LEADS
ADVANCED DIGITAL SKILLS

D1.2 FIRST DRAFT OF ADS DEMAND AND FORECAST REPORT

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EXECUTIVE SUMMARY

The LEADS project holds a critical role in enhancing European competitiveness in the area of Advanced Digital Skills. The initiative aims to provide substantiated insights and recommendations on skills that will help policy makers and other private and public institutions understand where to invest and why. LEADS is generating new knowledge through analysis of a wide array of data sources, generating additional new data regarding the supply and demand of Advanced Digital Skills (ADS). As a result, LEADS has proposed an ADS Framework, which includes identifying technology areas, skills, and job roles.

This report builds on the ADS Framework proposed by LEADS, analysing the demand for ADS skills and forecasting its growth over the next five years. The final version of this report will complement these findings 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.

Through the analysis of LEADS' methodology and data, it becomes apparent that most advanced digital skills, specifically in AI and Data Science, will register a significant growth in demand over the next five years. This growth will drive the development of adjacent areas such as Cloud, IoT, and Cybersecurity. However, given the current labour market and the existing talent and skills gap, meeting the demand for a workforce possessing these advanced skills will be a significant challenge not only for Europe but on a global level.

Thus, the LEADS project's findings highlight the critical need for investment in skills development to meet the demand for advanced digital skills. This report will serve as a foundation for policy makers and other private and public institutions to understand where to invest in the development of skills required to enhance Europe's competitiveness in the global market.

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ABBREVIATIONS

ADS	Advanced Digital Skills
AI	Artificial Intelligence
AIOTI	Alliance for the Internet of Things Innovation
BDVA	Big Data Value Association
BI	Business Intelligence
CAGR	Compound Annual Growth Rate
CATI	Computer-Assisted Telephone Interview
CISO	Chief Information Security Officer
EC	European Commission
ECF	e-Competence Framework
EU	European Union
GPU	Graphics Processing Units
HPC	High Performance Computing
ICT	Information and Communication Technologies
IoT	Internet of Things
IT	Information Technologies
JU	Joint Undertaking
ML	Machine Learning
MS	Member State
MSP	Managed Service Provider
NICE	National Initiative for Cybersecurity Education
NVME	Non-Volatile Memory Express
OECD	Organisation for Economic Cooperation and Development
SCM	Storage Class Memory
SDS	Software Defined Storage
SSDs	Solid State Driven
USD	US Dollar
WP	Work Package
5G	Fifth Generation

1. INTRODUCTION

LEADS is a project of paramount importance for the future of European competitiveness. Technology has been an asset for companies for many years, but in the last 5 to 10 years, adopting IT is no longer a choice, but a need. The shift towards Digital Transformation, lower costs of many technologies that were previously affordable for large corporates, supply chain disruption, need for sovereignty, cybersecurity attacks, economies of scale, servitization, social media, 5G, the request for real-time reaction…have all increased the demand for IT. Adoption of technologies, in particular emerging technologies, is not straightforward, and many factors can drive or prevent such adoption. One of the main barriers is the availability of skills and retention of talent. While in the past small companies were more likely to experience these difficulties due to limited resources (and the inherent difficulty in hiring people with the required skills), nowadays this problem affects companies across almost every sector due to the increasing demand for, and the shortage of professionals to cover the available positions. This gap between supply and demand is increasing for IT-based profiles. Data, AI or Cybersecurity specialists are needed in a wide range of organizations, whether public or private and covering a wide range of sectors (energy, agriculture, mobility, manufacturing, tourism, etc). Globalization and in particular the acceleration of teleworking or homeworking as a result of the COVID-19 crisis has also created a playground where companies from all over the world "fight" for the best people regardless of the country where they are located. Technologies like AI also have enormous potential to shape the workforce in the next 5-10 years. While some jobs or profiles may suffer a growth in the beginning because of increase of the demand for specific products and services as a result of AI application, they may fade away when the demand is saturated. Other jobs may directly be replaced or removed, and new skills will come into play to adapt to the new labour needs. This will still take a few years to be realized.

LEADS will not address all the angles of this complex picture because it would not be realistic due to limited resources but will provide substantiated insights and recommendations that will help policy makers but also private and public institutions in the skill supply and demand side to understand where to invest and why. In particular, LEADS is generating new knowledge as a result of the analysis of a wide array of data sources and the generation of additional -new- data regarding the demand and the supply of Advanced Digital Skills (ADS). WP1 focuses on the deep understanding of the demand, and for this, the proposed approach includes the following works: i) elaboration of the LEADS ADS Framework (considering the baseline of existing skills frameworks), including the identification of technology areas in scope for our study, skill pockets or groupings within those areas and job roles, ii) assessment of the demand for ADS skills and initial forecasting, and iii) projection of future demand for ADS skills in three different scenarios, leading to a refinement/validation of our forecast model enriched by new -primary- data.

D1.1 presented the proposed framework; D1.2 revises the framework based on feedback from external communities and provides the initial demand assessment and forecasting, as detailed in section 1.2.

1.1. TARGET AUDIENCE

The first draft of ADS Demand and Forecast Report targets multiple audiences, including policy makers within the European Union, education leaders, local governing bodies with responsibilities in education and members of the technology industry community who are interested in understanding the impact that technological advancements will have on advanced ICT skills and the future of the IT education industry. The project aims to provide these stakeholders with insights into the future demand for a set of identified advanced digital skills (see definition of advanced IT skills on D1.1), based on several market indicators, and to help them understand where the European Commission and MS should focus their efforts to develop policies that will support the growth of IT education in the regions.

The project is particularly relevant for policy makers within the EU who are responsible for shaping the education policies and digital agendas of their countries. The LEADS project can help these individuals to identify potential gaps in the IT education industry and develop policies that will address these gaps. Additionally, education leaders and local governing bodies can use the insights provided by the project to make informed decisions about the allocation of resources and the development of IT education programs that will meet the needs of their local communities. Ultimately, the LEADS project can help ensure that the IT education industry in the European Union is better equipped to meet the demands of the future and mitigate potential bottlenecks in the education system

1.2. CONTENT AND RELATIONSHIP TO OTHER PARTS OF THE PROJECT

The first draft of ADS Demand and Forecast Report is part of WP1 and builds on the output of D1.1 (ADS Framework), using the established skills taxonomy and framework to collect data on advanced digital skills demand through both secondary and primary data sources. The methodology leverages population statistics, economic growth statistics, and predictions, labour force and employment rates, age distribution, national and international IT workforce statistics, technology spending and predictions and a designed survey to assess the market demands for the identified advanced skills.

This is the step prior to conducting a final forecast of digital skills demand in Europe for the next 5-7 years, using scenario analysis. Overall, the first draft of ADS Demand and Forecast Report is an important intermediate step in the project, as it provides the indicators and approach

needed to generate forecasts of digital skills demand according to different -potential- scenarios. Without the demand mapping of this report, the final forecast that will be published in D1.3 (final version of this report) would not be as accurate or reliable.

Beyond the work developed in WP1, the skills framework, demand assessment and forecasting will be embedded into the work developed within WP2 (Programme and course mapping, gap analysis and validation). In addition to developing a programme and course mapping across the EU, WP2 will utilise the data collected on WP1's demand assessment and forecast to analyse the ICT educational landscape across the region and identify potential knowledge and skill gaps that exist or may emerge if insufficient subjects are addressed, which will result in a gap analysis between market demand for certain advanced digital skills and subjects being covered in higher education and specialised IT training courses.

Results uncovered by the work developed within WP1 and WP2 will then be used for the provision of recommendations and guidelines to increase excellence of ICT learning programs across European Member States, to increase collaboration between education stakeholders, industry, and government, and to help improve the attractiveness of the technology sector for learners so future skills bottlenecks can be mitigated.

2. ADS FRAMEWORK UPDATES

This section takes the framework from D1.1 and refines some elements, as outlined in that document. No major changes are presented, but some impact coming from the various external sources from which we got feedback.

2.1 FEEDBACK FROM EXTERNAL EXPERTS (WORKSHOP 15/12/2022)

LEADS partners contacted several experts in the initial phase of the project, resulting in the organization of a workshop on December 15, 2022, aimed at gathering feedback from experts on the current version of the framework. The workshop attracted 40+ experts in different technologies (50+ registrations), and especially in BI/Data science, Cloud, IoT and AI, thanks to wide dissemination performed by partners and with the active support of associations like AIOTI and BDVA (See Annex 2 of D1.1 for more information).

Three different sessions were run in parallel during the workshop, each focusing on one or two technology areas depending on the assigned expertise of each participant (one for AI, one for IoT combined with Cloud and another session for BI/Data Science skills). Miro was utilised as a collaboration tool so each of the experts could participate in the exercise and input their thoughts about the framework.

Through the workshop, the LEADS consortium collected over 200 different inputs from the participants and explained the key developments of the project. Prior to the event, participants were given the definitions list of all the skills details and were asked to identify gaps in coverage, as well as to assess whether the level of detail that had been reached with the project was satisfactory to fulfil the proposed scope of technologies and mapping of advanced skills.

Artificial Intelligence

During the workshop about Artificial Intelligence, participants provided a list of valuable skills suggestions that are part of AI development. Some of the recommendations made by the attendees include the **need for better understanding of federated learning, big data techniques, and continual learning**. Moreover, the participants emphasised the importance of **data governance architectures, risk management for operational AI, and compliance, governance, legality**.

The workshop attendees also expressed their interest in learning more about data visualisation tools and development, formal logic, and anomaly detection. It is worth noting that these skills pockets are already covered in other parts of the LEADS framework (especially under BI/

Data Science and IoT), indicating the framework's comprehensiveness and the importance to understand the overlap of different skills pockets within the framework.

Although valuable, some of the inputs were deemed not to have achieved a sufficient level of granularity that the LEADS project is aiming to cover with its skills framework. Some of these suggestions include ML Ops, AI Ops, and experimenting tools. Additionally, the participants mentioned machine learning in general, generative models and Trustworthy AI as areas of interest. Some of the topics were considered of too generic nature in order to be aligned with other skills already highlighted by the framework or already included somehow as part of the LEADS framework's specific skills pockets. After the session, the LEADS consortium agreed on the **inclusion of Sustainable and Socially Responsible AI under "AI Sustainability"** as a vital skill in its framework. This inclusion aims to ensure that capabilities under the LEADS framework cover emerging areas of sustainable development, considering the impact on the environment and society which had been mentioned several times during the workshop. The **skills associated with AI sustainability would include areas such as data ethics, privacy, and fairness, as well as environmental sustainability considerations, such as energy efficiency and reducing the carbon footprint of AI systems.**

Business Intelligence/Data Science

During the Business Intelligence/Data Science session, participants provided the consortium with suggestions to enhance the LEADS data science skills list. These suggestions include Federated Learning, Security and Privacy Data Analysis, Data Science Project Planning, Predictive Analytics, Different Levels of Interoperability, Distinction between Structured and Unstructured Data Skills, Data Ecosystems and Management Governance, Image Processing, and Federated Analysis. Although some of these topics were not so explicitly represented in the framework, they were already considered as part of the defined skill pockets of LEADS, and therefore assumed as included in the framework.

IoT & Cloud

During the IoT and Cloud session, participants provided the consortium with suggestions to enhance our skills details for those areas. However, some of the suggestions were already covered in other skills pockets throughout the LEADS framework (it is worth noticing that participants could see and discuss the skills under a specific Technology Area and not the others). Some of these suggestions include Tiny ML Applications (included in ML development), Scalability and Digital Twins (covered in Iot Data Management & Storage), IoT Virtualization, Orchestration, Cognitive Knowledge Management (Covered in AI Development and Deployment skills),

Data Sharing between devices and Application Consideration and Systems on a Chip (Covered in IoT Embedded hardware/software skills).

Participants have also given suggestions related exclusively to cloud skills. Some of these suggestions include Serverless Architecture (already covered in cloud architecture skills), Programming models, and languages (generally covered in application development skills), Slicing (Covered within cloud storage and datacentre development skills), and Intelligent Decision Support Systems (Covered in Cloud Performance Management).

With the help of the workshop, the LEADS consortium identified **IoT Application Orchestration and Robotics skills as some of the gap areas in the IoT framework**. These areas were seen as important components and will be included in the coverage of the framework. IoT Application Orchestration is aimed at providing a platform for the development and management of IoT applications, while Robotics involves the use of robotic systems in IoT development. By considering the inclusion of these gap areas into the IoT framework, the LEADS project would provide a more comprehensive approach to the requirements of advanced skills in IoT. The results of these add-ons to the ADS Framework are reflected in the diagrams included in Annex I.

2.2. FEEDBACK FROM THE LEADS STEERING COMMITTEE

After the first draft of the LEADS Framework report was delivered in December 2022, a round of revisions conducted by the project's steering board in January 2023 provided additional feedback on the technologies and skills sections of the framework. The feedback highlighted the need to clarify the Artificial Intelligence section of the framework. Reviewers expressed the belief that process automation should be a category. The paragraph in question was deemed incomplete as it only references IT-only processes and operations. Process automation was grouped within AI for quantification purposes, as IDC's AI tracker includes process automation use cases and is not fully detachable from the dataset. The reviewers recommended expanding the taxonomy of job roles within the LEADS project to incorporate non-IT job roles. However, the LEADS framework focuses on identifying advanced digital skills that will be in high demand over the next few years within the IT sphere. As a result, most of the job roles included in the LEADS taxonomy are ICT-related positions, and the framework does not aim to include more digital skills for non-ICT professionals at this stage of the research. To narrow the scope of skills and capabilities, the framework excluded areas of a more basic level, allowing the project to concentrate on critical areas that need attention.

The feedback also covered some specific questions related to the cybersecurity and IoT tracks of the framework. For example, there was a question about whether cloud security should have its own topic or be integrated into other sub-tracks. There were also suggestions to consider merging security analytics and security forensics in one topic and adding cybersecurity

operations as a field. Furthermore, the feedback recommended considering adding robotics as a field of IoT and exploring the possibility of merging it with adaptive learning. Outcomes of this analysis are explained below.

2.3. REVISED ADS FRAMEWORK

The revised version of the LEADS framework includes some of the valuable suggestions provided by experts during the LEADS workshop held in December 2022 and the Steering Committee feedback from January 2023. After analysing over 200 different inputs received during the brainstorming sessions of the workshop, **the revised ADS framework includes advanced skills related to IoT Application Orchestration and Robotics**. Furthermore, the LEADS consortium has identified the need to include **advanced skills related to cloud, AI and IoT sustainability** to this new iteration.

Cloud and AI sustainability skills are becoming increasingly important in the tech industry as companies seek to reduce their environmental impact and ensure ethical use of data. The LEADS framework, after gathering feedback from experts, has included Sustainable and Socially Responsible AI under "AI Sustainability" as a vital skill. This skill encompasses areas such as data ethics, privacy, fairness, as well as environmental sustainability considerations like energy efficiency and reducing the carbon footprint of AI systems.

Another criterion for inclusion of the inputs received during the workshops and brainstorming sessions was whether the mentioned advanced skills were quantifiable through the LEADS methodology approach (please refer to the Methodology section 3.1). The inclusions in the ADS framework can already be seen reflected in the demand assessment, forecasting and predictions included in this document.

3. INTERCONNECTING SKILLS ACROSS IDENTIFIED TECHNOLOGY AREAS

One of the goals of LEADS and in particular WP1, is to provide insights on technology trends and infer the effects that technology evolution will have on the demand for ADS. The skills framework proposed in D1.1 and refined here thanks to the feedback previously described, shows a granular identification of skills under Technology Areas that are characterized by a high demand (as one of the selection criteria). However, when looking at future demand and the forecast analysis of LEADS, it is worth deepening the understanding of such trends because some skills could evolve, merge and new others (for which figures and maybe definitions do not exist yet) may emerge in this fast-changing landscape. As we point out, current taxonomies, classifications and studies do not account for these changes and a quantitative approach cannot be adopted yet, but LEADS presents here a descriptive overview of major technology trends that may impact skills in the short-to-medium term, including the Computing Continuum, bringing together Cloud, Edge and IoT, the relationship between data and AI and in particular the momentum around data sharing, and the growing path of Quantum Computing.

3.1 COMPUTING CONTINUUM: FROM CLOUD TO EDGE TO IOT

Currently, Edge technology is expanding across various industries as it allows for advancements in areas such as automation of equipment, increased safety and reliability, and full digital integration of resources enabled by IoT developments. The integration of 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 . The convergence of Cloud and IoT within a computing continuum is a result of advancements in enabling technologies, such as the development of more intelligent and capable devices and federated AI architectures, as well as intelligent and programmable networks. Moreover, the current development and pricing of computational power, must be considered a push towards Edge Computing taking over from IoT, thus leaving larger and larger parts of the computation to the individual unit.

LEADS collaborates with several EC-funded projects in the domain, such as EU-IoT , support action building on top of the NGIoT results, and the initiative EUCloudEdgeIoT.EU , which comprises several projects that provide a better understanding of both the supply and the demand side in the Computing Continuum. These initiatives along with its partners have recently published major insight regarding drivers and barriers for the adoption of such technologies based on advanced skills shortage. According to IDC multi-cloud Survey skill shortage is the second biggest barrier for cloud adoption according to 24% of the respondents while the lack of available skills in the organization was ranked among top barriers for IoT adoption according to the IDC European 5G and IoT Survey, 2022 .

As a result, LEADS scope on this matter reflects that the connection and relation between Cloud and IoT/Edge Computing is significant, especially considering the inability of IoT/edge to exist without the Cloud. Even though the initial scoping of technologies was done according to the methodological approach mentioned in Deliverable D1.1, referring to the division of the Framework into Technology Areas, there is a practical and purposeful need to show the interconnections within ADS from different technologies area, specifically when it comes to Cloud-Edge-IoT (CEI) continuum. Consequently, the convergence of IoT and Cloud skills into the highly demanded and technological enabled CEI demands will be reflected in the CSA's current and future work.

While at this present Deliverable stage's the demand forecast will identify both Cloud and IoT technologies and demanded job roles separately, towards the definitive final report (D1.3) there will be a more comprehensive analysis of how investment is being directed into the convergence of bot technologies. Likewise, the re-grouping of ADS belonging to different Tech Areas, under a common CEI skills pocket, will also serve in the future to illustrate the upcoming need for interrelated tech areas into the Continuum. These different methodological procedure has allowed a granular analysis of currently and future demanded ADS while enabling in the short term the re-valorisation of the present classification to reflect not only the current and future demand in existing roles within specific technologies but on those yet to come.

3.2 DATA, AI AND DATA SPACES

While in the last years there has been a focus on data analytics and data-driven decision making, this field is being enriched nowadays by new trends. In particular, while data analytics is still at a peak, the need for data as the basis for future AI-enabled applications has pushed forward many actions around **data sharing**. In particular, in the last years the EC has released relevant regulations (AI Act[1] in April 2021; Data Governance Act[2] agreed by legislators in November 2021; Data Act[3] in February 2022) accompanied by support for the **concept of "data spaces" as trusted environments where data providers and consumers can share their data in a sovereign way**, i.e. keeping the control of how data is used and therefore being able to decide who accesses data, how and for which purpose. This momentum around data spaces is accelerating the development of technologies, governance models and standards in connection with the underlying infrastructure based on a federation of computing resources in compliance with the Computing Continuum concept explained in the previous section. While interoperability between sectors is one of the paramount areas of work nowadays, specific actions are under development to foster data sharing in specific vertical industries with high economic or societal value for the EU (e.g.

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52021PC0206

[2] https://ec.europa.eu/commission/presscorner/detail/en/IP_20_2102

[3] https://ec.europa.eu/commission/presscorner/detail/e%20n/ip_22_1113

manufacturing, green deal, mobility, smart cities and communities, tourism, agriculture, media, health and even skills). **This data sharing trend will act as catalyst for demand of data-related skills that will go hand-in-hand with the development of AI applications and services**. As an example, only a very small proportion of public organizations have a fully deployed initiative of data sharing. The main barriers for this are data security, trust and working culture.

Thus, the trends that may shape the demand for these skills in the next five years are:

- As more and more data is generated (not only structured data but also text, images, videos, etc), there will be an **increased need for professionals who can first integrate data and then analyze and interpret this data to provide insights** that can inform business decisions. **Experts in data integration and curation will be required**. The variety of data will demand experts for image processing and NLP. However, as data becomes increasingly important for business decision-making, there will be a growing need for professionals who can communicate data insights effectively to non-technical stakeholders which will require professionals with **skills in data visualisation and communication**.
- An increased focus on data spaces to enable the sharing and analysis of data across organizations and industries will demand **skills in interoperability, standards and harmonization**. Data spaces will be critical for enabling the development of new AI applications in all sectors.
- Greater emphasis on data governance and data privacy: with the complexity of data sources and data spaces, there will be a greater emphasis on data governance and privacy and on the ethical considerations surrounding the use of these technologies. This will create a demand for **professionals who can develop and implement data governance policies and procedures, as well as manage data privacy risks**.

Overall, the next five years are likely to see significant advancements in the field of AI and data science, with a particular focus on ethical considerations, natural language processing, image processing, interoperability, data curation and integration, and deep learning so that the demand is likely to continue to grow significantly in the next five years.

3.3. QUANTUM TECHNOLOGIES: AN EMERGING FIELD

While the common media references on Quantum tend to refer to Quantum Computing, technologies across Quantum can be separated into the following distinct areas:

- Quantum computing: development and application of quantum processors based on qubits.
- Quantum communications: development of quantum networks, encryption and cryptography

- Quantum sensors and metrology: leveraging the sensitivity of quantum states to detect miniscule variations in electromagnetic fields, temperatures, and quantum imaging.

Within this grouping of technologies there is a present variety of maturities; areas like that of quantum encryption and quantum key distribution area deployed on the market while quantum teleporting, temperature quantum sensors and commercial computers are still in nascent phases. Added to this is the interdependencies, whereby quantum algorithms exist and are theoretically feasible, but they are limited by the maturity of the quantum processors to be able to apply them. There are, however, immediate benefits being realised through the application of quantum-inspired algorithms on convention computing systems with methods such as quantum annealing and quantum approximate optimization algorithms (QAOA) which can deliver greater efficiencies, accuracies and performance on calculations compared to traditional algorithms.

The growth of this area, and the increased number of investments is reflected in the relative **growth in talent demand**.

Throughout the scoping and engagement of the LEADS project, the consistent outlier in terms of the technology areas has been that of Quantum Technologies (QT). **We are at a second quantum revolution that brings the practical application of this field into focus**. Between 2015 and 2022, investment into quantum technologies grew more than tenfold. The quantum computing market is expected to grow at a CAGR of 36%, from EUR 412 million in 2020 reaching EUR 8.6 billion in 2028 . The number of European quantum start-ups has grown from only a handful in 2015 to 147 in 2022 and continues to grow as new advancements and developments are made. Overall, investment into quantum technologies, both from the private and public sectors, has totalled over USD 35.5 billion surpassing other emerging technologies at such an early stage of development.

Quantum is a key priority for policy makers across the globe, and the race to develop capacities, develop markets and benefit from spill over effects is evidenced by the mobilisation of key strategies to secure research excellence and industry capacity through mechanisms like the Quantum Flagship within the EU, the funding of the development of secure communication infrastructure (EuroQCI) through the DIGITAL programme and the development of hybrid quantum capacities and excellence centres through the European High Performance Computing Joint Undertaking (EuroHPC JU) which builds on European, National and private funding.

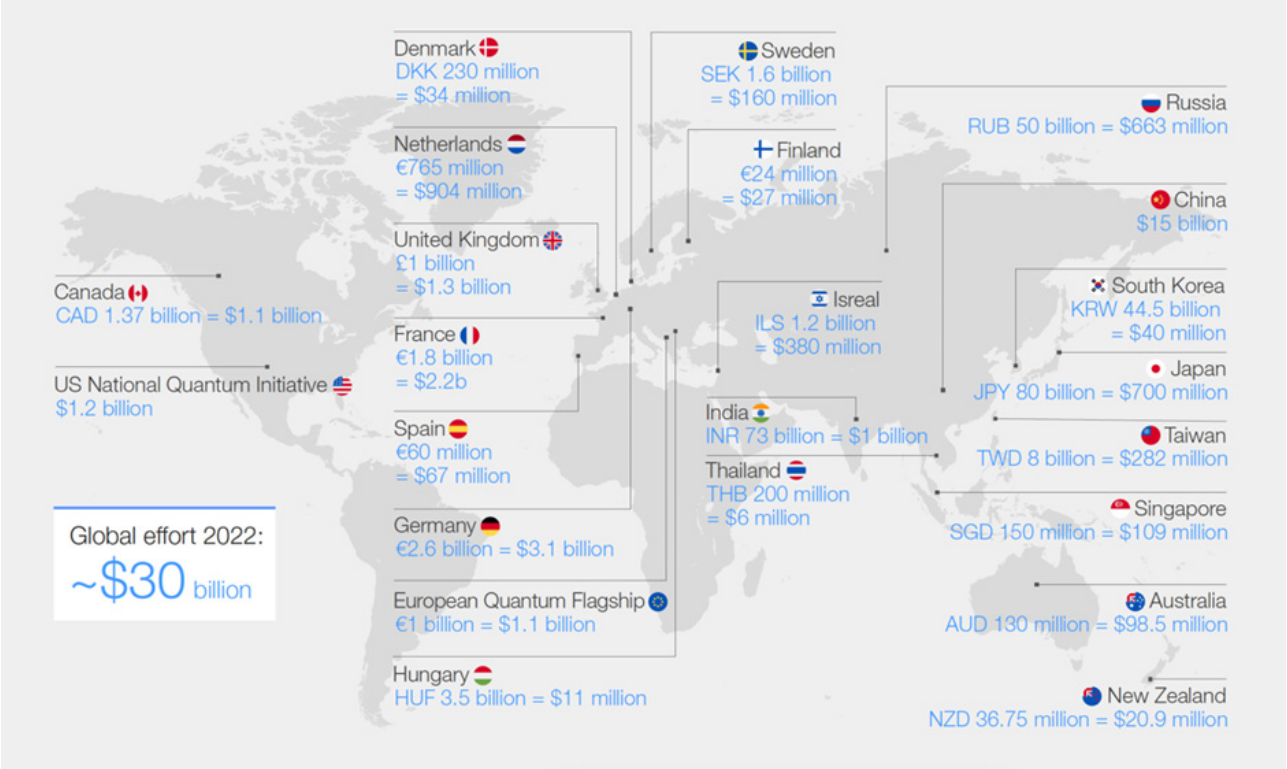

Figure 1: Worldwide public investment into Quantum (source: Qureca 2022[4])

Both the US and China are actively investing in and developing quantum computing strategies. The US passed the National Quantum Initiative Act in 2018, investing over $3 billion in quantum computing initiatives, while China has invested over $10 billion in building the world's largest quantum research facility. Other countries, such as Australia and the UK have formed alliances to share technological advances in fields like AI and quantum computing.

Because Quantum is an emerging field and figures about the past do not exist, it is hard for LEADS to make comparisons and forecasts as the project does for other technology areas. The methodology for the demand assessment and forecast will therefore be different in this case, as described in section 4.

[4] Defining the quantum workforce landscape: a review of global quantum education initiatives (2022) Qureca

4. LEADS DEMAND AND FORECASTING ANALYSIS

4.1. METHODOLOGICAL APPROACH FOR SKILLS DEMAND AND FORECASTING MODEL

The LEADS project aims to measure the current and future demand for advanced digital skills in Europe. The methodology of the project involves the use of multiple sources of data to establish a correlation between different use cases and the need for human capabilities covering these.

For the demand assessment and forecasting analysis, the project team established a correlation between the framework of identified advanced digital skills with over **150 market use cases that reflect how the industry is allocating financial resources** to develop the AI, IoT, Cybersecurity, Business Intelligence/Data Science, Cloud Computing and Quantum markets in software, hardware, and services. The current approach enabled the consortium to gain an understanding of the specific skills required for different use cases and the growth potential of these skills based on expected industry development, which ultimately allowed for a more quantifiable approach to model the future demand for such capabilities.

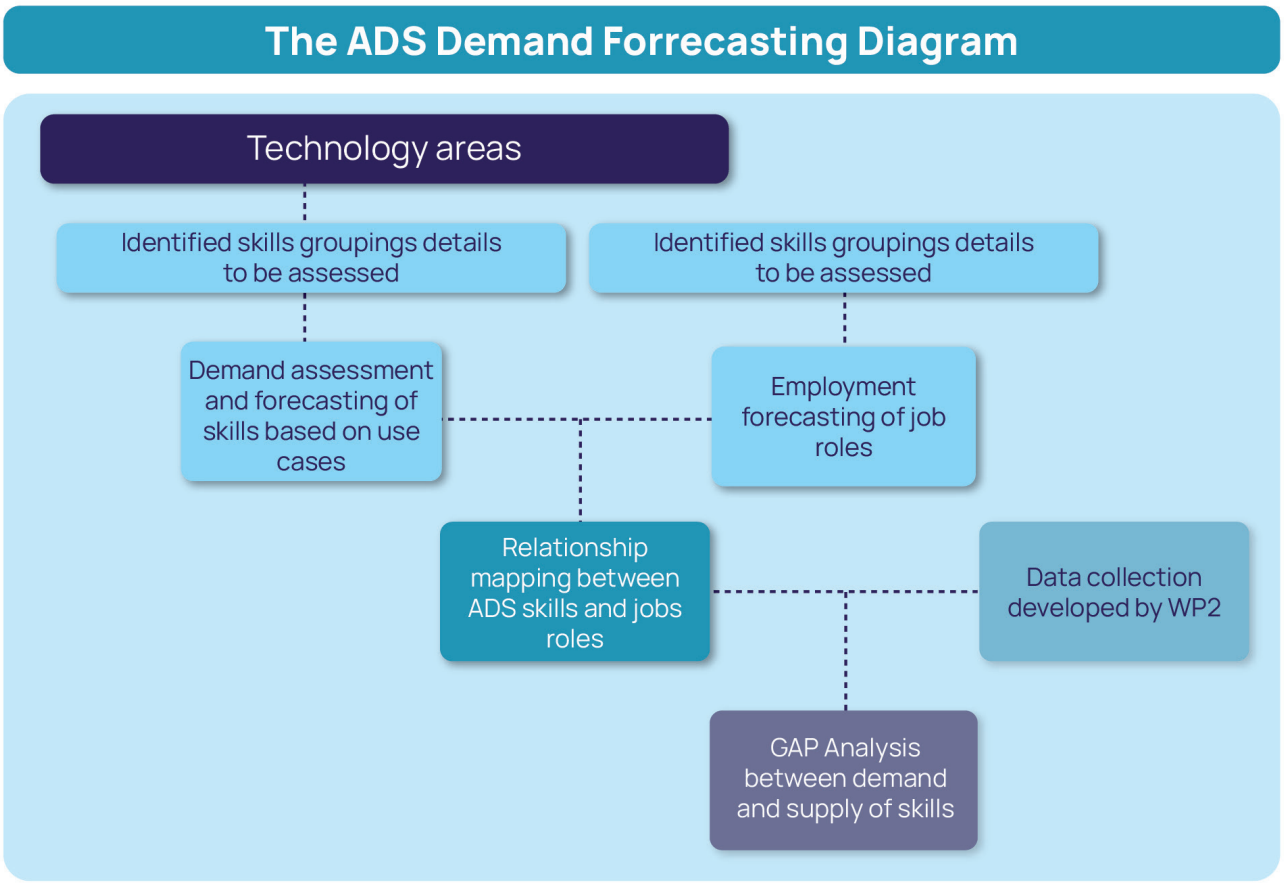

Figure 2: Methodology for ADS Demand and forecasting

To reach the current estimates, partners leveraged the **detailed information in use case expenditure provided by IDC trackers as a proxy to estimate the growth of skills in different technology areas**. The team identified that some of the use cases used for the modelling also overlap with other European Commission-led projects such as the EUCloudEdgeIoT.eu. These common denominators between different projects enabled LEADS to ensure that relevant market development examples were being selected to validate its findings and establish a level of synergy between different EC-led research projects.

In summary, the **LEADS approach for quantifying skills is demand-driven,** as explained below:

- **Technology and Technology sub-market**. If a certain technology or technology sub-market is in high demand and experiencing high growth, the skills related to that technology (market) are deemed relevant for additional detail.
- **Use case**. Skills definitions are linked to use cases where demand and demand growth can be quantified or estimated.
- **Industry**. Certain skills are related to a specific industry, or a sector of industries. Where the demand for the respective industries could be quantified or estimated, the related skills are deemed relevant for additional detail.

The LEADS project methodology involves the **use of multiple publicly available sources of data including IDC trackers, Bureau of Labor Statistics, Eurostat, and ILOSTAT, OECD data and other competence frameworks (such as EC-F and NICE).** It is important to take into consideration that the LEADS framework has a more detailed level of coverage when compared to the EC-F and NICE, and focuses on advanced digital skills whereas these cover a broader set of competences on a higher level.

Additionally, a **benchmark with skills development roadmaps from third party training providers was done to establish the correlation between different use cases and the need for human capabilities covering these**. However, the primary source for quantification of technology demand has been proprietary market data from IDC, especially when it comes to industry or use case specific skills.

It is important to mention that the current stage of LEADS findings still does not include the outputs of the LEADS survey which will be incorporated into the final analysis and reflected in D1.3, the final version of this deliverable. For more information about the survey, please refer to chapter 4.6 of this document.

The **current demand and forecasting assessments for identified advanced skills in LEADS are presented in indexes as an approach to add a quantification layer to its demand**.

4.2. LINKING THE JOB ROLE TAXONOMY TO RELATED SKILLS

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, defining a correlation between a base-layer of job roles and parallel job role taxonomies (for more information, please refer to the D1.1 - Demand Assessment Framework document).

The **correlation between job roles and skills aims to add another layer of quantification to LEADS estimates by using IDC's job role forecasting, employment data from Eurostat and other secondary sources**, and understand if the identified growth in skills demand will be matched with the expected growth in employment for certain roles.

It is important to mention that although **the LEADS framework** covers a list of 80+ advanced digital skills details grouped into 30 skills pockets spanning across six technology areas, it **does not aim to measure the level of competence in each of these skills for each job role**. Therefore, the **correlation between job roles and skills has been done on the technology area level only**, which enables the project to have a top line view of the employment demand at the skills pockets level.

The current level of comparison between roles and capabilities has allowed LEADS to:

- **Correlate job roles with skills** by estimating the number of job roles and headcount related to different technology areas.
- **Understand the current level of demand for job roles** and installed capacity of talent in the European ICT market.
- **Assess the potential employment growth** for the base layer of job roles and whether the hiring speed will match the growth in demand for different skill areas based on specific use cases.

4.3. MARKET INDICATORS: BASELINE

As explained in the methodology section, one of the key building blocks for the LEADS demand assessment and forecasting of advanced skills is the use of different IDC's Spending Guides. Spending Guides provide a framework to categorise and relate different technology elements within their correspondent dynamic markets and are broken down by different technology areas such as AI, IoT, Big Data and Analytics.

In IDC spending guides, market definitions for industries and related spending forecasting are broken down into several use cases which are an integral part of how the LEADS project can take a quantifiable approach to understand the future growth in demand for advanced skills.

Industry use cases, when summed together, form an addressable market for a certain technology and provide a quantifiable market size and expenditure in different geographies, deployment types (e.g., cloud or on-premises) and industry sectors (e.g., banking, retail and healthcare).

To reach current estimates for LEADS, **over 150 different industry use cases have been evaluated for the six covered technology areas, enabling a more granular approach to linking actual industry usage of technology, needed advanced skills to fuel technology development and expected investments to develop the adoption of new systems**. A detailed list of all of the analysed IDC Spending Guides for the LEADS project can be found on D1.1 ANNEX 1: List of TECHNOLOGY Taxonomies.

Below is an example of use cases analysed to estimate the demand of Healthcare specific IoT implementation skills in the LEADS project:

Technology area	Skills grouping	Skills detail	Use cases mapped with market forecasting data for the correspondent skill detail	Use case definition
Internet of Things (IoT)	IoT Applications skills	Healthcare - IoT implementation	Bedside Telemetry	IoT systems that support hospitalized patients whose physiological status requires close attention. In this use case these patients can be constantly monitored using IoT-driven, noninvasive monitoring. This type of solution employs sensors to collect comprehensive physiological information and uses gateways and the cloud to analyze and store the information and then send the analyzed data wirelessly to caregivers for further analysis and review.
			Health and Wellness	The Health & Wellness use case bridges healthcare payer and consumers with IoT technology that monitors an individual's physical condition. By allowing access to health indicators such as heart rate, glucose levels, blood oxygen concentration, or movement (e.g. footsteps), healthcare payers incentivize participants e.g. increasing price discounts/lower monthly insurance premiums. Devices can be activity based wearables such as fitness trackers or smart watches.
			Hospital Asset Tracking	Hospital asset tracking is a solution that locates high value medical assets within a medical facility enabled by pervasive wireless LAN (WLAN) networking and beacons or active RFID (RTLS) associated with each piece of equipment, person or tracked item (i.e. high value inventory like medicine…or a baby!). The solution typically integrates with ERP, hospital inventory management and work management.
			Remote Health Monitoring	Home or remote healthcare that uses the IoT technology platform to improve quality of life and care through accurate and focused medical home monitoring. Typical devices considered are glucometers, blood press cuffs, oximeters, and data gateways.

Table 1: Health-related use cases for IoT (Source: IDC)

In addition to enabling LEADS researchers to establish a common approach to quantifying advanced skills in different technology areas, use cases represent the real application of technology and human resources throughout different industry sectors and were identified as a suitable variable to assess the future growth in demand for specific skills.

The rationale behind the utilisation of use cases in LEADS demand and forecast of advanced skills factors is market growth and expenditure in such use cases, level of automation, deployment type and the consequential need for human skills for implementation, modernisation and continuous operation of these functions.

Understandably, **many of the use cases identified overlap with several of the advanced skills mapped within the LEADS framework and may influence the demand of multiple competences at the same time**. This overlap has been taken into consideration when estimating the demand for each of the skills details and groupings highlighted in the framework.

4.4. PRELIMINARY TRENDS AND SKILLS DEMAND FORECASTING

Section 4.4 presents the initial results of the demand assessment and forecasting developed by LEADS after the analysis of different data sources and following the specified methodology. This applies to all the technology areas defined by the ADS Framework apart from Quantum Computing, where the lack of associated figures due to the recent emergence of the quantum paradigm prevents us from following the same approach. As a result, we include Quantum as the last sub-section in 4.4 describing the path that LEADS will follow jointly with the expert communities.

The following picture represents the future market demand (2027) with respect to the demand based on data from 2022, providing a general overview of the growth for the demand of the skills represented in the LEADS framework. It can be noticed that most of them will experience a notable growth, with **those skills related to AI and data analysis being the ones with more prominent demand growth, followed by cloud and IoT**. In the following sections we provide the main insights derived from the quantitative assessment carried out by LEADS for each of the technology areas with the caveat about Quantum, as mentioned before.

Note: *The x-axis index serves as an indicator of demand growth for the skills pockets and details highlighted on the LeADS framework both at present and over the next 5 years. The skills demand index does not directly reflect the number of headcount/professionals related to these skills as these may pretrain to multiple job roles and may also be acquired through the reskilling of current ICT professionals. Instead, it aims to showcase the appetite of the industry for certain advanced capabilities based on technology adoption and growth of investments in underlying use cases.*

The initially considered baseline indicator for all the skills is 100. However, indexes may be above (ie. 110 for certain cybersecurity skills that are currently experiencing high demand) or below 100 (ie., 90 for certain infrastructure skills that benefit from a high level of automation). A substantial index growth (ie. For AI Application Development from 100 in 2022 to 404 in 2027) indicates that the industry will need a substantially higher amount of these ADS skills than it currently possesses to fuel technology adoption and enhance use cases going forward.

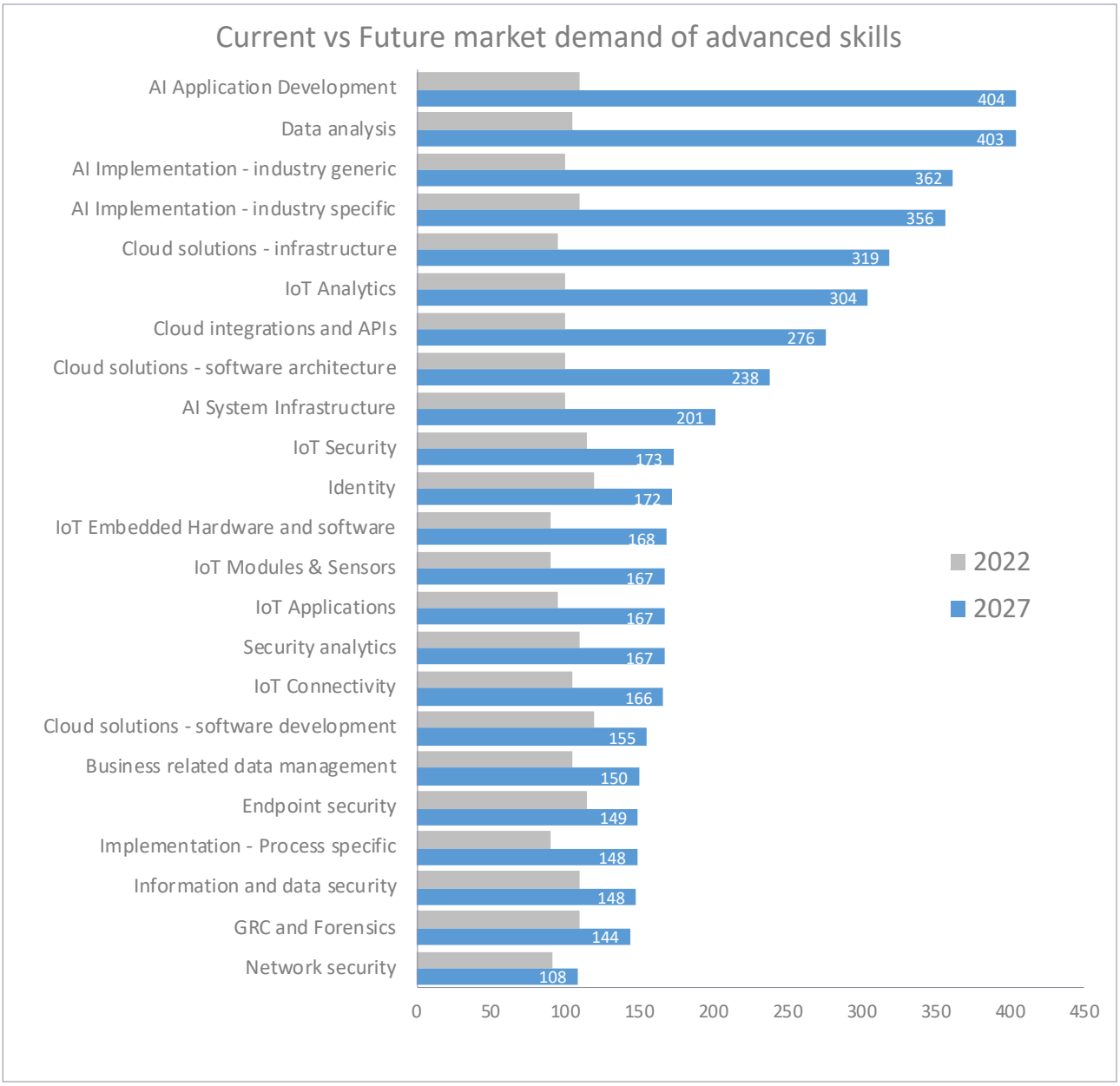

Figure 3: Current vs Future market demand of ADS

4.4.1. CLOUD

Our preliminary findings through the LEADS assessment and forecasting indicate that demand for skills related to all skills pockets in the area of Cloud Computing are expected to show substantial growth in the short to medium term increasing by almost two or three times in most cases. This is a reasonable finding since most ICT applications and services are riding the "virtualization wave"; thus, the shifting of software and services designed to run on centralised or distributed datacentres is expected to continue at an evolving pace. This is also related to the fact that **cloud technologies are entering an era of maturity**, which is also evident through our findings that show that **baseline technologies for cloud solutions/software development present the lowest skills demand growth rate** in this area (projection for about 180% growth)

compared to other skills pockets that relate to more advanced technologies that are needed to increase the efficiency, scalability and interoperability of cloud solutions. Due to the fact that cloud technologies have been researched for several years, mature and widely adopted solutions (in terms of hardware and software frameworks) related to their deployment and operation are causing a steadily **increasing demand for skills that are required to develop cloud native applications, monitor and manage their performance and apply migration techniques**. Similarly, **security and identity management** are also supported by mature frameworks but due to their increased importance for trustworthy services they yield a slightly higher forecasted demand for skills related to these skills pockets.

Cloud interoperability is expected to double demand for skills related to Multi/Hybrid cloud interoperability and orchestration, which is the third fastest growing demand in this area. The second fastest growing demand (with an expected demand growth rate above 200%) according to our findings is related to skills required to **develop improved cloud architectures exploiting latest trends in orchestration frameworks**. Due to their wide support by open-source communities, container orchestration platforms like e.g. Docker Swarm and Kubernetes are becoming highly popular and need highly skilled software engineers to efficiently use them to design scalable cloud infrastructures and efficient orchestration solutions applying state of the art cloud agile development methodologies and DevOps practices. DevOps emphasises automation, collaboration, and communication, which are all essential for managing microservices at scale enabling organisations to deliver software faster and with greater reliability.

Finally, the highest growth of cloud skills based on specific use cases according to our research results is expected in the area of **cloud infrastructures** (**almost tripling in the next five years**). This can be attributed to the fact that scalability of next generation cloud solutions requires scalable and sustainable storage and data center system architectures. In the era of fast emerging cloud storage technologies both in terms of hardware solutions like solid state drives (SSDs), non-volatile memory express (NVMe), storage class memory (SCM) etc. as well as their integration into cloud architectures like software-Defined Storage (SDS), object storage, multi-cloud storage, hybrid cloud storage, distributed file systems etc, data protection, increased scalability, reliability, and cost-effectiveness is expected.

In turn, this seems to be raising demand for relevant skills according to our forecast by an impressive more than 300%. The same applies to **skills related to scalable and power efficient data center design** exploiting advances in hyperconverged infrastructures and powerful HW accelerators like Graphics Processing Units (GPUs) to support the increased demand for cloud-based AI applications. The above trends are expected to also continuously drive growth (by more than 200%) of **demand for specific skills related to the network management of** the above **complex cloud infrastructures**.

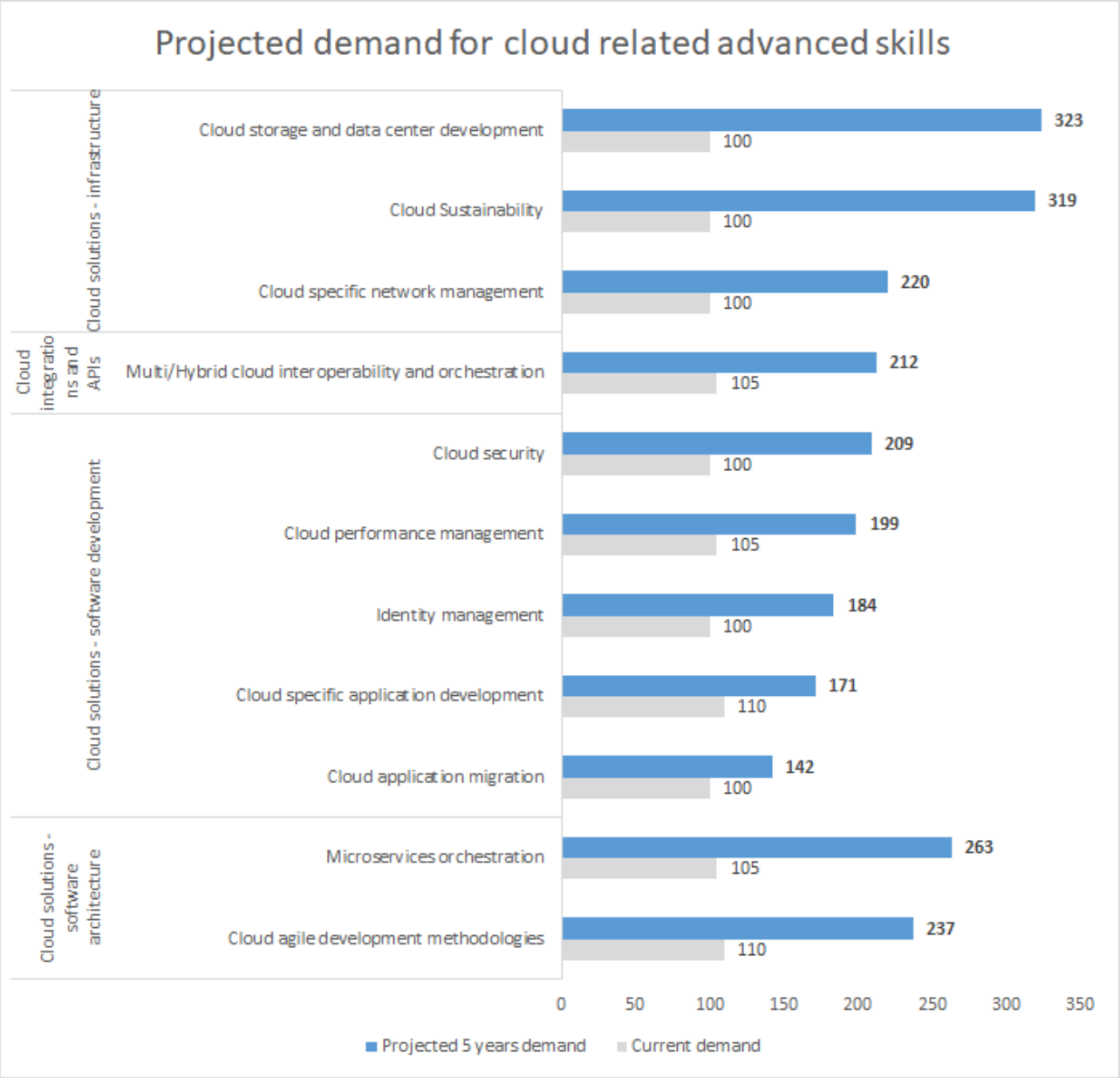

Figure 4: Demand and forecast for cloud skills

4.4.2. BUSINESS INTELLIGENCE-DATA SCIENCE

Preliminary findings of the forecasting that has been conducted in the LEADS project indicates that those skills highly related to Artificial Intelligence and Data Analysis will experience a high growth. In fact, **for the case of AI enhanced data analysis the demand will be multiplied by a factor of 3 in the next three years and almost by 7 by the end of 2027**.

This growth is in line with the demand that artificial intelligence will generally experience.

Surprisingly, the demand for other skills related to data management such as data governance or data curation will only slightly grow. This indicates the fact that during the next five

years companies will continue to be dedicated to digitalization of the processes, but digitalization of the company will not start. Only when main company processes become digital, and data is used to drive business, companies will realise that data governance is required as a main driver of the digital transformation. The **demand depends a lot on the sector** we focus on. Sectors such as retailing, marketing or finance with a long history of digitalization will be more focused on data governance explaining the growth of demand in the next few years. However, sectors such as manufacturing, agriculture, health or aviation will demand profiles with AI enhanced data analysis as they will be starting the processes of turning data into knowledge.

Concerning data management skills one can observe that **demand for data collection and data quality will double.** This is explained by the fact that companies will need to adapt data sources requiring and not only analysts but also those experienced in data quality. Despite the emergence of data federation in the last years, the demand is not expected to grow, explaining once again that **some sectors will be at an initial state of data driven processes**. Finally, we can also observe that process specific skills such as Customer Relationship Management will only slightly grow, explained again by the different maturity levels of sectors (in this case driven by the high maturity of retail).

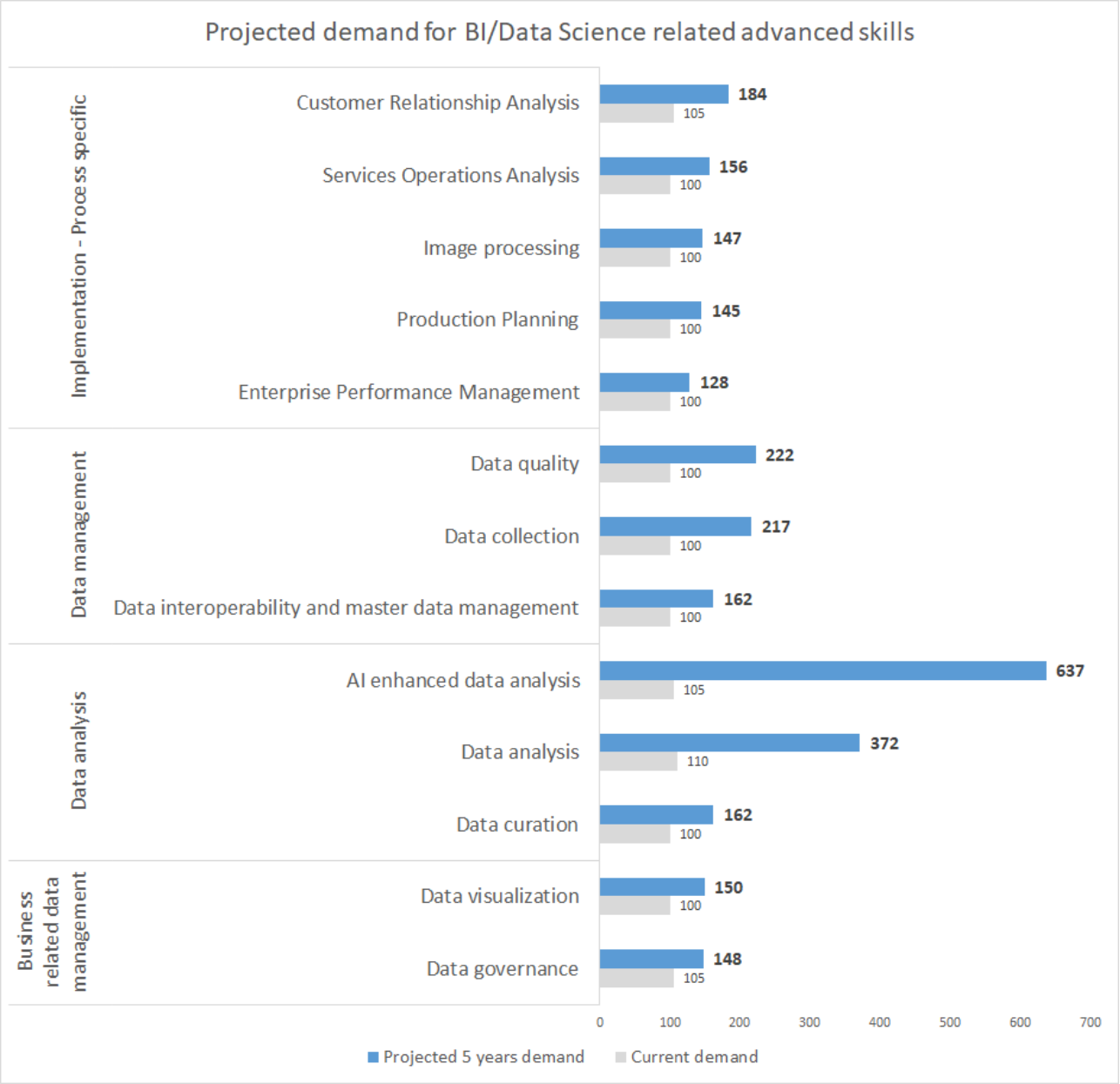

Figure 5: Demand and forecast for BI/Data Science skills

It is also important to notice that ADS Data Science skills such as -but not limited to- analysis, curation and visualisation are critical for several other technology pockets covered in this framework, such as AI, cybersecurity, and IoT. Therefore, when looking at the development of Data Science skills, it is crucial to observe the overlap of capabilities presented in this framework beyond isolated technology areas to form a picture of digital transformation in services, software and hardware development.

One possible deterrent from growth of some ADS data analysis skills such as image processing, data visualisation and curation is automation. Going forward, more data automation may allow companies to handle data more seamlessly by reaching a higher level of accuracy, lower time and a reduced headcount.

With Machine Learning, AI and automated tools becoming more advanced, human capabilities needed to perform certain tasks within Data Science, (although still in high demand) may show slower growth. However, ADS skills directly related to the development and enhancement of such tools such as AI enhanced data analysis will continue to show high demand growth.

4.4.3. CYBERSECURITY-DATA SECURITY

Cybersecurity related advanced skills are expected to see a substantial growth in demand for the next five years. It is important to note that, although growth in demand for security skills seems slower when compared to less mature areas of technology development such as AI, the area is already quite developed. Therefore, the demand for certain cybersecurity skills almost doubling translates into a huge effort needed by industry to fulfil certain positions and capabilities to secure IT enterprise physical and digital assets going forward.

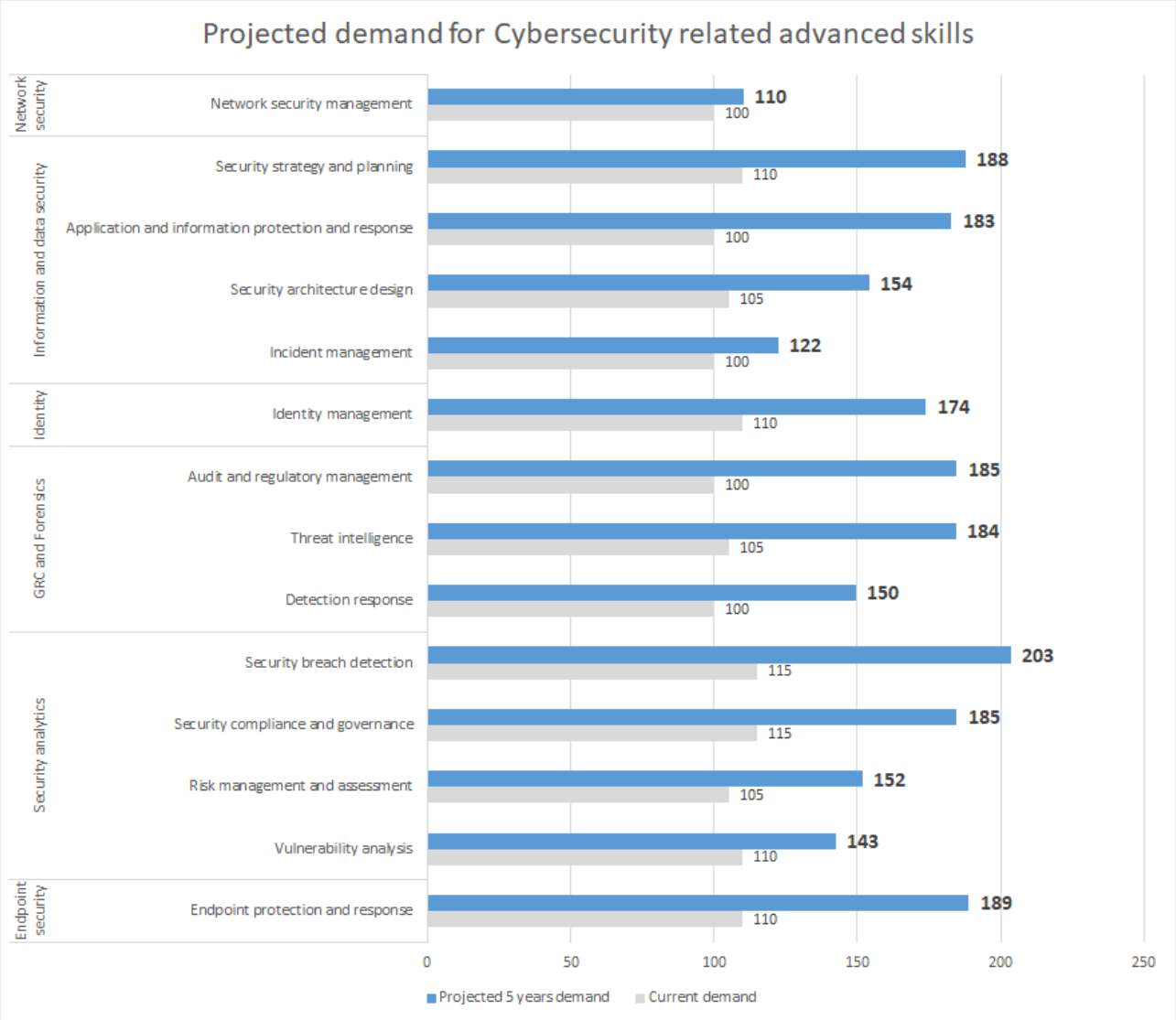

Figure 6: Demand and forecast for Cybersecurity skills

When looking at different skills details within these different cybersecurity skills groupings, **security breach detection (+88%), Audit and regulatory management (+85%), Endpoint security (+79%), and Threat intelligence (+79%) are expected to register the fastest growths in demand** for the next few years.

The expected growth in demand for security skills mentioned above highlights the need for both public and private organisations in Europe to achieve goals in certain technology areas that will enable the continent to **increase its digital sovereignty and respond to a higher level of threat in the digital space.**

With the current geopolitical turmoil driven by Russia's aggression against Ukraine, European organisations became increasingly concerned about possible cyberattacks by state-sponsored Russian actors against EU government and private institutions involved in imposing and enforcing sanctions against Russia. Therefore, **advanced security skills encompassing both the planning/strategy, regulation, detection and response of future breaches will continue to increase in demand and be treated as valuable assets by the European industry**.

Another important point to mention is how widespread advanced cybersecurity skills are becoming across different IT functions. Although cybersecurity is a well-established IT sector with different career paths reporting to the Chief Information Security Officer (CISO), embedded security pushes for the **need for application developers, enterprise architects, cloud engineers and application maintenance professionals to have a stronger notion of how to protect applications, networks and ecosystems** by adding security features to their core. Therefore, as embedded security develops within IT applications, so does the demand for advanced security skills across multiple IT job roles.

On the services side, although developing and acquiring advanced security skills is in high demand, end-users are also looking for automated solutions to enhance protection and response and decrease the need of a higher headcount and skills pool. With more automation in place, sweeping for breaches may become more efficient. However, companies selling such security platforms need to ensure there are enough people on the Managed Service Provider (MSP) and end-user companies to respond once breaches are identified.

4.4.4. ARTIFICIAL INTELLIGENCE

Preliminary findings of the LEADS assessment and forecasting indicate that **Artificial Intelligence (AI) is an area of exceptionally high growth within the framework, with AI application development and AI implementation (both generic and industry specific) skills expected to grow 4x over the next five years**.

Over the next few years, IT organisations will need a broader range of human capabilities to

manage enterprise AI and automation at scale and will need to educate the business to ensure successful and sustainable adoption by employees. The current early stage of AI usage in most sectors of the European industry indicates that skills related to the development and deployment, lifecycle management, architecture and regulation & compliance of AI will register some of the highest growths in demand.

As AI deployment becomes mainstream across more industry sectors, **skill priorities will continue to evolve as AI and automation initiatives move from experimentation to production**, as will the division of labour between humans and machines.

AI adoption is not homogeneous across different industry sectors. Some sectors of the European industry are ahead of the curve when it comes to the implementation of AI systems and automation. Some examples are Transportation, Banking & Finance, Healthcare, Manufacturing and Retail. The fast AI adoption in such sectors will also drive the growth for industry specific AI implementation skills that will create differentiators in expertise compared to generic implementation skills. As we have previously seen, this is also reflected in Business Intelligence specific skills.

IT will also be expected to optimise labour efficiency as organisations are facing a persistent challenge of a shortage of AI and automation skills. As a result, IT organisations are facing a dual pressure to build competency to expand AI and automation within IT operations and serve as a resource for lines of business to meet their automation needs. With existing talent gaps in the market, IT organisations will continue to make efforts in attracting, upskilling and retaining professionals with AI skills over the next few years and competition for such talent is expected to be fierce.

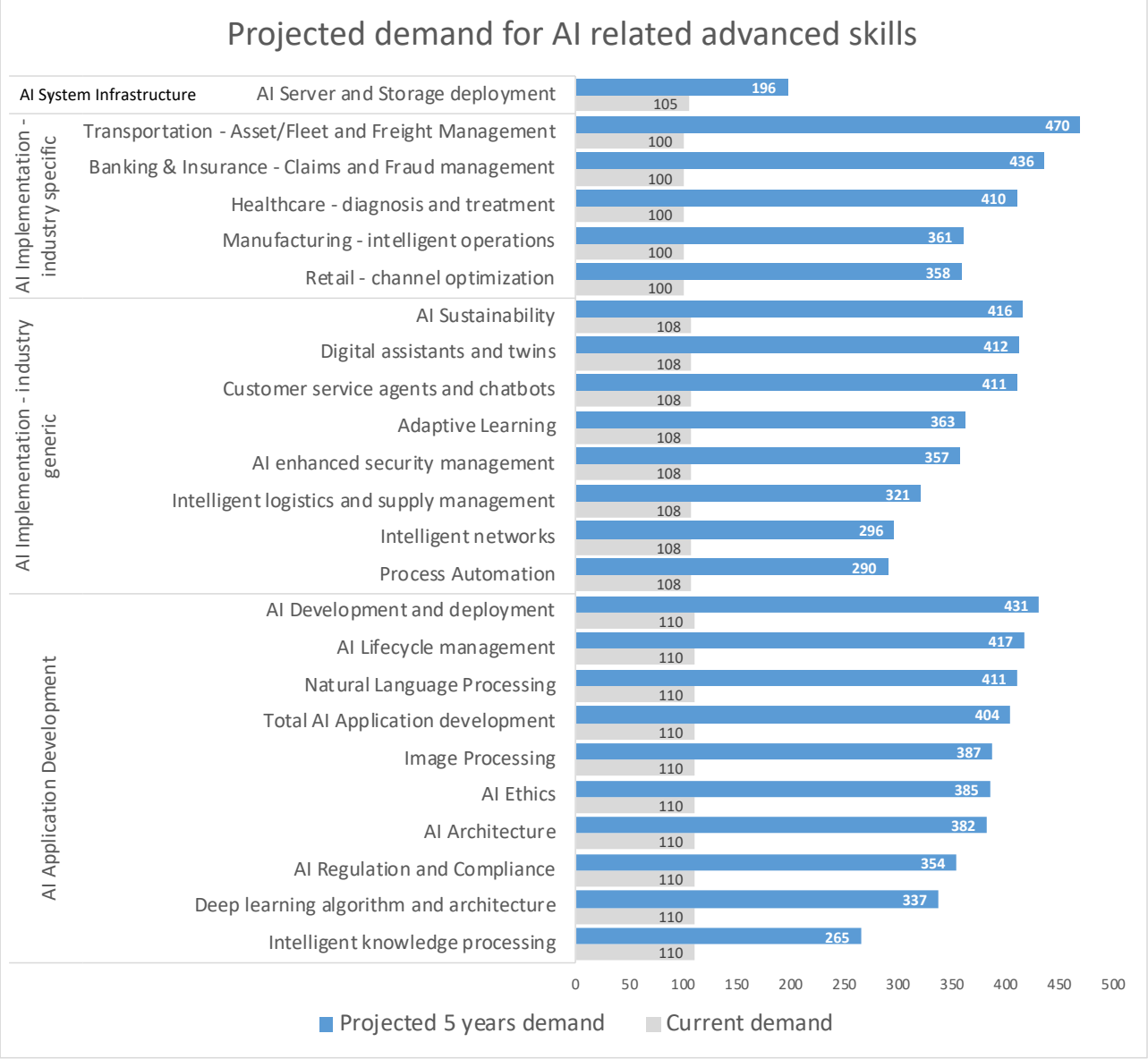

Figure 7: Demand and forecast for AI skills

4.4.5. INTERNET OF THINGS

Preliminary findings of the LEADS assessment and forecasting indicate that IoT is an area of significant growth within the technology industry. A substantial increase in the number of IoT devices is anticipated[5]. Likewise, there is **notable development in Edge Computing**[6], where data is processed closer to the source resulting in faster data processing and analysis. This growth is expected to result in a **substantial increase in demands for IoT-related skills across a variety of industries**.

[5] https://www.statista.com/statistics/1183457/iot-connected-devices-worldwide/

[6] https://www.marketsandmarkets.com/PressReleases/edge-computing.asp

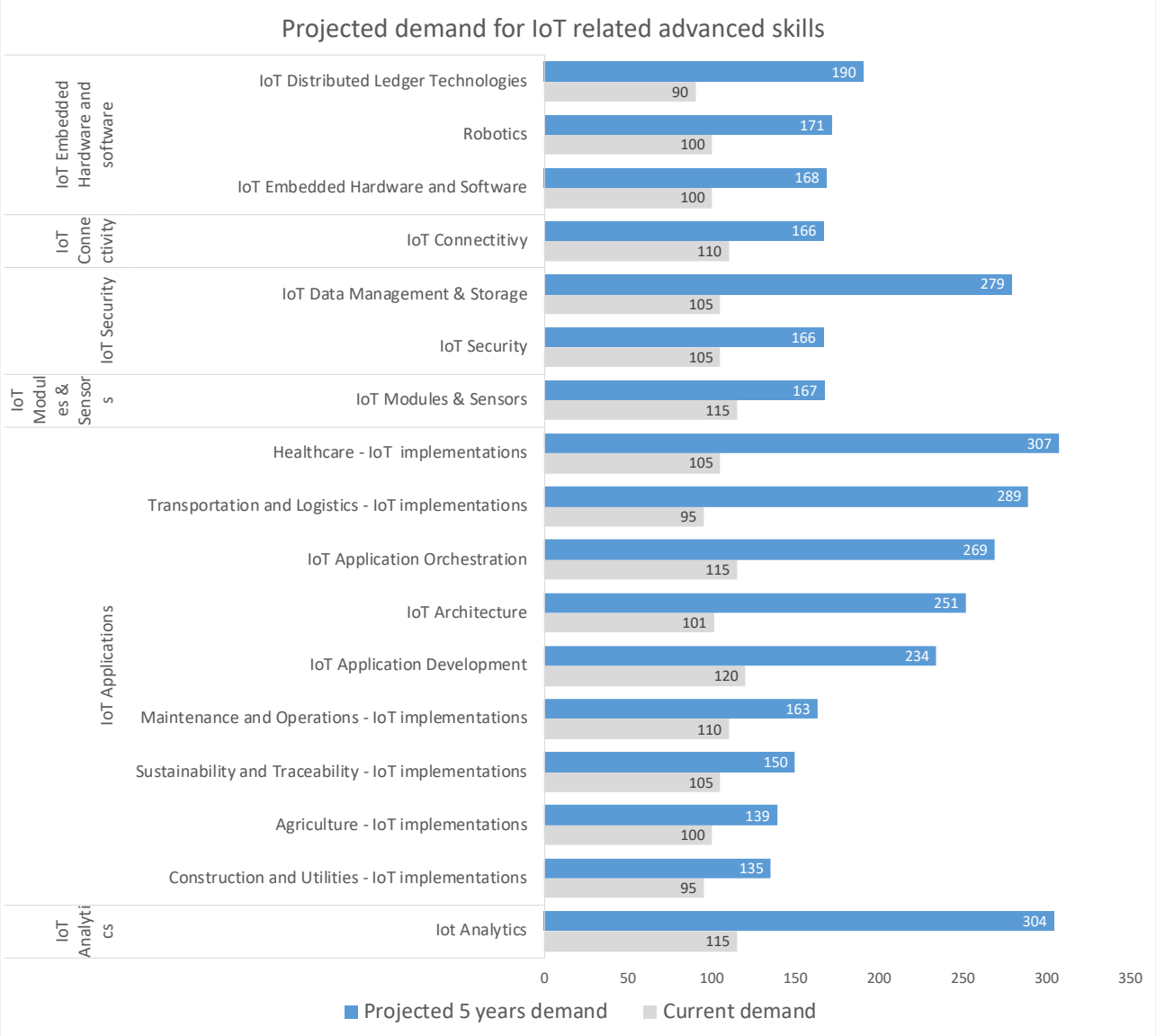

Figure 8: Demand and forecast for IoT skills

Out of the six identified skill areas within IoT (Analytics, Applications, Modules & Sensors, Security, Connectivity, and Embedded Hardware & Software), **IoT Analytics and IoT Security are expected to experience the most significant growth over the next five years**.

IoT Analytics skills are expected to experience the fastest growth, increasing by 204% by 2027. This indicates a significant increase in the **need for data processing and analysis capabilities, which is aligned with the expected explosion of IoT devices**.

IoT Security is the second fastest growing skill area within IoT, with a 73% increase in demand. The growth indicates a clear indication of the **increasing importance placed on securing the data transmitted between devices in IoT ecosystems**. IoT Security is broken down into two skill details: **IoT Security and IoT Data Management & Storage**. Both areas are expected to experience significant growth over the next five years, with IoT Data Management & Storage expected to increase by 179% and IoT Security by 66%.

The remaining four skill areas within IoT are expected to experience similar increases in demand, with an increase of 68% in IoT Embedded Hardware and Software, 67% for both IoT Modules & Sensors and IoT Applications, and 66% for IoT Connectivity.

It is worth highlighting a few skills within IoT applications that are also expected to grow rapidly in demand, namely Healthcare – IoT implementations with 207%, Transportation and Logistics – IoT implementations with 189%, IoT Application Orchestration with 169% and finally IoT Architecture with 151%.

4.4.6. QUANTUM TECHNOLOGIES

4.4.6.1. THE CHALLENGE IN SKILLS FORECASTING FOR QUANTUM

The complex interplay of various technologies and the co-existence of multiple maturities has a significant impact on both the definition of the market and skills demands. Quantum, perhaps more than the other technologies addressed, typifies the **dual challenge or demand of advanced digital skills within a European context; the need for highly specialised experts who will develop the next generation of advanced digital technologies and the skills capacity of industry to adopt and realise value**.

The skills demand within QT is in a race with the tech development, the current and significant need is for the hardware builders and fundamental technology developers, while the algorithm and software developers can only advance so far.

Industry, however, needs to be building its competences now and upskilling their organisations to catch the wave and avoid the learnings of the past from AI[7]. **The gap already exists**, in 2022 of 851 open quantum positions, only 290 graduates met the necessary requirements (34%), while over half of the jobs in quantum computing will remain unfilled by 2025 unless significant interventions occur[8]. Looking forward, however, **it is hard to predict when a shift in demand may occur, similar trends are observed but challenges of quantifying this demand and making a connection to defined job role or skill requirements remain**[9][10][11][12].

The **talent development itself is also lagging**, 67% of job positions in quantum require a PhD[13]. Candidates without a PhD are required to have extensive professional experience and

[7] Assessing the Needs of the Quantum Industry (2021) Cornell University

[8] Five lessons from AI on closing quantum's talent gap—before it's too late (2022) McKinsey

[9] The Next Decade in Quantum Computing—and How to Play (2018) BCG

[10] How to Build a Quantum-Ready Workforce (2020) Optics and Photonics News

[11] Achieving a quantum smart workforce (2021) Clarice D Aiello et al

[12] The next tech talent shortage: quantum computing researchers, (2022) The New York Times

[13] Defining the quantum workforce landscape: a review of global quantum education initiatives (2022) Qureca

training in quantum technologies to fulfil job requirements. The resource-heavy and timely developmental process of quantum experts is a bottleneck to the development of technologies in the quantum field. Several companies like IBM, Microsoft or Google have started upskilling specialists in quantum related fields- engineers, physicists, and developers, to tackle shortage of talent and speed up the process. Between 2016 and 2021, there was a tenfold increase in the number of quantum job posts published[14], but significant initiatives focusing on quantum education did not start until 2019[15].

Related to this is the uniqueness of the market dynamics of the technologies, except for the application of quantum-inspired algorithms, encryption solutions and early hybrid computing systems, there is **not yet a validated market for quantum**. There is a scarcity of use cases to track adoption. Many use cases and as such market value estimations, such as those identified for drug discovery and risk management within the beachhead markets of pharmaceuticals and finance respectively, are based on large assumptions which are wholly dependent on rate of development of the quantum computers. For this reason, **the ability to define future demand scenarios is guided mainly by public investment; only an estimated 1.4 billion USD of the total 35.5 billion USD investment comes from the private sector**.

Added to this, is the **challenge related to access to reliable and representative data**; according to COST, there are only an estimated 5000 quantum experts in Europe, producing a very small universe. Various industry reports and statistics are based on surveys with a non-representative sample of answers, for example, the survey by American Physical Society and Cornell University only surveyed 21 and 57 companies respectively yet are one of the most relevant studies done[16][17]. Due to the novelty of the field, industry reports often provide general estimates of shared data, which means that figures related to market size, demand, or growth can vary significantly.

Thus, the approximations of the primary data lead to further discrepancies between different data sources used in studies and analyses. Consequently, **whilst the demand for quantum talent is apparent, the actual levels of skills demand with significant accuracy remain unquantifiable at this time**.

4.4.6.2. LEADS – QUANTUM FLAGSHIP APPROACH

Skills demands and Quantum Technologies is a complex challenge. To overcome these challenges, the approach to Quantum must be different. **Working closely with the Quantum**

[14] Software firms race to address users' quantum talent shortage (2022) Fierce Electronics

[15] The Needs and Challenges of Workforce Development in Quantum Computing (2019) M. Amin

[16] Preparing for the quantum revolution: What is the role of higher education? (2020) American Physical Society

[17] Assessing the Needs of the Quantum Industry (2021) Cornell University

Flagship we are approaching this with the projects QuCats and QT Edu in a collaboratively way.

There are advances and contributions in defining skills profiles and jobs roles that have been made within the Quantum Flagship which have taken the technology development and outline key component areas and provide initial expert profiles[18]. Work now remains to separate the competence areas based on the mode of the technology, principally the software from the hardware to provide that distinction between job roles and the readiness of the technologies. It will consist of applying good practice and learning from digital skills certifications and competence frameworks towards quantum to provide a **competence framework in 2023 that can accelerate the adoption of a common taxonomy and engagement of certification bodies**.

Similarly, it will explore the diversity of the skills within an industrial context, identifying early signals of adoption of market ready technologies and the generation of supply for those areas under development. It will work closely with leading European Quantum organisations and education and training leaders to identify those specific mechanisms for university-industry collaboration and map the routes to **upskilling for quantum professionals across leading sectors**.

LEADS will explore the development of future scenarios with experts from across the Quantum Flagship and within the Quantum Industry Consortium to provide projections of timescales and demand shifts based on consensus.

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4.5. JOB ROLES DEMAND ANALYSIS

To understand how different advanced skills identified through the LEADS use-case methodology impact the European job market, research has been done to identify key ICT job roles across the region and how these different working areas relate to the LEADS skills groupings.

The work started by establishing a base job role taxonomy with 52 different standard ICT roles found in the industry by analysing IDC's current taxonomy (and other widely utilised official taxonomies such as EC-F, ENISA and NICE) and the need for each of these roles to possess the knowledge from different technology areas to perform their daily tasks.

Ultimately, having a standard job role taxonomy enabled LEADS to establish a quantifiable link between the number of headcounts for such occupations through IDC's yearly IT employment forecasting and the forecast assessment of skills done through the use-cases approach.

The following table shows a **mapping of established ICT job roles and their relation/requirements for advanced skills in technology areas**. It is important to notice, as shown below, that many of these job roles overlap with competences in different technology areas.

[18] Qualification Profiles for Quantum Technologies (2022), Greinert. F and Müller R.

Job role as per LEADS taxonomy	Current market demand for job role	May require Advanced:				
		Cloud Skills	IoT skills	AI skills	BI/Data science skills	Security Skills
ML Designer	High growth	YES	YES	YES	YES	YES
Mobile Application Developer	High growth	YES	YES	YES		
Software Developer/Engineer	High growth	YES	YES	YES		
Business Intelligence Analyst	High growth	YES		YES	YES	
Business Intelligence Architect/Developer	High growth	YES		YES	YES	
Data Analyst	High growth	YES			YES	
Data Engineer	High growth	YES		YES	YES	
Data Scientist	High growth			YES	YES	
IoT Designer/Developer/Engineer	High growth	YES	YES			YES
Business partner	High growth	YES				YES
Change Management	High growth	YES				YES
IT project Manager	High growth	YES			YES	YES
User Support specialist	High growth				YES	
Chief Information Security officer (CISO)	High growth					YES
Cyber Incident Responder	High growth					YES
Cyber Threat Intelligence Specialist	High growth				YES	YES
Cyber, Legal, Policy and Compliance Officer	High growth					YES
Cybersecurity Architect	High growth	YES		YES	YES	YES
Cybersecurity Auditor	High growth					YES
Cybersecurity Educator	High growth					YES
Cybersecurity Implementer	High growth	YES	YES			YES
Cybersecurity Researcher	High growth			YES		YES
Cybersecurity Risk Manager	High growth		YES		YES	YES
Digital Forensics Investigator	High growth					YES
Penetration Tester	High growth		YES			YES
UI/UX Designer	Moderate growth	YES				
Web Developer	Moderate growth					
Infrastructure and Cloud architect/analyst	Moderate growth	YES	YES		YES	
Infrastructure and Cloud engineer	Moderate growth	YES	YES			YES
Enterprise Architect	Moderate growth	YES	YES	YES	YES	YES
IT sourcing procurement and governance	Moderate growth	YES				
Technology integration consultant	Moderate growth		YES	YES		
Application Maintenance Manager	Low growth				YES	YES
Software Quality Assurance/Engineer/Tester	Low growth					
Systems Analyst	Low growth	YES	YES	YES		YES
Data Warehouse specialist	Low growth	YES			YES	
Database administrator	Low growth				YES	
Database Architect	Low growth	YES		YES		
Network Engineer/Architect	Low growth	YES	YES			YES
Operations Engineer/Technician	Low growth	YES			YES	
Social Media Manager/Administrator	Low growth				YES	
Telecom Engineering specialist	Low growth		YES			
Chief Information Officer/IT director	Low growth				YES	
Chief Information security officer	Low growth					YES
Chief Technology Officer	Low growth	YES	YES	YES		
Graphic Designer/desktop publisher	Low growth				YES	
Multimedia designer/animator	Low growth					
Uncategorized IT	Low growth					
Web designer	Low growth				YES	
Webmaster/administrator	Low growth					
Network Systems support Specialist	Low growth	YES	YES			
Support Specialist/Developer	Low growth	YES				

Table 2: Mapping of ICT job roles and ADS

Some of the initial analysis of the LEADS job roles vs skills assessment indicate that **almost half of the mapped job roles (25 out of the 52) are currently experiencing high growth in demand, especially on occupations requiring advanced skills in AI, Cybersecurity, Cloud**

and Data Science. Some examples of job roles in high demand that require a myriad of different advanced skills are: **Machine Learning Designer, Software/Application Developer, Software Engineers, Data Scientists, Business Intelligence Analysts**. These roles are usually responsible for unlocking vast amounts of data, being proficient in multiple tools and having a higher understanding of how different systems are intertwined. Therefore, such positions are particularly difficult to fill in the market which consequently impacts on the skills pool available to industry to carry out its business.

When looking at different technology areas, **occupations requiring a certain level of advanced skills particularly in Cloud, AI and Cybersecurity are more likely to register gaps in demand over the next five years**, adding to the risk for **expected levels of employment not to be met by the supply of professionals in these areas if robust upskilling/reskilling programs are not in place.**

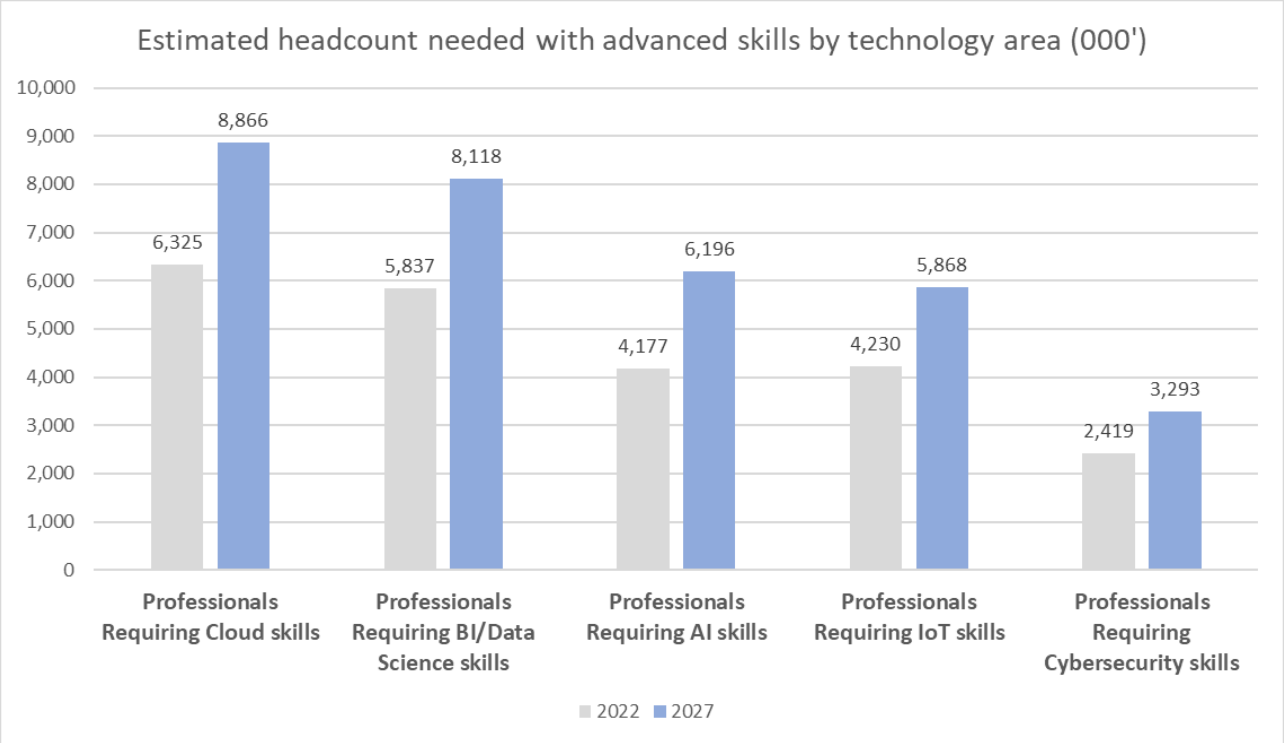

Figure 9: Demand for professionals with ADS

Over the next five years, although the demand for job roles requiring some level of advanced AI skills is expected to suffer the fastest growth in Europe (48% CAGR between 2022-2027), ICT professionals with cloud and BI/Data Science skills will be the most demanded in absolute terms. For instance, by 2027, it is expected that **over 60% of all ICT professionals in Europe will need some level of knowledge of advanced cloud skills to perform their tasks**.

The higher headcount requirement for cloud, despite its demand for advanced skills being set to grow slower than other areas such as AI, is explained by an already relatively mature cloud sector and the growing number of enterprises moving workloads to public and private cloud. On

the education side, IT training and education related to advanced cloud skills is also relatively more mature when compared to AI. With more upskilling programs available, the chances for the industry to meet human requirements for faster cloud adoption increase.

4.6. THE LEADS SURVEY

To validate current findings and enhance the analysis developed so far, a survey has been designed to **collect primary data to complement the existing sources and for further iteration and improvement of data particularly for dimensions such as skill distribution within Europe, demand of skills in different roles and expectations of future demand**.

The LEADS survey is being managed by IDC's Survey team and will span across **13 key markets** in the European Economic Area region, covering all the major markets and bringing a solid view from **over 600-800 respondents (HR professionals, IT decision makers and technology experts)** on the industry perspective of managing advanced ICT skills.

The survey will enable the LEADS consortium to enhance the demand forecasting model for its next deliverable through targeted questions aiming at ICT knowledgeable/decision making respondents working at different European industry sectors on their key pain points when it comes to sourcing skills for the target technology areas of LEADS.

In addition to **identifying current and future skills bottlenecks from an industry perspective**, the survey aims to **identify new trends on how the industry is sourcing, upskilling employees, perceiving the efficiency of current training programs (both internally and externally), funding learning and development and understanding whether companies have a strategic view of upskilling linked to future technology adoption**.

To reach the final questionnaire, several rounds of validation were conducted both with the LEADS partners and with technology experts to ensure the right level of information will be collected. There are, of course, limitations when running a dedicated Computer Assisted Telephone Interview (CATI) approach. Questions cannot be too granular as the interview time is limited for each participant. Therefore, deciding on the optimal level of information gathering that would benefit both the demand and forecasting modelling for skills and assist on the recommendation phase of the project was paramount to the success of this exercise.

The LEADS survey will also play a pivotal role in linking the findings of the framework, demand assessment and forecasting of advanced skills with the recommendations phase of the project which will be developed in WP3. It will help the project to identify key sourcing strategies from the IT sector in Europe, how higher education is perceived and whether fresh out of university candidates are equipped with necessary skills to apply their knowledge into daily industry usage to develop, maintain, secure and plan for technology transformation.

5. CONCLUSIONS AND NEXT STEPS

The LEADS project has identified that most of the covered areas in advanced skills will register a significant growth in demand over the next five years, especially on advanced capabilities related to AI and Data Science that will drive the development of adjacent areas such as Cloud, IoT and Cybersecurity. Based on the current market scenario and already existing talent/skills gap, meeting the demand for a workforce that possesses these advanced skills will be a major challenge not only for Europe, but on a worldwide level.

As the pace of development for AI, for example, is currently in high evidence and several major companies such as Microsoft, IBM and SAP are working on deploying enterprise layer AI tools to its existing services and platforms, the required supply of workforce to tailor and operate these new tools will have to increase so that the demand is met. The gap analysis to be developed in WP2 of the LEADS project will shine a light on how the European education sector is supporting learning in these topics and important advanced skills identified in WP1 and will enable the LEADS consortium to shape recommendations on which areas of advanced skills need to receive more attention and investments over the next years.

Demographically, there are limits on how many new workers can enter the ICT workforce or acquire these advanced skills through reskilling/continuous learning programs. When focusing on advanced skills these are more difficult, time consuming to learn and do not yield immediate impact on employment potential, a longer-term strategy needs to be in place to guarantee a steady flow of workforce supply and attract new professionals to work in ICT related areas.

It is important to notice that the results presented in this draft report of demand assessment and forecasting still do not incorporate findings of the LEADS survey. This is one of the major next steps for the final deliverable of WP1 (D1.3), as the survey will enable the consortium to validate the findings of the current model through a detailed questionnaire that has been developed and add a further layer of understanding for the demand of advanced skills and needed workforce in European enterprises.

Another important next step that will be added to the current analysis is the establishment of different forecasting scenarios to the current estimations. The LEADS consortium aims to analyse different assumptions to distinguish the current baseline growth scenario based on the use-case approach explained in the methodology section of this report, to a possible higher growth and challenge scenario.

These two additional scenarios will bring to light possible macroeconomic and societal changes that may disrupt the current trends and drive the demand for the identified advanced skills to grow slower or faster depending on a set of variables defined by the researchers, which will enable the demand and forecasting assessment to be broader and incorporate additional assumptions.

Furthermore, the final deliverable for WP1 is also expected to include a qualitative chapter on non-ICT job roles that may be impacted by the development of advanced skills and the need for certain occupations outside the ICT realm (such as engineers) to develop advanced capabilities in certain technology areas.

6. ANNEX I. ADS FRAMEWORK: DETAILED DIAGRAMS

In order to provide a comprehensive picture of the revised version of the ADS Framework proposed by LEADS once feedback from external communities has been analysed, we include here the diagrams resulting from this exercise. While no changes exist at high level influencing the identification of Technology Areas and Skills pockets (as we refer to groupings of skills), readers will realize that additional boxes have been added to the detailed views of skills within some technology areas in scope, notably Cloud, AI and IoT. These are represented in darker green colour.

High-level view of the ADS Framework (Technology Areas and Skills groupings)

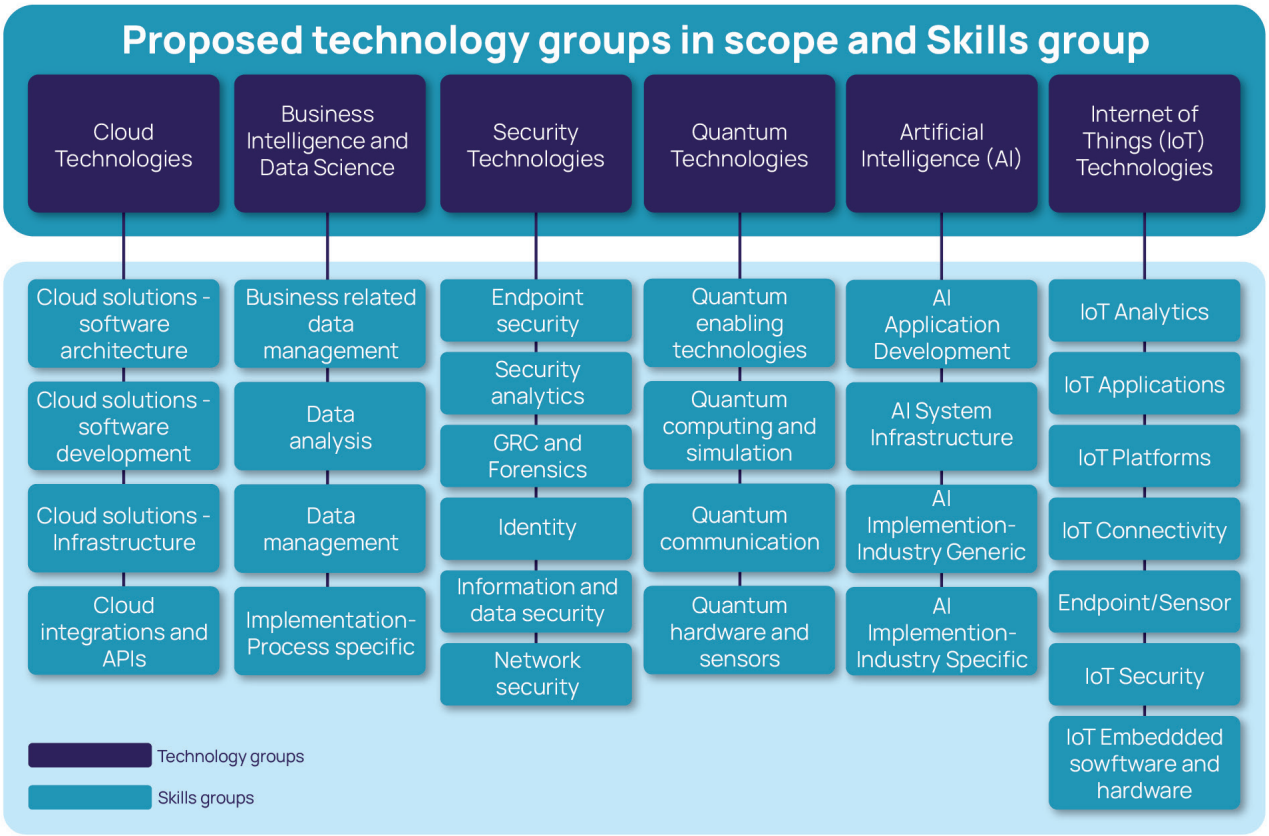

Figure 10: LEADS ADS Framework with Technology Areas and Skills groupings

Detailed view of ADS within each Technology Area

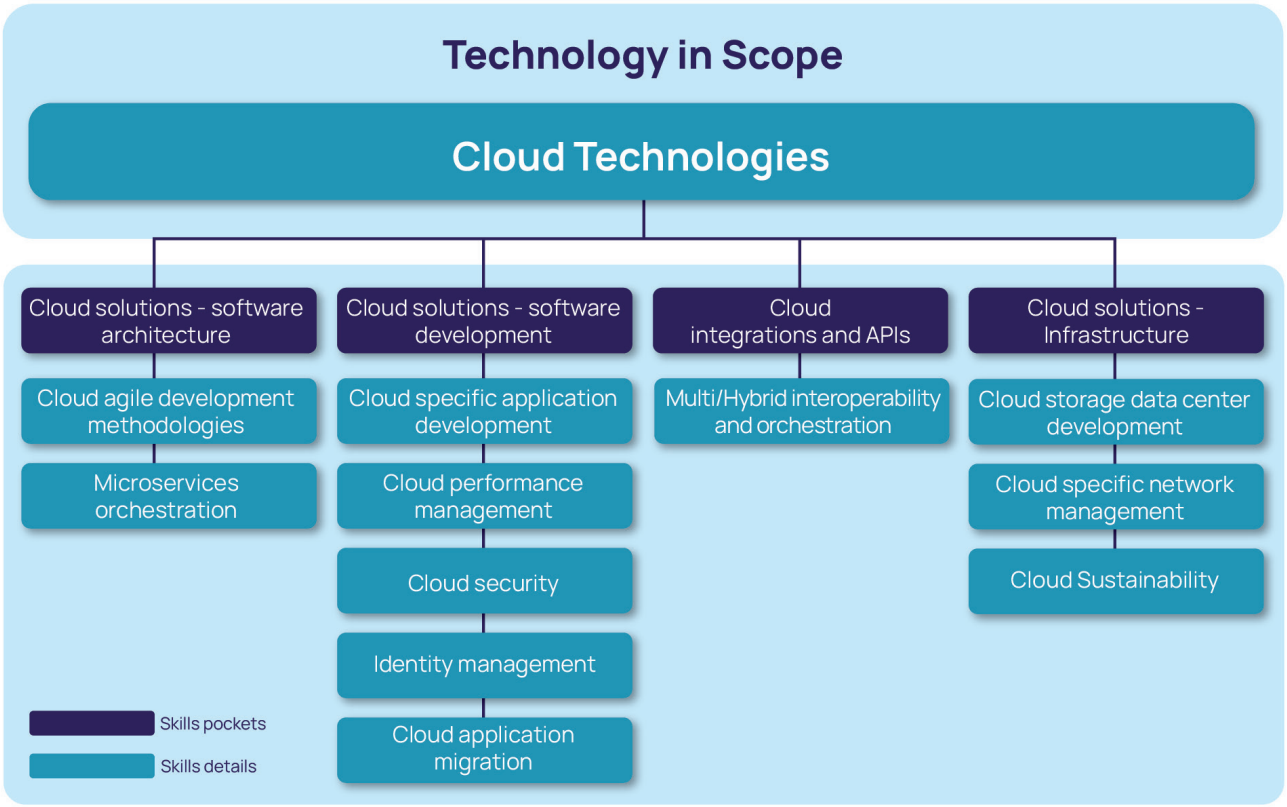

Figure 11: Detailed Skills within the Cloud Technology Area

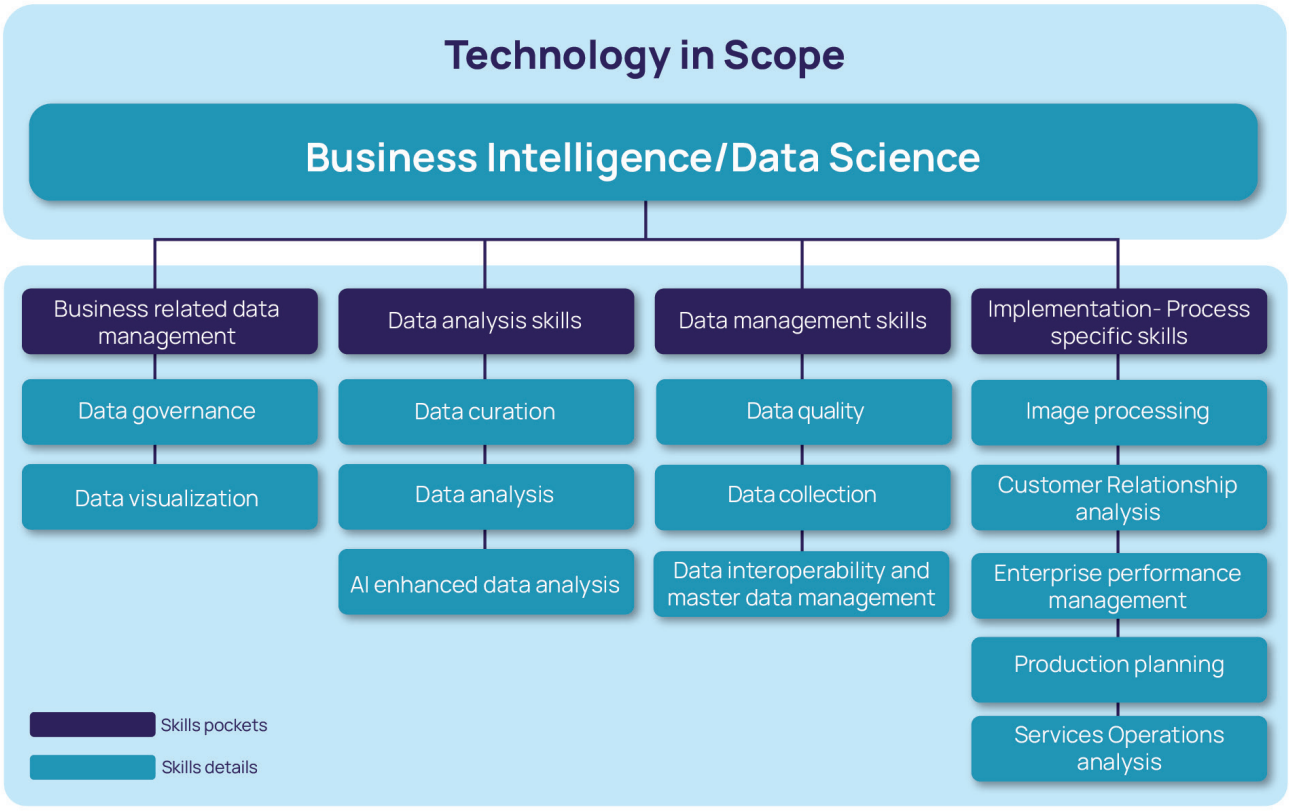

Figure 12: Detailed Skills within the Cloud Technology Area

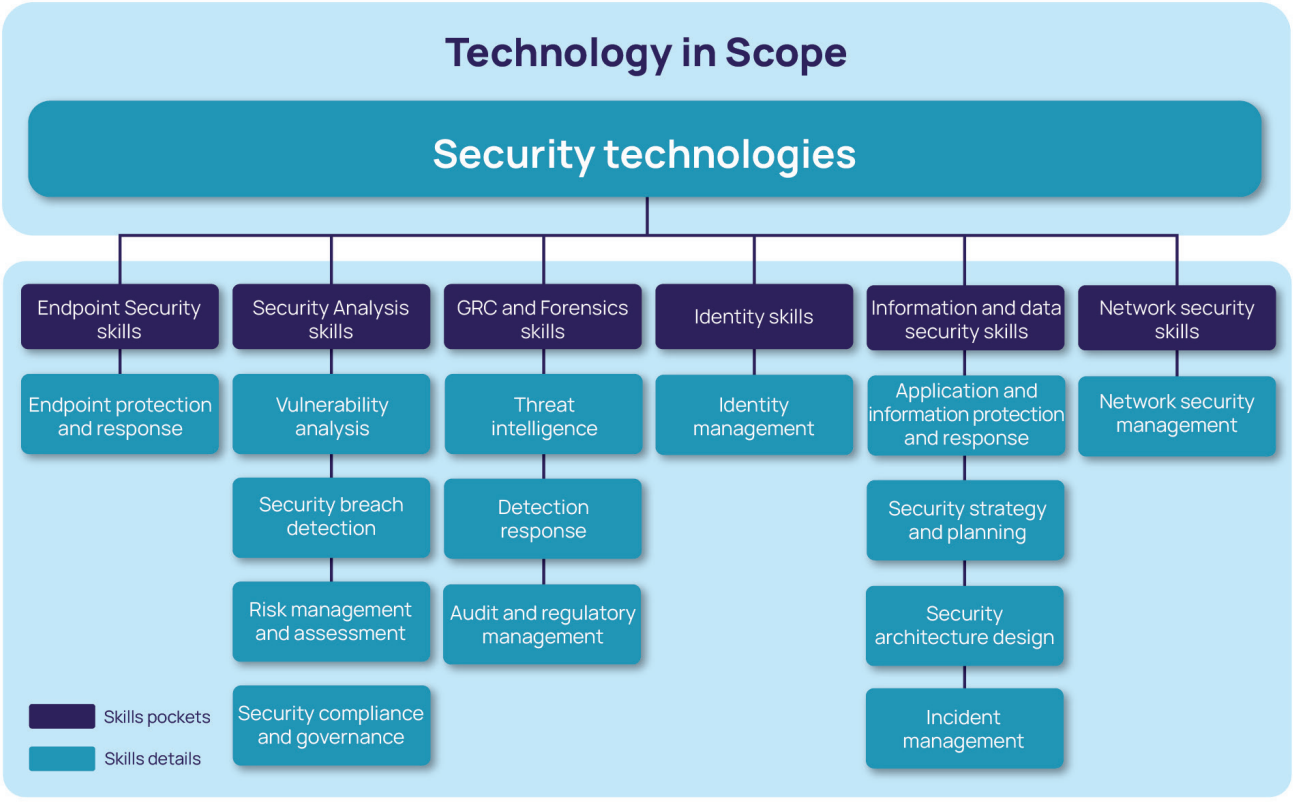

Figure 13: Detailed Skills within the Security Technology Area

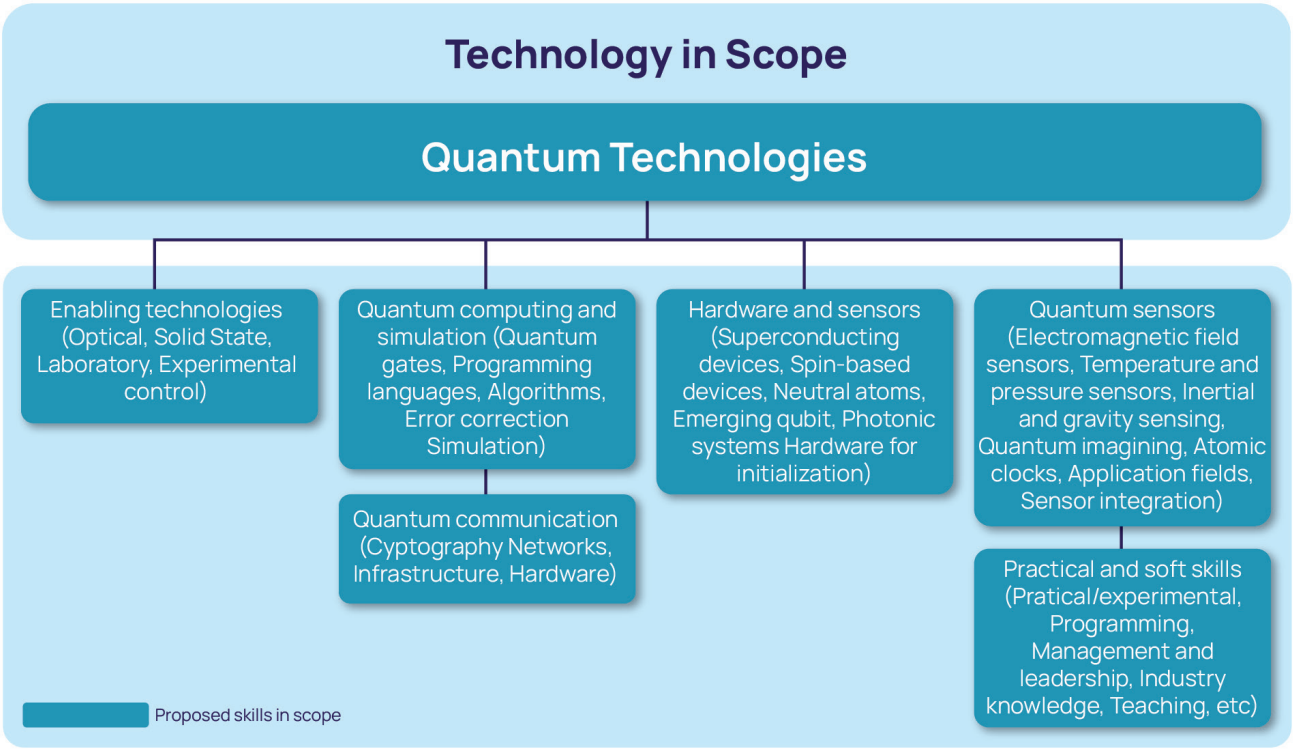

Figure 14: Detailed Skills within the Quantum Technology Area

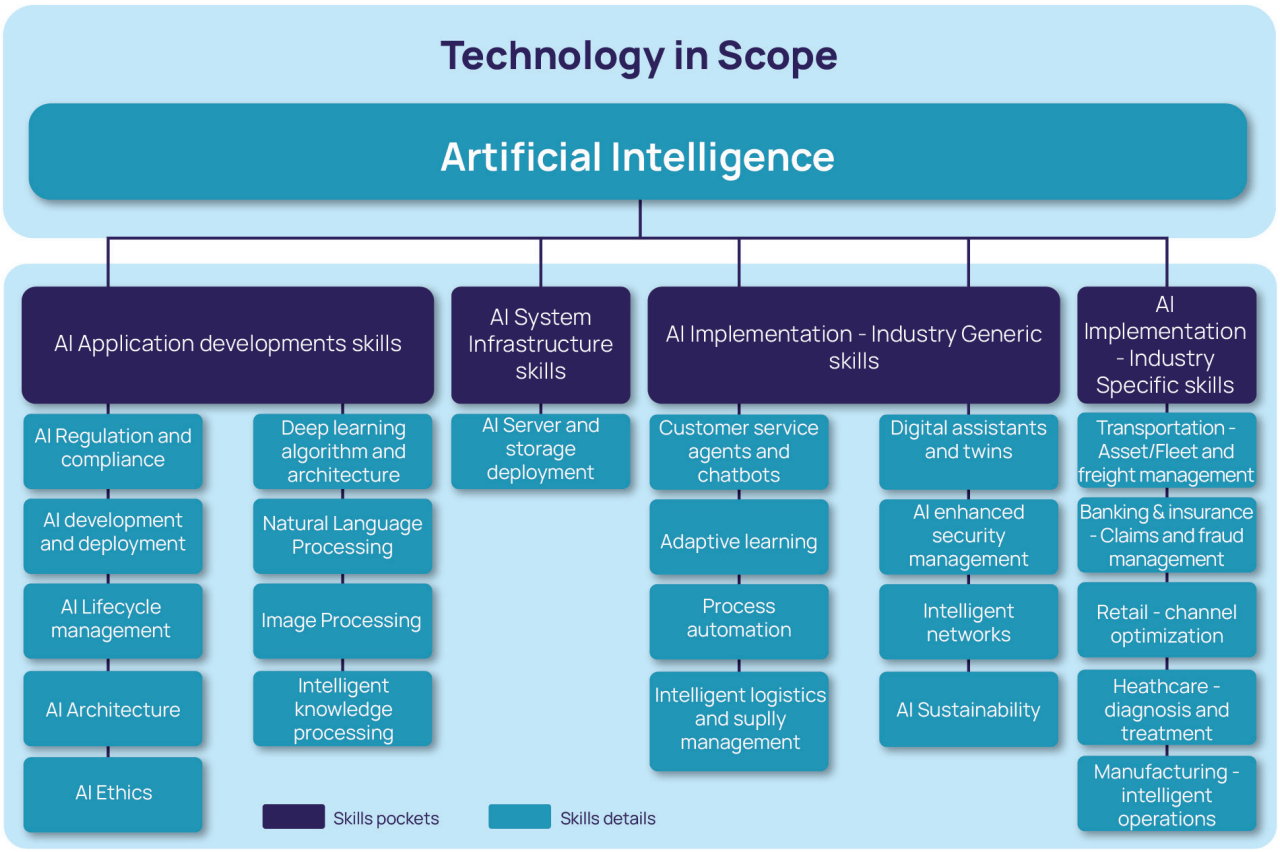

Figure 15: Detailed Skills within the Artificial Intelligence Technology Area

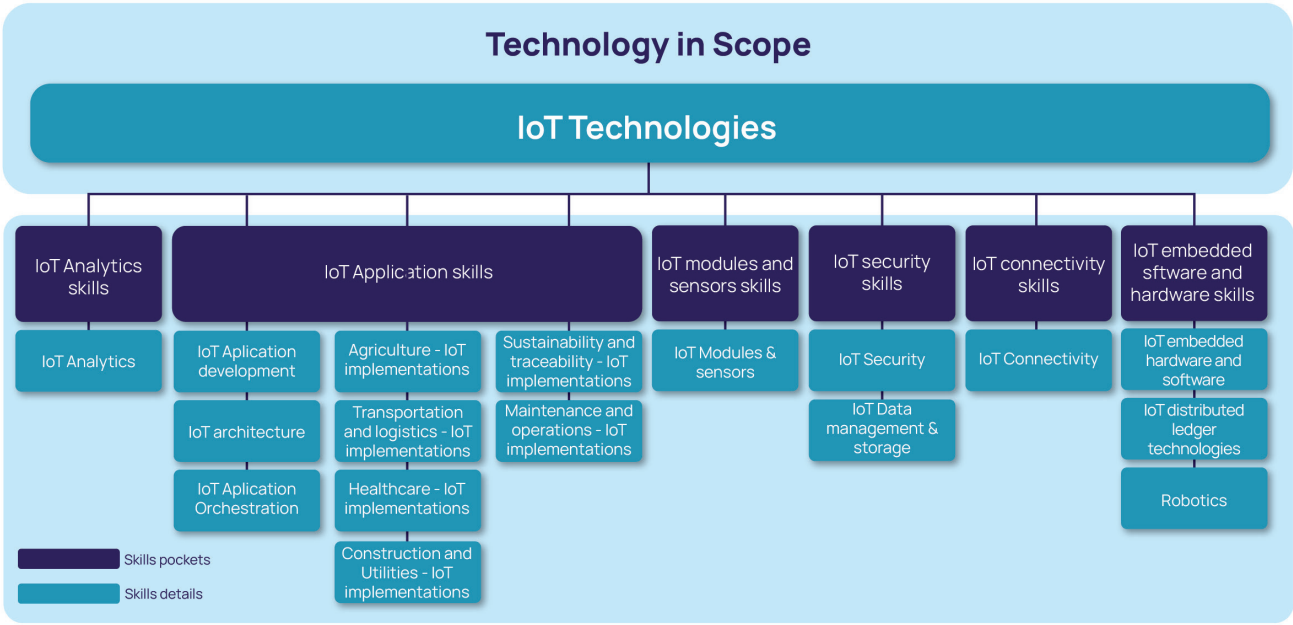

Figure 16: Detailed Skills within the IoT Technology Area