SMA CITE

Enhancing skills for smart city tech

SMACITE

Boosting the technical and non-technical skills and competences of smart cities technicians and engineers

WP2: Smart Cities competences map and curriculum

D2.1: Smart Cities competences map and emerging job profiles

Version 1.2

DELIVERABLE FACTSHEET

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1.1	Dr. Luis Fernandez-Sanz, Inés López-Baldominos and Vera Pospelova (UAH)	UAH	13/09/2022	Final version implementing suggested changes of internal Project reviewers: Vasileios Gkamas (U.Patras) and Pavel Varbanov (ESCI CEE)
1.2	Vera Pospelova (UAH)	UAH	07/12/2023	Removed personal information of the interviewed experts

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PROJECT SUMMARY

The project aims to address the skills gap of Smart Cities technicians and engineers, by designing and testing a vocational education and training program that is based on a novel and multi-disciplinary curriculum combining digital skills on Smart Cities enabling technologies, with soft, entrepreneurship and green skills.

The expected project outputs are:

- A Smart Cities competences map and ESCO-compliant Smart Cities role profiles.
- A Smart Cities curriculum combining both technical and non-technical skills and competences and promoting personalized learning pathways.
- Learning resources for Smart Cities enabling technologies and for building the soft, entrepreneurship and green skills of Smart Cities technicians and Engineers.
- A diagnostic tool to identify personalized learning pathways.
- A MOOC for Smart Cities enabling technologies.
- Virtual Worlds for building the soft, green and entrepreneurship skills of Smart Cities technicians and engineers.

The main project beneficiaries are Smart Cities technician and engineers either from the public sector (i.e. municipalities) or from enterprises providing Smart Cities solutions, as well as HEI and VET students interested in Smart Cities.

The curriculum will be tested through four national pilots in Greece, Bulgaria, Spain and Italy with at least 160 trainees. The certification of the skills and competences will follow a two-fold approach: (a) using micro-credentials to recognize the knowledge and skills gained through the successful completion of each online training module at the MOOC and Virtual Worlds and (b) designing the "Smart Cities Specialization Certification" that will be awarded to those passing online certifications exams with e-proctoring after the completion of the training modules.

The project will create an ecosystem for the co-design and co-development of an innovative curriculum and technology-enhanced learning tools for the upskilling/reskilling of Smart Cities technicians and engineers.

1 Introduction

WP2 aims to set the methodological framework for the upskilling and reskilling of Smart Cities technicians and engineers. As a first step towards the achievement of this objective, Smart Cities emerging job profiles will be defined. This goal is allocated to task T2.1 "Design the Smart Cities competences map and emerging job profiles".

The aim of T2.1 is to design the "Smart Cities Technician" and "Smart Cities Engineer" emerging job profiles in accordance with ESCO classification. Although the word "job" is present in the SMACITE project proposal, it is important to better adjust the terminology at the beginning of this work. According to the ESCO classification, "An occupation is a grouping of jobs involving similar tasks and which require a similar skills set. Occupations should not be confused with jobs or job titles. While a job is bound to a specific work context and executed by one person, occupations group jobs by common characteristics". Therefore, in principle, the real interest of this task should be oriented to occupation profiles. However, the work in projects and technology, especially flexible and constantly evolving in recently emerged areas such as Smart Cities, does not fit to rigid schemes of activities: one professional needs to play several roles during a project or during different processes (sometimes managing, other times developing solutions, etc.). **So, we consider more adjusted to reality to talk of professional role profiles instead of job profiles**. This terminology will be more helpful for subsequent phases of the project such as the development of training curricula.

The SMACITE project proposal mentions as main goal "Boosting the technical and non-technical skills and competences of smart cities technicians and engineers", being later more concrete in aspects to be considered: "...for building the soft, entrepreneurship and green skills of Smart Cities technicians and Engineers".

Activities planned for task 2.1 are the following:

1. Preliminary research, with the objective of analyzing the state of the art and the current approach to smart city profiles and defining the project's approach for further steps.
2. Desk research, including a deep study by UAH of ESCO, e-CF, and needs in smart cities followed by research carried on by the rest of partners of relevant references to identify important skills of the smart cities' profiles.
3. Field research, survey to reach stakeholders and confirm the appropriateness of the competences, functions, knowledge, and skills extracted from the desk research
4. Smart Cities Engineer and Technician profiles development. Based on the results that came out from previous steps two profiles are developed aligned to ESCO and e-CF, one for Smart City Engineer and another for Smart City technician.
5. Expert interview, with the aim of obtaining qualitative feedback and assistance in interpreting the data and results derived from the desk research and the

stakeholder survey. Experts are also asked to confirm whether the profiles are appropriate and relevant in terms of their experience in Smart Cities.

The main partners participating in this task are UAH (Spain), as leader of WP2, DIGITAL SME (Belgium), BASSCOM (Bulgaria), GAIA (Spain) and CADM (Spain).

2 Preliminary research

The activity around the concept of Smart Cities is very multidisciplinary and open to very different approaches. Therefore, the interpretation of the roles and responsibilities demanded to those role profiles could be varied and sometimes even controversial depending on the approach adopted. The activity of an (ICT) engineer to develop a capacity of being smart to a city setting may depend on the context. For example, if the infrastructure, buildings and urbanism are already developed and defined, probably it mainly requires specific interventions to add "intelligence" with digital mechanisms with minor work in construction and physical layout. Other possibility could be creating from scratch an urban smart environment with development of a new area; the role of construction work would be much bigger.

Due to the abovementioned challenges, the design and structuring educational programs and curricula that pretend to prepare professionals for entering the employment market, require constant adjustment to the requirements of the strategic projects, at least at governmental level. Nevertheless, generic modules as *introduction into the smart city concepts, sustainable economy, security and privacy implications in data science and network communications, digitization and automation of public services etc.* could be considered as compulsory part of those programs. In the next section, the modules in several BSc and MSc programs are reviewed.

2.1 Reference study programs

This section shows the result of a first preliminary analysis of the most relevant HE programs, in terms of similarity of concepts, applicable to the idea of training "Smart Cities Technicians and Engineers". From the results shown, we have selected the most specific program with wide range of topics as main indications and then some others to complete the analysis.

MSc Engineers for Smart Cities

- URL: https://mscsmartcities.imredd.fr/
- University: Université Côte d'Azur (France) 1 year 60 ECTS
- The learning modules include:
    - Smart and Sustainable City: identifying economic, social, cultural and environmental challenges of modern cities, proposing multi-disciplinary solutions for smart and sustainable cities.
    - Urban Design and Sustainability: understand the role of urban design in urban sustainability and resilience policies, analyze urban form in cities and existing urban projects, and understand the planning process behind the production of urban form.
    - Business Challenges in Smart Cities: describe and design business models, conceive and adapt a business model to complex products, services and environments, reinterpret smart cities strategy through

the lens of Business Models, multidisciplinary competences related to the management of territorial projects in complex ecosystems, etc.
- Connected City: Data Sensing and Transmission, Data Networking, Smart Sensors and Energy, etc.
- Smart Energy: Organization of the energy market: regulated and deregulated activities and players, new energy technologies for the 21st century: outcomes and trends, smart metering, efficient energy, growing new needs, In home / beyond meter energy solutions: smart and efficient homes, IoT solutions, auto-production & auto-consumption, etc.
- Smart Mobility: Identify major issues in mobility and transport systems, Conceive smart mobility models, assessing future evolution of transport systems, etc.
- Data and A.I. for Smart Cities: identify the potential of AI for decision support, design Smart Cities data analysis models, improve AI innovations for the benefit of users

Other programs for Smart Cities

Postgraduate Degree in Smart Cities
- URL: https://www.salleurl.edu/es/estudios/postgrado-en-smart-cities
- University: Ramon Llull University (Spain) own degree, 5 months
- Management of ICT infrastructures, energy and transportation systems
- Energy Sustainability and the Smart Grid Environment
- Internet of Things, Connectivity and Security
- Monitoring, Control and Data Management Systems in the City
- Sustainable Mobility
- Smart City Ecosystem

Master's in Global Smart City Management
- URL: https://www.e-zigurat.com/en/smart-cities-masters-program/
- Universidad: Zigurat + Universitat de Barcelona
- M1. The new urban agenda.
- M2. Financing and funding the smart city.
- M3. Citizens, data and decision-making.
- M4. Connectivity and networks.
- M5. Efficient, secure and rights-friendly digital management.
- M6. Humans vs Machines: myths, realities and future developments.
- M7. Built environment and Mobility.
- M8. Sustainability in the smart city.
- M9. Resilience and external influences.

Smart Cities and Urban Informatics

- URL: https://smartcities.huji.ac.il/
- Universidad: The Hebrew University of Jerusalem 36 ECTS

- GIS and Urban Informatics
- Urban Remote Sensing
- Urban Planning: From Modernism to Urbanism and Smart Growth
- Smart Cities: Reality in the Making
- Spatial Justice and Smart Cities
- Transitioning to Smart City Growth: Jerusalem: between Tradition and Innovation
- METHODS AND TOOLS: Python Programing, Urban Digital Data and Analytics, Urban Simulation
- THEMATIC COURSES:
- The Technological Infrastructure of the City, Smart Transportation, Smart Cities and Sustainable Mobility, Technologies for Managing the Smart City, Urban Energy and Smart City Growth

2.2 ESCO Occupations and skills

ESCO (https://esco.ec.europa.eu/) is the European classification of skills and occupations [1]. The aim of ESCO is to support job mobility across Europe and therefore a more integrated and efficient labor market, by offering a "common language" on occupations and skills that can be used by different stakeholders on employment and education and training topics. It provides descriptions for 2.942 occupations and 13.485 skills linked to these occupations and has been translated into 27 languages (all official EU languages plus Icelandic, Norwegian and Arabic). ESCO groups occupations into ISCO-08 code groups with four digits on ISCO code for the narrowest group of occupations, classifying the different occupational profiles and showing the relationships between occupations, skills, competences, and qualifications. ESCO structures its pillars hierarchically and inter-related with each other. It is also linked to other relevant international classifications, standards and frameworks, such as The Statistical classification of economic activities in the European Community (NACE), the International Standard Classification of Occupations (ISCO) and European Qualification Framework (EQF). According to implementation acts, the use of ESCO is compulsory for all Member States of EU from 2021 onwards. These are the reasons that motivate us to use ESCO as a reference for our project and the profiles of engineers and technicians in smart cities.

This section shows a first approach to the most similar existing occupations in ESCO connected to the idea of profiles "Smart Cities Technician" and "Smart Cities Engineer" with an ICT orientation. There are four identified occupations - urban planner, mobility services manager, smart home engineer and smart home installer-which have common points with the desired profiles. Obviously, they are not what the task needs to create but it is good to have closest reference already existing in ESCO. We have also collected six skills and knowledge close to the field of smart systems and cities. The results of this preliminary analysis are shown hereafter.

Urban planner

Urban planners create development plans for towns, urban areas, cities, and regions. They research the needs of the community or the region (economic, social, transport) and evaluate other parameters such as sustainability in order to present solid programs aimed at the improvement of the site.

- Alternative labels: smart city planner, urban planning engineer
- Concept Uri: http://data.europa.eu/esco/occupation/e14548c8-c2b9-4ef8-8670-d5967d7ad804

Mobility services manager

Development and implementation of programs that promote sustainable and interconnected mobility options, reduce mobility costs and meet the transportation needs of customers, employees and the community as a whole such as bike sharing, e-scooter sharing, car sharing and ride hailing and parking management. They establish and manage partnerships with sustainable transport providers and ICT companies and develop business models in order to influence the demand of the market and promote the concept of mobility as a service in urban areas.

- Alternative labels: smart city planner, mobility manager
- Concept Uri: http://data.europa.eu/esco/occupation/3b129d8d-268e-465a-b0c5-bf32cae59a41

Smart home engineer

Responsible for the design, integration and acceptance testing of home automation systems (heating, ventilation and air conditioning (HVAC), lighting, solar shading, irrigation, security, safety, etc.), which integrate connected devices and smart appliances within residential facilities. They work with key stakeholders to ensure the desired project outcome is achieved including wire design, layout, appearance and component programming.

- Concept Uri: http://data.europa.eu/esco/occupation/716df735-77eb-47c8-8c06-d86e46903989

Smart home installer

Install and maintain home automation systems (heating, ventilation and air conditioning (HVAC), lighting, solar shading, irrigation, security, safety, etc.), connected devices, and smart appliances at customer sites. In addition, they serve as a customer educator and resource for product and service recommendations that meet the customers' needs for home comfort, convenience, security and safety.

- Concept Uri: http://data.europa.eu/esco/occupation/15a7e87c-f7d5-4a60-bab7-9636b76143fe

Below are presented relevant knowledge and skills for Smart Cities profiles identified in ESCO.

Smart city features

Skill Type: KNOWLEDGE

The use of big data technologies in the context of smart cities in order to develop novel software ecosystems upon which advanced mobility functionalities can be created.

- Broader concepts: information and communication technologies not elsewhere classified
- Essential for: mobility services manager
- Optional for: autonomous driving specialist, urban planner
- Concept Uri: http://data.europa.eu/esco/skill/d5bcc417-a004-4165-b7f1-ab739eadd2f4

Smart grids systems

Skill Type: KNOWLEDGE

Smart grids are a digital electricity network. The system involves the electronic digital control of production, distribution and use of electricity, information management of the components and energy saving.

- Broader concepts: electricity and energy
- Essential for: smart home engineer, smart home installer, etc.
- Concept Uri: http://data.europa.eu/esco/skill/79a5bc25-5b59-47bc-a4c2-fb8e8cb1ddf6

Advise customers on smart homes technology

Skill Type: SKILL

Give advice to customers on the possibilities of installation of smart home technologies, given the requisites and the preconditions of the structure

- Broader concepts: advising on products and services
- Essential for: smart home installer
- Concept Uri: http://data.europa.eu/esco/skill/32f20d0e-d127-4901-a971-a53e26dfef14

Internet of Things

Skill type: KNOWLEDGE

The general principles, categories, requirements, limitations and vulnerabilities of smart connected devices (most of them with intended internet connectivity).

- Broader concepts: computer use
- Essential for: smart home engineer, smart home installer, etc.
- Concept Uri: http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51

Install smart devices

Skill Type: SKILL

Install connected devices, such as thermostats, indoor environmental quality sensors, movement detection sensors, electronic thermostatic radiator valves, light bulbs, light switches, relay switches for building services auxiliary, plugs, energy meters, window and door contact sensors, flooding sensors, EC motors for solar shading and automatic doors, smoke and CO sensors, cameras, door locks, doorbells and lifestyle devices. Connect these devices to domotics system and to the relevant sensors.

- Broader concepts: installing and assembling building fixtures
- Essential for: smart home installer
- Concept Uri: http://data.europa.eu/esco/skill/2f7b5fa1-5fa5-4bfc-b9c8-c0cef15b8b60

Implement route planning in smart mobility services
Skill Type: SKILL

Use specialized search engines such as route planners or journey planners to suggest optimized travel itineraries based of different criteria such as means of transport, departure and arrival time, location, duration of the journey.

- Broader concepts: using digital tools for collaboration and productivity
- Optional for: transport planner, mobility services manager
- Concept Uri: http://data.europa.eu/esco/skill/0a856d55-23b5-4bdc-ad24-3eb5bc83d81f

2.3 Profiles in Smart Devops project

This is an Erasmus+ KA2, Sector Skills Alliances, from 2019 to 2021 (https://smartdevops.eu/) aimed at addressing "the shortage of digital and transferrable skills in the municipalities' smart cities sector and will support this sector's employees in their professional development". It focused on the application of DevOps in the context of Smart Cities IT projects and management. As a result, the project defined three job profiles [2] :

- Smart City Planner. A smart city planner can be defined as a high-level official who is able to bridge the needs that arise from the traditional development and operational needs of cities and the strategic priorities of the city's political leadership. An SC planner will have overall knowledge of the city's strategic objectives. He/she shall be aware of the smart cities' trends and best practices in order to set up the city's strategy and strategic plan for the implementation of the city's vision. The profile of an SC Planner will combine different skills from different disciplines and backgrounds (e.g., strategic, management, communication, technological, legal).
- Smart City IT Manager. A smart city IT manager can be defined as an ICT consultant with responsibilities that include:
  - setting objectives and strategies for the IT department of the municipalities

- deciding and implementing suitable technological solutions to support all internal operations and optimize their strategic benefits,
- designing and customizing the IT systems, frameworks and platforms to improve citizen experience,
- planning the implementation of new IT systems and provide systematic guidance to IT professionals and other staff within the organization,
- Making procurement decisions for technological equipment and software as well as establishing partnerships with IT providers.
- Managing the technological infrastructure (e.g., networks and computer systems) of the smart city to ensure their performance
- Managing IT-related projects. A smart city IT manager should have a strong IT background to stay consistently updated with recent advancements in technologies at the SC subject area.

Transversal skills such as leadership, communication and team working skills and should be able to align the smart cities' strategic objectives with IT development, deployment and operation strategy so that IT services maximize the value offered to citizens.

- **Smart City IT officer**. An IT technical expert who should be able to analyze the city's organizational data
    - determine information system requirements and define project objectives,
    - apply software development process, development environments, tools, and techniques,
    - make recommendations for necessary IT system components (e.g., hardware, software, and networking systems),
    - design, implement, and deploy new IT services,
    - operate IT systems and services,
    - provide support and training to various types of users.

Transversal skills such as team working, social skills, ability to learn, etc.

2.4 Results

As a result of the research carried out so far, three options are proposed to define the project's approach to smart city profiles. The development of profiles in T2.1 may opt for a holistic approach that includes knowledge and skills in diverse areas. Some of these might be:

- Urban planning with knowledge also in the fields of sociology, GIS (geographic information systems), etc.
- Mobility
- Internet of Things, including sensors, networks (connectivity), cloud, simulation, artificial intelligence and big data
- Efficient buildings
- Energy, including renewables and energy efficiency

- Data processing, including programming
- Legal aspects
- Economic aspects
- Ecosystems/Environment
- Logistics

An option A, could be to define the applicable areas and the depth of the knowledge and skills of each area needed for each profile.

Another option B is an approach similar to the one in Smart DevOps project and keep our focus in IT side and its related knowledge and skills.

It is also possible to opt for an option C where the IT side is only complemented with some additional parts such as the mentioned in proposal: "soft, entrepreneurship and green skills". After a discussion with all the partners involved in the tasks during an online meeting, we set option C as the common approach for the project on further steps. This option included four different areas:

- Smart cities enabling technologies
  - Internet of Things
  - Cybersecurity
  - Cloud computing
  - Data analytics & visualization
  - Machine learning & Big Data
  - 3D printing
  - Blockchain
  - Drones
- Business and management skills
  - Project management
  - Entrepreneurial thinking
  - Business process
  - Design thinking
  - Quality management
- Soft skills
  - Leadership and management
  - Managing through change
  - Teamwork & collaboration
  - Critical thinking
  - Problem solving
  - Emotional intelligence
  - Interpersonal communication
- Green skills
  - Circular economy
  - Energy conservation
  - Waste management

3 Desk research

Once defined the project's approach and the scope of Smart City Profiles, the next activity to perform is desk research to identify relevant skills of the smart cities' profiles in ESCO, e-CF and other relevant references in the field. This provided a more precise and solid basis for our work in developing the profiles.

3.1 Occupations, skills and knowledge according to ESCO and e-CF

3.1.1 ESCO

Using ESCO Portal (https://esco.ec.europa.eu/), we analyzed the most similar occupations among more than three thousand that this classification has. The work was done by a focus expert group with experts from different partners led by Dr. Luis Fernández, from Universidad de Alcalá (partner leading this WP2), who was one of the few experts hired by European Commission to develop the ESCO classification for the sector of ICT services.

After careful and extensive analysis of information thanks to a local replica of the database of ESCO where we exploited the capacity of detecting terms like the ones involved in Smart Cities projects, we selected 15 occupations and its correspondent functions. These occupations cover all the areas proposed in the previous stage.

We extracted functions presented as part of occupations' descriptions and then determine whether each function (and its corresponding occupation) links to a technician or engineer profile. This collection of functions, classified into relevant for Smart Cities Engineer and relevant for Smart Cities Technician, also allowed us to identify essential and optional skills and knowledge for our profiles. In the following table, we show the 15 ESCO occupations most relevant for our project and Smart City profiles.

Relevant ESCO Occupations
Smart home engineer
Smart home installer
Civil engineer
Civil engineering technician
Cloud engineer
ICT security engineer
ICT security technician
Data analyst
Data scientist
3D modeler

3D printing technician
Blockchain architect
Blockchain developer
Project Manager
ICT Project manager

Table 1: Occupations in ESCO relevant for Smart Cities profiles

ESCO also provides for each occupation a set of essential and optional knowledge and skills, apart from the description of typical functions developed in each one. After determining which functions were appropriate for the technician and which ones for the engineer, we went through the same process with the knowledge and skill sets, according to the adopted approach for this task (see section 2.4). This was not a strict binary procedure of allocation to profiles as there are knowledge and/or skills that may link to technicians and to engineers. We analyzed a total of 89 knowledge and skills. Of course, it is always possible to consider many more aspects, skills, knowledge, competences, etc. as part of the study, even if they are loosely linked to the definition of our target profiles. However, we have focused on those that are most relevant and especially illustrative for the profiles and the vision of the SMACITE project, without pretending an exhaustive and thorough listing of all possible items, only the most illustrative ones. We also want to avoid unrealistic wishing lists of requirements for profiles, possibly only present in superheroes.

3.1.2 e-CF (standard EN16234:2019)

Linking the profiles of SMACITE to the standard EN16234:2019 [3], also known as e-CF, is something stated in the proposal of the project and it is well connected to the reality of job profiles in the EU: it is the specific standard for e-competences of IT professionals. The nature of e-CF is different from the one of ESCO:

- The normative part of EN16234 is focused on the description of the 41 e-competences in terms of the main functions and activities developed in each one
- It also includes descriptions of levels of proficiency and examples of skills and knowledge items, but they are only illustrative.

EN16234 includes an annex with a set of 30 examples of description of professional roles using its e-competences. However, there is none with a reasonable degree of similarity in functions or responsibilities to the target Smart Cities profiles. Moreover, these descriptions are also mere example, not exhaustive descriptions, as the number of e-competences mention in each of them is limited to five on purpose.

Therefore, the process with e-CF has followed a similar process as the one for ESCO. The work was done by another focus expert group with experts from different partners also led by Dr. Luis Fernández, from Universidad de Alcalá (partner leading this WP2), who was one of the few experts hired by CEN/CENELEC to develop the last version of EN16234, its user guide and the technical specification for metrics and indicators for e-competences.

The analysis focused on the functions extracted from the analysis of ESCO with similar occupations (see Section 3.1.1) and the rest of preliminary research (see Section 2). The final approach with e-CF was the mapping of the resulting set of functions from both sources to the most linked e-competences and proficiency levels in the standard resulting in nine e-competences (B.6, E.2, A.6., B.4, E.8, D.7, B.3, B.1 and C.1) and different levels ranging from level 1 to 4. There are a small number of functions which need to be linked to two e-competences to ensure good representation of activities. As the work with e-CF is not easy for those not previously used to, the reference to e-CF e-competences for the functions in subsequent phases (e.g., online survey) will be hidden: the connection to e-CF for the final descriptions of target profiles will be indirectly established through this mapping of functions of profiles to the e-competences.

Similarly to what we stated for ESCO (see Section 3.1.1), the aim of our representation of profiles with e-CF is also guided by the principles of pursuing illustrative descriptions, not exhaustive, and avoiding over demand of requirements for these professional profiles.

3.1.3 Soft skills

It is important to highlight that neither ESCO nor e-CF include explicit soft skills or non-cognitive skills (NCS) for occupations but they are crucial in the success of educational performance, employability, income and professional development or career [4].

Although ESCO and e-CF consider NCS in a way or another, they do not offer a specific framework structure by themselves. So, we will use the NCS framework (NCSF) from the Skills Match project [5], which maps skills to the ESCO Classification and was developed after an exhaustive analysis of sources on NCS.

Skills Match was a project funded by European Commission (DG CONNECT) which developed and demonstrated a European-wide assessment, learning, and guiding platform to help users to adapt their NCS to the demands of the labor market. The project expanded the experience of the previous project e-Skills Match which work with different competences standards and models for ICT occupations [6]. The Skills Match project created a comprehensive and solid NCSF as the basis for its work [5]. The team analyzed information from academic literature, reviewing 66 models and 403 publications with 2928 mentions to skills as well as 527 European Projects and other NCS existing frameworks. Skills Match uses ESCO as main reference and its 36 NCS of NCSF are mapped to ESCO skills generating 3138 connections at different levels. More than 700 buzzwords associated to each of the 36 NCS complement the description and help to identify mentions to NCS in other models and references. The visualization of the framework shows seven clusters for its 36 NCS, which group those ones most related among them (see Figure 1).

Figure 1. Non-Cognitive Skills Framework

3.2 Additional references

In parallel to ESCO and e-CF analysis, partners reviewed how the areas proposed in Option C could be relevant according to other variety of sources such as educational programs, other projects and white papers and reports.

According to each reference found, partners indicated which skills (of the ones defined previously) should be included in the profiles for Smart City Engineer and Smart City Technician in each category. We ranked its relevance according to the following scale: 0 not applicable; 1 collateral; 2 relevant; 3 essential; it was also possible to provide a neutral answer NS not sure.

For this particular activity, the following references were analyzed:

Bachelor programs in Software Engineering and in Informatics
- Reference type: Bachelor degree
- Webpage (URL): http://fmi-plovdiv.org/index.jsp?id=2572&ln=1; http://fmi-plovdiv.org/index.jsp?id=1750&ln=1 ; http://fmi-plovdiv.org/index.jsp?ln=1&id=342
- Country: Bulgaria
- Company or institution: University of Plovdiv, Paisii Hilendarski, Faculty of Mathematics and Informatics

With the continued growth of cities and pressure on the environment, the need for smarter and greener cities has never been stronger. Infrastructure provision, management, and finance face new challenges: cities are highly complex and subject to dire problems, traditional solutions negatively influence the environment, technology is evolving, and citizens have conflicting demands. In brief, modern infrastructure solutions must be sustainable, smart, and green. All this necessitates the creation of specialists in the field who know the technologies with which to implement the solutions of the green and smart city.

In the "Informatics" and "Software Engineering" bachelor programs at the Faculty of Mathematics and Informatics of the University of Plovdiv, "Smart Cities" are not specifically studied as a separate program, but subjects that are related to this topic are. "Artificial Intelligence", "Big Data", "Computer Networks and Communications", "Mobile Applications", and "Project Management" are mandatory courses that are an important part of the basic knowledge for application development in the domain of "Smart Cities". Additionally, in the elective courses, students have the possibility to study "Machine Learning and Deep Learning", "Semantic Web and Ontology engineering", "Internet of Things", "Blockchain", "Cloud Technologies", "Cognitive robotic", "Modeling of business processes ", and others.

Project Guidelines for facilitating the learning of Artificial Intelligence (AI) by School Students of Grades 7-12- FACILITATE - AI 2022-2024

- Reference type: EU Project
- Webpage (URL): https://uni-plovdiv.bg; facilitate-ai.eu
- Country: Bulgaria
- Company or institution: University of Plovdiv

The development of models and concepts for various aspects of the creation and operation of smart cities is one of the current topics in research related to the development of context-dependent cyber-physical spaces. This task stems from the trends and vision for the development of society in the period of the Fourth Industrial Revolution and the main directions in the development of the digital society. These services are especially important for people with disabilities, for whom the features of the physical world and their synchronization with the virtual world are of particular importance. For example - movement of people with mobility problems in the city and the need for relevant facilities such as ramps, elevators, escalators, etc.; creating routes in an unpolluted environment for people with respiratory problems; organizing optimized transport schemes, etc.

The Main Objectives of FACILITATE - AI project are to:

- Support school "facilitators for learning" in their understanding of AI use in everyday life
- Prepare school teachers to develop competence for becoming good facilitators of learning AI to their students, considering applications, strengths, and weaknesses, in line with Digital Competence Framework 2.0 and Digital Education Framework

- Contribute to the enhancing of digital skills and competences for the digital transformation, which requires basic digital skills and competences from an early age such as good knowledge and understanding of data-intensive technologies, such as AI
- Support teachers and students in developing problem solving skills, computational thinking and design thinking involving AI tools and methods.

Máster en ciudades inteligentes y sostenibles (master in smart and sustainable cities)

- Reference type: Master degree
- Webpage (URL): https://www.ucm.es/masterciudadesinteligentesysostenibles/presentacion
- Country: Spain
- Company or institution: Universidad Complutense De Madrid (UCM)

This entity works on the concept of quality applied to the university environment and the set of mechanisms, actions, programs and systems that allow improving the service that the Spanish university system provides to society, seeking its excellence, as well as its total efficiency and transparency. It offers a wide range of degrees, double degrees, masters, doctorates, international degrees and further training related to transversal competences in almost all areas of knowledge (science, engineering and architecture, arts and humanities, health sciences, social and legal sciences…).

The Master in Smart and Sustainable Cities - Smart Cities is aimed at students from different backgrounds and areas of expertise (social sciences and technical degrees: geographers, urban planners, architects, engineers, environmentalists, economists, sociologists, computer scientists, etc.)

The main objective of the program is to train professionals capable of analyzing and interpreting the reality of cities, and designing urban projects and programs to improve the well-being of citizens. This training focuses in theoretical knowledge as well as in the use of the technological tools that respond to the challenge of analysis and planning of the cities of the future based on sustainable economic, social and environmental development. Implementation of new information technologies: advanced analysis techniques for cities based on in new data sources (including Big Data), computer programming, the use of Geographic Information Systems or remote sensing and photo-interpretation tools, the development of online maps and applications or the use of drones for data capture and analysis of the territory, become key contents. The master also addresses some of these challenges from the perspective of artificial intelligence, in the field of governance, energy efficiency and the environment, and sustainable transport and mobility.

The offer of internships in reference institutions and companies in the field of urban studies facilitates competences acquisition and the integration of students into the labor market.

Libro Blanco Smart Cities (White paper in Smart Cities)
- Reference type: White paper or report
- Webpage (URL): http://libroblancosmartcities.com/index.html
- Country: Spain
- Company or institution: Enerlis, Ernst and Young, Ferrovial Servicios, Madrid Network

Starting from a large city like Madrid, the capital of Spain, the companies participating in the white paper have a recognized record of accomplishment and experience with the knowledge and services that help create long-term value for customers, people and society, and to generate confidence in the capital markets. Ferrovial is one of the main global transport infrastructure operators and we maintain a firm commitment to the development of sustainable solutions. Enerlis is an intelligent solutions company that offers integrated urban development, smart cities, and intelligent monitoring systems. Finally, Madrid network, the Innovation Network of the Community of Madrid, is a pioneer in the organizational model by encompassing all the regional strategic sectors under the same umbrella. That is the reason why they provide solutions from the point of view of globalization that has brought with it important economic and technological changes that require European cities to face simultaneously the challenge of combining jobs and competitive and innovative occupations with the technological and sustainable urban development.

It is a challenge with a great impact on the economy, business culture, finances and environmental and social conditions, but we focus on medium-sized cities and their development prospects, the "medium" cities that have to face competition from larger metropolises on corresponding issues, appear to be less well equipped in terms of critical mass, resources and organizational capacity.

The "medium-sized" cities throughout Europe have to compete to attract talent, people with knowledge and ideas, and for this, they require a transformation by creating an environment fully aligned with sustainability, the use of information technologies and communications (ICT) and the application of innovation. In this way, it will be possible to build an environment where everything revolves around the citizen. The cities with less than ten million inhabitants will be the protagonists, in the coming years, of the greatest processes of accumulation of capital and people.

Spain has all the elements to play a relevant role, since the typology of the municipalities is very different. This book tries to identify the steps to follow so that the application of the Smart City philosophy is viable in all municipalities within the country.

The thematic blocks studied are Government, Mobility, Sustainability, Population and Economy.

Emerging Smart City Occupations

- Reference type: White paper or report
- Webpage (URL): https://www.ictc-ctic.ca/wp-content/uploads/2021/05/Final-smart-city-occupations-May-19.pdf
- Country: Canada
- Company or institution: The Information and Communications Technology Council (ICTC)

ICTC is a national center of expertise on the digital economy. With over 25 years of experience in research and program development related to technology, ICTC has the vision of strengthening Canada's digital advantage in the global economy

The report outlines the overall responsibility, skills and competences, as well as the training needs of different roles in five domains of Smart Cities that could help us to identify the Smart Cities Technician and Smart Cities Engineer role profiles. The five domains identified in the report are the following: a) Privacy, Cybersecurity, and Risk Management, b) Equity, Ethics, and Inclusivity, c) Innovation and Growth, d) Infrastructure and Mobility and e) Sustainability and Resilience.

These occupations were identified based on a literature review of relevant smart city developments, insights from key informant interviews with individuals in senior level roles, and data scraping of online job boards across 16 countries.

Nineteen individuals from 13 cities (and four countries) were interviewed for this study. These individuals hold leadership or senior roles related to smart cities. They a) work in roles that are likely to become central in smart cities but currently exist only in different sectors, b) work in smart city roles outside of Canada, c) are leaders in departments that have increasing relevance to smart cities, and/or d) are knowledgeable about careers or emerging roles related to smart cities. Interview discussions focused on understanding the purpose and responsibilities of their roles, their educational and professional backgrounds, the team structures that support their work, their assessment of the evolution of their respective teams in the context of smart city growth, and the types of professionals and skill sets they seek to add to their teams going forward.

This analysis is supplemented with skills data insights obtained by extensive web scraping of online job boards, and labor market analytics from Emsi and Adzuna. The job titles, keywords, and search terms used for this analysis were shortlisted by combining insights from the literature review and from the key informant interviews.

Smart Technologies by Design project

- Reference type: Erasmus+ Project
- Webpage (URL): SMART BY DESIGN - Home
- Country: Bulgaria

- Company or institution: Knowledge, Innovation and Strategies Management Club (KISMC)

The main objective of KISMC is to promote the transfer and use of modern methods and tools for knowledge management, innovation and strategies in Bulgarian companies and organizations in order to achieve greater efficiency of governance in the country and improve the competitive position of individual companies and organizations. It is a member of the Sofia Knowledge City Cluster, which promotes projects related to cities and from KISMC seeks and designs the best training and methodologies to make them smart cities.

The main objective of the project is to develop a knowledge and skills development package for the target group of "smart city innovators" to drive smart disruptive technology for the cities' needs. This could foster the process of the digital transformation of the cities in Europe through elaborating, testing and providing a set of learning & training instruments to SME managers, owners of deep-tech businesses, smart city officers and managers and their trainers and mentors. More specifically the partners are working on production of a map of digital disruptive technologies for the cities' needs and a training program with modules and materials for the smart city innovators.

Some if the project's objectives relevant for our case are developing capabilities and competences framework for smart economy, developing soft skills towards the citizens in the local environment of the SME managers as their new customers and consumers under the umbrella of smart city, preparing for the next level of ICT connectivity called "city-as-a-platform" or supporting the uptake and use of digital technologies to create innovations to serve the needs of the society and the citizens and thus tap on social skills.

Smart Skills for Smarter Cities (Skills4city)

- Reference Type: Erasmus+ Project
- Webpage (URL): https://www.skills4cities.eu/
- Country: Bulgaria
- Company or institution: the Cluster Sofia Knowledge City (CSKC - Bulgaria) is the project coordinator.

The Cluster Sofia Knowledge City (CSKC) combines the efforts of business from the intensive knowledge sectors with the municipality, the research institutes, and the development, educational and financial organizations for transforming the city of Sofia from a traditional administrative capital into a Knowledge and Smart City. Through its activities, the cluster supports the implementation of the Strategy for Smart Specialization and the Green & Digital Transformation Strategies of the city and to contribute to a more efficient use of human and material resources to develop a "knowledge economy" in Sofia.

Skills4Cities is a continuation of another Erasmus+ project - Smart Technologies by Design (also analyzed for this task). Skills4Cities is aimed at understanding better the challenges

the smart city projects bring during their design and implementation and to propose new job roles of the experts involved in this process.

The main objective of the project is to develop and test learning and validation tools for the training of experts, personnel and managers of smart cities for their newly emerging roles. The project supports learning paths for the newly emerging role/professions of the smart city experts, personnel and managers through the elaboration of competence map, reference competence framework, recognition and validation of new curricula and training materials for the staff, managers, and experts of smart cities at European level.

3.2.1   Analysis of references

Each category of skills got a rate of importance based on the research done by each reference. We define the importance of each category according to a scale of 0 to 3, where 0 means not applicable, 1 marginal, 2 relevant, 3 essential and NS not sure. This section shows synthetized results of the analysis done. For more details on individual data, check Annex 1. Results show that not every skill was equally important for the target profiles; for example while cybersecurity or project management have the highest rating, others such as drones do not reach a high enough punctuation in importance.

Enabling technologies skills	Importance (mean value)
Internet of Things	2.83
Cybersecurity	3
Cloud Computing	2.67
Data analytics	2.83
Machine learning	2.5
Big Data	2.67
3D printing	1.17
Blockchain	1.83
Drones	1.83

Table 2. Importance of skills in enabling technology for Smart City profiles

Business and management skills	Importance (mean value)
Project management	3
Entrepreneurial thinking	2.33

Quality management	2.33
Business process	2.83
Design thinking	2.5

Table 3. Importance of skills in business and management for Smart City profiles

Soft skills	Importance (mean value)
Leadership and management	2.83
Managing through change	2.80
Interpersonal communication	2.67
Teamwork and collaboration	2.83
Critical thinking	2.67
Problem solving	2.83
Emotional intelligence	2

Table 4. Importance of soft skills for Smart City profiles

Green skills	Importance (mean value)
Circular economy	2.67
Waste management	2.83
Energy conservation	3

Table 5. Importance of green skills for Smart City profiles

3.3 Final conclusions of desk research

A focus group with representatives of the partners directly involved in Task 2.1 interpreted the results and drew out the main conclusions for the continuation of the process. Based on these results, skills rated with an importance mean value below 2 points were considered as not relevant enough to be included in the subsequent survey on Smart Cities professional profiles. More specifically, the survey should not include the areas of 3D printing, Blockchain and Drones, as they were not relevant enough for the profiles. As a result, the competences identified in ESCO were reduced to a set of 62 knowledge items and skills for the smart city engineer and 54 for the technician.

The research done with e-CF is not affected by these changes as the framework focuses on the functions and not in specific skills or knowledge (which are only illustrative and no normative in the standard EN16234). Therefore, the mapping between functions and e-competences of e-CF remained unaltered after this step.

Regarding soft skills, the focus group agreed to maintain all of them as none of the consulted sources rated them below 2 points in importance: there was only one case, Emotional Intelligence, rated exactly with 2 points. Therefore, the survey would follow the

adopted approach of the model of the Skills Match project, with soft skills in clusters of related skills.

4 Field research

4.1 Survey design

This field research addresses the skills gap of Smart Cities technicians and engineers reaching different stakeholders from the public, private or civil sector involved in Smart Cities projects with different roles. The aim is to reach as many participants as possible and to have solid results to support or reject the results obtained at the desk research stage. In order to achieve relevant and aligned results, it is important to emphasize in the description of the survey and in the wording of the questions that **the project is focused on ITC-oriented profiles**.

Main considerations considered in the design of the survey were the following ones:

- Answer options are designed follow 5-option Likert scale plus a "Not sure" option.

Essential	Relevant	Useful	Marginal	Worthless	Not Sure

- Statement and questions are designed trying to be concise and synthetic to avoid excessive length and dedication requirements.
- Each section should have a free text space for participants to provide open comments if whished.
- The survey is designed initially in English: however, those partners who considered it appropriate translated it into their respective languages.

The survey was designed in five different sections:

1. **Profile data**. In this section, participants are asked about their gender, nationality, and experience in the smart cities field, including years of experience, stakeholder category (client side, supply side or user side) and their role within the stakeholder.
2. **Functions and responsibilities**. Participants are asked to rate each function derived from the desk research according to the designed scale.
3. **Relevance of our categories of skills for the profiles**. Participants are asked to what extent each category of skills defined in our project (enabling technologies, management and business, green and soft skills) is important for smart city engineers and technicians.
4. **Skills and knowledge for engineers and technicians**. Participants are asked to what extent each statement of knowledge or of skills is relevant for smart city engineers and technicians.
5. **Soft skills**. Participants are asked to rate the importance of each group of soft skills for both profiles. Skills have been grouped in clusters according to the reference,

model and results developed in Skills Match EU project, which proposed a framework of 36 soft-skills directly matched to ESCO.

4.1.1 Questions design

A focus group by one expert per each of the partners directly involved in the Task 2.1 plus a support team of Universidad de Alcalá analyzed functions, skills and knowledge determined in the previous phase. The aim was extracting all the key terms from the descriptions for each category and to generate a single expression. Easier for respondents to give their opinion without information overload.

The work focused on linking through key terms all sources of information. On the one hand, the ESCO descriptions for functions, skills and knowledge and the survey statements. On the other hand, mapping functions statements of the survey with the corresponding e-CF functions and levels.

Experts decided not to explicitly include the reference to e-CF in the survey. The mapping has been done, so the connection exists but the experts preferred not to directly include the specific e-CF terms in the survey, as they are not well recognized by people not expert in the framework as well as to avoid saturating the user with more technical information.

Regarding soft skills, it was very difficult to ask, with precision, which ones may be more important and which ones may be less with such a wide range of options (e.g., 36 soft skills defined in the Skills Match Framework). The approach approved by the focus group for the survey is to refer to the Skills Match clusters and not the individual competencies. Skills Match proposes clusters of soft skills, closely related to each other in such a way that the development of one of them usually also leads to higher levels of development in the rest of the skills in the group. We have chosen to mention only the clusters, as representative of the whole group of skills.

These aspects make the survey more user-friendly in terms of dedication and comprehension requirements, while maintaining the link to the reference frameworks. For example, in the area of Internet of Things, engineers and technicians' profiles will require the same knowledge but its application will be different as their profiles have different skills. See Table 6 to verify how we generated single expressions for engineers' knowledge and skills in Internet of Things including the key points of the description provided in ESCO and Table 7 for the equivalent for technicians. ID is an internal indicator we used to identify ESCO occupations in our mapping.

Type	ID	ESCO Description	Single expression
Knowledge	IOT1	The general principles, categories, requirements, limitations, and vulnerabilities of smart connected	Principles, requirements, limitations and

Type	ID	ESCO Description	Single expression
		devices (most of them with intended internet connectivity).	vulnerabilities of smart connected devices and automatic control systems for digital control, distribution saving and use of energy and information management.
Knowledge	IOT2	Smart grids are a digital electricity network. The system involves the electronic digital control of production, distribution and use of electricity, information management of the components and energy saving.	
Knowledge	IOT5	Type of automatic control system where through a Building Managements System or Building Automation System (BAS) the control of a building's ventilation, humidity, heating, lighting and other systems is being automated at centralized location and monitored through electronic systems. Can be set to optimize energy consumption.	
Skill	IOT3	Design and calculate the smart grid system, based on heat load, duration curves, energy simulations etc.	Design and calculate smart systems, based on heat load, duration curves, energy simulations, etc.

Table 6. Mapping of ESCO and SMACITE expressions for engineers in IoT

Type	ID	ESCO Description	Single expression
Knowledge	IOT1	The general principles, categories, requirements, limitations and vulnerabilities of smart connected devices (most of them with intended internet connectivity).	Principles, requirements, limitations and vulnerabilities of smart connected devices and automatic control systems for digital control, distribution saving and use of energy and
Knowledge	IOT2	Smart grids are a digital electricity network. The system involves the electronic digital control of production, distribution and use of electricity, information management of the components and energy saving.	

Knowledge	IOT5	Type of automatic control system where through a Building Managements System or Building Automation System (BAS) the control of a building's ventilation, humidity, heating, lighting, and other systems is being automated at centralized location and monitored through electronic systems. Can be set to optimize energy consumption.	information management.
Skill	IOT4	Install connected devices, such as thermostats, indoor environmental quality sensors, movement detection sensors, electronic thermostatic radiator valves, light bulbs, light switches, relay switches for building services auxiliary, plugs, energy meters, window and door contact sensors, flooding sensors, EC motors for solar shading and automatic doors, smoke and CO sensors, cameras, door locks, doorbells and lifestyle devices. Connect these devices to domotics system and to the relevant sensors.	Install connected devices, (sensors, light switches, plugs, energy meters, cameras, etc.) and interconnect these devices to system and to relevant sensors.

Table 7. Mapping of ESCO and SMACITE expressions for technicians in IoT

The same research for identifying key terms in ESCO and e-CF and generating concise single expressions for SMACITE's survey was done in every area of the profile. All the questions, statements and single expressions for functions, knowledge and skills included in the survey are available in Annex 2.

4.2 Results

This survey was launched in English, Spanish, Italian and Greek and distributed to different stakeholders from the public, private or civic sector involved in Smart Cities projects with different roles, using the networks of the SMACITE partners and associated partners. We disseminated the access to the survey through links of URL shortener (Bit.ly) to get track of clicks on them. There were 394 clicks along the period of dissemination of the survey (end of July until September 18th 2022, with obviously really very low activity during August, both in dissemination of links and in interest of target stakeholders). The survey finally collected 134 contributions to the questionnaire (34% of the clicks: rate of response).

The survey was designed to address different data groups. First, as usual, we collect the respondent profile data, followed by functions and responsibilities for smart city technician and engineer, the relevance of categories identified in previous research (enabling technologies, management and business, green and soft skills) of technical skills, followed by relevant knowledge for smart city technician and engineer. The last topic was related to soft skills (non-technical skills). Due their importance in the correlation of these skills with success in employability, income and professional development or career.

4.2.1 Profile data

The survey collected aspects such as nationality and gender for the basic statistics of respondents' profile. Number of years of experience as ICT professional is also important for results and were measured in levels of five: less than five years, from 5 to 20 in different groups of five and more than 20. The stakeholder category helped to group in three main options the large variety of roles in Smart Cities: public sector and authorities, to explore the client side, business sector and providers to analyze the supply side and, finally, civil society and experts for user side. The question of familiarity with smart cities was also asked through a Likert scale of five options: none, basic knowledge with no practical application, application of concepts out of professional practice, professional experience in the area, highly qualified and experienced in the area.

The nationality of the respondents who replied to the survey was diverse with a total of 11 European countries as nationality, but the countries more contributions were Spain (34.07%), Greece (16.30%), Bulgaria (27.41%) and Italy (13.33%). See Figure 2 for more details. Gender was clearly unbalanced: 71.1% were male and the rest females. This is not strange, as IT technical fields tend to be most males in their population. There also were 2.2% of persons who declare to prefer not to say their gender. See Figure 3 for more details.
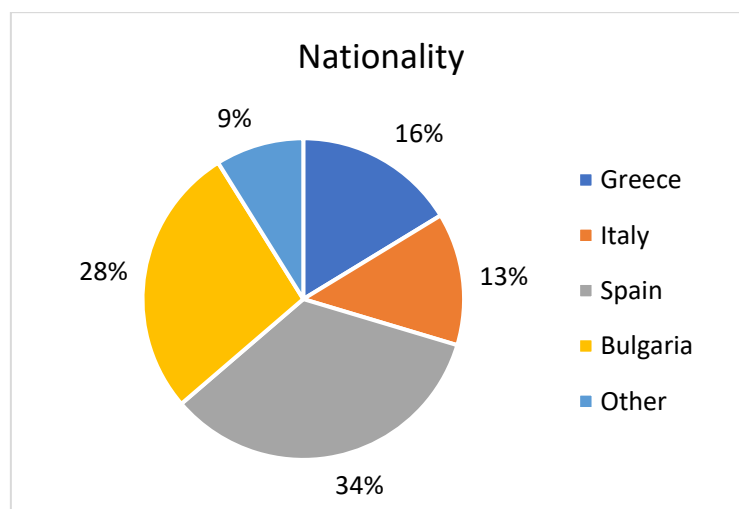
Figure 2. Distribution of participants by nationality
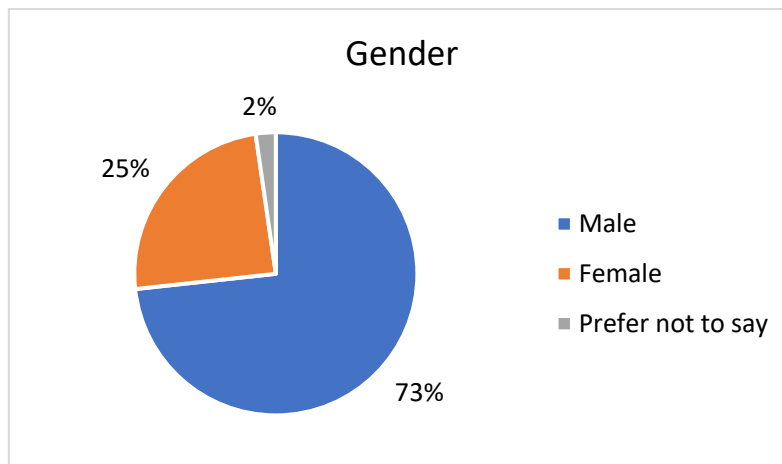
Figure 3. Distribution of participants by gender

Regarding the working experience, we got diverse replies, but mostly concentrated in less than 5 years (15.56%) and more than 20 years (48.15%). All the other groups obtained 11.11% of replies. See Figure 4 for more details.
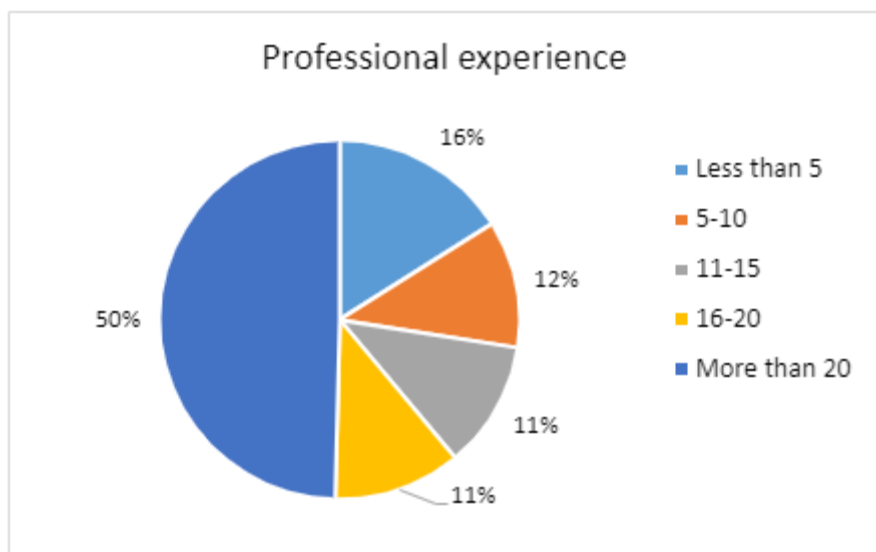
Figure 4. Distribution of respondents by professional experience

Regarding the five possible options of the familiarity with Smart Cities got the following results: none (5.19%), basic knowledge (30.37%), application of concepts out of professional practice (25.19%), professional experience in the area (28.15%) and highly qualified and experienced in the area (11.11%). See Figure 5.

We also asked for the stakeholder category to identify the type and context of respondents. The results presented in the survey were as follows in terms of categories and roles within them:

- Public sector and authorities (client side): 18.52%
  - Policy authority or decision maker: 5.19%
  - Municipal city planner or urbanism expert: 0%
  - Municipal technical manager: 3.70%
  - Municipal technician: 1.48%
  - Other: 8.15%
- Business sector and providers (supply side): 54.81%
  - Business manager in IT solutions provider: 20%
  - ICT project manager in solutions provider: 14.81%
  - ICT Engineer in solutions provider: 9.63%
  - ICT Technician in solutions provider: 2.96%
  - Other: 7.41%
- Civil society (user side): 26.67%
  - Expert in smart cities (academia, research, education, etc.: out of solution providers): 13.33%
  - Representative of citizens' association: 2.96%
  - Sociologist or similar specialist in urban life: 1.48%
  - Other: 8.89%
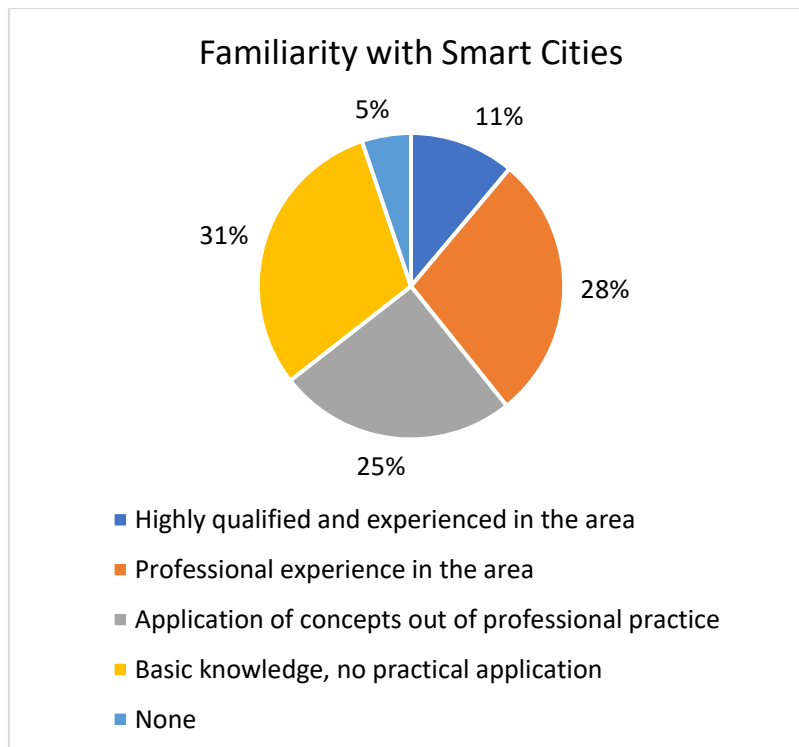
Figure 5. Respondents' familiarity with Smart Cities
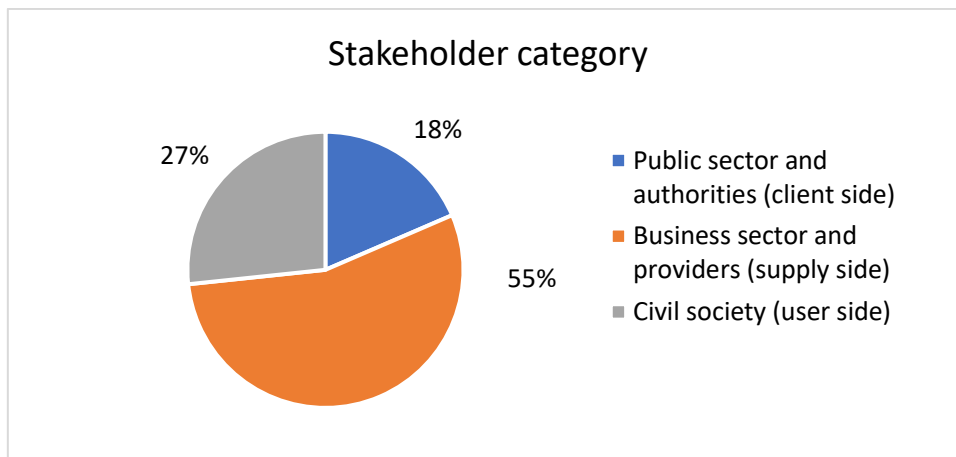
Figure 6. Distribution of respondents by stakeholder category

4.2.2 Functions and responsibilities

Analysis shows that stakeholders consider important all the proposed functions for Smart Cities Engineers. Figure 7 shows that every function was rated as essential or relevant by at least 74% of participants. Even 91% indicated that function A, related to project management and civil engineering, is essential or relevant. Apart from that, none of the functions appears as marginal or worthless for Smart City Engineers: all values of combined percentages of both values are under 8%.

For Smart City Technicians, analysis shows the same trend (see Figure 8): functions are rated as essential or relevant by at least 66% of respondents. None of the functions deserves being out of the final catalogue as their percentages of marginal or worthless values are under 6% in all cases.
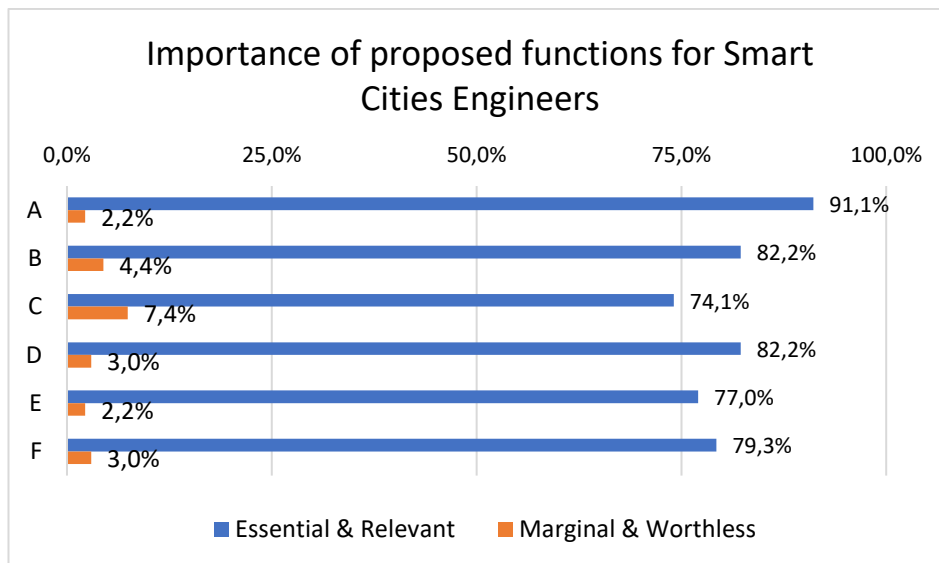
Figure 7. Importance of proposed functions for Smart City Engineers

A: Design, plan, and develop technical and engineering specifications and solutions for projects from infrastructure optimizing materials and integrating specifications and resource allocation within time constraints.

B: Oversee the project on daily basis and is responsible for high-quality results within objectives and constraints, ensuring effective use of resources. Responsible for risk and issue management, communication, and stakeholder management.

C: Design, plan, manage and maintain cloud-based systems. Responsible for developing, implementing and debugging cloud-applications and handle migration of applications to cloud.

D: Advise and implement solutions to control access to data and programs and ensure protection of processes. Responsible for protection and security of systems and network and design, plan and execute the system's security architecture, with models and security policies and procedures.

E: Collect and interpret rich data sources, manage large amounts of data, merge sources, ensure consistency and create visualizations to aid in understanding data using mathematical models and communicate insights and findings to team and, if required, to non-experts and recommend ways to apply data.

F: Design, integration and acceptance testing of automation systems integrating connected devices and smart appliances within residential facilities. Work with key stakeholders to ensure the desired project outcome including wire design, layout, appearance, and component programming.

Figure 8. Importance of proposed functions for Smart City Technicians

Complete statements asked in the survey are the following

A: Help in design and execution of plans and in organizational tasks, e.g., planning and monitoring, and in bidding and invoicing of development work, calculating, purchasing and organizing required resources and ensure quality of components. Can also develop and advise on policy implementing strategies for urban infrastructure (e.g., from traffic lights to water management systems).

B: Develop and implement cloud-systems, handle migration of existing applications to cloud, and debug cloud environment.

C: Propose and implement necessary security updates and measures whenever is required. Also advice, support, inform and provide training and security awareness.

D: Import, clean, validate, model, or interpret collections of data for business goals and given criteria. Also ensure consistent and reliable data from sources and repositories and prepare reports with visualizations such as graphs, charts, and dashboards.

E: Install and maintain automation systems, connected devices, and smart appliances at customer sites. Also, act as a user educator and resource for product and service recommendations for customers' needs for comfort, convenience, security, and safety.

4.2.3 Skill category

Before moving to specific knowledge and skills, participants are asked to decide up to what extent each category of skills defined in our project (enabling technologies, management and business, green and soft skills) is important for smart city engineers and technicians.

For engineers, technical enabling technologies is considered essential or relevant by a vast majority of stakeholders, 93%. Business and management and soft skills have a similar importance (72% and 73% respectively) and green skills is essential or relevant for 63%. See more details in Figure 9.

When focusing on technicians, the most relevant result is that only 44% consider business and management as essential o relevant for the profile and in the case of green skills just 55%. See Figure 10 for more details.

Figure 9. Importance of categories of skills for Smart Cities Engineers
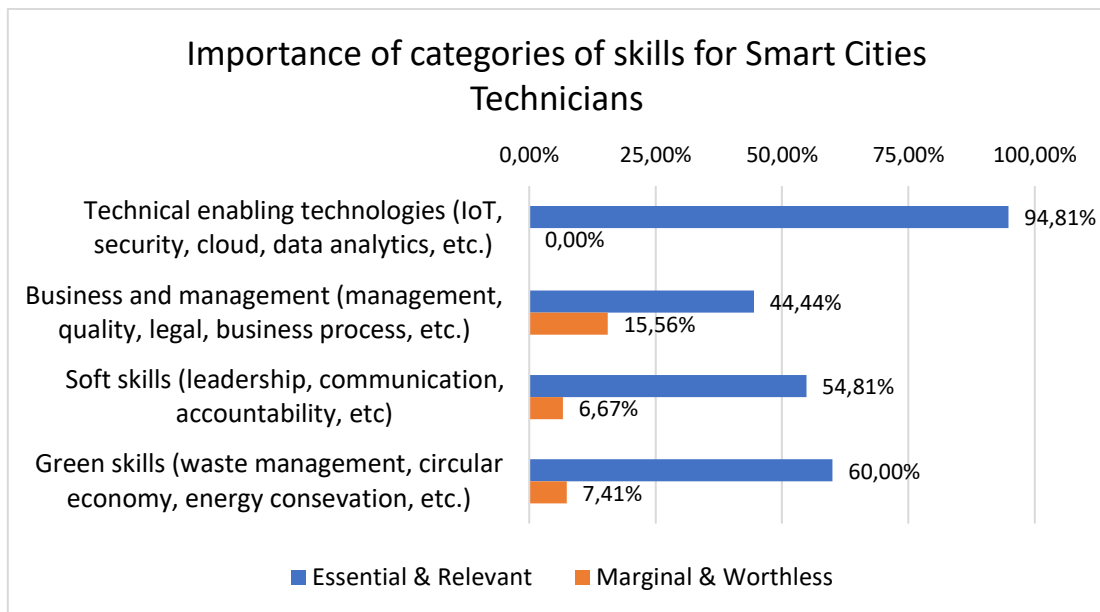
Figure 10. Importance of categories of skills for Smart Cities Technicians

4.2.4 Knowledge and skills

Respondents were asked about knowledge and skills related to our targeted areas (IoT, Security, Cloud Computing, Data Analytics, Machine Learning and Big Data, Business and Management and Green skills).

Focusing on Engineers, knowledge, and skills on enabling technologies are considered of high importance, being Internet of Thing the one with more important by more people (95% for knowledge and 90% for skills). The general situation is of acceptance being all items rated as essential or relevant by more than 57%. Business and management and Green knowledge and skills are the ones that seem less pertinent but even in these cases acceptance rating was above 50%. See Figure 11 for more details.
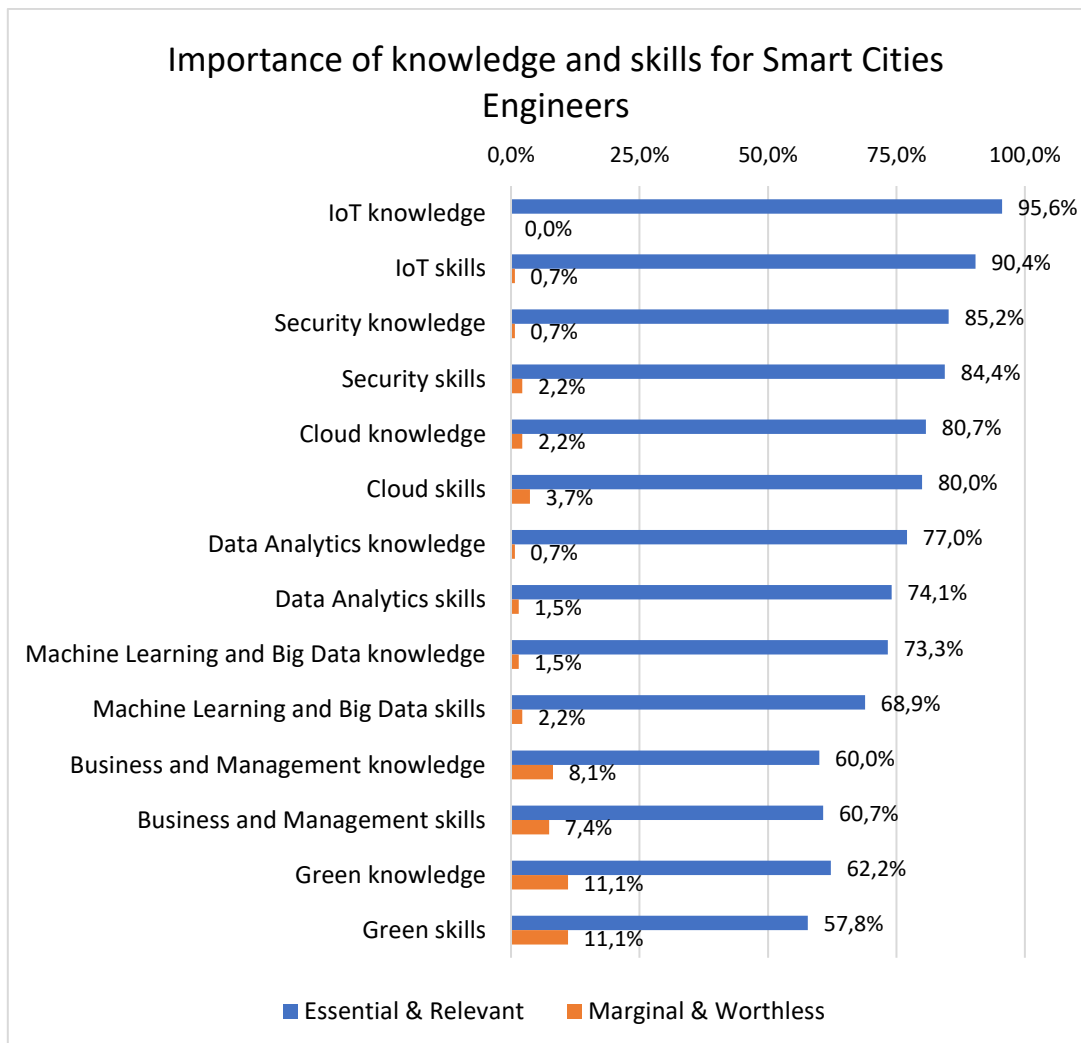
Figure 11. Importance of knowledge and skills for Smart Cities Engineers

The general situation for technicians is of acceptance in the cases of enabling technologies, except for Machine Learning and Big Data, which was only considered essential or relevant by less than 50%. See Figure 12 for more details. Business and management and Green items are the least pertinent areas. 33% for Business and management knowledge and 37% for Business and management skills, even when their scope in statements was more limited for technicians than the corresponding ones for engineers. Green knowledge and skills neither reach the 50% threshold.
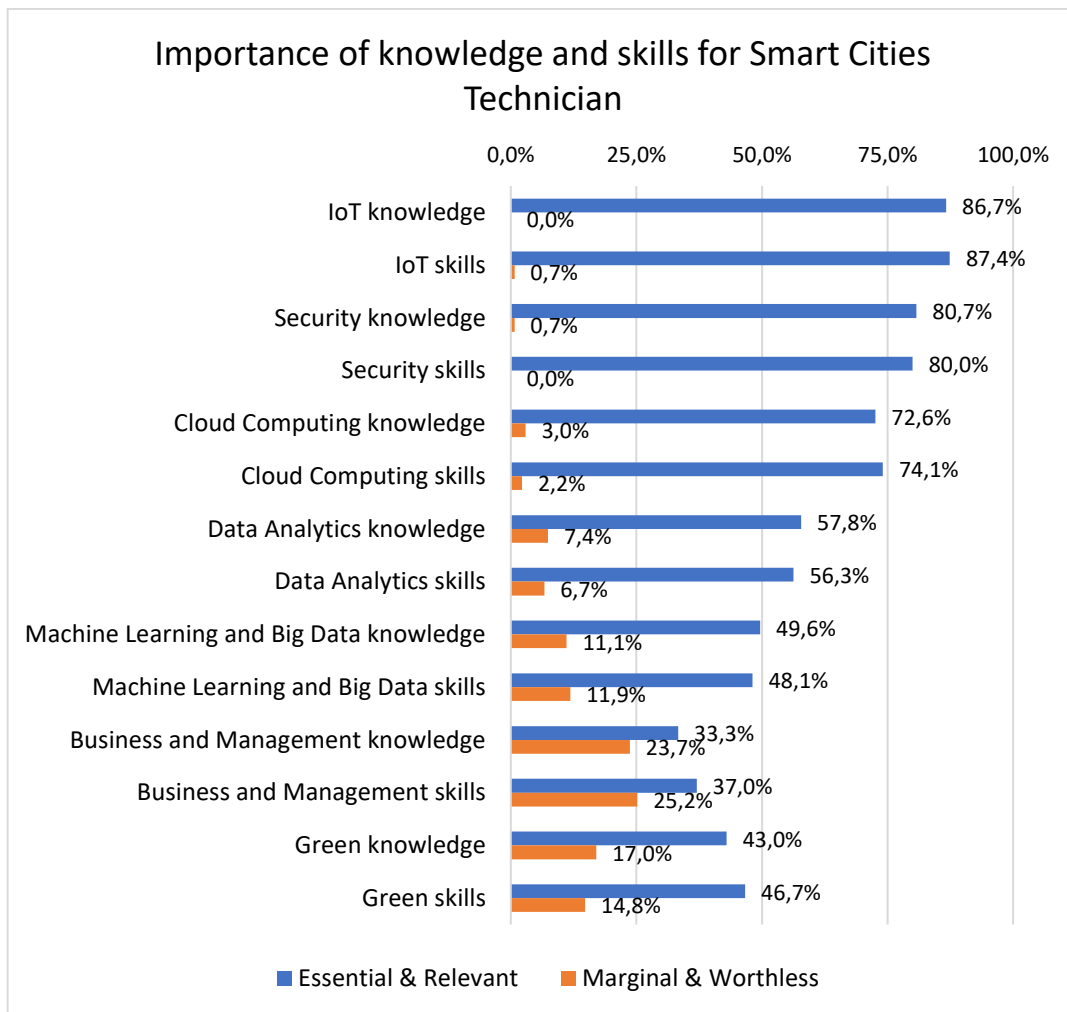
Figure 12. Importance of knowledge and skills for Smart Cities Technicians

Results show that there are differences when participants are asked about general categories (see section 4.2.3 Skill category) and when asked about more specific and detailed items as knowledge and skills. It is the case of Business and management. For example, while the general category was rated as essential or relevant for technicians by 44%, only 33% gave the same importance to knowledge on that area and only 37% considered skills as essential or relevant. This is the most representative example, but it happens in other categories for both profiles.

Another trend coming out from data is that respondents tend to allocate more importance to skills over knowledge in technicians while, in the case of engineers, knowledge is at the same level or higher in the different items.

4.2.5 Soft skills

After analyzing the results, SMACITE project consider that all the proposed soft skills are relevant to the profile of an engineer. As can be seen in Figure 1Figure 13, every cluster of soft skills was considered essential or important for engineers by at least 77% of the participants in the survey and values for marginal and worthless are insignificant.

In the case of technicians, there is a greater disparity of values. However, more than 50% of the participants consider all the proposed soft skills relevant, except in the case of leadership, whose acceptance of 48% does not reach the threshold of 50%, and creativity, which still reaches a relatively high value of importance (65%). See Figure 14 for more details.
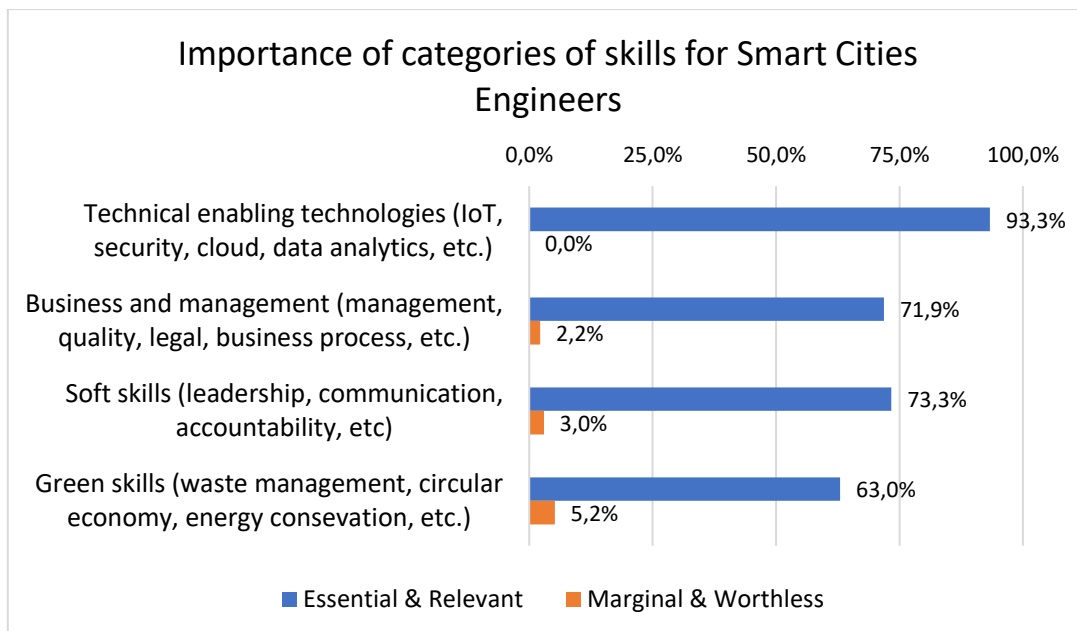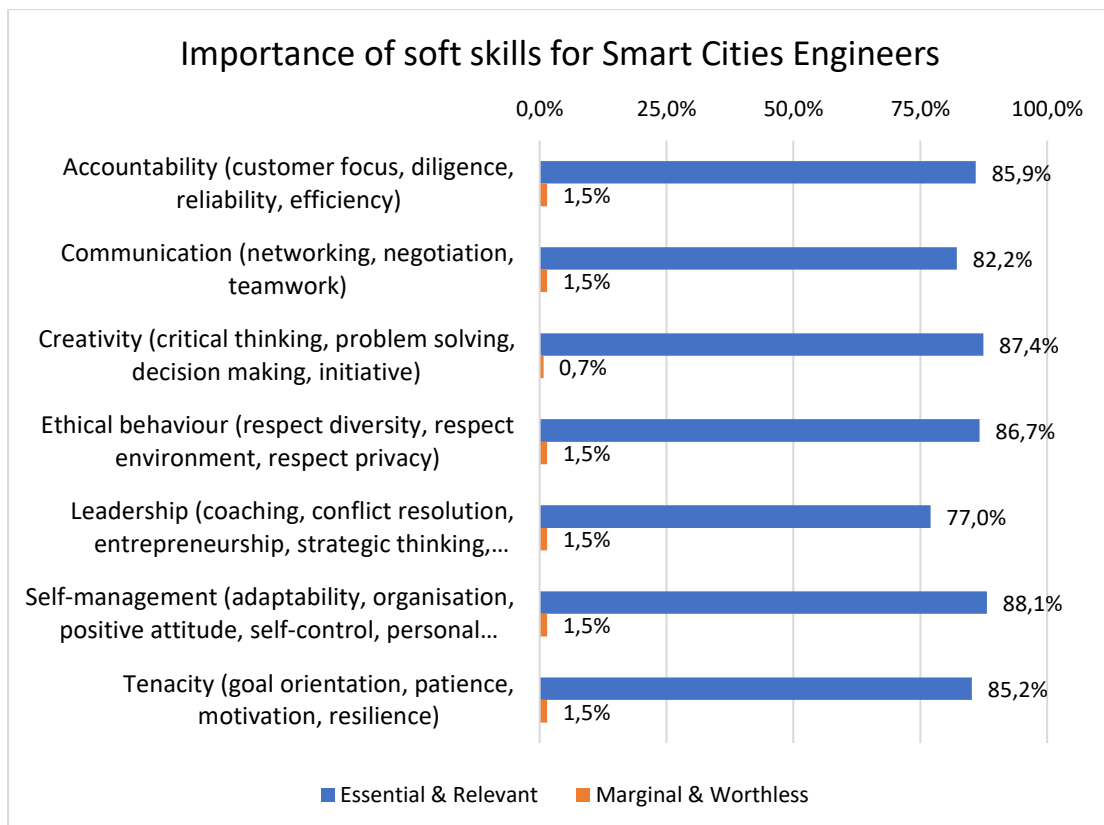

Figure 13. Importance of soft skills for Smart Cities Engineers
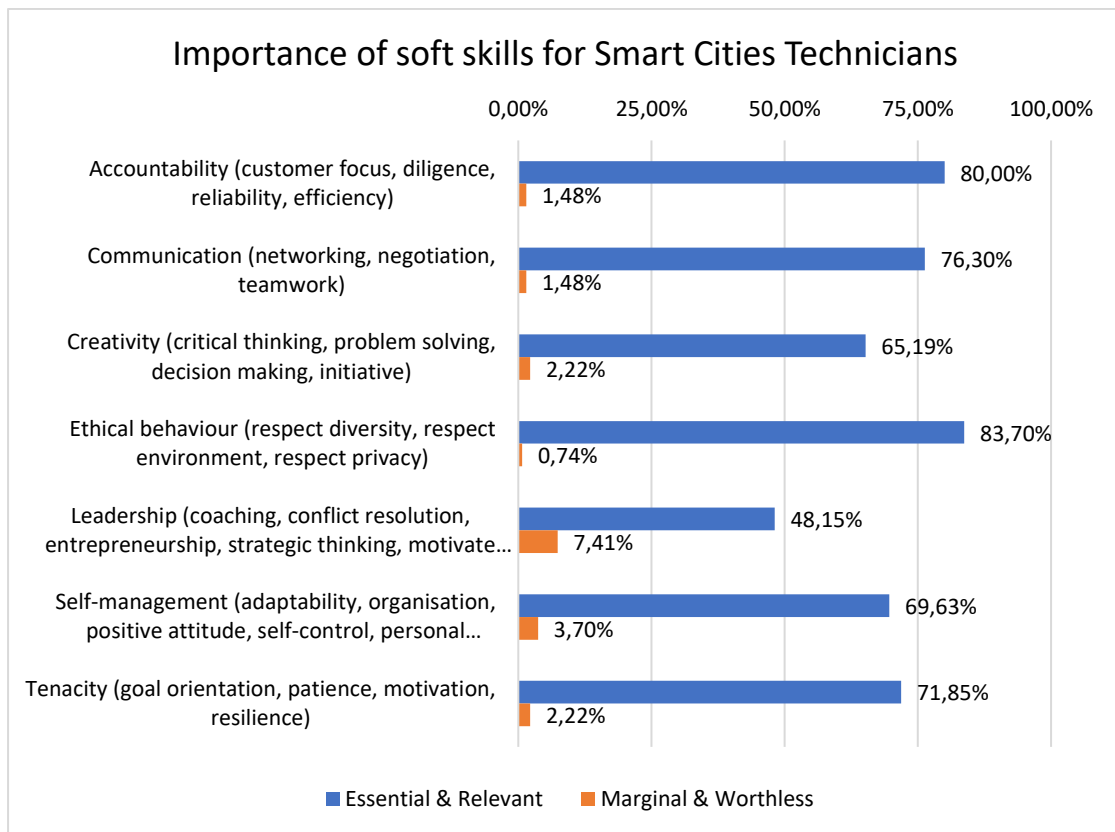
Figure 14. Importance of soft skills for Smart Cities technicians

In general, relevance of these groups of soft skills is higher than the relevance given to the general category of soft skills, which was 73% for engineers and 55% for technicians.

4.3 Proposed profiles

In order to design profiles that are complete, accurate and coherent in relation with data obtained in field research; we took into account two main indicators: percentage of people selecting the item as essential or relevant and the weighted average. The weighted average is calculated by allocating the numbers 0 to 4 to each of the values of the answer scale (e.g., 0 for Worthless and 4 for Essential).

Once calculated, the thresholds for assessment are:

- Above 3.5 means majority of 4 values, so indication of Essential value
- Above 2.5 is the equivalent for majority of 3 values or equivalent proportion, so it is an indication of Relevant value
- Above 1.5 represents majority if 2 values, so indication of Useful value
- Below 1.5 represents majority of responses indicating the item is worthless or marginal

When looking at percentages of values Essential and Relevant, we consider 90% as the minimum threshold for Essential and 50% as the minimum for Relevant. Items with values under 50% should be rated as Useful, or even discarded from final catalogue for profiles.

In the following sections, we present functions, skills, knowledge, and soft skills for Smart Cities Engineers and Smart Cities Technicians. Those highlighted in red are the ones in the limit of a category and the ones that may not have enough relevance. During the next stage interviewing experts, we would be able to determine the best way to proceed with these items.

4.3.1 Smart Cities Engineer

Functions

A. Design, plan, and develop technical and engineering specifications and solutions for projects from infrastructure optimizing materials and integrating specifications and resource allocation within time constraints.
B. Oversee the project on daily basis and is responsible for high-quality results within objectives and constraints, ensuring effective use of resources. Responsible for risk and issue management, communication and stakeholder management.
C. Design, plan, manage and maintain cloud-based systems. Responsible for developing, implementing and debugging cloud-applications and handle migration of applications to cloud.
D. Advise and implement solutions to control access to data and programs and ensure protection of processes. Responsible for protection and security of systems and network and design, plan and execute the system's security architecture, with models and security policies and procedures.
E. Collect and interpret rich data sources, manage large amounts of data, merge sources, ensure consistency and create visualizations to aid in understanding data using mathematical models and communicate insights and findings to team and, if required, to non-experts and recommend ways to apply data.
F. Design, integration and acceptance testing of automation systems integrating connected devices and smart appliances within residential facilities. Work with key stakeholders to ensure the desired project outcome including wire design, layout, appearance and component programming.

Knowledge and skills

	Type (knowledge or skill)	Weighted average	% Essential or relevant	Profile classification (C: clear; W: weak)		
				Essential	Relevant	Useful
IoT	K	3.6	95.6%	C		
IoT	S	3.4	90.4%	W		
Security	K	3.3	85.2%		C	
Security	S	3.3	84.4%		C	
Cloud	K	3.1	80.7%		C	
Cloud	S	3.1	80.0%		C	
Data Analytics	K	3.1	77.0%		C	
Data Analytics	S	3.1	74.1%		C	
M. Learning & Big Data	K	3.0	73.3%		C	
M. Learning & Big Data	S	2.9	68.9%		C	
Business and Manag.	K	2.7	60.0%		C	
Business and Manag.	S	2.7	60.7%		C	
Green	K	2.6	62.2%		C	
Green	S	2.6	57.8%		W	

Table 8. Knowledge and skills proposed for Smart Cities Engineers

Soft Skills

	Weighted average	% Essential or relevant	Profile classification (C: clear; W: weak)		
			Essential	Relevant	Useful
Accountability skills group	3.4	85.9%		C	
Communication skills group	3.3	82.2%		C	
Creativity skills group	3.3	87.4%		C	
Ethical behavior skills group	3.4	86.7%		C	
Leadership skills group	3.1	77.0%		C	
Self-management skills group	3.3	88.1%		C	

Tenacity skills group	3.2	85.2%	C	

Table 9. Soft skills proposed for Smart Cities Engineers

4.3.2 Smart Cities Technician

Functions

A. Help in design and execution of plans and in organizational tasks, e.g. planning and monitoring, and in bidding and invoicing of development work, calculating, purchasing and organizing required resources and ensure quality of components. Can also develop and advise on policy implementing strategies for urban infrastructure (e.g., from traffic lights to water management systems).

B. Develop and implement cloud-systems, handle migration of existing applications to cloud, and debug cloud environment.

C. Propose and implement necessary security updates and measures whenever is required. Also advice, support, inform and provide training and security awareness.

D. Import, clean, validate, model, or interpret collections of data for business goals and given criteria. Also ensure consistent and reliable data from sources and repositories and prepare reports with visualizations such as graphs, charts, and dashboards.

E. Install and maintain automation systems, connected devices, and smart appliances at customer sites. Also, act as a user educator and resource for product and service recommendations for customers' needs for comfort, convenience, security and safety.

Knowledge and skills

	Type (knowledge or skill)	Weighted average	% Essential or relevant	Profile classification (C: clear; W: weak)		
				Essential	Relevant	Useful
IoT	K	3.3	86.7%		C	
IoT	S	3.4	87.4%		C	
Security	K	3.1	80.7%		C	
Security	S	3.2	80.0%		C	
Cloud	K	3.0	72.6%		C	
Cloud	S	3.0	74.1%		C	
Data Analytics	K	2.7	57.8%		C	
Data Analytics	S	2.7	56.3%		C	

M. Learning and Big Data	K	2.6	49.6%		W	
M. Learning and Big Data	S	2.5	48.1%		W	
Business and Manag.	K	2.1	33.3%			C
Business and Manag.	S	2.1	37.0%			C
Green	K	2.3	43.0%			C
Green	S	2.4	46.7%			C

Table 10. Knowledge and skills proposed for Smart Cities Technician

Soft skills

	Weighted average	% Essential or relevant	Profile classification (C: clear; W: weak)		
			Essential	Relevant	Useful
Accountability skills group	3.2	80.0%		C	
Communication skills group	3.0	76.3%		C	
Creativity skills group	2.9	65.2%		C	
Ethical behavior skills group	3.4	83.7%		C	
Leadership skills group	2.5	48.1%			C
Self-management skills group	3.0	69.6%		C	
Tenacity skills group	3.0	71.9%		C	

Table 11. Soft skills proposed for Smart Cities Technician

5 Expert interviews

The aim of these interviews is collecting qualitative feedback and assistance for interpreting the data and results derived from the desk research and the survey to stakeholders. Experts are also asked to confirm whether the profiles are appropriate and relevant or not according to their experience in the area of Smart Cities. Each partner directly involved in the task had to interview one external expert. Partners participating in this task are UAH (Spain), as leader of WP2 and of Task 2.1, DIGITAL SME (Belgium), BASSCOM (Bulgaria), GAIA (Spain) and CADM (Spain).

5.1 Interview process

The final goal of interviews is to get the answer to the questions of the selected external experts (one per partner involved in Task 2.1). The results include:

- Transcription of responses in English to the questions of the interview
- Recording of interview in video format

Each partner was free of organizing an interview in remote or in site mode. In both cases, it is compulsory to have a videorecording (more or less complete) of the interview, as evidence of the execution of this process and as possible option for review of conclusions. Videorecording will remain internal to the project and we will never share with external persons, except in case of review or audit of the project to get proof of evidence of the interviews: this could be explained to the expert to ensure them there will be not problems of privacy.

The materials provided for the process are the following ones:

- **Questions for interview**: where each partner will document answers to questions and data of the interview in English.
- **Presentation of results**: summary of results from survey and suggested Smart Cities Engineer and Technician profiles. This is the base of information for the expert to answer the questions. They should have some time before the interview to read and analyze the information, as the questions of the interview are linked to that information.
- **Complimentary information** about the survey for experts: this document provides information that complements the presentation of the results, so experts can find the specific statements used for the survey in the field research.

5.1.1 Topics for the interview

We proposed interviewees some main topics to discuss and share their opinion throughout the questions.

- Functions allocated to each profile represent well the reality

- Importance to general categories is different to the declared when asked about more specific and detailed items within those same categories. E.g. soft skills, business and management
- There are specific knowledge and skills rated as essential or relevant by less than 50% of respondents, should these be kept in profiles, discarded, or represented with a scale of importance.
- Respondents of survey tend to allocate more importance to skills over knowledge in technicians while in the case of engineers' knowledge is at the same level or higher in the different items
- Overweight the opinion of respondents with higher self-declared qualification when developing the profiles.

Full questions for the interview can be consulted in Annex 4.

5.1.2 Recommendations for interviews

The recommended process for the interview would be the following one:

- Arranging the appointment with expert and sending him/her in advance the summary of results, recommending the expert to see them before the interview. It could be also relevant to give him/her the document with the questions in advance and asking to complete the answer to question 1 by him/herself.
- When starting the interview, it is essential to spend one minute:
  - Reminding the goals of the project, of this Task 2.1 (developing profiles for Smart Cities engineer and for Smart Cities technician) and of this activity (helping the team to interpret the results and to refine the profiles)
  - Indicating we will record the interview: recordings will only serve as proof of having had the interview, recording will be kept private and only in case of audit requesting proofs of activity they will be merely shown to auditors. The name of experts along with their affiliation and description of expertise will be included in the report of Task 2.1 will be only used in the context of the project.

The recommendation is to immediately document the answers after each question. Literal transcription is not expected but it is necessary enough details of answers and fidelity to what the expert expresses. Complete all the details of the document at the end if needed: including a screenshot of the interview.

It is compulsory to record the interview from the beginning and, after ending, immediately upload the file to the Google Drive folder within the subfolder in the folder of Task 2.1. Use a widely used format of video file to guarantee its usability (e.g., MP4, etc.).

5.2 Conclusions of the interviews

Given the results of functions allocated to the role of engineer and to the one of technician for Smart Cities projects, there are some evident differences: e.g., one very relevant is that technician have clearly less presence in data management than engineer, and normally lower levels of presence in the rest. Experts agree that functions defined for Smart Cities Engineers and Smart Cities Technicians represent well the reality and that those are relevant to cover the existing gap in the field. As complementary information, one expert highlighted that functions related with cloud-based systems may not need such a deep approach as those systems normally are either delegated to external providers specialized in computer engineering, who offer PaaS or IaaS modalities, or specific tools are contracted directly in SaaS modality. However, requirements of knowledge and skills in the area remain.

Other suggestions of skills from experts such, e.g. creativity and design thinking, are covered with further parts of the profile, so we have not taken them as functions for the profiles.

In the results of the survey, we detect that the allocation of importance to general skills and knowledge categories is normally significantly different to the ones allocated to more detailed knowledge items and skills, e.g., the importance of the category of soft skills is clearly less than the importance given to individual groups of soft skills (e.g., accountability, communication, etc.). Sometimes the effect is the opposite: more importance to a category such as business and management than to detailed knowledge or skills of that category. All the experts unanimously conclude that there is no lack of items, functions or categories to be added and justify these differences: it is normal that individually they are considered important, but as a whole, compared to other categories, they acquire less relevance.

When asked about important skills or knowledge missing in the profiles, there was a common response: profiles represent well the reality of those roles. However, they made some suggestions but there was no common agreement on which ones were relevant to be added to the profiles. These suggestions mostly refer to transversal skills and knowledge that do not affect the core definition of the profiles.

When discussing the possibility of discarding those knowledge and skills with less than 50% of responses in the essential and relevant values, the general opinion was maintaining them in the profiles while nuancing their importance or modulating their presence, especially in the case of management skills for technicians. One of the experts pointed that in the case of technical profiles, items related to management and business perhaps could be discarded.

Respondents of survey tend to allocate more importance to skills over knowledge in technicians while in the case of engineers' knowledge is at the same level or higher in the different items. Experts agree that this represents well the reality, as engineers are usually in the previous levels (strategic) of action in projects, higher than where technicians usually act in the hierarchy of organization (operational level).

Interviewees mostly think that the opinion of those with higher self-declared qualification should be overweighed when deciding the final shape of profiles, but with some reservations as it is not so easy to define expertise with just one question in the survey. So, after consulting with all partners involved in this task, we decided to continue with the complete set of results and do not discard the opinion of those with less self-declared qualification.

After seeing the proposed profile for Smart Cities engineer and for Smart Cities technician, experts believe that the profiles should remain essentially unchanged and should be tempered with what has been described previously.

All of them highlighted that the process followed to develop them is solid enough to recommend these profiles as main and trustable reference for those roles. Strengths are that both profiles adjust very well to the reality of their personal experience and are based on the results and analysis of a high number of responses to the survey, with enough detail and good design, not just a basic questionnaire. As limitation of the study, obviously the details of expertise of respondents were not explicitly checked (although disseminated through channels targeted to persons with expected background in the area), so we cannot guarantee that if the survey responses were provided by real experts in the field and from a reflective perspective.

In conclusion, after this last step of the process, we could not find solid reasons for changing the profiles developed after the survey. The only changes were the final adjustments to the scales in order to align information to the references and format of ESCO and e-CF.

The specific responses of all the experts are available in Annex 5.

6 Final Job Role Profile for Smart Cities Engineer

Functions of a Smart Cities Engineer aligned with ESCO

A. Design, plan, and develop technical and engineering specifications and solutions for projects from infrastructure optimizing materials and integrating specifications and resource allocation within time constraints.

B. Oversee the project on daily basis and is responsible for high-quality results within objectives and constraints, ensuring effective use of resources. Responsible for risk and issue management, communication and stakeholder management.

C. Design, plan, manage and maintain cloud-based systems. Responsible for developing, implementing and debugging cloud-applications and handle migration of applications to cloud.

D. Advise and implement solutions to control access to data and programs and ensure protection of processes. Responsible for protection and security of systems and network and design, plan and execute the system's security architecture, with models and security policies and procedures.

E. Collect and interpret rich data sources, manage large amounts of data, merge sources, ensure consistency and create visualizations to aid in understanding data using mathematical models and communicate insights and findings to team and, if required, to non-experts and recommend ways to apply data.

F. Design, integration and acceptance testing of automation systems integrating connected devices and smart appliances within residential facilities. Work with key stakeholders to ensure the desired project outcome including wire design, layout, appearance and component programming.

Map of e-CF e-competences and level

These are the e-CF e-competences and their levels that matches with the description of the job role and mainly the functions allocated to it.

TITLE	SMART CITIES ENGINEER (ROLE)		
e-Competences (from e-CF)	B.6	ICT Systems Engineering	Level 4
	E.2	Project and Portfolio Management	Level 4
	A.6.	Application Design	Level 3
	B.4	Solution Deployment	Level 3
	E.8	Information Security Management	Level 4
	D.7	Data Science and Analytics	Level 3
	B.3	Testing	Level 3

Knowledge and skills

This is the summary of knowledge and skills determined in the process for developing the role profile for Smart Cities Engineer. See Annex 3 for the detailed mapping between these knowledge and skills to ESCO equivalents.

Ratings as "Essential" and "Clear Relevant" are considered equivalent to the Essential category in job descriptions of the ESCO classification while the "Weak Relevant" and "Useful" ratings are classified as the ESCO Optional category.

	Type (knowledge or skill)	Profile classification (ESCO scale)	
		Essential	Optional
IoT	K	x	
IoT	S	x	
Security	K	x	
Security	S	x	
Cloud	K	x	
Cloud	S	x	
Data Analytics	K	x	
Data Analytics	S	x	
M. Learning and Big Data	K	x	
M. Learning and Big Data	S	x	
Business and Management	K	x	
Business and Management	S	x	
Green	K	x	
Green	S		x

Table 13. Final knowledge and skills for Smart Cities Engineers

Soft skills

The soft skills included in the engineer profile have been kept in line with the Skills Match model. There is a map of correspondence between Skills Match and ESCO skills. However, we do not include that information here, as the total number of ESCO elements that have some relation to the 36 Skills Match skills is 3138 in total. In e-CF there are not explicit references to soft skills.

	Profile classification (ESCO scale)	
	Essential	Useful
Accountability (customer focus, diligence, reliability, efficiency)	x	
Communication (networking, negotiation, teamwork)	x	
Creativity (critical thinking, problem solving, decision making, initiative)	x	
Ethical behavior (respect diversity, respect environment, respect privacy)	x	
Leadership (coaching, conflict resolution, entrepreneurship, strategic thinking, motivate others, manage quality)	x	
Self-management (adaptability, organization, positive attitude, self-control, personal development)	x	
Tenacity (goal orientation, patience, motivation, resilience)	x	

Table 14. Final soft skills for Smart Cities Engineers

7 Final Job Role Profile for Technician in Smart Cities

Functions of a Smart Cities Engineer aligned with ESCO

A. Help in design and execution of plans and in organizational tasks, e.g. planning and monitoring, and in bidding and invoicing of development work, calculating, purchasing and organizing required resources and ensure quality of components. Can also develop and advise on policy implementing strategies for urban infrastructure (e.g., from traffic lights to water management systems).

B. Develop and implement cloud-systems, handle migration of existing applications to cloud, and debug cloud environment.

C. Propose and implement necessary security updates and measures whenever is required. Also advice, support, inform and provide training and security awareness.

D. Import, clean, validate, model, or interpret collections of data for business goals and given criteria. Also ensure consistent and reliable data from sources and repositories and prepare reports with visualizations such as graphs, charts, and dashboards.

E. Install and maintain automation systems, connected devices, and smart appliances at customer sites. Also, act as a user educator and resource for product and service recommendations for customers' needs for comfort, convenience, security and safety.

Map of e-CF e-competences and level

These are the e-CF e-competences and their levels that matches with the description of the job role and mainly the functions allocated to it.

TITLE	SMART CITIES TECHNICIAN (ROLE)	
e-Competences (from e-CF)	E.2 Project and Portfolio Management	Level 2
	B.1 Application Development	Level 2
	B.4 Solution Deployment	Level 2
	E.8 Information Security Management	Level 3
	D.7 Data Science and Analytics	Level 2
	B.4 Solution Deployment	Level 1
	C.1 User Support	Level 1

Table 15. e-CF e-competences and their levels for Smart Cities Technicians

Knowledge and skills

This is the summary of knowledge and skills determined in the process for developing the role profile for Smart Cities Technician. See Annex 3 for the detailed mapping between these knowledge and skills to ESCO equivalents.

Ratings as Essential and Clear Relevant are considered equivalent to the Essential category in job descriptions of the ESCO classification while the Weak Relevant and Useful ratings are classified as the ESCO Optional category.

	Type (knowledge or skill)	Profile classification (ESCO scale)	
		Essential	Optional
IoT	K	x	
IoT	S	x	
Security	K	x	
Security	S	x	
Cloud	K	x	
Cloud	S	x	

Data Analytics	K	x	
Data Analytics	S	x	
M. Learning and Big Data	K		x
M. Learning and Big Data	S		x
Business and Management	K		x
Business and Management	S		x
Green	K		x
Green	S		x

Table 16. Final knowledge and skills for Smart Cities Technicians

Soft skills

The soft skills included in the engineer profile have been kept in line with the Skills Match model. There is a map of correspondence between Skills Match and ESCO skills. However, we do not include that information here, as the total number of ESCO elements that have some relation to the 36 Skills Match skills is 3138 in total. In e-CF there are not explicit references to soft skills.

	Profile classification (ESCO scale)	
	Essential	Useful
Accountability (customer focus, diligence, reliability, efficiency)	x	
Communication (networking, negotiation, teamwork)	x	
Creativity (critical thinking, problem solving, decision making, initiative)	x	
Ethical behavior (respect diversity, respect environment, respect privacy)	x	
Leadership (coaching, conflict resolution, entrepreneurship, strategic thinking, motivate others, manage quality)		x
Self-management (adaptability, organization, positive attitude, self-control, personal development)	x	
Tenacity (goal orientation, patience, motivation, resilience)	x	

Table 17. Final soft skills for Smart Cities Technicians

8 Final conclusions

The extended and detailed process followed along Task 2.1 has enabled the development of the two job role profiles intended as deliverable. The process collected extensive information from multiple sources, a deep analysis of ESCO and e-CF references as well as solid field research. Profiles that emerged from this process have been cross-checked with the opinion of experts in the area that confirmed that the process is solid enough to trust in adjustment of profiles to the reality of Smart Cities projects and activities.

There are some suggestions of the experts that we have not included in the profiles, as there was not a common position. These are the following points:

- Temper the relevance of functions related to cloud computing as, in general, their development is delegated to external providers specialized in technology.
- Adding mention to paperwork management: version control systems and repositories.
- Adding fleet management: large number of devices require specific management techniques for firmware updates, deployment policies, sensor calibration control.
- Mentioning blockchain applications and other techniques related to cryptocurrencies for data traceability and micropayments.
- Responsibility as specific mention within the set of soft skills. Although accountability is included but it may suggest different meanings. "Accountabilities" cannot be delegated and are more associated with management (engineers) while "responsibilities" can.

These points are included in this report to serve as reference to be considered, just in case, in the development of task 2.2 for training curricula thus involved partners in the task can more easily access to this information.

9 References

[1] European Commission, "European multilingual classification of Skills, Competences, Qualifications and Occupations," *ESCO*. https://esco.ec.europa.eu/en/classification (accessed Sep. 19, 2022).

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[3] CEN, "EN 16234-1:2019, e-Competence Framework (e-CF) - A common European Framework for ICT Professionals in all sectors - Part 1: Framework." 2019.

[4] Pospelova, V., López-Baldominos, I., Fernández-Sanz, L., and Castillo Martínez, A., "Big Data and Skills Frameworks to Determine Recommended Profiled of Soft Skills for IS Development," *Information Systems Development: Crossing Boundaries between Development and Operations (DevOps) in Information Systems (ISD2021Proceedings)*, 2021.

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Annex 1. Desk research analysis of references

This section shows the individual analysis importance of each category of skills for Smart Cities profiles based on the research done for each reference during the desk research.

Bachelor programs in Software Engineering and in Informatics

Profiles for Smart Cities (skills):

According to the reference found, indicate which skills should be included in the profiles for Smart City Engineer and Smart City Technician in each category (relevance: 0 not applicable; 1 marginal; 2 relevant; 3 essential; NS not sure)

Smart Cities Enabling Technologies

Internet of Things	3	Data analytics and visualisations	3	3D printing	2
Cybersecurity	3	Machine Learning	3	Blockchain	3
Cloud computing	3	Big Data	3	Drones	2

Others in this group (name + relevance): _____

Business and management skills

Project management	3	Quality management	3	Design thinking	3
Entrepreneurial thinking	2	Business process	3		

Others in this group (name + relevance): _____

Soft skills

Leadership and management	2	Teamwork and collaboration	3	Problem solving	3
Managing through change	NS	Critical thinking	2	Emotional intelligence	2
Interpersonal communication	3				

Others in this group (name + relevance): _____

Green skills

Circular economy	3	Waste management	3	Energy conservation	3

Others in this group (name + relevance): _____

Specify name and relevance (at least level 2 or 3): _____

Enabling technologies skills

To what extent are **skills in enabling technologies** important for smart city profiles?

X -Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Business and management skills

To what extent are **skills in business and management** important for smart city profiles?

X - Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Soft Skills

To what extent are **soft skills** important for smart city profiles?

☐ - Essential   X - Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Green skills

To what extent are **green skills** important for smart city profiles?

X - Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Additional skills

● Up to what extent are **legal skills** (e.g. privacy) important for smart city profiles?

☐ - Essential   ☐Relevant   ☐Collateral   ☐Not applicable   X -Not sure

In what big group they can be included:

☐ Technology ☐Business   ☐ Green   ☐Soft skills   ☐ Other or transversal

● Up to what extent are **sociology skills** (e.g. knowledge of human and society's habits and behaviours) important for smart city profiles?

X - Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

In what big group they can be included:

☐ Technology ☐Business   ☐ Green   X -Soft skills   X - Other or transversal

● Up to what extent are **urban planning skills** (e.g. land use planning) important for smart city profiles?

X - Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

In what big group they can be included:

X - Technology   ☐Business   X - Green   ☐Soft skills   ☐ Other or transversal

Project Guidelines for facilitating the learning of Artificial Intelligence (AI) by School Students of Grades 7-12- FACILITATE - AI 2022-2024

Profiles for Smart Cities (skills):

According to the reference found, indicate which skills should be included in the profiles for Smart City Engineer and Smart City Technician in each category (relevance: <u>0 not applicable; 1 marginal; 2 relevant; 3 essential; NS not sure</u>)

Smart Cities Enabling Technologies

Internet of Things	3	Data analytics and visualisations	3	3D printing	2
Cybersecurity	3	Machine Learning	3	Blockchain	3
Cloud computing	3	Big Data	3	Drones	3

Others in this group (name + relevance): _____

Business and management skills

Project management	3	Quality management	3	Design thinking	3
Entrepreneurial thinking	3	Business process	3		

Others in this group (name + relevance): _____

Soft skills

Leadership and management	3	Teamwork and collaboration	3	Problem solving	3
Managing through change		Critical thinking	3	Emotional intelligence	2
Interpersonal communication	2				

Others in this group (name + relevance): _____

Green skills

Circular economy	3	Waste management	3	Energy conservation	3

Others in this group (name + relevance): _____

Other skills (add any other important skills according to the reference) out of the categories:

Specify name and relevance (at least level 2 or 3):

Context-sensitive approaches to the study, modelling and control of dynamic processes

Enabling technologies skills

To what extent are **skills in enabling technologies** important for smart city profiles?

⊗Essential ☐Relevant ☐Collateral ☐Not applicable ☐Not sure

Business and management skills

To what extent are **skills in business and management** important for smart city profiles?

⊗Essential ☐Relevant ☐Collateral ☐Not applicable ☐Not sure

Soft Skills

To what extent are **soft skills** important for smart city profiles?

☐Essential ⊗Relevant ☐Collateral ☐Not applicable ☐Not sure

Green skills

To what extent are **green skills** important for smart city profiles?

⊗Essential ☐Relevant ☐Collateral ☐Not applicable ☐Not sure

Additional skills

- Up to what extent are **legal skills** (e.g. privacy) important for smart city profiles?

☐Essential ⊗Relevant ☐Collateral ☐Not applicable ☐Not sure

In what big group they can be included:

⊗ Technology ⊗Business ⊗ Green ⊗Soft skills ☐ Other or transversal

- Up to what extent are **sociology skills** (e.g. knowledge of human and society's habits and behaviours) important for smart city profiles?

⊗Essential ☐Relevant ☐Collateral ☐Not applicable ☐Not sure

In what big group they can be included:

⊗ Technology ⊗Business   ⊗ Green   ⊗Soft skills   ☐ Other or transversal

- Up to what extent are **urban planning skills** (e.g. land use planning) important for smart city profiles?

⊗Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

In what big group they can be included:

⊗ Technology ⊗Business   ⊗ Green   ⊗Soft skills   ☐ Other or transversal

Máster en Ciudades Inteligentes y Sostenibles (Smart Cities)

Profiles for Smart Cities (skills):

According to the reference found, indicate which skills should be included in the profiles for Smart City Engineer and Smart City Technician in each category (relevance: 0 not applicable; 1 marginal; 2 relevant; 3 essential; NS not sure)

Smart Cities Enabling Technologies

Internet of Things	3	Data analytics and visualisations	3	3D printing	1
Cybersecurity	3	Machine Learning	2	Blockchain	1
Cloud computing	3	Big Data	2	Drones	3

Others in this group (name + relevance): _____

Business and management skills

Project management	3	Quality management	2	Design thinking	2
Entrepreneurial thinking	3	Business process	3		

Others in this group (name + relevance): _____

Soft skills

Leadership and management	3	Teamwork and collaboration	3	Problem solving	3
Managing through change	3	Critical thinking	3	Emotional intelligence	2
Interpersonal communication	3				

Others in this group (name + relevance): _____

Innovation	3

Knowledge of enabling technologies	2

Green skills

Circular economy	3	Waste management	3	Energy conservation	3

Others in this group (name + relevance): _____

Agenda 2030	3
Objectives ESG	3

Other skills (add any other important skills according to the reference) out of the categories:

Specify name and relevance (at least level 2 or 3): _____

Legal skills 3

Governance and transparency 3

Enabling technologies skills

Up to what extent are **skills in enabling technologies** important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Business and management skills

Up to what extent are **skills in business and management** important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Soft Skills

Up to what extent are **soft skills** important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Green skills

Up to what extent are **green skills** important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Additional skills

- Up to what extent are **legal skills** (e.g. privacy) important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

In what big group they can be included:

☐ Technology   X Business   X Green   ☐Soft skills   X Other or transversal

- Up to what extent are **sociology skills** (e.g. knowledge of human and society's habits and behaviours) important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

In what big group they can be included:

☐ Technology   ☐Business   ☐ Green   X Soft skills   ☐ Other or transversal

- Up to what extent are **urban planning skills** (e.g. land use planning) important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

In what big group they can be included:

☐ Technology   ☐Business   X Green   ☐Soft skills   X Other or transversal

Libro Blanco Smart Cities

Profiles for Smart Cities (skills):

According to the reference found, indicate which skills should be included in the profiles for Smart City Engineer and Smart City Technician in each category (relevance: 0 not applicable; 1 marginal; 2 relevant; 3 essential; NS not sure)

Smart Cities Enabling Technologies

Internet of Things	3	Data analytics and visualisations	3	3D printing	1
Cybersecurity	3	Machine Learning	2	Blockchain	3
Cloud computing	3	Big Data	2	Drones	1

Others in this group (name + relevance): _____

Business and management skills

Project management	33	Quality management	2	Design thinking	2
Entrepreneurial thinking	3	Business process	3		

Others in this group (name + relevance): _____

Soft skills

Leadership and management	3	Teamwork and collaboration	3	Problem solving	3

Managing through change	3	Critical thinking	3	Emotional intelligence	2
Interpersonal communication	3				

Others in this group (name + relevance): _____

Innovation	3
Knowledge of enabling technologies	2

Green skills

Circular economy	3	Waste management	3	Energy conservation	3

Others in this group (name + relevance): _____

Agenda 2030	3
SDGS	3

Other skills (add any other important skills according to the reference) out of the categories:

Specify name and relevance (at least level 2 or 3): _____

Legal skills 3

Organization, 3

Enabling technologies skills

Up to what extent are **skills in enabling technologies** important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Business and management skills

Up to what extent are **skills in business and management** important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Soft Skills

Up to what extent are **soft skills** important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Green skills

Up to what extent are **green skills** important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Additional skills

- Up to what extent are **legal skills** (e.g. privacy) important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

In what big group they can be included:

☐ Technology   X Business   X Green   ☐Soft skills   X Other or transversal

- Up to what extent are **sociology skills** (e.g. knowledge of human and society's habits and behaviours) important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

In what big group they can be included:

☐ Technology   ☐Business   ☐ Green   X Soft skills   ☐ Other or transversal

- Up to what extent are **urban planning** skills (e.g. land use planning) important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

In what big group they can be included:

☐ Technology   ☐Business   X Green   ☐Soft skills   X Other or transversal

Smart by Technologies Design project [SMART by Design] Project No. 2019-1-BG01-KA202-062298

Profiles for Smart Cities (skills):

According to the reference found, indicate which skills should be included in the profiles for Smart City Engineer and Smart City Technician in each category (relevance: <u>0 not applicable; 1 marginal; 2 relevant; 3 essential; NS not sure</u>)

Smart Cities Enabling Technologies

Internet of Things	3	Data analytics and visualisations	2	3D printing	1
Cybersecurity	3	Machine Learning	3	Blockchain	2
Cloud computing	2	Big Data	3	Drones	1

Others in this group (name + relevance): _____

Digital Twins	1
Augmented Reality	3
Virtual Reality	3

Business and management skills

Project management	3	Quality management	2	Design thinking	3
Entrepreneurial thinking	2	Business process	3		

Others in this group (name + relevance): _____

UX Design	3
Intrapreneurship	2

Soft skills

Leadership and management	3	Teamwork and collaboration	3	Problem solving	2
Managing through change	2	Critical thinking	2	Emotional intelligence	2
Interpersonal communication	3				

Others in this group (name + relevance): _____

Innovation	3
Knowledge of enabling technologies	2

Green skills

Circular economy	2	Waste management	2	Energy conservation	3

Others in this group (name + relevance): _____

Agenda 2030	2
SDGS	2

Other skills (add any other important skills according to the reference) out of the categories:

Specify name and relevance (at least level 2 or 3): _____

Enabling technologies skills

Up to what extent are **skills in enabling technologies** important for smart city profiles?

☐Essential   x Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Business and management skills

Up to what extent are **skills in business and management** important for smart city profiles?

☐Essential   x Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Soft Skills

Up to what extent are soft skills important for smart city profiles?

☐Essential　　　☐Relevant　　　x Collateral　　　☐Not applicable　　　　　☐Not sure

Green skills

Up to what extent are green skills important for smart city profiles?

☐Essential　　　x Relevant　　　☐Collateral　　　☐Not applicable　　　　　☐Not sure

Additional skills

● Up to what extent are **legal skills** (e.g. privacy) important for smart city profiles?

☐Essential　　　☐Relevant　　　x Collateral　　　☐Not applicable　　　　　☐Not sure

In what big group they can be included:

☐ Technology　☐Business　　　☐ Green　　　☐Soft skills　　　x Other or transversal

● Up to what extent are **sociology skills** (e.g. knowledge of human and society's habits and behaviours) important for smart city profiles?

☐Essential　　　x Relevant　　　☐Collateral　　　☐Not applicable　　　　　☐Not sure

In what big group they can be included:

x Technology　　x Business　　　☐ Green　　　☐Soft skills　　　☐ Other or transversal

● Up to what extent are urban **planning skills** (e.g. land use planning) important for smart city profiles?

☐Essential　　　x Relevant　　　☐Collateral　　　☐Not applicable　　　☐Not sure

In what big group they can be included:

☐ Technology　☐Business　　　☐ Green　　　☐Soft skills　　　x Other or transversal

Emerging Smart City Occupations

Profiles for Smart Cities (skills):

According to the reference found, indicate which skills should be included in the profiles for Smart City Engineer and Smart City Technician in each category (relevance: <u>0 not applicable; 1 marginal; 2 relevant; 3 essential; NS not sure</u>)

Smart Cities Enabling Technologies

Internet of Things	2	Data analytics and visualisations	3	3D printing	1
Cybersecurity	3	Machine Learning	3	Blockchain	1

Cloud computing	2	Big Data	3	Drones	1

Others in this group (name + relevance): _____

Business and management skills

Project management	3	Quality management	3	Design thinking	1
Entrepreneurial thinking	2	Business process	3		

Others in this group (name + relevance): Agile methodology, 2

Soft skills

Leadership and management	3	Teamwork and collaboration	3	Problem solving	3
Managing through change	3	Critical thinking	3	Emotional intelligence	2
Interpersonal communication	3				

Others in this group (name + relevance): Written & Verbal Communication, 3

Organization, 3

Green skills

Circular economy	3	Waste management	3	Energy conservation	3

Others in this group (name + relevance): Climate Change Adaptation / Mitigation, 2

Water management, 2

Sustainable design, 2

Other skills (add any other important skills according to the reference) out of the categories:

Specify name and relevance (at least level 2 or 3): The skills under the domain "Equity, Ethics, and Inclusivity" that are essential (3)

Enabling technologies skills

Up to what extent are **skills in enabling technologies** important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Business and management skills

Up to what extent are **skills in business and management** important for smart city profiles?

☐ Essential   X Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Soft Skills

Up to what extent are **soft skills** important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Green skills

Up to what extent are **green skills** important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

Additional skills

- Up to what extent are **legal skills** (e.g. privacy) important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

In what big group they can be included:

X Technology   ☐Business   ☐ Green   ☐Soft skills   ☐ Other or transversal

Note: The term legal skills cover different aspects. In the case of privacy, this can be included in cybersecurity.

- Up to what extent are **sociology skills** (e.g. knowledge of human and society's habits and behaviours) important for smart city profiles?

☐Essential   X Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

In what big group they can be included:

☐ Technology   ☐Business   ☐ Green   X Soft skills   ☐ Other or transversal

- Up to what extent are **urban planning** skills (e.g. land use planning) important for smart city profiles?

X Essential   ☐Relevant   ☐Collateral   ☐Not applicable   ☐Not sure

In what big group they can be included:

X Technology   ☐Business   ☐ Green   ☐Soft skills   ☐ Other or transversal

Smart Skills for Smarter Cities (Skills4city)

Profiles for Smart Cities (skills):

According to the reference found, indicate which skills should be included in the profiles for Smart City Engineer and Smart City Technician in each category (relevance: 0 not applicable; 1 marginal; 2 relevant; 3 essential; NS not sure)

Smart Cities Enabling Technologies

Internet of Things	3	Data analytics and visualisations	3	3D printing	0
Cybersecurity	3	Machine Learning	1	Blockchain	1
Cloud computing	3	Big Data	2	Drones	1

Others in this group (name + relevance): AI: 3, Smart sensors (related to IoT): 3, Augmented and Virtual reality: 2

Business and management skills

Project management	3	Quality management	1	Design thinking	3
Entrepreneurial thinking	2	Business process	2		

Others in this group (name + relevance): Public communication: 2, budgeting: 2

Soft skills

Leadership and management	3	Teamwork and collaboration	2	Problem solving	3
Managing through change	3	Critical thinking	3	Emotional intelligence	2
Interpersonal communication	2				

Others in this group (name + relevance): Creative and Innovative thinking: 3

Green skills

Circular economy	2	Waste management	3	Energy conservation	3

Others in this group (name + relevance): Sustainable mobility and transport: 2, Predictive maintenance (related to smart sensors): 3

Other skills (add any other important skills according to the reference) out of the categories:

Specify name and relevance (at least level 2 or 3):

Policies affecting smart cities applications: 2, micro and macroeconomics (fundamentals): 2, contracts drafting (administrative / legal): 2

Enabling technologies skills

Up to what extent are **skills in enabling technologies** important for smart city profiles?

X Essential ☐Relevant ☐Collateral ☐Not applicable ☐Not sure

Business and management skills

Up to what extent are **skills in business and management** important for smart city profiles?

X Essential ☐Relevant ☐Collateral ☐Not applicable ☐Not sure

Soft Skills

Up to what extent are **soft skills** important for smart city profiles?

☐Essential X Relevant ☐Collateral ☐Not applicable ☐Not sure

Green skills

Up to what extent are **green skills** important for smart city profiles?

X Essential ☐Relevant ☐Collateral ☐Not applicable ☐Not sure

Additional skills

- Up to what extent are **legal skills** (e.g. privacy) important for smart city profiles?

☐Essential X Relevant ☐Collateral ☐Not applicable ☐Not sure

In what big **group** they can be included:

☐ Technology ☐Business ☐ Green ☐Soft skills X Other or transversal

- Up to what extent are **sociology skills** (e.g. knowledge of human and society's habits and behaviours) important for smart city profiles?

☐Essential ☐Relevant X Collateral ☐Not applicable ☐Not sure

In what big group they can be included:

☐ Technology ☐Business ☐ Green ☐Soft skills X Other or transversal

- Up to what extent are urban **planning skills** (e.g. land use planning) important for smart city profiles?

☐Essential X Relevant ☐Collateral ☐Not applicable ☐Not sure

In what big group they can be included:

☐ Technology ☐Business X Green ☐Soft skills ☐ Other or transversal

Annex 2. Questions and statements of the survey

1. Functions and responsibilities

To what extent are the following functions important for smart city engineers (ICT oriented profile)?

- Design, plan, and develop technical and engineering specifications and solutions for projects from infrastructure optimizing materials and integrating specifications and resource allocation within time constraints.
- Oversee the project on daily basis and is responsible for high-quality results within objectives and constraints, ensuring effective use of resources. Responsible for risk and issue management, communication and stakeholder management
- Design, plan, manage and maintain cloud-based systems. Responsible for developing, implementing and debugging cloud-applications and handle migration of applications to cloud.
- Advise and implement solutions to control access to data and programs and ensure protection of processes. Responsible for protection and security of systems and network and design, plan and execute the system's security architecture, with models and security policies and procedures.
- Collect and interpret rich data sources, manage large amounts of data, merge sources, ensure consistency and create visualizations to aid in understanding data using mathematical models and communicate insights and findings to team and, if required, to non-experts and recommend ways to apply data.
- Design, integration and acceptance testing of automation systems integrating connected devices and smart appliances within residential facilities. Work with key stakeholders to ensure the desired project outcome including wire design, layout, appearance and component programming.

To what extent are the following functions important for smart city technician (ICT oriented profile)?

- Help in design and execution of plans and in organizational tasks, e.g. planning and monitoring, and in bidding and invoicing of development work, calculating, purchasing and organizing required resources and ensure quality of components. Can also develop and advise on policy implementing strategies for urban infrastructure (e.g., from traffic lights to water management systems).
- Develop and implement cloud-systems, handle migration of existing applications to cloud, and debug cloud environment.
- Propose and implement necessary security updates and measures whenever is required. Also advise, support, inform and provide training and security awareness.
- Import, clean, validate, model, or interpret collections of data for business goals and given criteria. Also ensure consistent and reliable data from sources and

repositories and prepare reports with visualizations such as graphs, charts, and dashboards.

● Install and maintain automation systems, connected devices, and smart appliances at customer sites. Also act as a user educator and resource for product and service recommendations for customers' needs for comfort, convenience, security and safety.

2. Relevance of our categories of skills for the profiles

To what extent is each category of skills important for smart city engineers, (ICT oriented profile)?

● Technical enabling technologies (IoT, security, cloud, data analytics, etc.)
● Business and management (management, quality, legal, business process, etc.)
● Soft skills (leadership, communication, accountability, etc.)
● Green skills (waste management, circular economy, energy conservation, etc.)

To what extent is each category of skills important for smart city technicians, (ICT oriented profile)?

● Technical enabling technologies (IoT, security, cloud, data analytics, etc.)
● Business and management (management, quality, legal, business process, etc.)
● Soft skills (leadership, communication, accountability, etc.)
● Green skills (waste management, circular economy, energy conservation, etc.)

3. Skills and knowledge for Engineers

According to your experience, to what extent are these skills and knowledge important for smart city engineers (ICT oriented profile)?

● IoT knowledge - principles, requirements, limitations and vulnerabilities of smart connected devices and automatic control systems for digital control, distribution saving and use of energy and information management.
● IoT skills - Design and calculate smart systems, based on grid load, duration curves, energy simulations, etc.
● Security knowledge - methods and standards to protect ICT systems, resources and users against illegal or unauthorized use, identifying, assessing and dealing with all types of risks including from cloud computing
● Security skills - Create strategy for safety and security, with set of rules and policies. Analyze systems to identify risks and implement procedures for identifying, assessing, mitigating them and prepare recovery plans

- Cloud knowledge - Technologies to access resources (hardware, software, services, etc.) through remote servers and software networks irrespective of location and architecture and metrics and alarms for monitoring services.
- Cloud skills - Design infrastructure (networks and architecture) to implement optimized cloud solutions for customer requirements, fault toleration, workload and business needs. Identify elastic and scalable and cost-effective solutions and remediate deployment issues
- Data Analytics knowledge - Statistical methods, practices and data techniques for collection, organization, structure of data elements, analysis, interpretation and presentation of data (local and cloud) to reinforce the human understanding.
- Data Analytics skills - define data quality criteria; perform data analysis with statistical techniques to interpret data to assess development and innovation.
- Machine Learning and Big Data knowledge - Big data technologies (machine learning, datamining, etc.) for smart cities to develop novel software ecosystems upon which advanced mobility functionalities emerge.
- Machine Learning and Big Data skills - Explore large datasets to reveal patterns using statistics, database or AI and present information in a comprehensible way.
- Business and Management knowledge - Management principles and methodologies for projects or for own business venture, identifying creative solutions and according to quality standards and legal dispositions.
- Business and Management skills - Manage and plan resources (budget, deadline, results, quality), according to codes of conduct, and monitor progress and changes according to customer requirements and advice in a creative and feasible way according to legal dispositions.
- Green knowledge - Political and technical processes to design urban environment and optimize land use considering aspects such as infrastructure, water, green and social spaces, circular economy, energy conservation and waste management.
- Green skills - Apply principles, policies and regulations aimed at environmental sustainability (e.g., reduction of waste, energy and water consumption, reuse and recycling, and sharing economy) and promote a sustainability-oriented mindset on urban ecological attitude and on environmental impact of behavior, applying measures to reduce pollution (air, noise, light, water or environmental).

4. Skills and knowledge for Technicians

According to your experience, to what extent are these skills and knowledge important for smart city technicians (ICT oriented profile)?

- IoT knowledge - Categories, requirements, limitations and vulnerabilities of smart connected devices and automatic control systems for digital control, distribution, saving and use of energy and information management.
- IoT skills - Install connected devices, (sensors, light switches, plugs, energy meters, cameras, etc.) and interconnect these devices to system and to relevant sensors.

- Security knowledge - Methods or pathways deployed by hackers to penetrate or target systems illegally and techniques and tools to detect and avert malicious attacks and protect ICT systems, resources and users
- Security skills - Analyze functioning and performance of systems to identify and categorize weaknesses and vulnerability to intrusions or attacks. Deploy diagnostic tools and resources to solve them including firewall configuration.
- Cloud Computing knowledge - Technical concepts of cloud technologies and organization schemes for digital data storage locally (hard-drives and RAM memories) and remotely, via network, internet or cloud.
- Cloud Computing skills - identify and execute steps to provision cloud resources, creating code that interacts with cloud services to implement functional requirements in application design and code and automate manual or repeatable processes.
- Data Analytics knowledge - Understanding statistical methods, practices and data techniques for collection, organization, structuring data elements, analysis, interpretation and presentation of data (local and cloud) to reinforce the human understanding of information.
- Data Analytics skills - Collect data from connected devices, detect and correct corrupt records from data sets (according to defined quality criteria) and normalize data to minimize dependency, eliminate redundancy and increase consistency
- Machine Learning and Big Data knowledge - principles, methods and algorithms of machine learning, statistics and data mining.
- Machine Learning and Big Data skills - Explore large datasets identifying patterns according to predefined methods with statistics, databases or AI and generate reports of information in a comprehensible way.
- Business and Management knowledge - Understanding methodologies behind management of projects or of own business venture, identifying applicable quality standards and legal dispositions.
- Business and Management skills - Manage resources (budget, deadline, results, quality) according to plans and control and report progress and changes according to customer requirements in a feasible way according to legal dispositions.
- Green knowledge - Understand processes behind urban environment design considering aspects such as infrastructure, water, green and social spaces, circular economy, energy conservation and waste management.
- Green skills - Follow policies and regulations aimed at environmental sustainability (e.g., reduction of waste, energy and water consumption, reuse and recycling, and sharing economy) and adopt sustainability-oriented mindset on ecological attitude and on environmental impact of behavior, implementing designed measures to reduce pollution (air, noise, light, water or environmental).

5. Soft skills

Soft skills for smart cities engineers (ICT oriented profile):

- Accountability (customer focus, diligence, reliability, efficiency)
- Communication (networking, negotiation, teamwork)
- Creativity (critical thinking, problem solving, decision making, initiative)
- Ethical behavior (respect diversity, respect environment, respect privacy)
- Leadership (coaching, conflict resolution, entrepreneurship, strategic thinking, motivate others, manage quality)
- Self-management (adaptability, organization, positive attitude, self-control, personal development)
- Tenacity (goal orientation, patience, motivation, resilience)

Soft skills for smart cities technicians (ICT oriented profile):

- Accountability (customer focus, diligence, reliability, efficiency)
- Communication (networking, negotiation, teamwork)
- Creativity (critical thinking, problem solving, decision making, initiative)
- Ethical behavior (respect diversity, respect environment, respect privacy)
- Leadership (coaching, conflict resolution, entrepreneurship, strategic thinking, motivate others, manage quality)
- Self-management (adaptability, organization, positive attitude, self-control, personal development)
- Tenacity (goal orientation, patience, motivation, resilience)

Annex 3. Mapping to ESCO

Smart Cities Engineer

Item	SMACITE description	Name in ESCO
IoT knowledge	Principles, requirements, limitations and vulnerabilities of smart connected devices and automatic control systems for digital control, distribution saving and use of energy and information management.	Internet of things
		Smart grids systems
		Building automation
IoT skills	Design and calculate smart systems, based on grid load, duration curves, energy simulations, etc.	Design smart grids
Security knowledge	Methods and standards to protect ICT systems, resources and users against illegal or unauthorized use, identifying, assessing and dealing with all types of risks including from cloud computing	Cyber security
		ICT security standards
		Risk management
		Cloud security and compliance
Security skills	Create strategy for safety and security, with set of rules and policies. Analyze systems to identify risks and implement procedures for identifying, assessing, mitigating them and prepare recovery plans	Verify formal ICT specifications
		Analyze ICT system
		Identify ICT security risks
		Develop information security strategy
		Ensure information security
		Perform risk analysis
		Define security policies
		Manage disaster recovery plans

Item	SMACITE description	Name in ESCO
		Implement ICT risk management
Cloud Computing knowledge	Technologies to access resources (hardware, software, services, etc.) through remote servers and software networks irrespective of location and architecture and metrics and alarms for monitoring services.	Cloud technologies
		Cloud monitoring and reporting
		SaaS (service-oriented modelling)
Cloud Computing skills	Design infrastructure (networks and architecture) to implement optimized cloud solutions for customer requirements, fault toleration, workload and business needs. Identify elastic and scalable and cost-effective solutions and remediate deployment issues	Deploy cloud resource
		Design cloud networks
		Design cloud architecture
Data analytics knowledge	Statistical methods, practices and data techniques for collection, organization, structure of data elements, analysis, interpretation and presentation of data (local and cloud) to reinforce the human understanding.	Statistics
		Data models
		Visual presentation techniques
		Unstructured data
		Manage cloud data and storage
Data analytics skills	Define data quality criteria; perform data analysis with statistical techniques to interpret data to assess development and innovation.	Manage data
		Interpret current data
		Apply statistical analysis techniques
		Perform data analysis
		Define data quality criteria
		Machine learning

Item	SMACITE description	Name in ESCO
Machine Learning and Big Data knowledge	Big data technologies (machine learning, datamining, etc.) for smart cities to develop novel software ecosystems upon which advanced mobility functionalities emerge.	Data mining
		Smart city features
Machine Learning and Big Data skills	Explore large datasets to reveal patterns using statistics, database or AI and present information in a comprehensible way.	Perform data mining
		Analyze big data
Business and Management knowledge	Management principles and methodologies for projects or for own business venture, identifying creative solutions and according to quality standards and legal dispositions.	Project management principles
		Project management
		Project management methodology
		Entrepreneur
		Design thinking
		Quality standards
Business and Management skills	Manage and plan resources (budget, deadline, results, quality), according to codes of conduct, and monitor progress and changes according to customer requirements and advice in a creative and feasible way according to legal dispositions.	Perform project management
		Follow company standards
		Manage project changes
		Manage budgets
		Manage project information
		Manage staff
		Obtain permits for use of public spaces
		Identify customer requirements

Item	SMACITE description	Name in ESCO
		Perform smart grid feasibility study
		Advise customers on smart homes technology
		Stimulate creative processes
		Manage quality
Green knowledge	Political and technical processes to design urban environment and optimize land use considering aspects such as infrastructure, water, green and social spaces, circular economy, energy conservation and waste management.	Urban planning
		Circular economy
		Energy efficiency
		Waste management
Green skills	Apply principles, policies and regulations aimed at environmental sustainability (e.g., reduction of waste, energy and water consumption, reuse and recycling, and sharing economy) and promote a sustainability-oriented mindset on urban ecological attitude and on environmental impact of behavior, applying measures to reduce pollution (air, noise, light, water or environmental).	Promote sustainability
		adopt ways to reduce negative impact of consumption
		advise on sustainability solutions

Smart Cities Technician

Item	SMACITE description	Name in ESCO
IoT knowledge	Categories, requirements, limitations and vulnerabilities of smart connected devices and automatic control systems for digital control, distribution, saving and use of energy and information management.	Internet of things
		Smart grids systems
		Building automation
IoT skills	Install connected devices, (sensors, light switches, plugs, energy meters, cameras, etc.) and interconnect these devices to system and to relevant sensors.	Install smart devices
Security knowledge	Methods or pathways deployed by hackers to penetrate or target systems illegally and techniques and tools to detect and avert malicious attacks and protect ICT systems, resources and users	Cybersecurity
		Cyber-attack counter-measures
		Attack vectors
Security skills	Analyze functioning and performance of systems to identify and categorize weaknesses and vulnerability to intrusions or attacks. Deploy diagnostic tools and resources to solve them including firewall configuration.	Analyze ICT system
		Identify ICT system weaknesses
		Solve ICT system problems
		Define firewall rules
Cloud Computing knowledge	Technical concepts of cloud technologies and organization schemes for digital data storage locally (hard-drives and RAM memories) and remotely, via network, internet or cloud.	Cloud technologies
		Data storage
Cloud Computing skills	Identify and execute steps to provision cloud resources, creating code that interacts with cloud services to implement functional requirements in	Deploy cloud resource
		Automate cloud tasks

Item	SMACITE description	Name in ESCO
	application design and code and automate manual or repeatable processes.	Develop with cloud services
Data analytics knowledge	Understanding statistical methods, practices and data techniques for collection, organization, structuring data elements, analysis, interpretation and presentation of data (local and cloud) to reinforce the human understanding of information.	Statistics
		Data models
		Visual presentation techniques
		Unstructured data
		Manage cloud data and storage
		Automatic meter reading
Data analytics skills	Collect data from connected devices, detect and correct corrupt records from data sets (according to defined quality criteria) and normalize data to minimize dependency, eliminate redundancy and increase consistency	Perform data cleansing
		Collect ICT data
		Normalize data
		Manage data
Machine Learning and Big Data knowledge	Principles, methods and algorithms of machine learning, statistics and data mining.	Machine learning
		Data mining
Machine Learning and Big Data skills	Explore large datasets identifying patterns according to predefined methods with statistics, databases or AI and generate reports of information in a comprehensible way.	Perform data mining
		Analyze big data
Business and Management knowledge	Understanding methodologies behind management of projects or of own business venture, identifying applicable quality standards and legal dispositions.	Business management principles
		Quality standards
		Manage resources

Item	SMACITE description	Name in ESCO
Business and Management skills	Manage resources (budget, deadline, results, and quality) according to plans and control and report progress and changes according to customer requirements in a feasible way according to legal dispositions.	Analyze goal progress
		Comply with legal regulations
Green knowledge	Understand processes behind urban environment design considering aspects such as infrastructure, water, green and social spaces, circular economy, energy conservation and waste management.	Urban pollution implications
		Circular economy
Green skills	Follow policies and regulations aimed at environmental sustainability (e.g., reduction of waste, energy and water consumption, reuse and recycling, and sharing economy) and adopt sustainability-oriented mindset on ecological attitude and on environmental impact of behavior, implementing designed measures to reduce pollution (air, noise, light, water or environmental).	Assess the life cycle of resources
		Ensure compliance with environmental legislation

Annex 4. Questions of expert interviews

Day and starting time: xx / xx / 2022, at xx:xx

Mode: [] Online [] F2F

Full name of expert:

Affiliation:

Briefly describe your **experience in smart cities** projects or in equivalent systems which involve embedded or distributed systems or technologies like IOT, Cloud technology, etc. which are typical part of Smart Cities solutions.

1. Function for roles were extracted from descriptions of applicable related occupations in ESCO, the EU labor classification, as there were no specific profiles available for Smart Cities. Given the results of functions allocated to the role of engineer and to the one of technician for Smart Cities projects, there are some differences: e.g., one very relevant is that technician have clearly less presence in data management than engineer, and normally lower levels of presence in the rest.

   ● Do you think the differences between profile of engineer and the one for technician represent well the reality?

   ● Do you miss any function for the profiles or simply suggest some rewording or change in description of listed functions?

2. We detect that the allocation of importance to general skills and knowledge categories is normally significantly different to the ones allocated to more detailed knowledge items and skills, e.g., the importance of the category of soft skills is clearly less than the importance given to individual groups of soft skills (e.g., accountability, communication, etc.). Sometimes the effect is the opposite: more importance to a category such as business and management than to detailed knowledge or skills of that category.

   ● Do you think this could indicate that stakeholders are missing specific items in the list presented for each skills category?

   ● Do you miss any especially important skills or knowledge for the profiles or simply suggest some rewording or change in description of the ones listed?

3. There are items in the survey results that have collected less than 50% of responses in the essential and relevant values of the scale for a specific profile: e.g., green knowledge (42%) or business and management knowledge (43%) for technician.

   ● Do you think that the items below 50% should be kept in profiles or discarded or do you prefer presenting items with a scale of importance such as essential and optional (like in the ESCO labor classification) or other?
   ● Do you think that the items discarded or marked as marginal for the profile should be excluded from training itineraries for Smart Cities technician or Engineer? Or would you keep them as short complementary modules to ensure a complete coverage of all possible items?

4. Respondents of survey tend to allocate more importance to skills over knowledge in technicians while in the case of engineers knowledge is at the same level or higher in the different items. What do you think?

5. Respondents with higher self-declared qualification tend to allocate higher importance to more items than the ones with lower qualification (e.g., Machine Learning, Business and Management, Green skills, etc.)

   ● Do you think that opinion of those with higher self-declared qualification should be overweighed when developing the profiles?

6. After seeing the proposed profile for Smart Cities engineer and for Smart Cities technician:

   ● Would you change something?

   ● Do you think that the process followed to develop them is solid enough to recommend these profiles as main and trustable reference for those occupations? Briefly highlight possible strong points and weaknesses of the process.

Annex 5. Expert interviews

Expert 1 (interview by UAH)

Day and starting time: 29 / 09 / 2022, at 10:45

Mode: X Online [] F2F

Affiliation: Security and safety manager, Indra

Briefly describe your experience in smart cities projects or in equivalent systems which involve embedded or distributed systems or technologies like IOT, Cloud technology, etc. which are typical part of Smart Cities solutions.

My experience is focused on two programmes, one for the Defence market and one for the Transport and Traffic market where cloud-based technologies are used. Part of the functions that are implemented with these technologies have certain safety implications and my role is to ensure that all potentially dangerous situations are identified and the necessary measures are put in place to eliminate their risk and reduce them to an acceptable level.

1. **Function for roles were extracted from descriptions of applicable related occupations in ESCO, the EU labor classification, as there were no specific profiles available for Smart Cities. Given the results of functions allocated to the role of engineer and to the one of technician for Smart Cities projects, there are some differences: e.g., one very relevant is that technician have clearly less presence in data management than engineer, and normally lower levels of presence in the rest.**

1.1 **Do you think the differences between profile of engineer and the one for technician represent well the reality?**
In the programmes where I work, the profiles are even more hierarchical.
Normally the management tasks are usually carried out by engineering profiles and generally, the engineers are more oriented towards design and the technicians towards production, construction or maintenance. So it could be said from the results of the questionnaire and comparing it with the projects in which I work, being very multidisciplinary, with more than 100 or 200 people per project, they would reflect the reality.

1.2 **Do you miss any function for the profiles or simply suggest some rewording or change in description of listed functions?**
In the case of engineers, part of this work is reporting to senior or middle management, although this is part of the management that engineers, not technicians, do. And the technical management of teams, this is done by engineers, and these teams are themselves made up of engineers/technicians.

2. We detect that the allocation of importance to general skills and knowledge categories is normally significantly different to the ones allocated to more detailed knowledge items and skills, e.g., the importance of the category of soft skills is clearly less than the importance given to individual groups of soft skills (e.g., accountability, communication, etc.). Sometimes the effect is the opposite: more importance to a category such as business and management than to detailed knowledge or skills of that category.

2.1 Do you think this could indicate that stakeholders are missing specific items in the list presented for each skills category?

Not necessarily, what happens is that in highly technical environments such as this one, more importance is given to the technical part "Knowledge & Skills" than to the "Soft skills" part. But this is normal, if the questionnaire was addressed to non-technical staff or rather to management, or areas like HR, etc. It is likely that "soft skills" would be more relevant, but the objective of this study would be lost.

2.2 Do you miss any especially important skills or knowledge for the profiles or simply suggest some rewording or change in description of the ones listed?

In "soft skills", we talk about "accountabilities", I would add "responsibilities", the translation to Spanish is the same, but they have different meanings. Accountabilities" cannot be delegated and are more associated with management (engineers) while "responsibilities" can, and this would be more oriented towards technicians, although it is also applicable to engineers.

3. There are items in the survey results that have collected less than 50% of responses in the essential and relevant values of the scale for a specific profile: e.g., green knowledge (42%) or business and management knowledge (43%) for technician.

3.1 Do you think that the items below 50% should be kept in profiles or discarded or do you prefer presenting items with a scale of importance such as essential and optional (like in the ESCO labor classification) or other?

I think not, in some cases, because they are very relevant, such as Machine Learning, big data, etc.), but the fact that in this case it is less than 50% may be due to the type of training, normally engineers have a very solid training and these concepts are very well studied, while technicians may not.

Others such as "Green Knowledge" or "Green Skills", for example, I personally found it difficult to understand the concept and perhaps that is why it was less valued; perhaps a short introduction in the questionnaire, to explain in a few lines what each thing is, would facilitate its valuation.

It is evident that the Management part (Business and Management) is more oriented towards engineers and that is why it is less valued by technicians.

3.2 **Do you think that the items discarded or marked as marginal for the profile should be excluded from training itineraries for Smart Cities technician or Engineer? Or would you keep them as short complementary modules to ensure a complete coverage of all possible items?**

Yes, see the previous answer. Generally technicians do not manage "Business Management" and in other areas it is just necessary to clarify the concept.

3.3 **Respondents of survey tend to allocate more importance to skills over knowledge in technicians while in the case of engineers knowledge is at the same level or higher in the different items. What do you think?**

It could be because the vision of engineers is much broader, due to their training or their situation within the hierarchy of the company, managing teams, etc. Moreover, that means that the importance is more distributed, as for them the technical part is not the most important thing, everything must be homogeneous. Whereas technicians are much more oriented towards development and the technical part, and they do not have that vision.

4. **Respondents with higher self-declared qualification tend to allocate higher importance to more items than the ones with lower qualification (e.g., Machine Learning, Business and Management, Green skills, etc.)**

4.1 **Do you think that opinion of those with higher self-declared qualification should be overweighed when developing the profiles?**

Probably the higher self-reported qualification is directly related to experience and that may imply more knowledge and easier to answer because their vision is broader. However, on the other hand, people with more knowledge and experience tend over time to do more of the management side of the business, leaving the more technical activities to one side.

5. **After seeing the proposed profile for Smart Cities engineer and for Smart Cities technician:**

5.1 **Would you change something?**

No, in my experience it reflects the reality of the projects I work on.

5.2 **Do you think that the process followed to develop them is solid enough to recommend these profiles as main and trustable reference for those occupations? Briefly highlight possible strong points and weaknesses of the process.**

Yes, I think that is right.

Expert 2 (interview by CADM)

Day and starting time: 29 / 09 / 2022, at 11:30

Mode: X Online [] F2F

Affiliation: Asociación IoT open Tech

Briefly describe your experience in smart cities projects or in equivalent systems which involve embedded or distributed systems or technologies like IOT, Cloud technology, etc. which are typical part of Smart Cities solutions.

As president of the IoT open Tech association I have the opportunity to advise and train our members on issues related to all sectors in which IoT technology is providing new solutions or greater efficiency to existing ones, such as industrial management (digital twin), precision agriculture and farming, supply chain monitoring (logistics), efficiency (energy, thermal, water...), supply network management (water and gas), among the most relevant.

We also organize outreach and citizen science activities with the aim of facilitating access to IoT solutions of general interest, such as the use of pollution sensor networks (atmospheric and acoustic), management of urban gardens, construction of CO2 sensors as a support tool to the prevention of COVID, geolocation of people (for example, locating children or dependent people), pets and other assets.

More specifically, in the Smart Cities sector, we have participated in risk and breakdown detection projects in residential communities (supply cutoffs, floods, preventive maintenance of pressure pumps...), monitoring of irrigation networks, capacity control, waste collection management, fauna and pest control, and optimization of energy efficiency in home and building automation.

1. Function for roles were extracted from descriptions of applicable related occupations in ESCO, the EU labor classification, as there were no specific profiles available for Smart Cities. Given the results of functions allocated to the role of engineer and to the one of technician for Smart Cities projects, there are some differences: e.g., one very relevant is that technician have clearly less presence in data management than engineer, and normally lower levels of presence in the rest.

1.1 Do you think the differences between profile of engineer and the one for technician represent well the reality?
Yes, except for the development of cloud-based systems.
In Smart City solutions, IoT and Big Data techniques essentially converge, supported in some cases by AI techniques, the three are correctly identified in the functions of both profiles. Other techniques intervene auxiliary or transversally, such as deployment and computer security, business administration, and corporate social

responsibility (including environmental issues), also included in some of the categories.

Within these functional categories, the distinction made between engineers and technicians also corresponds to reality. Engineers perform tasks of solution design (including the preparation of specifications and proposals), development and/or deployment of tools (such as IoT platforms, or AI models), calculation and analysis of data, programming of auxiliary modules, organization of tasks, integration of information flows, and even research (such as attendance at conferences/fairs, or collaborations with universities, to identify new business opportunities). Technicians focus on installation, maintenance (who also benefit from the skills to handle tools that allow them to detect failures, such as those based on Big Data and AI), and commercial issues.

Regarding the exception mentioned at the beginning, in my experience, the development of cloud-based systems is a function that, except in large-scale projects or those that require absolute control of the infrastructure, generally does not address the engineer profile nor technical, because either they are delegated to external providers specialized in computer engineering, who offer PaaS or IaaS modalities, or specific tools are contracted directly in SaaS modality. The development of cloud-based computing systems entails such high complexity and attention/maintenance demands that it constitutes a field of specialization by itself. In our sector, engineers or technicians are limited to selecting, configuring, properly sizing, and monitoring these systems..

1.2 Do you miss any function for the profiles or simply suggest some rewording or change in description of listed functions?

Beside the exception made above regarding cloud systems, it is increasingly common to shift a part (sometimes very substantial) of the processing load from the cloud to the edge (Edge), whether it is at the doors of access (gateways) of the sensors/actuators to the Internet, or in the sensors/actuators themselves, seeking a reduction in the volume of data to be transmitted (and the corresponding energy savings), or even greater protection of privacy by avoiding, for example, transmit audio/video streams.

This displacement of the processing load to the edge requires knowledge/skills such as statistical analysis, normalization and data aggregation, or the choice, training and deployment of AI models, and it is the responsibility of the engineers/technicians who offer Smart City solutions because it depends on the particular conditions of each use case that in many cases can only be established with the final installation of the sensor/actuator, so I propose that it be included as an explicit function of both profiles..

2. We detect that the allocation of importance to general skills and knowledge categories is normally significantly different to the ones allocated to more detailed knowledge

items and skills, e.g., the importance of the category of soft skills is clearly less than the importance given to individual groups of soft skills (e.g., accountability, communication, etc.). Sometimes the effect is the opposite: more importance to a category such as business and management than to detailed knowledge or skills of that category.

2.1 Do you think this could indicate that stakeholders are missing specific items in the list presented for each skills category?

No.

Regarding soft skills, they are always desirable individual skills, but not necessarily essential. Their importance will depend on the role that each engineer/technician performs, and although they can undoubtedly be acquired or improved through training and education, they also largely depend on the character of each individual, their motivations and their vocation. I believe that it is normal that individually they are considered important, but as a whole compared to other categories they acquire less relevance, because either they can be balanced between the various members of a team, or they can be fostered through adequate recruitment and management of human resources.

Regarding Business and Management category, it is probably identified as a whole as essential for the viability of the business, but individually it deals with skills/knowledge that can be assumed by other less specific or more transversal profiles, such as those corresponding to the departments of accounting, commercial or quality, and are not essential, or at least not essential for engineers/technicians..

2.2 Do you miss any especially important skills or knowledge for the profiles or simply suggest some rewording or change in description of the ones listed?

Although they can be considered implicitly included in the existing categories, due to their importance I believe that the following should be specifically mentioned:

● Paperwork management: Version control systems and repositories.
● Fleet management: The large number of devices that are generally involved in Smart City solutions require specific management techniques for firmware updates, deployment policies, sensor calibration control…
● Block chains applications and other techniques related to cryptocurrencies to data traceability and micropayments (data monetization, such as WeatherMX, or infrastructure deployment incentives, such as Mesh+).
.

3. There are items in the survey results that have collected less than 50% of responses in the essential and relevant values of the scale for a specific profile: e.g., green knowledge (42%) or business and management knowledge (43%) for technician.

3.1 Do you think that the items below 50% should be kept in profiles or discarded or do you prefer presenting items with a scale of importance such as essential and optional (like in the ESCO labor classification) or other?

Personally, regarding Green knowledge/skills and Business and management knowledge/skills, I would keep both in the technician profile (and of course in the engineer profile).

I consider that the Business and management knowledge/skills, as described in the proposal, limit their scope to what is strictly necessary so that the technical profile can understand the motivations of efficiency, quality or legal that justify the applied production methodologies, and collaborate in the preparation of budgets and delivery deadlines. Without this understanding, motivation could be reduced, and even affect communication "upstream" of potential risks or opportunities for improvement.

Regarding the Green knowledge/skills, taking into account that many of the Smart City- solutions seek to improve the efficiency of the use of resources (lighting management, irrigation, energy efficiency in buildings...), it is essential that the technical profile is aware of these aspects. Additionally, some Smart City solutions require the installation of a large number of devices that hardly need maintenance, so their life cycle is apparently reduced to installation, start up, and withdrawal, tasks that fall under the technical profile. But the withdrawal cannot be the end, especially taking into account the volume of devices and their content of potentially dangerous elements for the environment such as batteries, but it must be followed by proper waste management, either oriented towards the recycling or reuse.

3.2 Do you think that the items discarded or marked as marginal for the profile should be excluded from training itineraries for Smart Cities technician or Engineer? Or would you keep them as short complementary modules to ensure a complete coverage of all possible items?

As I said before, I would not rule out any of the elements proposed for the profiles, all of them should be included in the training plan. However, the scope with which they should be treated does have to be modulated to accommodate real functions; for example, cloud development knowledge and skills should have a generic treatment for both engineers and technicians, since it is a task that they will most likely not develop and, in any case, due to its great breadth and rapid evolution pace would require a very notable effort to master them compared to the rest of the content. Regarding the other knowledge and skills, as described in the proposal, it seems to me that they have an adequate and reasonable scope for a training plan for the engineer and technician level (enlarging them with those indicated in question 3.2)..

3.3 Respondents of survey tend to allocate more importance to skills over knowledge in technicians while in the case of engineers knowledge is at the same level or higher in the different items. What do you think?

I agree.

Currently, most projects adopt agile work methodologies or even DevOps, which seek to speed up the development cycle. This makes it necessary to select existing tools for generic tasks and concentrate efforts on adapting or configuring them to the specific objective of the company, reducing the development of new code to the essential minimum. This, together with the fact that engineers usually are in the previous level (strategic) to that of technicians in the company´s line of command (operational level), implies that an important part of the work of engineers is to select the tools that are going to be used, whether they are infrastructures, platforms, applications or frameworks. This selection requires depth knowledge of the state of the art in each sector, in which new developments follow one another at a dizzying pace, and not so much an ability to handle them.

On the contrary, once the tools are chosen, technicians can specialize their skills in using them and get the best possible performance from them. In this daily work, they often encounter difficulties or limitations not initially foreseen, so, as indicated above, it is important for the technician to understand the business processes so as to boost "upstream" communication of these incidents..

4. Respondents with higher self-declared qualification tend to allocate higher importance to more items than the ones with lower qualification (e.g., Machine Learning, Business and Management, Green skills, etc.)

4.1 Do you think that opinion of those with higher self-declared qualification should be overweighed when developing the profiles?

Yes.

The IoT, Big Data and AI sectors, which are the basis of Smart City solutions, are relatively "young" or have advanced dramatically driven by recent innovations, so it is likely that the best qualified individuals have had to acquire their knowledge and skills in a self-taught way, especially considering that the supply of regulated training in these fields has not started to be available until very recently. This self-training process requires investigating, trying, making mistakes and discarding technologies in pursuit of a specific business objective, and taking into account that Smart Cities is a sector in which a "star application" (killer app), beyond the evolution of some such as consumption meters or intelligent lighting management, I consider that the experience accumulated by these individuals is of great value and, in my opinion, provides a better informed opinion..

5. After seeing the proposed profile for Smart Cities engineer and for Smart Cities technician:

5.1 Would you change something?

The identification of functions, knowledge and skills of both profiles seems to me complete and adequate.

In my opinion, the burden of cloud solution development knowledge and skills should be reduced, and displaced, or at least balanced, with edge solution development.

Also I believe that advances in the block chain and similar technologies can have an application and impact on Smart City solutions, such as data traceability, or the formalization of smart contracts between peers that allow the integration of different data sources, so they should be added to these profiles.

Finally, since the purpose of Smart City solutions is usually to improve the efficiency of processes, that efficiency must also include sustainability and, more broadly, corporate social responsibility, so I would personally keep them both in functions as in training plans with a modulated scope.

5.2 Do you think that the process followed to develop them is solid enough to recommend these profiles as main and trustable reference for those occupations? Briefly highlight possible strong points and weaknesses of the process.

Yes.

As a particular strength, it is remarkable to me that all the functions involved in the Smart City solutions have been identified in a very complete way, and that the scope of the description of the knowledge and skills of both profiles adjusts very well to the reality of my personal experience.

As a weak point or an aspect that could be improved, it worries me that in the survey sample only 40% declare to have professional experience in the Smart City sector, which implies that more than half of the answers are based on impressions with less real support. However, the results of the survey are quite in line with my personal perception of the needs of the sector, with the exceptions already indicated above.

Expert 3 (interviewed by GAIA)

Day and starting time: 03/ 10 / 2022, at 9:00h

Mode: X Online [] F2F

Affiliation: Basque Game

Briefly describe your experience in smart cities projects or in equivalent systems which involve embedded or distributed systems or technologies like IOT, Cloud technology, etc. which are typical part of Smart Cities solutions.

In Basque Game, the projects in which we participate aimed at smart cities, involve the development and use of technology, which is the part of the knowledge basque game provides. Some of these solutions have to do with IoT, for example, to measure noise in cities, iot issues for data exploitation or if we are talking about tourism, solutions linked to security and cybersecurity based on blokchain technologies, etc.

We are mainly involved in regional and national projects.

1. Function for roles were extracted from descriptions of applicable related occupations in ESCO, the EU labor classification, as there were no specific profiles available for Smart Cities. Given the results of functions allocated to the role of engineer and to the one of technician for Smart Cities projects, there are some differences: e.g., one very relevant is that technician have clearly less presence in data management than engineer, and normally lower levels of presence in the rest.

1.1 **Do you think the differences between profile of engineer and the one for technician represent well the reality?**
    In general terms, yes, the engineer profile is more linked to greater knowledge and is more relevant than perhaps the technical profile, which is more associated with skills. Although a technician specialising in something specific, for example, a certain technology, may have greater knowledge than an engineer, may be more expert, or possess greater knowledge in general terms...

1.2 **Do you miss any function for the profiles or simply suggest some rewording or change in description of listed functions?**
    Perhaps from the point of view of engineers, some competences on knowing how to distinguish and analyse governmental and management policies of cities in the different fields of urban development and in methodologies of citizen participation. In relation to both profiles (engineers and technicians), aspects linked to creativity, design thinking....

2. We detect that the allocation of importance to general skills and knowledge categories is normally significantly different to the ones allocated to more detailed knowledge

items and skills, e.g., the importance of the category of soft skills is clearly less than the importance given to individual groups of soft skills (e.g., accountability, communication, etc.). Sometimes the effect is the opposite: more importance to a category such as business and management than to detailed knowledge or skills of that category.

2.1 Do you think this could indicate that stakeholders are missing specific items in the list presented for each skills category?

It is difficult to answer this question but I sincerely do not think that those stakeholders are missing specific elements from the list, which has been presented to them for each category of competencies.

2.2 Do you miss any especially important skills or knowledge for the profiles or simply suggest some rewording or change in description of the ones listed?

Based on my personal experience and within the field of the Basque Game, as well as similar experiences in which we have been able to collaborate, we believe that both the skills and/or knowledge identified are correct as well as their descriptions.

3. There are items in the survey results that have collected less than 50% of responses in the essential and relevant values of the scale for a specific profile: e.g., green knowledge (42%) or business and management knowledge (43%) for technician.

3.1 Do you think that the items below 50% should be kept in profiles or discarded or do you prefer presenting items with a scale of importance such as essential and optional (like in the ESCO labor classification) or other?

In the case of technical profiles, items below 50% can perhaps be discarded, as we understand that it is not so much the task of a technician to know about management and finance, for example, but other functions such as assisting in the design, development, planning and supervision of solutions, and advising on the implementation of infrastructures, etc. Already collected and with ratings above 50%.

3.2 Do you think that the items discarded or marked as marginal for the profile should be excluded from training itineraries for Smart Cities technician or Engineer? Or would you keep them as short complementary modules to ensure a complete coverage of all possible items?

In general terms, if, in both cases, we are talking about general engineers and technicians, we could leave out all the items. And more on the technical side, in the case that we are targeting technical specialists, perhaps we could remove them and put the focus on the most ad-hoc and necessary items for them.

3.3   Respondents of survey tend to allocate more importance to skills over knowledge in technicians while in the case of engineers knowledge is at the same level or higher in the different items. What do you think?

Perhaps this could be because a technician is understood to have mastered the subject, i.e. knowledge, and perhaps has more need, either to train, etc. in other types of skills (leadership, management, communication, etc.).

In relation to the profiles of engineers, it is necessary and of interest to master both knowledge and skills, due to the performance of their functions, roles and responsibilities that tend to be in the jobs they perform.

4.   Respondents with higher self-declared qualification tend to allocate higher importance to more items than the ones with lower qualification (e.g., Machine Learning, Business and Management, Green skills, etc.)

4.1   Do you think that opinion of those with higher self-declared qualification should be overweighed when developing the profiles?

This may be a point to consider, but perhaps more than this I would be in favor of considering the opinion of people with more experience and expertise in the field of smart cities and/or in the field of designing both hard and soft skills and competences.

5.   After seeing the proposed profile for Smart Cities engineer and for Smart Cities technician:

5.1   Would you change something?

In preliminary, no. It seems to me that a good job has been done, both at the level of concept and items, as well as the exploitation of the responses to the questionnaire, resulting, therefore, in a very complete work.

5.2   Do you think that the process followed to develop them is solid enough to recommend these profiles as main and trustable reference for those occupations? Briefly highlight possible strong points and weaknesses of the process.

As I have been informed, the questionnaire has had more than 130 responses. I think it is a representative sample, so I consider that a solid process has been carried out, in fact, many of the items have very high scores, and so it may be an evidence of the kind of knowledge-skills that these profiles should require.

As a weak point, it may be the case that we do not know whether the survey responses have been provided by experts in the field and from a reflective perspective.

Expert 4 (interviewed by BASSCOM)

Day and starting time: 30/ 09 / 2022, at 10:00h

Mode: X Online [] F2F

Affiliation: Nemetschek Bulgaria Ltd. (Software company) / BASSCOM

Briefly describe your experience in smart cities projects or in equivalent systems which involve embedded or distributed systems or technologies like IOT, Cloud technology, etc. which are typical part of Smart Cities solutions.

Ognyan Petrov is the development teams' director at Nemetschek Bulgaria Ltd. He has more than 15 years of experience at software projects and almost 10 years at management positions.

Mr. Petrov has taken part in the design and execution of numerous projects in the fields of Property and Facility Management, Energy Management and optimizations, Agriculture, etc. Some of the technologies used are cloud computing, IoT, BI, Big Data, etc..

1. Function for roles were extracted from descriptions of applicable related occupations in ESCO, the EU labor classification, as there were no specific profiles available for Smart Cities. Given the results of functions allocated to the role of engineer and to the one of technician for Smart Cities projects, there are some differences: e.g., one very relevant is that technician have clearly less presence in data management than engineer, and normally lower levels of presence in the rest.

1.1 Do you think the differences between profile of engineer and the one for technician represent well the reality?
According to the expert, the findings of the survey correspond to reality. Usually, engineers are in charge of more complex and complicated projects/tasks.

1.2 Do you miss any function for the profiles or simply suggest some rewording or change in description of listed functions?
The expert would like to validate the survey results – according to him the profiles / functions of Smart City Engineers and Smart City Technicians are sufficiently detailed and well formulated.

2. We detect that the allocation of importance to general skills and knowledge categories is normally significantly different to the ones allocated to more detailed knowledge items and skills, e.g., the importance of the category of soft skills is clearly less than the importance given to individual groups of soft skills (e.g., accountability, communication, etc.). Sometimes the effect is the opposite: more importance to a category such as business and management than to detailed knowledge or skills of that category.

2.1   Do you think this could indicate that stakeholders are missing specific items in the list presented for each skills category?
This partial discrepancy in results may have occurred due to the generalized and stereotyped perception of the respondents when answering the general skills and knowledge questions for both engineers and technicians. When going into detailed knowledge and skill categories we get the actual important values.

2.2   Do you miss any especially important skills or knowledge for the profiles or simply suggest some rewording or change in description of the ones listed?
Deficiencies in the described skills or knowledge for the profiles have not been defined.

3.   There are items in the survey results that have collected less than 50% of responses in the essential and relevant values of the scale for a specific profile: e.g., green knowledge (42%) or business and management knowledge (43%) for technician.

3.1   Do you think that the items below 50% should be kept in profiles or discarded or do you prefer presenting items with a scale of importance such as essential and optional (like in the ESCO labor classification) or other?

The items below 50 % should be kept in the profiles. Green skills are equally important for both engineers and technicians. Technicians could benefit from Business and Management skills in their future professional development.

3.2   Do you think that the items discarded or marked as marginal for the profile should be excluded from training itineraries for Smart Cities technician or Engineer? Or would you keep them as short complementary modules to ensure a complete coverage of all possible items?
They could be kept as short complementary modules, but this decision should be made by the project team themselves depending on the available resources.

3.3   Respondents of survey tend to allocate more importance to skills over knowledge in technicians while in the case of engineers knowledge is at the same level or higher in the different items. What do you think?
This observation reflects the real situation and requirements for engineers and technicians as they are.

4.   Respondents with higher self-declared qualification tend to allocate higher importance to more items than the ones with lower qualification (e.g., Machine Learning, Business and Management, Green skills, etc.)

4.1 Do you think that opinion of those with higher self-declared qualification should be overweighed when developing the profiles?

To a certain extent yes. The training program should be as comprehensive as possible.

5. After seeing the proposed profile for Smart Cities engineer and for Smart Cities technician:

5.1 Would you change something?

Nothing to change at this stage. The profiles seem sufficiently focused and at the same time comprehensive.

5.2 Do you think that the process followed to develop them is solid enough to recommend these profiles as main and trustable reference for those occupations? Briefly highlight possible strong points and weaknesses of the process.

The process seems to be solid enough and the results produced seem to be relevant. The strong points are the survey and the analysis themselves as well as the presentation of results. No weaknesses have been identified.

Expert 5 (interview by Digital SME)

Day and starting time: 04 / 10 / 2022, at 11:45

Mode: X Online [] F2F

Affiliation: Huna (https://huna.io/)

Briefly describe your experience in smart cities projects or in equivalent systems which involve embedded or distributed systems or technologies like IOT, Cloud technology, etc. which are typical part of Smart Cities solutions.

Business development for the company Huna. To explore different markets, contacting and maintaining relations with clients and contributing to final the plan.

Cultivating relationship with local governments and making policy makers more sensitive against smart cities policies and the need they have for the city.

1. Function for roles were extracted from descriptions of applicable related occupations in ESCO, the EU labor classification, as there were no specific profiles available for Smart Cities. Given the results of functions allocated to the role of engineer and to the one of technician for Smart Cities projects, there are some differences: e.g., one very relevant is that technician have clearly less presence in data management than engineer, and normally lower levels of presence in the rest.

1.1 Do you think the differences between profile of engineer and the one for technician represent well the reality?
Yes. Not only because technicians have less experience and presence in data management, but also because they do not have the whole picture of a smart cities project. Not having the big picture means less skills to stir the project with the needs of cities and citizens in mind.

1.2 Do you miss any function for the profiles or simply suggest some rewording or change in description of listed functions?
No.

2. We detect that the allocation of importance to general skills and knowledge categories is normally significantly different to the ones allocated to more detailed knowledge items and skills, e.g., the importance of the category of soft skills is clearly less than the importance given to individual groups of soft skills (e.g., accountability, communication, etc.). Sometimes the effect is the opposite: more importance to a category such as business and management than to detailed knowledge or skills of that category.

2.1   Do you think this could indicate that stakeholders are missing specific items in the list presented for each skills category?

No, the list appears complete.

2.2   Do you miss any especially important skills or knowledge for the profiles or simply suggest some rewording or change in description of the ones listed?

There should be less specialization for what concerns technicians and engineers. It would be preferable to see technicians having clear in mind what is the goal of a smart city project (societal impact, awareness of the policy implications, etc.).

As for engineers, if they are too specialized, they can lose the sight of the goal, the sense of the project, the specific needs of decision makers and citizens as well. They can miss all this if too specialized in hard skills (electronics, etc.). Losing the sight of the societal goal (community-oriented goal) is the most important issue to tackle.

3.   There are items in the survey results that have collected less than 50% of responses in the essential and relevant values of the scale for a specific profile: e.g., green knowledge (42%) or business and management knowledge (43%) for technician.

3.1   Do you think that the items below 50% should be kept in profiles or discarded or do you prefer presenting items with a scale of importance such as essential and optional (like in the ESCO labor classification) or other?

No. It does not make sense to discard an item only because it scored less than 50%. As said before, transversal skills are an essential add-on to the technical skills to understand a smart city project.

3.2   Do you think that the items discarded or marked as marginal for the profile should be excluded from training itineraries for Smart Cities technician or Engineer? Or would you keep them as short complementary modules to ensure a complete coverage of all possible items?

No. On the contrary, there should be training on them. This is how technicians and engineers could bridge the gap.

3.3   Respondents of survey tend to allocate more importance to skills over knowledge in technicians while in the case of engineers knowledge is at the same level or higher in the different items. What do you think?

It makes sense. It´s a cultural gap that we are paying as a community as we see engineers more "knowledgeable" and less "practical", whereas it happens the opposite with technicians..

4. Respondents with higher self-declared qualification tend to allocate higher importance to more items than the ones with lower qualification (e.g., Machine Learning, Business and Management, Green skills, etc.)

4.1 Do you think that opinion of those with higher self-declared qualification should be overweighed when developing the profiles?
Not easy to define. The more we implement trainings, the more people will get higher qualifications so there will be less gaps.
If yes, a bias could be brought in.

5. After seeing the proposed profile for Smart Cities engineer and for Smart Cities technician:

5.1 Would you change something?
Not at the moment..

5.2 Do you think that the process followed to develop them is solid enough to recommend these profiles as main and trustable reference for those occupations? Briefly highlight possible strong points and weaknesses of the process.
The process got robustness already.
Strong: it went in deep, not basic questionnaire only.
Weaknesses: not identified at the moment..

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