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Growing a sustainable and comprehensive ecosystem

for Next Generation Internet of Things

D2.4: Expert consultations and dialogue report Version 2

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ABBREVIATIONS

AB	Advisory Board
AI	Artificial Intelligence
AR	Artificial Reality
BMI	Building Information Modelling
CB	Coordination Board
CSA	Coordination and Support Action
DEI	Digitising European Industry
DEP	Digital Europe Programme
DID	Decentralised Identifier
DLT	Distributed Ledger Technology
EG	Expert Group
FOSS	Free and Open Source Software
HEP	Horizon Europe Programme
IA	Innovation Actions
IoT	Internet of Things
JU	Joint Undertaking
M2M	Machine to Machine
ML	Machine Learning
MR	Mixed Reality
NGI	Next Generation Internet
NGIOT	Next Generation Internet of Things
NGO	Non-Governmental Organization
PLC	Programmable Logic Controller
RD&I	Research, Development and Innovation
RIA	Research and Innovation Action
R&I	Research and Innovation
SNS	Smart Networks and Services
SoS	System of Systems
SRIA	Strategic Research and Innovation Agenda
VR	Virtual Reality

1 INTRODUCTION

This document provides a summary of the outcomes of the recent engagement of the EU-IoT Expert Group and its members in September 2023. The engagement of the expert group is non-sequential, and each session is based on specific topics and challenges that are faced within the project's areas of focus and act as contributions towards other prominent and public deliverables. As such this report acts as an interim analysis of Expert Group input and is to be taken in context with other deliverables and project outputs which includes:

- D2.2: Towards a Vibrant European IoT Ecosystem v2 (October 2021)
- D2.5: NGIoT Roadmap and policy recommendations v1.1 (September 2022)
- D4.1: Report on best practices for use cases v2 (September 2022)
- D4.3: Report on IoT training activities v2 (September 2022)
- D5.6: Guidelines for IoT collaboration sustainability v1 (September 2022)[1]

The target audience for this report includes both tech developers and policy makers as well as the wider NGIoT Community actors to help identify early and weak signals that can guide further dialogues and activities for enabling a successful European NGIoT ecosystem.

The information presented within this document results from two workshops held on the 26th September 2022 in Brussels, in collaboration with the NGIoT Coordination Board. These two sessions are:

- The impact of European policy on NGIoT development; addressing key legislations
- The IoT skills of the future: An inspection of the profiles in current and future demand and key routes for supply

Section 2 provides a brief overview of the NGIoT initiative, the EU-IoT project and the Expert Group roles and activities.

Section 3 provides a summary of the main outputs on the first session related to the perceived benefits and impact of the upcoming European legislations with a deep dive into the Data Act, building upon the initial analysis provided within the NGIoT roadmap and policy recommendations v1.1.

Section 4 elaborates the discussion on current IoT skills profiles based on the survey performed as part of the WP4 Coach activities and makes an indicative prediction towards the future demand. This is further developed to create skills mapping and methods for their acquisition for the priority profiles identified by participants.

Section 5 isolates the key conclusions drawn from the analysis of the data provided and recommendations.

Finally, in Section 6, the composition of the EU-IoT Expert Group is presented.

[1] The description of the mentioned deliverables is publicly available through the NGIoT Portal: www.ngiot.eu/deliverables

2 THE NGIOT CONTEXT

2.1 The Next Generation IoT Initiative and EU-IoT

The Next Generation Initiative is a portfolio of 6 Research and Innovation Actions tasked with developing and trialling next-generation architectures that underpin the deployment and accelerated development of edge computing, distributed intelligence, federated microservices, collaborative IoT and tactile interfaces integrating holistically enabling technologies such as DLTs. The NGIoT Initiative is focused on supporting the transition to the Cloud-Edge-IoT paradigm, driven by the federation of cloud and edge technologies which are in turn facilitated by the increased computing power available on chips and devices and the realisation of the collaborative IoT enabled by 5G technologies[2].

These projects were awarded towards the end of the last Research and Innovation Framework Programme, Horizon 2020, as the IoT was evolving from a relatively delineated field and scope towards a computing continuum, from human to cloud. While the previous decade can be categorised by the widescale adoption of cloud computing and the rise of the hyperscalers, that have enabled much of the digital transformation, the next decade is expected to see the rise of edge computing, enabling a more distributed approach to data and intelligence. The successor of the NGIoT Initiative will be the EU Cloud Edge IoT Continuum which was launched in 2022 and will build upon both the work of the NGIoT and its cloud analogue Horizon Cloud initiative reflecting the blending of the two within the computing continuum.

EU-IoT is the Coordination and Support Action for the NGIoT Initiative and acts as an accelerator for the whole European IoT ecosystem towards transforming the current IoT community of researchers and innovators in Europe into an increasingly cohesive, dynamic, participatory, and sustainable ecosystem.

1.1 The EU-IoT Expert Group

The EU-IoT Expert Group is a high-level experts network whose members demonstrate clear experience and knowledge of the IoT landscape in Europe with strong international networks. It is tasked with providing guidance on concrete areas in order to guide its principal actions and to contribute on specific aspects of relevance to the Next-Generation IoT community. [3]

The Expert Group Members are regularly requested to provide impartial views and inputs to EU-IoT work through discussions and papers. The experts lend their experience, expertise, and opinion to provide strategic guidance in their areas of expertise to ensure that the work undertaken by the project has a full understanding of the ongoing challenges, trends and initiatives.

Their membership is on an individual basis and members do not represent any organisation or group while in position.

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[3] For full exhaustive selecting criteria see D.2.3 Experts consultation and dialogues report Version 1

2 IMPACT OF EUROPEAN LEGISLATION ON THE NGIOT

2.1 Background

Within the European Institutions, policy-makers are launching initiatives to update existing regulatory and normative frameworks, adapting them to the all-pervasive digital economy that is shaping society, business, and even politics. Many of them will have a direct impact on the future of the next-generation IoT and the move to the Cloud-Edge-IoT paradigm. Among these are included the following:

- Proposal for Data Act {SEC(2022) 81 final}
- Proposal for Digital Markets Act {SEC(2020) 437 final}
- Proposal for Digital Services Act {SEC(2020) 432 final}
- Proposal for Artificial Intelligence Act {SEC(2021) 206 final}
- Proposal for Chips Act {SEC(2022) 46 final}
- Proposal for Cybersecurity Resilience Act {SEC(2022) 321 final}
- Proposal for Data Governance Act {SEC(2022) 868 final}

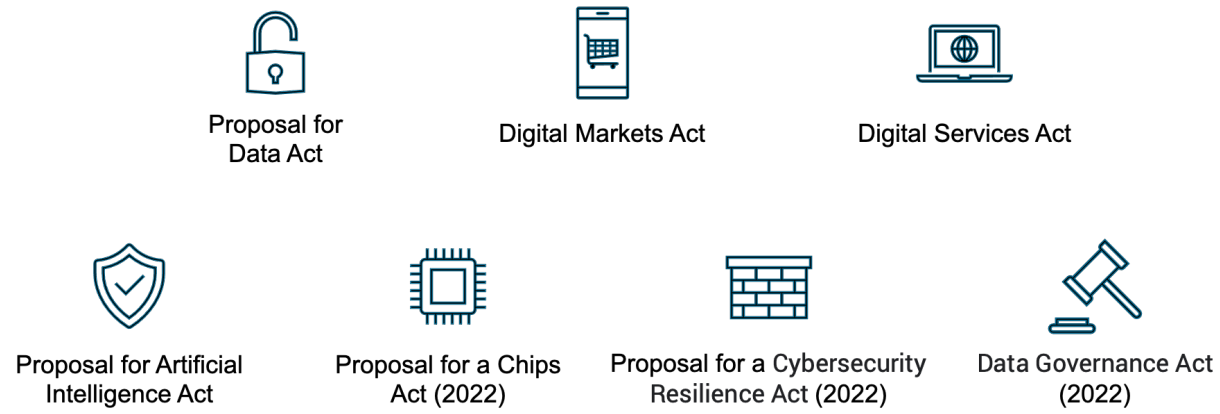


Figure 1. Principal regulations that are likely to have a direct impact on the NG-IoT

Within this portfolio of regulations, each will have its own impact to varying degrees on the tech development community, with the Data Act expected to hold the most direct and significant impact on how solutions are designed, developed, and deployed while also providing a new data flows and business opportunities. A fuller discussion on the foreseen roles and responsibilities can be found in Deliverable 2.5, Version 1.1[4].

In short, the Data Act covers data that is generated and collected through the use of a product, including virtual assistants, and also addresses the portability of cloud services between providers. In order to provide an understanding of the impact and generate an initial set of focus areas, the Expert Group was consulted on the foreseen benefits and disbenefits arising from the adoption of this legislation. The other intended function was to raise awareness among these leaders within the community of the raft of impending changes that can be expected from the identified portfolio above.

2.2 Identified opportunities and challenges

The Expert Group was led in a workshop through an overview of the set of regulations with particular emphasis given to both the Data and AI Act before performing a deep dive into the

[4] For full deliverable please see D2.5 NGIoT roadmap and policy recommendations Version 1.1

former. This included a review of the identified provisions within each context, principal exclusions, and the obligations on the principal affected stakeholders.

Within provisions the following were addressed; B2B and B2C data sharing and access, provision of data to public bodies for an exceptional need, portability of digital assets from cloud and edge platforms (data processing services), interoperability mechanisms and standards, while for obligations it focused primarily on the Data Holder (i.e. device OEM or service provider) and Data Processing Services Providers (i.e. cloud computing service providers).

Working across two teams, the Experts Debated the opportunities and challenges which have been captured in the following outcomes. In general, the experts present agreed with the principles of the regulation, however, much of the discussion was dedicated to the potential flaws and challenges that may arise as will be seen below.

Table 1. Overview of recorded responses within each group

	Group 1	Group 2
Benefits	• Improve cooperative mobility (e.g. Smart Utility) • New Formats for interoperability • Balances the ecosystem - benefits SMEs • Good for academia - possibility of greater access to data	• Promotes FOSS development and boosts the use of open source based solutions • Produces new data forms • Pushes all vendors to establish standardisation of the access/process method • Could contribute to the increase in available data on the market • Startups using cloud providers can expect less lock-in but also less funding from providers
Disbenefits	• Can reduce industry investment • Requires infrastructure investment	• Startups using cloud providers can expect less funding from providers • Ambiguity for portability of non-deterministic systems • Portability - difficult to implement due to lack of on-premise servers • High complexity and cost for PaaS providers (as opposed to IaaS) • Might increase the cost of commercial cloud service • Could deteriorate differentiated services

2.2.1 Opportunities to be realised

The overall acceptance was that the greater sharing of data and increased transparency will benefit the development of future systems as a data beneficiary which will result in overcoming some of the shortcomings present within the IoT and Cloud Computing market today, whereby users can find themselves restricted to specific suppliers or contract terms by barriers to access and change rather than by retention through quality of service.

Increased cybersecurity and resilience

With more data sharing between systems and platforms, better cybersecurity provisions are required. Although there are currently good practices and tools in place for porting data, the future exercising of the rights within the Act will encourage the generation of a software bill of materials. The production and sharing of such resources, enables tech providers and users to identify when their systems are at risk and to take shared actions to remove such risks or accelerate the response to breaches and attacks by clearly identifying the constituent software components present.

An increase in shared cybersecurity components will ultimately result in the common application of specific tools that will enhance the overall resilience of systems across commercially deployed devices.

Increase in open-source provision and investment

The high portability of many apps or systems is dependent on the level of infrastructure dependency, that is the level of dependency on vendor native APIs and applications. These native APIs and applications are simpler and quicker for developers to develop solutions and increase the functionality of their applications but have an inverse relationship to the portability or operation in a multi-cloud environment, something that containerisation partially mitigates.

Open-source solutions provide the route towards developing applications and systems with high portability and offer a practical solution towards the obligations encoded within the regulation. The Data Act, and the interoperability contained within, can therefore be expected to increase the use of open-source software components decoupling the performance from infrastructure environments. Within this will come investment, as developers seek to grow the functions and performance and increase the entry of new components, applications, and interfaces.

Detection of improper data use by individuals

Within the implementation, there will be increased transparency between the data owner/collector and the subjects or entities who generate the data. An additionality that can be expected is the increased monitoring and detection of poor behaviour and bad faith of organisations by individuals across the European Union. Traceability and accountability between data collected and actions taken can be formed and detection on a micro and massive scale can be enabled.

2.2.2 Perceived disbenefits

Generation of business conflicts and chilling effects on innovation

Strongest among the topics discussed is the potential for the generation of business conflicts that can be generated by the Act. These span over the following areas:

- Generation of data sets of value

Of first concern will be the impact on those businesses who attribute a commercial value to their datasets and rely on them as either a direct or indirect contributor towards income. The question is where the business case stands once this data needs to be shared with users and whether the investment into the continued building and maintenance of such datasets will continue as they open up their data. Will it make more sense to buy data rather than build it.

- Investment into innovation within services

Related to the above, within the context of the Cloud Service Providers and their native apps and solutions it was raised that there could be a chilling effect on the innovation in the development and delivery of such services that would hinder the growth of the facilities available to NGIoT developers in the future. Ultimately, this Act represents a change in the operations for many of the large cloud providers and the question of portability has an impact both technically and commercially that will be further defined.

- Cross-over between non-personal data and personal data

A particular risk exists for processes that have been designed with differential privacy systems in place to ensure the privacy of individuals with the intention of avoiding the crossing with GDPR, however, through the requirements to hold individual datasets this application can be hindered. Likewise, while some operational datasets can be kept outside the scope of GDPR, others that are commercially relevant may contain the mix of personal data and non-personal data increasing the business complexity for compliance against both the GDPR and Data Act.

IP leakage and anti-competitive practices

Although Trade Secrets and their non-disclosure are considered with the Act, there still exists a risk for IP leakage from both the agreements which define which data is being collected and from

the data exported itself, even if in a raw format. It can provide insights towards the hardware design and sensitive information regarding sensors which may lead to inferred information covered by Trade Secrets and non-patented or patentable IP.

More concerning perhaps, is the scenario where the mass aggregation of data by third parties through mechanisms established within the Act which can undermine the competitiveness of the data holder. This is an item that requires careful consideration in the practical implementation of the Act.

Homogeneity of service offering

Through the obligations of the Act on Data Processing Providers, there will be a higher value associated with the portability or the capacity to facilitate porting of data and applications when designing and selecting the services to be provided to European users. Combined with the expected move towards more interoperable and open-source based solutions, it can be assumed that the cloud market will achieve a level of homogeneity with limited differentiation for users and customers between offerings.

The increased cost of service and price inflation

With the increased complexity and activities to be executed by data holders, experts expressed concern about the increased cost that will eventually be passed onto the customer in terms of tariffs and charges.

On-premises portability

Finally, with the expected growth of hybrid cloud strategies and the reduction of business use of public cloud, there exists a question surrounding the overlap with on-prem facilities; will obligations be extended to cover such environments when providing portability. There is of course, under the EU Cloud Edge IoT Initiative the development of metaOS systems that may resolve this issue across heterogeneous cloud-edge environments.[5]

2.2.3 Contextual challenges

There were a set of challenges and barriers identified that may hinder implementation and compliance which are beyond a direct disbenefit and opportunities and sit in market and technological contexts.

Non-portability of specific assets and services

Systems that are non-deterministic and opaque are complex and cannot be transferred. Solutions which use such black-box algorithms will not be transferrable while maintaining an equivalent service. This is a limit to the provisions, especially within computing execution platforms. Equally, chatbots which are developed through many providers, each holding their models built on multiple customers, cannot be easily ported to another service provider as the outputs provided will not be the same.

Incompleteness of data

Without the inclusion of data arising from the use of phones, the provisions of the Act are only partial. Phones and similar devices are regularly used across deployments of connected systems as both sensor and interface for the involved human.

Cloud provider market

Surrounding the ambitions of the Data Act is, from a user/customer perspective, the need for a more competitive and dynamic European cloud marketplace. Currently, the exchange between providers will be mostly between the designated ‘Gatekeepers’ of AWS, Azure, etc. More European providers with compelling value propositions are required.

Consequentially, the market has invested significantly in providing unique applications that are not directly comparable across infrastructure providers or are completely absent. This can be taken up

[5] www.eucloudedgeiot.eu

by the open-source community and enter into a third-party developer environment but unlikely in the short term. In general, the transition of PaaS services within the existing market will be challenging.

Access for the research community

With many of the experts resulting from the RD&I community, especially from universities and RTOs, there was an expression of interest for their access to such data which is currently not provisioned.

Ambiguity in language

More clarity and specificity regarding terms can help ensure that the Act is limited to its purpose and does not allow minimal compliance nor an overreach. This is related to the definition of “fair, reasonable and non-discriminate terms” and what constitutes a public emergency and who determines it.

2.3 Main conclusions

It is evident that the greater flow of data will benefit society and the technology development community, however, there will be a set of both market-based and technological challenges that must be overcome to realise the opportunities presented by the Data Act.

Preparing industry and ensuring widespread dialogue

For the vast majority of the experts present, who are all active and representative members of the tech development community, much of the legislations that will be enacted, and their respective impacts were unknown to them. Given this, the discussions were animated and engaging, showing a clear need for this debate to be continuous among the NGIoT Community so that their respective solutions and companies are positioned to maximise the opportunities and minimise the potential disbenefits.

The implementation and the mechanisms that will be required by the Data Act, can generate significant concerns that must be addressed by direct engagement. Much of the discussion with the experts was dedicated to potential chilling effects, and while it is extremely important to address these concerns, the balance needs to be taken as a whole with open ideation on the new business models and technology solutions that will arise from this change in process.

Open source and competitive marketplaces

The success of the Data Act will deliver a significant boon to open-source solutions and development through the increase in demand as a means to ensure compliance and the standardisation of software components. This requires a stronger push over the coming years to ensure that such applications are commercially employed and that the communities who develop them are also coming from the same commercial ecosystem. Further developments within the orchestration of cloud-edge-IoT resources will be required and achieving the equivalence of not just functionality but of ease of use with native apps.

The same will be required of the European cloud market, the Act provides for an easier competitive landscape for mid-size and specialist providers, as well as for organisations to operate on multi-cloud environments, both public and private. The industry needs to be in place to offer a sufficient value differentiation and level of services to result in a dynamic multi-actor cloud-edge computing market and a competitive market for the consumer.

Finally, cybersecure interfaces and standards will need to be present to ensure the whole-system security from point of data collection to final processing. The community will need to overcome some of the existing competing standards between the IoT and Cloud environments and practices along the whole computing continuum.

Technical innovation and diversity

Addressing the concerns regarding innovation investment and service offering, it is evident that there is a concern that provisions within the Data Act could stymie innovation and private

investment in data collection and infrastructure development taken from existing and dominant business models. The stimulation of new business models and transformation of solutions, as previously mentioned, will be central to changing such narrative and encourage continued private investment in line with market demands.

The challenges will still remain around non-compatible solutions, and a maturing of the non-native apps will be required in order to remove barriers to switching or multicloud. A segmenting of the cloud market will perhaps resolve this, with a separation of the stack and a competitive cross-provider environment and third-party providers present at each layer that can provide consumers with a diverse selection of services and apps.

3 FUTURE SKILLS PROFILES OF THE NGIOT

3.1 Skills demand for the deployment of the Next Generation IoT

EU-IoT specified its own framework of IoT skills, which structures a set of important and prominent IoT skills in different categories and sub-categories. It can be thought as a simple taxonomy of IoT skills and can be found in the published deliverable on training activities and an upcoming White Paper on the topic which seeks to elaborate learning pathways.[6] To date the IoT skills framework has been implemented in the following activities:

- Executing a survey towards understanding the relevant importance of various IoT skills for the market.
- Collecting feedback from the IoT and human resources community on the framework towards properly revising the framework. Specifically, as part of the execution of the IoT survey, the project solicited feedback on important IoT skills that were lacking from the survey. This facilitated the revision of the framework based on market feedback.
- Improving the structure and metadata of the EU-IoT training catalogue. Specifically, the EU-IoT framework was used to structure the courses of the catalogue, while enhancing them with metadata relating to the IoT skills that each of the courses' support.

The skills survey with 183 qualified respondents from different industries, including manufacturing, smart cities, energy, agriculture, and security, identified some of the most popular IoT skills and an approach for the forming of skills profiles.

Within the expert group session, the participants were presented with the identified profiles and requested to provide an assessment of firstly which profiles were missing and secondly the change in relative demand over the coming 10 years. Following on from this, the experts in groups then identified their priority skills profiles to which they assigned the relevant skills and proposed the appropriate method for their respective acquisition.

The takeaways of these series of working sessions should not be seen read in terms of statistical representation of the IoT profile's ecosystem but as an additional tool when comprehending where the future of the IoT ecosystem is going in terms of skills' demand. The added value of this deliverable can be concluded to be not necessarily representative of the skills environment but definitely indicative that the trends that the programme has identified so far are shared by part of the knowledgeable stakeholders.

3.2 Key skills profiles

The skills profiles identified in this previous work were taken as the basis for further elaboration within the expert session. The list of profiles discussed are shown in the table below within their categories of the EU-IoT taxonomy.

Table 2. List and grouping of the skills profiles

Devices and Smart Objects	• Embedded Firmware Developers • IoT Hardware Designers	• Embedded Systems Engineers
Network, Connectivity and Cloud, Edge and Mobile Computing	• IoT Network Engineers • Digital Twins Experts	• IoT Cloud Experts • IoT Backend Developers

[6] D4.4 Report on Training Activities Version 2

Soldatos, J., The EU-IoT Framework for Internet of Things Skills: Closing the Talent Gap (unpublished)

Security, Protocols and Software Programming	• Cybersecurity Engineers • Automation and Systems Integration Engineers	• IoT Application Developers • IoT Programmers • HTML Requirements Expert
Development Methodologies and Tools	• IoT DevOps Engineers • Development and Operations • Semantic Engineer	• IoT Testing Engineers • Frontend Developer
Analytics	• Data Analytics Experts • Data Scientists	• Machine Learning Operations
Business and Management	• IoT Business Developers • IoT Product Managers • IoT Project Managers	• Chief Data Officer • User-centric Capacity Builder • IoT Architect
Legal and Regulatory	• Policy Recommendation	

Below provides a summary of the mapping performed across the three teams with a scoring of between 1 and 10 provided for the relative demand mapped.

Table 3. Skills profiles' mapping by the three teams according to current demand, + 5 years, +10 years ordered by profiles grouping

Profile	Existing/ Added	2022			2027			2032		
		Team			Team			Team		
		1	2	3	1	2	3	1	2	3
IoT Hardware Designers	Existing	8	10	5	6	10	5	4	10	5
Embedded Firmware Developers	Existing	5	9	5	3	9	5	1	10	5
Embedded Systems Engineers	Existing	5	10	5	3	2	5	1	1	5
IoT Network Engineers	Existing	10	7	5	7	8	7	6	10	9
IoT Backend Developers	Existing	8	8	5	6	9	5	4	10	5
IoT Cloud Experts	Existing	2	1	9	2	1	7	1	3	1
Cybersecurity Engineers	Existing	5	10	7	3	10	8	1	10	9
IoT Application Developers	Existing	8	7	4	7	10	4	6	10	4
Automation and Systems Integration Engineers	Existing	8	4	6	7	6	8	6	6	10
IoT Programmers	Existing	5	10	5	4	10	5	4	10	5
IoT Testing Engineers	Existing	10	10	2	10	10	3.5	10	10	5
IoT DevOps Engineers	Existing	10	10	9	9	10	7	9	10	5
Development and Operations	Existing	-	10	9	-	10	7	-	10	7
Frontend Developers	Existing	1	10	1	1	10	1	1	10	1

Data Analytics Experts	Existing	7	9	9	8	10	8	9	10	7
Data Scientists	Existing	5	-	9	3	2	8	1	10	7
Machine Learning Operations	Existing	10	2	9	-	2	8	7	2	7
IoT Business Developers	Existing	-	5	2	10	5	4	10	7	5
IoT Project Managers	Existing	10	4	4	10	4	3.5	10	4	5
IoT Product Managers	Existing	8	10	-	6	10	4	4	-	5
Digital Twins Experts	Added	-	-	-	-	-	10	-	-	10
HTML Requirements Expert	Added	-	-	6	-	-	8	-	-	9
Semantic Engineering	Added	-	10	-	-	10	-	-	10	-
Chief Data Officer	Added	-	-	-	10	-	-	10	-	-
User-centric Capacity Builder	Added	-	-	-	10	-	-	10	-	-
IoT Architect	Added	8	-	-	10	-	-	10	-	-
Policy Recommendation (IoT)	Added	-	-	-	10	-	-	10	-	-

Note: "-" refers to unavailable data. While for added profiles it indicative of lack of repetition of the spontaneously incorporated profiles within groups, for survey-mapped profiles is indicative of the groups lack of classification of that profile within a specific time period.

3.2.1 Key clusters of demand

In order to group and analysed the information shown in Table 3, the average was calculated for each skill profile within the respective time periods followed by a classification into the following demand bands: low, medium and high based on the ranges of average score. Additionally, the standard deviation for each profile's average was calculated to identify the dispersion of scoring among teams. Consequently, if teams coincided in mapping the profile within the high, medium and low bands the standard deviation is expected to be lower that if there was no agreement between the different groups[7]

The lack of more than one observation within same profile, same period but different team was observed principally with newly incorporated profiles; as teams worked separately the appearance of the exact same profile among two (or three) teams was extremely unlikely. Consequently, the following rankings and its subsequent analysis was made on survey-mapped profiles only. The discharged profiles for the quantitative analysis were those mapped in Table 3 as added. Yet, the analysis qualitative analysis on insights provided by new profiles will be developed in the present report.

Table 4. Top profiles identified where 1 is most demand with difference in global score compared to previous period presented in parentheses

Rank	2022	Band	2027	Band	2032	Band
1	IoT DevOps Engineers	High	IoT DevOps Engineers(-)	High	Data Analytics Experts (+1)	High
2	Development and Operations	High	Data Analytics Experts(+2)	High	Development & Operations (+1)	High
3	IoT Product Managers	High	Development & Operations (-1)	High	IoT Network Engineers (+2)	Med

[7] For full list of results see Annex 2

4	Data Analytics Experts	High	IoT Testing Engineers (+4)	High	IoT Testing Engineers (-)	Med
5	IoT Hardware Designers	High	IoT Network Engineers (+1)	High	IoT DevOps Engineers (-4)	Med

Table 5. Bottom profiles identified where 1 is the least in demand.

Rank	2022	Band	2027	Band	2032	Band
1	IoT Business Developers	Low	Embedded Systems Engineers (-6)	Low	IoT Cloud Experts (-1)	Low
2	IoT Cloud Experts	Low	IoT Cloud Experts (-)	Low	Embedded Systems Engineers (+1)	Low
3	Frontend Developers	Low	Frontend Developers (-)	Low	Frontend Developers (-)	Low
4	Automation & Systems Integration Engineers	Med	Data Scientists (-6)	Low	IoT Product Managers (-6)	Med
5	IoT Project Managers	Med	Machine Learning Operations (-)	Low	Machine Learning Operations (-)	Med

Current demand

The top 5 skills profiles in current high demand identified across the groups are:

- **IoT DevOps Engineers (9.7)**
- **Development and Operations (9.5)**
- IoT Product Managers (9.0)
- Data Analytics Experts (8.3)
- IoT Hardware Designers (7.7)

Both IoT DevOps Engineers and Development and Operations profiles scored the highest averages with the lowest standard deviation. Allowing to interpret that their mapping as high demand was consistent throughout the three teams. Regarding profiles categories, across the top 10, Development and Methodologies Tools was the taxonomy category that had the greatest participation with four profiles in the top 10, followed by Security Protocols and Software Programming and Analytics, with two profiles each.

The top 5 skills profiles in least demand identified across the teams are:

- IoT Business Developers (3.5)
- IoT Cloud Experts (4.0)
- Frontend Developers (4.0)
- Automation & Systems Integration Engineers (6.0)
- IoT Project Managers (6.0)

Across these profiles there was a relatively low consensus as standard deviation remained moderately high, yet the least demanded profile, IoT Business Developer, had the lowest dispersion, indicating that within this group the least demanded was the profile that gathered most consensus. Regarding Profiles categories, across the top 10 in least demand, three profiles belonged to Security Protocols and Software Programming, followed by Network Connectivity and Cloud and Analytics with two profiles each.

Moreover, regarding the consensus of current and future demand it is worth mentioning the changes in the standard deviation. While there was greater consensus in identifying currently demanded jobs (s.d. average 1.3 within Top 5) there less consent in identifying the least demanded. For this second group the standard deviation average was 3.4. This provides interesting insights in reinforcing the idea that there is agreement on the current skills shortage, stressing the importance of need for actions to be taken to shorten that gap.

Table 6. Dispersion comparison for 2022 top and bottom profiles

2022	Average S.D.
5 Most Demanded profile	1.3
5 Least Demanded Profiles	3.4

Demand in 5 years

The top 5 skills profiles in high demand by 2027 identified across the teams are:

- **IoT DevOps Engineers (-) (8.7)**
- **Data Analytics Experts (+2) (8.7)**
- Development and Operations (-1) (8.5)
- IoT Testing Engineers (+4) (7.8)
- **IoT Network Engineers (+1) (7.3)**

Across the profiles there was very high consensus in locating both IoT DevOps Engineers and Data Analytics Experts as highly demanded profiles, while IoT Network engineers had the greatest consensus among groups. Regarding profiles categories, across the top 10 in most demand by 2027, the distribution remained similar with the exception of both Development Methodologies and Tools and Security, Protocols and Software Programming having three profiles each[8].

Regarding the lower demand, there following profiles ranked lowest within the coincidental team's scoring:

The top 5 skills profiles in less demand identified across the teams are:

- Embedded Systems Engineers (-6) (3.3)
- IoT Cloud Experts (-) (3.3)
- Frontend Developers (-) (4.0)
- Data Scientists (-6) (4.3)
- Machine Learning Operations (-) (5.0)

Except for Embedded System Engineers that had a distribution between teams of 1.5 there was reduced consensus regarding the remaining four profiles (that presented between 3.2 and 4.2 variation). Therefore, Embedded System Engineers are expected to experiment an abrupt change in demand in the coming 5 years. Regarding Profiles categories, across the top 10 in least demand by 2027, Business and Management has three profiles followed by Analytics and Devices and Smart Objects with two each.[9]

Demand in 10 years

The top 5 skills profiles in high demand by 2032 identified across the teams are:

- **Data Analytics Experts (+1) 8.7**

[8] *For full list see Annex 2*

[9] Ibid

- Development and Operations (+1) 8.5
- IoT Network Engineers (+2) 8.3
- IoT Testing Engineers (-) 8.3
- IoT DevOps Engineers (-4) 8.0

Across the profiles there was unanimous consensus in locating both Data Analytics Experts as highly demanded profiles. Development and Operations, IoT Network Engineers, IoT Testing Engineers and IoT DevOps Engineers followed the rank with similar levels of consensus[10].

The top 5 skills profiles in least demand within 10 years identified across the teams are:

- **IoT Cloud Experts (+1) (1.7)**
- Embedded Systems Engineers (-1) (2.3)
- Frontend Developers (-) (4.0)
- **IoT Product Managers (+6) (4.5)**
- Machine Learning Operations (-) (5.3)

IoT Cloud Experts are identified as the least in demand profile in 2032, while IoT Product Managers had the least dispersion making it the profile in which most agreed about its future lack of demand Regarding Profiles categories, across the top 10 in most demand by 2027, the distribution remained similar with the lowest ranking profiles by 2027, presenting an overall disperse Profile Group's dispersion.

3.2.2 Future demand changes

From out of the top five demanded profiles throughout the 10 years' span, three remain in the top five. These are **Data Analytics Experts, Developers and Operators as well as IoT Developing Engineers.** The continuity of these profiles throughout time positions them as the key targeted profiles according to the expert's work. Along the same line, IoT Network Engineers and IoT Testing Engineers demand is expected to increase during the 2027-2032 period, locating such profile as those in future top demand.

On the contrary, **IoT Cloud Experts as well as Frontend Developers** are the two profiles which were consistently position within the least demanded rankings. While Embedded Systems Engineers and Machine Learning Operations appear to become less significant between the 2027-2032 period.

When identifying **Data Analytics,** as consistently in demand throughout time, teams emphasised their role in designing the models that will integrate the interacting parts when transitioning from the cloud to the edge continuum.

As another consequence of the transition, a common and consistent consensus emerged in identifying **IoT Cloud Experts** as those whose demand will fall more abruptly during the next years the due to the migration from cloud to edge computing. This provides valuable insights to why such change in the demand is expected to take place.

While in the year 2022 all top the Profiles that scored the highest vale were within the high demand band, by the year 2032 that selection already presents most profiles that were mapped as in medium demand. From an overall tendency point of view the high demand for certain profiles is expected to diminish throughout time. Nonetheless there is an expect increase in demand in the medium term.

[10] *For full list see Annex 2*

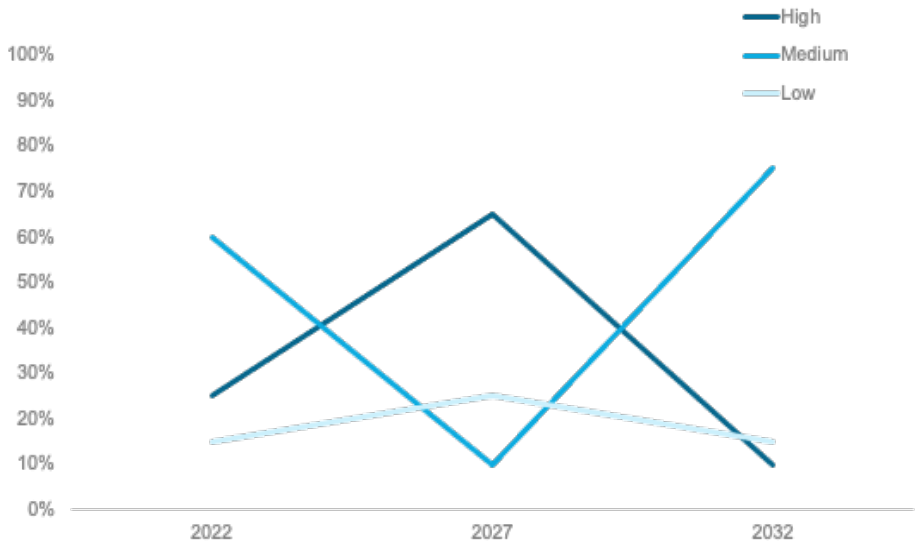


Figure 2. Expected demand bands throughout time

This could be interpreted as that after the highly demanded next years to come the gap between demand and supply will be shortened throughout the years as the significance of medium and low demanded profiles increases throughout the five- and 10-year period (both when considering all observations as well as when considering the frequency). A plausible explanation is that the ecosystem is expected by the expert groups to shorten the gap between the current supply and demand and the future demand and supply.

3.2.3 Presentation of new profiles

From a more qualitative point of view, there were interesting insights when taking into consideration the specific team's justification for introducing new profiles that were presented previously: Digital Twins Experts, HTML Requirements Expert, Semantic Engineering, Chief Data Officer, User-centric Capacity Builder, IoT Architect and Policy Recommendation (IoT). Regarding the newly mapped profiles, there were coincidences in identifying profiles that should have broader more systemic views of the IoT ecosystem needed in the next 5 to 10 years.

The role for a Chief User-Centric Capacity Builder and IoT Architect as two profiles that will be needed in the next 5 to 10 years due to their more holistic approach to the IoT environment. When referring to IoT Architect there was an emphasis on the capacity to have an overall understanding of the project. The introduction of "Semantic Engineering" with an emphasis on ensuring the correct communication and interaction within working parts was observed as a fundamental need to ensure the proper interaction and communication of the different actors within the IoT environment; stressing again the more integral approach that will be needed in the near future.

3.3 Priority skills roadmaps

During the second exercise, the same teams had to indicate three in-demand profiles and had to identify the path to acquire the necessary skills by picking the ideal methods to do so. Throughout this task not only the required skills were on the spotlight but the ideal methodology for the acquisition of such skills. The methodology included Education (Secondary, Tertiary and Post-graduate), Training (Online, Face-to-face and Blended) and On the Job (Self-led learning, Learn by doing, Guided/mentored) as shown on Table 8.

3.3.1 Priority profiles

Out of the ten profiles identified by the working teams, one coincided to be the most important currently: Data Scientist. It was followed by DevOps Machine Learning, Digital Twins Expert, IoT Architect, User Centric Capacity Builder, IoT Testing Engineers, Cybersecurity Engineer, Embedded Systems Engineer and IoT Network Engineer.

Regarding key skills, the most demanded skills were: Artificial Intelligence and Machine Learning, followed by 5G, Bluetooth, Deep Learning, Message Queue Telemetry Transport (MQTT), Programming Skills and Wi-Fi. Conversely, Design Thinking, Human-computer interaction and Doman Knowledge were three skills that emerged from the working groups and consequently presented low frequency[11].

Table 7. Most repeated skills

Skill	Frequency
Artificial Intelligence	4
Machine Learning	4
5G	3
Bluetooth	3
Deep Learning	3
Message Queue Telemetry Transport (MQTT)	3
Programming Skills	3

From the listed profiles, postgraduate education was identified as the most convenient method, followed by tertiary education and training when identifying the path to acquiring such skills. Within the methodology, there were several methods required for specific skills, as it can be seen from Table 9, where, for example, for the DevOps Machine Learning profile both tertiary education and on-the-job learning by doing methodologies were methods identified for a needed skill: Deep Learning. This duplicity of methodologies for a similar skill was repeated among groups and profiles and reflected the groups perspective that for any single skill there was a need to differentiate the skills acquired progressively throughout the person's career.

The need to consider more than one methodology for the same skill was an aspect that was repeated throughout all profile mapping within the different groups.

Finally, vocational education and training (VET) was incorporated as a new, not previously mapped methodology that later repeated consistently throughout the teams as a useful and important method of skills acquisition that will take a stronger role away from education settings like undergraduate and postgraduate. Such aspect, particularly at Secondary Education was identified by some groups as a key methodology to correctly guide the skills acquisition.

Table 8. Most commonly identified method for skills' acquisition

[11] For full frequency table see Annex 3

Method	Frequency
Education | Postgraduate	18
Education | Postgraduate	18
Education | Tertiary	11
Education | Tertiary	11
Education | Secondary	10
Education | Secondary	10
On-the-job| Guided/mentored	9
On-the-job | Learn by doing	6
Education | VET*	5
On-the-job | Self-led learning	5
On-the-job | Guided/mentored	4
Training	4

3.3.2 Summary of skills and methods

Table 9. IoT Skills Profiles and Preferred acquisition method(s)

Data Analytics Expert	
Skills	**Methods**
Artificial Intelligence	Education | Postgraduate
Machine Learning	Training | Blended
	On-the-job | Guided/Mentored
Deep Learning	Training | Blended
	On-the-job | Guided/mentored
Programming Skills	Education | Tertiary

Digital Twins Expert*	
Skills	**Methods**
Risk Assessment	Education | Tertiary
	On-the-job | Guided/mentored
Data Distribution Services	Education | Tertiary
	On-the-job | Guided/mentored
Integrated Development Environments	Training | Blended
Programming Skills	Education | Postgraduate
	Education | Tertiary
IoT Components Network	Education | Postgraduate
Edge Computing	Education | Tertiary

DevOps Machine Learning*	
Skills	**Methods**
Artificial Intelligence	Education | Tertiary
Machine Learning	Training | Blended
	On-the-job | Guided/Mentored
Deep Learning	Education | Tertiary
	On-the-job | Learn by doing
DataOps	Training | Blended
Mobile Computing	Training | Blended
Edge Computing	Training | Blended

Integrated Development Environments	Training | Blended
Cloud Computing	Training | Blended
IoT Architect *	
Skills	**Method**
Wi-Fi	Education | VET*
Bluetooth	Education | VET*
5G	Education | VET*
Artificial Intelligence	Education | Postgraduate
	Training | Online
Machine Learning	Education | Postgraduate
	Training | Online
Risk Assessment	Training | Online
Experience w/building systems	On-the-job | Learn by doing
User-Centric Capacity Builder*	
Skills	**Methods**
Arduino programming	On-the-job | Learn by doing
Design Thinking*	On-the-job| Guided/mentored
Human-Computer Interaction*	Education | Postgraduate
IoT Testing Engineers	
Skills	**Methods**
Actuators	Education | VET*
Sensors	Education | VET*
Pentesting	On-the-job | Guided/mentored
Wireless Sensor Network	Education | Secondary
Programming Skills	Education | Tertiary
Cybersecurity Engineer	
Skills	**Methods**
Bluetooth	Education | Secondary
	Training
	On-the-job | Self-led learning
Wi-Fi	Education | Secondary
	Training
	On-the-job | Self-led learning
5G	Education | Postgraduate
LPWAN	Education | Postgraduate
	On-the-job| Guided/mentored
Ad-Hoc Networks	Education | Postgraduate
	On-the-job| Guided/mentored
Message Queue Telemetry Transport	Education | Postgraduate
	On-the-job| Guided/mentored
IoT Network Engineer*	
Skills	**Method**
Bluetooth	Education | Secondary
	Training
	On-the-job | Self-led learning
Wi-Fi	Education | Secondary
	Training
5G	Education | Postgraduate
LPWAN	Education | Postgraduate
	On-the-job| Guided/mentored
Ad-Hoc Networks	Education | Postgraduate
	On-the-job| Guided/mentored

Message Queue Telemetry Transport	Education | Postgraduate
	On-the-job| Guided/mentored

**Newly incorporated during workshop*

3.4 Main conclusions

Based on the working sessions described and the data analysis produced several conclusions can be drawn from the evidence, particularly the program's previous work is considered.

Changes in type of profiles' demand:

With regards to specific profiles Data Analytics was the profile consistently identified as the most demanded and, as it derives from the analysis, such demand can be partly explained by the need for a greater user-centric capacity builder. Likewise, when pondering the new suggested profiles, and looking into the group's insights for justifying such new profiles, it is plausible to identify future demanded positions as those with a more holistic perspective of the IoT ecosystem, introducing profiles such as that of the IoT Architect. On the other hand, IoT Cloud expert was the profile for which consensus was unanimous when locating it in a low demanded position in the future. The IoT Cloud Expert's loss of relevance is also indicative of the validation of the Expert Group's opinion that the transition from cloud to the edge continuum will define the incoming years. This perspective is consistent with the IoT framework in its perspective of interpreting the IoT transition in such a direction.

Expected changes in demand trends:

There is agreement among the Expert Group that IoT-related skills are currently in high demand. When taking into consideration the profiles on which the experts coincided, all profiles were classified as in high demand. This confirms the general framework in which the IoT project is based that acknowledges a gap between the IoT skills demand and the market's current capacity to supply such demand, reinforcing the need for programmes and whole system approaches to narrow that gap. Moreover, closely related to the existing gap, the data also seems to indicate the agreement among consulted Experts that the gap is expected to increase in the next five years (by a high demand increase) before being closed significantly by 2032. Both when the overall composition of high, medium and low demand profiles is analysed and taking the top and bottom profiles, a progressive increase of medium and low demanded profiles towards 2032 is observed.

Skills and methods

Regarding the current profile mapping as well as the skills mapping, there was an even distribution of skills mapping within all relevant profiles. This can be indicative of the growing need for a complementary and integral perspective on IoT profile formations. Machine Learning, Artificial Intelligence, and Programming Skills, among others, were all identified as equally relevant skills. The lack of hierarchy within the skills distribution speaks of the fact that such are currently in similar levels of demand.

When considering methodologies, it can be concluded that post-graduate education was the most preferred delivery method currently. This reinforces the need for RD&I initiatives like the NGIoT to provide insights and guidance for the design of post-graduate programmes. Along the same line, Vocational Education and Training (VET) can be highlighted as a valuable insight from the workshops that should be considered, according to the Expert's opinion, when designing skills formation programmes. In fact, it has to be highlighted that secondary-level education and VET will be the preferred context for the future acquisition for the majority of the skills presented, implying a need to reform curricula and also talent development and acquisition processes over the coming 5-10 years.

Scope and reach of the workshops

The workshop provides scattered demand mapping evidence for many profiles such as Machine Learning Operators or Cybersecurity Engineers. Such variations can be explained by the diversity

and heterogeneity of the Expert backgrounds and reinforce the need of understanding these working sessions as a methodology to provide insightful qualitative views rather than representative generalizations over a diverse population as that of the experts.

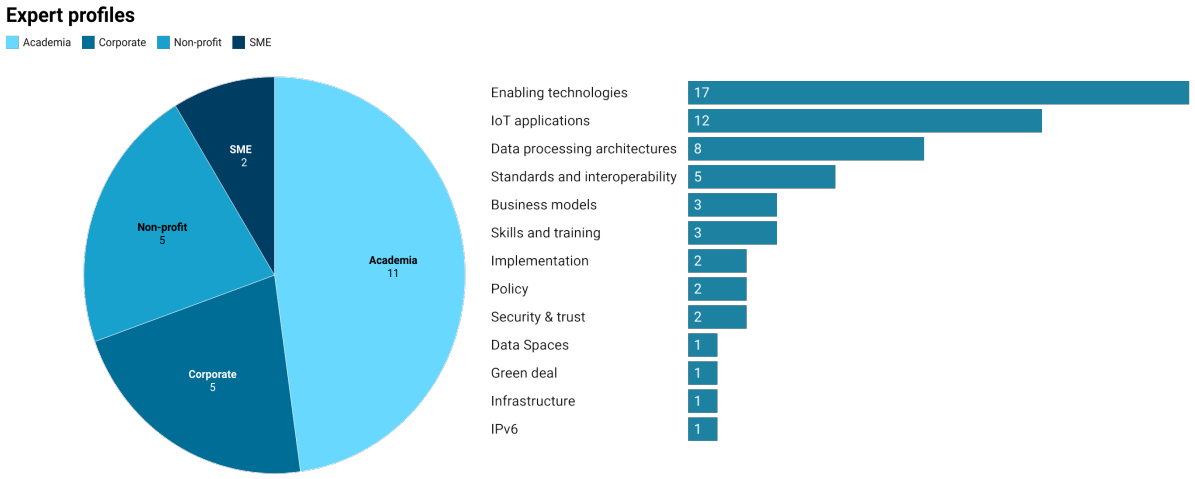
The results and value of the expert session must be read in the broader context of the EU-IoT programme and the insights and plausible explanations for current and future skills profiles needed must be added to the so far built research on that field that the present programme has developed.

4 EU-IoT Expert Group Membership

Membership of the Expert Group currently numbers 24 and has been engaged in a non-static approach with the entry and exit of different members. Analysing the current Expert Group composition, there is strong expertise in the area of enabling NGIoT technologies, IoT applications and data processing architectures. There is also good coverage in terms of standards. More expertise on IoT Skills and Training, Business models and technology implementation is required.

In terms of areas of expertise, the group of experts has vast experience in enabling technologies, IoT applications, data processing architectures and standards and inoperability. These are crucial areas when approaching the IoT environment with the program's objectives. Compared with previous compositions, recent incorporations did not increase the diversity within areas of expertise but did have an impact on the profoundness of possible insights in areas such as Enabling Technologies and Infrastructure[12].

Figure 3. Summary of Expert Group profiles and areas of expertise



The Experts Group currently reflects the NGIoT Community, with an overemphasis on the Research and Innovation. There is room for growth of the representatives from SMEs and large companies that, although proactive and responsive requests, the suitable candidates were not encountered, again reflecting the NGIoT Initiatives stronger links with RD&I.

[12] For full list of experts see Annex 5

ANNEX 1: SUMMARY OF EXPERTS' WORKSHOPS INPUTS

In the figures below, we present inputs collected from the Workshops on: Impact on European Data Act; The IoT skills of the future: An inspection of the profiles in current and future demand and; Key routes for skills supply

Figure 4. Input from workshop: Impact of EDA

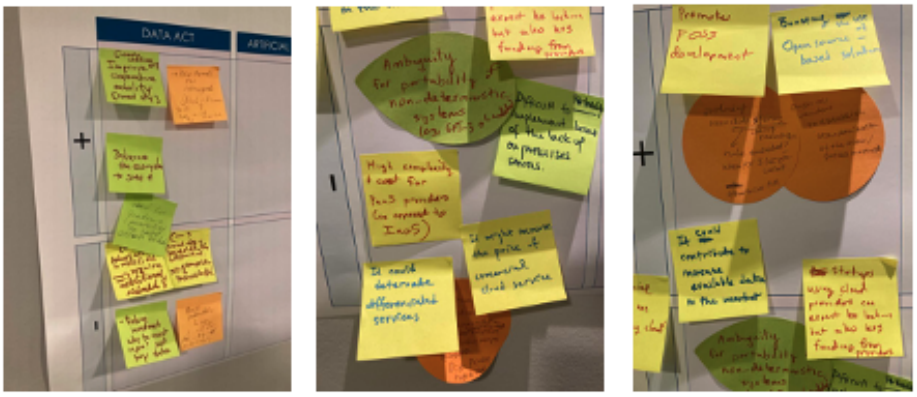
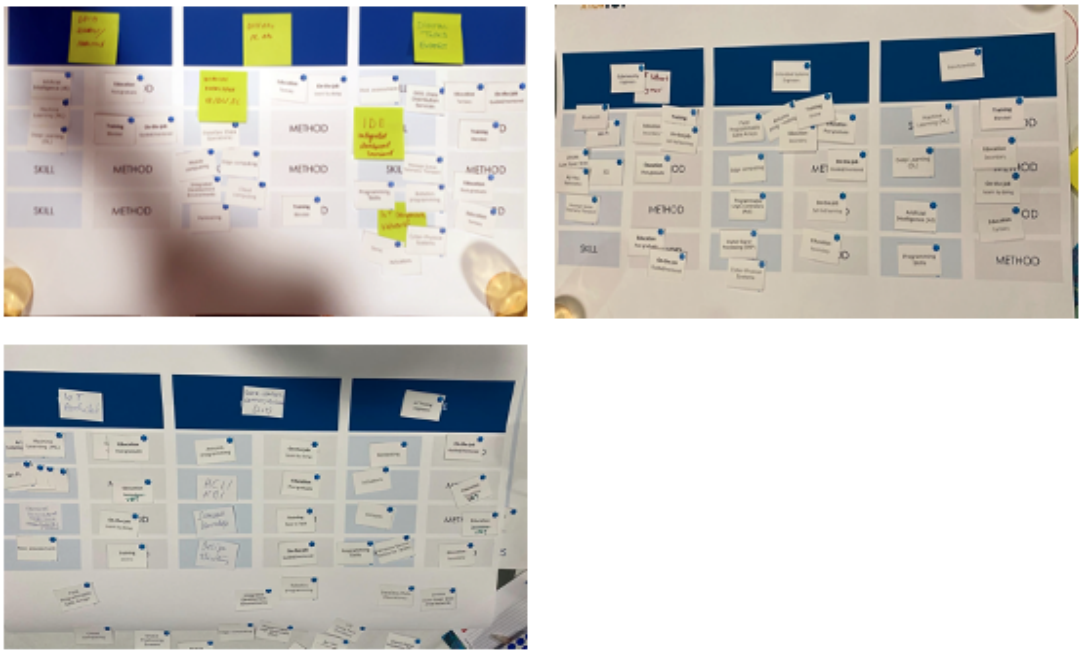


Figure 5. Input from workshop: IoT Skills of the future, inspection of current and future demand mapping

Figure 6. Input from workshop: Key routes for skills supply



ANNEX 2: IOT SKILLS OF THE FUTURE, INSPECTION OF CURRENT AND FUTURE DEMAND SCORING

Table 10. 2022 demand mapping data

2022						
Nr	PG*	Profile	Existing	Avg.	s.d	Band**
1	4	IoT DevOps Engineers	Existing	9.7	0.6	high
2	4	Development and Operations	Existing	9.5	0.7	high
3	6	IoT Product Managers	Existing	9.0	1.4	high
4	5	Data Analytics Experts	Existing	8.3	1.2	high
5	1	IoT Hardware Designers	Existing	7.7	2.5	high
6	2	IoT Network Engineers	Existing	7.3	2.5	medium
7	7	Cybersecurity Engineers	Existing	7.3	2.5	medium
8	4	IoT Testing Engineers	Existing	7.3	4.6	medium
9	2	IoT Backend Developers	Existing	7.0	1.7	medium
10	5	Data Scientists	Existing	7.0	2.8	medium
11	5	Machine Learning Operations	Existing	7.0	4.4	medium
12	1	Embedded Systems Engineers	Existing	6.7	2.9	medium
13	3	IoT Programmers	Existing	6.7	2.9	medium
14	1	Embedded Firmware Developers	Existing	6.3	2.3	medium
15	3	IoT Application Developers	Existing	6.3	2.1	medium
16	3	Automation & Systems Integration Engineers	Existing	6.0	2.0	medium
17	6	IoT Project Managers	Existing	6.0	3.5	medium
18	2	IoT Cloud Experts	Existing	4.0	4.4	low
19	4	Frontend Developers	Existing	4.0	5.2	low
20	6	IoT Business Developers	Existing	3.5	2.1	low
	2	Digital Twins Experts	Added	0.0		
	3	HTML Requirements Expert	Added	6.0		
	5	Semantic Engineering	Added	10.0		
	6	Chief Data Officer	Added	0.0		
	6	User-centric Capacity Builder	Added	0.0		

	6	IoT Architect	Added	8.0		
	7	Policy Recommendation (IoT)	Added	0.0		

**PG: Profile Groups 1=Devices and Smart Objects, 2= Network, Connectivity and Cloud, Edge and Mobile Computing, 3 = Security, Protocols and Software Programming, 4= Development Methodologies and Tools, 5=Analytics,6= Business and Management, 7=Legal and Regulatory*
***Band's range: 2.1*

Table 11. 2027 demand mapping data

2027						
Nr	PG*	Profile	Existing	Avg.	s.d	Band**
1	4	IoT DevOps Engineers	Existing	8.7	1.5	high
2	5	Data Analytics Experts	Existing	8.7	1.2	high
3	4	Development and Operations	Existing	8.5	2.1	high
4	4	IoT Testing Engineers	Existing	7.8	3.8	high
5	2	IoT Network Engineers	Existing	7.3	0.6	high
6	1	IoT Hardware Designers	Existing	7.0	2.6	high
7	7	Cybersecurity Engineers	Existing	7.0	3.6	high
8	3	IoT Application Developers	Existing	7.0	3.0	high
9	3	Automation & Systems Integration Engineers	Existing	7.0	1.0	high
10	2	IoT Backend Developers	Existing	6.7	2.1	high
11	6	IoT Product Managers	Existing	6.7	3.1	high
12	3	IoT Programmers	Existing	6.3	3.2	high
13	6	IoT Business Developers	Existing	6.3	3.2	high
14	6	IoT Project Managers	Existing	5.8	3.6	medium
15	1	Embedded Firmware Developers	Existing	5.7	3.1	medium
16	5	Machine Learning Operations	Existing	5.0	4.2	low
17	5	Data Scientists	Existing	4.3	3.2	low
18	4	Frontend Developers	Existing	4.0	5.2	low
19	1	Embedded Systems Engineers	Existing	3.3	1.5	low
20	2	IoT Cloud Experts	Existing	3.3	3.2	low
	2	Digital Twins Experts	Added	10.0		
	3	HTML Requirements Expert	Added	8.0		
	5	Semantic Engineering	Added	10.0		
	6	Chief Data Officer	Added	10.0		
	6	User-centric Capacity Builder	Added	10.0		
	6	IoT Architect	Added	10.0		
	7	Policy Recommendation (IoT)	Added	10.0		

**PG: Profile Groups 1=Devices and Smart Objects, 2= Network, Connectivity and Cloud, Edge and Mobile Computing, 3 = Security, Protocols and Software Programming, 4= Development Methodologies and Tools, 5=Analytics,6= Business and Management, 7=Legal and Regulatory*
***Band's range: 1.8*

Table 12. 2032 demand mapping data

2032						
Nr	**PG***	**Profile**	**Existing**	**Avg.**	**s.d**	**Band****
1	5	Data Analytics Experts	Existing	8.7	1.5	high
2	4	Development and Operations	Existing	8.5	2.1	high
3	2	IoT Network Engineers	Existing	8.3	2.1	medium
4	4	IoT Testing Engineers	Existing	8.3	2.9	medium
5	4	IoT DevOps Engineers	Existing	8.0	2.6	medium
6	3	Automation & Systems Integration Engineers	Existing	7.3	2.3	medium
7	6	IoT Business Developers	Existing	7.3	2.5	medium
8	7	Cybersecurity Engineers	Existing	6.7	4.9	medium
9	3	IoT Application Developers	Existing	6.7	3.1	medium
10	1	IoT Hardware Designers	Existing	6.3	3.2	medium
11	2	IoT Backend Developers	Existing	6.3	3.2	medium
12	3	IoT Programmers	Existing	6.3	3.2	medium
13	6	IoT Project Managers	Existing	6.3	3.2	medium
14	5	Data Scientists	Existing	6.0	4.6	medium
15	1	Embedded Firmware Developers	Existing	5.3	4.5	medium
16	1	Machine Learning Operations	Existing	5.3	2.9	medium
17	2	IoT Product Managers	Existing	4.5	0.7	medium
18	3	Frontend Developers	Existing	4.0	5.2	low
19	4	Embedded Systems Engineers	Existing	2.3	2.3	low
20	5	IoT Cloud Experts	Existing	1.7	1.2	low
	2	Digital Twins Experts	Added	10.0		
	3	HTML Requirements Expert	Added	9.0		
	5	Semantic Engineering	Added	10.0		
	6	Chief Data Officer	Added	10.0		
	6	User-centric Capacity Builder	Added	10.0		

	6	IoT Architect	Added	10.0		
	7	Policy Recommendation (IoT)	Added	10.0		

**PG: Profile Groups 1=Devices and Smart Objects, 2= Network, Connectivity and Cloud, Edge and Mobile Computing, 3 = Security, Protocols and Software Programming, 4= Development Methodologies and Tools, 5=Analytics,6= Business and Management, 7=Legal and Regulatory*
***Band's range: 2.3*

ANNEX 3 – FREQUENCY OF IDENTIFIED SKILLS DURING EXERCISE ON ROUTE TO SKILLS ACQUISITION

Table 13. Frequency of skills mentioned within profiles

Skill	Frequency
Artificial Intelligence	4
Machine Learning	4
5G	3
Bluetooth	3
Deep Learning	3
Message Queue Telemetry Transport	3
Programming Skills	3
Wi-Fi	3
Ad-Hoc Networks	2
Arduino programming	2
Cyber-Physical Systems	2
Edge Computing	2
Integrated Development Environments	2
LPWAN	2
Pentesting	2
Risk Assessment	2
Actuators	1
Cloud Computing	1
Data Distribution Services	1
DataOps	1
Design Thinking	1
Digital Signal Processing	1
Experience w/building systems	1
Field Programmable Gate Arrays	1
IoT Components Network	1
Mobile Computing	1
Programmable Logic Controllers	1
Robotics programming	1
Sensors	1
Wireless Sensor Network	1

ANNEX 4 - CURRENT EXPERT GROUP MEMBERS

The group of experts is currently a source of consultation for the EU-IoT project. Their presence in the following section does not imply their explicit participation in the workshops mentioned nor their agreement on the content presented on the current publication.

As of October 2022, the EU-IoT Expert Group is composed of the following members:

Table 14. Expert Group membership October 2022

Name	Affiliation	Role	Area(s) of expertise	Sector
Joao Ferreira	Instituto Universitario de Lisboa	Assistant Professor with Aggregation; head of IoT Lab	Security and trust Standards and interoperability IoT applications Enabling technologies Skills and training	Academia
Rui A. Costa	Ubiwhere	CEO	IoT applications Green deal	Corporate
Eiko Yoneki	University of Cambridge	Head of Data Centric Systems Group	Data processing architectures Enabling technologies	Academia
Rob Van Kranenburg	IoT Council	Director	IoT applications	Non-profit
Matthias Wählisch	Freie Universität Berlin	Head of Internet Technologies Research Group	IoT applications Enabling technologies Standards and interoperability Implementation	Academia
Latif Ladid	IPv6 Forum	Founder and President	Standards and interoperability IPv6	Non-profit
Jörg Ott	Technische Universität München	Chair of Connected Mobility	IoT applications Enabling technologies Data processing architectures Skills and training	Academia
Joerg Widmer	IMDEA Networks Institute	Research Professor and Research Director	Enabling technologies Implementation	Academia
Alexander Wilner	CISS TDI GmbH	Managing Director	Standards and interoperability	SME
Matthias	Huawei Technologies Duesseldorf GmbH	Principal Researcher	IoT applications Enabling technologies Standards and interoperability	Corporate

Xiaoming Fu	Georg-August-Universität	Professor and Head of Computer Networks Group	IoT applications Data processing architectures Enabling technologies Skills and training	Academia
Georgios Karamanolis	Hellenic Blockchain Hub	Chairman of Hellenic Blockchain Hub	Enabling technologies IoT applications	SME
Ioannis Psaras	University College London	University Lecturer and EPSRC Fellow	Data processing architectures Enabling technologies	Academia
Luca Bolognini	Istituto Italiano per la Privacy	President	Policy Security and trust	Academia
Wael Elrifai	Hitachi Vantara	Global VP of Solution	Enabling technologies IoT applications Business models	Corporate
Christian Winkler	Siemens AG	Senior Principal Expert IoT, Corporate Technology	IoT applications Enabling technologies Data processing architectures Business models	Corporate
Tiziana Ferrari	EGI Foundation	Director	Enabling technologies Data processing architectures	Non-profit
Michael Boniface	University of Southampton	Professorial Fellow of Information Systems, Head of the IT Innovation Centre	Data processing architectures Enabling technologies Policy	Academia
Charles Sheridan	Google Cloud	EMEA Technical Director for Industrial IoT, Google Cloud	Data processing architectures IoT applications Enabling Technologies Business models	Corporate
Natalie Samovich	Enercoutim	Head of RandI	Data Spaces Infrastructure	Non-profit
Asunción Santamaria	CeDInt-UPM	Director	Infrastructure Enabling technologies	Academia
Johann Marquez-Barja	University of Antwerp	Professor	Enabling technologies IoT applications	Academia
Eunsook Eunah Kim	UDG Alliance	Head Of Research and Development	IoT applications Enabling Technologies	Non-profit