Smart Cities
Body of Knowledge

Panos Fitsilis

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DEVOPS

DEVOPS COMPETENCES FOR SMART CITIES

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ERASMUS+ Project: 601015-EPP-1-2018-1-EL-EPPKA2-SSA

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ISBN 978-9963-711-91-8

Cite this Document

Fitsilis, P., & Kokkinaki, A. (2021). Smart Cities Body of Knowledge https://smartdevops.eu/scbok

Project Funded

This project has been funded with support from the European Commission. This presentation reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

To all my missed friends but always in my heart

- Panos Fitsilis

To the people who contributed to and the people who will be impacted by this book

- Angelika Kokkinaki

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Preface

Smart cities are complex ecosystems that use information and communication technologies for helping their citizens and organizations deal with the challenges of urbanization, safety, resilience, and sustainability. Their creation is a long and laborious transformation that should not be considered mainly as a technical challenge but as a movement to create citizen-centered ecosystems that improve quality of life and stimulate economic activity.

Smart city ecosystems are comprised of people, organizations and businesses, policies, technologies, legislation, and processes integrated to create the desired outcomes. Within this context, people comprise a vital constituent in these efforts and a highly skilled workforce is key in rendering smart city ecosystems a reality.

Today, more and more smart cities are emerging worldwide creating a sustainable and strongly growing market. According to various market reports, it is expected that this market will reach the size of 1 billion euros worldwide, but the most important fact is that is expected to change our daily lives.

Although for several years we were working on the development of this new smart ecosystem, quite recently we discovered that the people factor was not considered, sufficiently. We realized that even though billions were invested in technological or urban development, not sufficient effort has been spent in training the necessary workforce with the skills to fulfil this vision. Development of a smart city was considered "business as usual" by the IT vendors, or even yet another case of modern technology deployment. However, this is far from true as smart cities transvers every aspect of our lives and our activities.

As we routinely say, we are "living in a software-enabled society and we cannot risk it". And since our lives depend surprisingly so much on the smooth operation of digital services, we need to reassure ourselves and to invent new ways to develop software that empowers us to produce reliable software, with the ability to continuously develop new features and effortlessly deploy it and make it available to our citizens in a matter of seconds. This was the reason that we decided to promote DevOps culture. DevOps is a culture, is a set of practices that combines software development (Dev) and IT operations (Ops), and it aims to shorten the software life cycle and provide continuous delivery with high software quality. In simpler terms it allows us to innovate and rapidly deploy these

innovative solutions to the citizens or the customers. In fact, this is the case with commercial software, which is automatically deployed through mobile devices, but it is not necessarily the case with city mission-critical systems.

These observations were our motivation for the SmartDevOps project. The SmartDevOps project (https://smartdevops.eu) was funded by Erasmus+ KA2 with Project No.: 601015-EPP-1-2018-1-EL-EPPKA2-SSA and it commenced on January 1st, 2019.

Since then, several milestones were realized: three new smart cities professions, an extensive list of smart cities-related competences, extensive pilot training attended by hundreds of trainees that validated the training offerings, a network of experts, a community of practice at the European level.

This book presents the first version of the Smart Cities Body of Knowledge (SCBoK), which is the most important deliverable of the SmartDevOps project, that is an attempt to systematically approach the topic of required smart cities competences. Furthermore, it offers the curricula that can be used to develop the required knowledge coherently and systematically.

Moreover, we address the main question regarding the need of specialized professionals for the development of smart cities and whether this specialization constitutes one or more new, discrete profession(s).

The professions and skills presented were derived from various viewpoints, as well as from an international perspective through laborious market research. This research was conducted in the context of the SmartDevOps project, concluding that three new job professions with competences from four distinctive groups, are needed for smart city professionals, namely:

- Smart City Planner
- Smart City IT Manager
- Smart City IT Officer

Furthermore, this is a particularly informative and useful book, the content of which you not only need but you must also master, to develop your competences for smart city. This book provides a significant contribution to achieving that.

This is the first international book covering smart city professionals' needs and competences, which makes it not only unique but also important. It

offers every smart city stakeholder the opportunity to learn, understand, and apply these smart city competences.

We already mentioned that this is the first version of this book, since we strongly believe that the smart cities ecosystem is a complex, self-organizing, and dynamic system of systems which is evolving constantly. As such, the findings presented in this SCBoK should be regularly re-evaluated and updated, which is also the case for other existing "Bodies of Knowledge".

Smart city professions and their development has taken a significant first step with SmartDevOps project; however, much remains to be done. The recognition of these new professional needs, by society and the market, alike is an important step that must be taken. However, this is not the only one. We can enumerate some further actions needed: development of a certification schema, promotion of these new professions, and others.

Before concluding, we would like to thank all project partners and project team members who contributed to the development of this SCBoK, as well as all the participants of the SmartDevOps project who helped us improve it and encouraged us to continue this effort during the Covid19 pandemic. Finally, we would like to thank the European Commission, DG EAC, who through their funding enabled us to do all this important work, and our project officers, Silvia DE BENEDETTI and Vytaute EZERSKIENE for their advice and support through this long journey.

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01 Chapter

Introduction

The concept of a smart city has been evolving over time and according to the perspectives of involved stakeholders. Initially, a smart city was viewed through coupling the city's infrastructure with sensors to enable data collection. Then these data would be processed and would provide information to decision makers for supporting more efficient management of resources and services. At a later stage, interconnection of services was considered a significant advancement that would provide end-to-end visibility of data points, thus overall optimization of resources and services as opposed to topical improvements (Celino and Kotoulas, 2013; van den Bosch, 2017). During the next development stage, researchers underlined the importance of moving beyond the limits of the technical system to incorporate citizens, priorities, and needs, thus gradually forming the socio-technical viewpoint that examined how to design and develop services to improve the quality of life for a smart city's citizens (Angelidou, 2015). It soon became apparent that a socio-technical framework was better suited to identify needs, perspectives, and priorities of communities residing within smart cities, addressing a wider variety of involved social partners, beyond citizens; as businesses, governmental offices, NGOs and others (Angelidou, 2015; Zait, 2017) were no longer identified as end-users of services, but rather as contributors to shaping the needs and prioritization of smart city developments (Gartner, 2018). This view has been adopted by Hollands (2015), within the process of formulating working paradigms is still ongoing. It must be noted that over the last few years, a gradual shift is emerging from citizen-centric or community-based developments into sustainable initiatives for smart cities (Ahvenniemi et al., 2017). This trend is aligned with people-oriented approaches and introduces provisions

not only for current citizens but also for future generations. Overall, the framework for a smart, sustainable city includes economic, social and environmental sustainability conceptual extensions on services and tools that safeguard the needs of present and future generations.

From another point of view, it is interesting to see how the main stakeholders define a smart city's dimensions. As outlined above, emphasis is placed on the concept of *people-oriented* services. This is in accordance with academia that has contributed, with smart cities' definitions which emphasize the concept of *people-oriented* services targeting *higher quality of life*, *efficiency* and *sustainability* (Fernandez-Anez, 2016). However, governmental institutions have slightly different priorities, and they are depending on their level of administration (Fernandez-Anez, 2016). Local government officials are prioritizing aspects relevant to *people* and *sustainability*, including environmental and economic issues. Governmental offices and inter-governmental institutions emphasize concepts related to *governance* and the *environment,* followed by concerns about people. Private companies that offer technical solutions or support for smart cities prioritize *governance*, *economy*, and the *environment.* Technology transcends the definitions of these three groups of stakeholders, and it is understood that its ability for interconnectivity is a critical enabling factor. Local governments' definitions express a broader need for technological implementations; thus, they are not so focused on the idea of integration. All stakeholders point out as a critical enabling factor data captured by heterogeneous device networks, the Internet of Things, interconnected devices, intelligent infrastructure and processing of data to support existing services more efficiently and develop new added-value services for smart cities.

Using as a reference the dimensions discussed above, a **smart city can be defined as a system that promotes human and social capital, wisely using and interacting with natural and economic resources via technology-based solutions and innovation to address public issues and efficiently achieve sustainable development and a high quality of life on the basis of a multi-stakeholder, municipally based partnership** (Fernandez-Anez, 2016).

The prospect of developing smart city services in a constantly evolving citizen-centric manner calls for suitable software development paradigms. To this end, agile software development approaches are well suited to shorten the time gap between development and deployment. Similarly with agile software development approaches, DevOps facilitates and speeds up the continuous deployment of new software features (Sebastian et al.,

2017). From a business perspective, the DevOps methodology not only supports the development of emerging requirements in shorter cycle times (Lwakatare, Kuvaja and Oivo, 2015) compared to other software development approaches but at the same time it improves user experience regarding developed software services (Senapathi, Buchan and Osman, 2018).

The limited number of employees in smart cities without DevOps knowledge has severe implications for the sustainable development or enhancement of smart city services. The Smart DevOps ERASMUS+ Sector Skills Alliances project addresses the gap between current and future skill demands on the municipal workforce by emphasizing the exploitation of emerging employment paradigms such as DevOps.

This book presents the major outcomes of the Smart DevOps project. More specifically, Chapter 1 sets the dimensions through which the smart city concept has been evolving. This background information is evidently helpful as it provides the overall idea of how the conceptual definition of smart cities has evolved and illustrates that different stakeholders are not necessarily aligned or have the same perspectives. This observation has led to a major theme in the research of this project, namely what kind of job profiles are relevant for smart city planning, development and optimal operation, a topic that is further explored in the following Chapter.

Chapter 2 presents an analysis of the main intended users in smart city organization, and emphasis is placed on the professionals who undertake tasks relevant to the design, development and operation of smart city initiatives and services. The three main job profiles for smart city employees are presented, as well as the different perspectives and competencies between those distinct job profiles. Complementary to that, there is the need to identify to what extent different SC administrative profiles require different general/transversal and specific competencies.

In view of this requirement, Chapter 3 explains the methodology followed to extrapolate essential competencies for each job profile. Multiple methodological tools were applied to ensure that no significant viewpoint was missed or undervalued. As shown in Chapter 3, an extensive literature review of academic papers, professional publications, and governmental reports was conducted. Secondary data were complemented with primary data collected through interviews, focus groups, as well as an extensive survey in four member states. The outcome of this unprecedented endeavour resulted in extrapolating the necessary curricula and competencies for smart city professionals.

In Chapter 4, the competencies are organized into modules, and modules are grouped into categories consisting of i) transversal competencies, ii) general IT management competencies, iii) DevOps related competencies, and iv) smart city-specific competencies. Each category is colour-coded in this publication to enable readers to identify competencies of their interest and provide them with an implicit mind map of relevant competencies.

In Chapter 5 we present the inventory of competences per competence group. For each competence we present a short description, the basic terminology, the knowledge domain, the learning objectives, the competence content, the related learning outcomes, and readings. Competence groups are colour coded for the convenience of the reader.

Chapter 6 is a call to action as this is a constantly evolving topic and many additional contributions are sought to realize the vision.

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02 Chapter

Purpose and Intended Users

2.1 Definitions

In the literature, there are numerous definitions available for the words «competence» and «skills». We adopt the definition of CEDEFOP (cedefop.europa.eu) which best serve the objectives of SCBoK
According to CEDEFOP (2014) a competence is the «ability to apply learning outcomes adequately in a defined context (education, work, personal or professional development) or the ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development».
Similarly, knowledge is the «ability to apply knowledge and use know-how to compete tasks and solve problems».

2.2 Audience and Uses

The smart city is a multi-stakeholder ecosystem in which stakeholder participation is critical to the success of the city. Stakeholders, who may be classed as internal or external, have a good or negative influence on a smart city digital transformation project. As internal stakeholders we mainly consider all entities, organizations, and/or individuals that act in relation to a specific city, because they are established, they live/work/have vested interests in a specific city, e.g. the inhabitants of a city or a municipality in a city, or businesses established in a city. External stakeholders are influencing the development and the operation of the city, but they are not strongly tied to a specific city since their interest usually span to a number of cities. For example, multinational/national ICT providers, ministries, etc.
In order to leverage technologies for innovation and the digital transformation required, the municipalities' staff must develop new skills

and competencies that are many, diverse, multi-faceted and rather complex.
The SCBoK is intended to support a wide range of audiences across many uses. It was developed and written with these audiences in mind.
The following list presents the relevant stakeholders; however, this list should not be considered exhaustive.

Academia and Research Institutions
Academic research is helping kickstart smart cities and this has become apparent in recent years from rising interest of research institutes that has resulted in a large number of pilot smart city projects.

Local and regional administrations
Generally smart city initiatives necessitate enhanced and knowledgeable public services. Furthermore, it is critical that local and regional governments are actively involved in planning, initiating, promoting, and supporting all such initiatives. Finally, public administration can provide the necessary resources in smart city projects.

Municipality staff
Municipalities are the main actors that coordinate and oversee the development of a smart city at all levels (strategic, management and operation) and at all phases (planning, initiation, implementation, monitoring and operation). As such, the existence of well educated, trained personnel with relevant experience is of paramount importance for the success of the city.

Financial suppliers/Investors
Smart cities are both expensive to develop and to operate. As a result, reliance on financial providers is required, since obtaining the required financial resources is critical for the development of smart city projects. At the same time, investors are primarily concerned with the project's return on investment.

Energy suppliers
Sustainability is a major objective in the development of smart cities. As a result, the smart city's functioning requires a reliable and green energy source. In this context, a crucial function for smart cities is sustainable energy policies.

ICT suppliers
ICT suppliers provide the necessary IT infrastructure. Therefore, they constitute stakeholders involved in all phases of smart city development and operations.

Health care / Transportation / Logistics providers
Health/Transportation/Logistics are basic services that should be offered in the context of a smart city. As such, all of the above are considered as influential stakeholders for the development and operation of a smart city.

Businesses / Retailers/ Tourist / Leisure services
Business, tourist businesses, retailers, etc. are directly involved in developing the economy of smart city, they are providing requirements for innovative solutions and implementing smart solutions. Therefore, they play a decisive role in the transformation process for becoming a smart city.

Construction and real estate companies
Construction companies are facing many challenges to sustain growth and lead innovation in urban areas. All these innovations promote smart city sustainability, efficiency, and technological advances in both buildings and materials.

Citizens
Citizen participation is an essential component of urban transformation and smart city development. This implies that problems such as social exclusion, physical and functional marginalization, poverty, lack of services, and unemployment should be efficiently addressed.

Government and Policy makers
Cities are facing population growth, resulting in increased demands for infrastructure and innovative solutions while maintaining a high quality of life for its citizens. Furthermore, in a smart city, policy formulation and implementation are critical steps toward more openness and accountability.

Experts and scientists
Smart city scientists and professionals are also necessary to be included in the planning process for developing smart cities. Scientists and specialists are critical stakeholders to the innovation processes in a smart city.

Media

Media coverage of challenges and benefits of smart cities can have a positive impact on smart city projects.

The following table presents the relevant stakeholders and possible uses of the SCBoK. However, as already mentioned, this list is not exhaustive.

Table 01: *Possible uses of SCBoK*

Stakeholders	Possible uses of SCBoK
All stakeholders	• Common language for smart cities application domain • An easily readable baseline
Academia, Research Institutions and VET providers	• A baseline for assessment and possible certification • A new standard to promote a new profession and attract new professionals • New educational curricula and educational material • New opportunities for educational offerings • New research opportunities • Staff self-assessment
Local and regional administrations	• A baseline for assessment and possible certification • A new standard to promote a new profession and attract new professionals • Staff self-assessment
Municipality staff	• A baseline for assessment and possible certification • A new standard to promote a new profession and attract new professionals • New educational curricula and educational material • Staff self-assessment

Stakeholders	Possible uses of SCBoK
Financial suppliers/Investors **Energy suppliers** **ICT suppliers** **Health care / Transportation / Logistics providers** **Businesses / Retailers/ Tourist/Leisure services** **Construction and Real Estate companies**	• A basis for staff development for smart city professionals • Understanding smart city development and operational challenges • Staff self-assessment
Government and Policy makers	• A baseline for assessment and possible certification • Staff self-assessment
Citizens	• Understanding smart cities' development and operational challenges
Experts and scientists	• A baseline for assessment and possible certification • A new standard to promote a new profession and attract new professionals • New educational curricula and educational material • New research opportunities
Media	• Understanding smart city development and operational challenges

2.3 Curriculum Delivery Models

The proposed SCBoK competences can be delivered by employing three delivery models: MOOC, blended learning, and a work-based learning stage.

- A Massive Open Online course (MOOC) is an online course aimed at unlimited participation and open access via the web. As such, a

number of modules for acquiring the basic competencies of the job role profiles will be made available as MOOCs to all smart city professionals in Europe and worldwide.

- The blended learning approach combines online educational materials and opportunities for interaction online with traditional place-based classroom methods. It requires the physical presence of both teacher and student, with some elements of student control over time, place, path, or place.
- In parallel with the other two delivery modes, Work-based learning (WBL) may be used. WBL is an educational strategy that provides learners with real-life work experiences where they can apply academic and technical skills and develop their employability. WBL merges theory and practice and acknowledges the intersection of explicit and tacit forms of knowing.

2.4 Developing the Competences

There are many ways to develop SC competences. The decision is made according to the learner's preferences, current situation, availability of resources, etc. Some methods for developing competences which may be used are:

- Self-development of competences. Using SCBoK job profiles together with the inventory of competences identified and the learning objectives of each module, the learner may develop their knowledge (e.g. reading books, standards, case studies and articles) and reflect on their application in practical situations and derive learnings from that. This is best suited for learners already experienced in the development of systems for smart cities.

- Peer-development. This approach is based on teamwork where collaborative learning is used (using the SCBoK and the inventory of competences to reflect on a case by case basis on how things have been developed, what the best practices and the problem areas were, asking for feedback on their own performance). The learning team ideally should consist of members from different disciplines, so team members are able to benefit from different viewpoints presented by peers.

- Education and training. Based on SCBoK, the job profiles and the competences identified, learners should plan attending seminars,

lectures, and training. A SC Knowledge Assessment tool can be of assistance to identify knowledge gaps.

- Coaching and mentoring. A coach or a mentor is an experienced professional who guides the learner to SC knowledge development. He/she challenges the learner by asking questions, highlighting certain aspects, correcting mistakes, etc. In this nstance, the coach/mentor should use the SCBoK and the selected SC job profile in order to cover all necessary knowledge areas.

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03 Chapter

Market Insight

One of the main challenges addressed in the smart DevOps project was creating a systematic methodological approach that would support the identification and collection of competencies considered necessary for the professionals in smart cities. A mixed research method approach has been followed to minimize biases and include as many competencies as possible. More specifically, both secondary and primary data were collected, applying a variety of methods. This Chapter describes the methodological approach followed to gather market insights.

The remainder of this Chapter is structured as follows: Section 3.1 describes the literature review conducted; a survey has been conducted to select primary data, and it is outlined in Section 3.2; interviews and focus groups are described in Section 3.3. The Chapter concludes with the approach followed to synthesize the findings identified in previous sections.

3.1 Literature Review: Secondary Data Collection

For the purposes of this project, secondary data was collected through a narrative literature review based both on academic and corporate publications. Flowingly, we will include some key publications that guided the literature review on smart DevOps competencies, i.e. publications by city administrations or other Smart City associations, announcements on awards received by the cities, town hall/administration reports, press reports, web pages to identify best practices, etc.

One key finding of this research strongly points to integrating technical and general/transversal management competencies. One of the frameworks used to guide this research is that of Wiedemann and Wiesche (2018); this framework encompasses seven skill categories and an additional 36 skill

sub-categories. Furthermore, Fitsilis, Tsoutsa, and Gerogiannis (2018) presented a framework of competencies that differentiates among technical, behavioural and contextual skills. The conceptual work of Hecklau et al. (2016) provided an alternative approach. Based on a literature review, the authors related, from an HR perspective, the influences of the macro-environment (PESTEL factors) in the Industry 4.0 era to competencies of employees and clustered the competencies into a holistic competence model consisting of 4 categories and 26 sub-categories. The researchers posit the applicability of this model towards 'industry 4.0 readiness check' by displaying multivariate data into a two-dimensional radar chart.

The key characteristics of the Industry 4.0 phenomenon in terms of increased interconnectivity, real-time data exchange, and machine learning are also considered relevant to this research. Expanding on the model of Hecklau et al. (2016), especially in terms of contextual skills, Fitsilis, Tsoutsa, and Gerogiannis (2018) suggest that training of technical, transversal and contextual skills should be differentiated by the respective industry sector, software development and operations lifecycles, proficiency, up-to-date digital technological developments, and job profiles.

Synthesizing the models of Wiedemann and Wiesche (2018) and Hecklau et al. (2016), it is suggested to complement Wiedemann's and Wiesche's (2018) categories with the following factors: in the context of decision-making skills, switching from operational to more strategic skills; referring to social skills, including media skills and virtual communication and presentation skills as well as conflict management and compromising skills; in the context of analysis skills, increasing the emphasis on IT security and an implicitly enhanced compliance attitude; complementing the analytic skills with creativity skills triggered by the need for continuous improvement and innovation; the intensive change and digital transformation process imply continuous learning skills, motivation to learn and research skills as well as ambiguity tolerance and the ability to work under pressure; complementing the decision-making skills with entrepreneurial and leadership skills due to higher levels of decentralization and individual responsibility; in the context of social/intercultural skills explicitly mentioning language skills; to comply with the ultimate mission of a smart city, having a sustainable mindset.

In addition, soft competencies addressing entrepreneurial mindset, discursive culture, civil skills and everyday culture are suggested by Zait (2017) as integral requirements for managing smart cities at large.

Minnesota (2016) points to still existing training gaps relating to specific aspects in the technological competence category: skills related to product design concerning product discovery; skills on user experience design and software architecture; covering IoT topics.

DevOps practitioners (DevOps Institute, 2019) highlight key categories of skills to be agreed upon by three levels of employees: C-level executives leading the business or IT strategy; management and IT team and project leaders; and individual skill contributors. They differentiate between must-have, nice-to-have, and optional skills, a method also applied to this research. A descriptive study of the Institute shows that process skills and knowledge as well automation skills are must-have (>50%), skills whilst soft skills are a must-have for C-Level employees and team and project leaders. Interestingly, team interaction patterns for software delivery at scale are regarded as a significant success/fail factor by the DevOps practitioners.

Besides focusing on internal stakeholders, Feijter et al. (2018) suggest including external stakeholders, such as customers and software/components providers, when adopting DevOps. The researchers suggest a DevOps competence model based on three primary perspectives: Culture and Collaboration are paramount important and regarded as the 'roof of the house'; Product, Process and Quality mainly relating to a DTAP street (development, testing, acceptance and production environments); Foundation focusing on configuration management, architecture and infrastructure

A study by Bang et al. (2013) supports the findings of Feijter et al. (2018), holding that knowledge and abilities on agile software development methodologies (in particular, Scrum) support the following four perspectives of DevOps: Collaboration Culture; Automation; Knowledge (architecture, cloud computing, threat modelling); Sharing of knowledge (product and sprint backlogs).

A study in the Italian setting was conducted by Minchelucci, Marco and Tanda (2016). Due to the low response rate, the researchers chose an exploratory qualitative study and an exploratory factor analysis to analyze the quantitative data. Five factors appeared: technical skills including management of innovation and territorial planning; knowledge of private and public laws about procurement, innovation management, public, private partnerships, and open data; soft skills relating to general management, relationships and mediation, as well as leadership and personality; financial tools and economic principles; and general

management basic skills such as familiarity with ICT, knowledge of foreign languages, and professional experiences.

Based on the above, several research questions were formulated to examine how smart city professionals and involved external stakeholders would judge, prioritize, and categorize them. The survey described in the next section draws upon the theoretical outlook described in the section.

3.2 Survey: Primary Data Collection

Primary data were collected through an initial survey on a number of questions related to smart cities competencies; The survey was conducted in four EU member states: Germany, Italy, Greece, and Cyprus.

The quantitative research was designed in three stages. Initially, surveys with fully structured questions were developed; these were distributed via the Unipark system to SC administrators in the four participating countries. The second stage included data analysis; SPSS was used for frequency tables, correlation analysis, exploratory factor analysis, and multiple regression analysis with varimax rotation. The survey was challenged by the response rate, despite extensive online and offline campaigns. For the frequency tables and correlation analysis, significant data could be partially achieved. Factor and regression analysis proved more challenging. The responses for the Smart City planner questionnaire (pretested with one senior Smart City administrator and one academic representative of a Smart City association) were n= 63: Cyprus n= 5, Germany n=9, Greece n=20, Italy n=28, Romania n=1 – the latter was unsolicited. The responses for the Chief Digital Officer/IT officer questionnaire were n=15 (Cyprus: n=2; Germany: n=2 but only 1 valid; Greece: n=8; Italy: n=3; n total= 15).

3.3 Interviews and Focus Groups: Collection of Qualitative Data

Following the survey, interviews and focus groups were employed for qualitative data collection. Partner attendance facilitated the recruitment of interviewees and participants in the focus group into smart city events, academic conferences and/or professional conventions. Furthermore, the project aims to compose an overview of the requirements of smart city professionals in the four countries after the accurate analysis of the job market needs. Interviewees were encouraged to provide open answers. The qualitative data were partially analyzed via content analysis supported by NVivo software.

Regarding the first qualitative stage of interviews, respectively two professional figure heads of a City of the Future were interviewed. Complementary to the interviews, the four partners provided an analysis of previous publications by the chosen city administrations or other Smart City associations, e.g. awards received by the cities, reasons for the award, town hall/administration reports, press reports, web pages, to identify the benchmarks. Furthermore, the project also provides an overview of the professional needs of the Smart City Sector in the four countries following an accurate analysis of the job market needs. One part of the respective national competence analysis was provided for the partners in terms of the national quantitative research results based on the analysis of the questionnaire. As a second part of the respective national competence analysis, representing the second qualitative stage, each partner should provide the results of the interviews/focus groups/workshops conducted based on a provided reduced semi-structured questionnaire epitomizing key findings of the quantitative research. Interviewees were encouraged to provide open answers. The qualitative data were partially be analyzed via content analysis supported by NVivo software. Detrimental, from an analytical point of view, was the request of many interviewees to be kept anonymous, not agreeing to record the data.

Moreover, the respective partners conducted an analysis of the best practices in training. To complete this task, the partners conducted secondary/desk research in their countries and filled in the table called 'VET survey by national Partners on Best practices on Training provision' (see Appendix). The findings of all these steps were synthesized in a national report by each partner.

Finally, to enable a comparison with European competence frameworks, the Italian partner conducted a European report on transversal and technical competence needs and provisions based on desk research on selected European institutions by (a) listing the identified transversal and technical competence needs possibly differentiated by Smart City Planners, Chief Digital Officers and IT officers according to the reduced questionnaire; (b) using the VET Survey on provisions in the Appendix- Competences per job profile together with (c) a statement of European conclusions and (d) providing a conclusion on a possible mismatch of competences. Moreover, a consolidated report by the German partner synthesized the findings of the four national partners into a taxonomy of competencies of emerging job roles and the skills necessary to achieve them. Finally, the competence profiles elicited through all the methodological approaches form the basis for the MOOCs course content and training of the smart city administrators.

3.4 Conclusions

In conclusion, this Chapter describes the methodological approaches that have been followed in the smart DevOps projects to gather market insights regarding the job profiles and competences that are considered appropriate to be assigned for each job profile. This Chapter describes the mixed research method approach that included extensive literature review, a survey in partner states, interviews, and focus groups complemented by documentary analysis. The outcome of the process described above is fully analysed in the next Chapter.

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04 Chapter

Smart Cities Curricula and Competences Overview

4.1 Smart Cities Curricula Learning Objectives

The technical and the socio-economic environment are changing rapidly. Our lives depend more and on from the operation of diverse IT systems delivered and operated by a number of different stakeholders either at the city level or internationally.
As such, the professional development of the municipalities' staff is important, and especially for those municipalities attempting to transform into smart cities. To this end, our vision is to provide to municipality employees with the necessary skills, knowledge, tools, and techniques in order to:

- make the most of the human talent and potential available;
- inform, educate, and inspire staff to reach their professional goals;
- educate staff on new technologies and on new software development approaches;
- train staff to work in teams for managing complex projects;
- educate staff on cases and problems facing smart cities

The proposed curricula in this body of knowledge has four major learning objectives. These four learning objectives are the following:
LO1: Development of transversal skills.
LO2: Building an adequate IT knowledge background
LO3: Developing advances for software development and operation skills
LO4: Developing smart city management skills

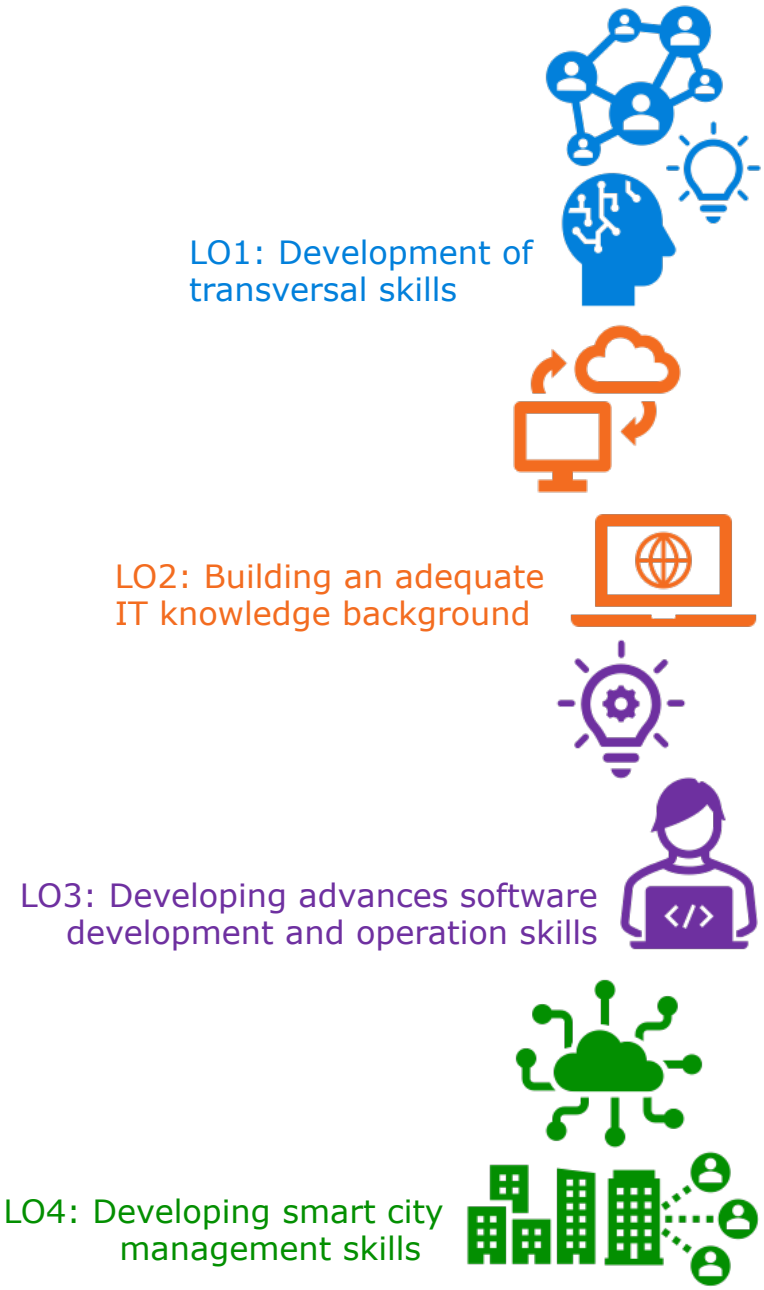

Figure 01: *Learning Objectives*

More specifically:

- According to UNESCO, transversal skills are not specifically related to a particular job, task, academic discipline or area of knowledge and they can be used in a wide variety of situations and work settings (for

example, organizational skills). As such, a smart cities curriculum should include the development of competences such as creativity, entrepreneurial thinking, ability to work in a team, social skills, ambiguity tolerance, motivation to learn, emotional intelligence, strategic vision, intercultural skills, project and process management, design thinking, decision making and problem-solving, leadership and management skills, stakeholder management, knowledge management, and advanced presentation skills.

- Rapid digital technology advancement is significantly impacting the development of smart cities. In some cases, these advancements are so rapid that have not yet been included in the curricula of universities offering relevant degrees. On the other hand, the development of smart cities is following this technological revolution, resulting in a knowledge gap facing the municipalities' staff. As such, the proposed curriculum should include the development of skills on a variety of topics. These topics should be focused either on traditional IT topics such as:

    - software development life cycles and agile methods,
    - IT quality assurance,
    - IT security,
    - system and software architecture, and
    - introduction to ITIL

  or on advanced key technologies such as:

    - Cloud computing,
    - Internet Of Things (IoT),
    - Data analytics,
    - Artificial intelligence.

- A third major LO is the development of DevOps skills. DevOps is a set of practices that combines software development (Dev) and IT operations (Ops). It aims to shorten the systems development life cycle and provide continuous delivery with high software quality. It is considered as the state-of-the-art software development approach since it is focusing on continuous delivery of high quality of IT services to customers, citizens in our case. As a result, this learning objective at the curriculum level should introduce learners to:
    - DevOps basic concepts (culture and practices),
    - Repository Management,

  - Continuous Integration,
  - Configuration Management,
  - Use of building, deployment and monitoring tools and
  - Code analysis and continuous testing tools.

- Smart cities evolved from the application of ICT technologies to urban problems to an ecosystem that addresses all aspects of life. As such, it constitutes a new market, a new business, technological and scientific domain with specialized know-how. This new domain includes among others:
  - Knowledge on smart cities platforms,
  - Smart cities business models,
  - Smart services and operating procedures,
  - Smart cities standards and legal issues,
  - smart city sustainability,
  - smart city resilience,
  - Urban management,
  - Citizen-driven/citizen orientation/user experience design, and
  - Smart city financial management and procurement.

The proposed curriculum is using Bloom taxonomy to classify educational learning objectives into levels of complexity and specificity. According to this taxonomy, the cognitive domain is broken into the following six levels of objectives namely: Remember, Understand, Apply, Analyse, Evaluate, Create.

4.2 Smart Cities Job Profiles

Research conducted in the context of SmartDevOps project, has revealed that three new job professions are needed for smart cities professionals

- Smart City Planner
- Smart City IT Manager
- Smart City IT Officer

4.2.1 SC Planner

A Smart City (SC) Planner can be defined as a high-level official that is able to bridge the needs that arise from:

- the traditional development and operational needs of cities,
- Smart and sustainable city frameworks, best practices, standards and technologies,
- Strategic priorities of the city’s political leadership.

An SC planner shall have overall knowledge of the city's strategic objectives. He/she shall be aware of the smart cities trends and best practices in order to set up the city's strategy and strategic plan for the implementation of the city's vision.
An SC Planner shall have competences to define specific Key Performance Indicators (KPIs) for monitoring the progress of the implementation of the city's strategic plan.
The profile of an SC Planner shall combine different skills from different disciplines and backgrounds, e.g. strategic, management, communication, technological, legal.

*4.2.2 **SC IT Manager***

A SC IT Manager can be defined as an ICT Consultant with responsibilities that include:

- Setting objectives and strategies for the IT department of the municipalities.
- Deciding and implementing suitable technological solutions to support all internal operations and optimize their strategic benefits.
- Designing and customizing the IT systems, frameworks and platforms to improve citizen experience.
- Planning the implementation of new IT systems and provide systematic guidance to IT professionals and other staff within the organization.
- Making procurement decisions for technological equipment and software as well as establishing partnerships with IT providers.
- Managing the technological infrastructure (networks and computer systems) of the smart city to ensure their performance.
- Managing IT-related projects.

A SC IT manager should have a strong IT background to consistently keep up-to-date with recent advancements in technologies at the SC subject area. Apart from technical skills and experience, he/she must possess transversal skills such as leadership, communication and teamworking skills and should be able to align the SC's strategical objectives with IT development, deployment and operation strategy, so that IT services maximize the value offered to city's citizens.

*4.2.3 **SC IT officer***

A SC IT officer is an IT technical expert that should be able to:

- Analyze the city's organizational data.

- Determine information system requirements and define project objectives.
- Apply software development process, development environments, tools and techniques.
- Make recommendations for necessary IT system components, e.g. hardware, software, and networking systems.
- Design, implement, and deploy new IT services.
- Operate IT systems and services.
- Provide support and training to various types of users.

Apart from technical skills and experience, an SC IT officer should have transversal skills such as teamworking, social skills, ability to learn, etc.

4.3 Smart Cities Job Profiles Competences

Research in the context of the DevOps project has identified four groups of competences. These groups of competences *are:*

- Transversal (total number of Transversal Skills 16)
- Generic IT Knowledge (total number of Generic IT Skills 9)
- DevOps related (total number of DevOps Skills 6)
- Smart City related (total number of Smart City Related Skills 11)

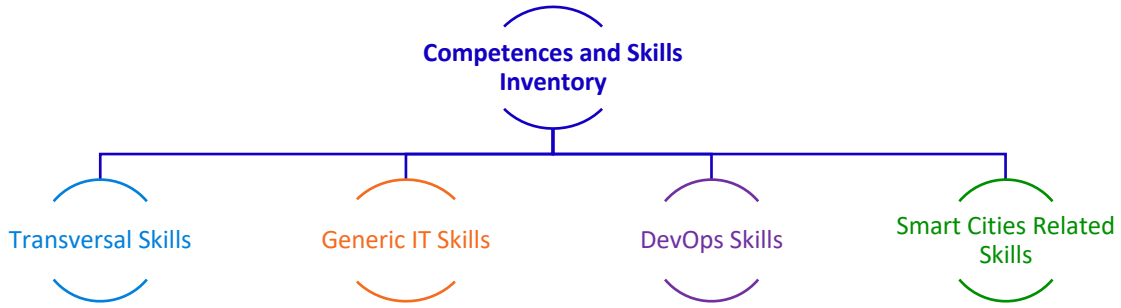

Figure 02: *Smart cities competences groups*

4.3.1 Transversal Competencies

A large number of the proposed competences/skills[1] of smart cities professionals should be transversal. According to UNESCO's UNEVOC

[1] Generally, the term "skill" is more specific and is related to the ability to execute a task. In contrast, the term "competence" is more generic and broader as it might include skills,

Glossary (https://unevoc.unesco.org/go.php?q=TVETipedia+Glossary+A-Z&id=577), transversal skills are those typically considered as 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. These skills are increasingly in high demand for learners to successfully adapt to changes and to lead meaningful and productive lives. Examples include, but are not limited to:

- Critical and innovative thinking
- Inter-personal skills (e.g. presentation and communication skills, organizational skills, teamwork, etc.)
- Intra-personal skills (e.g. self-discipline, enthusiasm, perseverance, self-motivation, etc.)
- Global citizenship (e.g. tolerance, openness, respect for diversity, intercultural understanding, etc.)

Development of the entrepreneurial capacity of European citizens and organisations is one of the key policy objectives for the EU and Member States. The European Commission has identified that the entrepreneurship competence is one of the 8 key competences necessary for a knowledge-based society (https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/entrecomp-entrepreneurship-competence-framework). In this context, the **Entrecomp framework** defines in detail the entrepreneurship competence.
The following table identifies the proposed set of skills as they were identified by the DevOps research initiative. The selection of a core set of transversal skills is quite challenging since numerous frameworks are in use, the definition of the competences is not rigid leading to overlapping, etc. However, the following list will be validated in a number of ways (e.g. DevOps focus groups, SC experts) so as to prove useful and appropriate for the domain of smart cities.

Table 02: *Transversal Competences*

No	Competences	Description
1	**Creativity**	• Develop several ideas and opportunities to create value, including better solutions to existing and new challenges,

knowledge and abilities. However, in this document these two terms are used interchangeably.

No	Competences	Description
		• explore and experiment with innovative approaches, • combine knowledge and resources to achieve valuable effects (EntreComp)
2	**Entrepreneurial Thinking**	Introduction to entrepreneurial thinking focusing on EntreComp framework
3	**Ability to work in a Team**	• Work together and cooperate with others to develop ideas and turn them into action • Network • Solve conflicts and face up to competition positively when necessary (EntreComp)
4	**Social Skills**	A social skill is any competence facilitating interaction and communication with others where social rules and relations are created, communicated, and changed in verbal and nonverbal ways. Examples of social skills are effective communication, conflict resolution, active listening, empathy, etc.
5	**Ambiguity Tolerance**	Tolerance for ambiguity is the ability to deal with ambiguous situations in a sensible and systematic way. It is directly related to risk management. According to EntreComp, this skill is similar to "Coping with uncertainty, ambiguity and risk". It includes: • Making decisions when the result of that decision is uncertain, when the information available is partial or ambiguous, or when there is a risk of unintended outcomes • Within the value-creating process, including structured ways of testing ideas and prototypes from the early stages, to reduce risks of failing • Handling fast moving situations promptly and flexibly
6	**Motivation to Learn**	Motivation in general includes: • **Personal drive to achieve**, the desire to improve or to meet certain standards;

No	Competences	Description
		• **Commitment** to personal or organisational goals; • **Initiative**, which is defined as 'readiness to act on opportunities'; and • **Optimism**, the ability to keep going and pursue goals in the face of setbacks. This is also known as resilience.
7	**Emotional Intelligence**	Emotional Intelligence is the measure of an individual's abilities to recognise and manage their emotions, and the emotions of other people, both individually and in groups. It includes: • Self-awareness • Self-regulation • Empathy • Motivation • Social skill
8	**Strategic Vision**	Strategic vision includes: • Imagining the future • Developing a vision to turn ideas into action • Visualising future scenarios for smart cities to help guide effort and action • Transforming future scenarios to strategic plans
9	**Intercultural Skills**	Intercultural communication skills are those required to communicate, or share information, with people from other cultures and social groups.
10	**Project and Process Management**	The skills required to manage projects and processes systematically. They include: • Project scope management • Project schedule management • Project Financial management • Project Quality Management, etc.
11	**Design Thinking**	Design thinking is a non-linear, iterative process which seeks to understand users, challenge assumptions, redefine problems and create innovative solutions to prototype and test. The method consists of 5 phases—Empathize,

No	Competences	Description
		Define, Ideate, Prototype, and Test, and is most useful when tackling problems that are ill-defined or unknown.
12	**Decision Making and Problem Solving**	Decision making can be regarded as the judgmental process resulting in the selection of a course of action. It includes: • The ability to gather and select information • Finding options and alternatives to given problems • Analysing different cases and problems • Defining selection criteria and determining their weights of importance • Evaluating alternatives Similarly, problem-solving skills help determine the source of a problem and find an effective solution. Some key problem-solving skills include: • Active listening • Analysis • Research • Creativity • Communication • Dependability • Decision making • Team-building
13	**Leadership and Management Skills**	Leadership is considered one of the key competences in all organisations. Usually but not exclusively, it consists of: • Strategic thinking • People management • Change management • Persuasion and influence • Planning • Communication
14	**Stakeholder management**	A stakeholder is any individual, group or organisation that can affect, be affected by, or perceive itself to be affected by a programme, project, change. Effective stakeholder management skills include:

No	Competences	Description
		• Communication • Active listening • Negotiation and influencing • Prioritization and expectation management • Team working
15	**Knowledge Management**	Knowledge management skills include: • Knowledge taxonomies and building knowledge architectures for the city/ organization • Contextualizing knowledge • Building knowledge networks
16	**Advanced Presentation skills**	Developing advanced presentation skills. It includes: • Traditional presentation skills • Public speaking • Storytelling • Pitching • Using physical and digital presentation tools effectively • Augmented Reality presentations

4.3.2 Generic IT Knowledge

Table 03: *Generic IT Competences*

No	Competences	Description
1	**Software development life cycles and agile methods**	Knowledge of mainstream software development concepts and methodologies. Emphasis will be given to knowledge of agile concepts and methodologies. Methodologies one should be aware of may include: • SCRUM • Disciplined Agile Delivery • Extreme programming • Kanban
2	**IT Quality Assurance**	IT Quality Assurance skills may include: • Writing software quality plans

No	Competences	Description
		• Defining software quality metrics • Preparing software quality checklists • Developing an overall process improvement plan • Executing quality audits
3	**IT security**	Introduction to IT security includes: • IT security goals • Hashing • Digital Signatures • Digital Certificates • Software Licensing • Organizational Processes • Security Governance
4	**System and software architecture**	System and software architecture is focusing on the principles and concepts involved in the analysis and design of large software systems. This module includes: • Introduction to enterprise architecture • Introduction to software architecture • Software architectural patterns • Cloud architecture • IoT architecture • Software analysis and design using UML • Software architecture evaluation
5	**Basic concepts of Cloud Computing**	Introduction to basic concepts and techniques of cloud computing, including: • Cloud basic technologies (e.g. virtualisation) • Cloud development tools • Different cloud service models: SaaS, PaaS, and IaaS • Major public cloud providers • Configuring and providing resources on a private IaaS cloud • Applying tips and best practices when adopting the cloud • Advanced applications of IoT systems in smart cities
6	**Basic Concepts of Internet of Things (IOT)**	Introduction to basic concepts and techniques of IoT, including:

No	Competences	Description
		• Introduction to basic electronics • Introduction to sensors and actuators • Introduction to Arduino and ESP devices • Programming IoT Systems • Advanced applications of IoT systems in smart cities
7	**Basic Concepts of Data Analytics**	Introduction to Data Analytics should enable SC personnel to develop skills in areas such as: • Data mining skills, including predictive analysis, statistical analysis, knowledge discovery, etc. • Understanding and Developing Data infrastructures for SC, including Data warehousing "Big Data Modelling", etc. • Knowing data visualization concepts and technologies • Analyzing data using various techniques from operations research, from data science, etc. • Knowing how data analytics can be used in smart cities
8	**Introduction to Artificial Intelligence**	Understanding how Artificial Intelligence works at a city level. • Being able to manage machine learning and deep learning projects. • Knowing most popular AI frameworks such as Google TensorFlow, Microsoft CNTK, Theano, Café, Keras, etc. • Understanding how Multi-Layer Neural Networks learn features automatically • Learning about deep learning algorithms • Knowing how data analytics can be used in smart cities
9	**Introduction to ITIL**	ITIL is a well-known service management methodology that has been used extensively during the last 20 years. It presents a service lifecycle that consists of four main phases, namely: • ITIL service strategy, which focuses on the business fundamentals to drive the need for IT services.

No	Competences	Description
		• ITIL service design, which focuses on design service processes. • ITIL service transition, which focuses on managing transitions of services and processes to ensure that the maximum benefits are delivered to the smart cities' citizens. It includes topics such as ITIL service operation, which focuses on how you can deliver value to citizens and users by managing service operation processes and activities.

4.3.3 DevOps Related

Table 04: *DevOps Competences*

No	Competences	Description
1	**DevOps basic concepts, culture and practices**	Introduction to DevOps methodology. It includes: • The business case for DevOps • Main concepts and steps of DevOps methodology • Benefits and drawbacks of the methodology • How DevOps can be used within a Smart City • Familiarity with DevOps culture and practices This skill refers only to the general knowledge of DevOps.
2	**Repository management**	A repository manager is a dedicated server application designed to manage repositories of binary components, and it is part of DevOps methodology deployment. The list of commercially available or open source repository managers is extensive, including: Apache Archiva, Bower, Yarn, PyPi, NPM, Maven, etc. Developing these skills implies that the officer should understand: • Functionality offered by a repository tools • Setting up a repository tool for a smart city • Using a repository tools
3	**Continuous integration**	

No	Competences	Description
		Continuous integration (CI) is the practice of merging all developers' work in a single piece of software regularly, usually daily. The process of CI is assisted by a number of automated tools such as Jenkins. Continuous integration skills include: • Knowledge of integration techniques • Knowledge of integration tools
4	**Configuration management**	Software Configuration Management (SCM) is the process of controlling the configurable items of a software project. • Plan and Run an SCM Process considering specific organizational aspects in terms of people, product, project, cross-organizational, process, and tools. • Identify and organise Configuration Items (CI) of the software • Effectively manage changes during the software life cycle of the project. • Etc.
5	**Using build, deployment and monitoring tools**	Build tools are programmes that automate the creation of executable applications from source code (eg. .apk for android app). Building incorporates compiling, linking and packaging the code into a usable or executable form. Many DevOps build tools exist in the market, such as Gradle, Git, Jenkins., Bamboo, Docker, Kubernetes, Puppet, etc. Deployment is a process that works subsequently with continuous integration. This skill implies knowledge of automated deployment tools such as Jenkins. Application monitoring refers to collecting key system performance metrics at periodic intervals over time. Application monitoring is done through a number of tools such as AppDynamics, Stackify Retrace, Scout, etc.
6	**Code Analysis and continuous testing tools.**	Source code analysis tools are designed to analyze source code and/or compiled versions of code to help find software flaws. They are also referred to as Static Application Security Testing (SAST) Tools. Code Analysis is

No	Competences	Description
		done by a number of commercially available or open source tools, such as Review Assistant, Reshift, Gerrit, Codestriker, etc. Continuous test-driven development is a software development practice that extends test-driven development by means of automatic test execution in the background, sometimes called continuous testing. The main objective is to define the delivery pipeline which includes source code management, build tools, continuous integration, etc.

4.3.4 Smart City Related

Table 05: *Smart City Related Competences*

No	Competence	Description
1	**Smart cities platforms**	Explore the role of technology and data in cities, and learn how you can participate in the creation of smart cities.
2	**Smart cities business models and financial management**	This module refers to: • Social and technical innovation within smart cities • Smart cities business models • Engaging businesses within smart city ecosystem • Financing smart cities
3	**Smart services and operating procedures**	This module is about: • Understanding available smart cities cutting edge technology services • Understanding business and technical aspects of smart cities services • Selecting best practices and award winning services • Selecting and prioritizing the development of smart cities services • Delivering value to your customers and users by managing service operation processes and activities.
4	**Smart city sustainability**	Sustainability is defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. As such, sustainable development skills include: • Understanding of equality and diversity, inclusivity and social cohesion • Developing trust and sense of community

No	Competence	Description
		• Developing responsible citizens • Understanding and practicing group decision making • Ability to see the "bigger picture" • Commitment in developing a sustainable picture • Knowledge of ecological and circular economy approaches This skill relates to EntreComp's "Ethical and sustainable thinking" skill.
5	**Smart city standards and legal issues**	• Developing knowledge on existing smart cities' standards • Selecting standards to be applied to each specific system • Developing a system of smart city indicators for measuring progress and performance based on international standards • Developing an understanding of smart city legal framework and an understanding of security, privacy, confidentiality, correct usage of citizen data, etc.
6	**Smart city resilience**	• Developing an understanding of the requirements of developing a resilient smart city • Developing a plan for increasing the resilience of the city • Implementing the plan for increasing the resilience of the smart city • Monitoring progress and resilient city indicators
7	**Urban management**	Urbanization and generally urban management and planning is a general concept that all city officials should be aware of. Urban planning is a technical and political process concerned with the development and design of land use and the artificial environment, including air, water, and the infrastructure passing into and out of urban areas, such as

No	Competence	Description
		transportation, communications, and distribution networks.
8	**Citizen Driven/Citizen Orientation/User Experience Design**	• Learning and understanding strategies and techniques on engaging citizens • Developing a communication strategy and communicating with citizens • Establishing automated systems for recording citizen behaviour and their satisfaction • Developing communities of practice
9	**Smart city procurement.**	Procurement is an important aspect of a smart city's development. As such, SC officials should have knowledge of principles of procurement, ICT and green related procurement, private-public partnerships, etc.
10	**Digital Twins**	Today, Smart cities are complex systems that not only fulfill their functions, but also communicate with other components, products, clouds and services. Generally, a "digital twin" is a digital replica of physical assets (physical twin), processes, people, systems and devices that can be used for various purposes in the context of a smart city. This module will present: • fundamental concepts of digital twins for smart cities • the different levels of the digital twin: the master, the shadow and the twin • different products that can be used for constructing digital twins, and • best practices for smart cities and the benefits realized.

11	**Green cities**	Green city directly means "greening the city", where "green" is not synonymous to sustainable but rather refers to a comprehensive design method, innovation, and renovation, to minimize the impact on the environment. In other words, Green city is an environmentally friendly city that is represented by environmental performance indicators (i.e., diversified housing, public transportation system, human-oriented traffic, ecological footprint, etc.).

05 Chapter

Competences and Skills Inventory

In this Chapter we present the inventory of competences per competence group. For each competence we present a short description, the basic terminology, the knowledge domain, the learning objectives, the competence content, the related learning outcomes, and readings. Competence groups are colour coded.

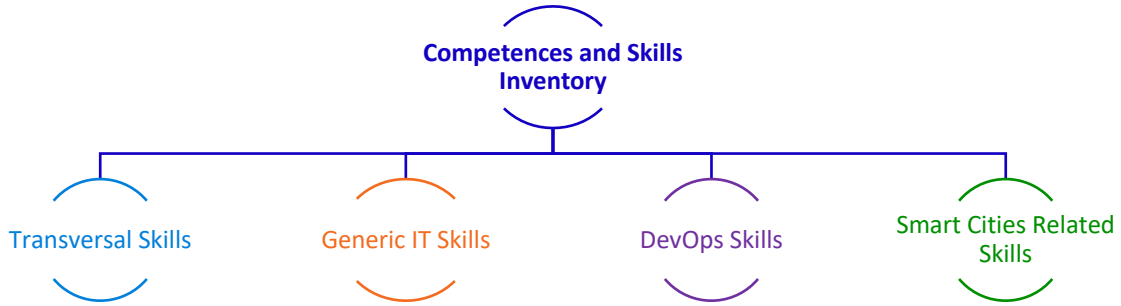

Figure 02: *Smart cities competences groups*

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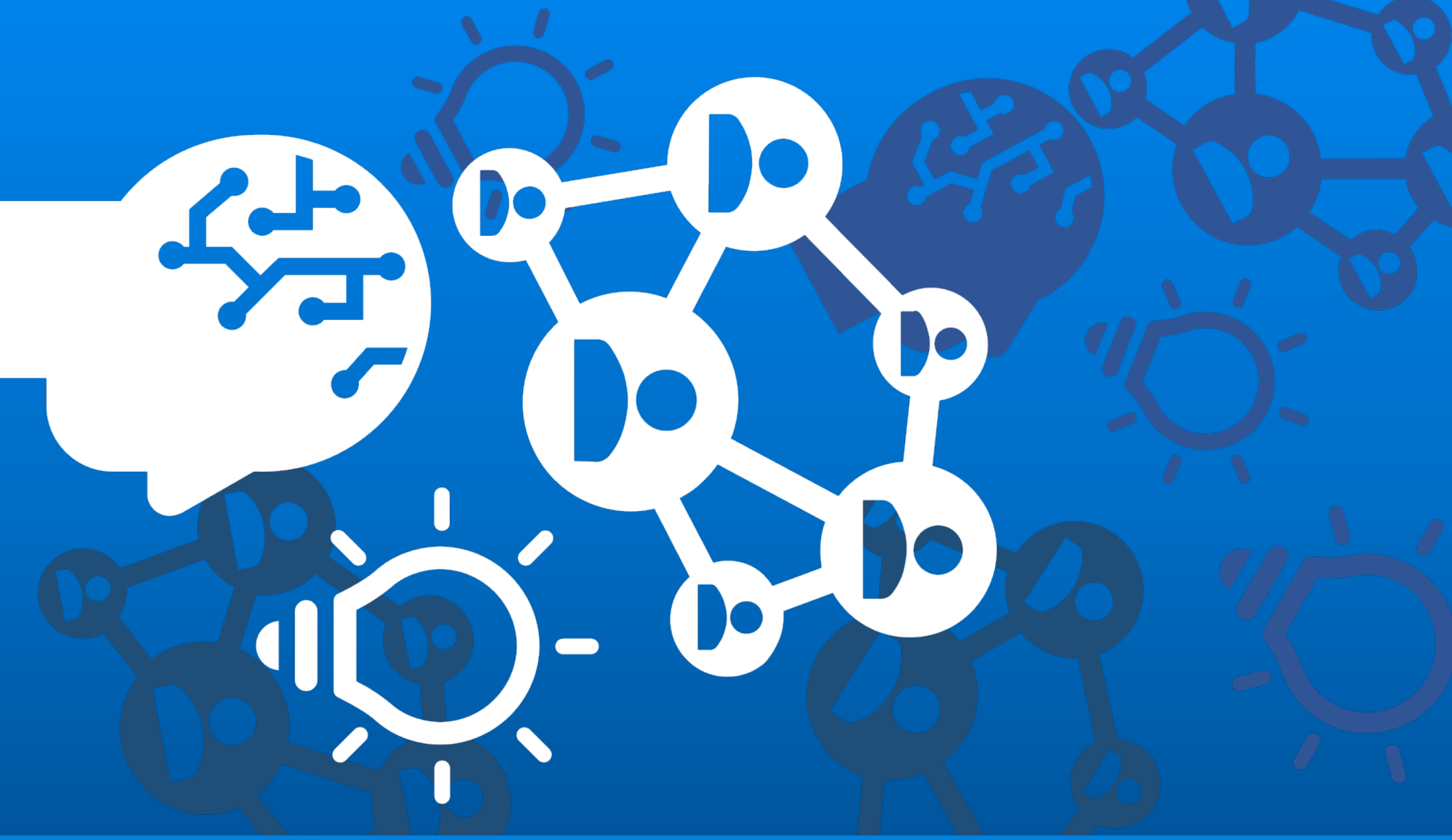

Transversal Skills

5.1 Transversal Skills

5.1.1 Competence title: Creativity

5.1.1.1 Competence description

Professionals who understand and manage the creative process and foster creativity are an increasingly valuable asset for their organizations. This module examines aspects of creativity, tools and techniques for fostering individual and group creativity as well as methods for evaluating creative outcomes, that is, new products or services.

5.1.1.2 Definitions

Business creativity is an internal environment fostering creativity that enables organizations to develop innovative processes, products/services.

Creative internal environment is an internal environment within an organization that encourages employees to think out of the box, challenges established processes & behavior patterns, accepts diversity, provides stimulation, and invests in employee engagement.

Creative thinking is the capacity synthesize existing ideas together in new configurations. It determines how flexibly and imaginatively individuals approach problems. This capacity depends mainly on the individual's personality and work habits.

Creativity is the ability to develop new ideas and discover new ways of looking at problems and opportunities.

Entrepreneurship is the result of a disciplined, systematic process of applying creativity and innovation to needs and opportunities in the marketplace.

Experience is a dynamic set of knowledge & skills, perceptions & feelings.

Expertise is everything an individual knows and can do in the broad domain of his or her work. This knowledge pertains to techniques and procedures related to work, as well as a thorough understanding of overall work circumstances.

Innovation is the ability to apply creative solutions to those problems and opportunities to enhance people's lives or to enrich society.

5.1.1.3 Knowledge domain

- Entrepreneurship

- Management

5.1.1.4 Learning objectives

After completing this module, the trainees will be able to:

- Understand the concept of creativity and its interplay with innovation and entrepreneurship
- Describe the creative process and explain the value of creativity, innovation and entrepreneurship for organizations
- Discuss aspects of individual and group creativity
- Identify barriers to creativity and ways to overcome them
- Foster creativity and recognize the value of having an innovation–friendly culture

5.1.1.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to Creativity**	This unit introduces learners to creativity. It includes: • The concept(s) on creativity; • Dimensions of creativity; • Relation of creativity to innovation and entrepreneurship; • Insightful creativity vs Divergent creativity.
2	**Creativity Process**	This unit introduces learners to the creativity process. It includes: • Two views on creativity: elite vs developmental; • The five stages of the creativity process; • Three themes on creativity (experience, creative thinking and motivation)
3	**Individual and Group Creativity**	This unit introduces learners to individual creativity, group creativity, and their respective value. It includes: • The concept of individual creativity; • The value of individual creativity; • The concept of group creativity; • The value of group creativity.

4	**Barriers to Creativity and best practices to overcome them**	This unit raises learners' awareness to barriers to creativity. It includes: • Most commonly cited barriers to creativity; • Mini Case Studies regarding barriers to creativity; • Best practices to overcome barriers to creativity.
5	**Fostering creativity to create added value in organizations**	This unit introduces learners to creativity-enabling strategies. It includes: • Creativity-enabling strategies; • Added value of innovation-friendly culture; • Applying the creativity process in a given context.

5.1.1.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Identify the concept of creativity
- Define the concept of innovation
- Identify the notion of entrepreneurship
- Describe the relationship between creativity, innovation and entrepreneurship
- Discuss the different views of creativity: elite vs. developmental
- Describe the different steps of the creativity process
- Discuss the different types of creativity
- Explain the different aspects of individual creativity (Imaginative, Purposeful, Original, Of Value)
- Explain the value of creativity for individuals
- Discuss the concept of group creativity
- Explain the value of creativity for organizations
- Identify the barriers to creativity
- Present a number of best practices to overcome barriers to creativity
- Identify strategies for promoting creativity
- Recognize added value for an innovation–friendly culture

5.1.1.7 References

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5.1.2 Competence title: Entrepreneurial Thinking

5.1.2.1 Competence description

Innovative entrepreneurship is an expectation from smart cities, since new entrants and start-uppers utilize smart technologies (IoT, big data, cloud computing, etc.) to develop new products and services. In this regard, skills related to Entrepreneurial Thinking are useful for all the stakeholders that belong to the ecosystem of a smart city, in order for delivering smart services, infrastructure and data in forms that can enhance the development of new companies and jobs.

To become successful entrepreneurs, trainees must be prepared to meet the challenges of understanding, developing and applying their entrepreneurial and intrapreneurial skill-set and competences. The course introduces the characteristics and background of entrepreneurs and addresses principles, which are the underpinnings of the entrepreneurial spirit and mind-set. Trainees obtain knowledge and learn essential skills required to launch successful entrepreneurial projects.

After an introduction to entrepreneurship/intrapreneurship, entrepreneurial thinking concepts and common characteristics of successful entrepreneurs, trainees will learn the stages of the entrepreneurial process and they are expected to understand key differences between managerial and entrepreneurial skills. Trainees will be introduced to the basic concepts of entrepreneurship as competence, according to the EntreComp framework. Finally, trainees will be introduced to key entrepreneurial characteristics which compose the entrepreneurial mindset.

5.1.2.2 Definitions

Competence is an asset, resource, skill, capacity, knowledge, or strength that generates a competitive professional advantage.

An **entrepreneur** is an individual who identifies business opportunities; transforms opportunities into workable/marketable business concepts/ideas; adds values to ideas by devoting time, effort, and money and by applying entrepreneurial skills; assumes the risks of the market to implement the ideas; implements the ideas and gets rewards from all these efforts.

Entrepreneurship is the process of creating new products and/or services (with additional market value) by devoting necessary time and effort, assuming the associated risks (e.g. financial, psychological, social risks, etc.), and getting the resulting returns and rewards in terms of money and personal satisfaction.

Incremental innovation is an innovation that seeks to incrementally, progressively, and systematically improve existing business operations, systems, and products and make them better, cheaper, and more effective.

Innovation is the process by which entrepreneurs transform opportunities into marketable ideas which meet the market needs identified.

Intrapreneurship (or Corporate Entrepreneurship) is entrepreneurship within an existing corporation/organization. It is the process of creating entrepreneurial culture and innovation within the environment of an existing business.

Radical innovation is the development of a new product and an innovative business model that rapidly changes the status/shape of an existing market.

Value is the outcome of the entrepreneurship process: financial, cultural, or social.

5.1.2.3 Knowledge domain

- Entrepreneurship
- Entrepreneurial Thinking and Entrepreneurial Skills

5.1.2.4 Learning objectives

After completing this module, the trainees will be able to:

- To recognize the role of entrepreneurship in the smart city context and understand the impact of entrepreneurship on smart city development and vice versa.
- To learn and explain the terms of entrepreneurship and intrapreneurship.
- To identify typical characteristics of successful entrepreneurs.
- To highlight the differences between entrepreneurial and managerial/administrative skills.
- To describe the stages of the entrepreneurial process.
- To consider entrepreneurship as a transversal competence based on the EntreComp framework.
- To learn key entrepreneurial attitudes.

5.1.2.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to Entrepreneurship/ Intrapreneurship**	This unit introduces learners to the basic concepts of entrepreneurship and entrepreneurial spirit. It includes: • Entrepreneurship in smart cities • Definition of Entrepreneurship • Definition of Intrapreneurship (Corporate Entrepreneurship) • Entrepreneurial vs. Managerial Decision Making
2	**The Entrepreneurial Process**	This unit introduces learners to the basic steps of the entrepreneurial/intrapreneurial process. It includes: • The Entrepreneurial Process Phases • The Corporate Entrepreneurship (Intrapreneurship) Process
3	**EntreComp: the European Entrepreneurship Competence Framework**	This unit introduces learners to the basic concepts of the EntreComp Framework. It includes: • Entrepreneurship as a competence • EntreComp conceptual model
4	**Key Entrepreneurial Attitudes**	This unit introduces learners to some key entrepreneurial attitudes (i.e., need for achievement, need for independence,

		creativity, internal locus of control, calculated risk taking). Trainees will follow a presentation aiming to describe each one of these key attitudes of entrepreneurs. Finally, trainees will be asked to answer a test with the aim of associating certain behavioral patterns/personal beliefs with each one the key entrepreneurial attitudes.

5.1.2.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the basic concepts of entrepreneurship and the characteristics of entrepreneurs.
- Identify different roles of entrepreneurship in smart cities.
- Define differences between managerial and entrepreneurial/intrapreneurial decision making for each one of the five key business dimensions.
- Describe various entrepreneurial competence areas based on the EntreComp framework.
- Outline the key entrepreneurial attitudes.
- Describe different ways in which entrepreneurship is influenced by smart cities and vice versa.
- Describe actions for establishing intrapreneurship in an organization.
- Describe the differences between entrepreneurial and managerial decision making.
- Explain the steps of a corporate entrepreneurship strategy.
- Describe various entrepreneurial competences based on the EntreComp framework.
- Recognize key entrepreneurial attitudes from behavioural patterns and personal beliefs.

5.1.2.7 References

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5.1.3 Competence title: Ability to Work in a Team

5.1.3.1 Competence description

Teamwork is a powerful business tactic that can benefit all business sectors. Relying on the best of each team member's skills to offset possible weaknesses of team workers is a sound strategic move to successfully perform business processes, build competitive advantage, or address emerging business challenges. Managing conflict and managing diversity in teams are two very important aspects in relation to teamwork, and both are addressed in this module.

5.1.3.2 Definitions

Competition is a scenario in which different organizations vie for limited resources or goods through manipulation of the following aspects: price, product, promotion, and place.

Conflict is a state of discord caused by the actual or perceived opposition of needs, values, and interests between people working together.

Ground norms are rules that define appropriate and inappropriate behaviour in a group.

A **group** is a collection of individuals who coordinate their individual efforts.

Group cohesion is the tendency for a group to be united while working towards a group objective.

Group socialisation is the process by which a person becomes a member of the group.

Social loafing describes the tendency of individuals to put less effort when they are part of a group.

A **team** is a group of people who share a common purpose and objectives. Team members are committed to the goals of the team and to each other.

5.1.3.3 Knowledge domain

Management, Entrepreneurship

5.1.3.4 Learning objectives

- To understand the concept of teamwork and the conditions that promote effective collaboration
- To describe the different stages of progressively cohesive teamwork
- To discuss the fundamental concepts of team processes
- To discuss competition and cooperation within a group
- To understand how to manage conflict
- To describe the principles of managing diversity

5.1.3.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to Teamwork**	This unit presents learners with the fundamentals of teamwork. It includes: • Distinctions between groups and teams; • Types and purposes of teams; • Team success criteria and preconditions; • Effective utilization of teams.
2	**Stages of Teamwork**	This unit enables learners to identify the stage of a team from various perspectives. It includes: • Stages of teamwork from a group development perspective;

		• Stages of teamwork from a project development perspective; • Stages of teamwork from a cyclical perspective; • Processes for team working.
3	**Team processes**	This unit introduces learners to team processes of significance. It includes: • The concept of motivation; • The concept of group cohesion; • The main roles in teams.
4	**Managing Teams**	This unit introduces learners to the concepts of competition and cooperation, conflict, possible contributing factors to conflict in an organization, resolution strategies and the fundamentals of negotiation. It includes: • An introduction to mixed motive situations; • Influences on people's competitiveness; • Advantages and limitations of each strategy: competition and cooperation; • Conflict: what it is and how it is generated; • Conflict resolution approaches; • Negotiating principles; • Managing conflict.

5.1.3.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Identify the concept of groups and teams and define the concept of team success
- Define the stages of teamwork from Group Development Perspective
- Define the stages of teamwork from Project Development Perspectives
- Define the stages of teamwork from Cyclical Perspectives

- Define the concept of motivation and discuss the main roles in every team
- Define the concept of conflict
- Define negotiation principles

5.1.3.7 References

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Reeve, J. (2017). Understanding motivation and emotion, (7th ed). John Wiley & Sons.

5.1.4 Competence title: Social Skills

5.1.4.1 Competence description

This module focuses on important social skills which, emphasizing the relational dimension and group dynamics, allow to effectively manage different situations regarding an individual's private and social life. Many skills are involved, such as communication, negotiation, decision making, cooperation, problem solving, and positive and constructive conflict management. Social skills are transversal since they seem to be necessary in many areas and they affect the quality of interventions. One of the fundamental principles of Social Skills is learning: any social behaviour can be learned, enhanced and/or modified through experience and training.

5.1.4.2 Definitions

Active listening is an assertive communication technique, based on acceptance and empathy, which is useful not only for improving the ability to express our emotions or arguments correctly and effectively but also for knowing how to listen and perceive the reasoning and feelings of others.

Assertiveness is the ability to express your feelings, to choose how to behave in a given moment/context, to defend your rights, to calmly express an opinion of disagreement (if appropriate), to follow your own ideas and beliefs, always respecting those of others.

Communication is a process that involves an exchange, a relationship of transmission, sharing, socialization of perceived information.

Conflict can be defined as a divergence in which each of the actors involved wants to impose their point of view without making concessions to the other.

Empathy is the ability to "put oneself in someone's shoes", perceiving their emotions and thoughts. It is an important emotional competence that allows us to easily connect with the person we are talking with.

A **mentor** is a person who guides a less experienced person by supporting and encouraging people to manage their own learning so that they may maximise their potential, develop their skills and finally improve their performance.

Negotiation is a process where at least two parties with different perceptions, needs, and motivations try to reach an agreement on a topic of mutual interest.

Passive listening is characterized by unconscious listening, which does not help us to establish contact with the person we are talking with.

Verbal communication utilizes the spoken word and is essential to most interactions; it is the one we are most aware of and usually pay the most attention to.

5.1.4.3 Knowledge domain

Sociology and Psychology (social, work and communication)

5.1.4.4 Learning objectives

- Learn to know personal and other people's behaviours;
- Develop a balanced and constructive behaviour to improve your sense of self-esteem and self-efficacy;

- Communicate with others in a more competent and effective way increasing interpersonal skills in order to obtain constructive responses in different relational and intervention contexts;
- Know how to make decisions;
- Know how to work in a team and understand the importance of disciplinary and professional interdependence;
- Face and manage problematic and/or stressful situations.

5.1.4.5 Competence content (units)

The competence content is divided in the following units:

1	**Effective Communication**	The unit addresses the following topics: • characteristics of communication and relationships; • specific processes concerning communication dynamics in different areas.
2	**Group dynamics and conflict resolution**	This unit addresses the following topics: • Group and group dynamics; • The group structured in norms and roles; • Trust and cohesion in the group; • Leadership styles; • The mechanisms and the underlying causes of conflicts, in order to choose the most appropriate strategy.
3	**Problem solving and stress management**	This unit addresses the following topics: • Problem Solving skills; • how to prevent stress so as to deal with the feelings we experience when losing control of the situation.

5.1.4.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Define different interpersonal communication methods
- Describe conflict management skills
- Select between strategies to deal with and propose solutions to problems
- Identify different methods of working in a team

- Recognize the most effective way to communicate
- Identify the most appropriate strategies to negotiate and manage conflicts
- Identify the most appropriate strategies (actions and behaviours) to work in a team
- Describe the most appropriate strategies to deal with problems and make decisions
- Analyze the context in order to choose "how to move" in communicative, relational and decisional terms
- Develop relational and communicative skills
- Develop the most appropriate strategy to manage conflicts

5.1.4.7 References

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5.1.5 Competence title: Ambiguity Tolerance

5.1.5.1 Competence description

This module focuses on providing attendants with an overview of concurrent basic theoretical insights of the concept of ambiguity tolerance. Considering that nowadays work settings are confronted with high levels of

ambiguity, employees need to efficiently operate within this context of ambiguity. Thus, the module specifically focuses on investigating both the nature and the implications of different attitudes towards ambiguity and ambiguity tolerance in work settings. It also aims to tackle the rather controversial issue of ambiguity tolerance among ethnic and national cultures.

5.1.5.2 Definitions

Ambiguity is the lack of distinction between multiple interpretations or meanings in a situation that is related to a business decision.

Ambiguity tolerance refers to an individual's systematic, stable tendency to react to perceived ambiguity with greater or lesser intensity. It is used to define and measure how well an individual, for example an entrepreneur, responds when presented with an uncertain event that results in ambiguous situations.

Assertiveness is an individual's propensity for taking control of situations.

Mindfulness is an individual's ability to regulate and control their emotions.

Power distance is defined as the extent to which the less powerful members of organizations tolerate the unequal distribution of power within the organization.

Sensitivity refers to the degree of reaction that an individual exhibits as a response to an ambiguous stimulus.

Uncertainty avoidance is an individual's degree of feeling threatened by uncertainty and ambiguity.

Uncertainty is a situation which involves imperfect or unknown information concerning a future event, and it arises in partially observed, complex or stochastic environments.

5.1.5.3 Knowledge domain

- Ambiguity in work settings
- Ambiguity tolerance in work settings
- Cultural variability
- Ethnic variability
- Tackling ambiguity

5.1.5.4 Learning objectives

- Define the concept of ambiguity.

- Define the concept of ambiguity tolerance.
- Discuss the distinction between ambiguity and ambiguity tolerance.
- Investigate the nature and consequences of attitudes towards ambiguity and uncertainty at work.
- Descr ibe aspects of ambiguity tolerance in organizations.
- *Describe the connections among tolerance ambiguity and cultural variability.*

5.1.5.5 Competence content (units)

The competence content is divided in the following units:

1	**Ambiguity vs ambiguity tolerance**	This unit introduces learners to the theory of ambiguity and ambiguity tolerance. It involves: • Basic theoretical concepts of ambiguity theory • Basic theoretical concepts of ambiguity tolerance theory
2	**Tolerance of ambiguity in organizations**	This unit introduces learners to the theory of ambiguity and ambiguity tolerance in work settings. It involves: • Discussion of the basic research findings concerning the effects of ambiguity at work settings • Discussion of the basic research findings concerning ambiguity as a stress factor in workplaces
3	**Tolerance ambiguity and cultural variability**	This unit introduces learners to the theory of ambiguity and ambiguity tolerance under the scope of cultural variability. It presents a description of connections between tolerance ambiguity and cultural variability. It also presents a description of the effects of cultural diversity and discusses the factors differentiating ethnic from national cultures.
4	**Practical Implications**	This unit introduces learners to practical implications of ambiguity and ambiguity

		tolerance theory in municipal administration. It involves: • Discussion of the necessary actions for tackling the controversial issue of ambiguity

5.1.5.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the basic aspects of ambiguity
- Describe the basic aspects of ambiguity tolerance
- Identify the differences between the concepts of ambiguity and ambiguity tolerance
- Describe the concepts of aversion and attraction towards ambiguity
- Identify the effects of ambiguity at work settings
- Describe ambiguity as a stress factor in workplaces
- Identify the effects of cultural variability in ambiguity situations
- Describe factors differentiating ethnic from national cultures
- Describe job-performance implications under ambiguity situations
- Summarize a set of actions to prevent aversion of ambiguity situations
- Produce an action plan to deal with ambiguity in work settings
- Illustrate work-specific ambiguity situations in municipal administration

5.1.5.7 References

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5.1.6 Competence title: Motivation to Learn

5.1.6.1 Competence description

This module focuses on providing attendees with an overview of concurrent basic theoretical insights of the psychological concept of motivation. Specifically, it focuses on pinpointing the key aspects of motivation theory, analyzing the basic psychological needs that promote high quality motivation and wellness, and how they are supported in social contexts. It provides attendants with essential knowledge of how the styles and strategies of motivators can promote engagement on learning activities. Motivation represents a decisive challenge for contemporary organizations. Thus, this module will identify motivation problems and how motives and strategies can help attendees towards the accomplishment of their goals.

5.1.6.2 Definitions

Autonomy is the level of independence in decision-making at work, and it determines the extent to which employees are free and independent in carrying out their work.

Centralization is the concentration of administrative power.

Cross-functional rotation is the job rotation in different parts of the organization.

Decentralization is the dispersion of functions and powers.

Diversity of skills refers to the number of different types of activities and the number of different skills and abilities a task demands.

Feedback is the information an employee is receiving during his/her job appraisal.

Hygiene factors are the factors that characterize the context of an employee's work.

Intrinsic motivation is a behaviour that is driven by internal rewards.

Job satisfaction is an employee's perception of the degree of fulfillment or enjoyment that derives from his/her job.

Lifelong learning is the process of gaining knowledge and skills throughout a person's life.

Motivation is an internal process that directs a person to goal-oriented behaviours.

Motivators are the factors that can create job satisfaction.

Within-function rotation is the job rotation between jobs with similar levels of responsibility.

5.1.6.3 Knowledge domain

- Motivation to learn Theory
- Performance goals
- Goals as intrinsic motivation
- Staff motivation and lifelong learning
- Actions towards motivation enhancement

5.1.6.4 Learning objectives

- Define the theoretical construct of motivation as a psychological concept.
- Identify the convoluted aspects the notion of motivation is fraught with.
- Discuss how needs, either inborn and universal or learned through experience, enhance motivation to learn.
- Provide an outline of setting effective goals and expectations.

5.1.6.5 Competence content (units)

The competence content is divided in the following units:

1	**Motivation to learn**	This unit introduces learners to the theory and practice of motivation to lean. It involves: • Basic theoretical concepts of motivation theory
2	**Goal Theory**	This unit introduces learners to the Goal Theory. It involves: • Establishing goals as intrinsic motivation • Introduction to Performance-approach goals • Introduction to Performance-avoidance goals • Introduction to goal achievement theory
3	**Staff motivation and lifelong learning**	This unit introduces learners to basic theoretical concepts of staff motivation in municipal administration. It involves: • Introduction to the Work Characteristics Model

		• Description of the Essential Work Characteristics component of the Model • Description of the Critical Psychological States component of the Model • Description of the Personal and Activity Results component of the Model • Motivation for lifelong learning
4	**Practical Implications**	This unit introduces learners to the practical implications of motivation theory in municipal administration. It involves: • Discussion of the necessary actions towards motivation enhancement

5.1.6.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the basic aspects of motivation as a psychological concept
- Identify the convoluted aspects the notion of motivation is fraught with
- Identify performance-approach goals
- Identify performance-avoidance goals
- Describe staff motivation characteristics in municipal administration
- Outline actions towards staff motivation enhancement
- Describe Goal Theory
- Summarize necessary steps towards goal achievement
- Produce a set of goals as intrinsic motivation
- Illustrate work-specific motivation characteristics in municipal administration
- Develop lifelong learning attitude

5.1.6.7 References

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5.1.7 Competence title: Emotional Intelligence

5.1.7.1 Competence description

This module will help people to acquire competences in emotional intelligence (EI) in order to improve the quality of their performance at work, and for this reason, it is highly important that people are aware of their own emotions.
EI is a transversal skill that can be applied to all sectors and it can help to understand personal feelings, turn intention into action, and make informed decisions.

5.1.7.2 Definitions

Emotion is the language of a person's internal state of being, normally based in or tied to their internal (physical) and external (social) sensory feeling.

Emotional intelligence is the ability to identify, assess, and control one's own emotions, the emotions of others, and groups.

Emotional skills are defined as those skills capable of identifying and naming feelings, expressing feelings, and evaluating their intensity.

Empathy refers to sensing what people are feeling, being able to take their perspective, and cultivating rapport and attunement with a broad diversity of people.

Nonverbal communication is the nonlinguistic transmission of information through visual, auditory, tactile, and kinesthetic (physical) channels.

Relationship management is the supervision and maintenance of relationships between a company and its external partners, especially its customers.

Self-awareness is knowing what we are feeling in the moment and using those preferences to guide our decision-making: having a realistic assessment of our abilities and a well-grounded sense of self-confidence.

Self-control is an intermediate condition between *motor inhibition* and the *mental control* of emotions. This competence aims to understand how our body's reactions affect our minds, and how negative thinking has a negative influence on our behavior.

Self-regulation refers to handling our emotions so that they facilitate rather than interfere with the task at hand: being conscientious and delaying gratification to pursue goals, recovering well from emotional distress.

Social skills refer to handling emotions in relationships well and accurately reading social situations and networks; interacting smoothly; using these skills to persuade and lead, negotiate and settle disputes, for cooperation and teamwork.

5.1.7.3 Knowledge domain

- Social and behavioural science
- Cognitive psychology
- Teamwork
- Personal development
- Emotional awareness

5.1.7.4 Learning objectives

- To improve the qualification of workers through the promotion of a series of transversal competences deriving from the use of Emotional Intelligence (Self-knowledge, mood management, self-motivation, empathy, and managing relations)
- To increase the motivation and satisfaction of the workers as they will be able to manage their work in an emotionally intelligent way
- To improve the quality of life for beneficiaries of the fields where this module was implemented

5.1.7.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to Emotional Intelligence**	Emotional Intelligence is a skill you are born with or trained in, which influences everybody's daily life activities, including, family, friendly relationships, work, and how you view yourself. It involves perceiving emotions, using

		emotions, understanding emotions, and managing emotions.
2	**Managing Emotions**	In this unit, the learner will understand the importance of emotions and how to better recognize emotions in his/her own and others' reactions.
3	**Working with colleagues**	This unit addresses the following topics: • Relationship management • Empathy, trust and respect • Collaborative working environment

5.1.7.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Define_Emotional Intelligence
- Identify the benefits of being emotionally intelligent
- List a number of EI competencies (Self-awareness, self-regulation, social skills, empathy, motivation)
- Identify ways for building good relationships
- Recognize the importance of cooperation for successful results
- Choose the most successful way to communicate with others
- Apply these concepts and techniques in the workplace
- Use emotions more consciously
- Analyze which domains of EI need strengthening
- Relate_EI to workplace situations
- Assess the acquired level of EI

5.1.7.7 References

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5.1.8 Competence title: Strategic Vision

5.1.8.1 Competence description

The module Strategic Vision is about planning and running the total business enterprise.
It seeks to understand the following:

- Challenges and the environment in which the business operates.
- The direction the management intends to head toward, the strategic plans for getting the enterprise moving in the intended direction, and
- the tasks of implementing the chosen strategy and vision successfully.

This course aims to teach you the core concepts, frameworks, and techniques of strategic management, which will allow you to understand what managers must do to make an organization – be it a for-profit or a non-profit one – to achieve superior performance.
The module is based on interdisciplinary topics and tries to see the big-picture, focusing on two important aspects:

- Theories and concepts of strategic management
- Practical use cases to understand the theoretical concepts

5.1.8.2 Definitions

Core business is the central, and usually the original, focus of an organization's activities which differentiates it from others and makes a vital contribution to its success.

Environmental scanning is the monitoring, evaluating, and disseminating of information from the external and internal environments to key people within the organization.

A **learning organization** is an organization skilled at creating, acquiring, and transferring knowledge and at modifying its behaviour to reflect new knowledge and insights

Policies are the broad guidelines for decision-making that link the formulation of a strategy with its implementation.

Strategic flexibility is the ability to shift from one dominant strategy to another.

Strategic management is a set of managerial decisions and actions that determines the performance of a corporation in the long-run.

Strategic vision is the presentation of the challenges and the environment in which the business operates, the direction the organization intends to take, the strategic plans for getting the enterprise moving in the intended direction, and the tasks of implementing the chosen strategy successfully.

Strategy formulation is the development of long-range plans for the effective management of environmental opportunities and threats in light of organizational strengths and weaknesses and according to environmental opportunities and threats.

Strategy implementation is the process by which strategies and policies are put into action.

5.1.8.3 Knowledge domain

- Strategic Management and Vision
- Environmental Analysis
- Organizational Analysis
- Tools and Instruments of Strategic Vision

5.1.8.4 Learning objectives

Upon completion of the course, the learner will become proficient in:

- Basic concepts of strategic vision and management
- Elements of strategic management and its process
- Vision and Mission Statements
- Strategic decision making process (Mintzberg)
- Macro Environment and PEST Analysis
- Environmental Scanning
- Market and Resourced Based Strategies
- Core Competences
- Value Chain Analysis
- SWOT Analysis

5.1.8.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to Strategic Management and Vision**	This unit introduces learners to the theory and practice of strategic management and vision. It includes:

		• Basic concepts of strategic management • Elements of strategic management and its process • Vision and Mission Statements • Strategic Decision Making Process
2	**Environmental Scanning and Industry Analysis**	This unit introduces learners to the theory and practice of environmental scanning and analysis as part of strategic management and vision. It includes: • External environmental analysis • Macro Environment and PEST Analysis
3	**Internal Scanning: Organizational Analysis**	This unit introduces learners to the theory and practice of Internal Scanning and Organizational Analysis as part of strategic management and vision. It includes: • Core competitive advantage • Resource based and market based view • Organizational structure: Core competences, value chain, and SWOT analysis

5.1.8.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe basic concepts of strategic management
- Identify elements of strategic management and its process
- Define vision and mission statements
- Describe the strategic decision making process
- Outline external environmental analysis
- Perform a Macro Environment and PEST analysis
- Arrange resource based and market based strategies
- Identify core business competences of capabilities, processes, and technologies
- Outline organizational analysis
- Perform a Value Chain analysis
- Describe a SWOT analysis

5.1.8.7 References

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5.1.9 Competence title: Intercultural Skills

5.1.9.1 Competence description

The module Intercultural skills provides an overview of the importance of acquiring these skills in an era of globalization. The module provides an understanding of the impact of national cultures on the way of doing business. It will ensure that the participants understand the cultural process as well as many of the elements involved which affect business relationships and performance.
This course aims to provide you with core cultural concepts, frameworks, and tools for understanding and managing cultural diversity successfully.

5.1.9.2 Definitions

A **channel** is the means through which messages are transferred from person to person. Channels provide the necessary connection. Channels can take a variety of forms.

Cultural awareness is the understanding of the differences between one's own culture and other cultures.

Cultural blindness is the inability to understand how particular matters might be viewed by people of a different culture because of rigid adherence to the views, attitudes, and values of one's own culture.

Message Decoding is the process of receiving the message and interpreting the meaning of the communication.

Message Encoding is an internal activity: the person will select verbal/non-verbal symbols to transmit the message.

Intercultural communication refers to the exchange of information, ideas, and values between people from different cultures.

Messages are the content of the communication, which is a set of written, pictorial, verbal, or nonverbal symbols.

Negotiation is a process where at least two parties with different perceptions, needs, and motivations try to reach an agreement on a topic of mutual interest.

Noise is an intended or unintended stimulus that affects the fidelity of the senders' message and disrupts the communication process.

A **receiver** is a person or a device that receives the message.

5.1.9.3 Knowledge domain

- National cultures
- Cultural concepts and tools

5.1.9.4 Learning objectives

- Identify the potential difficulties involved in international business relationships
- Improve your intercultural communication skills
- Deal with potential barriers in intercultural communication
- Explore tools to successfully manage cultural differences
- Further develop your intercultural competences and soft skills to become an intercultural leader

5.1.9.5 Competence content (units)

The competence content is divided in the following units:

1	**Cultural awareness and cultural blindness**	This unit provides learners with an awareness of the importance of intercultural skills. It discusses the consequences of companies or

		individuals deciding not to acknowledge different cultures. The unit guides the learner to develop cultural awareness and helps with coping and managing cultural diversity.
2	**Intercultural verbal and non-verbal communication**	This unit introduces learners to the theory and practice of intercultural communication. Different uses of internal and external communication are addressed, as well as the impact of new technologies on the communication process. Finally, the importance of non-verbal communication is examined. The unit guides learner to develop an intercultural communication awareness and to use different techniques and recommendations for successful communication.
3	**Tools for understanding cultures**	This unit introduces learners to the theory and use of the different existing tools for understanding cultures. The unit encourages learners to reflect on their own cultural values and put them into perspective with another culture. The unit guides learners to an understanding and integration of cultural differences.
4	**Intercultural negotiations**	This unit introduces learners to the theory and practice of intercultural negotiations. The unit encourages learners to reflect on the negotiation process and indicates main difference between Eastern and Western negotiators. The unit provides learners with some recommendations and tactics in order to become successful in international negotiations.
5	**Intercultural Leadership**	This unit introduces learners to the theory and practice of how to lead

		people. It presents the main activities, skills and competences that international leaders need to have. The unit provides learners with rich insights and recommendations to become an intercultural leader.

5.1.9.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe basic concepts of culture and its elements
- Identify 2 different tools for analysing business cultures
- List the different steps in the negotiation process
- List the different factors influencing intercultural negotiations
- Describe potential barriers in intercultural communication
- List the aspects affecting non-verbal communication
- Describe the steps for effective cross-cultural leadership
- Describe the Globe cultural dimensions for leadership
- Describe how to use time in different cultures
- Describe the concept of national cultures and its elements
- Indicate some examples of negotiation behaviour in different countries
- Describe different communication channels and techniques
- Describe Hofstedes' and Hall's cultural models and their implication for international business
- Summarize strategies for effective intercultural leadership

5.1.9.7 References

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5.1.10 Competence title: Project and Process Management

5.1.10.1 Competence description

According to the Project Management Institute (www.pmi.org), project management is "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements". As such, this module will not only build the required project management body of knowledge, but it will also present tools and techniques needed for successful project management.

Knowledge areas required by a project manager for successfully managing projects, such as project requirements management, change management, cost management, time management, quality management, risk management, communication management, etc., will be presented in detail, along with a number of tools for managing the respective processes. Furthermore, emphasis will be placed on agile approaches for software project management, as well as on peculiarities of software projects, covering topics such as software life-cycle models, effective estimation of software effort and size, software quality metrics, and team management. Finally, since this module is targeted at smart cities officials, an attempt should be made to establish the link between project management and organizational strategy.

5.1.10.2 Definitions

A **portfolio** is a collection of projects or programmes grouped together in order to facilitate effective management. They represent investments made or planned, they are aligned with the organization's strategy, and they can be quantified and measured.

A **project** is a temporary endeavour undertaken to produce a unique product or service.

Project management is the application of skills, knowledge, tools, and techniques to meet the needs and expectations of stakeholders for a project.

Project scope management defines the boundaries of a project and it involves a) product scope, which describes the features and functions that

are to be included in the project's products or services or results, and b) project scope, which is the work that must be done to deliver the specified product.

Project stakeholders are people or organizations with an interest in the project, affecting a project, or affected by a project.

The **Project Management Body of Knowledge (PMBOK)** is a set of standard terminology and guidelines (a body of knowledge) for project management developed by the Project Management Institute (PMI).

A **requirement** is a capability that the project product must deliver, needed by the user to solve a problem to achieve an objective or a quality that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed documentation.

Cost is a resource sacrificed or foregone to achieve a specific objective or something given up in exchange. Costs are usually measured in monetary units like euros, dollars, rubles, etc.

The **project budget** is a plan that identifies the resources, goals, and schedule that allow a firm to achieve those goals.

Project cost management includes the processes required to ensure that the project is completed within an approved budget. Project managers must make sure their projects are well defined, have accurate time and cost estimates, and have a realistic budget that they were involved in approving.

A **risk** is an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives.

Risk management is the systematic process of identifying, analyzing, and responding to project risk. It includes maximizing the probability and consequences of positive events and minimizing the probability and consequences of adverse events to project objectives.

5.1.10.3 Knowledge domain

Management skills

5.1.10.4 Learning objectives

The learning objectives of this module are the following:

- To understand key principles in managing software projects
- To understand the strategic character of smart city development

- To understand that smart city development should be managed as a portfolio of projects.
- To be familiar with the different methods and techniques used for software project management.
- To be able to do the Project Scheduling, Scope Management, Risk Management, Quality management, and Project Cost estimation using different techniques

5.1.10.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to Project Management**	This unit introduces learners to project management. It includes: • Project definition; • Project management definition; • Success and failure factors; • PM triple constraint; • Portfolio and program definition.
2	**Project management standards**	This unit introduces learners to the project management standards. It includes: • International and national project management standards; • Presentation of PMBOK; • Presentation of IPMA ICB.
3	**Project Organization**	This unit introduces the learners to the project organization standards. It includes: • Project organization; • Functional organization; • Project organization; • Matrix organization.
4	**Project Scope Management /Requirements management**	This unit introduces learners to the project management standards. It includes: • Basic definitions of scope management; • Basic concepts of requirements management;

		• Functional and non-functional requirements; • Requirements gathering techniques; • Good writing requirements; • Requirements for management support activities; • Requirements for change management.
5	**Project Scheduling**	This unit introduces learners to the project scheduling standards. It includes: • Project Scheduling introductory concepts; • Work Break-Down Structure; • Network planning techniques; • AON, AOA; • Critical Path Method and PERT; • Task duration probability.
6	**Project Quality Management**	This unit introduces learners to the project quality management standards. It includes: • Basic concepts and approaches of quality management; • Project management quality planning; • Project management quality assurance; • Project management quality control.
7	**Project Risk Management**	This unit introduces the learners to the project risk management standards. It includes: • Basic concepts of risk management; • Risk management processes; • Risk taxonomies; • Risk analysis; • Risk response planning.
8	**Project Costing**	This unit introduces learners to the project cost management standards. It includes: • Project cost basic concepts;

		• Cost estimation methods; • Project budgeting; • Cost types and cost components.
9	**Project Team Management**	This unit introduces learners to the project team management standards. It includes: • Basic concepts of project Human Resource Management; • Project organization; • Project roles; • Project team acquisition; • Project team management activities.

5.1.10.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the concept of project management.
- Define the concepts of a project, portfolio and programme
- Describe project life cycle
- List PMBOK knowledge areas
- Define the concept of requirement and of requirements management
- Define requirements management support activities
- Outline the basic steps of scheduling
- Define the concept of quality
- Present the contents of a quality plan
- Present the main processes of project quality management
- Define the concept of risk and risk management
- Present the contents of a risk management plan
- List PMBOK risk management processes
- List risk analysis tools and techniques
- Define the concept of cost and of project cost management
- List the roles needed for a software project
- Define the concept of resource loading and levelling
- Illustrate project success and failure factors
- Describe how triple constraint factors are influencing each other
- Illustrate different project organization structures

5.1.10.7 References

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5.1.11 Competence title: Design Thinking

5.1.11.1 Competence description

The current global environment is complex and in constant change. The race for global competition presents a challenge for those companies especially which are following traditional methods and processes that have never been questioned. This course will encourage the learner to reflect upon these issues and will present an alternative way of thinking and acting to question the current status quo of companies.

5.1.11.2 Definitions

Creative problem solving refers to solving wicked problems adopting both analytical and intuitive thinking.

Creative confidence refers to engaging with people to make them more confident with creative processes.

Creative thinking involves the mental processes leading to a new invention, solution, or synthesis of a new concept, product, or service.

Co-creation is the collaborative development of new concepts, solutions, products, and services together with experts and/or stakeholders (such as

customers, suppliers, etc.). Co-creation is a form of collaborative innovation.

Corporate culture refers to beliefs, values, and assumptions determining how employees and management of a company interact and handle inside and outside business transactions.

Design thinking is a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success. It is based on understanding customers' needs, rapid prototyping, and generating creative ideas that will transform the way products, services, and processes are developed.

Ideation is the process of developing new ideas, where an idea is understood as an elementary concept, whether visual, tangible, or abstract. This includes the entire thought cycle, from invention to development to actualization.

Innovation of meaning is envisioning new directions that aim at proposing meaningful experiences to people.

Organizational transformation is the process of transforming and changing the existing corporate culture.

Prototyping is an elaboration process where project teams transform ideas into various tangible forms of products of varying degrees of fidelity to capture and communicate design concepts to users.

Sprint execution is delivering and testing viable products in order to learn from customers and improve the solution.

5.1.11.3 Knowledge domain

- Design thinking
- Change of paradigm
- Creative organizational cultures
- Organizational transformation
- Multicultural teams

5.1.11.4 Learning objectives

- To understand the importance of design thinking change paradigm
- To identify the practical application of this competence and its impact on value creation
- To describe how design principles can be embedded into an organization

- To identify design thinking approaches as an answer to business challenges
- To understand how business cultures support or limit design thinking
- To highlight the importance of teams' cultural diversity in design thinking and innovation

5.1.11.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to design thinking**	This unit introduces learners to the main ideas and concepts of design thinking. Moreover, it shows the learner the different ways of thinking and how the mindset needs to be changed • Design thinking history • Design thinking definitions • Changes in the way of thinking
2	**Design thinking principles**	This unit introduces learners to the main principles of design thinking that redefine business management. It includes: • 10 Design thinking principles • Examples of companies using design thinking principles • Core activities of design thinking
3	**Design thinking process**	This unit introduces learners to the process and implementation of design thinking. Moreover, the great contribution of multidisciplinary teams in the design thinking process will be explored. It includes: • The Standford design thinking model • Multidisciplinary teams • Diversity and the power for innovation
4	**Organizational transformation**	This unit introduces learners to the concept of organizational culture and how in modern times organizations need to transform themselves in order to survive. It includes: • Organizational culture definitions • Visible and invisible corporate cultures

		• Corporate risk cultures • Values framework in a corporate culture • Types of business cultures • Organizational transformation and customer value

5.1.11.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the origins of design thinking
- Define the concept of design thinking
- Identify 10 design thinking principles.
- List the processes of design thinking.
- Name the core activities of design thinking styles.
- Describe a multidisciplinary team
- Define the term "business culture"
- Describe the design thinking paradigm change
- Explain the contribution of multidisciplinary teams to design thinking
- Explain the importance of company culture to achieve business performance
- Understand how design thinking links to solutions to business challenges
- Describe customer value

5.1.11.7 References

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5.1.12 Competence title: Decision Making and Problem Solving

5.1.12.1 Competence description

The particular course module introduces the Decision Making process and Problem Solving approaches to trainees that will be able to first realize the general characteristics and scope of Decision Making problems, as well as the fundamentals, methods and techniques of Decision Theory. Furthermore, the module focuses on the nature of uncertainty of most Decision Making problems, for which special consideration in the problem solving approach need to be given. Within this framework analyses of different Decision Making problems under uncertainty are demonstrated in a systematic way. In making well-informed decisions, the ability to acquire the appropriate data, generate proper information, establish the solution alternatives, as well as determine the suitable decision criteria are of paramount importance. In addition, problem solving requires a number of skills aiming at identifying the source of a problem and obtaining an effective solution. It encompasses aspects of analysis and creativity, research, communication and team building. Moreover, the Decision Tree Analysis is introduced to illustrate an established graphical solution approach to DM problems, whereas the fundamentals and several applications of the Linear Programming method for solving DM problems are also discussed.

5.1.12.2 Definitions

Ethical decision-making is the process of evaluating and choosing among alternatives in a way consistent with ethical principles such as autonomy, nonmaleficence, beneficence, justice, and fidelity.

Decision-making, as a scientific area, is a process in which a reconciliation of several aspects occurs in a systematic procedure that entails several sequential procedural steps aiming at reaching a decision.

Decision-tree is a visual tool where a tree-like model is used to represent decisions and their possible consequences, including chance event outcomes.

Hurwicz criterion in decision making is the weighted average of the best and worst outcomes for each alternative decision is estimated.

A **model** is a purposeful representation of a real situation, usually in mathematical form. Models can be mathematical, conceptual, visual, etc.

Linear programming is a widely used modeling method that can be employed to facilitate the effective allocation of available resources.

Maximin strategy when applied to a decision-making problem is aiming to select the best of a set of worst possible outcomes or payoffs.

Minimax strategy when applied to a decision-making problem is aiming either to minimize the maximum losses of an individual or to reduce the most an opponent gain.

Problem solving is the process of studying the problem under investigation and the related information and finding all possible solutions through invention or discovery. Problem solving is a step towards decision making.

Sensitivity analysis is the evaluation if the overall outcome of a model is affected by potential changes of uncertain input variables.

5.1.12.3 Knowledge domain

Decision Making Analysis / Operations Research

5.1.12.4 Learning objectives

The learning objectives of this module are the following:

- To realize the wide scope and characteristics of Decision Making and Problem Solving processes
- To understand the concept of an appropriately developed mathematical model representing a Decision Making problem and be able to formulate this model for addressing the problem
- To become familiar with the most widely used Decision Making and Problem Solving methods and tools (such as the Decision Trees and Linear Programming techniques)
- To recognize the probabilistic nature of Decision Making problems and basic characteristics of Decision Making under uncertainty
- To be able to apply the concepts and applications learnt to a real-world Decision Making problem

5.1.12.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to Decision Making and Problem Solving**	This unit introduces learners to the Decision Making (DM) and Problem Solving (PS) processes. Decision making can be regarded as the judgmental process resulting in the selection of a course of actions. In particular, it encompasses the following topics: • The DM Process; • General Characteristics of DM Problems; • Building the Appropriate Mathematical Model Representing a Problem. Furthermore, problem-solving skills help you determine the source of a problem and find an effective solution. Some key problem-solving skills include: • Active listening • Research • Analysis • Creativity • Communication • Team-building
2	**Decision Making under Uncertainty**	This unit introduces the basic concepts and theory of DM emphasizing the specific features and applications of DM under uncertain conditions, which is the real-world case. It focuses on an intuitive learning approach through examples offering an experiential understanding of DM and PS approaches to trainees. In particular, topics to be discussed in this unit are: • The DM under Uncertainty Framework; • Data Gathering and Information Acquisition; • Alternatives Identification, States of Nature Determination, Payoff Table Generation, Opportunity Cost and Expected Value Estimation; • Decision Criteria; • Evaluating Alternatives.

3	**Decision Trees**	The particular unit introduces the Decision Tree Analysis and method to enable trainees to establish an alternative way for formulating and solving a DM problem under uncertainty. The unit deals with the following topics: • Decision Tree Analysis (Scope and Terminology); • Data Illustration in Decision Trees; • Solution Approach.
4	**Linear Programming for Addressing DM Problems**	This unit introduces the fundamentals of the Linear Programming (LP) method for solving DM problems, as well as the graphical and computational solution approaches to LP problems. LP is one of the most commonly used methods in DM and it entails a systematic PS approach for many real-world problems. The unit covers the following topics: • The LP model for particular DM problems; • The graphical solution and interpretation of LP problems; • LP problem solving with the use of computer software; • Solution report and sensitivity analysis.

5.1.12.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- describe the Decision Making Process
- outline the general characteristics of Decision Making problems
- define what a mathematical model is and what it entails
- identify a model's possible limitations
- describe the Problem Solving process and pertinent elements
- list the basic features in Decision Making under uncertainty
- outline the basic features and structure of a Decision Tree
- define the general structure of Linear Programming (LP) models
- outline the graphical solution approach to an LP problem
- recognize the probabilistic nature of Decision Making problems

- explain the terms of expected value, opportunity cost, payoff table and states of nature
- illustrate the Decision Tree Analysis approach
- distinguish the problems that can be solved through LP
- explain the results of an LP problem
- use the appropriate model representing a Decision Making problem to be solved
- apply the Problem Solving approach through Decision Trees in Decision Making problems
- demonstrate the process of evaluating alternatives under different DM criteria
- interpret Sensitivity Analysis results

5.1.12.7 References

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5.1.13 Competence title: Leadership and Management Skills

5.1.13.1 Competence description

The topic of leadership is very broad. This course is dedicated to exploring the many aspects of leadership and their impact on organizational performance. The participant in this course will get an overview of how to lead people. In order to achieve this, leadership skills, traits and types of

leadership behaviours will be presented. Moreover, it will be shown how the new digitalization era influences leadership.

5.1.13.2 Definitions

Artificial intelligence is the ability of a computer or computer-controlled robot to perform tasks commonly associated with intelligent beings.

Cognitive intelligence is the ability to perceive and understand information, use intuition and imagination, make judgments and decisions.

Cultural intelligence is the ability to interact effectively in multiple cultures. It reveals a person's capability to gather, interpret, and act upon radically different situations and function effectively across cultural settings.

Emotional intelligence is the ability to identify, assess, and control one's own emotions, the emotions of others, and groups.

Human skills represent the ability to work effectively as a group member and to build cooperative effort within a team.

Leadership is a process that integrates influence, occurs in groups, and involves common goals. It includes organizing, directing, coordinating, and motivating individuals toward achieving certain organizational goals.

Management skills are skills required to execute management functions: planning, organizing, staffing, leading, and controlling. Important management skills are planning, communication, decision-making, problem-solving, motivation, etc.

Mission defines the company's business, its objectives, and the way to reach those objectives.

Motivation is an internal process that directs a person to goal-oriented behaviours.

Personality is a distinctive character or quality of a person. Personality characteristics include: openness, conscientiousness, extraversion, agreeableness, and emotional stability

Power is the ability to influence others, even when they are resisting this influence, and it is derived from control over rewards, punishments legitimacy power), expert knowledge and skills, etc.

Vision indicates the desired future position of the company.

5.1.13.3 Knowledge domain

- Leadership
- Leadership roles, traits and skills
- Managerial roles
- Next generation Leadership 4.0

5.1.13.4 Learning objectives

- To highlight the difference between leadership and management
- To understand how personality traits influence leaders' emergence and performance
- To learn and explain the influence leaders have on people.
- To identify typical characteristics of successful leaders
- To describe different types of leadership
- To understand how top executives can influence organizational processes and performance
- To identify which new leadership competences are required in the new 4.0 environment

5.1.13.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to leadership and managerial roles**	This unit introduces learners to the theory and practice of leadership and management: • Leadership and management definitions • Leadership versus management • Vision and mission • Leadership roles • Management roles
2	**Traits, skills and characteristics of leaders**	This unit introduces the learners to the traits and skills for effective leadership. It includes: • Definition of traits and skills • Identification of traits related to leadership effectiveness • Skills model
3	**Leadership behaviour and**	This unit introduces learners to the different leadership behaviour and focuses on the

	charismatic leadership	importance of charisma in leadership. It includes: • Different leadership behaviour • The importance of charisma • Charismatic leadership
4	**Change, Transformational leadership and Leadership 4.0**	This unit introduces learners to the different phases of organizational change. It analyses the reasons of resistance to change and how leadership can contribute to the acceptance of it. The aspects of transformational leadership are presented in preparation for the changes required for the new skills development in order to master the new digitalization era. The course includes: • Change process • Reasons for resistance or acceptance of change • Guidelines for implementing change • ADKAR model • Transformational leadership steps • Digital transformation • Digital leadership
5	**Strategic and Empowering leadership**	This unit introduces the learner to core activities for organizational strategic leadership. It would help the learner to develop strategic steps influencing employees performance and the overall success of the company. In addition, how to empower employees, the importance of delegation and the participation in leadership task are explored. It includes: • Strategic leadership tasks • The components of strategic leadership • Guidelines for strategic leadership • Types of leadership participation • Guidelines for participative leadership

5.1.13.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Define the concept of leadership and management
- Define the concept of personality traits
- Define the role of leaders and managers
- Describe different leadership characteristics
- Describe different leadership styles
- Identify different leadership behaviours
- Discuss the importance of leadership in organizations.
- Discuss the importance of vision and mission in an organization
- Explain the concept of charisma
- Explain the different traits and their impact on successful leadership
- Explain the main role of leadership in the change process
- Explain the reasons for resistance to change
- Describe the concept of transformational leadership
- Explain how leaders influence organizational performance
- Describe how digital transformation requires another leadership style
- Explain the different ways to empower employees
- Illustrate the influence leaders have on employees' performance

5.1.13.7 References

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5.1.14 Competence title: Stakeholder management

5.1.14.1 Competence description

According to Project Management Institute (www.pmi.org), Project Stakeholder Management includes "the processes required to identify the people, groups, or organizations that could impact or be impacted by the project, to analyze stakeholder expectations and their impact on the project, and todevelop appropriate management strategies for effectively engaging stakeholders in project decisions and execution".
Nowadays, projects operate within a project environment of uncertainty and complexity due to high degree of change. To cope with this situation, adaptive teams are engaged with stakeholders directly and information is exchanged in a dynamic co-operative process that enables more stakeholder engagement.
In such an environment the knowledge areas required by a stakeholder manager to be familiar with for successfully managing project stakeholders are: stakeholder identification and prioritization, stakeholder engagement and expectation management, stakeholder communication, negotiating and influencing.
These areas will be presented in detail with a number of techniques that support the respective processes.

5.1.14.2 Definitions

A **project stakeholder** is an individual, group, or organization, who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project.

Project stakeholder management is the systematic identification, analysis, planning, and implementation of actions designed to engage with stakeholders.

Identifying stakeholders is the process of identifying project stakeholders regularly, analyzing and documenting relevant information regarding their interests, involvement, interdependencies, influence, and potential impact on project success.

Planning stakeholder engagement is the process of developing approaches to involve project stakeholders based on their needs, expectations, interests, and potential impact on the project.

The **stakeholder management strategy** identifies and documents the approach that should be taken to increase support and/or decrease negative impacts of stakeholders' actions/attitudes throughout the life of

the project. It should identify the **key stakeholders** along with the level of power and influence they have on the project.

Stakeholder analysis refers to a set of techniques/tools used to identify and understand the needs and expectations of major stakeholders either internal or external to the project. This understanding of attributes, interrelationships, and interfaces between project advocates and opponents assists managers in defining strategic project planning.

Stakeholder prioritization is the arrangement of project stakeholders according to some specific attributes they have. As such, several categorization methods have been proposed based on a single attribute or a combination of these attributes. Additionally, an index value can be assigned to each stakeholder to increase the accuracy of the prioritization process.

Stakeholder negotiation is a discussion between two or more project parties aimed at reaching an agreement.

Stakeholder influencing in a project is the process of making stakeholders have a positive attitude or involvement in a project.

5.1.14.3 Knowledge domain

Stakeholder Management

5.1.14.4 Learning objectives

The learning objectives of this module are the following:

- Define key principles in stakeholder management
- Identify stakeholder management processes
- Describe aspects of stakeholder identification and prioritization process
- Describe stakeholder identification and prioritization methods
- Describe aspects of stakeholder negotiation and influence process
- Identify stakeholder negotiation practices and phases
- Identify communication aspects related to stakeholder management
- Describe aspects of stakeholder engagement and expectation management process
- Identify methods of stakeholder engagement and expectation management

5.1.14.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to Stakeholder Management**	This unit introduces learners to the theory of stakeholder management. It involves: • Basic theoretical concepts of stakeholder management
2	**Stakeholder Identification and Prioritization**	This unit involves: • Basic aspects of stakeholder identification and prioritization • Techniques to perform stakeholder identification and prioritization
3	**Stakeholder Engagement and Expectation Management**	This unit involves: • Basic aspects of stakeholder engagement and expectation management • Techniques to perform stakeholder engagement and expectation management
4	**Stakeholders Negotiation and Influencing**	This unit involves: • Basic aspects of stakeholder negotiation and influencing • Techniques to perform stakeholder negotiation and influencing

5.1.14.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the concept of stakeholder management
- Identify the main aspects of stakeholder identification and prioritization process
- Describe stakeholder identification and prioritization methods
- Identify the main aspects of stakeholder negotiation and influence process
- Describe stakeholder negotiation and influence methods
- Identify the main aspects of stakeholder engagement and expectation management process
- Describe stakeholder engagement and expectation methods
- Identify communication aspects in stakeholder management
- Identify the stages of stakeholder engagement lifecycle
- Identify the stages of stakeholder negotiation lifecycle

- Identify stakeholder negotiation pitfalls
- Identify stakeholder management processes
- Describe the processes of stakeholder identification
- Summarize a set of actions towards successful stakeholder management
- Describe the levels of stakeholder engagement

5.1.14.7 References

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5.1.15 Competence title: Knowledge Management

5.1.15.1 Competence description

The goal of this course is to train learners to consider the latest knowledge management (KM) ideas, methods, tools and strategies so as to tackle the complexities of organizing and handling knowledge.
This course discusses current problems in information management, intellectual capital and other intangible assets through exploration and interpretation of the fundamental principles of information analysis, collection, classification, manipulation, storage, retrieval, movement, dissemination, and protection.

5.1.15.2 Definitions

Data are individual facts, statistics, or items of information, often numeric, that is collected through observation. Data usually are encoded in a form suitable for moving or processing.

Explicit knowledge is the knowledge that can be readily articulated, codified, stored, accessed, and communicated to others through written and digital media.

Knowledge is the state of being familiar with something or aware of its existence, or understanding usually resulting from experience or study

Knowledge Management is the coordination and exploitation of organizational knowledge resources, to create benefit and competitive advantage.

Organizational knowledge is the collective knowledge and abilities possessed by the employees of an organization, and it includes individual, group, structural, organizational, and extra-organizational knowledge.

Organizational learning is the process that focuses on knowledge creation and usage within the organization, and it is based on principles such as shared and open knowledge, continuous learning, learning from our mistakes, etc.

Tacit knowledge is knowledge informally acquired rather than explicitly taught, and it enables a person to succeed in certain environments and activities.

5.1.15.3 Knowledge domain

- Management Science
- Information Science

5.1.15.4 Learning objectives

- To understand the difference between knowledge, data and information
- To understand what KM is
- To become familiar with KM in organizations
- To become familiar with KM models
- To become familiar with KM tools and applications

5.1.15.5 Competence content (units)

The competence content is divided in the following units:

1	**Knowledge, Data, Information**	In our everyday language, within specific fields, and even within the same disciplines, the word "knowledge" often takes on a variety of meanings. Hence, this unit analyzes what constitutes knowledge and

		what falls under the category of information or data.
2	**What is Knowledge Management?**	The specific unit introducing the concept of Knowledge Management. In specific, it elaborates on various definitions, the advantages and the life cycle of the Knowledge Management system.
3	**Organizational Knowledge**	This unit introduces learners to what organizational knowledge is and its significance for the knowledge management (KM) process.
4	**Organizational Learning**	This unit presents the process of a) creating, b) retaining, and c) transferring knowledge within an organization.
5	**Knowledge Management Models**	This unit familiarizes learners with the components and definitions that relate to knowledge management (KM). In specific, it deals with knowledge management frameworks and models.
6	**Knowledge Management Tools**	This unit presents an overview of the IT-based tools that support knowledge management (KM). In specific, learners will be presented with an overview of the available types of KM tools in order to understand their role in the KM process. Selecting a KM tool is a very important step, since there are many options to choose from.

5.1.15.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Identify what Knowledge is
- Identify what Knowledge management is
- Identify the advantages of Knowledge management
- Recognize the different aspects of the SECI Knowledge Model
- Identify Knowledge Management tools and techniques
- Identify different types of learning within an organization
- Identify the basic components of a knowledge management framework

- Distinguish the types of Knowledge
- Explain the role of information system technology in knowledge management

5.1.15.7 References

Bali, R., Wickramasinghe, N., & Lehaney, B. (2009). Knowledge Management Primer. New York: Routledge.

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Gherardi, S. (2009). Organizational knowledge: The texture of workplace learning. John Wiley & Sons.

5.1.16 Competence title: Advanced Presentation Skills

5.1.16.1 Competence description

The Advanced Presentation Skills course will help you create and deliver more powerful presentations to increase your influence and impact with stakeholders. From calming your nerves to clarifying your message, the biggest thing standing in the way of engaging your audience with confidence is mastering public speaking skills. This course will enhance your skills and confidence by providing techniques to structure presentations in order to deliver effective messages to your audience. You will explore techniques to fine-tune your skills as a speaker and the "golden rules" to help you take your presentations from good to great.
This course is designed for anyone who would like to improve their ability to design and deliver an impactful presentation. Whether you have been presenting regularly or occasionally, this course provides skills to do so even more successfully.

5.1.16.2 Definitions

Active learning is learning where students are engaged with the course material through discussions and the use of interactive methods such as role-playing, serious games, case studies, capstone projects, peer teaching, debates, and demonstrations.

Augmented reality is defined as a real-time direct or indirect view of a physical real-world environment that has been enhanced/augmented by adding virtual computer-generated information to it. It is a combination of a real scene viewed by the user and a virtual scene generated by a computer that augments that scene with additional information.

A **learner model** is a structured representation of a learner's knowledge, preferences, particularities, misconceptions, and difficulties that is constructed with learner data usually gathered from learning management systems.

Pitching an idea is the act of attempting to persuade someone to do something through an oral or visual presentation. It is commonly used as a persuasion tool for customers, fundraising, etc.

Presentation skills are the skills needed for delivering effective and engaging presentations. These skills include structuring of the presentation, body language and movement, and verbal delivery.

Storytelling is the social and cultural activity of sharing stories, often with improvisation, theatrics, or embellishment.

Visual aids are elements designed to assist learners to comprehend the topic under study and include presentations, video, podcasts, graphs, various types of interactive visualizations, etc.

5.1.16.3 Knowledge domain

Presentation Skills

5.1.16.4 Learning objectives

The learning objectives are the following:

- To learn how to get to know what the audience wants to hear and how to shape the presentation accordingly
- To be able to maintain confidence and handle nerves
- To be able to prepare, practice and achieve successful presentations which fulfill their objectives
- To understand how to keep audience attention throughout the presentation

- To understand the golden rules and inappropriate techniques of advanced presentation skills
- To learn the popular techniques of storytelling and pitching
- How to use Augmented Reality to Enhance Presentations

5.1.16.5 Competence content (units)

The competence content is divided in the following units:

1	**Human beings - 'presentation nerves'**	This learning object will address knowledge areas required to get to know what the audience want to hear and how to shape the presentation accordingly as well as to be able to maintain confidence and handle nerves.
2	**Your audience**	This unit provides learners with the essential skills required to improve presentation structure in order to suit any audience. It includes: • Being able to prepare, practice and achieve successful presentations which fulfill their objectives
3	**Storytelling**	This unit introduces learners to the practice of storytelling. It includes: • The benefits of employing stories during a presentation • Popular techniques of storytelling and pitching

4	**Augmented Reality presentations**	This unit introduces learners to augmented reality and the approaches to create augmented reality. It inclu des: • How to use Augmented Reality to enhance Presentations
5	**Tools for presenters**	This unit introduces learners to the "golden rules" and techniques of a presenter. It includes: • To understand how to keep audience attention throughout the presentation • To understand the golden rules and inappropriate techniques of advanced presentation skills

5.1.16.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Recognize the symptoms of "presentation nerves"
- Outline the physiology of fear tasks that can affect a presentation
- Identify the roles in presentations that can trigger the fight-flight system
- Recognize why your audience is there
- Identify Purpose, End Point, and Time
- Describe outcomes: structure, roles, timing
- Describe the main points in the process of getting to know and practicing your content
- Describe the learning model (slides, visual aids, interaction)
- Recognize the different elements of a story
- Describe various popular storytelling techniques used by presenters
- Describe the different main types of augmented reality
- Describe the technology you need to create augmented reality presentations

5.1.16.7 References

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Generic IT Skills

5.2 Generic IT Skills

5.2.1 Competence title: Software Development Life Cycles and Agile Methods

5.2.1.1 Competence description

A Software Development Life Cycle (SDLC) prescribes a series of related activities combined into phases, which constitute the "life stages" of an information system. An SDLC provides software project managers with proper control and guidance over their software development projects. The primary objective of an SDLC is to ensure that high quality information systems are delivered to end-users and the productivity of the development staff is maximized. An SDLC can described through an SDLC model to facilitate more the understanding of the SDLC phases.
Trainees will be introduced to the basic concepts of the software development life cycle (SDLC) and its importance to information system development projects. Upon completion of this module, trainees will learn the concepts of some traditional SDLC models (Waterfall, Prototyping/Iterative, Incremental, Spiral, V-Model). The advantages/disadvantages and the cases of applicability of each model will be critically discussed.
Then, trainees will be also introduced to contemporary and more flexible SDLC models, such as the Agile model, an SDLC combining iterative and incremental development. The differences between the Agile model and traditional SDLC models (e.g., Waterfall) will be discussed.

5.2.1.2 Definitions

Agile software development life-cycle model is a combination of iterative and incremental process models with a focus on process adaptability and customer satisfaction by rapid delivery of working software products. An agile model defines a software process that follows the agile principles and applies an agile software development method.

Agile methods are a group of methodologies for developing software based on the values and principles of agile philosophy. Representative methods are Extreme Programming, SCRUM, KANBAN, Disciplined Agile Process, etc.

Incremental development is a software development life-cycle model that combines waterfall and prototyping to implement a system through repeated iterations and in smaller segments (builds/increments) at a time.

Prototyping model is an iterative software development life-cycle model that results in successive software product increments, so-called "prototypes".

Software development life-cycle is a number of work phases that are used by the software development team and all project stakeholders to plan, design, build, test, and deliver a software product.

A **software development life-cycle model** is a high-level description of the software development life-cycle model phases.

Spiral Model is a risk-driven model that adopts elements of different process models, such as incremental, waterfall, and prototyping, placing very high emphasis on risk analysis.

Waterfall is a sequential software development life-cycle model where the completion of a specific phase is required for the development process to proceed to the next phase.

V-Model is a modified and enhanced version of the waterfall model that explicitly emphasizes testing activities

5.2.1.3 Knowledge domain

- General IT Knowledge

5.2.1.4 Learning objectives

After completing this module, trainees will be able to:

- Explain what SDLC is and describe the SDLC phases.
- Offer a general overview of traditional SDLC models (Waterfall, Prototyping/Iterative, Incremental, Spiral, V-Model) and identify the advantages/disadvantages of each model.
- Provide an overview of what an "agile" SDLC is and how it is compared with traditional SDLC approaches (e.g., Waterfall).

5.2.1.5 Competence content (units)

The competence content is divided in the following units:

1	**Software Development Life-Cycle (SDLC) and Traditional SDLC Models**	This unit introduces learners to the basic concepts of the software development life cycle (SDLC). The unit presents: • Definition and basic stages of SDLC.

		• Representative (traditional) SDLC models (Waterfall, Prototyping/Iterative, Incremental, Spiral, V-Model). The presentation of each SDLC model emphasizes highlighting the advantages and disadvantages of each model as well as the cases of each model's application.
2	**Introduction to Agile Software Development Life-Cycle**	This unit introduces learners to the basic concepts of agile software development. In particular, the unit presents basic concepts, principles, phases and application cases of the agile model. The unit emphasizes illustrating the differences between agile SDLC and traditional SDLC approaches (e.g., Waterfall).

5.2.1.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Define the SDLC concepts and the basic stages of SDLC.
- Define the characteristics of each one of the traditional SDLC models (Waterfall, Prototyping/Iterative, Incremental, Spiral, V-Model).
- Describe the stages of development in each traditional SDLC.
- Describe the basic concepts of the Agile model.
- Describe different cases in which each of the traditional SDLC models can be applied.
- Identify the advantages and the disadvantages of each of the traditional SDLC models.
- Identify the advantages of following an Agile approach.
- Indicate the differences between Agile SDLC and traditional SDLC approaches (e.g., Waterfall).

5.2.1.7 References

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Sommerville, I. (2015), Software Engineering (10th ed.). Addison-Wesley.

5.2.2 Competence title: IT Quality Assurance

5.2.2.1 Competence description

IT Quality Assurance contains a well-defined set of processes that are aligned with software development standards associated with regulatory guidelines. The course module is designed to provide everyone with the necessary knowledge and skills in order to understand the main quality assurance processes and their flow with a view to the quality of software deliverables. The module does not require any previous knowledge in quality assurance issues and it assumes that the learner can understand the basic concepts of software development.

5.2.2.2 Definitions

Quality is the fitness for purpose or the degree of conformance of the outputs of a process or the process itself to requirements.

Quality assurance is the systematic process that is used to monitor and provide continuous improvement of the quality system of the organization.

Quality audit is an independent examination of a product, service, or process usually done by an external entity.

Quality control is the set of practices and processes used to ensure that deliverables of developed products meet customer expectations.

Quality metrics are measurements of the value and/or performance of products, services and processes. Quality metrics could refer to customer satisfaction, rating of products and services, failure rates, quality of service, software performance.

Software process improvement is a methodology which includes a sequence of activities, tools, and techniques to plan and construct improvement tasks to achieve specific goals.

Software Quality Plan is a well specified list of arrangements for the development of a product or service. It details quality assurance and quality control policies needed to control the quality processes and results.

5.2.2.3 Knowledge domain

General IT management knowledge

5.2.2.4 Learning objectives

- To understand and design a software quality plan
- To recognize and arrange a set of quality metrics
- To understand and form a quality checklist
- To understand the significance of the process improvement plan
- To recognize the key steps of the quality audits and their order

5.2.2.5 Competence content (units)

The competence content is divided in the following units:

1	**Software quality plans**	This unit introduces learners to software quality plans. It includes: • The parts of a software quality plan • The requirements of a software quality plan
2	**Software quality metrics**	This unit introduces learners to software quality metrics. It includes: • The categories of software quality metrics • A list of possible quality metrics
3	**Software quality checklists**	This unit introduces learners to software quality checklists. It includes: • The types of software quality checklists • The common items of software quality checklists
4	**Process improvement plan**	This unit introduces learners to the process improvement plan for software quality. It includes: • The PDCA (plan-do-control-act) cycle • The goals of a process improvement plan

		• The risks of a process improvement plan
5	**Quality audits**	This unit introduces learners to the quality audits for software quality. It includes: • The key steps of a software quality audit • The pitfalls of a software quality audit

5.2.2.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Recognize at least 3 key ingredients of an adequate quality plan
- Recognize at least 4 special requirements of an adequate software quality plan
- Recognize at least 5 categories of the possible quality metrics
- Memorize the 4 types of software quality checklists regarding the main stages of the software testing lifecycle
- Memorize the 4 steps of the PDCA (plan-do-control-act) cycle and their order
- Define the 4 common goals of a process improvement plan aiming at software development
- Recognize 3 common risks of the proposed improvement that derived from a process improvement plan
- Recognize 3 common pitfalls of the quality audits execution
- Select at least 3 software quality metrics for a specific software project
- Identify 2 items for each type of software quality checklists
- Select 5 specific checklist items for a software project deliverable
- Demonstrate the 4 key steps in quality audits for software development
- Construct a software quality plan with 2 requirements for a specific case

5.2.2.7 References

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5.2.3 Competence title: IT Security

5.2.3.1 Competence description

IT Security is a complex and multidimensional challenge. The landscape of threats is constantly changing and evolving. Modern societies are highly dependent on IT infrastructure, particularly in the context of smart cities. The building blocks of smart cities are IoT devices, which in essence are permanently connected mini computers. Despite the new novel services that are made available, most of these systems are susceptible to all kinds of cyberattacks.
This module focuses on providing learners with an overview of IT Security and highlights its need in information and communication systems with emphasis on IoT devices and smart cities. The purpose of this module is to provide knowledge of the security risks of information systems as well as of the available mechanisms and technologies to protect them. The aim is to train learners in identifying vulnerabilities, developing security policies and implementing protection measures.

5.2.3.2 Definitions

Attack is the exploitation of a vulnerability to gain access to a computer system/network.

Computer security is the protection afforded to an automated information system in order to attain the applicable objectives of preserving the integrity, availability and confidentiality of information system resources (includes hardware, software, firmware, information/data and telecommunications).

Countermeasures is a protective mechanism that can mitigate or eliminate an attack and minimize the damage.

Cipher is an encryption or decryption algorithm.

Ciphertext is the encrypted message.

Cryptanalysis is a systematic scientific effort to reveal the contents of a ciphertext.

Cryptography is the theoretical and technical foundation for protecting sensitive and private information from unauthorized access.

A cryptographic key is the necessary input to a cipher to determine its output.

Decryption is the process that transforms encrypted information into its original format.

Encryption is the process of concealing the message's contents. Encryption secures digital data using one or more mathematical techniques, along with an "encryption key" used to decrypt the information.

A **risk** is an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives.

Security policy is a document that defined a set of rules on how a company plans to protect the company's physical and information technology (IT) assets.

A **threat** is anything that can cause damage, interfere or prevent a resource from providing its services. It includes any unauthorized access to any asset or data.

Vulnerability is defined as a person's or a group's inability to foresee, cope with, resist, and recover from the effects of natural or man-made danger. This security gap in a system can be exploited by an attacker.

5.2.3.3 Knowledge domain

- IT threats and risk assessment
- Cryptographic applications
- Software and Network Security
- Practical Implications for IoT devices and smart cities

5.2.3.4 Learning objectives

- Acknowledge the fundamental concepts in IT security

- Identify software and network vulnerabilities and threats. Perform risk assessment in an Information System and propose a methodology for mitigation of possible attacks
- Evaluate the usability of a security solution
- Assess the main cryptographic algorithms and combine them into a secure development environment
- Develop a security policy for IoT Ecosystems

5.2.3.5 Competence content (units)

The competence content is divided in the following units:

1	**Fundamentals of IT Security**	This unit introduces learners to the fundamentals of IT Security. It involves: • Basic theoretical concepts of IT Security • Introduction to threats, risk and countermeasures • Understanding of the core elements of a security policy
2	**Cryptography: Application and Examples**	This unit introduces learners to the basic concepts of computer cryptography. The objective is to facilitate secure communication, information exchange and data storage for personal and professional use by facilitating PKI cryptography, symmetric cryptography and their functions.
3	**IoT Security: A holistic approach for smart cities**	This unit introduces learners to Internet of Things (IoT) Security. It involves: • Basics of software security • Basics of network security • Basics of hardware security • IoT security risk assessment • IoT security measures • A methodology to implement a security policy for IoT Environments

5.2.3.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Outline the basic principles of IT Security
- Describe the fundamentals of symmetric cryptographic algorithms
- Describe the fundamentals of the Public Key Infrastructure cryptography
- Outline the operation of cryptographic hash functions
- Describe the fundamentals of Software Security
- Outline the fundamentals of Network Security
- Describe the fundamentals of Hardware Security
- Identify the different layers of IT Security
- Identify assets, threats, and possible countermeasures in IT Security
- Identify the differences between symmetric and PKI cryptography
- Present one IT risk assessment methodology
- Produce a security policy to minimize risk in IoT Environments

5.2.3.7 References

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5.2.4 Competence title: System and Software Architecture

5.2.4.1 Competence description

This course module aims at introducing trainees to the main basic concepts of system and software architecture. In particular, it will discuss the purposes of software architecture and it will make clear why it is important. The most common architectural styles will be explored and methods for architecture evaluation will be presented.

5.2.4.2 Definitions

An **architectural pattern** is a general recurring solution to a recurring problem in software architecture.

An **architectural style** is a recurrent architectural design, a specific method of construction, characterized by the features that make this style notable.

Behavioural diagrams are diagrams that represent the dynamic structure of the system.

A **component** is an element encompassing a specific subset of functionalities and/or data.

Configuration is a connected graph of components and connectors describing the architectural structure and the final IT system.

A **model** is a purposeful representation of a real situation, usually in mathematical form. Models can be mathematical, conceptual, visual, etc. A model is an abstraction aiming at capturing the essential features of the system of interest.

A **modelling language** is a language that can be used to describe the model of a system.

Software architecture is a blueprint of the fundamental structures of a software system. This blueprint includes all system components, how they interact, the operating environment, and the design principles.

Software quality attributes are features that facilitate the measurement of performance of a software product, such as availability, maintainability, performance, etc. Quality attributes are measurable and testable properties of a system.

Structural diagrams are diagrams that represent the static structure of the system.

A **system** is a collection of interacting or interrelated or integrated components that are organized according to a set of rules and able to accomplish specific functions as a unified whole.

System stakeholders are individuals, teams, or organizations with interests in, or concerns relating to, a system.

The 4+1 view model is a model describing the architecture of software-intensive systems, through multiple, concurrent views.

The **unified modelling language** is a graphical language for visualizing, specifying, constructing, and documenting the artifacts of a software-intensive system.

5.2.4.3 Knowledge domain

General IT Knowledge

5.2.4.4 Learning objectives

The learning objectives of this module are the following:

- Definition of the objective of software architecture;
- Understanding architectural views;
- Describing the properties of some of the most common architectures;
- Evaluation of a software architecture.

5.2.4.5 Competence content (units)

The competence content is divided in the following units:

1	**Software architecture: introduction and views**	This unit will provide an introduction to software architecture explaining its purposes and why it is important. The concept of architectural views will be introduced and the 4+1 architectural view model will be explored.
2	**Architectural styles**	This unit will present some of the common architectural styles

		(component-based, pipes and filters, client-server, peer-to-peer, layered, etc.).
3	**Software architecture evaluation**	This unit will explore the evaluation criteria of a software architecture.

5.2.4.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Define the role and main purposes of software architecture
- Explain why software architecture is important
- List the main characteristics of the software elements
- Define the concept of view of software architecture
- List different architectural styles
- Illustrate the 4+1 architectural view model
- Recognize a UML diagram
- Illustrate the quality attributes of an architecture
- Illustrate the ATAM method for architecture evaluation

5.2.4.7 References

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5.2.5 Competence title: Basic Concepts of Cloud Computing

5.2.5.1 Competence description

This course module introduces the concept of Cloud Computing considering the topics concerning the management of smart city services using cloud technology.

5.2.5.2 Definitions

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

Cloud elasticity is a capability of the cloud to scale rapidly outward and inward proportionally to demand without the customer noticing the change in the system's capability of performance.

Infrastructure as a service (IaaS) is a cloud computing model that provides customers with virtualized computing resources over the internet.

PaaS (Platform as a Service) is a cloud computing model where customers may use PaaS to develop, run, and manage apps without having to develop and maintain the necessary cloud infrastructure for developing and deploying an app.

On-demand self-service is the cloud property where a customer can unilaterally use cloud computing capabilities, e.g. server time and network storage, on-demand without any intervention from an operator.

Private cloud. The cloud infrastructure provided is for the exclusive use of a single organization

Public cloud. The cloud infrastructure is provisioned for open use by the public according to a set of predefined rules.

Resource pooling. The cloud resources are pooled for serving multiple customers using a multi-tenant model, where cloud resources are assigned dynamically according to customers' demands.

Software-as-a-Service (SaaS) is a software licensing model in which the software is provided on a subscription basis, and the software is operating on the cloud rather than on servers located in-house.

5.2.5.3 Knowledge domain

Technical skills, management, IT services, data processing.

5.2.5.4 Learning objectives

- Basic cloud concepts
- Cloud basic technologies (e.g. virtualization)
- Cloud development tools
- Different cloud service models: SaaS, PaaS, and IaaS
- Major public cloud providers
- Configuration and provision of resources on a private IaaS cloud
- Lifecycle of a Cloud Computing Solution
- Applying tips and best practices when adopting the cloud

5.2.5.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to cloud computing**	This unit introduces the concept of cloud computing by describing the main basic technologies and the most relevant service models.
2	**Implementation of cloud computing to smart city service management**	This unit illustrates the main advantages of using cloud computing in smart city management, providing some examples of applications of the best solutions from cloud service providers.
3	**Lifecycle of a Cloud Computing Solution**	This unit illustrates the lifecycle of a cloud computing solution in urban management.

5.2.5.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Define the concept of Cloud Computing
- List 3 main characteristics of Cloud Computing
- Recognize 3 cloud service models
- Recognize 3 major public cloud providers with city management services

- List 3 advantages of adopting the cloud computing in the management of smart cities
- Indicate the 3 relevant roles involved in GovCloud
- List the 4 phases of the lifecycle for Governmental Clouds

5.2.5.7 References

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5.2.6 Competence title: Basic Concepts of Internet of Things

5.2.6.1 Competence description

The module Internet of Things (IoT) is about systems of interrelated computing devices, mechanical and digital machines provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.
The fast-increasing connectivity and integration of devices and objects, which is doubling every year in the 2020s worldwide, is enabling a broad and massive usage as the technological backbone of the smart city.

The definition of the Internet of Things has evolved due to the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems. Traditional fields of embedded systems, wireless sensor networks, control systems and automation including home and building automation all contribute to propelling the Internet of Things towards the broadly available, ubiquitous and pervasive Internet of Everything.
The module is based on interdisciplinary topics and tries to provide a big picture focusing on two important aspects:
- Theories and concepts of IoT
- Practical use cases to understand the theoretical concepts

5.2.6.2 Definitions

Actuator: A device that converts a control signal from a connected system to a physical task or a mechanical motion.

Embedded System usually is a computer with a dedicated function, usually a control function, within a larger mechanical or electrical system

Industrial internet of things refers to the extension and use of the internet of things (IoT) in industrial sectors and applications.

Internet of things (IoT) is a world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes. Services are available to interact with these "smart objects" over the Internet, query their state and any information associated with them, considering security and privacy issues.

Internet of things Cloud Platform provides services that simplify the integration of IoT devices and software services usually provided by cloud platforms. They include development and data analytics capabilities.

Radio Frequency Identification (RFID) tags are using radio frequencies to tag objects. It consists of three main components: an antenna, transceiver, and transponder.

A **Sensor** is a device that perceives and responds to physical stimulus produced from the physical object or from its environment, where the sensor is attached to.

Smart Objects are objects that are equipped with computing, positioning, and communication technologies and are integrated into the Internet of Things (IoT). Smart objects can produce, store and process data, and interact with other objects, systems, or people. They can be embedded or

fixed in other physical objects and capture data about position and sensors, as well as execute decision and control functions.

5.2.6.3 Knowledge domain

- Digitalization of Products, Processes and Business Models
- Internet of Things (IoT) and Internet of Everything
- Internet of Things for Consumers, Industry and Smart City

5.2.6.4 Learning objectives

Upon completion of the course, the learner will become proficient in:

- Connectivity of potential of devices and objects
- Tec hnological drivers and Phases of digitalization
- Steps of the digital value chain
- Value of data and analytics in digitalization
- Dimensions of digitalization
  - Products
  - Processes
  - Business Models
- Definition of IoT and Internet of Everything
- Basic concepts of IoT and IoT Services
- Components of IoT infrastructure
- Industrial and consumer IoT
- Industry Solution Model
- Smart City Internet of Things
- General Overview
- Smart Grids and Smart Metering
- Smart Mobility

5.2.6.5 Competence content (units)

The competence content is divided in the following units:

1	**Digitalization of Products, Processes and Business Models**	This unit introduces learners to the theory and practice of Digital Business. It includes: • Connectivity potential of devices and objects • Technological drivers and Phases of digitalization • Steps of the digital value chain • Value of data and analytics in digitalization • Dimensions of digitalization ○ Products

		○ Processes ○ Business Models
2	**Internet of Things (IoT) and Internet of Everything**	This unit introduces learners to the core theory and practice of Internet of Things (IoT) and Internet of Everything as central part of the module of the same name. It includes: • Definition of IoT and Internet of Everything • Basic concepts of IoT and IoT Services • Components of IoT infrastructure
3	**Internet of Things for Consumers, Industry and Smart City**	This unit introduces learners to the practice and use cases of Internet of Things for Consumers, Industry and Smart City as part of Internet of Things. It includes: • Industrial and consumer IoT • Industry Solution Model • Smart City Internet of Things ○ General Overview ○ Smart Grids and Smart Metering ○ Smart Mobility

5.2.6.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe Connectivity potential of devices and objects
- Identify Technological drivers and Phases of digitalization
- Define Steps of the digital value chain
- Describe the Value of data and analytics in digitalization
- Outline Dimensions of digitalization: Products, Processes and Business Models
- Define IoT, Internet of Everything and Basic Concepts of IoT and IoT Services
- Arrange Components of IoT infrastructure
- Identify Industrial and consumer IoT
- Outline the Industry Solution Model
- Describe Smart City Internet of Things
- Explain Smart Grids, Smart Metering and Smart Mobility of the Smart City IoT

5.2.6.7 References

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5.2.7 Competence title: Basic Concepts of Data Analytics

5.2.7.1 Competence description

This course offers an introduction to data analysis in order to produce useful predictions and conclusions from data. Emphasis will be placed on modelling real problems, comparing different methods in terms of their practical effectiveness and scaling. Students will also gain direct experience in collecting data from several sources and will develop the necessary skills to deal with data analysis problems in business applications.

5.2.7.2 Definitions

Big data refers to the large amounts of data that large organizations are collecting in various forms, e.g. streams of social media data, data collected from sensors, etc. Big data are routinely analyzed for revealing patterns, trends, and relationships.

Data analytics is the science of using algorithms for inspecting, cleansing, transforming, and modelling datasets to find trends and draw conclusions about the information they contain

Data mining is a technology used for extracting and identifying patterns in large data sets using machine learning, statistics, and database systems.

Descriptive statistics are statistics that are used to illustrate the essential characteristics of a study's data and they provide summaries of the sample and the metrics.

Estimation theory is a field of statistics that deals with estimating parameter values based on empirical data having a random component that has been measured

Machine learning is a field of artificial intelligence that focuses on the use of data, algorithms, and statistical models for analyzing and drawing inferences from patterns in data.

Predictive modelling is a statistical technique for predicting future behaviors. Predictive models are using historical and current data to generate a model that predicts future outcomes. It is a synonym of or largely overlaps with machine learning.

A **statistical hypothesis** is an assertion or conjecture concerning one or more populations. It is an assumption or statement, which may or may not be true concerning one or more populations.

5.2.7.3 Knowledge domain

- Data science

5.2.7.4 Learning objectives

After completing this module, the trainees will be able to:

- To understand the concept of data collection, processing and analysis;
- To demonstrate the basic relationships among the different variables of the data set;
- Interpret the results of data analysis according to the framework;
- To demonstrate the ability to make statistical propositions about a population;
- To demonstrate the uses of real-world data and analytics.

5.2.7.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to Data Analysis**	This unit presents learners with an introduction to the fundamentals definitions of Data Analysis
2	**Descriptive Statistics**	

		This unit presents learners with the fundamentals of Descriptive Statistics.
3	**Estimation Theory**	This unit presents learners with the fundamentals of Estimation Theory
4	**Statistical hypothesis generation and testing**	This unit sensitizes learners to barriers to creativity. It includes: • Most commonly cited barriers to creativity; • Mini Case Studies regarding barriers to creativity; • Best practices to overcome barriers to creativity.

5.2.7.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Understand the basic definitions of variables and data categorization
- Recognize different levels of measurement
- Define measures of central tendency
- Define measures of location of dispersions
- Perform graphical interpretations of the data
- Find patterns in the data set
- Explain the fundamental relationships among the variables of the data set
- Explain the fundamentals of Estimation Theory
- Apply estimation theory in real-world problems
- Demonstrate ability to understand hypothesis testing for a single sample
- Conduct statistical inference for two samples to solve smart problems
- Discuss the results of statistical hypotheses
- Perform design and analysis of multifactor case studies

5.2.7.7 References

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5.2.8 Competence title: Introduction to Artificial Intelligence

5.2.8.1 Competence description

In this module, learners will understand what Artificial Intelligence (AI) is, as well as its applications and use cases, and how they have transformed our lives.
AI concepts including machine learning, deep learning, and neural networks as well as use cases and applications of AI will be explored.
Learners will also deal with concerns surrounding AI such as ethics, bias, jobs, and their impact on society.
This module does not require any programming or computer science expertise and is designed to introduce the basics of AI to anyone, whether they have a technical background or not.

5.2.8.2 Definitions

Artificial Intelligence (AI) refers to intelligence exhibited by machines rather than natural intelligence posessed by people or animals.

Deep learning is a subfield of machine learning. The main characteristic of deep learning is the complexity of the mathematical model used in the analysis. Deep learning along with the increased computing power of modern computers has allowed researchers to increase this complexity to reach levels that appear not only quantitatively but also qualitatively different from before.

Machine learning is a field of artificial intelligence that focuses on the use of data, algorithms, and statistical models for analyzing and drawing inferences from patterns in data.

A **neural network** is a computational learning system that uses a network of functions to comprehend and transform input data into the desired output, generally of another form. Neural networks were inspired by human biology and the way neurons in the human brain work together to interpret sensory inputs.

Supervised learning is a category of machine learning which maps an input to an output based on example input-output pairs.

Unsupervised learning is a type of machine learning where the neural network is trained with data which are neither classified nor labeled, thus allowing the algorithm to act without supervision.

5.2.8.3 Knowledge domain

- Computer science
- Computational theory

5.2.8.4 Learning objectives

- To become familiar with the fundamentals of AI principles
- To understand the basic rules between AI and problem solving
- To understand the contribution of AI in real-life conditions
- To understand the most popular machine learning models
- To explore the potential, limitations, and implications of AI systems

5.2.8.5 Competence content (units)

The competence content is divided in the following units:

1	**What is Artificial Intelligence?**	Definitions of Artificial Intelligence, related scientific fields and a summary of its philosophy
2	**Artificial Intelligence and problem solving**	Presentation of the problem-solving process and how Artificial Intelligence can contribute to this end.
3	**Artificial Intelligence and uncertainty**	This unit introduces learners to the relationship between Artificial Intelligence and uncertainty.
4	**Machine learning**	This unit introduces learners to the relationship between Artificial Intelligence and "learning".

5	**Neural networks**	This unit introduces learners to a popular machine learning technique entitled Neural Network.
6	**Potentials and implications of Artificial Intelligence**	This unit summarizes the aspects of the Artificial Intelligence domain and provides an important discussion about the Implications of Artificial Intelligence domain in society (e.g. smart cities) and its future.

5.2.8.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Recognize if an application is AI or not.
- Recognize the different types of machine learning
- Understand the activation functions of a Neural network linear regression
- Convert odds to probabilities
- Convert probabilities to odds
- Indicate the AI-related fields involved in a given set of example tests
- Describe basic concepts of AI and its principles
- Construct a Taxonomy showing the relationships between the following things: AI, machine learning, computer science, data science, and deep learning.
- Solve "The Tower of Hanoi" problem
- Compute a linear regression example
- Compute the output of a given recommendation system.

5.2.8.7 References

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Jackson, P. C. (2019). Introduction to artificial intelligence. Courier Dover Publications.

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Nilsson, N. J. (2014). Principles of artificial intelligence. Morgan Kaufmann.

5.2.9 Competence title: Introduction to ITIL

5.2.9.1 Competence description

This course module introduces the trainees to ITIL best practices for IT Service Management.

5.2.9.2 Definitions

Continual Service Operation points at maintaining value for customers through the continual evaluation and improvement of the quality of services and the overall maturity of the ITSM service lifecycle and its underlying processes.

ITIL is the acronym of Information Technology Infrastructure Library and it is a public framework that describes best practices in IT service management. It provides a framework for the governance of IT, and the management and control of IT services.

ITIL Service Strategy deals with long-term decisions, ultimately aimed at defining a plan that, using a clear set of principles, can provide a solution to a business problem in a particular situation.

ITIL Service Design deals with the design and planning of new services or the modification and improvement of existing ones. In the context of the IT lifecycle, this is the stage that turns a new requirement coming from SS into a design that realizes business objectives.

ITIL Service Operation deals with delivering the agreed upon levels of service to users and customers, and managing applications, technology, and infrastructure that supports the delivery of services.

ITIL Service Transition is the IT lifecycle activity that takes care of modifying the existing infrastructure by updating or adding components.

A **service** is a means of delivering value to customers by facilitating outcomes customers want to achieve without the ownership of specific costs and risks.

Service management is a set of specialized organizational capabilities for enabling value for customers in the form of services.

5.2.9.3 Knowledge domain

General IT Knowledge

5.2.9.4 Learning objectives

The learning objectives are:

- Explaining what ITIL is;
- Defining roles in IT Service Management;
- Illustrating ITIL Service Lifecycles;
- Illustrating ITIL best practices.

5.2.9.5 Competence content (units)

The competence content is divided in the following units:

1	**Service Management and ITIL**	This unit introduces learners to IT Service Management and to the ITIL framework.
2	**ITIL Service Lifecycles: Service Strategy, Service Design and Service Transition**	This unit describes the ITIL Service Lifecycle focusing in particular on the three following phases: Service Strategy, Service Design and Service Transition. The principles and the processes of every phase will be explored.
3	**ITIL Service Lifecycles: Service Operation and Continual Service Improvement**	This unit describes the remaining two phases of the ITIL Service Lifecycle, namely the Service Operation and Continual Service Improvement. The principles and the processes of both phases will be explored.

5.2.9.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Define Service Management
- Define ITIL and its purposes
- Recognize the key-points of an IT Service
- Identify ITIL service lifecycles
- Define the service lifecycles phases
- Describe a number of Service Strategy practices
- Describe a number of Service Design practices
- Describe a number of Service Transition practices
- Describe a number of Service Operation practices

- Describe a number of Continual Service Improvement practices

5.2.9.7 References

AXELOS Limited. (2019). ITIL Foundation, ITIL 4 Edition. TSO (The Stationery Office).

Beisse, F. (2014). A guide to computer user support for help desk and support specialists. Cengage Learning.

Bon, J. V. (2019). ITIL 4-a pocket guide. Van Haren Publishing.

Cartlidge, A., Rudd, C., Smith, M., Wigzel, P., Rance, S., Shaw, S., & Wright, T. (2012). An introductory overview of ITIL. London: The Stationery Office.

Steinberg, R. A. (2014). Implementing Itsm: From Silos to Services: Transforming the It Organization to an It Service Management Valued Partner. Trafford Publishing.

DevOps Skills

5.3DevOps Skills

5.3.1 Competence title: DevOps Basic Concepts, Culture and Practices

5.3.1.1 Competence description

DevOps is a set of best practices that combines the two main phases of the software systems lifecycle: software development (Dev) and software system operations (Ops). This is a contemporary approach that aims to shorten the systems development life cycle and provide continuous delivery with high software quality.
Especially today, this is a mandatory requirement since software systems are critical to the operation of all organizations and particularly of complex systems such as smart cities, that have to operate on a 24/7 basis, with pressing and changing needs.

5.3.1.2 Definitions

Continuous Integration is a software engineering practice where changes are immediately tested and reported on when they are added to a larger codebase.

Deployment automation is the ability to automatically deploy software to testing and production environments**.** It includes the tools that enable automatically deploying software to testing and production environments.

DevOps is defined as "a set of practices intended to reduce the time between committing a change to a system and the change being placed into normal production while ensuring high quality".

Infrastructure automation is the process of scripting IT environments.

Release management is the process of managing, planning, scheduling, and controlling a software build through different stages and environments, including testing and deploying software releases.

A **software Build** specifies how the software is to be built, what steps are needed and in what order, what dependencies are required, and what other software is needed to be present for the build to succeed.

Version control is a system that records changes to software system components over time so that we can recall specific versions later.

5.3.1.3 Knowledge domain

DevOps Skills

5.3.1.4 Learning objectives

The learning objectives of this module are the following:

- To understand key principles and concepts of the DevOps approach.
- To understand the DevOps process
- To understand the key DevOps capabilities such as continuous delivery capabilities, architectural capabilities, product and process capabilities, lean management and monitoring capabilities, etc.
- To understand the DevOps culture

5.3.1.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction DevOps Foundational Terminology and Concepts**	This unit introduces learners to DevOps approach. It includes: • Software development methodologies; • IT operation methodologies; • Development, Release, and Deployment Concepts; • Infrastructure concepts; • Cultural concepts.
2	**DevOps Capabilities to drive improvement**	This unit presents: • Continuous delivery capabilities; • Architectural capabilities; • Product and process capabilities; • Lean management and monitoring capabilities; • DevOps Cultural capabilities.

3	**DevOps tools ecosystem**	This unit includes: • Version control; • Development environment; • Configuration management; • Infrastructure automation; • System provisioning; • Test and build automation; • Monitoring; • Teamworking environment.

5.3.1.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the key principles and concepts of the DevOps approach
- Describe the DevOps lifecycle
- Define the concepts of continuous delivery capabilities
- Describe the DevOps architectural capabilities
- Describe DevOps teamworking and interaction with customers
- Define the concepts of lean management and monitoring capabilities
- Define key tools in a DevOps ecosystem
- Explain the differences of DevOps and traditional software lifecycles
- Describe DevOps best practices
- Demonstrate understanding of DevOps culture

5.3.1.7 References

Davis, J., & Daniels, R. (2016). Effective DevOps: building a culture of collaboration, affinity, and tooling at scale. O'Reilly Media, Inc.

Freeman, E. (2019). DevOps For Dummies. John Wiley & Sons.

Humble, J., & Kim, G. (2018). Accelerate: The science of lean software and devops: Building and scaling high performing technology organizations. IT Revolution. Retrieved from https://cloud.google.com/devops

Senapathi, M., Buchan, J., & Osman, H. (2018, June). DevOps capabilities, practices, and challenges: Insights from a case study. In Proceedings of the 22nd International Conference on Evaluation and Assessment in Software Engineering 2018 (pp. 57-67).

Verona, J., Duffy, M., & Swartout, P. (2016). Learning DevOps: Continuously Deliver Better Software. Packt Publishing Ltd.

5.3.2 Competence title: Repository Management

5.3.2.1 Competence description

This module introduces learners to critical, high-level theory, best practice, and practical application in order to make them familiar with the basic principles and terminology related to repository management systems.

5.3.2.2 Definitions

A **repository manager** is a server application that manages all repositories necessary for development. It is an optimized system that is used to manage parts of the development process.

Metadata describes a binary artifact, is stored and specified separately from the artifact, and can have multiple uses.

A **software component** is an entity with a discrete structure within a system and it can be any resource used by an application. A component, also known as an artifact, is a resource, like a library or a framework, that is used as part of an application at run-time, integration, or unit test execution time, or required as part of the build process.

A **software repository** is known as a place to keep resources that users can pull from when necessary. Software repositories serve the general purpose of promoting collaborative use by offering remote access to code modules and software packages. A software repository is also known as a code repository.

5.3.2.3 Knowledge domain

Information Science, software development, DevOps

5.3.2.4 Learning objectives

- Recognize the main parts and basic functions of a repository manager
- Become familiar with components and formats that are supported in a repository manager
- Identify the different repository types
- Know main RM tools
- Make an organizational repository planning checklist

5.3.2.5 Competence content (units)

The competence content is divided in the following units:

1	**What is a Repository Manager?**	In this unit, learners will become familiar with the basic functions of a repository manager. In specific, they will be able to a) describe the importance of a repository manager in modern software development, and b) determine current and future software supply chain goals and the role of a Repository Manager within an organization.
2	**Architecture of a Repository Manager**	In this unit, participants will learn to describe the main ingredients of a repository manager, such as components and formats, as well as the interaction between them.
3	**Types of repositories**	In this unit, learners will familiarize themselves with the basic types of a repository, such as proxy, hosted and group repository. In addition, a process for the selection of the appropriate type of repository for an organization will be presented.
4	**Examples of using RM (e.g. Archiva) from a build tool**	In this learning object, learners will become familiar with the basic functionalities of the Archiva repository manager system.

5.3.2.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Recognize what a repository manager is
- Recognize what a component is
- Recognize what a repository format is
- Recognize what a repository type is
- Recognize the purpose of a repository group
- Identify the main characteristics of a repository manager
- Describe how a repository manager can support the software development cycle
- Understand the usage of RM in DevOps
- Describe the role of a RM within Smart City architecture

5.3.2.7 References

Hethey, J. M. (2013). GitLab Repository Management. Packt Publishing.

O'Brien, T., & Mountain View Sonatype Inc. (2008). Maven: the definitive guide. O'Reilly.

Pathania, N. (2017). Learning Continuous Integration with Jenkins: A Beginner's Guide to Implementing Continuous Integration and Continuous Delivery Using Jenkins 2. Packt Publishing Ltd.

Westby, E. J. H. (2015). Git for teams: a user-centered approach to creating efficient workflows in Git. O'Reilly Media, Inc.

Wolff, E. (2017). A practical guide to continuous delivery. Addison-Wesley Professional.

5.3.3 Competence title: Continuous Integration

5.3.3.1 Competence description

Continuous integration is a software development methodology of daily developer integrations verified by automated builds. More specifically, in Continuous Integration after a code commit, the software is built and tested immediately. In a large project with many developers, commits are made many times during a day. With each commit code is built and tested. If the test is passed, build is tested for deployment. If deployment is successful, the code is pushed to production. This commit, build, test, and deploy is a continuous process, hence the name continuous integration/deployment.
A Continuous Integration Pipeline is a powerful instrument that consists of a set of tools designed to host, monitor, compile and test code, or code changes. This course will describe the continuous integration process, the instruments that are being used during this process and the benefits for business through explained cases.
Further, emphasis will be given to Jenkins, the open source Continuous Integration Server, capable of orchestrating a chain of actions that help to achieve the Continuous Integration process in an automated fashion.

5.3.3.2 Definitions

Continuous delivery is a software development discipline where developers build software in such a way that the software can be released to production at any time.

In **continuous deployment,** every change a developer is making automatically gets deployed through the deployment pipeline.

Continuous integration is a software development practice where members of a team integrate their work frequently; usually, each person integrates at least daily leading to multiple integrations per day. It is the practice of merging development work with the main branch constantly.

GitHub is a well-known public repository for external collaboration

Integration is the process of merging all software and/or hardware components into one functioning system.

A **continuous delivery pipeline** is an automated process for delivering software from version control directly to users and customers. This process involves building the software in a reliable and repeatable manner, as well as progressing the built software through multiple stages of testing and deployment.

A **software build** is a process by which source code is converted into a stand-alone form that can be run on a computer.

5.3.3.3 Knowledge domain

Management skills; Software Engineering skills; computer science skills

5.3.3.4 Learning objectives

The learning objectives of this module are the following:

- To understand the importance and the key principles in continuous integration.
- To become familiar with the continuous integration pipeline.
- To recognize the tools that are being used under the continuous integration process.
- To be able to describe how the continuous integration process is being performed via Jenkins

5.3.3.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to Continuous Integration**	This unit introduces learners to the Continuous Integration (CI) context. It includes:

		• The parts of a software build process and the requirements for Continuous Integration (CI) • The pros and pons of CI
2	**Continuous Integration Tools**	This unit introduces learners to CI tools. It includes: • The Continuous Integration (CI) Pipeline tools • An overview of a representative CI tool: Jenkins
3	**The Continuous Integration pipeline**	This unit introduces the learners to the Continuous Integration (CI) pipeline. It includes: • A typical Continuous Integration (CI) pipeline • An analysis of the Continuous Integration Pipeline with a typical CI tool (Jenkins)
4	**The Continuous Integration tools: management, administration, scaling**	This unit introduces learners to the management, administration and scaling processes of a CI tool. It includes: • CI Management, Administration and scaling processes • Performing the processes with a typical CI tool: the Jenkins Management, System Administration and scaling context

5.3.3.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the concept of continuous integration
- Define the concepts of software project, code commits, version control, delivery and deployment, automation
- Present a number of risks that are being reduced via continuous integration
- List the continuous integration process steps
- Present the advantages of continuous integration

- Name 2 examples for each of the 4 sets of continuous integration tools
- List the 6 build phases needed for a software project
- List the advantages and disadvantages of using CI tools
- Outline the Continuous Integration (CI) pipeline with a CI tool
- Explain the terms that deal with CI tools (pipeline, visualization, management, administration, scaling)
- Describe business cases of Continuous Integration errors
- Refer and apply good practices for CI planning and management
- Perform simple Continuous Integration (CI) tasks with a CI tool

5.3.3.7 References

Amazon (2017). Practicing Continuous Integration and Continuous Delivery on AWS: Accelerating Software Delivery with DevOps. Retrieved, May 10, 2020 from https://d0.awsstatic.com/whitepapers/DevOps/practicing-continuous-integration-continuous-delivery-on-AWS.pdf

Duvall, P. M., Matyas, S., & Glover, A. (2007). Continuous integration: improving software quality and reducing risk. Pearson Education.

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5.3.4 Competence title: ***Configuration Management***

5.3.4.1 Competence description

The module Configuration Management (CM) is a discipline applying technical and administrative direction and surveillance to:

- identify and document the functional and physical characteristics of a configuration item,
- control changes to those characteristics,

- record and report change processing and implementation status, and
- verify compliance with specified requirements.

5.3.4.2 Definitions

Baseline is defined as the starting point for a project or a development activity and it is fixed at a specific time during a configuration item's life cycle. This baseline can be used as the basis for further development of the system.

Configuration Management is a discipline applying technical and administrative direction and surveillance to a) identify and document the functional and physical characteristics of a configuration item, b) to control changes to those characteristics, c) to record and report change processing and implementation status, and d) to verify compliance with specified requirements.

A **release** is a program (package) that has been completed by development. It consists of several SCIs that work together in a defined configuration.

Release Management is the process of planning, manufacturing, testing, and deployment of hardware and software. It includes version control and software storage.

A **Software Configuration Item (SCI)** or simply Configuration Item (CI) is a component of a system that can be identified as a self-contained unit for purposes of change control and identification. A complete set of CI constitutes a release of a software system.

5.3.4.3 Knowledge domain

- Software Configuration Management (SCM) as classical approach
  - Activities in SCM
  - Tools in SCM (SCM Library)
  - System Example classical SCM (iTop)
  - Elements in SCM (Software Configuration Items)
  - Change Requests in SCM
  - Audits in SCM
- Release Management (RM) for implementation status and compliance
  - Workflow in RM
  - Roles in RM
  - Example Microsoft for RM

- Disadvantages and Problems of classical SCM and RM approach
- DevOps as agile approach for CM
  - DevOps Fast Release Cycles
  - DevOps Deployment Pipeline
  - Example Continuous Delivery at Spotify
  - Advantages of CM and RM
- System Examples DevOps (Chef, Puppet)

5.3.4.4 Learning objectives

Upon completion of the course, the learner will become proficient in:

- Configuration Management as classical and agile approach.
- Identifying and documenting the functional and physical characteristics of a configuration item, control changes to those characteristics, recording and reporting change processing and implementation status, and verifying compliance with specified requirements.
  This course aims to equip you with the core concept of configuration management as well as agile concept for DevOps, pros and cons, system examples and use cases from Microsoft and Spotify.

5.3.4.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to Configuration Management**	This unit introduces learners to the theory and practice of Configuration Management. It includes: • Basic concepts of Configuration Management (CM) • Activities, Tools and Elements of CM • Change Requests and Audits in CM
2	**Release Management**	This unit introduces learners to the theory and practice of Release Management as part of Configuration Management. It includes: • Workflow in Release Management (RM) • Roles in RM • Example for RM • Disadvantages and Problems of classical SCM and RM approach

3	**DevOps Specifics of Configuration Management**	This unit introduces learners to DevOps Specifics of Configuration Management. It includes:
		• DevOps as agile approach for CM
		  ○ DevOps Fast Release Cycles
		  ○ DevOps Deployment Pipeline
		  ○ Example for Continuous Delivery
		• Advantages of CM and RM
		• System Examples DevOps (Chef, Puppet)

5.3.4.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe basic concepts of configuration management
- Identify activities, tools and elements of configuration management
- Describe workflows and roles of release management
- Distinguish between classical approach and DevOps specifics of configuration management
- Describe how to implement configuration management in a microservice environment

5.3.4.7 References

Aiello, B., & Sachs, L. (2010). Configuration Management Best Practices: Practical Methods that Work in the Real World. Pearson Education.

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Humble, J., Farley, D. (2010). Continuous Delivery: Reliable Software Releases Through Build, Test, and Deployment Automation. Addison-Wesley Signature Series.

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Sommerville, I. (2015). Software Engineering, Global Edition (10. Aufl.). Harlow, Essex: Pearson Education.

5.3.5 Competence title: Using Build, Deployment and Monitoring Tools

5.3.5.1 Competence description

This course module provides the trainees with the main introductory concepts on build, deployment and monitoring tools within the DevOps framework.

5.3.5.2 Definitions

Build automation is the process of scripting and automating the creation of a software build and the associated tasks.

Deployment automation is the automated process that enables the deployment of software to testing and production environments with the push of a button.

A **software build** is a process by which source code is converted into a stand-alone form that can be run on a computer.

Software deployment is the process required for preparing a software application to run and operate in a specific environment. It involves: a) installation, b) system configuration, c) testing, and d) optimization of software performance.

5.3.5.3 Knowledge domain

DevOps skills

5.3.5.4 Learning objectives

The learning objectives of this module are the following:

- Build automation in DevOps;
- Deployment routines, processes, systems and tools for building either applications or entire end-to-end services;
- Deployment Patterns for Building Applications or Services;
- Monitoring and alerting criteria.

5.3.5.5 Competence content (units)

The competence content is divided in the following units:

1	**Build and deployment tools**	This unit analyzes build and deployment tools in DevOps. The most common automated build and deployment tools will be explored.
2	**Monitoring tools**	This unit describes monitoring tools in DevOps. The most common monitoring tools will be explored.

5.3.5.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the build automation process;
- List a number of build tools in DevOps;
- Describe the deployment process;
- List a number of deployment tools in DevOps;
- Describe the monitoring process;
- List a number of monitoring tools in DevOps;
- Discuss the advantages in build automation process using DevOps;
- Discuss the advantages in deployment process using DevOps;
- Discuss the advantages in monitoring process using DevOps.

5.3.5.7 References

Clark, M. (2004). Pragmatic project automation: how to build, deploy, and monitor Java applications. The Pragmatic Programmers, LLC.

Humble, J., & Farley, D. (2010). Continuous delivery: reliable software releases through build, test, and deployment automation. Pearson Education.

Leszko, R. (2017). Continuous Delivery with Docker and Jenkins. Packt Publishing Ltd.

Pressman, R. S. (2005). Software engineering: a practitioner's approach. Palgrave macmillan.

Wolff, E. (2017). A practical guide to continuous delivery. Addison-Wesley Professional.

5.3.6 Competence title: Code Analysis and Continuous Testing Tools

5.3.6.1 Competence description

In DevOps there is an increased need for source code analysis and review tools that assist software developers in avoiding bugs. An example of the former is the SpotBugs or SonarQube tools that can be used to detect various types of issues. An example of the latter is GitHub which enables code reviews.
Furthermore, using both systematic and automated testing, developers are assured that their source code meets both functional and quality criteria. This module will equip learners with the required skills to use static analysis and code review tools, as well as tools for systematic and automated testing.

5.3.6.2 Definitions

Automated testing is an approach in software testing that makes use of software testing tools to control the execution of tests and then compares the test results with the expected results.

Branching (also known as trunk), in version control and software configuration management, is the duplication of a software artifact (object) under version control.

Code review (also known as peer review) is a software quality assurance activity in which one or more individuals, members of the project team, examine the software aiming at gathering as many errors as possible early on in the software development process and consequently creating a software product of better quality.

Software metrics are measuring the "success" of a software or a software process. Metrics can be used to improve the development process and makes future projects more successful or to improve the software quality as such.

Static code analysis is a method of debugging that involves analyzing source code before running a program. It is accomplished by analyzing software code against a set (or several sets) of coding rules.

Testing is an activity where a system or software component is executed under clearly defined conditions and the results of this execution are observed to ensure that they are correct or that they meet customer expectations.

5.3.6.3 Knowledge domain

Software Engineering

5.3.6.4 Learning objectives

The learning objectives of this module are the following:

- To understand key concepts of static code analysis.
- To understand key concepts of collaborative source code development and review.
- To understand key concepts of systematic and automated testing.
- To become familiar with some of the tools and techniques for static analysis and review.
- To be able to develop and apply systematic and automated testing in the source code under development.

5.3.6.5 Competence content (units)

The competence content is divided in the following units:

1	**Static code analysis**	This unit discusses static source code analysis. Static source code analysis is analysis that is performed without executing the software. Instead, it uses some source code representation to derive conclusions about the quality of the program, including possible error conditions that are not detected by the compiler alone. Types of issues detected by static analysis include: • Bugs, such as infinite loops, methods not checking for null arguments and using them right away, etc. • Vulnerabilities, such as hardcoded database passwords, etc. • Code smells, such as method returning null when they have Boolean return type, etc. • Introduction of the above by using tools.

2	**Collaborative software development and review**	This unit will discuss collaborative software development, in general, and software inspections and reviews, in particular. First, the various formal approaches to software inspections and reviews are introduced along with the advantages of using software inspections as a tool for software quality. Then, contemporary approaches to software peer review practices will be discussed. Finally, we will approach software reviews as a composite part of collaborative software development using modern tools such as Git and GitHub. We will discuss the process as well as the various tools that can be used in such approaches, and we will examine practical applications scenarios.
3	**Systematic and automated software testing**	This unit discusses the various pieces that make up contemporary software testing in everyday software development practice. In particular, we will examine software unit testing as the cornerstone of quality in professional software development. We will also discuss software test coverage that can be used to indicate when enough testing has been performed. Finally, we will discuss other pieces of the testing landscape, including mock objects and performance testing. The unit will introduce the above-mentioned approaches to testing, using tools and numerous practical application examples. The tools that we will use include, Junit framework, Mockito, EclEmma and Apache JMeter.

5.3.6.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the 3 types of issues that can be present in the source code (i.e. bugs, vulnerabilities and code smells)
- Identify 5 types of bug patterns that can be detected with static analysis.
- State 3 different ways in which a static analysis tool can be incorporated in the development lifecycle.
- Distinguish the 5 types of SEVERITY of issues (i.e. Blocker, Critical, Major, Minor, Info).
- Describe the 3 different types of code review approaches (i.e. Tool-based, Ad-hoc and Meeting-based).
- Outline the 3 different types of supporting branches on Git/Github.
- Explain at least 3 benefits of code reviews.
- Explain at least 3 steps of code reviews on GitHub.
- Identify at least 3 different types of automated tests (e.g. Unit, integration, acceptance, etc.).
- Describe 3 advantages of automated and systematic testing.
- Describe 3 different types of code coverage.
- List 3 advantages of using mock objects.

5.3.6.7 References

Chacon S., & Straub B. (2014) Github (chapter). In: Pro Git. Apress, Berkeley, CA.

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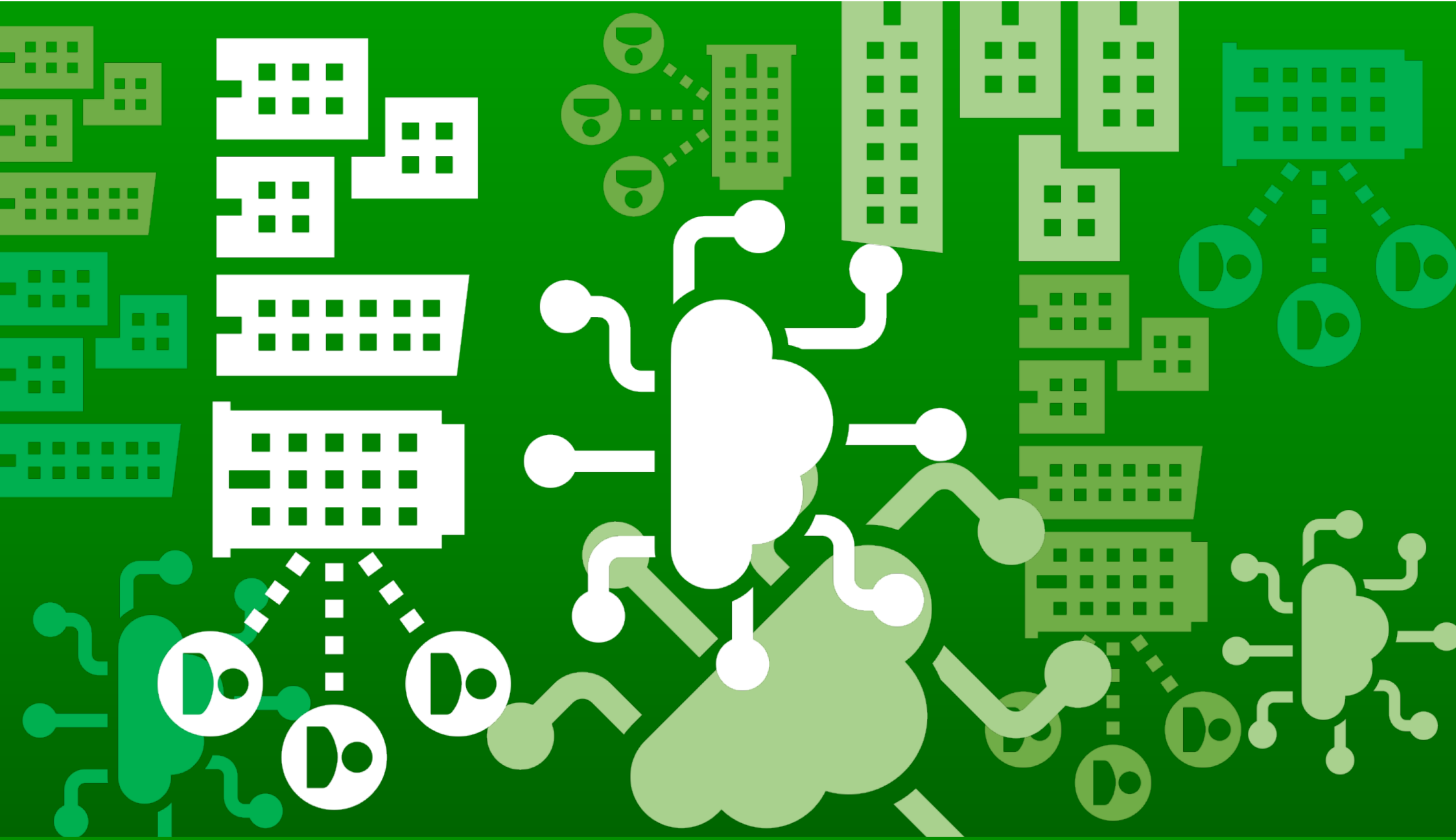

Smart cities Related Skills

5.4 Smart Cities Related Skills

5.4.1 Competence title: Smart Cities Platforms

5.4.1.1 Competence description

This module explores the role of technology and data in cities, and teaches how to participate in the creation of smart cities.

5.4.1.2 Definitions

A **digital platform** is a technological artifact facilitating the interactions between two or more parties through a data-driven approach.

A **smart city application** is a smart system application that has a specific function: e.g. smart street lighting, smart bins, or smart drains

A **smart infrastructure** could be defined as a digital system that provides integrated management of all elements of urban infrastructure.

A **smart city platform** is a digital platform applied to a smart city. It consists of a framework for sensing, communications, and integration. Smart city platforms are IoT-enabled solutions that allow smart city end users to gain seamless access to data previously spread across multiple silos of functionality.

5.4.1.3 Knowledge domain

Management

5.4.1.4 Learning objectives

- Define what makes a City a Smart City
- Identify the domains of a Smart City
- Identify the three layers of "smartness" of a Smart City
- Know some examples of Smart Cities

5.4.1.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to Smart City**	The unit allows you to share a single thesaurus on the definition of smart city, to share what global trends are, to learn what the hidden costs of a city are, and to

		identify the challenge facing the city manager.
2	**The Domains of a Smart City**	This unit allows you to identify which the 8 main domains of a smart city are
3	**The three layers of "smartness"**	After acquiring a common thesaurus and identifying the domains on which a smart city impacts, it is necessary to identify the three levels of "smartness".
4	**The platform approach**	The unit aims at introducing the concept of platform and identifying its advantages compared to a silos approach.
5	**Examples of Smart Cities around the world**	The unit analyzes some examples of smart cities around the world to help stakeholders imagine which examples are relevant to their smart city.

5.4.1.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Define a Smart City
- Identify the smart city drivers
- Identify the domains of a smart city
- Identify the layers of "smartness" of a Smart City
- Describe why a platform approach is necessary
- Analyze some example of Smart Cities around the world

5.4.1.7 References

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5.4.2 Competence title: Smart Cities Business Models and Financial Management

5.4.2.1 Competence description

Cities are challenged with increasing population and need to implement smart solutions to become more resilient to economic, environmental and social challenges. This module examines the innovative business models in the context of smart cities, analyzes the most important existing business models as well as the emerging business models for smart cities.

5.4.2.2 Definitions

A **business model** describes the rationale of how an organization creates, delivers, and captures value. It is a method by which a firm builds and uses its resources to offer customers better value.

Business model canvas is a strategic management template that enables the development of business models. It enables the description of business value proposition, resources, customers, and finances.

An **innovative business model** is a variation of a generic value chain underlying all businesses, which deals with the production or the marketing of business activities.

A **smart city business model** defines how a smart city can create and deliver value to its citizens through the development of smart services that are economically and socially viable, while minimizing the city's environmental footprint.

5.4.2.3 Knowledge domain

Management, Entrepreneurship

5.4.2.4 Learning objectives

- To define a framework for understanding and describing innovative business models.
- To recognize the different types of companies in smart city and emphasize the smart city ecosystem.
- To select a smart city business model.
- To explain what smart cities are, exploring the contrasting visions of how they will transform our urban environments and lives, and to consider whether smart cities can be sustainable.
- To identify the role of people in smart cities and different approaches that cities are taking, from city led roadmaps, to smart business services, and to co-designed solutions with citizens through living labs.
- To understand the role that technology, data and urban analytics can play in transforming cities and to consider challenges and best practices in order to overcome them, such as data ownership, privacy, and ethics.
- To define a methodological approach of analyzing business models.

5.4.2.5 Competence content (units)

The competence content is divided in the following units:

1	**Business model and business model innovation**	This unit introduces learners to innovative business models. It includes: • The concept of innovative business models and different types of innovative business models; • The concept of a business model; • Patterns of classifying business models; • Building blocks of Business Model Canvas; • Methodological approach for analyzing business models.

2	**The ecosystem around the Smart city**	This unit introduces learners to the ecosystem around the smart city. It includes: • Debates around smart, sustainable and future cities; • The components of a smart city ecosystem; • The smart city conceptual models.
3	**Smart city business models**	This unit introduces learners to smart city business models. It includes: • The smart city value; • Types of companies in smart city; • Smart city business models; • Role of leadership and governance in creating smart cities.
4	**Challenges and opportunities for smart city business models**	This unit sensitizes learners to challenges and opportunities to smart city business models. It includes: • Most commonly cited barriers to smart city business models; • Addressing key urban challenges; • Mini Case Studies regarding barriers to smart city business models; • Best practices to overcome barriers to smart city business models; • Importance of ICT, data and urban analytics.

5.4.2.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Define the concept of innovative business models
- Identify different types of innovative business models
- Describe the concept of a business model
- Define patterns to classify business models

- Identify the building blocks of Business Model Canvas
- Recognize the concepts and current debates around smart, sustainable and future cities
- Define the components of a smart city ecosystem
- Identify smart city conceptual models
- Describe different groups related to business models for Smart Cities
- Discuss different approaches for citizen engagement in smart city planning
- Identify the connections between urban innovation, enterprise and smart city business models
- Discuss the challenges related to the smart city business model
- Explain the role and importance that ICT, data and urban analytics can play in addressing key urban challenges.

5.4.2.7 References

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5.4.3 Competence title: Smart Services and Operating Procedures

5.4.3.1 Competence description

The topic of Smart Cities inspires people to imagine how new technologies could support city services and change their daily life. This course module in the introductory unit offers trainees a basic understanding of Smart City concepts and discusses the challenges that a city faces in order to become smart. Then, it elaborates further, describing the cutting edge technologies employed in the running of a Smart City. Furthermore, it introduces some of the most used smart services, it presents the different perspectives on Smart City services from different sectors of stakeholders, and in the final unit it concludes by describing success stories about Smart Cities and their development experience.

5.4.3.2 Definitions

Digitalization is the use of digital technologies to implement a business model and at the same time to provide business innovation.

A **smart infrastructure** could be defined as a digital system that allows for integrated management of all elements of urban infrastructure.

A **Smart Service** is a digital cross-functional business service that reacts on collected and analyzed data based on networked, intelligent technical systems and platforms. Smart services are considered as individually configured systems, merging physical layer (infrastructure), digital services (access to computational capacity), and data (integrating contextualized and personalized data).

The urban infrastructure consists of the basic facilities, services, and installations needed for the functioning of a community or society.

5.4.3.3 Knowledge domain

Smart Cities

5.4.3.4 Learning objectives

- Learn fundamental concepts about SCs
- Challenges to develop a SC
- Infrastructures of a SC
- Introduce the cutting-edge technologies that could transform a city
- Have a holistic view of SC major services
- Understand the involvement of different stakeholders

- Introduce some best practices examples of SCs worldwide
- Understand business aspects of SC services

5.4.3.5 Competence content (units)

The competence content is divided in the following units:

1	**Smart Cities and their development procedure**	The purpose of the first unit is to cover the foundations of Smart Cities (SC) and introduce trainees to how they are being developed. Moreover, trainees will become familiar with the challenges that must be confronted and understand the main steps and considerations of the SC transition.
2	**Smart Cities cutting edge technologies and infrastructures**	A Smart City utilizes technology to develop and connect components across the city, and it impacts every layer of a city, from underneath the streets to the air that citizens are breathing. This is achieved through progress in new technologies. In this unit, trainees will gain an understanding of the City Infrastructure Model and the innovative technologies employed to improve city applications and services.
3	**Smart City stakeholders roles and needs regarding SC services**	This unit introduces the major sectors of stakeholders of Smart Cities and explains the different perspectives that different stakeholders have about services in a SC.

4	**Success stories: Smart Cities and their development experience**	This final unit introduces trainees to some best practices examples of Smart Cities worldwide and the specific models that are applied. Trainees will discuss the implications of digitalization on cities, the different perspectives participants of a Smart City have, understand the business aspects of Smart City services and their performance, in particular their management and governance.

5.4.3.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the main concepts of a SC
- Describe what a SC is
- Outline the infrastructures and how they could be transformed in a SC context
- Identify the cutting edge technologies that enable a city to become smart
- Identify the challenges of introducing new technologies, new approaches to digital citizenship
- Name 4 SC worldwide
- Describe 5 smart services that a SC could provide
- Recognize what challenges a city faces in order to become smart
- Explain the different perspectives that stakeholders have in a SC
- Give examples of stakeholder involvement
- Describe the role of technologies involved in a SC
- Recognize models, reference architectures and different strategies used to implement the various smart cities
- Argue whether a city has the qualifications to be a SC

5.4.3.7 References

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5.4.4 Competence title: Smart City Sustainability

5.4.4.1 Competence description

This module explores the theme of sustainability of smart cities by analyzing the methods to measure it, monitor it and improve it.

5.4.4.2 Definitions

Blue economy refers to economic activities that create sustainable wealth from the world's oceans and coasts.

Climate change is the long-term shift in global weather patterns or average temperatures. Rising temperatures can lead to extreme weather conditions, such as droughts, rising sea levels, and retreating glaciers.

A **smart sustainable city** is an innovative city that uses ICTs and other means to improve quality of life, the efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental, as well as cultural aspects.

Sustainability is most commonly referred to as: "meeting the needs of the current generation without compromising the ability of future generations to meet their own needs".

Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

5.4.4.3 Knowledge domain

Planning, management, monitoring.

5.4.4.4 Learning objectives

- Understanding of equality and diversity, inclusivity and social cohesion
- Developing trust and sense of community
- Developing responsible citizens
- Understanding and practicing group decision making
- Ability to see the "bigger picture"
- Commitment in developing sustainability
- Knowledge of ecological and circular economy approaches

5.4.4.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to city sustainability**	In this learning unit, the concept of sustainability is introduced by examining the different aspects involved in urban areas.
2	**Monitoring smart city sustainability**	This unit introduces some methods to measure the degree of sustainability of a city through the use of multiple indicators and combinations of them with the aim of monitoring its progress over time.
3	**Improving smart city sustainability**	This unit introduces sustainable urban planning and illustrates how to implement a process for assessment and on-going improvement.

5.4.4.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Define the concept of sustainable city
- List the 3 aspects of urban sustainability
- List 3 requirements of a sustainable smart city
- List 3 main methods for measuring the sustainability of cities
- List the 3 classes of key performance indicators (KPIs)
- List 3 thematic priorities to understand urban systems and improve city sustainability

- Identify 3 major steps of the roadmap of environmental sustainability and resilience.
- Analyze some aspects related to the sustainability of a city
- Propose methods to improve the sustainability of a city

5.4.4.7 References

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5.4.5 Competence title: Smart City Standards and Legal Issues

5.4.5.1 Competence description

Standardization is the process of "technological convergence", as well as of innovation clarification. It is defined as "the consistent use of methodologies, procedures, tools, and techniques specified above the level of individual projects". Smart city (SC) is an emerging topic, which has been evolving since the early 1990s. Almost all standardization bodies develop standards for SC. The aim of this module is twofold: it will describe the SC standardization process together with specifications and guidelines for the SC development that are introduced at international, supranational and national levels; since standardization introduces norms for the SC development, existing rules/legislation will be demonstrated that come up from European and International organizations.

5.4.5.2 Definitions

A **smart city** is a concept and a model, which applies the new generation of information technologies, such as the internet of things, cloud computing, big data, and space/geographical information integration, to facilitate the planning, construction, management, and smart services of cities.

Smart City standardization is the application of the standardization process to the smart city domain in an attempt to define the terms and provide specifications for smart city products and services.

Standardization is the consistent use of methodologies, procedures, tools, and techniques specified above the level of individual projects.

A **standard** is a document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines, or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.

5.4.5.3 Knowledge domain

Standardization; Smart City

5.4.5.4 Learning objectives

The learning objectives of this module are the following:

- To understand key principles in smart city (SC) standardization.

- To become familiar with existing SC standards, specifications and techniques and with European and International norms.
- To compare competitive SC standards.
- To be able to use standards for SC development and to align to SC legal rules.

5.4.5.5 Competence content (units)

The competence content is divided in the following units:

1	**The Smart City (SC) standardization environment**	This unit introduces learners to the standardization and the SC standardization processes. It includes: • An introduction to standardization • A brief presentation of SC standardization • SC standardization process at the international level • A brief analysis of the ISO and ITU SC series
2	**European SC standardization**	This unit introduces learners to the European SC standardization process. It includes: • The standardization structure in Europe • SC standardization in Europe
3	**National SC standardization**	This learning object introduces learners to national SC standardization process. It uses the case from BSI in UK as a model. It includes: • SC standardization at the national level • A brief demonstration of the UK SC standard (BSI)

4	**Policies, norms and frameworks for SC development**	This learning object introduces learners to the SC legal framework and norms, with a focus on Europe. It includes: • A brief introduction to the SC frameworks and norms • The European SC policy

5.4.5.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Define the terms standardization and smart city (SC) standardization.
- Describe the SC technological and service context according to ISO and ITU international standards
- List the international and supranational standardization bodies that work with SC
- Outline different SC standardization areas
- List competitive SC international and supranational standards
- Present an typical standardized SC development framework
- Outline the basic steps of SC development
- Describe how SC standardization is interrelated at international, supranational and national levels
- Highlight the European SC policy and legal framework
- Illustrate the European SC standardization environment
- Explain the concept of "SC ecosystem" that requires standardization

5.4.5.7 References

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5.4.6 Competence title: Smart City Resilience

5.4.6.1 Competence description

This module explores the topic of resilience by providing the tools to make smart cities ready to adapt to crises and changes. Planning the resilience of a city also allows to seize the opportunities that can arise from negative events.

5.4.6.2 Definitions

Disaster resilience is a combination of a smart city's preparedness for a hazard, and its ability to plan, mitigate, and respond immediately and effectively to it. It involves a city's ability to recover and regenerate from the event

Resilience is "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner."

A **resilient city** is a city where strong leadership, coordination, and responsibilities in disaster risk management are clearly defined. Stakeholder engagement, well-defined policies and strategies, effective lines communication, and effective risk management are all characteristics of a resilient city.

Sendai framework for disaster risk reduction is a major international agreement and aims for "the substantial reduction of disaster risk and losses in lives, livelihoods, and health and the economic, physical, social, cultural and environmental assets of persons, businesses, communities, and countries."

Urban resilience is the ability of the city to adapt to changing conditions, and withstand and rapidly recover from disruption due to emergencies.

5.4.6.3 Knowledge domain

Planning, management, monitoring.

5.4.6.4 Learning objectives

- Definitions for resilient cities.
- Strategy and planning of resilience smart cities.
- Transformation of smart cities to resilient smart cities.
- Standards and performance indicators for smart city resilience.

5.4.6.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction to city resilience**	This learning unit introduces the concept of urban resilience by describing the main principles and concepts of the resilience of smart cities.
2	**Monitoring smart city resilience**	This unit presents some useful tools for local governments for assessing risks and the degree of resilience of a city, for the development of disaster risk reduction [DRR] action plans, and for improving resilience.
3	**Improving smart city resilience**	This learning unit introduces some key points for making cities resilient by promoting sustainable urban development and resilience activities and increasing local understanding of risk.

5.4.6.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- List 3 requirements of a resilient city
- List 3 of the priorities for action of the Sendai Framework for Disaster Risk Reduction
- Identify 4 of the main actors involved in obtaining sustainable development and disaster risk reduction
- Recognize 2 necessary risk assessments
- Identify 2 steps to prepare a resilience assessment report
- Identify 3 of the ten essentials for making cities resilient
- Recognize 2 of the requirements to strengthen institutional capacity for resilience
- Analyze some aspects related to the resilience of a city
- Propose methods to improve the resilience of a city

5.4.6.7 References

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5.4.7 Competence title: Urban Management

5.4.7.1 Competence description

Urban Management is a broad discipline that consists of multiple dimensions. The importance of urbanization in overall economic development has further made this discipline more versatile. In order to deal with this complex challenging environment relating to urban planning and management, a dynamic content is required that will address the gaps in the knowledge and discipline and will aid to develop up-to-date knowledge from recent developments in the area. This will enable the learners to be well equipped with the recently developed knowledge domain.

5.4.7.2 Definitions

City Branding is a tool borrowed from marketing practices by city planners to promote urban economic development. It is an initiative undertaken to build up image and reputation in order to overcome city competition in fighting over economic resources at the local, regional, national and global level.

Urban governance refers to the pursuit of collective goals through relations and networks that reach beyond formal government institutions to include a range of social and market actors.

Urban planning is a technical and political process that focuses on the development and design of a region or a city and it includes usage of the land, built environment, waste and water management, transportation, communications, distribution networks, etc.

Urban management is considered as a management system coupled with a set of policies, plans, programmes, and practices with an attempt to access public services. It is considered as an exercise of responsibility to improve the efficiency of a city. Urban management is integrating and coordinating public and private stakeholders aiming for a more equitable and competitive city.

5.4.7.3 Knowledge domain

- Urban Management
- Urban Governance
- Urban Planning

5.4.7.4 Learning objectives

- To understand the domain of urban management from different and diverse perspectives.
- To develop knowledge and understanding of the up-to-date recent developments in different areas of urban management.
- To develop and acquire a practical skillset and problem solving approaches through various pragmatic/practical work assignments on urban management themes.
- To understand how technology can aid the development and application of urban management.
- To understand urban management from multi-disciplinary perspectives.
- To develop applied knowledge in different trending and specialized areas of urban management.

5.4.7.5 Competence content (units)

The competence content is divided in the following units:

1	**Definitions and diverse perspectives of Urban Management.**	This unit provides definitions and a historical development of the concept of Urban management emphasizing the current debate on data/technology, supply or citizen driven, human or identity centered perspective. It enables the learners to

		understand both current mainstream themes, as well as still existing gaps and emerging themes. It aims to create awareness of the increased complexity of urban management necessitating a multitude of multidisciplinary competences. The topics covered are: 1. Diverse Perspectives of Urban Management. 2. Factors responsible for the complexity of Urban Management. 3. Emerging themes in Urban Management.
2	**Multidisciplinary conceptualisation of Urban Management.**	The unit provides a synthesis of urban management, urban governance, urban planning, eco-system models. It focuses on an integrated horizontal and vertical methodology, as well as on the various relevant outputs of the models. It enables the learners to apply measurement tools to monitor the effectiveness of applied urban management models. The following topics will be covered in this unit: 1. Different models relating to urban management, urban governance and urban planning. 2. Integrated urban management model. 3. Perspectives and prospects of Smart cities in modern urban management systems.
3	**The contribution of data for Urban Management.**	This unit introduces earners to various categories of data and implicit technologies which need to be acquired in order to plan, implement and monitor prioritized urban functions. In doing so, it also points to still existing gaps when acquiring, analyzing, interrelating and applying data. The learners become familiar with the objectives and elements of a

		data support system. Due to its proclaimed revolutionizing influence, the unit will emphasize the contributions of Big Data to planning and implementation tasks. The following topics will be covered: 1. Influence of data management technologies on urban management. 2. Existing knowledge on different stages of data management acquiring, analyzing, interrelating and applying data in the domain of urban management. 3. Contributions of Big Data to planning and implementing tasks under urban management.
4	**The effects of metropolisation on urban and regional development.**	This unit discusses the implications of rapid urbanization on regions, i.e. in terms of brain-drain, impoverishment or marginalization. Learners recognize the disparities between cities and regions. They learn how to develop city and regional branding as well as sustainable strategies on an urban and a regional level. The following topics will be covered: 1. Concepts of city and region. 2. Concepts of city and regional branding. 3. Differences and disparities between cities and regions. 4. Development of city and regional branding.

5.4.7.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Label diverse driving perspectives of Urban Management.
- Identify the factors responsible for the complexity of urban management.
- Describe emerging themes in Urban Management.

- Recall the steps of an integrated Urban Management Model.
- Relate the models of Urban Management, Urban Governance and Urban Planning to each other.
- List the outputs of an Integrated Urban Management Model.
- List the various data categories.
- Outline the innovative contributions of 'big data' for Urban Management.
- Identify the disparities between city and regional development.
- Describe the concepts of City and Regional Branding.
- Explain the rationale for a citizen driven and human or identity centered Urban Management perspective.
- Summarize the competences to reduce Urban Management complexity.
- Discuss possible barriers to co-ordinate the diverse interests of the Smart City eco-system's stakeholders.
- Recognize scientific principles reflected in KPIs/benchmarks/indices when applying urban management models.
- Indicate the importance and elements of a planning data support system.
- Explain the implications of big data for data management.
- Illustrate sustainable strategies on an urban and regional level.

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5.4.8 Competence title: Citizen Driven/Citizen Orientation/User Experience Design

5.4.8.1 Competence description

This module facilitates attendants to learn how to enhance the collaboration and communication with citizens in smart cities. It presents strategies and techniques for engaging citizens, how to develop and implement communication strategies with them, how to apply citizen-driven innovation, and how to set up and run communities of practice and communities of interest.

5.4.8.2 Definitions

Citizen engagement is a form of interaction between citizens and their governments. It includes individual and collective actions designed to identify and address issues of public concern

Living Labs are defined as user-centered, open innovation ecosystems based on a systematic user co-creation approach, integrating research and innovation processes in real-life communities and settings.

Open smart cities are related to open data infrastructures, open standards, open-source information, and open collaboration that enables building new or modifying existing services for their residents at any scale.

Urban innovation is a compendium of innovative methods, ideas, and services that enable cities to adapt to and anticipate changing processes. Technological advancements, as well as social, cultural, political, and climatic changes, cause large cities to grow and transform.

5.4.8.3 Knowledge domain

1. Civic engagement
2. Communication
3. Organizational behaviour
4. Social psychology

5.4.8.4 Learning objectives

- Define citizen engagement and describe main strategies and techniques to engage citizens of smart cities

- Develop and implement a communication strategy with smart cities citizens
- Implement citizen- driven innovation
- Initiate and run communities of practice and communities of interest

5.4.8.5 Competence content (units)

The competence content is divided in the following units:

1	**Engaging citizens**	Engaging citizens aims at presenting the main citizen engagement trends, strategies and techniques, to discuss Organizational Citizenship Behavior, and to identify the effects of emerging technologies on citizen engagement
2	**Communicate with citizens**	Citizen-centric communication is at the heart of smart cities. The reader goes through citizen-oriented communication strategies and policies, reviews the steps of citizen-centric communication, learns how to form communication teams, identifies how to develop a communication campaign, and explores communication initiatives for smart cities.
3	**Citizen-driven innovation**	The objectives of this unit are to introduce the reader to the concept of Open Innovation, to explain the term and the stages of Citizen-driven innovation, and to discuss the Living Labs approach.
4	**Communities of Practice and Communities of Interest for smart cities**	The objectives of this unit are to define Communities of Practice and Communities of Interest, identify their use for smart city design and development, and detail the steps of establishing them.

5.4.8.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the fundamentals of citizen engagement
- Name the principles of Organizational Citizenship Behavior (OCB)
- Define open innovation
- Select the most appropriate citizen engagement strategies and techniques for citizen oriented smart cities
- Identify information technologies affecting citizens' behaviour in smart cities
- Identify lessons learned from best practices that can support the development of a citizen-centric communication strategy
- Identify the steps of citizen-driven innovation
- Explain the Living Labs concept
- Distinguish between Communities of Practice and Communities of Interest
- Develop a communication campaign oriented to citizens of smart cities
- Select the most appropriate information and communication technologies to communicate with the citizens of a smart city
- Develop a community of practice or community of interest

5.4.8.7 References

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5.4.9 Competence title: Smart City Procurement

5.4.9.1 Competence description

The objective of this module is to deliver comprehensive knowledge that covers theoretical aspects, modern methods and good practices in the subject of Procurement, using established models (e.g. ITIL) and guidelines issued by the EU and international organizations. Trends like Green/Sustainable Procurement and topics like ICT procurement and Public Private Partnerships are also discussed.

5.4.9.2 Definitions

Green Procurement is the procurement of products and services that cause minimal adverse environmental impacts. It incorporates human health and environmental concerns into the procurement cycle.

Procurement Cycle is a sequence of related activities, from needs assessment, through competition and award, to payment and contract management, as well as any subsequent monitoring or auditing.

Procurement is a concept/function that describes the activities and processes dealing with covering end-to-end strategies for sourcing, negotiation of contracts, and acquiring goods, raw materials, services, or work from external sources while following through to ensure contracts are fulfilled according to contract terms.

Public-Private Partnerships is a long-term contract between a private party and a government entity for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance.

Purchasing is a rather simple activity, where an organization pays for and receives goods or services. It is generally performed on a transactional basis with little strategy.

Request to Tender is a formal, structured invitation to suppliers to submit a bid to supply products or services.

Requests for Quotation is a procurement type that is used for small value procurements of readily available off-the-shelf goods, small value construction works, or small value services, and usually does not require the preparation of tender documents to the same extent as open tendering.

Statement of work is referred to as the narrative description of a project's work requirement. It defines project-specific activities, deliverables, and timelines for a vendor providing services to the client. It typically also includes detailed requirements and pricing, with standard regulatory and governance terms and conditions.

Terms of reference is a document that explains the objectives, scope of work, activities, tasks to be performed, respective responsibilities of the employing organization and the employer, and expected results and deliverables of the assignment.

5.4.9.3 Knowledge domain

Procurement

5.4.9.4 Learning objectives

- Differences between the terms "purchasing" and "procurement"
- The procurement principles and cycle
- Decision making between "make, lease or buy" options
- The procurement procedures available to select
- Defining the requirements of a contract
- Setting evaluation criteria for potential tenderers
- Contract awarding methods available
- The basic structure of a contract
- Establishing contract management activities
- Contract performance evaluation
- Green and ICT procurement issues
- Good practices in ICT procurement
- Public Private Partnerships

5.4.9.5 Competence content (units)

The competence content is divided in the following units:

1	**The Procurement Process**	In this section: a) The differences between the terms Purchasing and Procurement are explained; b) Basic principles of procurement are discussed and an overview of the Procurement Cycle is presented; c) A brief debate on "make, lease or buy" options is presented; d) The procurement procedures available are presented.
2	**Contract Requirements Selection**	This section deals with the topic of defining the requirements, technical and other specifications of a contract.
3	**Supplier Evaluation**	This section deals with the topic of defining evaluation criteria for potential tenderers and the stages involved in their evaluation process.
4	**Contract Awarding and Management**	This section deals with the topics of: a) Contract awarding; b) Contract management and evaluation.
5	**Special Topics in Procurement**	This section deals with the topics of: a) Green/Sustainable Procurement and ICT related procurement; b) Public-Private Partnerships, their characteristics, pros and cons.

5.4.9.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Differentiate between purchasing and procurement
- List the 4 basic principles of procurement
- Name the 5 basic procurement stages according to ITIL

- Describe the procurement process/cycle
- Debate on "make, lease or buy" options
- Name the 6 procurement procedures available
- Define the requirements (technical and other) of a contract
- Establish tenderer evaluation criteria
- Name the 5 stages of bid evaluation
- Apply contract award methods
- Define the basic structure of a contract
- Establish contract management activities
- Evaluate contract performance
- Identify Green and ICT procurement issues
- Appraise good practices paradigms in ICT procurement
- Identify pros and cons of Public Private Partnerships
- Assess the risk factors involved in the procurement process

5.4.9.7 References

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5.4.10 Competence title: Digital Twins

5.4.10.1 Competence description

Digital Twin (DT) technologies are considered as key technologies that allow us to construct a virtual duplicate of our actual system and as such to provide a platform to review activities, to test interactions and the results of alternative decisions within the real system.
Usually, DT technologies are used, whenever a system is complex, dynamic, and its operation is considered as critical. Smart cities can be easily characterised as a complex system, where changes occur on a daily basis and its operation is considered critical for the citizens. Furthermore, the performance of smart cities is an important factor for citizens and businesses and it relies, in many cases, on the interaction of different subsystems.
Smart cities as a complex system, as a collection of interacting systems, transportation systems, health care systems, education systems, administration systems, etc., create challenges that must be resolved in a test environment, because of its stochastic nature.
Therefore, the implementation of DT technologies is necessary and important, in the context of a smart city, since it will be used as a management tool for improving smart city efficiency and operation, but for minimising the systems' risk as well, and improving policymaking and decision-making in general.

5.4.10.2 Definitions

A **data-driven model** is based on the analysis of the data about a specific system and is carried out using techniques such as machine learning and artificial intelligence.

A **digital twin** is a virtual model of a process, product, or service. This pairing of the virtual and physical worlds allows analysis of data and monitoring of systems to head off problems before they even occur, prevent downtime, develop new opportunities and even plan for the future by using simulations.

A **smart city twin** is a dynamic three-dimensional city model based on collaborative data collection that can support an integrated environment, to be used for developing analytical applications, for test-bedding or experimentation, for validation of the provision of services, and generally for research and development purposes.

A **model** is a simplified description, especially a mathematical one, of a system or process, aimed at assisting with calculations and predictions.

A **physics-based model** is a model that is based on the laws of physics, where input variables are taking values from sensors (usually that capturing forces, movement, weather conditions, etc.) It is used to minimise the risk in complex engineering and operational scenarios.

5.4.10.3 Knowledge domain

Digital Twin Skill

5.4.10.4 Learning objectives

The learning objectives of this module are the following:

- To understand key principles and concepts of digital twin technologies
- To understand how a digital twin can be introduced in a smart city
- To understand key principles and concepts of modelling a digital twin.

5.4.10.5 Competence content (units)

The competence content is divided in the following units:

1	**Introduction Digital Twin Concepts**	This unit introduces learners to Digital Twin concepts and technologies. It includes: • Digital twin definitions • Digital twin architectures • How digital twin works • Digital twin enabling technologies • Usage examples of digital twin
2	**Digital Twin modelling of smart cities**	This LO introduces learners to concepts needed for modelling a Digital Twin. It includes: • Digital twin models • Creating a smart city model • Using smart city models and digital twin for decision making

5.4.10.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Describe the key principles and concepts of digital twin technologies
- Define the digital twin modelling process

- Describe key tools that can be used for the development of smart cities' digital twin's models.
- Describe how digital twin can be used for smart cities decision making
- Explain cases where digital twin may offer significant advantages in the development of smart cities

5.4.10.7 References

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5.4.11 Competence title: Green Smart City

5.4.11.1 Competence description

At the end of the twentieth century, the "green movement" became popular in urban development. More and more countries now attach importance to the planning issues of ecological and livable cities. Under the vision of the "green movement," discussion has since revolved around notions such as sustainable development, environmental coexistence, sustainable cities, compact cities, healthy cities, quality of life, eco-cities, green cities, etc. The goal of an ideal green city is to be achieved via the vision, strategy and planning, based on an ecological, environmental approach. This module discusses the concept of green city and the theories of developmental strategies, presents related technologies and approaches, and explores corresponding ranking.

5.4.11.2 Definitions

A **green city** is an environmentally friendly city, measured by environmental performance indicators, where all developments have as a

major objective to minimize the impact of human activity on the environment. It is a community of residents, neighbors, workers, and visitors who strive together to balance ecological, economic, and social needs to ensure a clean, healthy and safe environment for all members of society and for generations to come.

Green city ranking is a model of how people's quality of life and city economic and management preparedness is likely to fare in the face of an uncertain future. It consists of a set of indicators to measure Green city interventions, such as public transit, renewable energy, local food, development approaches, etc.

Green infrastructure or blue-green infrastructure is a network of resources providing the "ingredients" for solving urban and climatic challenges.

5.4.11.3 Knowledge domain

Green city; eco-city; smart city

5.4.11.4 Learning objectives

The learning objectives of this module are the following:

- To provide a brief introduction to the green city concept.
- To outline the green city development strategies.
- To provide examples that apply the green city concept.
- To compare alternative green city approaches.
- To introduce green city solutions.
- To introduce green city evaluation frameworks.
- To present the concept of European Green capital.
- To provide a comparison of green city ranking in Europe and the US.

5.4.11.5 Competence content (units)

The competence content is divided in the following units:

1	**Green City Vision, Strategy, and Planning**	This unit introduces learners to the green city, its vision and practices. It includes: • The green city concept • Construction of a green city • Development strategies for a green city

2	**Green City Cases**	This unit introduces learners to Green City Cases. It includes: • Green City Cases
3	**Green city practical achievements**	This learning object introduces learners to green city practical achievements. It includes: • Green city practical achievements
4	**How Green is your city?**	This learning object introduces learners to the green city ranking. It includes: • Definition of green city ranking • European green city ranking • US green city ranking

5.4.11.6 Competence learning outcomes

Upon completion of this module, the learner will be able to:

- Explain the green city concept.
- Define the term "green city" and its synonyms
- List green city examples.
- Outline alternative green city approaches.
- Present how to implement a green city.
- Explain alternative technologies for green city.
- Outline a green city evaluation framework.
- Highlight the European green city ecosystem.
- List cities in Europe and the US according to their green city ranking.

5.4.11.7 References

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06 Chapter

Call to Action

6.1 Inviting Smart City Ecosystems to Contribute

Smart cities' domain echoes the complexity of today's societies, where societal, economical, technological, and environmental issues are tightly interconnected. Furthermore, the first steps of "software-enabled societies" introduce myriads of challenges at all levels. Not only, we use continuous running smart digital services or smart objects, but unquestionably we entrust our well-being to them.

Additionally, continuous delivery of software, the new must for 21st-century cities is intensified and commonly used by all software development companies. This is taking place with the same intensity as the electrification of cities at the beginning of the 20th century.

At the same time, we are investing in technologies, infrastructures, automation in an attempt to minimize human intervention, simply because it is costly or because a workforce with the correct skillset is not available.

According to the authors' position, it is imperative to intensify our efforts for developing the necessary workforce for smart cities. Market research is indicating that smart cities employers cannot find people with the skills they need. This "skills gap" represents an enormous pool of available talent, and it has severe effects, including economic underperformance, social unrest, and individual despair.

As one of the first attempts to define formally smart cities' professional skills and competences, it is quite important to continue this effort. We already stated that this is the first version of this book since we believe that the smart cities ecosystem is an evolving domain. Moreover, you may not see all the topics you expected to see in this guide or you may disagree with the elements we have selected to include.

However, having recognized the importance of this subject we call for action in the following areas

Action 1: Continuously monitor smart cities labor market needs

Action 2: Continuously evaluate and standardize body of knowledge for smart cities professionals

Action 3: Continuously evaluate and standardize and promote smart cities occupational profiles

Action 4: Develop a certification schema for smart cities occupational profile

Action 5: Promote smart cities body of knowledge and occupational profiles.

A lot remains to be done. However, it is important to recognize that in this challenging and thrilling "software-enabled society" the only safeguard is knowledge. Knowledgeable cities workforce and citizens.

We call on your passion to improve the cities we are living in. This "learn, experiment, gain feedback, and experiment again" game will help all of us and it will guide us to future editions of this document. Please use the following form for communicating with us your ideas, improvements, and experience.

6.2 SCBoK Evaluation Form

Book Title: Smart Cities Body of Knowledge	**Ratings**			
Editors: **Panos Fitsilis** **Angelika Kokkinaki**	**1** (Poor)	**2** (Fair)	**3** (Good)	**4** (Excellent)
Table of Contents: Material presented in a clear and coherent manner.	☐	☐	☐	☐
Terminology: Unfamiliar or specialized terms are well-defined, and their pronunciations are included.	☐	☐	☐	☐
Bibliography: Books and other references are comprehensive and current.	☐	☐	☐	☐
Writing Style: Main ideas are explicit and writing is descriptive and thought-provoking.	☐	☐	☐	☐
Headings/subheadings: Headings and subheadings support the content in a clear and concise manner.	☐	☐	☐	☐
Introductory sentences for section/chapter: These communicate what is being discussed/developed in the paragraph or section/chapter; allow the reader to establish, identify, and absorb main ideas; and provide helpful information for before-reading activities.	☐	☐	☐	☐
Section/Chapter Summaries: Key ideas and main points supporting the topic discussed in the section/chapter are clear and accurately restated.	☐	☐	☐	☐
Page Layout:	☐	☐	☐	☐

Appropriate graphic elements (illustrations, photographs, maps, charts, etc.) support the text in a "less-is-more" rule: they do not crowd the page or overwhelm the student with too much textual or visual information.				
Type Style, Line Length, and Leading: The point size of the type, length of the line of type, and space between each line all work together, producing a page that is not only visually appealing but also readable and accessible.	☐	☐	☐	☐
Graphic Elements (photographs, illustrations, maps, charts, etc.): Graphics are located with the text that they refer to rather than pages before or after it.	☐	☐	☐	☐
Graphics are consistently identified with call outs, such as Figure 1, Figure 2, etc.	☐	☐	☐	☐
Each Figure/Table includes a caption that succinctly identifies it and makes a direct connection between in and the text.	☐	☐	☐	☐
At least half of the graphics are in color.	☐	☐	☐	☐
Additional Comments:				
Total for Each Column				
Grand Total				

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Smart Cities
Body of Knowledge

Panos Fitsilis
Angelika Kokkinaki

DEVOPS
DEVOPS COMPETENCES FOR SMART CITIES

This book is the main deliverable of the SmartDevOps project, and it is the first systematic approach on smart cities competences development. It offers curricula for developing the required knowledge coherently and systematically. The profession and skills presented were elaborated from various viewpoints, through laborious market research. This Body of Knowledge was developed in the context of the SmartDevOps project, concluding that three new job professions are required for smart city professionals, namely: Smart City Planner, Smart City IT Manager and Smart City IT officer.

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