SKILLS4CITIES

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SMART SKILLS FOR SMARTER CITIES

TOOLKIT

for smart city competencies framework

Project Output 1

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CONTENT

This Toolkit is entirely dedicated to “agents of change” for digital transformation of the cities as well as for the city administrations, that need professionals in the smart city development

There is a real need for experts who know how to develop, implement and manage "smart city projects"

To develop an effective smart city plan and implement a smart city project, experts with diverse knowledge, skills and competencies are needed. It usually takes interdisciplinary teams made up of people from different structures, organizations and areas of expertise brought together to implement a smart city initiatives or projects.

This toolkit provides methodological and practical guidance to upgrade the competencies of those experts who are interested in the development, management and implementation of smart city projects.

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This toolkit shares the insights and experiential knowledge accumulated by the member of cluster Knowledge, Innovation, and Strategies Management Club (KISMC), during the development of the results of the project Smart by Design and the practices and experience of all other partners that participated in it.

The toolkit has been produced by the international project team with the support and participation of the following partners:

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- GAIA - Spain
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Introduction

Toolkit for smart city competencies framework is an output of the project "Smart Skills for Smarter Cities", financed by the Erasmus + Programme of the European Union.

The **main objective** of the project, as a whole, was to develop and test learning & validation tools for training of professionals who will play important role for the success of digital transformation of cities. The tools elaborated in the project include a referent competence framework, new curricula and validation paths for these roles, based on common methodology and competencies map.

The Toolkit itself aims to provide means for better development, implementation and overall management of the 'building blocks' of a smart city - the **smart city projects**.

In this way, an opportunity and conditions for upskilling are created by training the target groups in specific skills that are necessary for the development, implementation and management of smart city projects as well as all its components.

The key elements of competencies framework concern the three specific professional, roles selected in the mapping process (smart city project manager, smart city project management consultant and smart city project developer) and include their knowledge, skills, experience, professional qualities, abilities and attitudes that lead to the successful performance of a specific work role in the **management of smart city projects.**

The development of the competency framework for the above-mentioned professional roles includes **the following 4 steps**:

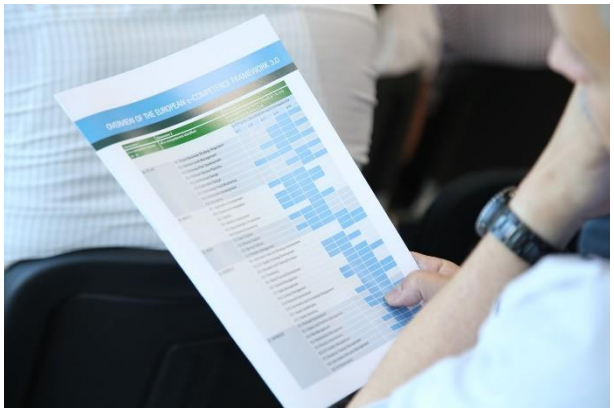
First step (deliverable). A1. Smart city competencies map

This first stage in the preparation of the competency framework was based on research and analysis of relevant sources, good practices and examples. To prepare the competency map, a rich literature on currently existing concepts, policies and initiatives related to smart cities and competencies was drawn upon. Suitable analyses and existing case studies describing the challenges in designing, implementing and managing smart city projects were collected by the project partners.

Second step (deliverable). A2. Reference competencies framework

At the second stage after identifying and the description of all competencies, the definition of the proficiency levels of every one of them, and after specifying and validating which of them are mandatory and optional for the three professional roles a **Competency Framework Explorer** was developed as an integration of all aspects - 4 competence areas, 40 competences, 5 proficiency levels and the relevant knowledge and skills.

It explores the competences and the three SC professional role profiles identified by mapping process. These are the typical roles performed by the smart city projects professionals, covering the full business processes.



This framework is used as a basis for the competency identification and help to clarify each professional profile with its mandatory competency description for corresponding proficiency levels, the main tasks and deliverables for any of these roles.

Third step (deliverable). A3. Curricula package

The Curricula packages is developed in the context of whole Toolkit. There are developed 4 training modules, corresponding to the fourth groups competencies. The training module presents the competences to be acquired at the conclusion of the training program and the structure of the training program, along with the training and evaluation methodology as well.

The last part of every module is built upon the training material organized in order to create the specific curricula for each of the three job profiles. The professionals who are interested in developing knowledge and skills to better perform in the competitive market of smart cities' projects, have clear learning path to fulfil.

Forth step (deliverable). User Guide for implementation

A User Guide is a brief statement of instructions on how this toolkit can be used and benefit users. These instructions would be particularly useful for the target group of professionals who perform or can perform one of the three selected professional roles.

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The study under this project found that biggest issues when implementing smart city projects are not about the technology itself but rather the problems that arise when the ideas have to be put into action and related to the professionals with relevant expertise and specific competencies that are able to either develop or manage or implement such complex and multidisciplinary projects as the smart city ones.

One project is considered a smart city project when it's associated with a higher number of smart city main dimensions which are economy, people, governance, environment, mobility, and living. Undoubtedly, smart city projects are very complex, multidimensional, multi-stakeholder, citizen-centric, and citizen opinion sensitive, requiring serious leadership, managing change approach, and building on the normal managerial and project management knowledge and skills.

A1. Smart City Competence Map

1. Introduction to competence map

To prepare the Smart City Competency Map, a rich literature on currently existing concepts, policies and initiatives related to smart cities and competencies was drawn upon. Suitable analyses and existing case studies describing the challenges in designing, implementing and managing smart city projects were collected by the project partners. In the preparation, an expert opinion from the representatives of the target groups was received, and feedback from a focus group organized in Sofia on 21.09.2022 was used.

A1. Smart City Competences Map is the first deliverable and preparatory stage of the process of development of **Toolkit for smart city competencies framework**, that is the first output (IO1), elaborated within the project "Smart Skills 4 Smarter Cities", financed by EU's Programme Erasmus +. It integrates the following interrelated components (deliverables) that together represent the mentioned above Toolkit:

A1 - Smart city competences map;
A2 - Reference competencies framework;
A3 - Curricula package;
A4 - User guide;

During realisation of this output the team was focused on the challenges of the professional development of the target group of the project that was defined at the very beginning. This group includes these professionals that can provide significant support for the **development, management and implementation of successful smart city projects** and they were called "**agents of change for cities**".

To do the smart city competency mapping at the process of the peer working on this project the following presumptions and findings have been taken into consideration:

1. Among many different drivers for the smart cities' development, it was decided the project team to be focused on the **smart city project** as a key instrument and "**building brick**" for making cities smart.

2. Among the many work profiles that concern smart city development and management it was decided to pay attention to those representatives of the target groups to which not enough attention has been paid so far, but which have crucial impact on the success of the smart city projects. Those are smart city project managers, developers and project management consultants. This is one of the main findings from the mapping the smart city projects challenges and the smart city skills domains. In fact, the project role was to result in the professional profiles of these practitioners upgraded with a new set of competencies that should make them agents of change for the cities and rise the efficiency and efficacy of the smart city projects.

3. For the needs of the competency mapping a **conceptual model** had to be developed.

4. It was clarified also that a large group of internal and external experts can play the defined job roles of smart city project managers, project management consultants and project developers.

This large group includes members of the urban and regional administration, representatives of the urban economic environment, architects, engineers, as well as experts and technicians who work in the field of planning and implementation of smart solutions, suppliers of solutions, economists, geologists, cartographers, lawyers, consultants, project managers, etc.

All of them depending on the entry level they have can improve and certify their skills and become smart city project managers, project management consultants and project developers after proper training.

USED TERMINOLOGY

- **Smart city project:** Any undertaking that requires the organization of knowledge, experience and resources to achieve predetermined goals and tasks of making a city smart within a given budget and time frame. Regardless of its scope and size, any such undertaking is complex, multi-dimensional, multi-stakeholder, directly citizen-centric, therefore particularly sensitive to public opinion, and requires a high-level set of competencies.
- **Competence:** a set of practical, knowledge-based skills. An expression of the individual's ability to successfully combine and integrate in the performance of various elements of the possessed knowledge, skills, experience, professional qualities and other personal traits and characteristics. It also includes appropriate qualities, abilities, attitudes that lead to the successful performance of a specific work role. Competence is part of competence.
- **Competency:** a broader and integral concept, a set of personal qualities (values, knowledge, skills, habits, abilities), conditioned by experience and activity in certain socially and personally significant spheres. A concept that is closer to the understanding of professional qualification (a measure of the degree of mastery of knowledge, skills and professionally significant qualities acquired through training and/or work experience. It also means the ability to perform a specific position, functions and roles, which is proven by a relevant document (certificate).
- **Competency model** (conceptual model): a set of competencies organized in a common matrix in a way that corresponds to the needs to perform a specific role, describing all competencies and their distribution according to certain criteria. In this case, it is the result of research and design thinking.

Keywords

smart city, smart city project, competencies, competencies mapping, gap analysis, competencies model, job roles.

2. Mapping process

2.1. Smart city state of the art

The Smart City concept requires a relationship with citizens, tourists, suppliers and public workers based on transparency, accountability, appropriate use and consumption of resources and early identification of needs. The application of Information and Communication Technologies (ICT) to improve the quality of life of its inhabitants and to ensure sustainable economic, social and environmental development are elements common to all definitions, however, there does not seem to be an agreement on the concept of Smart City or the minimum elements that must be present in a city to be considered as such. In this sense, we list different concepts of what is understood by a Smart City:

"Smart City is the holistic vision of a city that applies ICT to improve the quality of life and accessibility of its inhabitants and ensures sustainable economic, social and environmental development in permanent improvement. A smart city allows citizens to interact with it in a multidisciplinary way and adapts in real time to their needs, in a quality and cost-efficient way, offering open data, solutions and services oriented to citizens as people, to solve the effects of the growth of cities, in public and private areas, through the innovative integration of infrastructures with intelligent management systems" [1].

"The concept of smart cities is the translation and adaptation of the English term smart cities. They are cities based on sustainable urban development, which apply innovation and Information and Communication Technologies (ICT) to the management and provision of their different services. A smart city interconnects different areas such as governance, economy, mobility, environment, energy, health, security, among others, and thus allows it to be more efficient and provide better and new services. The technological basis of smart cities are the technological platforms, made up of software and hardware that allow the exchange of data and information between the different systems and areas, and thus provide a centralised place of control and management of the city. In addition, smart cities are increasingly integrating technologies such as sensorisation, IoT, algorithms, cloud, big data, artificial intelligence and blockchain into their system". (Smart city definition).

"Smart cities can be identified and classified according to six main axes or dimensions: smart governance, smart economy, smart mobility, smart environment, smart people, and finally, smart living. Therefore, a city can be defined as "smart" when investments in human and social capital and in transport and ICT infrastructure contribute to sustainable economic development and improved quality of life, with sound management of natural resources, through participatory governance" [2].

A Smart City, therefore, is a city that sets its priorities through a smart strategy, the result of a reflection exercise, in which its main social and economic agents determine a city model towards which they want to evolve and define and prioritise the initiatives that will enable this model to be achieved. The basic pillar of these initiatives is the use of Information and Communication Technologies (ICT), which enable the optimisation of infrastructure management and urban products and services, as well as the products and

[1] Definition of AENOR's Technical Standardisation Group 178

[2] European Parliament definition, 2014

services provided to citizens, all with the aim of sustainable, intelligent and inclusive development. In order to carry out this work, we considered the standard definition of the Smart City concept, which will serve as a starting point for the design of the competency framework for Smart Cities.

As described in the "Mapping Smart Cities in the EU", IP/A/ITRE/ST/2013-020[3], examples of Smart Cities come in many variants, sizes, and types. This is because the concept is very broad.

The Smart City concept continues to be a subject to debate, and definitions of smart cities vary. However, in most cases, smart cities are connected to initiatives that use digital innovation to make urban service delivery more efficient and thereby increase the overall competitiveness of a community.

The infographic in **Fig.1** is one of the many similar ones that present the concept of a smart city and its main characteristics.

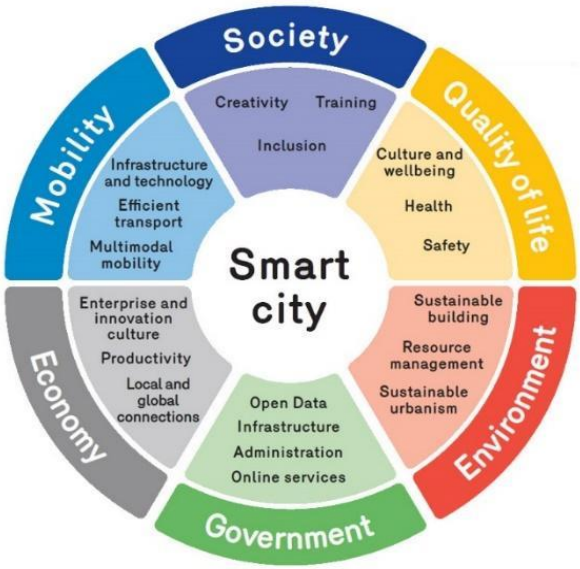


Fig.1. *Smart city concept*

With the development of new technological innovations, the concept of the Smart City is mostly being engaged with the understanding to achieve more efficient and sustainable cities. Cities are becoming smart not only in terms of the stage of their technological development, but also in ways that enable us to monitor, understand, analyse, and plan the city in order to improve the urban performances. Currently more attention has been paid to the social and environmental benefits that smart cities bring and thus distinguishes them from a pure technology-centric concept.

To be smart, the urban organism needs to develop addressing altogether the economic competitiveness, environmental sustainability, the social factor, thus ensuring an increased quality of life for its citizens. While digital innovation remains central to the smart city concept, a key question is whether investment in smart technologies and digital innovations ultimately contribute to improve the well-being of citizens. The human-centric approach is also considered a key to make a city smarter.

That is why in a recent OECD publication[4] smart cities initiatives are defined as "*initiatives or approaches that effectively leverage digitalisation to boost citizen well-being and deliver more efficient, sustainable and inclusive urban services and environments as part of a collaborative, multi-stakeholder process*".

[3] https://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdf

[4] Smart Cities and Inclusive Growth, 2020 https://www.oecd.org/cfe/cities/smart-cities.htm

2.2. Mapping activities

The following activities were carried out grouped in seven stages (**Fig.1**) to obtain **A1. Smart City Competence Map:**

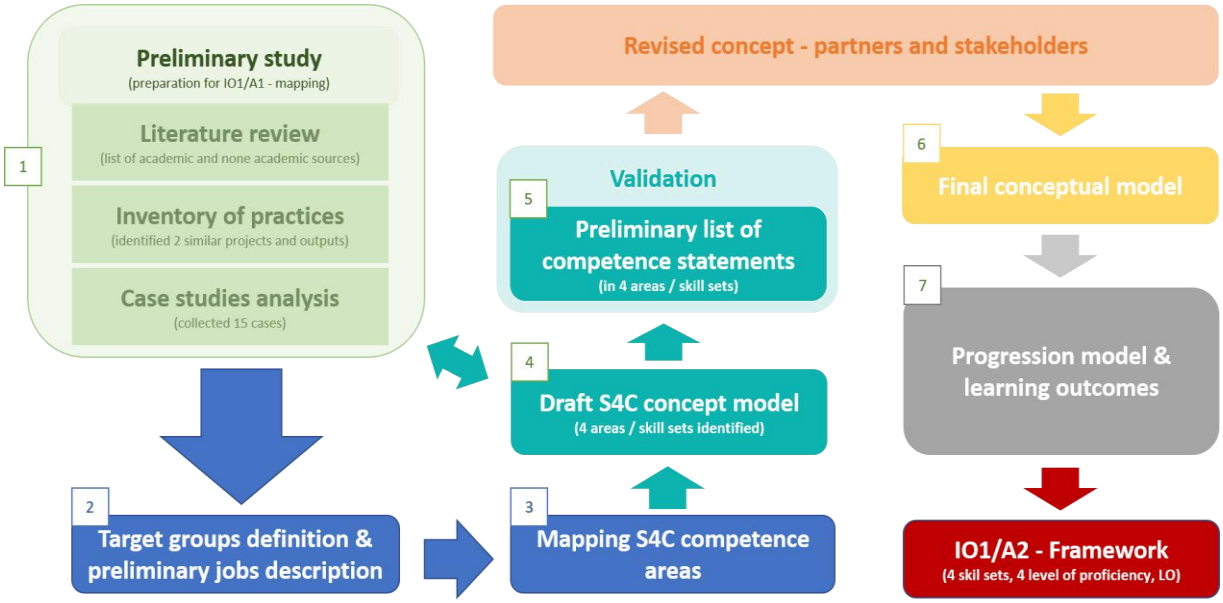


Fig.2. *Development stages*

Preliminary study

The preliminary study was the most important stage for generating and arguing the main thesis on the basis of which to develop the conceptual model and perform mapping. It includes the following activities:

Literature review - many articles, manuals, books, publications, white papers, studies and surveys from many resources like EC, UN, independent publishers, think-tanks and consulting organizations were studied to understand the existing concepts, policies and initiatives referring to smart city competencies (**Annex 1**).

There is common understanding in many publications regarding the challenges of one smart city project and they concern mostly the following:

- lack of understanding of the solutions that lead to poor decisions;
- leadership style and manager's technical and social skills;
- absence of educated and qualified teams who can work in these complex and high-tech projects;
- resistance to change;
- inadequate training;
- diversity of the stakeholders creates conflicts between them about who will govern and finance or who will capture the created value;
- multiple goals provide to miscommunication of the project's objectives to the local community.

Undoubtedly, **smart city projects** are very complex, multidimensional, multi-stakeholder, citizen-centric and citizen opinion sensitive, requiring serious leadership, managing change approach, and to build on the normal managerial and project management knowledge and skills.

Inventory of practices - similar projects have been found, in which the challenge and the need for new competencies were mapped as a result of the digital transformation that cities are experiencing. Four similar projects

were identified and compared and some templates and important findings were used from two them. Here is the short description of these two Erasmus+ projects that were found useful to follow as an approach and ready-to-use results:

- **Smart by Design**.[5] The main objective of this project, which is still under development is to elaborate a competences package (knowledge and skills development package) for the target group of „smart city innovators" to drive smart disruptive technology business more specifically for the city needs. The package includes a training program with content, modules and materials for smart city innovation. The target group in this project is innovative enterprises, their owners, management and developers that provide the cities with disruptive technologies for becoming smarter. It is up to the partnership to decide during the project execution what kind of new job role profiles and professions to be developed.
- **DevOps Competences for Smart Cities**[6]. The target group in this project are employees working in smart cities / municipalities. The project addresses the shortage of digital and transferrable skills of this group and supports them in their professional development. It identified the competencies, designed the corresponding job role profiles of Smart Cities Development and Operations professionals and design VET curricula combining digital and transferrable skills. The following three new professions were identified and designed under this project: Smart City Planner; Smart City IT Manager; Smart City IT officer.
- **European e-Competence Framework** (e-CF)[7]. e-CF provides a reference of 41 competences as required and applied in an IT professional work context, using a common language for competences, skills, knowledge and proficiency levels that is applied and understood across Europe. The objective of the e-CF creation was to provide a common, shared, European tool to support organisations and training institutions in recruitment, assessment, competence needs analysis, learning programmes, career path design and development. The framework can be applied to IT services provision and IT professional development by public and private organisations, IT professionals, managers and HR departments, higher education, vocational education and training (VET), assessment and accreditation bodies, social partners, professional associations, market analysts and policy makers. For the needs of the S4C project Toolkit (Output 1) was a document which describes the methodological grounding for the development of e-CF.[8]
- **Case studies analysis** - collection and analysis of case studies so that to understand and demonstrate the challenges and opportunities that the cities meet when smart city projects are implemented and to make conclusions what are the factors one project is successful. 15 smart city case studies were collected to use in this output. (**Annex 1**).

[5] Smart by Design (https://www.smartbydesign.eu/)
[6] DevOps: Competences for Smart Cities; Project No.: 601015-EPP-1-2018-1-EL-EPPKA2-SSA; Erasmus+ Program, KA2: Cooperation for innovation and the exchange of good practices-Sector Skills Alliances
[7] European e-Competence Framework (e-CF) version 3.0 – a common European framework for ICT Professionals in all industry sectors (https://itprofessionalism.org/about-it-professionalism/competences/the-e-competence-framework/)
[8] Building the e-CF - a combination of sound methodology and expert contribution

Table 1. *Overview of the six Smart City characteristics (Mapping Smart Cities in the EU, IP/A/ITRE/ST/2013-020)*

Characteristics	Description
1. Smart governance	By Smart Governance we mean joined up within-city and across-city governance, including services and interactions which link and, where relevant, integrate public, private, civil and European Community organisations so the city can function efficiently and effectively as one organism. The main enabling tool to achieve this is ICT (infrastructures, hardware, and software), enabled by smart processes and interoperability and fuelled by data. International, national and hinterland links are also important (beyond the city), given that a Smart City could be described as quintessentially a globally networked hub. This entails public, private, and civil partnerships and collaboration with different stakeholders working together in pursuing smart objectives at city level. Smart objectives include transparency and open data by using ICT and e-government in participatory decision-making and co-created e-services, for example apps. Smart Governance, as a transversal factor, can also orchestrate and integrate some or all of the other smart characteristics.
2. Smart economy	By Smart Economy we mean e-business and e-commerce, increased productivity, ICT-enabled and advanced manufacturing and delivery of services, ICT-enabled innovation, as well as new products, new services, and business models. It also establishes smart clusters and eco-systems (e.g., digital business and entrepreneurship). Smart Economy also entails local and global inter-connectedness and international embeddedness with physical and virtual flows of goods, services, and knowledge.
3. Smart mobility	By Smart Mobility we mean ICT supported and integrated transport and logistics systems. For example, sustainable, safe and interconnected transportation systems can encompass trams, buses, trains, metros, cars, cycles and pedestrians in situations using one or more modes of transport. Smart Mobility prioritises clean and often non-motorised options. Relevant and real-time information can be accessed by the public in order to save time and improve commuting efficiency, save costs and reduce CO2 emissions, as well as to network transport managers to improve services and provide feedback to citizens. Mobility system users might also provide their own real-time data or contribute to long-term planning.
4. Smart environment	By smart environment we include smart energy including renewables, ICT enabled energy grids, metering, pollution control and monitoring, renovation of buildings and amenities, green buildings, green urban planning, as well as resource use efficiency, re-use and resource substitution which serves the above goals. Urban services such as street lighting, waste management, drainage systems, and water resource systems that are monitored to evaluate the system, reduce pollution, and improve water quality are also good examples.
5. Smart people	By Smart People we mean e-skills, working in ICT-enabled working, having access to education and training, human resources, and capacity management, within an inclusive society that improves creativity and fosters innovation. As a characteristic, it can also enable people and communities to themselves input, use, manipulate and personalise data, for example through appropriate data analytic tools and dashboards, to make decisions and create products and services.
6. Smart living	By Smart Living we mean ICT-enabled life styles, behaviour and consumption. Smart Living is also healthy and safe living in a culturally vibrant city with diverse cultural facilities, and incorporates good quality housing and accommodation. Smart Living is also linked to high levels of social cohesion and social capital.

2.3. Mapping smart city projects skills domains

Among many different drivers for the smart cities' development, it was found, as previously mentioned, that the **Smart City project is a key instrument for making cities smart**. For that reason, the Smart City project was put on the stage as the main standpoint for competencies mapping and modelling. Within the Skills4Cities project and for the aims of the elaboration of the Competencies map, the Smart City project is considered the Smart City "building block". In order to conduct a skills gap analysis and to define the main skills that are crucial for the smart city projects development, implementation and management, it is important to bring light to what a smart city project is and what are its specific characteristics.

A project is considered a **smart city project** when it is associated with the mentioned in **Fig 1.** six smart city main dimensions which are economy, people, governance, environment, mobility, and living. Each dimension represents a particular aspect of the city where a smart project aims to achieve smart city goals in efficiency, sustainability, and high quality of life.

One of the challenges of smart city projects is their **size and scope** where two types of projects can be defined. Greenfield projects, which are huge, long-term, and usually start from zero, and brownfield projects - smaller sized projects, short-term and fast implemented, which are usually built on existing infrastructure and are preferred by investors for generating fast revenues.

Undoubtedly, smart city projects are **complex, multidimensional, multistakeholder, citizen-centric, and citizen opinion sensitive**, requiring serious leadership, managing change approach, and building on the normal managerial and project management knowledge and skills.

Smart cities project domains

Following the main findings in the research "*Smart City Solutions for a Riskier World*" (based on a survey of ESI ThoughtLab) [9] which explored how **167 world cities** use smart innovation to drive results, we tried here to simplify and systematize the answer to the question "**where, in what domains the smart city projects are usually created, developed, and implemented and what are they**". The answer to this question gives useful information and rich knowledge about already implemented projects in hundreds of cities. This knowledge can be embedded in the set of competencies, which the smart city project professionals could include in their professional profiles. Let's start, in a systematic way, to map the smart city projects, showing where the cities usually invest, domain by domain. As it was already stated, this is based on the study of the results of the mentioned survey. The following is a description of the **eight domains** that our study shows as the most relevant and necessary to describe the competencies of the target groups:

1. Economy, trade, and industry

This domain includes projects and initiatives for attracting business, generating growth, and industrial development. The most effective projects that one city implements to improve economic, trade, and industry development are these that make it possible to track economic & industrial trends to make

[9] Smart City Solutions for a Riskier World https://thoughtlab-group.com/wp-content/uploads/2021/03/Smart-City-Solutions-eBook-.pdf

decisions; working with business & academic community; aligning higher education with local industry needs; attracting companies through incentives & work with trade groups and attracting/developing talent & skills.

2. Government and education

In this smart city domain, the cities usually look for investors for the following city projects: Remote work for city employees; Command-and-control centres; Digital twins for decision-making; Data-based systems for policymaking; New digitized education models; Digitized services & experiences; Automated processes & workflows; Digital payments.

3. Living and health

This domain includes projects for ensuring the well-being and equity of citizens. In this smart city domain, the cities usually look for investors for the following city projects: Remote medicine & telehealth services; Online government benefits portal; Real-time air-quality information; Use of track & trace technology to ensure health & well-being; Use of data to redesign public welfare programs; Real-time air-quality data & apps for those with chronic diseases; Collect & analyse data on diseases; Use of data to redesign welfare programs; Online government benefits portal.

4. Public safety

This domain includes projects for disaster early warning systems, computer-aided dispatch, drones, and in-car and body cameras for police. In this smart city domain, the cities usually look for investors for the following city projects: Data-driven policing; Command & control centres to integrate data; Communication systems enabling collaboration; Smart ground surveillance; Computer-aided dispatch; Crowdsourced crime reporting, emergency apps; Drones & aerial surveillance; In-car & body cameras for police; Disaster early warning systems.

5. Mobility and transportation

This domain includes projects for partnerships, innovative funding, technology, data, and governance and policy to help people and goods move faster, more safely, and efficiently, and without leaving a carbon footprint. In this smart city domain, the cities usually look for investors for the following city projects: Data & analytics for predictive maintenance; Smart parking apps; Digital transit payments/open-loop systems; Smart traffic signals/real-time traffic management; Mobility as a service (MaaS) apps; Demand-based micro-transit; Real-time public transportation apps; Public EV charging infrastructure.

6. Environment and sustainability

This domain includes projects for promoting the circular economy and using gamification to boost recycling, reduce food waste, adopt

zero waste programs, and digital track waste disposal. In this smart city domain, the cities usually look for investors for the following city projects: Predictive analytics for advanced flood warning; Use of data to optimize waste collection routes; Real-time water quality monitoring systems; Real-time air quality monitoring systems.

Energy, water, utilities

This domain includes projects to enhance services, encouraging the use of renewable energy, and promoting efficient water usage. In this smart city domain, the cities usually look for investors for the following city projects: Data for predictive maintenance of electric infrastructure; Microgrids/distributed generation; Data for predictive maintenance of water infrastructure; Real-time water network monitoring; Smart grids/smart meters; Apps to track water usage; Apps to track energy usage; Smart water meters.

7. Digital infrastructure and networks

This domain includes projects to become better at using data and analytics to understand where the divide exists, providing free Wi-Fi, working with partners to provide free devices, and leveraging PPPs to foster digital equity, partnerships with telecom providers to provide smart services, to use data analytics to understand the digital divide and to use PPPs. In this smart city domain, the cities usually look for investors for the following city projects: V2X connectivity; Mesh networks; Smart beacons; 5G; Public fibreoptic network; Municipal broadband utility; Low-powered wide area networks; Edge-computing; Data centres; Smart streetlights; Smart stations; Cloud technology; IoT; Public Wi-Fi network.

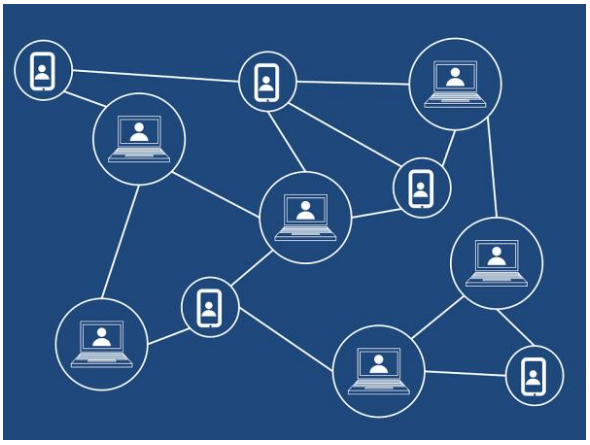
The Skills4Cities project considers these **8 Smart City project domains** as essential in regard to building and upskilling professionals working in the smart city projects field.

The basic knowledge and understanding of the components and sub-topics of these eight domains plays an essential role in the successful and quality development, management, and implementation of smart city projects.

Moreover, the collected in the review diverse types of investment projects taken from hundreds of cities generated within the eight smart city domains, report a very high return on investment of over 90%. Thus, these projects can facilitate the identification of good practices in studying each city and can be a basis for measuring and benchmarking results. The mapping of smart city projects provides a good basis for the accumulation of knowledge that the smart city project professionals should be familiar with before committing to develop, manage, and consult smart cities projects.

2.4. Mapping smart city projects challenges

The urban organism is a complex system, involving many different domains, infrastructures, organizations and activities. All these systems need to integrate and work together effectively for that city to become smart. This integration needs to take place at many levels, technical, but also about integration of business processes and management, integrated strategies, and regulations. It is clearly impossible to develop a single model of a smart city that will be simple enough and at the same time comprehensive enough to cover all the key aspects. While urban infrastructure may provide facilities to the citizens, they can only be converted into smart solutions and services through the use of Digital technology.



Digital technology has the main role in the implementation of the Smart city solutions in the city. While implementation of the Digital technology solution shall immensely enhance the effectiveness of the urban infrastructure, there is very little capacity amongst the city administrators to understand and implement such technology solutions effectively. Thus, the cities and the professionals working in this field face innumerable challenges in implementing Smart City projects.

After an in-depth study of recent reports on the problems, constraints and challenges which the smart city projects face the Skills4Cities the team identified, and the project partners agreed that the main challenges of a smart city are related to the development, management and implementation of Smart City projects.

Considering the various topics that Smart City projects are addressing and the fact that they are usually multidisciplinary and multistakeholder, Skills4Cities partners decided to use a template to present the Smart City projects case studies, emphasizing on the initially identified challenges, showing in more detail eventually how the identified challenges have been resolved. All partners' case studies are collected in **Annex 1**.

Thus, resulting in the identification of the main Smart City project knowledge challenges described in this report. Of course, this list is not entirely exhaustive and probably there are many other challenges that arise due to the complexity of those projects. However, the Skills4Cities partners agreed to focus on those they find most common and relevant in relation to the identified targets group under this project:

1. Technological challenges

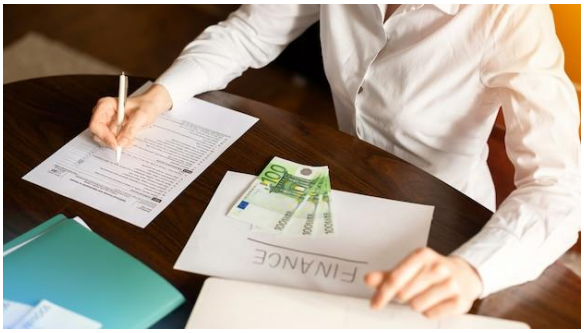
Most of the Technology solutions in the Smart City space belong to the advanced technologies like Internet of Things (IoT) based data acquisition and analysis, Advanced data analytics using Artificial

Intelligence and Machine Learning, Use of advanced Video technology. While the implementing practitioners do not have to get into the details of these technologies, there is a need for them to at least know the nuances of these technologies. However, such working knowledge of these technologies is very often missing from the Smart City practitioners/professionals in the field.

Another aspect of the technological challenges that should be emphasized upon is the implementation of advanced information technology projects.

Typically, city municipalities are involved in the implementation of urban infrastructure projects. However, the life cycle of implementing an urban infrastructure project differs a lot from that of an advanced Information technology project. Lack of knowledge in implementing large Information Technology projects severely limits the ability of the municipalities in implementing such projects.

2. Financial constraints



Transforming the regular city into a smart one requires big budget allocations. One of the reasons is the lack of a general understanding and vision on the big picture behind a smart city project, which is usually multidisciplinary and requires knowledge in different aspects, especially including basic knowledge and comprehension on the financial dimension of an advanced information technology project. Another viewpoint is that of the needed public private partnerships. Such partnerships are required but sometimes difficult to manage and this could be one of the constraints for the successful development and implementation of Smart City projects. In many cases it shows out that procurement processes are not designed for quick application of innovative Smart City solutions/projects.

3. Collaboration among stakeholders and governmental restraints

Another challenge is how to make stakeholders come together and achieve a sense of collective responsibility and common purpose. Usually, Smart City projects require multiple departments to align. It is not rare that progress of such complex and multidisciplinary projects is slowed by elections or other political cycle challenges. Sometimes city departments or employees resist the implementation of disruptive systems exactly because they lack the specific knowledge and competencies for it to comprehend and elaborate.

Last but not least, should also be considered that Smart City projects in most cases are pre-assumed as such bearing many potential risks for politicians in case, they opt to be the first movers to implement them. Sometimes the communication of Smart City projects' relevance and importance is not communicated well. Thus, leading to misconception on the usage and the application of such

projects and the resistance from one side of the citizens, and from another side - from the municipality authorities to go after introducing such projects.

4. Management and organizational challenges

Smart City projects usually involve different stakeholders. Therefore, Smart City projects need smarter management. It is a huge challenge to follow and coordinate a Smart City project. To make it successful it should involve stakeholders within the whole process, but also to have the respective competencies and knowledge to coordinate all stakeholders of different fields of expertise. A structured and disciplined approach to project governance can help, along with capacity building in the specific Smart City projects topics, at least those targeting the main Smart City projects domains.

5. Social challenges

When it comes to ensuring inclusion while building smart cities, examples of unsuccessfully implemented initiatives could prove to be quite helpful. Failing to ensure inclusion could potentially negate even the best intentions. For example, a city may fail to launch a healthcare initiative for elderly citizens because most of them don't know how to use the technology. Thus, smart city initiatives should be implemented in a way that fosters social inclusion and speaks to all categories of citizens, not just the well-off and tech-savvy ones.

Considering the above-mentioned findings, could be concluded that the biggest issues when implementing Smart City projects are not about the technology itself but rather the problems that arise when the ides must be put into action. These are related to those professionals who can demonstrate relevant expertise and specific competencies of being able to either develop, or manage or implement very complex and multidisciplinary projects as the Smart City projects are.

Therefore, all of the above-mentioned challenges require a specific set of skills and knowledge the smart city professionals/practitioners must have. They must have good understanding about the enabling technologies, to have a knowledge of how to effectively manage such technology-intensive and human-centric projects, to have good procurement and financial acumen and great communication skills.

The smartness of a city describes its ability to bring together all its resources, to effectively and seamlessly achieve the goals and fulfil the tasks it has set itself. Undoubtedly, the administration and other professionals that work for smart cities require new competencies that currently the education systems provide quite fragmented.

3. Smart city professionals

To create a smarter urban environment is a multi-sectoral, interorganisational and intergovernmental task. In order to develop an effective Smart City plan, it is necessary to bring together people from different backgrounds and with different skills and competencies. This should be usually cross-functional teams composed by individuals from different departments and spheres of expertise brought together to complete a Smart City project. Cross-organizational and interdisciplinary teams are the solution in case of integrated plans oriented to a variety of social groups, affected by the problems of shared resources, decreasing budgets and scarce profit prospects, as in the case of smart city projects[10] .

Thus, some European cities have started creating dedicated Smart City Departments. Undoubtedly, the administration and other professionals that work for smart cities require new competencies that currently the education systems provide are quite fragmented. Few universities provide to the learners a well-balanced curriculum for smart city governance.

The new types of jobs require the experts to be well trained to meet the needs of smart cities. Such learners, being the future drivers of these industries and smart city agents, are the main human resource to fulfil the vacancies of these workforces. Constant improvements in and re-evaluation of the curriculum taught to the learners have to be done regularly to keep the learners up to date in fulfilling the requirements of the industries and corporations.

So, the project team understanding is that the new era cities need well addressed vocational training of experts who should upgrade their competencies and skills after their classic (normal & formal) education, based on assessment or self-assessment of their skills.

3.1. Proposal for smart city projects professionals

Considering the smart city competencies' needs, the professionals who are most involved in the process of transforming the cities into smart and implementing smart city plans and activities into three main groups.

1. Internal staff (employees of the cities) of the urban and regional administrations, that is directly committed to the realization of the local government policies, strategies, and plans. From one side these are city officers who are members of the specialized administrations and departments engaged with the smart city matters and from another side, in case of lack of specialized departments these are regular city officers who could be engaged with the realization of such activities on a project basis.
2. Large group of hired external representatives of the urban economic environment, architects, engineers, as well as technicians who work in the field of technical solutions for smart cities, economists, geologists, cartographers, lawyers, among others, all working as service and equipment suppliers (individuals or companies).

[10] Piercy et al., 2013; Nam and Padro, 2011 https://www.tandfonline.com/doi/abs/10.1080/10630732.2016.1164439

3. Free-lance professionals, hired on a project base, that has competencies to develop, manage and implement smart city projects - milestones of the cities' transformation process.

Skills4Cities project defines these professionals as smart city project developers, managers, and consultants. To our understanding these professionals are the most important agents of change that can motorize the process of transformation. They are design thinkers and very often leaders of realization of smart city projects. After the expert meeting and following the conclusions from the study of practices (see 1.1.

Preliminary study) the project team took in consideration that the target group of the first cited project Smart by Design were the innovative enterprises or in other words the suppliers and developers of innovative technologies, products and solutions for the needs of the cities. The target group of the second project DevOps were the cities' operators & managers, which tasks are to plan, administrate and implement the smart city products and technologies.

It was found logical that, between the providers of innovative solutions (enterprises) and the smart city operators (city administrations) lays the role of a target group of high-level experts who are enough qualified and skilled to secure the success of undertaken smart city projects starting from the enough well designed and developed project, whatever its dimensions is, excellent and agile project management carried out by certified project manager and professional support from experienced project management consultant, as an extra garniture that, without doubt will bring success of the project.

To play all these three roles one has to upgrade his/her professional profile with new specific competencies frame. As a result, the following **three professions** were identified, studied and designed during the project:

- Smart City Project Manager
- Smart City Project Developer
- Smart City Project Management Consultant.

The specificity in developing these profiles which require new curricula and training & learning content is that for a training and certification for SC Project managers (management consultants, or developers) can apply both, the members of city administration as well external professionals.

This is because a city may decide to hire either an internal officer or an external professional for the management and/or development of one particular project. For both of them the package of competences will be same.

3.2. Job roles description

In the **Table 2** on the next page are given the preliminary role descriptions and responsibilities of the **three job roles** defined in 3.1. They should be further elaborated during the second phase of the Toolkit development (IO1) - the smart city skills competency framework drafting.

The three job roles have been defined and described based on the conducted fast-track desk study - the mapping of the smart city projects within its main domains and also, on the identified challenges that the Smart City projects face derived from its complex and multidisciplinary field.

Table 2. *Skills4Cities job roles*

Smart city project developer (SCPD)

Role description, prerequisites and requirements	Example activities and functions
This role can be performed by an external professional employed on a temporary performance contract, and in rare cases by an official from the city administration. SCPD is a highly qualified and knowledgeable practitioner who can be engaged by cities or other stakeholders to initiate, demonstrate, lobby, plan, communicate and present at city level various smart city projects and know how to manage and facilitate adoption and the implementation of such projects in relation to the needs, strategies and tasks of a given city. This person must have the qualifications, experience and skills to apply the principles of innovation management, project management and change management in a diverse, complex and conflictual environment. SCPD must know and be able to apply analysing and prioritizing the needs of a city, engaging stakeholders and using best practices of successful smart city projects. The SCPD is expected to be an excellent high-level designer and conceptualist, able to design, generate and defend feasible initiatives that are then transformed into smart city projects. SCPD should know very well the critical (key) success factors and common challenges and mistakes that every city faces in the conceptual and in the implementation phase of digital transformation. One of the most important competencies to fulfil this role is a good awareness and a high level of knowledge of the impact of disruptive digital technologies and their areas of application in such projects. A good knowledge of similar case studies around the world and/or personal experience in the design and implementation of smart city projects is also necessary. The scope of SCPD's activity includes preparation and defend of the conceptual concepts and project proposals in the field of digital transformation of the city and the introduction of smart solutions and their presentation and coordination with all stakeholders in the city. It must be able to match the content of the project with the necessary funds and the possible ways of providing them - grants, private investors or application for hybrid investment instruments. A set of specific knowledge and skills in the field of law and finance are required, for example to carry out feasibility studies, cost-benefit analyses, business and financial planning, public-private partnerships, etc.	- Researches and recommends breakthrough digital technologies for the implementation of smart city project development tasks. - Develops smart city project initiatives by analysing cities' needs, strategies, challenges, quality and level of efficiency in city management. - Performs design and development activities of a smart city according to the needs, tasks and specifics of the specific city. - Prepares project proposals and projects for a smart city, including analysis and concept development, planning, feasibility study, budgeting, project presentation and defences, etc. - Coordinates project proposals with the municipality and its specialized units as well as with the local community and all interested parties (for example, contractors, suppliers, city organizations, municipal authorities, specialized teams in the municipality, with project managers, if there are any at the given time, etc. - Develops technical assignments and specifications for the detailed implementation of smart city projects, aligning the framework and content with the city's goals and strategy. - Present and deliver to the Smart Cities Project Manager (SCPM) an accepted and agreed upon city-level project for further management and implementation. - As necessary, participates in the development of project action plans, budgets and schedules in support of the Smart City Project Manager (SCPM)).

Existing similar certified job roles
· Business developer & business development strategist (ESCO: 2431.5); · Certified Business Development Professional (RBNC) · Project Developer

Smart City Project Manager (SCPM)

Role description, prerequisites and requirements	Example activities and functions
The SCPM can be an external professional employed on a temporary performance contract, as well as an internal person in a city administration position (in rarer cases). His role is to manage smart city projects of various types and scales by planning, organizing, securing, monitoring and controlling project resources, teams and schedules in order to achieve the goals and objectives of these projects in an effective and efficient manner. The SCPM is expected to have graduated from a university with at least a bachelor's degree in ICT/Electronics/Computer Engineering/Economics, have at least 5 years of project management experience and/or hold a project management certificate issued by a recognized national or an international certification body. SCPM can be engaged by the city administration and/or other stakeholders to manage and implement diverse smart city projects based on a previously developed task (term of reference), to be involved in their conceptual phase and to participate fully or partially in their development. The SCPM clarifies the city's digital transformation strategy and the place and role of the specific project in sync with that strategy and with other key city governance documents. Must have management skills, demonstrate leadership, be able to build teams and work in a team, have the ability to present and justify strategic directions, perform methodological and technical supervision, mentor project teams, develop and controls the implementation of work plans, budgets and schedules. Should be able to effectively manage relationships in the partner network at all levels (local government, partners, private sector, NGOs and academia) in relation to the project she/he manages. More than many other project manager categories, the SCPM must demonstrate written, analytical, presentation, reporting and computer skills as well as knowledge	- Provides technical and project management and coordinates the implementation of projects (project activities) for a smart city, ensuring synchronization of the project with the vision and strategy of the municipality and with the goals of the digital transformation of the city. - Presents / agrees the project to the city management, prepares action plans, updates and reports. - Analyses the key factors for successful implementation using the resources of academia, industry and representatives of the key stakeholders of this project. - Supports the attraction of allies for the successful implementation of a project and takes actions for the commitment of already attracted partners. - Establishes close cooperation and forms an interdisciplinary team with experts from the municipality, the private sector, professional organizations and citizens' associations and does good coordination in sync with the city's digitalization strategy and plan. - Develops and offers the project owner ideas for subsequent mobilization of funds/resources from other sources, necessary for post-project sustainable development of the smart city. - Reports progress and resolves implementation issues and challenges. - Participates in workshops, events and initiatives and through it is able to impact the success and sustainability of the managed project.

of modern communication systems (Internet, World Wide Web, email, etc.). The SCPM is expected to have knowledge of the digitization process, ICT policies and regulations. SCPM should have developed skills in conflict and change management, know the critical success factors of a project and the common mistakes that a city makes in the design and implementation of smart city projects, and have information about case studies and good practices for other smart city projects.	- Participates in the development of technical tasks (terms of reference), profiles of suppliers and consultants for the implementation of specific tasks and activities from the plan and schedule of the project and the specifications for supplies. - Monitors, controls and organizes parallel and complementary activities with other stakeholders of the project

Existing similar certified job roles	
· Project Manager (ESCO: 1219.6) · Certified EU Project Manager (ECQA); · Project Manager Professional (PMI: PMP); · Agile Project Management Practitioner (APMG-UK: AgilePM)	· Master Project Manager (MPM) · PRINCE2 Practitioner · Professional in Project Management (PPM) · Project Management Professional (PMP) · Certified Project Manager (IPMA: Level C);

Smart city project management consultant (SCPMC)

Role description, prerequisites and requirements	Example activities and functions
A Smart City Project Management Consultant (SCPMC) may be an external professional management consultant employed on a temporary performance contract. In very rare cases, this role may also be performed by an internal consultant working in the city administration. This role requires the SCPMC to have: (1) proven solid knowledge and skills in project management and/or have expertise in a specific area thereof; (2) experience in the implementation of "best practices" for the management of smart city projects and/or proven participation in solving practical situations and case studies related to the implementation of such projects in cities; (3) knowledge about the relationships between stakeholders in the smart city (i.e., understanding the problems of cities, skills in formulating recommendations and implementing decisions); (4) demonstrated trustworthiness (i.e., why he would be hired to work as such). SCPMC can be hired by city authorities to provide specific services on various aspects and stages of the smart city project life cycle or directly by project managers (SCPM) when more and/or more specialized information or expertise is needed in the relevant project teams. According to some studies, more and more cities around the world are using outsourcing or contract consulting services for such projects. Smart city project management consulting services are used when management expertise is lacking or	SCPMC analyses data, identifies trends, and monitors the effectiveness of smart city projects and, on this basis, can prevent problems in its management. Develops roadmap and makes recommendations to Project Manager (SCPM) or Project Owner or directly to City Government. Develops and possibly monitors the implementation of plans to mitigate the impact of adverse and emergency situations on the project. Tasks SCPMC can perform: · assists in organizing and smoothly conducting meetings with interested parties, including citizens in support of the projects. · mediates to build positive relationships with suppliers of technologies, products and any solutions for urban processes. · supports or replaces SCPM in functional analyses, cost-benefit analyses and the application of decision-making tools regarding project cohesion and the selection of appropriate technical solutions. · supports all or part of the phases of public procurement

an unbiased assessment of the manner and results of the activities of developers (SCPD) and project managers (SCPM) is required. SCPMCs are expected to have specialized knowledge and skills to make the best possible decisions on specific challenges that project managers (SCPMs) face during the life cycle of a project. The SCPMC may assist the Project Manager (SCPM) with advice on a variety of project matters, and sometimes act as a mentor to some of the project team members. In another case, SCPMC may participate in the supervision and management of the project throughout its life cycle or only for a certain phase of it. SCPMC can participate in the planning and management of the project budget, resources and relationships, the development and implementation of project schedules, the implementation of control for compliance with the deadlines for the individual phases of the project. In some cases, may define and oversee the role and function of each member of the project team and coordinate some of the team activities as well as identify and propose how to manage project risks.	· participates in in-depth studies and analysis of needs for project implementation. Prepares impact assessment reports. · distributes the results of the project, organizes feedback and services for better communication and positioning in front of interested parties. · makes contacts with potential investors, organizes pitching and work meetings. · prepares, organizes and presents projects to stakeholders and investors to find consensus support. .

Existing similar certified job roles

- Business & Management consultant (ESCO: 2421.2);
- Professional Service Consultant (ESCO: 1219.1).
- Project Management Consultant
- Certified Management Consultant (ICMCI: CMC)
- Certified Business Consultant (AIBMC: CBC)

4. Mapping Smart City projects competencies

A **competency** is the ability to use a set of relevant skills, knowledge, and abilities to successfully perform work functions as defined.

Competencies mapping is the process of identifying the specific skills, knowledge, abilities to operate effectively in a specific profession, or job position. One of the main goals is to gain awareness of the current skills inventory, as well as identify existing skill gaps. Competency maps are often referred to as competency profiles or skills profiles or skill maps etc. They are the product of competency mapping and provide a visual representation of the skill inventory.

Competency model (map) is the number of competencies that jointly define a successful job performance. It sets out the specific skills, knowledge and behavioural requirements that enable an employee to perform their job successfully. It is very important that each competency is defined properly with the use of competency definition that makes it very clear what these competencies mean.

For the needs of the Skills4Cities project the key steps in the competences mapping process were followed as shown in **Fig. 3** below.

4.1. Skills4Cities classification of competencies

Mapping smart city competencies areas

Competences mapping in the Skills4Ciries project is a process that creates a map of competencies of the smart city project target group, that were identified Since this project is focused on the smart city project as a basic component (as building brick as well as process) it particularly addresses the shortage of digital and transferable skills of experts working as a staff in the smart cities or as external experts working for smart cities. The mapping will clarify what are the required competencies of the smart city practitioners who work on developing, advising and managing smart city projects of different kinds and scale.

The structure of the competence map is to be based on the Skills4Cities fields of competencies model (for knowledge, skills, and abilities). This model has been prepared to facilitate the process of elaborating job profiles of the mentioned target groups. It serves to clarify and test the set of competencies that the target groups should upgrade through the corresponding certified training in order to respond to the needs of the cities so that they have more effective development, management, and implementation of smart city projects.

So, the following **four set of competencies** were identified for mapping at the preparation stage that had to be verified in the next level of development:

Fig. 3. *Key steps in the Skills4Cities competency mapping process applied*

1. Transversal skills;
2. Smart city technologies competency areas - knowledge about key disruptive technologies;
3. Competences for dealing with the smart city projects challenges;
4. Competences for smart cities projects areas of action (of applications and solutions).

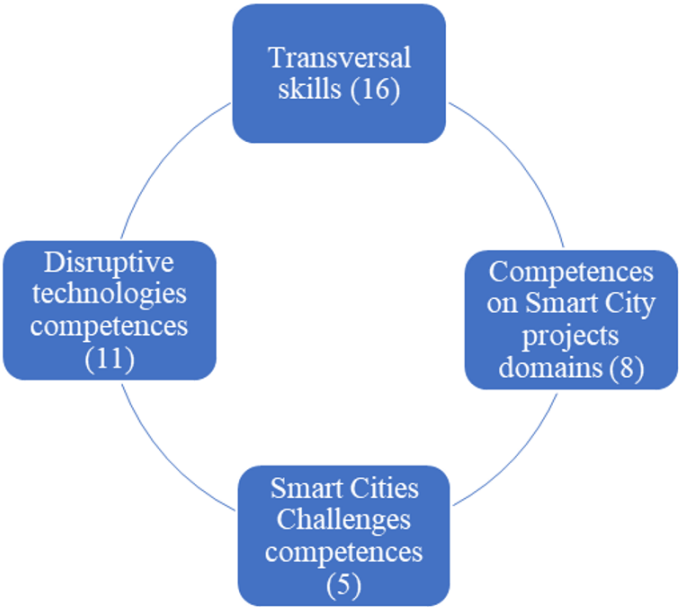


Fig. 4 *Skills4Cities four main groups of competencies*

Undoubtedly, people working on smart city projects need access to accumulated knowledge and information for good practices of how smart city projects are generated, initiated, developed, and implemented in the listed smart city areas.

- **Transversal competencies**

They are not specifically related to a particular job, task, academic discipline, or area of knowledge but as skills that can be used in a wide variety of situations and work settings. The number of transversal skills is large, so in this case should be selected those that may play an important role in the job roles of these specific target groups. Transversal Competencies are competencies that are transferable between different job roles. They could also be described as "experience". Skills4Cities partner identified and agreed upon *16 basic and most relevant transversal skills* essential for the identified three job roles and distributed per each of them, depending on how relevant they are to the particular skills and knowledge the professionals should possess.

- **Disruptive technologies competencies**

These competencies include basic knowledge about the digital disruptive technologies and the way of their implementation into the digital transformation of the cities, some digital skills, and structured information about existing standards, platforms, impact, and good practices. Such competencies of the target group support their job to develop and manage smart city projects of all possible kinds and dimensions.

The map of disruptive technologies and the needed competencies of those who work for smart city projects is elaborated within the project Smart by Design (https://www.smartbydesign.eu/) and will be used as a good example and basis for the Skills4Cities project as well. So, based on the map of Smart by Design, the partners

identified and agreed upon *11 basic and most relevant disruptive technologies competencies*.

- **Competencies related to the Smart City projects domains**

These competencies include knowledge about the areas of application of smart city technologies and the way such technologies are used to implement for resolving challenges of the cities. Includes also accumulated knowledge and information for good practices of how smart city projects are generated, initiated, developed, and implemented in the listed smart city areas. As it was already stated in the Mapping smart city domains, based on the cited study there are eight domains where the competencies of the targeted job roles can be identified and described.

- **Competencies related to Skills4Cities projects challenges**

A lot of knowledge, skills, and abilities should be added to the minimum required list of competencies that the three proposed job roles have, so that they can successfully develop, manage, and advise smart city projects after the training.

The selection of the most proper competencies will be made through careful analyses and discussions during the project. Nevertheless, at this stage it is clear that it is a must for the proposed job roles to have knowledge on smart city standards, resilience of cities, integrated urban planning, the basics of the digitalization process, to be able to use smart business models and to measure the impact of their projects. They also have to possess skills in managing the divergent and contradictory interests of a big number of stakeholders in one city during the project's life cycle, as well as many other topics. All smart city challenges and the skills required for better dealing with them are grouped in *5 competence areas*.

The main groups of competencies that the proposed job roles need to cover have been identified. Considering that the transversal competencies and those connected to the disruptive technologies are well defined and common for the three job profiles, the current gaps analysis intends to focus in particular on the more specific ones required to develop, implement and manage a multidisciplinary smart city project (**Table 3**.).

Based also on the defined three job roles for development, implementation, and management of smart city projects – the "building block" of the smart city, an initial competency model has been drafted. It aims to facilitate the process of mapping the skill gaps, and for further elaborating the job profiles for upgraded competencies in the next stages of the implementation of the Skills4Cities project.

The proposed model will be used to clarify and elaborate in detail the competencies (knowledge, skills, and abilities) that the proposed job roles should upgrade through the corresponding certified training to respond to the needs that the cities have for more effective generation, management and implementation of smart city projects.

4.2. Definition of competences and setting the Competence Framework aspects

It is very important that a competency is defined well. This helps in providing a clear picture on what exactly is the detail about the set of skills and abilities required. Each competency description has been defined in regard to the three smart city projects related job roles. Each competency definition considers in detail the main smart city projects domains that the project Skills4Cities builds on and the identified smart city projects challenges for the development, implementation, and management of smart city projects.

The identified **40 competencies** in total are grouped within the **four core groups** of competencies - listed in **Table 3** on the next page. After the definition of each of the competencies within the 4 main sets it was in addition analysed and indicated whether the given competence is mandatory or optional for the three given job roles (**Table 4**).

Further during the development of the Toolkit, in the next component**, A2. Smart City Competence Framework** (**SCCF**) the partners had to develop in detail the behavioural indicators for each of the identified competencies within the four core groups of Skills4Cities competencies identified at the first stage. A specific focus was given on the competencies related to the identified smart city project domains and the Smart city project challenges.

This Toolkit is aimed to create opportunities and conditions for upskilling of the target group with already existing formal education in competency that are necessary for the development, implementation and management of smart city projects.

The key elements of competencies framework concern the three specific job roles selected in the mapping process (smart city project developer), smart city project manager and smart city project management consultant) and include their knowledge, skills, experience, professional qualities, abilities and attitudes that lead to the successful performance of smart city projects.

- Smart city project developer (D);
- Smart city project manager (M);
- Smart city project management consultant (C).

Table 3. *Definition the EQF levels for the three job roles*

Skills Competence	**Knowledge and skills descriptor** (to be used as a basis for defining (improving) the learning outcomes for each role separately)	**EQF levels**				
		4	**5**	**6**	**7**	**8**
I. Transversal skills						
1. Creative thinking	Knows and is able to use detailed practical and theoretical knowledge and to apply new approaches to solving problems and challenges. Is able to find appropriate solutions taken from another environment, to modify them and to import them for the needs of a city. Is able to use a creative approach to problems and has the ability to find new solutions to existing urban problems. He knows and is able to use methods and tools in this field and is able to easily find arguments and justifications for solving the tasks and for the implementation of any smart city project.			D M C		
2. Familiarity with new technologies & ICT	Uses the most common information technologies, being well aware of the limits of his knowledge and knows how to increase his awareness for each specific case. Able to select and use digital tools to solve problems and performs effective work for the benefit of smart city projects. Is able to search, collect and share information in an ethical manner based on good ICT knowledge.		D M C			
3. Innovative thinking	Is able to use theoretical and practical knowledge to generate new ideas and to apply flexible approaches to problem solving incl. design thinking approach. Is able to research, formulate, create, implement and adapt existing solutions to lead to new knowledge and use good practices in solving the smart city project challenges. It has tools and approaches to solve existed problems with new means and in a new way.		M	D C		
4. City / urban planning policies	Possesses and is able to implement a knowledge of urban spatial structure and the way a city functions, knows the role of urban planning and its evaluation, the legal framework for functioning, the interrelationship and interaction between economy, transport, health, utilities, regulations and use of urban land/property. Possesses a strategic attitude to investigate and is able to define the problems related to urban planning and its connection with the smart city. Knows and understands the social and environmental impact of urban planning policies on communities and project stakeholders.		M D	C		

5. Legal familiarity	Possesses a general legal culture, uses a wide range of theoretical and practical knowledge in the field of the legal framework (national and local) and knows how and where to look for legal information. Is able to identify legal issues, collect legal information using information sources related to the legal case, interpret and transmit legal information to third parties, use and relate legal information to the solved case or problem of the smart city. Is able to work with legal advisers and to set them clear tasks to solve.	M	D C			
6. Critical thinking	Is able to objectively analyse data and information and draw rational conclusions. Possesses analytical thinking and good communication skills, thinks unbiased (based on objective information), asks the right questions (based on results), practices self-reflection and makes well-informed decisions. Is able to participate in, understand and interpret complex cases.			D M C		
7. Working in teams	Is able to share information, knowledge, personal strengths and achievements. Understands and is able to build on the perspectives of others to improve the effectiveness of the entire team. Is able to promote the team work, participate and partner, support proactivity and inclusion, advise and resolve conflicts, and build bridges.	C	D	M		
8. Intercultural competences	Is able to effectively and appropriately communicate with people from other cultures through respect, empathy, interaction, understanding of reactions in conditions of uncertain and unpredictable cultural differences. Captures and understands the specific perceptions, thinking, feeling and acting in contact and interaction with people from foreign cultures and possesses ability to communicate with them.		C	D M		
8. Learn by experience	Is able to accumulate knowledge from his own activity and knows how to consider each of his valuable initiatives as an opportunity to learn. Knows how and is able to learn from successes and failures, his and others', including both from more experienced mentors and from peers and colleagues.		D M C			
10. Emotional Intelligence / empathy	Knows how to maintain harmonious professional relationships by demonstrating respect and sensitivity to others. Is able to demonstrate flexibility and professionalism, manage sensitive situations, build mutual trust and recognize and support diversity and differences.			D M C		
11. Mobilising others	Knows how and is able to mobilize people, organizations and partners to set goals, implement plans and achieve results. Is able to build coalitions with key stakeholders to achieve success. Is able to develop and cultivate effective relationships, motivate teams, gain support through influencing and negotiation, gain trust, actively listens and creates an open, positive environment, to encourage enthusiasm and the achievement of common goals.		C	D M		

12. Task/time management	Demonstrates mastery of time management and organization (own and others) and possesses self-management habits leading to higher productivity. Is able to identify critical and less critical activities in a project, to prioritize tasks and adjust priorities according to the performance, to optimize use of resources (people, processes, units, and tools) and focus work to prevent irrelevant problems from occurring or of excessive deconcentrating to affect project efficiency.		C D	M		
13. Decision-making	Is able to provide and/or to follow rules for solving emerging problems based on their consideration in a broader perspective and variant, can use ready-made solutions, integrate different approaches into a single complete solution, create new conceptual models. Knows and uses techniques for negotiation, for attracting interested parties, for anticipating and presenting change in a positive light. Solves problems by systematically using different sources of knowledge.		C	D M		
14. Leadership and conflict-management	Shows strategic thinking, knows how to keep emotions under control and limit negative reactions when provoked or when faced with opposition or hostility from opponents or even partners, knows how to manage people, plan and manage changes, communicate. Is able to use specialized knowledge of conflict theory, knows and uses the principles for systematic analysis of a conflict situation, has a built-in reflection on individual patterns of behavior in similar situations. Knows ways to improve personal effectiveness, understands the role of conflict management as a strategic resource of the leader in carrying out effective development of the organization. Is able to manage conflicts through mediation and negotiation, apply alternative strategies to neutralize conflicts, able to intervene in complicated situations.		C	D M		
15. Finance management	Has detailed knowledge and is able to oversee the financial aspects of the organization and/or project, including performing budget analysis and calculating project return on investment, making procurement and personnel spending decisions. Knows the methods of planning and developing scenarios of cash flows, knows how to analyse financial data, forecast future income and expenses, apply contractual provisions, use statistical modelling software and develop spreadsheets.			D M C		
16. Public communication	Has knowledge and is able to use language as a flexible tool for sharing and gathering information, masters the exchange of ideas and the open exploration of different points of view, adjusting the style and content. Is able to communicate and to understand the different points of view, to adapt messages to a specific audience, to communicate results, promote mutual understanding, implement strategic communication, and to successfully convey complex messages.		C	D M		

II. Disruptive technologies						
17. Artificial Intelligence	Has basic knowledge and ability to critically evaluate the use of AI technologies to solve urban problems, communicates and collaborates freely in this field. Demonstrates skills and experience in organizing the use of this technology in projects. There is knowledge of how the most popular frameworks and platforms work, where machine learning and multilayer neural networks can be used, what is possible, feasible and permissible in using AI to solve city problems.	D M C				
18. Data analytics	Has basic knowledge of how data analysis helps to solve smart city challenges, is able to apply techniques to discover useful information and to use data analysis software, can extract data, interpret and use data infrastructures, including knows data modelling, the principle of data lakes, data warehousing methods, etc., knows the concepts and technologies of data visualization and is able to analyse data using various techniques.	D M C				
19. Cloud Computing	Knows and uses the basic terms and concepts of cloud computing, the concept of services accessible from any device connected to a network, for citizens to access applications to use services from anywhere in the city. Knows the applicability of the main types of cloud-based services - Software as a Service (SaaS), Infrastructure as a Service (IaaS) and Platform as a Service (PaaS), new service models such as Big Data as a Service, Graphics as a Service, Desktop as a Service. Knows some existing cloud computing platforms and standards used by cities. Is able to use remote services on the Internet, to share data and files, and to use digital storage.	D M C				
20. Internet of Things	Knows the basic concept of IoT and its application in the smart city. Has a general knowledge of software and electronic components to connect and exchange data without human intervention, understands the basic concepts and techniques of IoT, including electronics, sensors and actuators, knows the most popular existing IoT platforms and standards, best practices and can use them in the development and/or implementation and management of smart city projects.		D M C			
21. Cyber physical systems	Knows how these systems can transform urban assets to become smart and interconnected ones. Is able to use them within a smart city project. Is able to interpreted how they interact to create an intelligent environment, how information security systems are used to maintain and update data and to implement and monitor security solutions in real time. Knows and is able to use existing platforms and existing standards as well as areas of application of these systems in the city.	D M C				

22. Smart sensors	Is well informed and understands how smart sensors are used to monitor, control and obtain environmental data in real time, how data is collected automatically, thus improving the quality of measures taken. Knows the essence of smart sensors, their functions, the type of built-in computing resources and predefined functions. Knows how smart sensor technology is used to optimize existing processes, improve efficiency and conduct continuous monitoring. Knows and is able to use existing platforms and standards and key application areas in cities.	D M C				
23. Collaborative robotics	Is able to use a wide range of information and understands the basics of computer programming and electronics. Understands how and where cobots can be used in the urban environment and in systems other than industrial processes, know their most important advantages over traditional robots, good practices for their use in the smart cities, and knows where to collect and use information about the existing platforms and standards.	D M C				
24. Cybersecurity	Has a general understanding of cyber security technology and the concept of preventing the theft and misuse of online information such as personal data, institutional and banking information, passwords, purchases, reservations, etc. Understands the principles of cybersecurity technologies, information assurance, risk management, and incident detection and response. Knows examples and good practices for successful implementation of cyber security in cities.	D M C				
25. Blockchain	Is able to understand the principle of a digital ledger of transactions between users belonging to the same network in a secure, reliable and permanent manner. Has basic knowledge of how it works and knows why the technology is safe and how to use it. He has an understanding of the basic technologies required for blockchain implementation and their benefits, knows best practices for using blockchain in smart cities, and the most advanced and popular existing blockchain platforms and standards.	D M C				
26. Augmented reality (AR)	Is able to understands the augmented version of reality, where objects found in the real world of a city are enhanced by computer-generated perceptual information, sometimes in multiple sensory modalities, including visual, auditory, haptic, somatosensory, and olfactory. There is theoretical knowledge about the principles of operation of this technology, and about the key areas of its application in smart cities. Knows case studies and good practices and is able to use them in his activity and knows some existing platforms and standards in.	D M C				

27. Virtual Reality (VR)	Is able to understand the computer simulated environment replacing the real environment and to use theoretical knowledge about the principles of operation of this technology, and about the key areas of its application in smart cities. Is familiar with case studies and good practices and is able to use in his activity as well as is informed about and knows existing platforms and standards in this area.	D M C				
III. Smart city project domains						
28. Economy, trade, and industry	Possesses and is able to use detailed theoretical and practical knowledge of economics and industry, incl. in micro- and macroeconomics, trend analysis, investment climate analysis, value chains and international trade and production models. Is able to use tools for solving micro- and macro-economic problems, to manage resources, collect, analyse and interpret data and results from the areas of research, coming from applying economic criteria and choosing alternatives. Is able to track and interpret macroeconomic trends and analyse economic challenges and propose appropriate solutions. Possesses knowledge on and is able to develop and/or use strategic plans, including for smart cities.		M	D C		
29. Government and education	Possesses and is able to use theoretical and practical knowledge as well as sources of information related to state administration and, in particular, to the administration of a city. Is able to successfully operate and/or create and implement standards that enhance the effectiveness of public administration in implementing government policies and obligations to protect the public interest and improve education.		M	D C		
30. Living and health	Is able to use general knowledge and a wide range of information and information sources related to public health and the risk of hazards in an urban environment. Is able to demonstrate and apply knowledge, skills, behavior and judgment on topics related to health care and quality of life. May develop and implement quality assurance procedures in this area.		M	D C		
31. Public safety	Possesses and is able to apply general knowledge and a wide range of information and information sources for crisis management, public safety, measures, procedures and plans for behavior in critical situations, including in the cities (floods, fires, terrorist attacks, earthquakes, etc.), mitigation plans in crisis situations. Is able to make situation analysis, to define problems and to design proposals for solutions in this area, to apply crisis management techniques and to use technology to prevent and manage situations and people during emergencies and crises.		M	D C		

32. Mobility and transportation	Knows the models for the organization of public transport and is able to interpret information about trends and innovations in the transport sector. Uses a wide range of knowledge about information infrastructure and the use of digital technologies in the field of transport. Knows and uses good practices and case studies for the digitization processes and platforms in the field. Is able to identify, analyse and assess challenges in old infrastructure and in new urban mobility projects. Can collect and interpret data from the field, find, support and propose arguments and make justifications in solving problems in urban mobility through the application of new technologies. Is able to promote compliance with air quality standards and other quality of life measures by implementing solutions for efficient, equitable, safe and secure public transport systems, digital vehicle innovation and sustainable infrastructure - physical and digital.		M	D C		
33. Environment and sustainability	Knows and understands the international sustainability framework and knows how different stages and activities are managed in green transformation projects. Is familiar with the urban geography and the principles of sustainable functioning and development of a city. Is able to apply a holistic approach, set goals, perform tasks and solve problems related to green transformation, sustainability and the environment in cities. Sets and implements goals for ICT implementation to improve quality of life, develops and/or implements sustainability strategies and monitoring systems. Undertakes initiatives based on sustainability indicators, proposes and/or implements projects with ecological components and related to environmental protection protocols in all and/or in individual stages and phases of the life cycle of such smart city projects.		M	D C		
34. Energy, water, utilities	Possesses general knowledge and is able to use information sources and understands how energy, waste, water use affect a given smart city project. Knows the models for the organization of the supply of water, energy and communal services and is aware of the trends for the entry of innovation and digital technologies in these sectors. Knows the information infrastructure in the field of transport, knows and is able to use good practices and case studies for the digitalization processes and platforms in these areas of the smart city. Demonstrates ability to perform tasks and solve problems related to sustainable energy and water management, use utility management in the life cycle of a project, is able to organize access to and analysis of data from networks and to ensure open access to the public for reference and consumption analysis. Develops and/or is able to use an urban framework for utilities and waste management, may create and/or use a smart city roadmap in the field of utilities, develop or use digital platforms for water, heating, gas, energy management and others.		M	D C		

35. Digital infrastructure and networks	Knows and understands the impact of digital infrastructure on the economy in general and on the city and urban processes in particular. Uses general theoretical knowledge of digital infrastructure such as backbone networks, internet backbone, broadband, mobile telecom and digital communication packages including applications, data centers and networks. Knows and is able to use best practices for digital infrastructure and networks. Is able to map and/or interpret and use strategic infrastructure, develop and/or participate in the implementation of localized smart city projects, interpret geographic data and use maps and/or perform GIS analysis, initiate and/or manage and coordinates localized smart city projects and identifies processes, phenomena and patterns in urban areas.			D M C		
IV. Smart City Challenges						
36. Technological challenges	Has and is able to use detailed theoretical and practical knowledge of advanced technologies such as data collection and analysis based on the Internet of Things (IoT), the use of artificial intelligence and machine learning, the use of advanced video technologies, etc. Demonstrates expertise in areas of application of such technologies. Knows the specifics of the process of planning and introducing technologies and, in general, the process of digital transformation of a city. Knows and is able to use examples of failed smart city projects due to the emergence of technological challenges or due to the misunderstanding (or misunderstanding) of the technologies by the stakeholders in the context of the objectives. Knows the big picture behind any smart city project that requires serious digital skills and use of digital infrastructure. Understands the role of technology and its life cycle and the need to synchronize it with the project life cycle.			D M C		
37. Financial constrains	Knows the specifics of financing smart city projects and the process of planning and implementing budgets for such initiatives. Knows and is able to use examples of unsuccessfully implemented projects due to financial challenges or misunderstanding of financial instruments and to use them in the design and implementation of new projects. Knows the big picture behind any smart city project, which is usually multidisciplinary and requires an understanding of the financial dimension of such a project. He has the knowledge and is able to supervise and manage budgets of large multidisciplinary projects, to produce detailed and accurate forecasts of cash flows and budget expenditures. Is able to collect and interpret financial data and to make judgments on project planning and execution. Is able to use theoretical and practical knowledge of public-private partnerships and public procurement as an important factor in the success of most smart cities. Demonstrates knowledge and experience of interacting and working with investors.			D M C		

38. Collaboration among stakeholders and governmental re-straints	Uses detailed theoretical and practical knowledge including that obtained as a result of review and study of specialized literature, scientific developments, professional survey studies, case analyses and results from other cities as well as own studies. Able to gather and use information related to how to achieve a good level of collaboration and cooperation between stakeholders in the implementation of smart city projects. Uses information and knows how to apply methods to communicate, share and agree on such projects between the various stakeholders. He knows and uses examples of unsuccessfully implemented projects due to the presence of administrative barriers or due to mutual misunderstanding between the municipality and other interested parties and uses them in the design and implementation of new pro-jects. Good knowledge and experience of solving administrative and organizational obstacles related to the participation of city authorities and ways to eliminate or solve them.			D M C		
39. Managerial and organizational challenges	Knows the challenge of organizing and coordinating the development, implementation and management of a smart city project that includes multiple stakeholders. Uses detailed theoretical and practical knowledge in the field of organization and management and applies methods and tools to manage complex systems as well as demonstrate innovation in their application. Has an innovative and critical understanding of the process of administering such projects and can find and support arguments for its improvement. Able to apply a structured and disciplined approach to managing such projects. Is able to build organizational capacity to implement a project in its entirety or in specific areas and topics. He knows how to coordinate the interests and activities of the parties interested in the project from different fields and with different expertise.			D M C		
40. Social challenges	Uses detailed theoretical and practical knowledge about the social factors that often represent obstacles and reasons for unsuccessfulness of the smart city initiatives. Knows methods and models for social entre-preneurship and knows how to use them in the implementation of smart city projects. Knows examples of failed SC projects due to social factors and uses them in the design and implementation of new projects. Knows and uses methods to promote social inclusion in smart city projects, has good insight and excellent communication skills to win over and involve large groups of stakeholders and all categories of citizens for the realization of smart city projects.			D M C		

Table 4. *Definition of Skills4Cities mandatory levels of the competencies by the three job roles*

List of 40 competences	Manager		Devel-oper		Consult-ant	
	M	O	M	O	M	O
I. Transversal competences						
1. Creative thinking	X		X		X	
2. Familiarity with new technologies & ICT	X		X			X
3. Innovative thinking	X		X			X
4. City/urban planning policies		X	X		X	
5. Legal familiarity		X		X		X
6. Critical thinking		X	X		X	
7. Working in teams	X			X		X
8. Intercultural competences	X		X		X	
9. Learn by experience		X		X		X
10. Emotional intelligence / empathy	X		X		X	
11. Mobilise others	X			X		X
12. Task/time management	X			X		X
13. Decision-making	X			X		X
14. Leadership and conflict management	X		X			X
15. Finance management	X			X		X
16. Public communication	X		X			X
II. Disruptive technologies competencies						
17. Artificial Intelligence		X		X		X
18. Data analytics		X		X		X
19. Cloud Computing		X		X		X
20. Internet of Things	X		X		X	
21. Cyber physical systems		X		X		X
22. Smart sensors	X		X		X	
23. Collaborative robotics		X		X		X
24. Cybersecurity		X		X		X

25. Blockchain		X		X		X
26. Augmented reality		X		X		X
27. Virtual reality		X		X		X
III. Smart city projects domains competencies						
28. Economy, trade, and industry		X	X		X	
29. Government and education		X		X		X
30. Living and health		X		X		X
31. Public safety		X		X		X
32. Mobility and transportation		X		X		X
33. Environment and sustainability		X		X		X
34. Energy, water, utilities		X		X		X
35. Digital infrastructure and networks	X		X		X	
IV. Smart city challenges knowledge						
36. Technological challenges	X		X		X	
37. Financial constraints	X		X		X	
38. Collaboration among stakeholders and gov. restraints	X		X			X
39. Managerial and organizational challenges	X			X	X	
40. Social challenges		X		X		X

Legend:

M: Mandatory level and/or advanced knowledge level
O: Relevant to some extent

4.3. SCCF proficiency levels

The European Qualifications Framework (EQF) Levels

The purpose of levels within a framework is to provide benchmarks with which framework users can readily identify performance at a predefined capability level. Levels are often described and given a numeric abbreviation, the EQF uses eight levels (1-8). To provide consistency, each level is identified through a common set of parameters; the descriptors deployed in the EQF are knowledge, skills and competence.

The EQF definitions are described In **Table 5** below. Within the EQF, Competence, Skills and Knowledge are described in terms of height, depth, and breadth within an increasing context complexity. (Recommendation of the European parliament and of the Council on the establishment of the European Qualifications Framework for lifelong learning)[11].

SCCF proficiency levels

When defining the proficiency levels close alignment to the EQF categories has been followed.

At the same time the smart city projects specificities have been considered and so, the competences and level of experience addressing the related problems, challenges and sub-topics in the process of development, implementation and management of such projects. Based on that **five proficiency levels** have been defined which relate to the EQF as described in detail in the **Table 6** on the next page.

Table 5. *EQF definitions*

Knowledge	Skills	Competence
Knowledge' is the outcome of the collection and assimilation of information through learning. In the EQF, knowledge is described as theoretical and/or factual.	'Skills' are the ability to apply knowledge and use knowhow to complete tasks and solve problems. In the EQF, skills are described as cognitive (use of logical, intuitive and creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments)	Competence' is the proven ability to use knowledge, skills and other abilities to perform a function against a given standard in work or study situations and in professional and/or personal development. In the EQF, 'Competence' is described in terms of "responsibility and autonomy".

[11] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008H0506(01)&from=EN

Table 6. *SCCF definition of proficiency levels*

Proficiency Level	Competence descriptor (Knowledge and skills)	Responsibility and autonomy
Level 1. Basic EQF 4	Factual and theoretical knowledge in broad contexts within a field of work or study. A range of cognitive and practical skills required to generate solutions to specific problems in a field of smart city projects. Problem solving with basic methods, tools, materials and information, responsibility for completion of tasks in work or study, adapting own behaviour to circumstances in solving problems of smart cities. Learners can generate ideas that create value for smart city stakeholders.	Exercise self-management within the guidelines of work or study contexts that are usually predictable, but are subject to change; supervise the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities.
Level 2. Intermediate EQF 5	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge. A comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems. Learners can develop and introduce multiple ideas that create value for smart city stakeholders.	Exercise management and supervision in contexts of work or study activities where there is unpredictable change; review and develop performance of self and others.
Level 3. Proficient EQF 6	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles. Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study.	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups
Level 4. Expert EQF 7	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research. Critical awareness of knowledge issues in a field and at the interface between different fields. Specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields.	Manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams

Level 5. Expert EQF 8	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields. The most advanced and specialised skills and techniques, including synthesis and evaluation, required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or professional practice.	Demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contexts including research

Conclusions

In conclusion, the completion of the Skills4Cities Competencies map/ mapping process, is the first step towards accomplishing the project aims to:

- Develop a unified scheme for training, certification, and recognition of upgraded competencies of project developers, managers, and consultants to generate, develop, manage and consult diverse and sophisticated smart city projects over the world.
- Elaborate skills cards needed for the professions of the smart cities project managers, consultants, and developers that will be a base for new competence framework for these professions.
- Develop a modular program for training and up-skilling of the Smart City project developers, managers, and consultants for the needs of upgrading their professional qualification.
- Promote certification in a training centre which complies with high standards and quality of training, valid on European level.
- Promote new job roles of the future.

Links to sources

- https://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET%282014%29507480_EN.pdf
- https://theinnovatorsforum.org/content/challenges-implementing-smart-city-initiatives
- https://www.riskierworld.com/articles/esi-thoughtlab-reveals-how-167-cities-worldwide-are-leveraging-technology-data-and-partnerships-to-drive-social-development-goals
- https://smartdevops.eu/dev/
- https://theinnovatorsforum.org/content/challenges-implementing-smart-city-initiatives
- https://www.allerin.com/blog/4-challenges-faced-by-smart-cities
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- https://mitefcee.org/smart-cities-challenges-and-opportunities/
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- https://www.ecompetences.eu/methodology/
- https://europa.eu/europass/en/description-eight-eqf-levels
- https://ec.europa.eu/social/main.jsp?catId=1317&langId=en
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- https://www.oecd.org/innovation/research/1842070.pdf
- Defining the Role of the Smart-City Manager: An Analysis of Responsibilities and Skills; https://www.tandfonline.com/doi/abs/10.1080/10630732.2016.1164439

Chapter A2. Reference Competence Framework

1. The objectives of the Competence Framework

1.1. Concept

The competence reference framework is based on A1. Smart City Competence Map. The following perspectives from the mapping process were taken in consideration to use in the design and development of the framework:

- Public sector demand, through public sector services linked to Smart Cities.
- Demand from private sector actors, mainly large municipal and city service management companies.
- The supply of smart services from the ICT sector, especially from ICT operators and companies, and from the sector's benchmark associations.

One of the objectives of this competence framework is to facilitate the process of **elaborating job profiles for upgraded competencies of three target groups** of the Skills4Cities project:

1. Smart City Project Developer (SCPD): The SCPD is a highly skilled and knowledgeable practitioner who could be engaged by the cities or other city's stakeholders to initialize, demonstrate, lobby, plan, communicate with all of them, and pitch on the city level various smart city projects and know how to run and facilitate a smoother project acceptance and development in relation with the city's needs, strategies, and tasks.

2. **Smart City Project Manager** (SCPM): The SCPM can be a practitioner preferably with at least bachelor's degree in ICT/Electronics/Computer Engineering, many years of technical expertise, and project management certification, recognized by international project management certification bodies.

3. Smart City Projects Management Consultant (SCPMC): The Smart City Project Management Consultants bring specialized skills and knowledge to assist the implementation of such projects in the cities as well as in making the best possible decisions in resolving concrete challenges that Project managers meet during the life cycle of the project.

The model will be used to clarify and test the group of competencies (knowledge, skills, and abilities) that the target groups should upgrade through the corresponding certified training in order to respond to the needs that the cities have for more effective generation, management and implementation of smart city projects.

Concept

Once the smart city concept has been framed, the main functional dimensions that make up and in which cities must advance in order to become "Smarter" are proposed.

In order to arrive at these dimensions, the following have been taken into account: the reports, work and perspectives of various public entities and bodies, local administrations, private entities or public-private organisations involved in the development of Smart Cities; and, especially, the perspective and needs of citizens and companies as the main users of a city and its services. In relation to public bodies and organisations, the European Parliament's Directorate-General for Internal Policies [12] considers that a city is smart has at least one initiative that addresses one or more of the following six characteristics: Smart Economy, Smart People, Smart Mobility, Smart Environment, Smart Governance and Smart Living. These **six smart city characteristics**, which are a prerequisite for developing the competence framework, have been defined in previous chapter A1. Smart City Competency Map.

1.2. Objectives and priorities

The first thing that is recommended to those involved in the development of a smart city is to analyse and validate the dimensions and scope of the same in the short, medium and long term in order to plan the implementation of a Smart City strategy. To this end, and in order to design the framework of the Smart City competency model, the strategic documentation of the different areas of the City Council's government that would be most involved in the Smart City project (transversal skills, disruptive technologies, smart city project domains, smart city challenges, etc.) will be analysed. Likewise, special interest will be paid to the documentation containing the Smart City competency map, in order to understand the most relevant aspects of daily operations, focusing on the services with the greatest impact for citizens and for the City Council itself. In order to carry out this deliverable, in addition to the above, several interviews and/or working groups with the heads of the Government Areas, key bodies and staff from technology companies have also been considered with the purpose of validating and completing the information available in order to: confirm the competences required by the different roles selected according to the classification of the competences established, in order to establish the training structure and the user's guide.

The development of the Smart City strategy translates into a progressive improvement in the management of the city's resources in order to achieve a better economic balance, improve the quality of life and the welfare system as well as environmental conditions.

The Smart City model of the municipality will be the conceptual scheme that gives a satisfactory response to the objectives, characteristics and elements to aspire to be a Smarter City. In this way, taking into account the objectives and priorities defined by the city and the citizens, assessing that each city has different characteristics defined, among others, by population density, natural spaces or the main source of income, and highlighting those essential elements that define it, it is possible to obtain the desired Smart City Competence Framework. Smart Cities provide opportunities in the different areas of action related to mobility, people, employment, urban planning and housing, government, administrations, renewable energies, etc. For this reason, depending on the analysis of the objectives and priorities of the municipality and its characteristics, a specific competence framework can be chosen. To cite a few

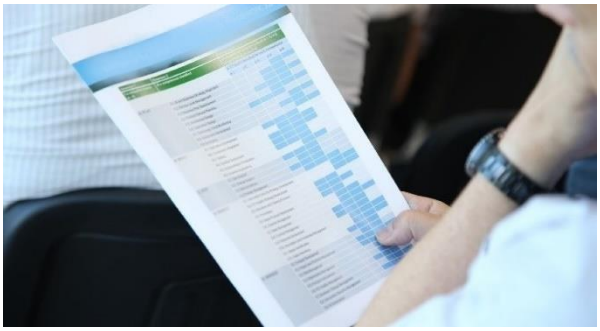
[12] Overview of the six Smart City characteristics (Mapping Smart Cities in the EU, IP/A/ITRE/ST/2013-020)

examples: there will be cases of training actions that will focus on environmental sustainability, which will be those where green areas predominate or that wish to reduce high pollution rates; others will focus on improving the living conditions of specific groups, often characterised by ageing populations in need of specific telecare services; some cities, whose main source of income is based on tourism, will want to improve those services that make the tourist experience more pleasant by developing mobile applications or digital spaces where all the information about the municipality can be found; others will want to position themselves among the most transparent cities, substantially improving their relationship with citizens and making them more involved in public decision-making; some will want to improve their public transport network, etc.

Once the ideal approach to the reality of the Smart City competence framework of the municipality has been made, this framework will be adapted, taking into account aspects such as: roles of the people to whom it will be addressed (**project managers, project advisers and project developers**) as well as whether it is recommended that it be a compulsory competence or a certain level of knowledge, for which a series of variables have been considered such as budgetary restrictions, degree of maturity of the applications, opportunity in the application of certain measures, needs of the citizens, etc. In practical terms, this exercise will be translated into the selection of competences in relation to their thematic areas in order to achieve the competence framework of a Smart City, which will be translated into a specific training structure.

These priorities will shape the Curriculum, based on the framework, and a curriculum package (Skills4CityCurr) will be developed in the context of the occupational skills and roles of smart city staff. In a schematic and step-by-step manner, after knowing the list of competences by domain / profession / professional role developed in the competence map (A1), we will have to organise the list of competences by each of the selected dimensions, so that by knowing the areas of application of smart city technologies and the way in which these technologies are implemented to solve the challenges of cities, we can determine the necessary competences. All of this has been obtained, as mentioned above, from accumulated knowledge and information linked to good practices, from the case study models analysed in A1, from experiences of other projects related to smart cities, and from interviews with personnel related to smart cities and participation in working groups for the deployment of smart cities.

1.3. Aspects for building SCCF



Following the findings in the Smart City Competence Map the Smart City Competence Framework (SCCF) integrates the **following four aspects:**

1. 4 competence areas
2. 40 smart city competences
3. 5 proficiency levels
4. Knowledge and skills descriptor.

Aspect 1 4 competence areas	Four groups (areas) of competencies are derived from the smart city competence mapping (IO1/A1): 1) Transversal; 2) Disruptive technologies; 3) Project domains; 4) Challenges. They provide the entry point to the smart city competences and reflect a process perspective based upon the waterfall approach.
Aspect 2 40 smart city competences	40 competences in total the project have identified and included in the general references' framework of the three professional roles. Each competence is described with title and a generic information, defined from an organisational perspective of the smart city projects and the tasks the concrete profession will play for developing, managing and implementing such projects. In the Competence Framework Explorer on the next page one can find all identified 40 competences while in the competence frame of anyone of the three particular professions only mandatory competences will be taken into consideration.
Aspect 3 5 proficiency levels	5 competence proficiency levels characterised by increasing levels of context complexity, autonomy, influence and typical behaviour. The levels respond to the EQF descriptor. To each competence, specifically relevant proficiency levels are assigned. The Aspect 3 level descriptors provide the individual perspective of competence performance. The relevant proficiency levels for the three professional roles are between 4th and 6th EQF levels.
Aspect 4 Knowledge and skills examples	Examples of knowledge and skills relate to the Competences generic descriptions in Aspect 2. These examples are provided to add value to the competence descriptor and are not intended to be exhaustive. They offer inspiration and orientation for the identification of further specific knowledge and skills assignment according to contextual needs.

1.4. Integration of aspects into Competence Framework Explorer

In order to be able to use the initially elaborated competence framework in identifying each specific case and clarifying each individual professional profile with corresponding levels of competences, it was developed a Competence Framework Explorer that helps configuration of every professional role based on its mandatory competences, main tasks and results expected for each one of the three professional roles.

Competence Framework Explorer

Aspect 1. Competence areas	Aspect 2. Identified competencies	Aspect 3. Proficiency levels (EQF)				
		4	5	6	7	8
A. Transversal skills	A1. Creative thinking			■		
	A2. Familiarity with new technologies & ICT		■			
	A3. Innovative thinking		■	■		
	A4. City / urban planning policies		■	■		
	A5. Legal familiarity	■	■			
	A6. Critical thinking			■		
	A7. Working in teams	■	■	■		
	A8. Intercultural competences		■	■		
	A9. Learn by experience		■			
	A10. Emotional Intelligence / empathy			■		
	A11. Mobilizing others		■	■		
	A12. Task/time management		■	■		
	A13. Decision-making		■	■		
	A14. Leadership and conflict-management		■	■		
	A15. Finance management			■		
	A16. Public communication		■	■		
B. Disruptive technologies	B1. Artificial Intelligence	■				
	B2. Data analytics	■				
	B3. Cloud Computing	■				

	B4. Internet of Things		■			
	B5. Cyber physical systems	■				
	B6. Smart sensors	■				
	B7. Collaborative robotics	■				
	B8. Cybersecurity	■				
	B9. Blockchain	■				
	B10. Augmented reality (AR)	■				
	B11. Virtual Reality (VR)	■				
C. Smart city project domains	C1. Economy, trade, and industry		■	■		
	C2 Government and education		■	■		
	C3. Living and health		■	■		
	C4. Public security		■	■		
	C5. Mobility and transportation		■	■		
	C6. Environment and sustainability		■	■		
	C7. Energy, water, utilities		■	■		
	C8. Digital infrastructure and networks			■		
D. Smart City Challenges	D1. Technological challenges			■		
	D2. Financial constrains			■		
	D3. Collaboration among stakeholders and governmental restraints			■		
	D4. Managerial and organizational challenges			■		
	D5. Social challenges			■		

SMART CITY PROJECT DEVELOPER

Aspect 1: Competence areas	Aspect 2: Mandatory competencies	Aspect 3: Proficiency levels (EQF)				
		4	5	6	7	8
A. Transversal skills	A1. Creative thinking			x		
	A2. Familiarity with new technologies & ICT		x			
	A3. Innovative thinking			x		
	A4. City / urban planning policies		x			
	A6. Critical thinking			x		
	A8. Intercultural competences			x		
	A14. Leadership and conflict management			x		
	A16. Public communication			x		
B. Disruptive technologies	B4. Internet of Things		x			
	B6. Smart sensors	x				
C. Project domains	C1. Economy, trade, and industry			x		
D. Smart City challenges	D1. Technological challenges			x		
	D2. Financial constrains			x		
	D3. Collaboration among stakeholders and governmental restraints			x		

SMART CITY PROJECT DEVELOPER (Aspect 4)

Summary	Analyse, provides leadership and apply deep knowledge and practice in the design and development of smart city projects and initiatives		
Mission	Drives digital transformation process in cities by generating and delivering smart city projects and adopting innovative business models for digital transformation and resilience of cities		
Deliverables	Accountable	Responsible	Contributor
	• Concepts notes • Smart City Project Proposals	• Feasibility studies and analysis • Smart City Projects	• Digital Transformation Roadmap • Smart city project implementation plan • Action plans, budgets and Gantt chart
Main Tasks	• Researches and recommends digital technologies to fulfil the tasks of digital transformation and smart city. • Develops initiatives for smart city projects. • Develops proposals for smart city projects and coordinate them with the stakeholders until successful launch. • Prepares and coordinates the smart city projects between the municipality and all stakeholders. • Develops terms of references and specifications for detailed implementation of smart city projects, aligning the framework and content with the goals and strategy of the city.		
Mandatory competences			
A1. Creative thinking: Level 6	Advanced knowledge and range of skills involving critical understanding on innovation in solving complex and un-predictable problems in a field of work of smart cities, and management of complex technical and professional activities or projects. Practical skills to develop and implement creative solutions and introduce multiple ideas that create value for smart city stakeholders.		
A2. Familiarity with new technologies & ICT: Level 5	Comprehensive factual and theoretical knowledge of the information technologies, being well aware of the limits of knowledge. Knowledge within a field of how to increase the awareness for each specific case. Range of cognitive and practical skills in accomplishing tasks based on ICT. Competence to search, collect and share information and select and use digital tools to solve problems and performs effective work for the benefit of smart city projects. Exercise supervision on the ICT implementation and can review and develop performance of self and others.		
A3. Innovative thinking: Level 6	Advanced knowledge of process of ideation and to apply flexible approaches to problem solving incl. design thinking. Knowledge and skills to use tools and approaches to solve existing problems with new means and in a new way. Critical understanding of theories and principles, range of skills in solving complex and even un-predictable problems in a smart city digital transformation process.		

A4. City / urban planning policies: Level 5	Comprehensive or specialised factual and theoretical knowledge within a field of urban development and planning. Range of cognitive and practical skills to develop creative solutions to problems of urban development. Ability to supervise the urban development and to develop and review of self and others.
A6. Critical thinking: Level 6	Advanced knowledge and critical understanding of theories and principles of decision-making. Advanced skills in critical analysis and solving complex and unpredictable problems in a field of digital transformation of cities.
A8. Intercultural competences: Level 6	Advanced knowledge of a field of communication with diverse people. Advanced skills to communicate with people from other cultures through respect, empathy, interaction, understanding of reactions in conditions of uncertain and unpredictable cultural differences. Take responsibility for managing professional development of others.
A14. Leadership and conflict management: Level 6	Advanced knowledge of a field of conflict theory and the role of conflict management as a strategic resource of the leader in carrying out effective development of the organization. Advanced skills in negotiation, apply alternative strategies to neutralize conflicts, and in intervene in complicated situations. Take responsibility for managing conflict situations and decision-making.
A16. Public communication: Level 6	Critical understanding of theory of communication. Range of skills to communicate, to use the language as a flexible tool for sharing and gathering information, to adapt messages to a specific audience, to communicate results, promote mutual understanding, implement strategic communication, and to successfully convey complex messages.
B4. Internet of Things: Level 5	Theoretical knowledge in broad context of IoT and its application in the smart city and knowledge of best practices in the development and/or implementation of digital transformation in cities. General knowledge of software and electronic components basic skills to generate and use IoT platforms and solutions.
B6. Smart sensors: Level 4	Theoretical knowledge in broad context within the field of smart sensors and how they monitor, control and obtain data in real time. Range of skills to use existing platforms and standards and key application areas of sensors in cities.
C1. Economy, trade, and industry: Level 6	Advanced knowledge of economics and industry. Advanced skills to use tools for solving micro- and macro-economic problems, to manage resources, collect, analyse and interpret data and results.
D1. Technological challenges: Level 6	Advanced knowledge of the role of technology and its life cycle and the need to synchronize it with the project life cycle and the specifics of the planning and introducing technologies. Demonstrating mastery and innovation, required to solve process of digital transformation of a city. Range of skills to manage complex technical activities in smart city projects.
D2. Financial constrains: Level 6	Advanced knowledge of financial planning, understanding the urban projects and PPP and the measurement of financial return. Advanced skills to collect and interpret financial data and to make judgments on sophisticated budget planning and execution.
D3. Collaboration among stakeholders and governmental restraints: Level 6	Advanced knowledge, skills and experience of applying communication methods, sharing and coordinating the interests of stakeholders on smart city projects. Range of advanced skills to solve administrative and organizational obstacles related to the participation of city authorities in such projects.

SMART CITY PROJECT MANAGER

Aspect 1. Competence areas	Aspect 2. Mandatory competencies	Aspect 3. Proficiency levels (EQF)				
		4	5	6	7	8
A. Transversal skills	A1. Creative thinking			x		
	A2. Familiarity with new technologies & ICT		x			
	A3. Innovative thinking		x			
	A7. Working in teams			x		
	A8. Intercultural competences			x		
	A10. Emotional Intelligence / empathy			x		
	A11. Мобилизиране на другите			x		
	A12. Task/time management			x		
	A13. Decision-making			x		
	A14. Leadership and conflict-management			x		
	A15. Finance management			x		
	A16. Public communication			x		
B. Disruptive technologies	B4. Internet of Things		x			
	B6. Smart sensors		x			
C. Project domains	C8. Digital infrastructure and networks			x		
D. Smart City challenges	D1. Technological challenges			x		
	D2. Financial constrains			x		
	D3. Collaboration among stakeholders & govern.			x		
	D4. Managerial and organizational challenges			x		

SMART CITY PROJECT MANAGER (Aspect 4)

Summary	Managing and implementing diverse smart city projects and initiatives		
Mission	To advance the transformation process into a sustainable and smart city by leading and managing smart city projects in sync with the city's strategic development documents.		
Deliverables	Accountable	Responsible	Contributor
	• Smart city project reports • Budgets • Monitoring	• Smart city project implementation plan • Action plans and Gantt charts	• Digital Transformation Roadmap • Smart City Projects Proposals • Terms of Reference
Main Tasks	• Organize, coordinate and lead the project team • Maintain stakeholder engagement and communication • Supervise project progress • Coordinate, record and ensure quality compliance • Circulate and distribute information from the project owner • Ensure the project helps to support the organisation's wider goals • Comply with budgets and delivery times • Update the project according to changing circumstances		
Mandatory competences			
A1. Creative thinking: Level 6	Advanced knowledge and range of skills involving critical understanding on innovation in solving complex and unpredictable problems in a field of work of smart cities, and management of complex technical and professional activities or projects. Practical skills to develop and implement creative solutions and introduce multiple ideas that create value for the stakeholders.		
A2. Familiarity with new technologies & ICT: Level 5	Comprehensive factual and theoretical knowledge of the information technologies, being well aware of the limits of knowledge. Knowledge within a field of how to increase the awareness for each specific case. Range of cognitive and practical skills in accomplishing tasks based on ICT. Competence to search, collect and share information and select and use digital tools to solve problems and performs effective work for the benefit of smart city projects. Exercise supervision on the ICT implementation and can review and develop performance of self and others.		
A3. Innovative thinking: Level 5	Comprehensive, factual and theoretical knowledge within field of managing innovation and problem solving. Large range of cognitive and practical skills to innovate and develop creative solutions for smart city projects.		

A7. Working in teams Level 6	Advanced knowledge and range of skills to promote and lead the team work, enhance proactivity and inclusion of team members, resolve conflicts, and build bridges.
A8. Intercultural competences: Level 6	Advanced knowledge of a field of communication with diverse people. Range of skills to communicate with people from other cultures through respect, empathy, interaction, understanding of reactions in conditions of uncertain and unpredictable cultural differences. Take responsibility for managing professional development of others.
A10. Emotional Intelligence Level 6	Advanced knowledge and critical understanding the emotional intelligence of people. Advanced skills, demonstrating mastery and innovation to maintain harmonious professional relationships in project team.
A11. Mobilizing others Level 6	Advanced knowledge and skills to mobilize people, organizations and partners to set goals, implement plans and achieve results, and mastery to cultivate effective relationships and motivate through actively listens and creates an open, positive environment, to encourage enthusiasm and the achievement of common goals.
A12. Task/time management Level 6	Advanced knowledge, elaborated habits and skills to managing time leading to higher productivity. Advanced skills to prioritize the tasks and optimize use of all project resources.
A13. Decision-making Level 6	Critical understanding of theory and principles of decision-making and knowledge on use of management techniques in this field. Rich range of skills to integrate different approaches into a single complete solution and create new conceptual models.
A14. Leadership and conflict-management Level 6	Advanced knowledge of a field of strategic thinking, leading people and managing change. Critical understanding the conflict theory and the principles for resolving through mediation and negotiation, and applying strategies to neutralize conflicts. Advanced skills of limiting negative reactions and taking responsibility to lead the project team to a successful end.
A15. Finance management: Level 6	Detailed and advanced knowledge of a field of financial management of projects including methods of planning and developing scenarios of cash flows and analysing financial data. Critical skills to forecast future income and expenses, apply contractual provisions, use statistical modelling software and develop spreadsheets. Taking responsibility to oversee the financial aspects of the organization and/or project, including performing budget analysis and calculating project return on investment, making procurement and personnel spending decisions.
A16. Public communication: Level 6	Critical understanding of theory of communication. Range of skills to communicate, to use the language as a flexible tool for sharing and gathering information, to adapt messages to a specific audience, to communicate results, promote mutual understanding, implement strategic communication, and to successfully convey complex messages.
B4. Internet of Things: Level 5	Comprehensive and theoretical knowledge in broad context of IoT and its application in the smart city and knowledge of best practices in the development and/or implementation of digital transformation in cities. General knowledge of software and electronic components basic skills to generate and us IoT platforms and solutions.

B6. Smart sensors: Level 5	Comprehensive, factual and theoretical knowledge within the field of smart sensors and how they monitor, control and obtain data in real time. Comprehensive range of cognitive and practical skills required to develop smart solutions, based on sensor technology. Reviewing and develop performance of self and others in use of sensors in cities.
C8. Digital infrastructure and networks Level 6	Advanced knowledge of a field of digital infrastructure in a city. Advanced skills, demonstrating mastery and innovation required to solve problems of use in a smart city projects backbone networks, internet backbone, broadband, mobile telecom and digital communication packages including applications, data centers and networks. Can develop and introduce multiple ideas that create value for smart city stakeholders.
D1. Technological challenges: Level 6	Advanced knowledge of the role of technology and its life cycle and the need to synchronize it with the project life cycle and the specifics of the planning and introducing technologies. Demonstrating mastery and innovation, required to solve process of digital transformation of a city. Range of skills to manage complex technical activities in smart city projects.
D2. Financial constrains Level 6	Advanced knowledge of financial planning, understanding the urban projects and PPP and the measurement of financial return. Advanced skills to collect and interpret financial data and to make judgments on sophisticated budget planning and execution.
D3. Collaboration among stakeholders and governmental restraints: Level 6	Advanced knowledge, skills and experience of applying communication methods, sharing and coordinating the interests of stakeholders on smart city projects. Range of advanced skills to solve administrative and organizational obstacles related to the participation of city authorities in such projects.
D4. Managerial and organizational challenges Level 6	Advanced theoretical and practical knowledge in the field of management and applying methods and tools to manage complex organisational systems. Demonstrating mastery and innovation to apply a structured approach and organisational capacity to managing such projects. Taking responsibility for decision-making in an complex environment of multiple and diverse stakeholders.

SMART CITY PROJECT MANAGEMENT CONSULTANT

Aspect 1. Competence areas	Aspect 2. Mandatory competencies	Aspect 3. Proficiency levels (EQF)				
		4	5	6	7	8
A. Transversal skills	A1. Creative thinking			X		
	A4. City / urban planning policies			X		
	A6. Critical thinking			X		
	A8. Intercultural competences		X			
	A10. Emotional Intelligence / empathy			X		
B. Disruptive technologies	B4. Internet of Things		X			
	B6. Smart sensors	X				
C. Project domains	C1. Economy, trade, and industry			X		
	C8. Digital infrastructure and networks			X		
D. Smart City Challenges	D1. Technological challenges			X		
	D2. Financial constrains			X		
	D4. Managerial and organizational challenges			X		

SMART CITY PROJECT MANAGEMENT CONSULTANT (Aspect 4)

Summary	Providing specific services to the city on various aspects and stages of the smart city projects life cycle or directly to project managers when deeper and/or more specialized information and/or expertise is needed in the relevant project teams.		
Mission	Smart city project management consulting services are used when management expertise is lacking or an unbiased assessment of the manner and results of the activities of project developers and project managers is required.		
Deliverables	Accountable	Responsible	Contributor
	• Consulting reports	• Consulting analysis and proposals • Impact assessment reports • Feedback reports	• Smart City Projects Proposals • Project implementation plans • Terms of Reference
Main Tasks	• performs analyses and developments, more general or highly specialized for the needs of the development, justification, management and implementation of smart city projects, based on a wide range of management methods and techniques. • marketing and dissemination of smart city projects and the results • public procurement • feedbacks and impact assessment reports. • working with potential investors		
Mandatory competences			
A1. Creative thinking: Level 6	Advanced knowledge and range of skills involving critical understanding on innovation in solving complex and un-predictable problems in a field of work of smart cities, and management of complex technical and professional activities or projects. Practical skills to develop and implement creative solutions and introduce multiple ideas that create value for smart city stakeholders.		
A4. Level 5	Comprehensive factual and theoretical knowledge of the information technologies, being well aware of the limits of knowledge. Knowledge within a field of how to increase the awareness for each specific case. Range of cognitive and practical skills in accomplishing tasks based on ICT. Competence to search, collect and share information and select and use digital tools to solve problems and performs effective work for the benefit of smart city projects. Exercise supervision on the ICT implementation and can review and develop performance of self and others.		
A6. Critical thinking Level 6	Advanced knowledge and critical understanding of theories and principles of decision-making. Advanced skills in critical analysis and solving complex and unpredictable problems in a field of digital transformation of cities.		

A8. Intercultural competences: Level 5	Factual and theoretical knowledge of communicating with diverse people with an awareness of boundaries of that knowledge. Range of cognitive and practical skills required to develop creative solutions of the problem of communicating with people from other cultures through respect, empathy, interaction, understanding of reactions in conditions of uncertain and unpredictable cultural differences. Reviewing and developing performance of self and others.
B4. Internet of Things: Level 5	Theoretical knowledge in broad context of IoT and its application in the smart city and knowledge of best practices in the development and/or implementation of digital transformation in cities. General knowledge of software and electronic components basic skills to generate and use IoT platforms and solutions.
B6. Smart sensors: Level 4	Theoretical knowledge in broad context within the field of smart sensors and how they monitor, control and obtain data in real time. Range of skills to use existing platforms and standards and key application areas of sensors in cities.
C1. Economy, trade, and industry Level 6	Advanced knowledge of economics and industry. Advanced skills to use tools for solving micro- and macro-economic problems, to manage resources, collect, analyse and interpret data and results.
C8. Digital infrastructure and networks Level 6	Advanced knowledge of a field of digital infrastructure in a city. Advanced skills, demonstrating mastery and innovation required to solve problems of use in a smart city projects backbone networks, internet backbone, broadband, mobile telecom and digital communication packages including applications, data centers and networks. Can develop and introduce multiple ideas that create value for smart city stakeholders.
D1. Technological challenges: Level 6	Advanced knowledge of the role of technology and its life cycle and the need to synchronize it with the project life cycle and the specifics of the planning and introducing technologies. Demonstrating mastery and innovation, required to solve process of digital transformation of a city. Range of skills to manage complex technical activities in smart city projects.
D2. Financial constrains Level 6	Advanced knowledge of financial planning, understanding the urban projects and PPP and the measurement of financial return. Advanced skills to collect and interpret financial data and to make judgments on sophisticated budget planning and execution.
D4. Managerial and organizational challenges: Level 6	Advanced theoretical and practical knowledge in the field of management and applying methods and tools to manage complex organisational systems. Demonstrating mastery and innovation to apply a structured approach and organisational capacity to managing such projects. Taking responsibility for decision-making in an complex environment of multiple and diverse stakeholders.

Chapter A3. Curricula Package

The Curricula package as a chapter of this Toolkit is developed for the target group of learners so they can easily understand which educational path is to be followed to gain all the necessary knowledge of understanding and managing smart city projects. It is built upon the activities carried out previously and provides an additional tool in this Toolkit to help mainstreaming the professionals in the area of the Smart City projects.

1. Structure of the package

The package is structured as follows:

It contains an *introductory part* which sets the tone and degree of focus in relation to the objectives of the Skills4Cities project. It puts the Curriculum in the context of whole Toolkit, as it is strictly inter-connected with the single objectives of each of other chapters, namely *A1. Smart City Competency Map; A2. Reference competences framework and A4. User Guide*. As it is critical for the understanding of the project's objectives it reiterates the experts (professionals, individuals, freelancers etc.) to whom the Curriculum and the deliverables produced in the context of the Toolkit and the project are addressed.

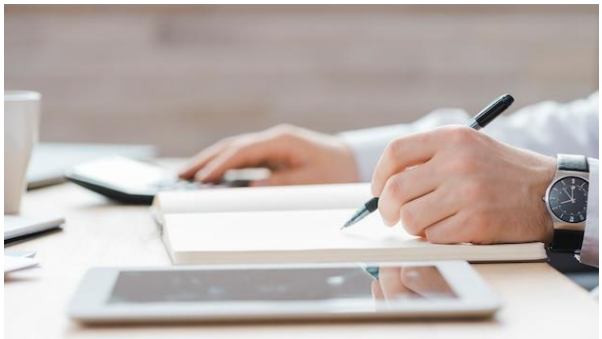
The core part is a description of the content of Curriculum that is divided in four training modules, corresponding to the 4 sets of competencies, identified in the previous steps of the project and described in the chapter A1.

The *four sets are modular* and are explored according to the skills deemed necessary for professionals working in the transversal sector of Smart cities. The training module presents the competences to be acquired at the conclusion of the training program and the structure of the training program, along with the training and evaluation methodology as well.

The final part of the package is built upon the training material organized in the previous chapter in order to create the specific curricula for each of the three job profiles identified and deemed relevant for this project:

- Smart City Project Developer (SCPD),
- Smart City Project Manager (SCPM) and
- Smart City Project Management Consultant (SCPMC).

In so doing, the professionals who are interested in developing knowledge and skills to better perform in the competitive market of smart cities' projects, will have a clear learning path to fulfil. The Curricula can benefit from the validation of recognized experts, as well as the background work carried out and which has brought to the development of this document, as well as the *Validation tool for Smart city competences*. Finally, a conclusive section is foreseen to pave the way to the following deliverable to be produced in the context of the User Guide.



Target audience

It is crucial to clearly understand the target audience not only of this Curriculum but also of the project as a whole, so to better align to the expectations of those that will

profit and make the best of the insights produced by the context of Skills4Cities. Smart Cities are, after all, a transversal endeavour which have taken place in recent years thanks to the large-scale implementation of information and digital technologies for solving both extemporaneous and strategic challenges.

However, for this implementation to take place, the bureaucratic machine defining the framework of cities' development in terms of policies, legal framework and so forth must be included and activated. Finally, smart city projects, for the innovation the concretely bring to the texture of the urban areas they are developed in, will greatly affect the landscape to which people, businesses and common citizens are used to.

Correlation with chapters (stages)

The Curriculum as an education tool aims to present the learning path that individuals, be them professionals, adult learners, or young people, must follow in order to achieve and master a determined set of competencies.

The first phase of the project revolved around the identification of these competences. Given the complexity of Smart Cities themselves, as well as their relative projects, the identification of the competences needed is a crucial step in understanding how it is possible, at the current state of the art, to effectively manage and develop projects that apply information and digital technologies for the sake of urban areas. The chapter A1 and chapter A2 include this information. In the context of the findings in the chapter A1, the team was engaged in deep research of the ongoing and completed projects that have helped making cities "smarter" around the world. In gaining a better understanding of the core areas that are touched when these pro-jects are put in place, the consortium started gathering an in-depth knowledge of the experts working on these activities and the big scope of challenges they face during all the phases of the smart city projects.

In such a way the core 4 groups of competences were identified and became a base of this curriculum, namely: Transversal skills, Disruptive technologies competences, Competences on smart city projects domains, Smart cities challenges competences. These groups are then further developed into learning units, with standing learning outcomes and relative skills and knowledge.

However, the other core component of this Curriculum, contemplated in the second part of the second chapter, are the job profiles that have been identified as one of the most important in driving the disruptive innovation process of smart cities' projects.

These are: already mentioned before: Smart City Project Developer (SCPD), Smart City Project Manager (SCPM) and Smart City Project Management Consultant (SCPMC). In particular, the Competences Frame, developed in the context of A2, has helped exploring the connections between smart cities, their main dimensions of actions and the professionals involved in the process.

Finally, the goal of the Curriculum is to contribute to these two processes of

competences research and competences mapping, by bringing together the competencies needed to face the challenges brought by Smart Cities. This way, the Curriculum coherently organizes the body of knowledge needed as a whole and at the same time adjust it to the role and needs of each job profile identified.

Curriculum Development

In this second chapter, the Curricula for the four areas of competences identified will be explored more in detail. These four areas are the following ones:

1. *Transversal skills*
2. *Disruptive technologies competences*
3. *Smart city projects domains*
4. *Smart city challenges competences.*

These areas include *40 competencies* that have been identified as necessary, in a transversal way, for conceptualizing, developing, and implementing Smart City projects.

The methodology underpinning the definition of the 4 areas and the 40 competencies has been extensively discussed and described in the two deliverables that set the base for the development of the Curriculum, namely the Competencies Map and the Competencies Frame. Given the highly innovative component underlying all Smart cities' projects, the team agreed to thoroughly research and study the current state-of-the-art for what characteristics these projects have, what challenges they address and face and finally what sort of professionals (before the actual professions) supporting these endeavours.

In particular, this package explores the competences associated with each area, to understand in particular their educational characteristics in terms also of skills and knowledge.

They are described through the following categories:

The definition of the 4 competence areas, the relative 40 competencies and the three job profiles laying the basis for this Curricula package

- General description
- Competences
- Skills & Knowledge needed to achieve the competences
- Training methods
- Assessment methods
- Lab experience
- Learning units

Following the above structure for description there 4 modules have been developed corresponding to the 4 identified groups of competencies.

These are described in **ANNEX 2.**

From Training Modules to Job Profiles: Smart Cities' Curricula

This second part links the Competences as presented in the previous section, and sorted as well in the four areas, with the three job profiles *A1. Smart City Competency Map* have identified thanks to the extensive background research and analysis carried out and supporting the intellectual endeavour of Skills4Cities.

The professions identified are the following:

1. Smart City Project Developer (SCPD)
2. Smart City Project Manager (SCPM)
3. Smart City Project Manager Consultant (SCPMC).

These are going to be explored and will all have, to different extents, to learn and absorb knowledge from the four areas of competences presented so far. The innovation of the Skills4CitiesCurr lies in its modularity approach. With the creation of these strong links between the Smart City projects (their characteristics, challenges etc.), the competences needed to manage and coordinate such projects and the definition of three job profiles, the Skills4CitiesCurr goes one step further, is directly the single competencies, skills, and knowledge to define three innovative and flexible curricula for the professionals that, in the future, will enable the wider uptake of Smart City projects.

The Curricula package is structured as follows:

- General Description
- Competences
- Training methods
- Assessment Methods
- Lab Experience Learning Pathway

In **ANNEX 3** are presented the curricula for the three job roles.

Conclusions

The objective of the curricula package is that *to provide a ready-to-use and thoroughly verified learning pathways for those professionals that, currently or in the next future, will be employed by city councils, town halls and other urban consortiums to design, develop, implement, and coordinate Smart Cities' projects*.

The curricula are prepared in a multidisciplinary way, reflecting the nature of such particular projects, and they provide the accurate and detailed knowledge and skills to be acquired in order to develop specific Smart cities 'related competences.

The curricula package as a component (tool) is to be understood in close relation with the other components / chapters / tools of this Toolkit, namely:

- A1. Smart City Competences Map
- A2. Reference competences Framework
- A4. User Guide

All of them can only be understood as closely communicating with each other, as a coherent set of tools enabling the mainstreaming and wider uptake of relevant competencies for cities and Smart Cities specifically.

As previously presented, A3. Curricula package builds upon the findings of the first two chapters in order to accurately identify and allocate competences to the relative job profiles. At the same time, these three documents represent the core of what A4. User Guide revolves around.

Chapter A4. User Guide

The **Toolkit for smart city competence framework** was elaborated under the Project "Smart Skills for Smarter Cities", financed by the Erasmus + Programme of the European Union. The **main objective** of the project, as a whole, was to develop and test learning & validation tools for training of professionals who will play important role for the success of digital transformation of cities.

What does this guide represent?

The user guide is a brief statement of instructions on how the toolkit can be used and what the users would benefit. These instructions are in a form of Q&A would be particularly useful for the target group of professionals who perform or can perform one of the three selected professional roles (see next page).

What is SCCF?

The main component of the Toolkit is *Smart City Competency Framework (**SCCF).*** This competency framework is a model that broadly describes performance excellence in developing, management and implementing smart city projects.

The framework includes 40 competencies that are applied to three professional roles played by individuals or within an organization.

Each competency defines, in generic terms, the level of working behaviour; this definition then establishes the benchmark against which the smart city professionals can self-assess themselves or can be assessed by the city administrations or by the management of the organizations that develop, manage or implement smart city projects. SCCF is a means by which all stakeholders in a smart city project can communicate each other on that which behaviours are required, valued, recognized and rewarded with respect to the three specific occupational roles.

SCCF ensures that all involved in a smart city project parties in general, have a common understanding of the values and of the expectations about the performance of any smart city project. SCCF can be used by the city administrations, the freelances, training centres, as well as in many government and private sector organizations that are involved in smart city development, management and implementation.

For which professional roles is the competency framework developed?

SCCF is developed in order to facilitate the process of **elaborating job profiles for upgraded competencies of three target groups**:

1) Smart City Project Developer (SCPD): The SCPD is a highly skilled and knowledgeable practitioner who could be engaged by the cities or other city's stakeholders to initialize, demonstrate, lobby, plan, communicate with all of them, and pitch on the city level various smart city projects and know how to run and facilitate a smoother project acceptance and development in relation with the city's needs, strategies, and tasks.
2) Smart City Project Manager (SCPM): The SCPM can be a practitioner preferably with at least bachelor's degree in ICT/Electronics/Computer Engineering, many years of technical expertise, and project management certification, recognized by international project management certification bodies.
3) Smart City Projects Management Consultant (SCPMC): The Smart City Project Management Consultants bring specialized skills and knowledge to assist the implementation of such projects in the cities as well as in making the best possible decisions in resolving concrete challenges that Project managers meet during the life cycle of the project.

The model is to be used to clarify and test the group of competencies (knowledge, skills, and abilities) that the target groups should upgrade through the corresponding certified training in order to respond to the needs that the cities have for more effective generation, management and implementation of smart city projects.

How was this Toolkit developed?

The Toolkit itself was aimed to provide means for better development, implementation and overall management of the 'building blocks' of a smart city - the smart city projects. In this way, an opportunity and conditions for upskilling was created by training the target groups in specific skills that are necessary for the development, implementation and management of smart city projects as well as all its components.

The **key elements** of competencies framework concern the three specific professional, roles selected in the mapping process (smart city project manager, smart city project management consultant and smart city project developer) and include their knowledge, skills, experience, professional qualities, abilities and attitudes that lead to the successful performance of a specific work role in the management of smart city projects.

The development of the competency framework for the above-mentioned professional roles included the following **4 steps** (components, deliverables):

First step: A1. Smart city competence map

This stage in the preparation of the competency framework was based on research and analysis of relevant sources, good practices and examples. To prepare the competency map, a rich literature on currently existing concepts, policies and initiatives related to smart cities and competencies was drawn upon. Suitable analyses and existing case studies describing the challenges in designing, implementing and managing smart city projects were collected.

Second step: A2. Reference competences framework

At the second stage after identifying and the description of all competencies, the definition of the proficiency levels of every one of them, and after specifying and validating which of them are mandatory and optional for the three professional roles a Competency Framework Explorer was developed as an integration of all aspects - 4 competence areas, 40 competences, 5 proficiency levels and the relevant knowledge and skills. It explores the competences and the three SC professional role profiles identified by mapping process. These are the typical roles performed by the smart city projects professionals, covering the full business processes. This framework was used as a basis for the competency identification and help to clarify each professional profile with its mandatory competency description for the corresponding proficiency levels, the main tasks and deliverables for any of these roles.

Third step. A3. Curricula package

The Curricula package was developed in the context of whole Toolkit. There are developed 4 training modules, corresponding to the four groups (sets) of competences. The training module presents the competences to be acquired at the conclusion of the training program and the structure of the training program, along with the training and evaluation methodology as well.

The last part of every module is built upon the training material organized in order to create the specific curricula for each of the three job profiles.

The professionals who are interested in developing knowledge and skills to better perform in the competitive market of smart cities' projects, in a such way possess clear learning path to follow.

How to use the Chapter A1 of this Toolkit?

This chapter is dedicated to clarifying the terms, typologies and professional characteristics of the three job roles that were identified as important "agents of change" for smart cities.

The content of this chapter was built to be in the context of developing, managing and implementing smart city projects as "building blocks" for the digital transformation of cities. For that purpose, all findings in this chapter were results from the first stage of the development of this toolkit named "mapping". It is recommended that the reader first familiarize himself with this first chapter of the Toolkit, as in the process of reading he/she will understand the logic of selecting the competencies that are necessary for the development, management and implementation of smart city projects. On the basis of the cited and

presented studies and case studies attached in the annex, the reader will be able to better understand the reason for choosing exactly these areas of competences, as well why one competence is mandatory and what is its recommendatory proficiency level.

How to use the Chapter A2 and what does the users have to know about its structure?

The users have to know that A2. *Smart City Competence Framework* is structured from **four components (aspects)**. These aspects reflect different levels of professional roles in the planning, managing and implementing smart city projects and are specified as follows:

Aspect 1: Four competence areas (sets) derived from the mapping process where the most important drivers for the success of the smart city projects were identified: 1. Transversal skills, 2. Technologies competences, 3. Key project domains knowledge, 4. Knowledge and experience on the project challenges. These areas are instrumental in assessment and the allocation of training programmes as well as the identification and self-assessment of smart city competences for the selected professional roles. This aspect helps city administration, freelancers and managers of the companies involved in the smart city projects to communicate each other and make joint decisions. In addition, it is a first guide to organize and list smart city competences for three concrete job roles. They provide the entry point to the smart city competences and reflect a process perspective based upon the waterfall approach.

Aspect 2: The core of the SCCF is a set of **40 reference competences** with a generic description for each competence. Some of the competences (in total 16 transversal) are not business sector-specific, i.e., they do not address specific applications. They are general competences customizable and applicable to any industry or business sector including for smart cities and the related to them projects. Those skills that are not specifically related to a particular job, task, academic discipline, or area of knowledge but as skills that can be used in a wide variety of situations and work settings. The number of such skills is large so, in every concrete case, should be selected those that may play an important role in the job roles of these three specific target groups.

Other competences (in total **8 digital disruptive technologies**) bring digital skills, basic knowledge and structured information about existing standards, platforms, impact, and good practices in every one of them. Such competencies of the target group support their job to develop and manage smart city projects of all possible kinds and dimensions.

The set of **8 smart city projects domains** includes knowledge and skills about the areas of application of smart city technologies and the way such technologies can be used to resolve challenges of the cities. Includes also accumulated knowledge and information for good practices of how smart city projects are generated, initiated, developed, and implemented in the listed smart city areas.

The last set of competences includes minimum required knowledge, skills, and abilities about concrete **5 smart city challenges** that were identified as commonly problem areas in the development, management and implementation of smart city projects.

Aspect 3: For each competence, suitable proficiency level specifications ranging between competence levels 1 and 5 have been constructed. They relate to EQF levels 4 to 8. Nevertheless, this aspect involves "behaviours" and levels of "individual" competences is created that were found to enter into **scope of 4 to 6 EQF level**.

Aspect 4: Knowledge and skills embedded within competences are listed. They are not intended to be exhaustive but are examples of competence content. These examples can be useful, in defining specific and precise outcomes to be assessed within an individual competence assessment programme. In addition, they provide inputs for training institutions to help define learning outcomes and design training initiatives. Within the Aspect 4 are listed and described mission, main tasks and deliverables for every one of the three professional roles. Aspect 4 components refer to Aspect 2 but are not related to specific competence levels in Aspect 3. However, Aspect 3 has been used to verify the applicability of knowledge and skills identified for the mandatory competences for the particular professional role.

Who can be user of SCCF?

The SCCF was designed for any person who needs skills and competence to plan, create and/ or develop and implement smart city projects. SCCF can serve to measure and upgrade competences of wide range of actors, who would like to play the role of smart city project managers, project developers and project management consultants, spanning from civil servants, engineers to simple end-users such as the now "digitalized" citizens. Here is one of many possible descriptions of these categories, taken from *A1. Smart city competence map*:

- The professionals directly involved in the organization and approval of smart city projects. These persons are usually part of the city administrations, either as civil servants or appointed by the relevant departments in order to oversee the actualization of the developmental plan of the city. Professionally speaking, they are urban planners, architects, politicians working in the city hall, and other figures that affect the dimension of the project.
- The following group regards all those professionals that are hired externally so to bring their highly specific and needed competences for the development and implementation of the project. These experts can be technical, such as IT specialists, economists, geologists, lawyers etc., or more service-oriented, such as utility companies' representatives.
- Finally, the third group is a less formalized one as it is usually hired by those funding the initiative on a mere project basis. However, they represent the core working capacity of such projects, usually leading the process given their interest, competence, and experience in the topic of Smart Cities. These project managers will represent the central target audience of Skills4Cities, as these are usually the persons driving the process of change inside the cities.

Can I use the SCCF to measure and assess competences?

Yes, this is one of the application possibilities of the framework. Assessment tools will be developed in near future, for different purposes, using the SCCF as a basic reference. Development of assessment tools does not incur a license fee.

Why does the SCCF has 5 levels when the EQF has 8?

The SCCF was developed from an perspective of "owner / employer of smart city project" by adding value to described job roles

ANNEX 1

Smart City Projects (Case Studies)

In this annex, 15 examples (case studies) of developed and implemented smart city projects are presented with their challenges and success factors. All case studies were collected by project partners and described within the framework of the development of IO/A1 following a model (template).

The data for each smart city project, insofar as they have been collected, is presented in tabular form, in which the challenges encountered and solved during the development and implementation of smart city projects are identified and described.

The **ultimate purpose of this model** was the project team can draw conclusions about what competencies the smart city project managers, smart city project developers and smart city project consultants have applied. The following data was gathered and presented for the need of description of the challenges of every one of the smart city projects:

- Project name
- City name
- Start (when did the project started?)
- End (when did the project finish?)
- Main stakeholders (Who participated in developing and who was responsible for the project)? Is it ordered only by the city or it is an initiative by stakeholders?
- Investor(s) (Who is/are the investor(s)?
- Financial model (from where and how did the money come or will come)
- Business model (how and who proof the cost-benefit result and the feasibility of the project)
- Impact (who was mainly affected by this project and what are the results, measured with some metrics).

Specifically included are the following types of challenges that were identified during the mapping process:

- technological,
- financial,
- collaboration among stakeholders.
- managerial and organizational,
- social

So, where data were found, there was included in the model explanation of how the challenges were solved in each of the following two stages of the smart city projects:

- smart city project development
- smart city project implementation.

Case Study 1

Project name	Participatory Budgeting Platform
City name	Cluj-Napoca, Sibiu, Turda, Fagaras, Deva, Targoviste, Targu Secuiesc
Start	May 2017
End	Launch date July 2017. The project development is continuing
Main stakeholders	Cluj-Napoca Municipality wanted an online participatory budgeting platform. EvoZon is the developer of the online solution. Other 6 municipalities from Romania were interested in developing such an online platform since 2018 - Sibiu, Turda, Fagaras, Deva, Targoviste and Targu Secuiesc.
Investor(s)	EvoZon developed the online solutions on demand from each of the municipalities listed above.
Financial model	The local city budgets financed the development, launch and maintenance of the participatory budgeting online solution
Business Model	Public Private Partnership
Impact	Citizens in the cities that started using the online participatory budgeting solution could propose small scale projects to address their needs, covered from the municipality's budget. The online voting system was open to all citizens in that city

Type of challenges	Smart city project development	Smart city project implementation
Technological	The time to develop the first solution for the Cluj-Napoca Municipality was very short, 1 month, thus there was little time for research on the optimal technological solution. The solution was to use existing and stable frameworks and platforms and to deliver the solution incrementally. The first deadline, when the platform went live / was launched, the only functionality was to create user accounts and submit project proposals. Afterwards we continued developing other functionalities of the platform, in the next 2 months, while the registration / submission phase of project proposals was on.	Finding a way to restrict the online registration and voting to citizens in the area of the city / municipality was a challenge. The solution was based on limiting the user registration process to IP classes in the city's area. The 2 Factor Authentication (confirmation email and SMS) system put in place to register users caused some users/citizens to drop the registration process and not participate in the voting system. Therefore, some administrations have chosen to replace the initial 2FA solution by only a confirmation email.

Financial	There were some minor financial issues during the development stage due to the fact that various 3rd party online modules or features that needed to be integrated into the solution can only be purchased by card transactions. The municipalities do not have the possibility to purchase goods or services via card transactions, and thus the developer had to advance expenses and integrate them in the contract.	There were no financial issues during the operation / in production stage of the solution.
Collaboration among stakeholders	A single point of contact from the beneficiary is desirable when developing online solutions. This situation is / was hardly possible when working with public authorities since the decision is rarely with a single person. Therefore, the solution to this situation was to create and add all relevant stakeholders in an online group (skype, WhatsApp etc.) so that everybody can be aware of the status, discussions and take part in the decision-making process.	A continuous dialogue took place between the municipality representatives and those of the solution provider in order to make sure that new features and maintenance were available on time and secured the functionality of the platform.
Managerial and organisational	Multiple discussions and meetings had to take place on the same topic with different representatives of the beneficiary before reaching an agreement, due to the fact that more people and / or departments of the municipalities were involved in various stages of the solution development.	The decisions on specific extra features after the solution was launched weren't always consistent coming from various representatives of the beneficiary. However, eventually agreements were reached into what needed to be added or changed to best reflect the overall aim of the participatory budgeting process.
Social	There were significant differences in terms of user engagement from one municipality to another. The more consistent the awareness raising campaign made by the City Hall among its citizens, the bigger the number of users registered to propose projects and to vote. In the cities where advertising the online participatory budgeting process was scarce, the turnout was smaller.	In almost every city the first year was the one that managed to draw the attention of most people. Setbacks in terms of implementation issues, authorizations that prolonged the implementation period more than 1 year, until a new participatory budgeting process began, decreased citizens' trust in it. The municipalities that performed a more thorough evaluation process of the proposed projects (in terms of eligibility and feasibility) and supported smaller scale projects that could be implemented in 1 year, had more success with the public, and a higher return rate in further editions.

Case Study 2

Project name	ZONIZ
City name	Alba Iulia
Start	2018
End	Ongoing
Main stakeholders	Alba Iulia Municipality. The collaboration started as part of the Alba Iulia Smart City pilot project, coordinated by Orange, aiming to digitize and develop the city.
Investor(s)	Global E Business Solutions developed the solution on demand, making it adjustable according to the demands of stakeholders.
Financial model	The local city budgets financed the development, launch and maintenance of the solution.
Business Model	Public Private Partnership
Impact	The Municipality launched the app in order to drive citizen engagement and promote tourism. The app is available free of charge to all citizens and includes access to information on restaurants, retail, etc.

Type of challenges	Smart city project development	Smart city project implementation
Technological	The project responded to the needs of a new concept for Romania at the time: smart city. The app had to respond to specific needs in order to maintain the engagement of users in terms of content rather than technological. The content was to be provided by the Municipality.	The solution was not difficult to implement and launch, as users were responsive to the app.
Financial	The app is customizable depending on the communication needs of the Municipality, so there is the option of having sponsors participate with content in order to engage users.	There were no financial issues during the operation / in production stage of the solution.
Collaboration among stakeholders	There are some difficulties in working with public authorities in terms of embracing the adoption of such app. Multiple stakeholders should be involved in order to generate relevant content, both from the private and public sector.	All issues were solved through open discussions with all stakeholders involved in the early development process.
Managerial and organizational	In terms of having the app respond to suggestions of citizens, there is a difficulty in creating a new job for a person to be in charge of this aspect within the City Hall.	The app was customized to be used at the neighbourhood level as well, and it carries out messages of public interest.
Social	There were significant disruptions in terms of creating new content to keep users engaged, as well as in terms of marketing the app.	The citizens were interested in using this app in order to receive updated information.

Case Study 3

Project name	Smart metering and energy consumption management system
City name	Cluj Napoca
Start	April 15, 2021
End	April 15, 2022
Main stakeholders	Cluj Napoca Municipality, RF Meters, Transylvania IT Cluster
Investor(s)	Cluj Napoca Municipality
Financial model	EU grant through REFLOW Project
Business Model	Public Private Partnership
Impact	Citizen, reduced energy consumption, reduced air pollution.

Type of challenges	Smart city project development	Smart city project implementation
Technological	The project started with the goal of reducing the energy consumption of a Cluj Napoca Municipality owned building. No measurement or reporting system was considered. After several meetings, the idea of a proper energy consumption management system appeared.	Multiple buildings in the area are using the same power line. Energy consumption metering on each of these buildings was necessary. The system installed consists in energy consumption monitoring in 7 different points. The data from the smart metering system is available on a web platform and an interface with the REFLOW database is under construction.
Financial	Being a pilot project with general requirements, several phases had to be considered in addition to the technical solution	Besides the cost of the energy smart metering and management system, a monitoring and development phase was added to measure the results of the whole system implementation and to build an interface with the REWFLOW database.
Collaboration among stakeholders	Different areas stakeholders could lead to poor collaboration and lack of confidence.	All differences were covered by a good communication through several online meetings.
Managerial and organizational	Managerial challenges occurred because of the COVID-19 pandemic situation.	To avoid the spread of the pandemic, teams involved in the project worked in the building on different schedules. Informative meetings were held to inform the stakeholders about the work progress. Due to a very good management, no problems occurred even with the pandemic situation.
Social	The local building management was not very aware of the benefits of the system installed.	Even if local management team was not considered a stakeholder, special meeting was held to raise the awareness of the project's benefits. Thus, no delays were added.

Case Study 4

Project name	Smart payment system of local taxes
City name	Ciugud
Start	February 2020
End	ongoing
Main stakeholders	It was Ciugud Town Hall's project, developed and implemented by 2 subcontractors
Investor(s)	Ciugud Town Hall
Financial model	City budget
Business Model	Public investment - no business model
Impact	Citizens - it offered the possibility for Ciugud's inhabitants to pay their taxes through automated payment machines / robots available close to their home, sparing them the presence and queue at the Town Hall during the pandemic.

Type of challenges	Smart city project development	Smart city project implementation
Technological	The need of the project arose during the outbreak of the COVID-19 pandemic. The Town Hall seized the opportunity to implement a "zero cash" policy for payments made by citizens for their annual taxes. They had in place an online payments system, but wanted to automate the "cash payments". Thus, providers of automated payment machines were contacted; their hardware solution needed to be integrated with the payment modules already used by the Town Hall.	During implementation, due to the shortage of components, the hardware providers (of the automated payment machines) could only supply machines which didn't offer change. This was a drawback, which was solved in about 2 months. Other than that, integration with the existing payment solutions worked just fine.
Financial	There were no financial setbacks, since the Town Hall has been investing in Smart City solutions since 2005 and has a yearly budget for the projects they prioritize.	There were no financial setbacks, since the Town Hall has been investing in Smart City solutions since 2005 and has a yearly budget for the projects they prioritize. The financial model was that of using the solution offered by the hardware suppliers as a service, for a negotiated fee based on the income generated. Thus, Town Hall avoids maintenance and operation costs of the automated payment machines. Also, the generated payments are handled by the hardware

		provider, who has to pay it to the Town Hall, upon withdrawing its fee. Therefore, risks of handling cash is on the provider, not the Town Hall.
Collaboration among stakeholders	The collaboration model was the following: Town Hall needed the automated payment solution, to dispose of the cash payments at their counters. They've contacted hardware suppliers of automated payment machines, who needed to update their possible payments, and integrate it with the existing Town Hall database. This was possible through the collaboration between the developer of the software payments solution, who made sure the 2 solutions are compatible and fully automated.	No issues during implementation in what regards collaboration among stakeholders.
Managerial and organizational	No managerial issues have been identified regarding managerial and organizational aspects during project development.	No managerial issues have been identified regarding managerial and organizational aspects during project implementation.
Social	Ciugud's elderly citizens weren't very keen on making payments through automated machines.	Specially because the first generation of machines that were installed didn't offer change, the citizens were even more reluctant to use them, as they didn't always have the exact amount of money which they had to pay. The employees of the Town Hall helped them during the first weeks. Afterwards, with the arrival of automated machines which offered change their usage increased. Another important factor was taking the machines closer to the citizens, so they were installed in local shops that are usually visited by the people. As a result, citizens increased their trust and usage of digital payment methods and their digital competences, while helping the Town Hall increase the percentage of collected taxes all without cash.

Case Study 5

Project name	Sistema robo cable (Anti-theft cable system) https://www.em-beblue.com/en/proyectos-2/
City name	Navarra-Spain
Start	2021
End	2023
Main stakeholders	Embeblue
Investor(s)	Embeblue and Saltoki.
Financial model	Embeblue investment + R&D&I grant from the Government of Navarra (not yet awarded) in collaboration with Saltoki.
Business Model	Sale of devices and platform rental
Impact	Reduction of cable theft from luminaires.

Type of challenges	Smart city project development	Smart city project implementation
Technological	There was a challenge in creating a device with improved functionality to existing products and it has been solved with the ingenuity and experience of Embeblue as well as some ideas from companies in the sector.	The system integration part of the system is being solved by a long-established platform in the industry.
Financial	The need for investment has been solved on one hand with Embeblue's own financing and on the other hand with an R&D grant that will most likely be awarded in the next few months.	The investment in marketing, training and support will be made in principle by Saltoki.
Collaboration among stakeholders	An agreement is being finalized defining the rights and obligations of all the companies involved.	It is covered by the agreement created for the development part.
Managerial and organizational	Embeblue is taking the lead on the development side.	Saltoki is expected to take the lead.
Social	On a social level, one of the reasons for developing this project was to create safe working environments, preventing theft and so on. Another aspect was that the company does not have to incur losses due to password theft and to avoid compensating for the losses by increasing the cost of passwords to customers due to password theft.	In order to control the area, video surveillance cameras were installed, which provided greater security and control in the area.

Case Study 6

Project name	CODE CONTRACT (https://codecontract.io/)
City name	BASQUE COUNTRY
Start	2018
End	Continues
Main stakeholders	Code contract
Investor(s)	Code contract
Financial model	Code contract investment + R&D&I grant from the Government of Basque Country
Business Model	Rental of platforms and sale of licences
Impact	Facilitating good technology project management

Type of challenges	Smart city project development	Smart city project implementation
Technological	In many times we are looking for the opportunities to apply new technologies and appear in the social media as innovators but with the time the solution is useless and the investment for the company is a disaster. The technology is nice and it has the potential to solve many problems but firstly we need to understand which is the real problem to solve and see the most potential technology for that solution	Is used to be easier close a project Proof of Concept development than close a implementation. Also, it is true that other software's once that are developed are implemented.
Financial	When a new project is started it is difficult to estimate a budget in financial aspect and in time; it is why always the companies makes an approximation for the implementation but never are full filled	We are used to work with agile methodologies where we are showing what we do in each two weeks, in that way we can accelerate and adequate the development in times
Collaboration among stakeholders	On the one hand, the most important is to define well which are the steps and task to do from each part and how. On the other hand, while the job is doing there must be a coordination with others.	That´s the most difficult because once implement there is a growth strategy, so we are used to sign a contract of how, who and when will be done this job.
Managerial and organizational	We manage through a software tool to show and preview how would be the final solution that the customer demands, but in many occasions, it is really different from the beginning to the real solution.	We try to manage these situations with a lot of weekly meetings and showing the development. Sometimes it is different, but we try to be as close as possible to the real solution.
Social	The main problem is when we look to apply a solution in a problem that the people of the company don´t see it. Even you offer the best solution in the world, they won´t use it	The best way is to show them and understand together the real problem. Besides of speaking about the quantity of money or time they will be saving thanks to the new solution.

Case Study 7

Project name	Smart Kalea http://www.fomentosansebastian.eus/smart-kalea/en/smartkalea
City name	San Sebastian (SPAIN)
Start	2014
End	Continues
Main stakeholders	This initiative has been carried out through a public-private agreement. Based on the interest of the city itself, through its city council and having been advised by ICT companies.
Investor(s)	San Sebastian City Council and technology companies
Financial model	Hybrid (It has been financed through a public call for proposals and has been self-financed by the companies that have developed the technological solution).
Business Model	Public-private partnership; ongoing cost-benefit; reimbursement by San Sebastian city council for use of the solution
Impact	Shops in the area, citizens with less agglomerations, the city council itself knowing predictive behaviours of citizens in terms of their shopping habits, etc.).

Type of challenges	Smart city project development	Smart city project implementation
Technological	The city of San Sebastian wanted to become a Smart City. Some of the issues they were concerned about were the crowds of citizens at certain events or areas of the city and how to control them, and on that basis regulate the public lighting system. Another aspect was the behaviour of citizens and tourists in terms of the type of products and establishments they choose to buy.	Given these challenges, the ICTA sector itself analysed the type of solution that could be required for this type of challenge, for which a multidisciplinary consortium was created where each company contributed its knowledge and technology, from sensors and IoT issues, to software development for data analysis, etc. And so, a joint solution was developed and implemented.
Financial	For the development of the technological solution by the City Council of San Sebastian, a call for proposals was issued to which the consortium formed for its development applied. The consortium was aware that the call for applications granted a subsidy that did not cover 100% of the development of the solution.	Through the call for tender the consortium understood very well what the requirements were and how they could be met. There was good coordination between the project leader and the rest of the partners to meet the tender. As for the cost of the solution, the project consortium self-financed the total development of the solution because it understood that the Smart Kalea initiative could be a "showcase" for its technologies that could later be acquired by other city councils, etc. So, there were not many problems in this respect.

Collaboration among stakeholders	The collaboration between the interested parties was done through a collaboration agreement and through a tendering process. Among the parties are the San Sebastian City Council itself, in which the areas of Environment, Infrastructures and Urban Services, Mobility and the Municipal Computer Centre will be involved. On the other hand, local technology companies were also involved.	In the agreement between the parties and in the tender proposal, the work plan, the phases and tasks, the timetable, as well as roles and responsibilities were detailed, which prevented conflicts in this regard. It should also be noted that the local partners are close to each other and most of them knew each other from other initiatives. Finally, the project plan itself included the consideration of other actors such as shops, restaurants, and citizens for the development of the solution.
Managerial and organizational	In terms of the management and organisation of the project, there were no major complications because there was strong leadership on the part of San Sebastian City Council, which involved the economic development agency of San Sebastian, called Fomento de SS, as it was a strategic commitment of the city. Even at the technical level, one of the work packages mentioned interoperability issues so that there would be no problems of understanding between the different technologies. If anything, development times and resources had to be managed very well and good communication channels had to be deployed so that communication was fluid between the parties.	For its implementation, it was necessary to raise awareness among shopkeepers and restaurants and inform them of the benefits that this type of solution can bring, as well as to publicise the initiative among the public, for which written media, bus shelters, etc. were used. On the other hand, questions such as who owns the technological solution, who owns the information-data generated, how people's privacy is guaranteed, the business model, etc., were raised. Questions that are still sometimes asked today.
Social	The project was carried out about 7-8 years ago, at that time there was not much talk of the Smart City concept and neither was the Smart Territory concept included in the RIS3 strategy of the Basque Country, which came later, so there were not many references on which to base it. But even so, an attempt was made to convey to the public the benefits of using this type of technology.	Little by little, the participation of traders, citizens and others was achieved. Today this project is still alive and more and more issues are being analyzed, measured and monitored that concern and occupy both the citizens of San Sebastian and the town council itself. Among these issues are electricity, water, environment, cleanliness, etc.

Case Study 8

Project name	
City name	Trikala (Greece)
Start	September 1,2012
End	August 31, 2016
Main stakeholders	Coordinator: UNIVERSITA DEGLI STUDI DI FIRENZE https://cordis.europa.eu/project/id/314190
Investor(s)	European Union and 45 partners.
Financial model	Around 65% will be European funding, the rest will be covered by the partners.
Business Model	European Commission
Impact	automation, transport, road safety, vehicles, infrastructure, citizens

Type of challenges	Smart city project development	Smart city project implementation
Technological	The main problems of the projects are the safety of the automated vehicle and where the vehicle should run. CityMobil2 defined where these systems should run and how to adapt roads to make them as safe as rail transport though as flexible as cars.	Road vehicle automation technology brought two different (not necessarily competing) concepts: on one hand the "Autonomous vehicle" which is a conventional road vehicle with increasingly Advanced Driver Assistance Systems (ADAS) and which, one day, will allow the driver to distract (e.g. texting), to sleep or even to be absent; on the other hand, the cybercar, a vehicle which is part of an ARTS, it does not have a driver and can drive itself on a preapproved road network, offering last mile transport mostly to supplement mass transit.
Financial	No financial challenges were met during the development or the implementation of the project	
Collaboration among stakeholders	The local authorities will have to approve the vehicles, which must be specifically designed for the needs of the city. For that reason, all the awareness tools of the vehicles were city specific.	Appropriate measures were taken regarding the brake and deceleration capabilities specifically for the emergency braking mechanism (used by the onboard operator) which seemed to negatively impact comfort and safety of the passengers
Managerial and organizational	Questions were risen regarding the proper legislation and legal background for the usage of fully automated vehicles inside the city.	Even though the project was aimed as a test for automated vehicles and was not to be used as an alternative means of transport the city of Trikala implemented it as a new means Public Transport

Social	The social impacts computed with the qualitative methodology include safety and accessibility for disabled and elderly people. According to the computations, these social impacts will be positive in the collective automated scenario, for all urban contexts, while in the private automated scenario the impact on safety is assumed moderately negative, as the reduction of self-driving vehicle accident risk would be more than offset by a significant increase in the total mileage. The positive impact on accessibility will be higher in the private automated scenario compared to the shared self-driving transport scenario, as in the former privately owned cars will be available at the door-step.	Overall, public attitudes towards implementation of automated buses were positive. On average, about two thirds of the respondents stating that they would choose an automated bus if both automated and conventional buses were available on a route. The results relating to user acceptance indicators of the ARTS service (Usefulness of the service, level of integration with other modes and level of service) were in general positive in all cities with average ratings above mean values, but only a low percentage of users were willing to pay more than the current Public Transport fare

Case Study 9

Project name	Smart city of Rio de Janeiro
City name	Rio de Janeiro
Start	2009
End	2020
Main stakeholders	IBM, Oracle, City of Rio De Janeiro
Investor(s)	Private sector
Financial model	35% by private investors managed by municipal government the rest is public finds Public Private Partnerships PPP
Business Model	Attract new businesses and funding from the private sector.
Impact	Citizens, Infrastructure

Type of challenges	**Smart city project development**	**Smart city project implementation**
Technological	Because of a terrible landslide accident, the city of Rio De Janeiro had to overcome a huge technological gap as to how to monitor and survey natural disasters in the city. The city built a Centre of Operations which acts as the emergency response and coordination of various incidents inside the city.	During implementation, the Center of Operations needed to repurpose the technologies available that the city had in order to tackle incidents. One example was the repurpose of garbage trucks by installing them with a linked GPS system in order for them to be able to be used for other tasks thus limiting response time for the city.

Financial	The city tackled the extensive financial constraints by cutting fiscal funding. The municipal government turned to private investors. Smart city investment in Rio was also accelerated by natural disasters, specifically landslides due to flooding, which killed tens of people a year. Mayor Paes believed that a more coordinated response was required by the city, and that a control room would be instrumental in facilitating this. As such, the city partnered with IBM and Oracle to create a 'state of the art situation room'. This has been the city's primary investment in smart technology and is being used as a basis for their continued investment.	Private Partnerships (PPPs) are being newly exploited in Rio to manage these investments. In the past, PPPs had been extremely difficult to execute due to bureaucratic barriers, but regulation has since been changed to facilitate public-private relationships.
Collaboration among stakeholders	The municipal government collaborated with the private sector to tackle financial and managerial problems. Service contracts exist between the private companies and the city to ensure a smooth collaboration for both.	Previously legislation had prevented private investment in the area, so policy mechanisms and urban regulations have been introduced to ensure that private investment could support local development. Rio sees PPPs as being able to deliver virtuous schemes where the contractors are paying extra for the construction rights and contributing to regenerating the area.
Managerial and organizational	One of the challenges in creating smart city investment metrics is that it takes time to create a system that is easy to use, transparent, and understandable. Rio employs 15,000 public sector staff, and a core challenge is to align all stakeholders in the same direction. This takes clear leadership, cultural change, and time.	City workers have performance-related pay, meaning that if the departments reach their targets (say, over mortality rates reduction, etc.) they get a bonus. This incentive scheme runs across the whole public sector from the front-line staff such as teachers and doctors, to back-end roles in the city administration.
Social	Rio views the social challenges in the city as one of the most important they have. One of their strategic views is to urbanise all the favelas by 2020, and are working with public finance on this, focusing on the key risk areas (e.g. natural disasters). The developments are focused around their poor communities, and all investments are focused on the bottom of the social scale.	The challenges of society are vast and constantly change. Crime is high and transparency is vague for that reason Rio has made a significant amount of their data freely available to the public. Largely these datasets fall into two categories: 1) The data portal data – which provides in-depth city information, such as crime rates, mortality rates etc. 2) Centre of Operations data – which holds information for everyday management - e.g. congestion, weather etc.

Case Study 10

Project name	Smart Community Creation Project (https://www.esci-ksp.org/archives/project/kitakyushu-smart-community?task_id=915)
City name	Kitakyushu, Hokkaido, Japan
Start	2010
End	2014
Main stakeholders	National Government, City Government, Civil Society's Associations, University, Fuji Electric System, IBM and Nippon Steel
Investor(s)	Local government
Financial model	Public funding
Business Model	16.3 billion yen (roughly 125.2 million euro)
Impact	Citizen, reduced pollution and improved waste management

Type of challenges	Smart city project development	Smart city project implementation
Technological	In order to make the project more appealing to international stakeholders and to the media, part of the consortium pushed for the pilot testing of hydrogen vehicles. However, no real feasibility tests existed prior to the implementation of the project, which thus required the technical partners to install the necessary infrastructure.	
Financial	During the first phase, the most innovative partners (IBM, Nippon Steel) were reluctant to accept old-fashioned player like the Kyushu Electric Power Company, the regional provider of electricity, which indeed was not funding any part of the project. However, the Ministry of Economy, Trade and Industry lobbied so that that the company was accepted, in a larger scheme to reduce nuclear energy dependency in Japan. The company was accepted through indirect funding with a model of dynamic pricing, an innovation for an old-fashioned company such as Kyushu Electric Power Company.	Due to the financial arrangement reached in order to bring into the consortium the Kyushu Electric Power Company, electricity producer had to install new generation lithium or lead batteries that were never tested on field but that could adapt according to the dynamic demand. This also meant an increase in required financial capacities, which in part was funded by the Fukuoka regional government.
Collaboration among stakeholders	Citizens protested for a much cleaner city, while the priorities of the businesses appeared to be more economic-oriented at first. Citizens' support was secured through the intervention of trusted public servants.	Cooperation within private businesses and citizen was structured with information meetings in 2011: however, only few responses were recorded. Shortly after the Fukushima incident,

		citizens were much more active during the meetings.
Managerial and organizational	Stakeholders, when first approaching the project, shared a common but vague idea about the goals of the project. However, thanks especially to a long-term relationship between IBM and Nippon Steel and a period of negotiation behind closed doors, they managed to find a solution.	The Japanese legislation in terms of energy management did not allow, through the contract of the regional electricity company, the implementation of a TEMS (Town Energy Management System). However, thanks to the wide organisation of the consortium, an ad-hoc permit was granted for the project to pilot this system.
Social	This project started as a solution proposed by the major industrial stakeholders (like Nippon Steel) in response to organised movements of protests against environmental pollution and pro-smart solutions. These associations are neighbourhood-based and are typical in the history of the city.	The implementation of dynamic pricing was economically harsh for a population used to subsided prices for electricity: for this reason, a system of social influence was set up, with the allowance of "social points" which could be spent during local events and that citizens could gain through a smarter consumption of energy. This is the basic idea behind the "prosumers" instead of "consumers".

Case Study 11

Project name	**DECODE https://decodeproject.eu/**
City name	Barcelona, Spain
Start	2017
End	2019
Main stakeholders	BCMI Labs AB, City of Amsterdam, CNRS, Dribia, Dyne.org, Eurecat, Institute Municipal d'Informatica de Barcelona (IMI), Nesta, Open University of Catalonia, Politecnico di Torino/ Nexa, Stichting Katholieke Universiteit Nijmegen Privacy & Identity Lab, Thingful, Thought Works Ltd, UCL, Wagg.
Investor(s)	European Commission
Financial model	€5 million from the EU's Horizon 2020 research and innovation programme
Business Model	Under the support of the EU commission up to 340 million euros can be committed to innovation and research practices.
Impact	Technology, People, Data privacy

Type of challenges	Smart city project development	Smart city project implementation
Technological	The pilots aim at testing the use of DECODE technology with real users, in order to enable real data sovereignty for citizens and offer communities the possibility of commonly sharing data to enhance the public good. The technological challenges in this sense were to organise the flow of data coming combining private and public sources so that to address issues in a collective way.	On the one hand, the technological front has been relatively easier to manage with regards to the users with more research time spent on software optimization, but the hardest one to do internally, as interaction with communities has been limited to testing the developed technology. Substantial efforts have been devoted to design and implement tailored solutions for the user groups, gathering requirements and feedback as well as coordinating the diverse development teams. When this has been achieved, the community has been able to boost their digital rights such as privacy and right to information.
Financial	No data was found	No data was found
Collaboration among stakeholders	Excellent collaboration was practiced among the partners of the project during the development of the project.	All partners contributed to communications, dissemination, exploitation and events where required. Specifically, they were responsible for: their own individual communication, dissemination and exploitation plans. They were also responsible for producing blogs about their work and proactively communicating with Nesta to prepare communication assets and plans. The website was built to allow decentralised access and publishing by partners. Each individual participating on the project was given the ability to post events and blogs directly to the website without the need for Nesta to sign-off. This was to avoid bottlenecks and to embrace the decentralised ethos of the project. An agile working method was used with a set of core strategic objectives and an agile approach to achieving this. The regular all consortium calls were used for high-level coordination. For specific activities, meetings, frequencies and communication approaches were judged on the needs of the task at hand

Managerial and organizational	Ethical issues concerning both the creation of digital commons and the management of digital data as commons, e.g., freedom of expression, transparency, data sovereignty, and openness. Although these issues will arise in the practical use (e.g., within the Pilots) of DECODE OS, according to the legal rules that allow and enforce it.	In the legal and policy front, the collaboration of the City Council has allowed to test the feasibility of the proposed solutions into real world scenarios, making a strong impact regarding innovative data policies and approaches tested by cities. Work has been done elsewhere with regards to potential scenarios. However, a proper legal fit for the solutions proposed was challenging as it was exploring uncharted territory: they will only be properly tested after they have been rolled for a long period of time in production, as legal hazards can be foreseen but are only fully known after real issues emerge. Policy makers at municipal, national, European and global level have been recognizing the novelty and strengths of the DECODE approach, showing strong interest and joining efforts to adopt similar approaches, as in the case of the Cities Coalition for Digital Rights. This Coalition is now a central part of the UN-Habitat effort to extend Barcelona's citizen-centric smart city approach (of which DECODE is a central part) globally.
Social	The realization of the pilots raised interest in the civil society and acted as proof for the need of the continuation of the project.	The socioeconomic front has been the one where more ground for experimentation and co-creation has been attained. The reason for that is simple: Interaction with communities, most notably non expert individuals, has allowed the DECODE consortium to gain a real-world (*out of the lab)* perspective on the projected pilot implementation. Rich, participatory processes and co-creation tools are key to new forms of social innovation. Work must be articulated in terms of multi-layered

SKILLS4CITIES

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ANNEX 2

Training Modules for the defined sets of competencies

Module: Transversal Skills

General Description
The content of this training module does not reflect the specific necessities of any job profiles: however, they do apply to all of them. The competencies that the learners will acquire in this context will support the execution of a successful work in an innovative and creative way, necessary for different contemporary situations – beyond Smart Cities' projects. These competences will promote a culture of a lifelong learning across various jobs, for the learner to be able to adapt to differ contexts according to various parameters (geographical, cultural, sectorial etc.).
Competences
▪ Creative thinking ▪ Innovative thinking ▪ City/urban planning policies ▪ Critical thinking ▪ Working in teams ▪ Self-learning ▪ Emotional intelligence / empathy ▪ Mobilize others ▪ Task/time management ▪ Decision-making ▪ Leadership and conflict-management ▪ Public communication
Skills & Knowledge needed to achieve the competence
By the conclusion of this training module, the learner will have acquired the following piece of knowledge insomuch as being able to carry out the relative activities and tasks. ▪ Be able to come up with innovative and disruptive solutions capable of inspiring others in implementing his or her vision. ▪ Know and distinguish innovative trends in terms of information and digital technologies' developments. ▪ Be capable of developing tailor-made solutions for specific needs building upon the new technologies available on the market. ▪ Adapting oneself knowledge in different contexts and situations with a positive and open attitude. ▪ Research and sort all the necessary information in a legal and developmental perspective that could potentially affect the implementation of a project. ▪ Being able to understand the background of a project and provide relevant input to stakeholders. ▪ Comprehension of legal standards of communication and assignments. ▪ Understanding of group dynamics, communication techniques and successful ways to manage conflicts and work-induced stress. ▪ Act as an inspirational leader. ▪ Implementation of peer monitoring and improvement. ▪ Prioritize, organize, and manage tasks and activities in a time and resource-effective manner. ▪ Imagine a long-term positive impact for the community. ▪ Comprehension of financial and economical documents. The learner will have also developed the following skills, as the practical counterpart to the knowledge acquired in the training module. ▪ Innovation/creative thinking skills. ▪ Learning by experience skills.

- Critical thinking.
- Research skills.
- Problem solving.
- Team management and collaboration skills.
- Negotiation skills.
- Legal skills.
- Economic and financial analysis skills.
- Project management skills.

Training methods

- Asynchronous online course: 5 hours
- Synchronous sessions: 1 hour
- Practical session: N.A.

Assessment method

- Asynchronous online course:
- Institutional assessment (quiz)
- Synchronous session:
- Live Q&A
- Practical session:
- Project-based exercises

Lab Experience

No applicable

Learning Units

- Vision
  - Adaptability to different contexts (cultural, political, stage of development etc.)
  - Ways of formulating goals and digital-based solutions
  - Monitoring and Improvement Process
  - Meaning of innovative thinking
  - Innovation standards
  - Defining valuable impact
- Analytical Skills
  - Basics of Geographic Analysis
  - Disciplines for Geographic Analysis: GIS, Remote Sensing, Digital Cartography
  - Urban Development theories
  - Urban and Regional policies' mapping
  - General legal framework analysis
  - Legal framework for Project Management
  - Process of critical thinking
  - Critical thinking abilities
- Soft skills
  - Strategies to create well-balanced teams
  - Workforce capabilities' profiling
  - Interculturalism
  - Different cultures and international teams
  - Methods of communication
  - Communication problems
  - Ways to implement solutions
  - Monitoring and Improvement process for self-development
  - Leadership styles
  - Cross-cutting characteristics of a good leader

- Project Management skills
  - Project lifecycle
  - Project designing
  - Project planning
  - Roles and tasks' allocation
  - Monitoring and Risk Assessment
  - Handle responsibilities and decisions
  - Management of financial documentation

Resources

- ASQ, What it the Plan-Do-Check-Act (PDCA) Cycle? https://asq.org/quality-resources/pdca-cycle
- SALTO, Intercultural Communication – Resource Pack. https://www.salto-youth.net/downloads/4-17-1789/Booklet%20Intercultural%20Communication%20Resource%20Pack.pdf
- Culturewise, Cultural awareness – Training Exercise Pack. https://www.culturewise.net/wp-content/uploads/2013/05/Cultural-awareness-training-exercise-pack.pdf
- Hawking, R., Blind, K., Page, R. (ed.). Handbook of Innovation and Standards. EE Elgar, 2017.
- Project Management Institute, A Guide to the Project Management Body of Knowledge – PMBOK GUIDE. Seventh Edition, 2021.
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  Friedman, A. Fundamentals of Sustainable Urban Design. Springer, 1st edition, 2021.
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- Stanford Encyclopaedia of Philosophy, Critical Thinking. https://plato.stanford.edu/entries/critical-thinking/
- Milojevic, N. The complete team management guide, 2022. https://clockify.me/blog/business/team-management-guide/
- Management Study Guide, Team Management – Meaning and Concept. https://www.managementstudyguide.com/team-management.htm
- MindTools, Leadership Styles – Choosing the Right Approach for the Situation. https://www.mindtools.com/pages/article/newLDR_84.htm
- Asan, 11 Common leadership Styles (plus how to find your own). https://asana.com/resources/leadership-styles

Module: Disruptive Technologies Competencies

General Description

New and deeply innovative technologies are becoming more and more available for commercial use. The way these are going to be implemented at a larger scale is going to represent a long-hailed revolution that will digitalize our societies like never before. The goal of this TM is to provide the necessary knowledge to understand these technologies and the relative impact they can have and already have on our lives. The learner will go through the basic information in regard of this new devices, protocols and so forth, while also acquiring practical and to a lesser extent technical capability to implement solutions powered by such technologies.

Competences

- Artificial Intelligence
- Data analytics
- Cloud Computing
- Internet of Things
- Cyber physical systems
- Smart sensors
- Collaborative robotics
- Cybersecurity
- Blockchain
- Augmented reality
- Virtual reality

Skills & Knowledge needed to achieve the competences

By the conclusion of this training module, the learner will have acquired the following piece of knowledge insomuch as being able to carry out the relative activities and tasks.

- How to interface oneself with devices employing Artificial Intelligence technology.
- Communication with technologies employing Artificial Intelligence to improve the working process and the overall execution of the activities.
- Assessment of new and innovative appliances powered by AI.
- To know what Big Data is and represents for the current technological revolution.
- Read the analysis made by smart machines employing Big Data.
- To carry out complex analysis using statistical models building upon Big Data.
- Executing tasks remotely, using the most recent cloud and distance working arrangements for cooperation.
- Integration of online and offline work.
- To know the protocol for interacting with multiple devices connected and communicating among each other.
- To understand the communication process of IoT devices based on the most common connection protocols: Wi-Fi, Bluetooth, 4/G connection.
- Knowledge of sensors: what they are, their purpose and their applications.
- Machine learning types, knowledge, and techniques.
- Basics of cybersecurity: online security and data privacy.
- Introduction to computer programming.
- Aware of data protection challenges and regulations to be dealt with when working with sensible information.
- Knowledge of security measures to be implemented in sensible digital frameworks: firewalls, proxy, and protocols.
- Risks and challenges addressed by cybersecurity systems.
- Blockchain basic knowledge: what is it, most common applications, and opportunities.

Designing innovative blockchain-powered solutions.
- Augment and Virtual Reality introduction and applications.
- Application of AR/VR technologies to a wide range of contexts.
- Knowledge of open sources and digital tools simulating VR environments.

The learner will have also developed the following skills, as the practical counterpart to the knowledge acquired in the training module.

- Digital communication skills.
- Analytical skills in a digital environment.
- Technology-based design thinking.
- Digital maps analysis and reporting skills.
- Remote working skills.
- Ability to develop and implement cybersecurity protocols.
- To be able to read and incorporate information gathered through sensors.
- AR/VR environments-powered solutions implementation skills.

Training methods

- Asynchronous online course: 35 hours
- Synchronous sessions: Not applicable
- Practical session: 10 hours

Assessment method

- Asynchronous online course: Institutional assessment (knowledge quiz) Real-life situations exercises
- Synchronous session: Not applicable
- Practical session: Simulation of technical, small-scale solutions development Project-based exercise

Lab Experience

Applicable and advisable. The use of Internet of Things labs, where possible, either remotely or through direct access to simulation labs, is strongly advised for the development of practical technical competences.

Learning Units

Next Generation Data Management

- Big Data
  - Introduction to Big Data: theory and opportunities
  - Focus on Big Data technologies and reporting
  - Big Data solutions: case studies
- Artificial Intelligence
  - Definition of Artificial Intelligence
  - Computer's architecture and AI
  - Data analysis process
- Social Media
  - The role of social media nowadays
  - AI and Social Media interactions for content production
- Blockchain
  - Definition and basic applications for information validation
  - Cryptocurrency, Proof of Stake and Proof of Authority
  - Smart contracts and commercial blockchains

Remote working and cybersecurity assurance

- Remote services
  - Enabling digital technologies
  - Digital repositories

- Concepts of cloud computing
- Cybersecurity
  - Notion of cybersecurity
  - Evaluation of risks
  - Development and implementation of cybersecurity policies
  - Ensure protected communication

Cyber-physical systems

- Sensors
  - Introduction to sensors
  - The role and solutions of implementing sensors.
  - Types of sensors
- Computer programming
  - Introduction
  - Technology-based design thinking
  - Technology-based problem solving
- Networking and ecosystems
  - Types of connections
  - Integration of sensors and communication protocols
  - Receiving data
  - Web services
  - Introduction in IoT networking
  - IoT Networking; WiFi, LoRa, Bluetooth, GSM, Protocols
  - Building IoT project
- Augment and Virtual Reality
  - AR/VR tools and software
  - Design thinking for virtual environment-based solutions
  - Application of computer-generated environment

Resources

- Gartner. Gartner Top Strategic Technology Trends for 2022. https://www.gartner.com/en/information-technology/insights/top-technology-trends
- Forbes, How Big Data Empowers Organizations to Work Smarter, Not Harder. 2021. https://www.forbes.com/sites/forbestechcouncil/2021/08/23/how-big-data-empowers- organizations-to-work-smarter-not-harder/
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- Forbes, The 4 Biggest Trends in Big Data and Analytics Right for 2021. 2021. https://www.forbes.com/sites/bernardmarr/2021/02/22/the-4-biggest-trends-in-big-data-and-analytics-right-for-2021/?sh=165b66497df8
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- Analytics Insight, Top 10 Big Data Analytics Tools Used by Tech Giants in 2022. 2022. https://www.analyticsinsight.net/top-10-big-data-analytics-tools-used-by-tech-giants-in-2022/
- Future of Life Institute. Benefits & Risks of Artificial Intelligence. https://futureoflife.org/background/benefits-risks-of-artificial-intelligence/
- Investopedia, Machine Learning. https://www.investopedia.com/terms/m/machine-learning.asp
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Module: Competencies on smart city projects domains

General Description

The purpose of this module is to gather the competences needed in all the sectors transversally touched by projects developed to make cities smarter. For this reason, the TM will go through different disciplines, spanning from economics, public policies, sustainability, and basic engineering. All these areas have been found to enter into play whenever a Smart City project is either conceived, developed, and implemented.

Competences

- Economy, trade, and industry
- Government and education
- Living and health
- Public safety
- Mobility and transportation
- Environment and sustainability
- Energy, water, utilities
- Digital infrastructure and networks

Skills & Knowledge needed to achieve the competences

By the conclusion of this training module, the learner will have acquired the following piece of knowledge insomuch as being able to carry out the relative activities and tasks.

- Microeconomics and macroeconomics dimensions.
- Industries' trends.
- Value chain and localized geopolitics of trade.
- Patterns of production and clusters identification.
- Concepts of urban and smart governance.
- Public administration architecture.
- Interfacing with public offices, officials, and bureaucracy.
- Public policy analysis.
- Public health and risk of hazards in the urban area.
- Risk management measures and protocols.
- Patterns of public transportation arrangements.
- Trends in transportation sector and innovation.
- Public utilities and challenges.
- Holistic approach to sustainability assurance.
- Knowledge of Information and Digital technologies' infrastructures.
- Urban geography.

The learner will have also developed the following skills, as the practical counterpart to the knowledge acquired in the training module.

- Economic analysis skills
- Ability to understand and interpret economic models
- Be able to carry out comparative and cross-sectoral studies
- Critical skills
- Ability to implement and manage smart governance arrangements.
- Scenario analysis
- Institutional communication skills
- Risk management capacity
- Solution thinking
- Holistic urban analysis

- Digital skills
- Green skills
- Maps and digital chartography.

Training methods

- Asynchronous online course: 25 hours
- Synchronous sessions: Not applicable
- Practical session: 5 hours

Assessment method

- Asynchronous online course: Institutional assessment (knowledge quiz)
- Synchronous session: Not applicable
- Practical session: Project-based exercise

Lab Experience

Not applicable

Learning Units

Economy

- Microeconomics
  - Concepts of microeconomics
  - Analysis of local economic texture
  - Identification and networking with clusters
- Macroeconomics
  - Concepts of macroeconomics
  - Value chain and International Trade: analysis and reporting
  - Geopolitics and international role of cities

Public Governance

- Institution
  - Institutional mapping
  - Institutional relations
- Public policies
  - Policy making process
  - Agenda setting and lobbying
  - Urban and regional framework for development
  - Policy recommendations

Health

- Policies
  - Public health policies
  - Health arrangements and trends
  - Concepts of good quality of life
- Risks
  - Contemporary health hazards and risks
  - Risk and emergency management

Public utilities

- Overview
  - Urban framework for utilities management
  - Privatization and public procurements
  - Interconnected urban solutions
- Single utilities analysis
  - Water management
  - Heating and gas

- Energy mix
- Public transport trends and patterns
- Urban housing policies
- Waste management

Sustainability

- Overview
  - The international framework for sustainability: SDGs
  - Other relevant framework of cooperation
- Sustainable development
  - Theories of sustainable development
  - Environmental component and protocols for environmental protection
  - Smart mobility
  - Eco-friendly buildings
  - Setting up comprehensive monitoring systems
  - Sustainability indicators

Digital infrastructures

- Urban Geography
  - Maps and GIS analysis
  - Development of localized Smart Cities' projects
- New Infrastructures
  - Disruptive technologies and infrastructure requirements
  - Resource management
  - Environmental considerations
  - Mapping of strategic infrastructures

Resources

Module: Smart Cities Challenges Competences

General Description

Smart Cities' projects, given their highly complex and interconnected nature in terms of solutions and technologies employed, are often source of moments of impasse, challenges, and general difficulties. To ensure the smooth implementation of the largest number of projects possible, this TM is specifically focused on targeting and addressing the most common challenges emerging during all the phases of project development and implementation. These roughly cover the same sectors the Smart Cities' project managers have to face in order to conceive and practically implement the project idea.

Competences

- Technological challenges
- Financial constraints
- Collaboration among stakeholders and governmental restraints
- Managerial and organizational challenges
  Social challenges

Skills & Knowledge needed to achieve the competences

By the conclusion of this training module, the learner will have acquired the following piece of knowledge insomuch as being able to carry out the relative activities and tasks.

- Technological constraints of smart city project management.
- Technical constraints of smart city projects' technologies.
- Knowledge of financial budgeting and prospects.
- Step-by-step analysis and troubleshooting.

- Project management process.
- Stakeholder's networking and management.
- Qualitative organizational culture.
- Communication and debating process.

The learner will have also developed the following skills, as the practical counterpart to the knowledge acquired in the training module.

- Ability to understand sound technical analysis.
- Drafting budget sheets and levelled financial analysis.
- Debating and communication skills.
- Problem-solving skills.
- Creative solution thinking.
- Urban-level SWOT analysis.
- Organizational skills.
- Project management skills.
- Time management skills.

Training methods

- Asynchronous online course: 20 hours
- Synchronous sessions: Not applicable
- Practical session: 5 hours

Assessment method

- Asynchronous online course: Institutional assessment (knowledge quiz)
- Synchronous session: Not applicable
- Practical session: Project-based exercise

Lab Experience

Not applicable

Learning Units

Technological Area

- Public digital services and synergies
- Mainstreaming of common technological tools: QR codes and geo-localization
- Advanced Smart Cities' technological solutions: data databases and networks

Economic Area

- Financial analysis and prospects
- Budget drafting
- Projects' finance management
- Grant management

Cooperation and Partnership

- Multi-stakeholders networking and platform development
- Human resources management
- Public speaking and clear communication
- Organization of public events
- Problem-solving discussions and mediation

Social challenges

- Multidisciplinary approach to development
- Networking with local civil societies and public opinion
- Digital and public identity of the project.

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ANNEX 3

Training Modules for the identified professional roles

Smart City Project Developer (SCPD)

General Description

The role of the Smart City Project Developer (SCPD) is usually framed at the very beginning of the project. The professional works either as an external consultant or a regularly hired figure. Thanks to the in-depth knowledge of the disruptive technologies enabling the transformation of cities into "Smart" ones, the professional is able to link this knowledge to the analytical analysis of the needs of the specific context he or she is asked to operate. The professional is able to pitch the idea in a concrete way, presenting the initial plans for implementing the activities foreseen and how these will create a positive impact for the city. It is possible to see the SCPD participates also in the implementation of the project, although remaining more as a project designer role, looking more at the general ideas, objectives, and impact.

Competences

Transversal Skills

- Creative thinking
- Innovative thinking
- City/urban planning policies
- Critical thinking
- Working in teams
- Self-learning
- Task/time management

Disruptive technologies Competences

- Artificial Intelligence
- Data analytics
- Cloud Computing
- Internet of Things
- Cyber physical systems
- Smart sensors
- Collaborative robotics
- Cybersecurity
- Blockchain
- Augmented reality
- Virtual reality

Competences on Smart City projects domains

- Economy, trade, and industry
- Government and education
- Environment and sustainability
- Public safety
- Mobility and transportation
- Energy, water, utilities
- Digital infrastructure and networks

Smart Cities Challenges Competences

- Financial constraints
- Managerial and organizational challenges
- Cooperation and Partnership

Skills & Knowledge needed to achieve the competences

Training methods

- Asynchronous online course: 80 hours

- Synchronous sessions: Not applicable
- Practical session: 10 hours

Assessment method

- Asynchronous online course: Institutional assessment (knowledge quiz)
- Synchronous session: Not applicable
- Practical session: Project-based exercise

Lab Experience

IoT Lab

Learning pathway

1. Transversal Skills

Vision

- Adaptability to different contexts (cultural, political, stage of development etc.)
- Ways of formulating goals and digital-based solutions
- Meaning of innovative thinking
- Innovation standards
- Defining valuable impact

Analytical Skills

- Basics of Geographic Analysis
- Disciplines for Geographic Analysis: GIS, Remote Sensing, Digital Cartography
- Urban Development theories
- Urban and Regional policies' mapping
- Process of critical thinking
- Critical thinking abilities

Soft skills

- Interculturalism
- Management of international teams
- Methods of communication
- Leadership styles
- Cross-cutting characteristics of a good leader

Project Management skills

- Project lifecycle
- Project designing

2. Disruptive Technologies Competences

Next Generation Data Management

Big Data

- Introduction to Big Data: theory and opportunities
- Focus on Big Data technologies and reporting
- Big Data solutions: case studies

Artificial Intelligence

- Definition of Artificial Intelligence
- Computer's architecture and AI
- Data analysis process

Social Media

- The role of social media nowadays
- AI and Social Media interactions for content production

Blockchain

- Definition and basic applications for information validation
- Cryptocurrency, Proof of Stake and Proof of Authority
- Smart contracts and commercial blockchains

Remote working and cybersecurity assurance

Remote services

- Enabling digital technologies
- Digital repositories
- Concepts of cloud computing

Cybersecurity

- Notion of cybersecurity
- Evaluation of risks
- Development and implementation of cybersecurity policies
- Ensure protected communication

Cyber-physical systems

Sensors

- Introduction to sensors
- The role and solutions of implementing sensors
- Types of sensors

Computer programming

- Introduction
- Technology-based design thinking
- Technology-based problem solving

Networking and ecosystems

- Types of connections
- Integration of sensors and communication protocols
- Receiving data
- Web services
- Introduction in IoT networking
- IoT Networking; Wi-Fi, LoRa, Bluetooth, GSM, Protocols
- Building IoT project

Augment and Virtual Reality

- AR/VR tools and software
- Design thinking for virtual environment-based solutions
- Application of computer-generated environment

3. Competences on Smart City Projects Domain

Public Governance

Public policies

- Policy making process
- Agenda setting and lobbying
- Urban and regional framework for development
- Policy recommendations

Health

Policies

- Public health policies

Public utilities

Overview

- Urban framework for utilities management
- Privatization and public procurements
- Interconnected urban solutions

Single utilities analysis

- Water management
- Heating and gas
- Energy mix
- Public transport trends and patterns
- Urban housing policies
- Waste management

Sustainability

Overview

- The international framework for sustainability: SDGs
- Other relevant framework of cooperation

Sustainable development

- Theories of sustainable development
- Environmental component and protocols for environmental protection
- Smart mobility
- Eco-friendly buildings
- Setting up comprehensive monitoring systems

Digital infrastructures

Urban Geography

- Maps and GIS analysis
- Development of localized Smart Cities' Projects

New Infrastructures

- Disruptive technologies and infrastructure requirements
- Mapping of strategic infrastructures

4. Smart Cities Challenges Competences

Technological Area

- Public digital services and synergies

- Mainstreaming of common technological tools: QR codes and geo- localization
- Advanced Smart Cities' technological solutions: data databases and networks

Economic Area

- Financial analysis and prospects
- Budget drafting
- Projects' finance management
- Grant management

Cooperation and Partnership

- Multi-stakeholders networking and platform development
- Public speaking and clear communication

Resources

Transversal Skills

Disruptive Technologies Competences

Competences on Smart City Projects Domain

Smart Cities Challenges Competences

Smart City Project Manager (SCPM)

General Description

The Smart City Project Manager (SCPM) is an experienced professional, with a background in technical or STEM studies that have specialized in coordinating and implementing important projects in the urban context and beyond (possibly in international and transnational context). The role of the SCPM is that of cooperating with the Smart City Project Developer in order to create a feasible and realistic plan to draft and implement a work plan of activities on an annual basis. In practice, the professional will deal with the day-to-day coordination of the working teams, while also managing two other important components of the project as a whole: the administrative/financial part and the networking with the stakeholders and funders.

Competences

Transversal Skills

- Critical thinking
- Working in teams
- Learn by experience
- Emotional intelligence / empathy
- Mobilize others
- Task/time management
- Decision-making
- Leadership and conflict-management
- Public communication Disruptive technologies competences
- Artificial Intelligence
- Internet of Things
- Cybersecurity
- Blockchain
- Augmented reality
- Virtual reality

Smart Cities' Project Domain competencies

- Economy, trade, and industry
- Government and education
- Living and health
- Public safety
- Mobility and transportation
- Environment and sustainability
- Energy, water, utilities
- Digital infrastructure and networks

Smart Cities' Problem-Solving Competences

- Financial constraints
- Collaboration among stakeholders and governmental restraints
- Managerial and organizational challenges

Skills & Knowledge needed to achieve the competences

Training methods

Asynchronous online course: 70 hours

Synchronous sessions: 5 hours

Practical session: 5 hours

Assessment method

Asynchronous online course: Institutional assessment (knowledge quiz)

Synchronous session: Live Q&A

Practical session: Project-based exercise

Lab Experience

No applicable

Learning pathway

1. Transversal Skills

Vision

- Adaptability to different contexts (cultural, political, stage of development etc.)
- Monitoring and Improvement Process
- Meaning of innovative thinking
- Innovation standards
- Defining valuable impact

Analytical Skills

- Basics of Geographic Analysis
- Urban Development theories
- Urban and Regional policies' mapping
- General legal framework analysis
- Legal framework for Project Management
- Process of critical thinking
- Critical thinking abilities

Soft skills

- Strategies to create well-balanced teams
- Workforce capabilities' profiling
- Interculturalism

- Different cultures and international teams
- Methods of communication
- Communication problems
- Ways to implement solutions
- Monitoring and Improvement process for self-development
- Leadership styles
- Cross-cutting characteristics of a good leader

Project Management skills

- Project lifecycle
- Project designing
- Project planning
- Roles and tasks' allocation
- Monitoring and Risk Assessment
- Handle responsibilities and decisions
- Management of financial documentation

2. <u>Disruptive Technologies Competences</u>

Next Generation Data Management

Big Data

- Introduction to Big Data: theory and opportunities

Artificial Intelligence

- Definition of Artificial Intelligence

Social Media

- The role of social media nowadays

Blockchain

- Definition and basic applications for information validation

Remote working and cybersecurity assurance

Remote services

- Enabling digital technologies

Cybersecurity

- Notion of cybersecurity
- Evaluation of risks

Cyber-physical systems

Networking and ecosystems

- Types of connections
- Augment and Virtual Reality
- AR/VR tools and software

3. <u>Competences on Smart City Projects Domain</u>

Economy

Microeconomics

- Concepts of microeconomics
- Analysis of local economic texture
- Identification and networking with clusters

Macroeconomics

- Concepts of macroeconomics
- Value chain and International Trade: analysis and reporting
- Geopolitics and international role of cities

Public Governance

Institution

- Institutional mapping
- Institutional relations

Public policies

- Policy making process
- Agenda setting and lobbying
- Urban and regional framework for development
- Policy recommendations

Health

Policies

- Public health policies
- Health arrangements and trends
- Concepts of good quality of life

Risks

- Contemporary health hazards and risks
- Risk and emergency management

Public utilities

Overview

- Urban framework for utilities management
- Privatization and public procurements
- Interconnected urban solutions

Single utilities analysis

- Water management
- Heating and gas
- Energy mix
- Public transport trends and patterns
- Urban housing policies
- Waste management

Sustainability

Overview

- The international framework for sustainability: SDGs

Sustainable development

- Theories of sustainable development
- Environmental component and protocols for environmental protection
- Smart mobility
- Eco-friendly buildings
- Setting up comprehensive monitoring systems
- Sustainability indicators

Digital infrastructures

- Urban Geography

- Development of localized Smart Cities' projects

4. Smart Cities Challenges Competences

Technological Area

- Public digital services and synergies

Economic Area

- Financial analysis and prospects
- Budget drafting
- Projects' finance management
- Grant management

Cooperation and Partnership

- Multi-stakeholders networking and platform development
- Human resources management
- Public speaking and clear communication
- Organization of public events
- Problem-solving discussions and mediation

Social challenges

Multidisciplinary approach to development

Smart City Project Management Consultant (SCPMC)

General Description

The Smart City Project Management Consultant (SCPMC) is a professional experienced as, usually, an external consultant hired to provide knowledge and expertise during critical phases of Smart Cities' projects. The SCPMC provides support to the Smart Cities Project Manager in different phases of the project, also according to the SCPMC own expertise: in practice, the tasks may span from financial management, networking, and coordination with stakeholders or to improve the design of the project and its related activities. The competences of the SCPMC reflect his or her ability to manage delicate situations in the context of Smart Cities' challenges, and the support of this professional is considered necessary on most occasions in order to ensure the smooth implementation and continuation of the project.

Competences

Transversal Competences

- City/urban planning policies
- Legal familiarity
- Critical thinking
- Working in teams
- Learn by experience
- Task/time management
- Decision-making
- Leadership and conflict management
- Finance management

Disruptive technologies

- Artificial Intelligence
- Internet of Things
- Cybersecurity
- Blockchain
- Augmented reality

- Virtual reality

Smart Cities' Project Management

- Environment and sustainability
- Digital infrastructure and networks

Smart Cities' Problem-Solving Competences

- Technological challenges
- Financial constraints
- Collaboration among stakeholders and governmental restraints
- Managerial and organizational challenges
- Social challenges

Skills & Knowledge needed to achieve the competences

Training methods

Asynchronous online course: 60 hours

Synchronous sessions: 5 hours

Practical session: 5 hours

Assessment method

Asynchronous online course: Institutional assessment (knowledge quiz)

Synchronous session: Live Q&A

Practical session: Project-based exercise

Lab Experience

Not applicable

Learning pathway

1. Transversal Competencies

Vision

- Adaptability to different contexts (cultural, political, stage of development etc.)
- Ways of formulating goals and digital-based solutions
- Monitoring and Improvement Process
- Meaning of innovative thinking
- Innovation standards

Analytical Skills

- Basics of Geographic Analysis
- Urban and Regional policies' mapping
- General legal framework analysis
- Legal framework for Project Management
- Process of critical thinking

Critical thinking abilities

Soft skills

- Strategies to create well-balanced teams
- Workforce capabilities' profiling
- Interculturalism
- Different cultures and international teams
- Methods of communication
- Communication problems

- Ways to implement solutions
- Monitoring and Improvement process for self-development
- Leadership styles

Project Management skills

- Project planning
- Roles and tasks' allocation
- Monitoring and Risk Assessment
- Handle responsibilities and decisions
- Econometrics
- Management of financial documentation

2. Disruptive Technologies Competencies

Next Generation Data Management

Big Data

- Introduction to Big Data: theory and opportunities

Artificial Intelligence

- Definition of Artificial Intelligence

Social Media

- The role of social media nowadays

Blockchain

- Definition and basic applications for information validation

Cyber-physical systems

Augment and Virtual Reality

- AR/VR tools and software

3. Smart City Project Domain Competences

Economy

Microeconomics

- Identification and networking with clusters

Public Utilities

Overview

- Privatization and public procurements
- Interconnected urban solutions

Sustainability

Overview

- The international framework for sustainability: SDGs

Sustainable development

- Theories of sustainable development
- Sustainability indicators
- Environmental component and protocols for environmental protection

Digital infrastructures

Urban Geography

- Development of localized Smart Cities' projects

New Infrastructures

- Disruptive technologies and infrastructure requirements
- Resource management

- Environmental considerations

Smart Cities' Problem-Solving Competences

Technological Area

- Public digital services and synergies
- Mainstreaming of common technological tools: QR codes and geo- localization
- Advanced Smart Cities' technological solutions: data
- databases and networks

Economic Area

- Financial analysis and prospects
- Budget drafting
- Projects' finance management
- Grant management

Cooperation and Partnership

- Multi-stakeholders networking and platform development
- Human resources management
- Public speaking and clear communication
- Organization of public events
- Problem-solving discussions and mediation

Social challenges

- Multidisciplinary approach to development
- Networking with local civil societies and public opinion
- Digital and public identity of the project

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ANNEX 4

Examples of training courses on smart city

Some key training in relation to value creation are related to the design and development of products, components and services, they would rather be technical training. There are also some trainings that could be implemented related to commercial aspects and interaction with partners and clients. These activities are as important as development and some of the activities are communication, data aggregation and infrastructure. The training is intended to describe key aspects related to smart cities.

It is an opinion of the project team that the focus on training and skills and companies' understanding of their resources and skills will be analysed throughout the A3. This appears to be a natural first step in helping companies better understand how they can thrive on the smart cities' agenda. In order to have references and examples of training courses that are being taught today for the design and development of solutions for Smart Cities, there is listed below a series of them classified according to the dimensions that exist around a Smart City.

- Advancement of BIM in the Smart Cities Sector
- LEAN methodology of the ultimate planner in the design, definition, and development of Smart city solutions.
- Topics based on the following six dimensions:

ENVIRONMENT

Course name	Content
Introduction to the environment and environmental engineering International environmental regulations and legislation:	The course provides an accurate overview of international regulations affecting water, soil and air pollution cities.

TRANSPORT

Course name	Content
Software applied to transport and road safety. Modelling	This course will enable you to understand the basic principles of modelling in the realisation of different alternative solutions to problems associated with mobility in cities.
Intelligent Transport Systems	The course in Intelligent Transport Systems is a theoretical and practical course that allows the student to know, identify and understand Intelligent Public Transport Systems for Passengers and Traffic in the City and on the Road. It allows the student to lead the decision-making process regarding this type of system, analysing the practical cases of [...]
Railway Telecommunications Systems and New Technologies	This online course on railway telecommunications systems and new technologies is aimed at engineers, professionals and students who wish to acquire knowledge about fibre optic networks used in high-speed train communications, as well as to learn what is necessary to be fluent in the world of networks.

CONSTRUCTION

Course name	Content
BIM applied to civil works with Autodesk Civil 3D software	This course on design and modelling with Autodesk Civil 3D will train students to generate Digital Terrain Models and incorporate intelligent 3D elements of linear works, using specific workflows applied to road layout for subsequent integration into BIM work environments. Starting from different databases [...]

BIM applied to civil works with Bentley Power Civil Software. (Design, construction, control and maintenance of civil works with BIM).	Bentley Inroads/Power Civil is a civil works application used by many multinationals in the infrastructure sector (roads, housing developments, landfills, mining, etc...) and used in large engineering projects, which will allow the student to participate in projects where this tool is required. During this training, the student will learn about [...]
Systemsarchitecturecourse,technologyforBigDataandenterpriseinformationsystems (ERP,CRM, SCM, etc.).	The course is mainly based on exposing and explaining each of the pieces that make up a Big Data ecosystem through the second most used distribution in companies (Hortonworks), as well as the study and analysis of the different business strategies focused on customers such as CRM and the integration [...].

ENABLING TECHNOLOGIES APPLIED TO SMART CITIES

Course name	Content
Business Intelligence Information Systems Course (Data Warehouse)	The business intelligence information systems course aims to provide students with the skills to design, build, maintain and operate the most common business intelligence information systems, i.e. those based on the use of relational databases for the construction of a data warehouse [...].
Course on the Internet of Things and new possibilities for interaction with users.	The Internet of Things is a recently conceptualised technological application area, in full evolution and development. The course covers the basics and tools to develop and participate in projects in this vast field from multiple approaches: devices, communications, protocols, platforms, software, mathematics, machine learning, Aimed at: IT professionals. General Objective: The [...]
Big Data and the web of data course	The course "Big Data and the web of data" will delve into the relationship between Big Data and the Internet, addressing different implications that will allow the professional to embark on a self-sustainable project from the perspective of automatic consumption of existing data on the web, as well as in the evaluation of the performance of a site. The teaching [...]
Course in applied mathematics and statistics for data analysis (Big Data mathematics and data mining).	The theoretical and practical course will help to develop analysis, synthesis, planning and deductive reasoning skills to extract value from large volumes of data. Aimed at: The course is aimed at students of engineering, architecture, business, statistics or professionals who want to get into the field of Business Intelligence (Business Intelligence) through the use of data analysis, synthesis, planning and deductive reasoning skills.
AutoCAD P&ID and AutoCAD Plant 3D	This Petroleum Geology course is specially designed for engineers and technicians mainly, but easily accessible to all professionals who want to delve into the world of the petroleum industry by developing a critical opinion in any work environment.
Course on Office and workspace interiors (use of rendering software, animations, virtual reality and augmented reality).	Theoretical and practical course for the creation and initiation in interior design for offices and workspaces, with the use of rendering software applying animation techniques, virtual reality and augmented reality. Aimed at: This course is aimed at professionals with degrees in Higher and Technical Architecture, Civil Engineering, Designers, as well as [...]
Secure Development Course Operations in Information and Communications Security	Theoretical and practical course that deals with the topics of physical and logical security, operational information security controls defined in the ISO/IEC 27002 standard, and finally the controls for

	cloud services ISO/IEC 27017, giving an overview of the security aspects that are necessary to know in order to carry out the process [...].
Course on Ethical Hacking and Cybersecurity. Forensic Analysis	To train students in ethical hacking and forensic analysis, so that they acquire the knowledge and skills as an ethical hacker or forensic analyst.

ENERGY EFFICIENCY

Course name	Content
Energy efficiency in buildings course	This course compiles the main technical parameters for the analysis and design of an energy-efficient building, grouping together the key criteria for the mitigation of solar heat loads, passive design, urban microclimates, lighting control, air conditioning systems, among other elements. Aimed at [...]
Course on energy efficiency in industrial installations	Industry is one of the three largest energy consumers historically, so implementing energy efficiency strategies in industrial plants will mean acting on more than a third of a country's demand, with the significant economic and environmental impact that this implies. In this course, [...]

SUSTAINABILITY

Course name	Content
Courses on Smart and Sustainable Cities (SSC - SMART AND SUSTAINABLE CITIES)	To train students in the most recent notions of planning, design and management of smart and sustainable cities, as well as in the instrumental tools relating to the technologies and methods that enable the development of initiatives in this urban model.
Sustainable Architecture Course	The purpose of the course is the student's knowledge of the best practices of sustainable architecture, for its application in projects
Course on sustainable urbanism and urban planning	Students will learn about the most important pillars of sustainable architecture: Main concepts of sustainable architecture and terminology, impacts on natural resources, indoor and outdoor habitat, climate and sunlight analysis, selection of climate-appropriate passive strategies, etc. Target group: The course is aimed at the different professionals involved in sustainable architecture [...].
Course on Virtual Reality, augmented reality and 3D printing in architecture and town planning	Learn the basics of 3D design programmes that allow immersion in augmented reality, virtual reality and 3D printing technologies for the presentation and development of architectural and urban planning projects.
Planning and management of sustainable urban mobility course	To train students in the most recent basic notions of planning, design and management of sustainable urban mobility, with emphasis on the tools and instruments of analysis and case studies that allow them to understand the current panorama of the subject
Smart Home and Smart buildings course: Demotics and smart building management	The purpose is fundamentally to obtain the knowledge to know how to decide which existing technologies lead us to efficiency, sustainability, economy and optimisation of the different buildings that will form the Smart City, and to coordinate the professionals or companies involved in the project.
Course on Big Data applied to city and building management	The course will help to have an initial insight into the use of analytical data and information so that they are able to design and

	implement business intelligence strategies, facilitating decision making through the analytical exploitation of data.
Course on Smart Water and Waste Management in the Smart City	To enable the student to distinguish and assess the implementation of different Smart Water City technology systems.

GOVERNANCE

Course name	Content
City Governance Course	To train graduates from different fields to carry out professional tasks related to the application of Smart Governance in urban contexts and in the general field of Smart Cities.

Conclusions

In conclusion, in order to carry out this work, the standard definition of the Smart City concept has been considered, which has served as a starting point for the design of the Smart City competence framework.

In designing the competency framework, the following perspectives have also been considered:

- Demand from the public sector, through its services linked to Smart Cities.
- Demand from private sector actors, mainly large municipal and municipal service management companies.
- The supply of Smart services in the ICT sector, especially ICT operators and companies, and leading industry associations.

On the other hand, among the recommendations we would say that when designing a training programme for ICT professionals in the field of Smart Cities, based on our experience and after analysing a series of studies, we would say that there are a series of factors that must be taken into account in the development of a smart initiative for a specific city, so on the one hand we have:

- Need to align with the city's strategy: each project has to follow the right direction to achieve the city's smart objectives and taking into account that the decisions taken will affect the long term.
- Involvement of the public administration: the public sector is essential in defining the strategy for the projects to be developed in the city. Likewise, consensus between different political forces is essential for the development of a city.
- Involvement of citizens/businesses: As the target audience of City 4.0 projects, their engagement with all elements of the concept is crucial. Also, their participation in determining the future of the city.
- Improving urban services: the design of an efficient urban services portfolio implies improvements in city verticals and citizen perception.
- Definition of a business model: it is advisable to describe how each business offers its products or services to customers, how it reaches them, its relationship with them and how its sustainability is ensured.
- Economic viability and sustainability: the implementation of these projects must be subject to the existence of sufficient funds to guarantee their execution. Likewise, their sustainability over time must be guaranteed.
- Technology and innovation: technology development drives the smart city world

Finally, the final impact of this model for the partners, and through the involvement of ECQA, each partner, respectively within its Smart Cities Qualification Centre (if it decides to have and promote such a centre) could expect to receive:

- A unified scheme for training, certifying and recognising the enhanced competencies of project developers, managers and consultants to generate, develop, manage and consult on diverse and sophisticated smart city projects worldwide;
- Skills cards required for the professions of smart city project managers, consultants and developers that will form the basis for a new competency framework for these professions;
- Modular programme to train and retrain developers, project managers and consultants for their professional qualification upgrade needs;
- Certification as a training centre that meets high standards and training quality, valid worldwide;
- Promoting new jobs in Europe and the world.