managers at 195%, are indispensable in safeguarding digital assets from ever-evolving cyber threats and ensuring network reliability and security.

Profile	Avg Risk	Risk By Constituent Skills													
Cybersecurity Manager	307%	352%	347%	347%	338%	331%	331%	306%	306%	274%	274%	241%	241%		
Cloud Engineer	302%	607%	323%	323%	250%	220%	202%	189%							
Data Scientist 2	299%	607%	392%	392%	379%	379%	338%	323%	268%	217%	216%	187%	175%	162%	150%
AI/ML research engineer	288%	607%	607%	268%	266%	222%	222%	216%	162%	162%	147%				
Data scientist 1	245%	392%	338%	336%	322%	306%	222%	217%	217%	162%	162%	156%	110%		
Production Manager/scientist	241%	470%	361%	304%	304%	274%	268%	171%	168%	150%	148%	145%	128%		
Data Manager 3	238%	607%	352%	352%	217%	209%	177%	162%	162%	150%	122%	110%			
Technical Manager	229%	607%	336%	268%	266%	241%	222%	217%	168%	158%	151%	150%	145%	145%	128%
Cloud Performance Manager	227%	361%	336%	209%	202%	142%	110%								
Data Manager 2	223%	382%	352%	338%	241%	217%	209%	183%	172%	161%	145%	141%	139%		
IoT DevOps	206%	323%	266%	250%	216%	202%	195%	189%	168%	158%	151%	145%			
IT / Process Manager	201%	323%	304%	217%	209%	189%	184%	177%	172%	161%	150%	122%			
Network Engineer	197%	323%	250%	217%	209%	176%	158%	151%	147%	145%					
Network manager/IT manager	195%	266%	250%	234%	189%	172%	171%	150%	130%						
Developer	187%	250%	250%	216%	216%	209%	184%	184%	156%	156%	156%	142%	128%		
Software Engineer	182%	250%	216%	209%	195%	156%	147%	142%	139%						
IoT/edge researcher	180%	266%	266%	266%	158%	158%	158%	151%	151%	151%	145%	145%	145%		
Data Manager 1	152%	184%	184%	161%	145%	141%	141%	110%							
AI/Data Science researcher	152%	184%	184%	184%	183%	172%	161%	150%	147%	130%	110%	110%	110%		

Figure 7. Skills shortage risk by job role

Data-centric roles, such as both Data Scientist profiles, with a 245% and 299% growth rates per use case, as well as two out of three Data Manager Roles, underscore the huge growth in significance of data in all aspects of business, with companies eager to capitalise on data-driven insights and actively seeking skilled professionals to analyse, manage, and extract valuable information from extensive datasets.

The cloud sector is also set to witness a substantial boom. Cloud Engineers boasting a growth rate of 302% as well as Cloud Performance Managers predicted to grow 227% indicate the widespread adoption of cloud technologies.

In the realm of cutting-edge technology, AI, and ML Research Engineers with a growth rate of 288% play a vital role in developing advanced AI/ML models and algorithms, powering the automation revolution across industries. Nonetheless, AI/Data Science Researchers seem to be affected less by risk with a growth rate of 152%, the lowest of all profiles, mostly due to the sum of the constituent skills being less under threat compared to the Research Engineer counterpart.

Moreover, the role of Technical Managers with a growth rate of 229%, alongside Production Managers/Scientists at 241% and IT/Process Managers at 201%, highlights the need for skilled individuals who can oversee and optimize technology-driven processes, ensuring smooth operations and productivity.

Although IoT devices are becoming increasingly crucial in transforming various industries, job roles like IoT DevOps and IoT/Edge researchers, with 206% and 180% growth rates each, suggest that the overall risk level for profiles associated with these technologies is moderate to low when compared to profiles with less common skills, which are considered to be at higher risk.

Software Engineers and Developers, growing at 182% and 187% respectively, remain pivotal in creating, maintaining, and improving software applications and technology solutions that underpin the digital ecosystem. Nonetheless, their overall risk levels remain low, primarily due to the accessibility of the required skillset being higher overall compared to other profiles.

In conclusion, the figures reveal that four profiles, accounting for approximately 20% of the total, face a considerably high risk of not meeting the future skill demand, given the projected tripling of demand until 2027. Conversely, only around 10% of all profiles are deemed to be at low risk, experiencing a growth rate half the size of the very high-risk profiles. The majority of profiles fall within the medium to high-risk categories, with growth rates ranging from 220% to 180%.

Use Case	Avg. Risk	Risk By Constituent Skills													
Disaster Management	254%	361%	336%	209%	202%	142%	110%								
		607%	352%	352%	217%	209%	177%	162%	162%	150%	122%	110%			
		607%	323%	323%	250%	220%	202%	189%							
Smart Ports	237%	323%	304%	217%	209%	189%	184%	177%	172%	161%	150%	122%			
		323%	266%	250%	216%	202%	195%	189%	168%	158%	151%	145%			
		607%	392%	392%	379%	379%	338%	323%	268%	217%	216%	187%	175%	162%	150%
		607%	336%	268%	266%	241%	222%	217%	168%	158%	151%	150%	145%	145%	128%
Precision Farming	225%	382%	352%	338%	241%	217%	209%	183%	172%	161%	145%	141%	139%		
		607%	607%	268%	266%	222%	222%	216%	162%	162%	147%				
		323%	250%	217%	209%	176%	158%	151%	147%	145%					
		250%	216%	209%	195%	156%	147%	142%	139%						
Smart Cognitive Manufacturing	217%	392%	338%	336%	322%	306%	222%	217%	217%	162%	162%	156%	110%		
		266%	250%	234%	189%	172%	171%	150%	130%						
		470%	361%	304%	304%	274%	268%	171%	168%	150%	148%	145%	128%		
		184%	184%	161%	145%	141%	141%	110%							
Smart Grids Flexibility & Resilience	207%	266%	266%	266%	158%	158%	158%	151%	151%	151%	145%	145%	145%		
		352%	347%	347%	338%	331%	331%	306%	306%	274%	274%	241%	241%		
		250%	250%	216%	216%	209%	184%	184%	156%	156%	156%	142%	128%		
		184%	184%	184%	183%	172%	161%	150%	147%	130%	110%	110%	110%		

Table 7. Skills shortage risk by use case

Turning to the examination of risk per use case, the data reveals that Disaster Management emerges as the most vulnerable use case. This heightened risk is attributed to a substantial portion of required skills being proportionally in higher demand, culminating in an average growth rate of 254%.

Smart Ports and Precision Farming occupy the middle section of the analysis, also displaying a notable number of critical skills at risk, albeit fewer than the first use case, with average growth rates of 237% and 225% respectively.

Smart Cognitive Manufacturing, along with Smart Grids Flexibility & Resilience, concludes the use case risk analysis, both exhibiting growth rates slightly surpassing 200%. This is mainly due to the involvement of skills predicted to experience lower demand growth than the remaining. It is also worth noting that within the Smart Grids Flexibility & Resilience use case, the profile of the Cybersecurity Manager stands out for facing a substantially higher risk than the use case's average.

It is worth noting that, overall, the risk levels did not vary greatly across use cases, considering the highest risk was 254% and the lowest was 207%. This serves to highlight the high level of risk across the board, agnostic of use case or sector.

6 CEI Skills Development

6.1 Strategy And Approach

6.1.1 SMEs vs. Larger Organisations

On the topic of how SMEs and large companies differ in their approach, it was noted that large organizations tend to keep these skills separate, often having dedicated teams or departments focused on specific areas of expertise. This allows them to build deep knowledge and specialization in particular domains. The availability of resources and capacity in large companies enables them to allocate personnel to specialised roles, resulting in teams that can efficiently handle complex projects and a wide range of digital technologies.

In contrast, SMEs face limitations in terms of resources, including budgetary constraints and smaller teams. As a result, SMEs tend to rely on individuals who possess a broader skill set and can handle various tasks across the digital continuum. These individuals act as generalists, proficient in multiple areas of advanced digital skills. Their versatility and adaptability allow SMEs to navigate the digital landscape with agility, leveraging their diverse expertise in cloud computing, IoT, data analytics, software development, and more. This approach enables SMEs to address a variety of challenges despite their resource limitations.

It was acknowledged that while large organizations benefit from specialised teams, SMEs leverage the versatility of individuals who possess a breadth of knowledge across advanced digital skills. However, as SMEs grow and reach a critical mass of work, the possibility of developing specialised roles and departments was recognised. This evolution would mirror the structure of larger organizations, allowing SMEs to accommodate the increasing complexity and scale of their digital initiatives.

6.1.2 From research to application

The challenge of translating technology progress in a research context into applied, commercially viable solutions has proven to be a challenge in Europe for decades, i.e. 'The European Paradox'. This extends into the fields of advanced digital technologies, for a number of reasons, as indicated by attendees.

Certain participants indicated that although their projects operate within a commercial setting, the methodologies employed for deployment may lack the desired level of agility. This implies a necessity for more efficient and adaptable deployment practices to achieve successful commercial implementation.

Conversely, there were individuals who strongly believed that the skills present within their project teams were indeed suitable for deployment in a commercial environment. They viewed their projects as precursors to future advancements, underscoring the significance of further developing and refining existing proficiencies to meet the evolving demands of the commercial landscape.

Another attendee felt that the skill requirements for deployment aligned well with the current composition of project teams, although, they acknowledged the essentiality of incorporating additional profiles, such as commercial and product specialists, during the subsequent operational phase. This is an indication of the diverse skill sets required beyond the initial deployment stage to effectively leverage and capitalise on the outcomes of the project.

Additionally, some participants recognised the possibility of needing supplementary skills as the products remain operational for extended periods, i.e., that deployment skills alone may not be sufficient in the long run, and continuous skill development and adaptation will be necessary to address emerging needs.

Finally, some attendees emphasised the challenge of finding commercial personnel with expertise in IoT/Edge knowledge, despite having dedicated IoT/Edge teams and products. This suggests the emergence a specific skill gap for individuals who possess both commercial acumen and knowledge in IoT/Edge technologies.

ANNEXES

Annex 1: Event Agenda

<table>
<tr><th>Time</th><th>Item</th><th colspan="2">Description</th></tr>
<tr><td>11:00</td><td>Introduction</td><td colspan="2">- Welcome
- Objectives
- Methodology</td></tr>
<tr><td>11:05</td><td>Key market demand use cases</td><td colspan="2">Overview of opportunities for CEI adoption</td></tr>
<tr><td>11:15</td><td>Advanced Digital Skills as levers of adoption</td><td colspan="2">Presentation on the skills demands over the next 5 years and how skills within CEI are evolving</td></tr>
<tr><td rowspan="2">11:30</td><td rowspan="2">Role mapping on key use cases
Working in 5 groups to understand the key profiles within diverse MetaOS use cases, each group consists of 5 in total, focusing on one use case each</td><td>Parallel Session 1</td><td>Smart cognitive manufacturing
Data driven cognitive production lines / aerOS</td></tr>
<tr><td>Parallel Session 2</td><td>Precision farming
Precision bio-spraying / NEMO</td></tr>
<tr><td rowspan="3">12:05</td><td rowspan="3">Building skills profiles
Applying the LEADS taxonomy to build up a skills profile and be able to predict high risks</td><td>Parallel Session 3</td><td>Smart ports
Smart edge services for the port continuum / aerOS</td></tr>
<tr><td>Parallel Session 4</td><td>Smart grids flexibility and resilience
Energy management in smart buildings & cities / NEPHELE</td></tr>
<tr><td>Parallel Session 5</td><td>Disaster management
Crisis management / NEBulOUS</td></tr>
<tr><td>12:30</td><td>Future skills demands for EU CEI</td><td colspan="2">Discussing on the impact the skills dimension will have for the commercial feasibility of systems and applications</td></tr>
<tr><td>12:50</td><td>Plenary discussion</td><td colspan="2">Discussion of the workshop outputs and recommendations for the exploitation plans of the projects</td></tr>
<tr><td>13:00</td><td>Close</td><td colspan="2">Closing remarks</td></tr>
</table>

Annex 2: Contributing Projects

Session	Use Case	Representative
Session 1	**Smart cognitive manufacturing** Factory robotics / aerOS	Pablo Patús Diaz
Session 2	**Precision farming** Smart farming and agriculture lab / NEMO	Harry Skianis Konstantinos Psychogios Michail Karadimos
Session 3	**Smart ports** Smart ports (Cyprus) / aerOS	Eduardo Garro
Session 4	**Smart grids flexibility and resilience** Smart city / NEPHELE	Elena Torrogloso
Session 5	**Disaster management** Crisis management / NEBulOUS	Amir Azimian

Annex 3: Use Case Detail

Smart cognitive manufacturing (Factory robotics / aerOS)

Partners: MADE, Innovalia, SSF, Siemens, POLIMI, Nasertic, SIPBB

Locations: Bilbao, Spain; Milan, Italy; Biel, Switzerland; Nuremberg, Germany

Overview:

- Evolution of existing modular manufacturing systems needs strategies towards mass customisation for processing a wide range of products.
- The fast use and processing of data is of paramount importance to make intelligent automated human-centred augmented and assisted decisions.
- aerOSwill introduce the enablers to raise production autonomy as its distributed edge-powered modular approach will facilitate IoT edge-cloud continuity

Objectives and expected benefits:

- First worldwide autonomous production line (Level 4) introducing an open modular edge orchestration approach/OS building on IoT, Big Data & ROS2 communities.
- Quality, circularity, zero footprint and AI testing and validation.
- Effective data distribution and sharing closer to the source ensuring data integrity and security.
- Safe human/machine collaboration.
- Dynamic intralogistics adaptation and autonomous production scheduling

Location of the use case: Siemens Innovation Factory, Manufacturing facilities, Didactic factory at AIC, Cloud infrastructure at NASERTIC, Made Competence Centre, Polimi Industry 4.0 Lab Facilities, SSF Open Factory Lab at SIPBB

Constrains, challenges, risks: High latency response, big data volumes to process, Mass customization needs, Cloud's computing resources, Complexity and variety of production processes, Manual processes, Data sources variety, Adaptation to all production lines, Send information securely to the cloud, Obsolete machinery, Obsolete IT infrastructures.

Stakeholders: INNOVALIA, SIEMENS, MADE, Nasertic, Switzerland Innovation Park Biel, POLIMI

User centred impact:

- Production lines Intelligence and analytics service providers/users need an efficient yet secure data management and processing using AI. Smart devices and Containerised services which will contribute towards continuous improvement of production processes and optimised production.
- Quality control/ dimensional monitoring providers/users want real-time operation warnings with self-diagnostics and recovery capabilities achieved using AI, databases and dimensional instrumentation devices which will together increase the efficiency and safety, avoid defects in production and allow zero-touch service management
- Real-time logistics/ AGV providers need various functionalities including real-time, low latency autonomous operations and processes thorough manufacturing execution systems, PLCs and AGVs leading to zero-breakdown logistics and optimised processes.
- Industrial equipment and IT infrastructure providers/users' needs high yield production lines and decrease costs not only due to data intelligence and predictive capabilities but also data sharing and integration.

Precision farming (Smart farming and agriculture lab / NEMO)

Partners: Synelixis, Agia Sofia Estate, OTE

Locations: Peloponnese, Greece

Overview:

- Precision farming solution combining multiple types of ground micro-climate/soil/leaf information stations, agri-drones, semi-autonomous mobile robots, and wearable devices.
- Pilot done in organic olive plantations in Greece and NEMO will support technologies already implemented, e.g., Anti-frost system, irrigation system, etc.

Objectives and expected benefits:

- Reduce crop spraying and support organic olives harvesting while validating NEMO OS on heterogenous and fast-moving scenario.
- Make intelligent decisions through real-time positioning and CF-DRL functions hosted on the IoT or at the edge.
- Create extensive Data Sets to be shared as FAIR data via the European Open Science Cloud (EOSC)
- Validate NEMO user acceptance from a farmer viewpoint evaluating bio-spraying efficiency, simplicity, and cost

Location of the use case: Ground robots, Mobile Apps, Cloud server, Drones, Synfield nodes, Edge server, Agia Sophia estate Peloponnese

Constrains, challenges, risks: Rural areas and limited availability of high-end infrastructure (5G nets), Weather conditions, Plethora of diverge devices and architectures (legacy systems), Limited datasets, Dataset security, Security in M2M interactions, Physical Security of Network, and devices.

Stakeholders: European Commission, IoT device manufacturers, Farmers, IoT/edge/Cloud solution provider, Citizens, Business in olive oil value chain

User centred impact:

- Smart Farmer who needs to optimise the use of resources, specifically organic pesticides using precision spraying to reduce operations costs.
- Smart Farmer who needs to grow healthy olive trees to increase harvest.
- Smart Farmer who needs to situational awareness of the farm through integrated IoT-edge-cloud solution which will result in optimised operations and greater harvest.
- Smart Farmer requires fast and robust smart farming tools through spraying precision (aerial & terrestrial) with advanced ML-based models which will preserve organic certifications and secure product supply.

Smart ports (Smart ports (Cyprus) / aerOS)

Partners: EUROGATE

Locations: Port of Limassol, Cyprus

Overview:

- With the constant increase in international commerce, existing ports are currently at capacity with physical expansions of terminals being difficult. The best solution is to increase the efficiency and productivity of existing ports through digitalisation and use of new technologies.
- **aerOS** will allow to orchestrate smart services in the edge, allowing maritime companies to react faster without the need of a high-performance processing in the cloud

Objectives and expected benefits:

- Ensure that the data generated in the sources of the information are manipulated at the edge
- Enough computing performance in the edge elements in compliance with the smart orchestration approach of **aerOS**
- New AI and abstraction cloud methodologies application that will allow sophisticated cognitive services validation

Location of the use case: EUROGATE Limassol, STS Crane, Straddle Carrier, Edge, Cloud, AV cameras, Video recorder / processor, Containers, Computer vision software, CMMS

Constrains, challenges, risks: Proprietary maintenance solutions, Cargo handling quality check, Worker's safety, Preventive maintenance solutions, Reactive -> Not proactive, Security risks sending to cloud, old infrastructure, Costly (money-wise) OCR solutions, Computational demanding CV solutions, Heterogeneous manufacturers.

Stakeholders: Container terminal board, Maintenance team, Shipping company, AI-based service provider, Crane manufacturer, Freight forwarder, IoT Technology provider, Crane driver.

User centred impact:

- Container terminal board needs to optimise crane operations to provide safe working environment, quality assurance and increased efficiency thought an IoT platform that can be connected to various sensors and monitor operations resulting in optimised operations of the port.
- Container terminal maintenance team needs to extend the lifespan of cranes to decrease costs and optimize operations using terminal operating system connected to crane monitoring management system based on AI-based IoT service proactively alerting potential damages on cranes.

- IoT technology provider wants to provide a secure and affordable IoT platform for asset monitoring using storage and processing infrastructure which will be based on IoT platform running over an aerOS supported in any infrastructure environment.
- AI-based service provider needs a service proactively alerting potential damages on cranes to optimise operations using computer vision which will result in AI/ML services at good value and increased security in the working environment.

Smart grids flexibility and resilience (Smart city / NEPHELE)

Overview:

- Smart applications and services can help to manage control actions of building equipment.
- This is implemented by deploying an automation scheme that gathers real-time information from a variety of IoT devices together with Edge nodes that will instantiate VOs.

Objectives and expected benefits:

- High-performance level of benefits in terms of:
    - Latency.
    - Energy consumption.
    - Reliability of the offered services.
- Energy Efficiency Management security, which is of paramount importance for smart building applications

Location of the use case: Gateways, Sensors, Buildings, Cameras, Cloud, Edge, Appliances, Urban furniture, Network infrastructure

Constrains, challenges, risks: Economic risks, Heterogeneous devices, No network infrastructure, Reliability of the network, Physical security of humans, User data security, Regulatory limitations, Real-time execution, Trust, Constrained IoT devices, Privacy risk.

Stakeholders: Energy communities, Network operators, Architects & builders, Energy providers, Ministry of Economy, Transport & Industry, Citizens, City government, Businesses, and companies, IoT device manufacturers, HVAC manufacturers & installers, Appliance manufacturers.

User centred impact:

- Citizens want energy efficient and secure homes using secure group communications, real time monitoring and execution resulting in a dashboard with authentication & authorisation features and reduced energy costs.
- The local government wants to reduce resource usage while improving services offered using data analysis and IA-driven decision based on distribution of smart energy management applications.
- Building managers want to reduce resource usage while improving services offered with data security and analytics achieving smart energy management.
- Security services need to ensure citizens' security while respecting privacy using distributed AI and real-time monitoring resulting in improved object detection and better security.

Disaster management (Crisis management / NEBulOUS)

Partners: Bibo, @Fire

Overview:

- One of the most difficult challenges in dealing with large-scale disasters is coordinating response crews, materials, and equipment from various stakeholders. Obtaining a clear picture of the situation in the affected area is critical for operational management, allowing for the efficient and safe deployment of available resources.

Objectives and expected benefits:

- To enable widespread communication and computing in crisis scenarios by delivering a flexible fog computing platform that can adapt to the situation at hand.
- By combining the NebulOuS platform with modern LPWAN technologies, not only a situational map can be developed but also AI algorithms can be deployed on multiple levels of the edge-cloud-continuum.

Location of the use case: Anywhere! Off the grid, Local Server, On Edge Point/IoT, Smartphones / Mobile App.

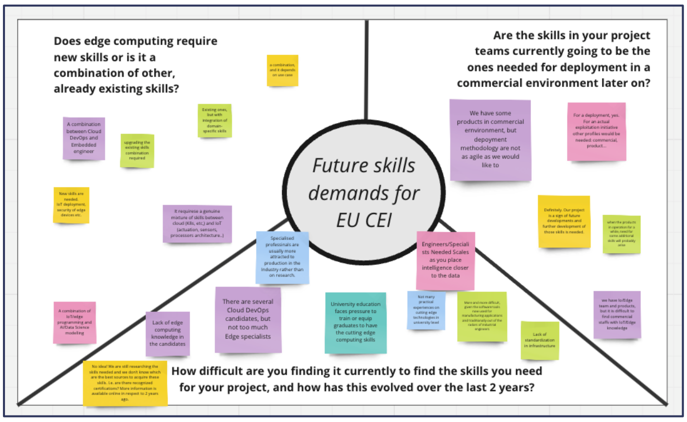
Constrains, challenges, risks: Different Cloud provider, Internet connectivity, Communication Possibilities, Connectivity between Nodes/Edge to Cloud, On-field data processing, Data acquisition, Orchestration between edge points and designated cloud.

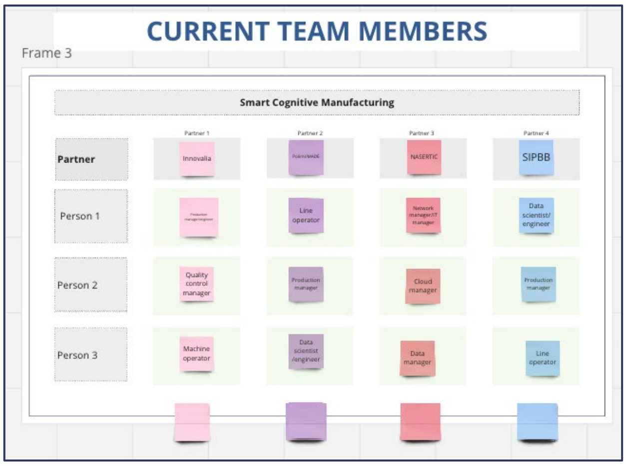
Stakeholders: System Operator (@fire), Affected Public, Application Developer, Other Emergency Services, First Responder, General Public, Government Authorities.

User centred impact:

- Disaster Response Management Cell needs to have data management on field using mobile computational capacity which will consequently increase total information processed digitally in disaster management.
- Governmental Authorities need better coordination between different teams and efforts to deliver post-process information and to have access to better and faster information.
- Responders need to be able to communicate digitally even in remote areas with low coverage while having reliable communication and instant access to information.
- Citizens need to have faster updates and information on the status of a disaster response with information filtering and post process which will be publicly available and visualized.

Annex 4: Miro boards from sessions





Annex 5: Workshop Agenda and Breakout Room Layout

	Session 1	Session 2	Session 3	Session 4	Session 5
Project	aerOS	NEMO	aerOS	nephele	NebulOuS
Use case	Data-driven cognitive production lines	Smart farming: precision bio-spraying	Smart edge services for the port continuum	Energy mgmt. in smart buildings & cities	International Disaster Response
Facilitator	G. Pourabdohallain	Sam Jones	J.E. Álvarez	Brendan Rowan	Martín Robles
Presenter(s)	Pablo Patús Diaz	Harry Skianis	Eduardo Garro	Elena Torrogloso	Amir Azimian
Expert(s)	E. Menasalvas	K. Psychogios Michail Karadimos Leonardo Freitas	Rudolf Sušnik	Francesco Bellesini Prashanth Kumar	-
Attendees	**All other attendees** – choose the session which interests/applies to you most!				