SMACITE

Enhancing skills for smart city tech

SMACITE

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

WP2: Smart Cities competences map and curriculum

D2.2: The SMACITE curriculum for Smart Cities

Final Version

Co-funded by the European Union

DELIVERABLE FACTSHEET

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Version	Name	Partner	Date	Comments
0.1	Vasileios Gkamas, Maria Rigou	UPATRAS	11/10/2022	Structure of the deliverable
0.2	Vasileios Gkamas, Maria Rigou	UPATRAS	30/11/2022	1st edition
0.3	Ioannis Voyiatzis Evangelos Fotopoulos	UNIWA	5/12/2024	Review of deliverable
1.0	Vasileios Gkamas, Maria Rigou	UPATRAS	28/01/2025	Final edition

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PROJECT SUMMARY

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

The expected project outputs are:

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

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

The curriculum will be tested through 4 national pilots in Greece, Bulgaria, Spain and Italy with at least 160 trainees. The certification of the skills and competences will follow a two-fold approach: (a) using micro-credentials to recognize the knowledge and skills gained through the successful completion of each online training module at the MOOC and Virtual Worlds and (b) designing the "Smart Cities Specialization Certification" that will be awarded to those passing online certifications exams with e-proctoring after the completion of the training modules.

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

1 Introduction

This deliverable consists of the SMACITE curriculum aiming to provide Smart Cities Engineers and Technicians with an adaptive blend of both technical and non-technical skills and competences that are essential for the design and operation of Smart Cities applications and solutions. The curriculum will be driven and supported by all key stakeholder groups including SMEs and other industrial partners, education and training providers, the public sector and last but not least, learners themselves.

We would like to emphasize that this consists of the first version of the SMACITE curriculum. This first version will be revised in order to address the main findings derived from its pilot testing in Greece, Spain, Italy and Bulgaria. The final version of the SMACITE curriculum is planned to be ready on 31st January 2025.

1.1 Structure of the deliverable

This deliverable is divided into 3 main Sections.

- **Section 1** introduces the deliverable. More specifically, Section 1.1 describes the structure of the deliverable, Section 1.2 describes the target audience, Section 1.3 describes the dependencies with other WPs and deliverables and Section 1.4 provides the key terms used in the curriculum.
- **Section 2** describes the curriculum's development process. More specifically, Section 2.1 describes the ADDIE model and its application in the design of the SMACITE curriculum and Section 2.2 describes the main resources consulted for the curriculum development.
- **Section 3** describes the SMACITE curriculum. More specifically, Section 3.1 describes the key characteristics of the curriculum, Section 3.2 describes the courses for Smart Cities enabling technologies and Section 3.3 describes the course for building the soft skills, entrepreneurship skills and green skills of Smart Cities Technicians and Engineers.
- **Section 4** provides the references used in the deliverable.
- **Section 5** provides the mapping between the learning outcomes defined at macro-level and the learning outcomes of each course of the SMACITE curriculum.

1.2 Target Audience

The target audience of the includes the following stakeholders:

- Smart Cities Technicians and Engineers as the main beneficiaries of the curriculum
- Education and training providers at vocational level and higher education that are interested to update their training offers with new programs at the domain of Smart Cities.
- Public organizations developing Smart Cities solutions.
- Enterprises operating in the Smart Cities market.
- Research institutions that are working at the domain of education and training.
- Policy makers at the domain of education and/or Smart Cities.

1.3 Dependencies with other WPs and deliverables

Deliverable D2.2 has direct connections with the following WPs and deliverables:

- **D2.1** under WP2. This deliverable defines a Smart Cities competences map and emerging job profiles, i.e. the Smart Cities Technician and Smart Cities Engineer profiles including their functions, as well as knowledge and skills (at macro level).

- **D2.3** under WP2. This deliverable provides a methodology for the training and assessment of the learners exploiting the SMACITE curriculum.
- **D3.1** – **D3.4** under WP3. Those deliverables consist of the training material of the SMACITE curriculum for the upskilling and reskilling of Smart Cities Technicians and Engineers.
- **D4.2** under WP4. This deliverable describes the MOOC for the delivery of the courses of SMACITE curriculum.
- **D4.3** under WP4. This deliverable describes the Virtual Worlds for the delivery of the courses of SMACITE curriculum on soft, entrepreneurship and green skills.

1.4 Key terms

The key terms used in the SMACITE curriculum are described below. Their definition is coming from ESCO.

Learning outcomes

Learning outcomes are "*statements of what a learner knows, understands and is able to do on completion of a learning process, defined in terms of knowledge, skills and competences*". Education and training institutions are increasingly describing their qualifications in terms of learning outcomes following the approach adopted by the European Qualifications Framework (EQF) [1].

Competence

ESCO applies the same definition of "competence" as the EQF. According to this "*competence means the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development*." They are described in terms of responsibility and autonomy [2].

Knowledge

ESCO applies the same definition for knowledge as the European Qualifications Framework (EQF). According to this, "*knowledge means the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study.*" [3].

Both skills and competences rely on factual and theoretical knowledge, the difference lies in the way this knowledge is applied and being put into use.

Skill

ESCO applies the same definition of "skill" as EQF. According to this "*skill means the ability to apply knowledge and use know-how to complete tasks and solve problems*" [4]. They can be described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments).

While sometimes used as synonyms, the terms skill and competence can be distinguished according to their scope. The term skill refers typically to the use of methods or instruments in a particular setting and in relation to defined tasks. The term competence is broader and refers typically to the ability of a person - facing new situations and unforeseen challenges - to use and apply knowledge and skills in an independent and self-directed way.

2 Curriculum development

2.1 Methodology

The methodology adopted for the design of the SMACITE curriculum is based on the ADDIE model [5]. It is a flexible, systematic process used by instructional designers and training developers to break down the training development process into actionable steps and create effective learning experiences.

Figure 1: The ADDIE model (source https://www.cdc.gov/training/development/addie-model.html)

The ADDIE model consists of 5 steps that are described below together with their application for developing the SMACITE curriculum.

Step 1: ANALYZE

The analysis phase is focused on the target audience and can be considered as the "goal-settings" phase. At this phase, a needs analysis is conducted to determine the needs of the target audience as well as standards and competencies to establish a foundation when determining what students need by the completion of the curriculum/training. At this phase we are addressing the following indicative questions to guide the subsequent activities for the next phases of the ADDIE model.

- Which is the target audience, and which are their training needs?
- What is the typical background of the students/participants who will undergo the program.
- What is the purpose of the curriculum?
- What do the students need to accomplish at the end of the training?
- Which are the various options available with respect to learning environment?
- Which are the limiting factors that be restraints to achieve the overall goal of the curriculum?

Step 2: DESIGN

The design phase translates all the information derived from the analysis phase into a learning design. The main questions that should be addressed at this phase are the following:

- Which are the different courses of the curriculum?
- Which are the aims of each course?

- Which are the learning outcomes of each course?
- Which are the learning units of each course?
- Which is the duration of each learning unit?
- How the performance of the students will be assessed?

We are addressing this phase in details in Section 3 where the SMACITE curriculum is presented in detail.

We would like to emphasize that the learning outcomes of each course of the SMACITE curriculum are identified based on the outcomes of Task 2.1 in terms of the Smart Cities Engineer and Smart Cities Technician job profiles. More specifically, while designing the learning outcomes of each course, we ensure that they cover the required knowledge and skills identified at macro level in the deliverable "D2.1: Smart Cities competences map and emerging job profiles".

We would like also to mention that although in Deliverable D2.1, the relevance of 3D printing, Blockchain and Drones technologies has been evaluated as marginal for the 2 Smart Cities job profiles (their importance got a mean value slightly lower than the identified threshold), we decided to include them in the SMACITE curriculum for two reasons: (a) none of the consulting resources and experts considered them as not relevant for Smart Cities and (b) it is likely that some students will be interested in such cutting-edge technologies. Moreover, we decided to include Autonomous Vehicles as an additional course that is relevant to the domain of Smart Cities.

The Annex to the deliverable provides a mapping between the learning outcomes of the 2 Smart Cities job profiles defined by Task 2.1 and the learning outcomes defined at the courses of the SMACITE curriculum (except for the 3D printing, Blockchain and Drones courses).

Step 3: DEVELOP

The development phase is about the development of the training material and required technology for the delivery of the curriculum based on the design done at the previous phase. The main questions that should be addressed at this phase are the following:

- How the training material will be delivered?
- Which is the format of the training material?
- How the quality of the training material will be evaluated?

In SMACITE project, the development phase is coved by WP3 and WP4 which aims to develop the training material and online tools respectively for the delivery of the curriculum.

Step 4: IMPLEMENT

The implementation phase is about the delivery of the training. Key elements include communication with participants, collection, and running a train-the-trainers program for the roll-out of the piloting of the curriculum. This phase also includes in the implementation of a communication plan to build excitement around the training intervention.

In SMACITE project, the implementation phase is coved by WP5 which aims to pilot the curriculum and evaluate its impact.

Step 5: EVALUATE

The evaluation phase aims to evaluate whether or not you achieved the goals you identified in the analysis phase. Common questions that should be addressed at this phase are the following:

- Did the learners learn what you wanted them to learn?
- Were they able to apply new skills?
- Were they motivated to learn?

In SMACITE project, the evaluation phase is covered by WP5 which aims to pilot the curriculum and evaluate its impact.

2.2 Resources considered

The main documents we considered for the development of the SMACITE curriculum are following:

1. **Guidelines for developing ICT Professional Curricula as scoped by EN16234-1 (e-CF)**
   URL: https://standards.iteh.ai/catalog/standards/cen/5079746f-4750-46bd-b07d-546b98eeb0c6/fprcen-ts-17699
   This document provides guidance and inspiration on how to design/redesign, develop, maintain, adjust, and compare ICT Professional curricula and learning programmes as scoped by EN 16234 1:2019 and related documents. EN 16234 1:2019 (e-CF) is the starting guiding point for this document, for a shared European language for ICT professional development.
2. **CEDEFOP, Defining writing and applying learning outcomes**
   URL: https://www.cedefop.europa.eu/en/publications/4156
   This CEDEFOP handbook is addressed to individuals and institutions actively involved in defining and writing learning outcomes in education and training. Its ambition is to act as a reference point for cooperation in this area. It offers concrete examples of the use of learning outcomes and provides an overview of existing guidance and research material supporting the definition and writing of learning outcomes.
3. **SMACITE project. Deliverable D2.1: Smart Cities competences map and emerging job profiles**
   URL: N/A
   This report defines a Smart Cities competence map and the description of 2 emerging job profiles, i.e. the Smart Cities Technician and Smart Cities Engineer. For each profile are defined a) the functions aligned with ESCO, b) a mapping of e-CF e-competences and level and c) the essential and optional knowledge and skills for each profile, including soft skills.

3 The SMACITE curriculum

3.1 Short description of the curriculum

The SMACITE curriculum implies a shift from a narrow perspective, viewing the curriculum as a list of subjects to be taught, towards a broader perspective, characterizing it as the overall learning experience of individuals (and groups) not only in schools, but throughout their professional lives.

The key characteristics of the SMACITE curriculum are 3: **multidisciplinary**, **modular** and **flexible**. The curriculum combines an adaptive blend of technical courses for Smart Cities enabling technologies (e.g. cloud computing and IoT) and non-technical courses for building the soft, entrepreneurship and green skills and competences of Smart Cities Technicians and Engineers. Each course is divided further into learning units allowing students to build their own learning personalized learning pathways based on their needs and the outcomes of the diagnostic tool (Task 4.1), thus promoting student-centered learning. Moreover, the curriculum promotes problem-based learning, technology-enabled learning, as well as experience-based learning.

More specifically, the curriculum includes 12 courses (training modules). 9 of them deal with technical knowledge and skills, while the rest 3 with non-technical knowledge and skills. The total duration of the curriculum is estimated to 460 hours including self-study.

	Course	Estimated effort in hours
Technical courses	Smart Cities	40
	Internet of Things	40
	Cybersecurity	50
	Cloud Computing	40
	Data Analytics and Visualizations	40
	Machine Learning with Big Dta	40
	3D Printing	28
	Blockchain	28
	Drones	24
	Autonomous Vehicles	24
Non-technical courses	Soft skills	40
	Entrepreneurship skills	40
	Green skills	26
	Total duration	**460**

For each course the following elements are provided:

- The course category, name, code and duration.
- The course description
- The course objectives
- The learning outcomes (i.e. knowledge and skills) for each of the identified job profiles (i.e. Smart Cities Technicians and Smart Cities Engineers) and their link to the identified objectives.

- The teaching and learning methods for the course.
- The assessment methods to evaluate the performance of the students
- The recommended textbook(s)
- The outline of the course that includes the different learning units, the target Smart Cities profile, the associated learning outcomes, the week(s) for the delivery of each learning unit and the estimated effort in hours for each learning unit.

3.2 Technical courses

3.2.1 Smart Cities

COURSE CATEGORY	Enabling Technologies
COURSE NAME	Smart Cities
COURSE CODE	SC
DURATION	40 hours during 7 weeks

COURSE DESCRIPTION
This course presents the general architecture of Smart City-type solutions, with special attention to agents (stakeholders), integration of different data sources, and the management, analysis and visualization of information. The student will learn about vertical use cases in various sectors, and will become familiar with the essential technological tools that allow these isolated solutions to work in complex Smart City applications that improve citizen's quality of life making an efficient use of non-renewable natural resources, therefore optimizing available resources.

OBJECTIVES	
This unit aims to:	
O1	Highlight the technological, ethical and environmental challenges that may arise in the deployment of Smart City solutions.
O2	Present Smart City real use cases and identify how different technologies are applied identifying its capabilities and limitations.
O3	Explain the layered architecture of Smart City-type solutions, from data generation, to decision-making processes and information's release.
O4	Familiarize the student with the requirements managed by Smart City solutions deployment, and main steps to follow

LEARNING OUTCOMES		
Smart Cities Engineer		Link to aims
By the end of the course, the students will (knowledge):		
K.A1	Understand that Smart City-type solutions require the integration of very diverse technologies and highlight how each one of them intervenes in the general architecture as a system of systems.	O1, O2
K.A2	Become familiar with the capabilities, limitations, and use of Smart City technologies.	O2, O3
K.A3	Know basic tools for data management, analysis and presentation to support decision-making processes in Smart City solutions.	O3, O4

K.A4	Acknowledge the importance of responsible funding, finance, sustainability and citizen participation in the success of Smart City solutions.	O1, O4
K.A5	Be aware of the impact of Smart City solutions in our way of life and our footprint management.	O1
Moreover, by the end of the course, the students will be able to (skills):		
S.A1	Explain Smart City-type solutions and technologies.	O2, O3
S.A2	Recognize the different systems within the Smart City system itself.	O2
S.A3	Identify and use appropriate tools to process and manage in real time large amounts of data.	O3
S.A4	Commit to address major ethical and environmental challenges of Smart city solutions from a holistic perspective	O1, O4
Smart Cities Technician		
By the end of the course, the students will (knowledge):		
K.B1	Understand that Smart City-type solutions require the integration of different enabling technologies.	O1, O2
K.B2	Become familiar with the capabilities, limitations, and use of Smart City technologies.	O2, O3
K.B3	Know basic tools for data management, analysis and presentation to support decision-making processes in Smart City solutions.	O3, O4
K.B4	Be aware of the impact of Smart City solutions in our way of life and our footprint management.	O1
Moreover, by the end of the course, the students will be able to (skills):		
S.B1	Explain Smart City-type solutions and technologies.	O2, O3
S.B2	Recognize the different systems within the Smart City system itself.	O2
S.B3	Identify and use appropriate tools to process and manage in real time large amounts of data.	O3

TEACHING & LEARNING METHODS	Total Hours: 40
The course is delivered through online asynchronous courses (38 hours) and an online synchronous revision session (2 hours) at the end of the course.	

ASSESSMENT METHODS		
Type	Submission Week	% contribution
Evaluation quiz #1	Week 2	20%
Evaluation quiz #2	Week 4	20%
Evaluation quiz #3	Week 5	20%
Evaluation quiz #4	Week 6	20%
Final assessment	Week 7	20%

RECOMMENDED TEXTBOOK(S)
1. Song, H., Srinivasan, R., Sookoor, T., & Jeschke, S. (2017). Smart cities: Foundations, principles, and applications (1;1st; ed.). Wiley. https://doi.org/10.1002/9781119226444 2. https://smart-cities-marketplace.ec.europa.eu/insights/solutions?f%5B0%5D=solution_type%3Asolution_booklet

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1 Introduction to the concept of Smart City				
1.1 Definitions of Smart City, objectives (to improve the quality of life of citizens while respecting the environment), agents (citizens, communities, companies and institutions) and applications (transport/mobility management, waste, road lighting, air quality alerts (pollution/pollen), supplies (water, gas, electricity…), security (crime prevention, natural crises, and health/care system), capacity…	T&E	K.A1, K.A5, S.A1, K.B1, K.B5, S.B1	Week 1	0.5
1.2 Smart Cities enabling technologies in the perception, network, data management, and application layers	T&E	K.A1, K.A5, S.A1, K.B1, K.B5, S.B1	Week 1	0.5
1.3 IoT, home and building automation: Digital twins	T&E	K.A1, K.A5, S.A1, K.B1, K.B5, S.B1	Week 1	0.5
1.4 Cloud Computing, Edge Computing and Fog Computing	T&E	K.A1, K.A5, S.A1, K.B1, K.B5, S.B1	Week 1	0.5
1.5 Big Data, AI and Distributed Ledger Technology (DLT)	T&E	K.A1, K.A5, S.A1, K.B1, K.B5, S.B1	Week 1	0.5
1.6 APIs, GIS platforms, Open Data and Security	T&E	K.A1, K.A5, S.A1, K.B1, K.B5, S.B1	Week 1	0.5

1.7 Other challenges in the development of Smart Cities (lack of standardization , proprietary vs. open solutions, security, integration of heterogeneous data sources in real time, data quality and security, privacy, digital divide...)	T&E	K.A1, K.A5, S.A1, K.B1, K.B5, S.B1	Week 1	2
2 Cases of success				
2.1. Introduction	T&E	K.A2, S.A2, K.B2, S.B2	Week 2	1
2.2. Optimization of mobility and transport/logistics networks.				
2.3. Optimization of supply chain and waste management systems.	T&E	K.A2, S.A2, K.B2, S.B2	Week 2	2
2.4. Comparison of linear and circular economic models in cities.	T&E	K.A2, S.A2, K.B2, S.B2	Week 2	1
2.5. Optimization of communication networks (optic fibre, LPWAN, 5G...)	T&E	K.A2, S.A2, K.B2, S.B2	Week 2	2
2.6 Energy Efficiency (Sustainable building construction and remodeling, Renewable energy sources, Intelligent distribution networks, Energy storage systems, Lighting systems, Traffic solutions, District air conditioning systems).	T&E	K.A2, S.A2, K.B2, S.B2	Week 3	2
2.7. Monitoring and automation (Automatic irrigation control, Capacity control and visitor counting, Pollution monitoring, Security).	T&E	K.A2, S.A2, K.B2, S.B2	Week 3	2
2.8. Economic development (responsible consumption habits and zero environmental impact policies)	T&E	K.A2, S.A2, K.B2, S.B2	Week 3	1
2.9. Examples of technological developments in each of these areas: • Decarbonization of Mechelen, Belgium • Bicycles for freight transport in the center of Prague	T&E	K.A2, S.A2, K.B2, S.B2	Week 4	1

• DC Rotor: Reuse of building materials • Second-hand market in Vienna				
3 Technological solutions for Smart Cities				
3.1. Introduction	T&E	K.A3, S.A3, K.B3, S.B3	Week 4	1
3.2. Data origins (meters, sensors/IoT/V2X, APIs, open data, social networks, web scraping, citizen science projects, weather services, satellite images…)	T&E	K.A3, S.A3, K.B3, S.B3	Week 4	4
3.3 Communications	T&E	K.A3, S.A3, K.B3, S.B3	Week 4	1
3.4. Types of data management tools: CKAN (Comprehensive Knowledge Archive Network), FIWARE, Grafana, Node-RED and FlowFuse, Sentilo, Snap4City, Things Board Community Edition, IoT data analysis.	T&E	K.A3, S.A3, K.B3, S.B3	Week 5	4
3.4. Formats, standards and protocols for system integration.	T&E	K.A3, S.A3, K.B3, S.B3	Week 6	4
3.5. IoT Data Processing.	T&E	K.A3, S.A3, K.B3, S.B3	Week 5-6	1
3.6. Data Storage in IoT solutions.	T&E	K.A3, S.A3, K.B3, S.B3	Week 6	1
3.7. Business Intelligence.	T&E	K.A3, S.A3, K.B3, S.B3	Week 6	1
3.8. Formats, standards and protocols for integration between systems.	T&E	K.A3, S.A3, K.B3, S.B3	Week 6	1
4. Planning and deployment of Smart Cities solutions				

4.1. Introduction.	E	K.A4, S.A4, K.B4, S.B4	Week 7	0.5
4.2. Phases proposed for project realisation (Vision, Decide and Commit, Plan, Do, Check, Act, REplicate and Scale up, Conclusion).	E	K.A4, S.A4, K.B4, S.B4	Week 7	1
4.3. Identification of problems and study of available technical solutions (Smart City standards, Indicators (part I &II), Technical solutions, Interoperability, Cybersecurity).	E	K.A4, S.A4, K.B4, S.B4	Week 7	1
4.4. Feasibility analysis and business models.	E	K.A4, S.A4, K.B4, S.B4	Week 7	0.5
4.5. Governance, communication and public participation.	E	K.A4, S.A4, K.B4, S.B4	Week 7	0.5
4.6. Deployment, monitoring (KPI) and improvement/modification implementation (continuous development).	E	K.A4, S.A4, K.B4, S.B4	Week 7	0.5
4.7. An example of a Wi-Fi enabled city.	E	K.A4, S.A4, K.B4, S.B4	Week 7	0.5
4.8. Tools and Processes for future improvement.	E	K.A4, S.A4, K.B4, S.B4	Week 7	0.5
5 Revision				
5.1 Course revision			Week 7	2

3.2.2 Internet of Things

COURSE CATEGORY	Enabling Technologies
COURSE NAME	Internet of Things
COURSE CODE	IoT
DURATION	40 hours during 8 weeks

COURSE DESCRIPTION
This course deals with the Internet of Things (IoT) technology. Emphasis is placed on a) the key concepts of the IoT technology and its applications in the Smart Cities domain, b) the architecture and different types of IoT devices, including sensors and actuators, c) the communication technologies employed by the IoT and d) the integration between IoT and cloud computing.

OBJECTIVES	
This unit aims to:	
O1	Make the students familiar with the fundamentals of IoT technology, including the different hardware and software components, the IoT architecture and messaging protocols
O2	Discuss IoT applications in Smart Cities
O3	Describe the architecture, different components and vulnerabilities of IoT devices
O4	Present the different communication protocols available for IoT
O5	Present how IoT can be utilized to develop automation and control systems
O6	Explain the interconnection between the IoT and the cloud

LEARNING OUTCOMES		
Smart Cities Engineer		Link to aims
By the end of the course, the students will (knowledge):		
K.A1	Know the main principles of IoT technology	O1
K.A2	Learn the typical architecture of IoT	O1
K.A3	Be familiar with IoT application in Smart Cities	O2
K.A4	Learn the architecture of an IoT device, its distinct components and how they interact	O3
K.A5	Know the common limitations and vulnerabilities of IoT devices	O3
K.A6	Be familiar with the different communication protocols applied in IoT and their main characteristics	O4
K.A7	Learn how they can use the IoT technology to build automation and control systems in Smart Cities	O5
K.A8	Be familiar with the role of cloud computing in IoT	O6
Moreover, by the end of the course, the students will be able to (skills):		

S.A1	Identify different applications of IoT technology in Smart Cities by utilizing smart connected devices and/or control systems	O1-O6
S.A2	Design the architecture of smart systems for Smart Cities by exploiting the IoT technology	O1-O6
Smart Cities Technician		
By the end of the course, the students will (knowledge):		
K.B1	Know the main principles of IoT technology	O1
K.B2	Learn the typical architecture of IoT	O1
K.B3	Be familiar with IoT application in Smart Cities	O2
K.B4	Learn the architecture of an IoT device, its distinct components and how they interact	O3
K.B5	Know the common limitations and vulnerabilities of IoT devices	O3
K.B6	Be familiar with the different communication protocols applied in IoT and their main characteristics	O4
Moreover, by the end of the course, the students will be able to (skills):		
S.B1	Install and configure IoT devices	O3
S.B2	Interconnect IoT devices with sensors and the IoT system	O3 and O4

TEACHING & LEARNING METHODS	Total Hours: 44
The course is delivered through online asynchronous courses (42 hours) and a revision online synchronous session (2 hours) at the end of the course.	

ASSESSMENT METHODS		
Type	Submission Week	% contribution
Evaluation quiz #1	Week 2	20%
Evaluation quiz #2	Week 4	20%
Evaluation quiz #3	Week 5	20%
Evaluation quiz #4	Week 7	20%
Project	2 weeks after the revision	20%

RECOMMENDED TEXTBOOK(S)

Rashmi Nanda, IoT and Smart Cities: Your smart city planning guide, BPB Publications, ISBN-10: 9388511328, 2019.

Luis Hernández-Callejo, Sergio Nesmachnow, Mobility and IoT for the Smart Cities, Mdpi AG, ISBN-10 : 3039430505, 2020.

H. Samih, Smart cities and internet of things, Journal of Information Technology Case and Application Research, Vol. 21, No. 1, 3–12, 2019.

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1 Introduction to IoT				
1.1 What is the Internet of Things	E & T	K.A1, K.B1	Week 1	2
1.2 Hardware and software components of IoT	E & T	K.A1, K.B1	Week 1	3
1.3 IoT architecture	E & T	K.A2, K.B2	Week 2	2
1.4 IoT data flow and messaging protocols	E & T	K.A1, K.B1	Week 2	2
1.5 IoT applications for Smart Cities	E & T	K.A3, K.B3	Week 2	2
2 IoT Devices				
2.1 Sensors and actuators	E & T	K.A4, K.B4	Week 3	3
2.2 Microcontrollers	E & T	K.A4, K.B4	Week 3	3
2.3 System interfaces	E & T	K.A4, K.B4	Week 4	2
2.4 Limitations and vulnerabilities	E & T	K.A5, K.B5	Week 4	2
2.5 Installation and configuration of common IoT devices	E & T	S.B1, S.B2	Week 4	4
3 IoT Communications				
3.1 Radio Frequency protocols	E & T	K.A6, K.B6	Week 5	2
3.2 Low Power Wide Area Networks	E & T	K.A6, K.B6	Week 5	5
4 IoT Cloud				
5.1 IoT and cloud integration	E	K.A8, S.A2	Week 6	3
5.2 Application development and cloud processing	E	K.A8, S.A2	Week 7	5
5 Revision				
6.1 Course revision	E & T	N/A	Week 8	2

3.2.3 Cybersecurity

COURSE CATEGORY	Enabling Technologies
COURSE NAME	Cybersecurity
COURSE CODE	CYB
DURATION	50 hours during 6 weeks

COURSE DESCRIPTION
This course provides an overview of the cybersecurity concepts, technologies, capabilities and use cases especially in Smart Cities. This will help students gain the necessary knowledge to design and implement cyber secure smart systems regarding data integrity, confidentiality and availability. Emphasis will be placed on a) cybersecurity threats identification, b) implementation of cybersecurity measures c) cybersecurity tools and techniques d) monitoring of IoT networks.

OBJECTIVES	
This unit aims to:	
O1	Make the students familiar with the fundamentals of cybersecurity
O2	Present the cybersecurity implications in Smart Cities
O3	Define a cyber secure architecture for Smart Cities
O4	Present the most important cyber threats
O5	Explain the most important cybersecurity measures and techniques are
O6	Present what is a risk management plan

LEARNING OUTCOMES		
Smart Cities Engineer		
By the end of the course, the students will (knowledge):		Link to aims
K.A1	Know the implications of cybersecurity in Smart Cities	O1, O2
K.A2	Understand the digital architecture of a Smart City	O3
K.A3	Learn the main cybersecurity threats in a Smart City	O4
K.A4	Know the main measures that improve cybersecurity	O5
K.A5	Know which are the most important cybersecurity techniques	O5
K.A6	Know what is the risk management plan	O6
Moreover, by the end of the course, the students will be able to (skills):		
S.A1	Explain the implications of cybersecurity in a Smart City	O1
S.A2	Identify the main cybersecurity threats in Smart Cities	O4
S.A3	Configure and use cybersecurity equipment and tools	O5
S.A4	Use cybersecurity monitoring tools	O5
S.A5	Define a basic cybersecurity policy	O5
S.A6	Propose a secure architecture for Smart Cities	O3

Smart Cities Technician		
By the end of the course, the students will (knowledge):		Link to aims
K.B1	Learn the main cybersecurity threats in a Smart City	O4
K.B2	Know the main measures that improve cybersecurity	O5
K.B3	Know which are the most important cybersecurity techniques	O5
Moreover, by the end of the course, the students will be able to (skills):		
S.B1	Identify the main cybersecurity threats in Smart Cities	O4
S.B2	Configure and use cybersecurity equipment and tools	O5
S.B3	Use cybersecurity monitoring tools	O5
S.B4	Define a basic cybersecurity policy	O5

TEACHING & LEARNING METHODS	Total Hours: 50
The course is delivered through online asynchronous courses (48 hours) and a revision online synchronous session (2 hours) at the end of the course.	

ASSESSMENT METHODS		
Type	Submission Week	% contribution
Evaluation quiz #1	Week 1	10%
Evaluation quiz #2	Week 2	15%
Evaluation quiz #3	Week 3	15%
Evaluation quiz #4	Week 5	15%
Evaluation quiz #5	Week 6	10%
Evaluation quiz #6	Week 6	10%
Project	2 weeks after the revision	25%

RECOMMENDED TEXTBOOK(S)

Smart Cities Cybersecurity and Privacy, Elsevier, 1st Edition - December 4, 2018, ISBN: 9780128150320

Link: https://www.elsevier.com/books/smart-cities-cybersecurity-and-privacy/rawat/978-0-12-815032-0

Deloitte, Making smart cities cybersecure

Link: https://www2.deloitte.com/content/dam/Deloitte/de/Documents/risk/Report_making_smart_cities_cyber_secure.pdf

ENISA, Cyber security for Smart Cities

Link: https://www.enisa.europa.eu/publications/smart-cities-architecture-model/at_download/fullReport

Industrial Cybersecurity: Efficiently monitor the cybersecurity posture of your ICS environment, 2nd Edition, October 2021 (Ed. Packt Publishing)

ISBN-10 : 1800202091

Practical Cloud Security: A Guide for Secure Design and Deployment, Ed. O'Reilly Media; 1st edition (April 9, 2019)

ISBN-10 : 1492037516

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1 Introduction to Cybersecurity in Smart Cities				
1.1 Critical services in Smart Cities	E	K.A1, K.A2/S.A1	Week 1	1
1.2 Industrial Control Systems (ICS) and IOT	E	K.A1.K.A2/S.A1	Week 1	4
2 Cyber threats and attacks				
2.1 Passive and active attacks	E & T	K.A3, K.B1/S.A2, S.B1	Week 1	7
2.2 Malware	E & T	K.A3, K.B1/S.A2, S.B1	Week 1	2
2.3 Social engineering	E & T	K.A3, K.B1/S.A2, S.B1	Week 1	1
3 Cybersecurity measures				
3.1 Industry standards	E & T	K.A4, K.B2	Week 3	2
3.2 Cybersecurity policies and measures	E & T	K.A4, K.B2	Week 3	4
4 Cybersecurity tools and techniques				
4.1 Segmentation (Firewalls, VLAN…)	E & T	K.A5, K.B3/S.A3, S.B1	Week 4	3
4.2 Data security	E & T	K.A5, K.B3/S.A3, S.B1	Week 4	3
4.3 Securing communications (VPN, secure protocols …)	E & T	K.A5, K.B3/S.A3, S.B1	Week 4	6
4.4 Secure code development	E & T	K.A5, K.B3/S.A3, S.B1	Week 5	1
5 Monitoring a Smart City				
5.1 Monitoring software (IDS, IPS, SIEM)	E & T	K.A5, K.B3/S.A4, S.B2, S.A6	Week 5	2
5.2 IDS/IPS free tools (Wireshark, Snort…)	E & T	K.A5, K.B3/S.A4, S.B2, S.A6	Week 6	4

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
6 Risk management				
6.1 Risk Management	E	K.A6, K.B4/S.A5, S.B3	Week 6	1
6.2 System Recovery	E	K.A6, K.B4/S.A5, S.B3	Week 6	1
7 Course revision				2

3.2.4 Cloud computing

COURSE CATEGORY	Enabling Technologies
COURSE NAME	Cloud Computing
COURSE CODE	CC
DURATION	40 hours during 7 weeks

COURSE DESCRIPTION
This course presents the characteristics of different Cloud Computing solutions, highlighting their advantages and disadvantages for each use case. The student will gain experience in the deployment and use of cloud infrastructures, platforms and applications, both private and public. An introduction to native application development paradigms for Cloud Computing is also made, with special attention to integration and continuous deployment.

OBJECTIVES	
This unit aims to:	
O1	Explain the technological advances that have stimulated the centralization of computing capacity in cloud services, and the needs that are causing part of this capacity to return to the edge.
O2	Describe the characteristics, advantages and disadvantages, of different Cloud Computing solutions.
O3	Familiarise students with the deployment of cloud infrastructures, platforms and applications.
O4	Outline the capabilities of commercial cloud computing services.
O5	Present the most common programming paradigms for the development of native Cloud Computing applications, together with efficient and secure deployment strategies.
O6	Highlight Cloud Computing and new technologies synergies.

LEARNING OUTCOMES		
Smart City Engineer		Link to aims
By the end of the course, the students will (knowledge):		
K.A1	Identify the most appropriate Cloud Computing solution for each use case.	O1, O2
K.A2	Become familiar with deploying cloud infrastructures, platforms, and applications.	O3, O4
K.A3	Learn key maintenance and monitoring procedures in Cloud Computing solutions.	O3, O4
K.A4	Appreciate capabilities of major commercial Cloud Computing services.	O4
K.A5	Understand native programming paradigms for Cloud Computing	O5

K.A6	Know the possibilities of edge computing.	O6
Moreover, by the end of the course, the students will be able to (skills):		
S.A1	Choose the most appropriate Cloud Computing solution for each use case.	O1, O2
S.A2	Use deployment tools for different Cloud Computing solutions.	O3, O4
S.A3	Point out key tasks to maintain and monitor Cloud Computing solutions.	O3, O4
S.A4	Be inquisitive regarding new developments/technologies applied to Cloud Computing.	O5, O6
Smart City Technician		Link to aims
By the end of the course, the students will (knowledge):		
K.B1	Identify the most appropriate Cloud Computing solution for each use case.	O1, O2
K.B2	Become familiar with deploying cloud infrastructures, platforms, and applications.	O3, O4
K.B3	Learn key maintenance and monitoring procedures in Cloud Computing solutions.	O3, O4
K.B4	Appreciate capabilities of major commercial Cloud Computing services.	O4
Moreover, by the end of the course, the students will be able to (skills):		
S.B1	Choose the most appropriate Cloud Computing solution for each use case.	O1, O2
S.B2	Use deployment tools for different Cloud Computing solutions.	O3, O4
S.B3	Point out key tasks to maintain and monitor Cloud Computing solutions.	O3, O4

TEACHING & LEARNING METHODS	Total Hours: 40
The course is delivered through online asynchronous courses (38 hours) and an online synchronous revision session (2 hours) at the end of the course.	

ASSESSMENT METHODS		
Type	Submission Week	% contribution
Evaluation quiz #1	Week 2	20%
Evaluation quiz #2	Week 4	25%
Evaluation quiz #3	Week 6	25%
Evaluation quiz #4	Week 7	10%
Final assessment	Week 7	20%

RECOMMENDED TEXTBOOK(S)
1. Chopra, R. (2018). Cloud computing: A self-teaching introduction. Mercury Learning.
2. L. Jackson, K., & Goessling, S. (2018). Architecting cloud computing solutions: Build cloud strategies that align technology and economics while effectively managing risk. Packt Publishing, Limited.
3. Comer, D. (2021). The Cloud Computing Book: The Future of Computing Explained (1st ed.). Chapman and Hall/CRC. https://doi.org/10.1201/9781003147503

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1 Introduction to Cloud Computing				
1.1. Definition and characteristics of Cloud Computing	E&T	K.A1, S.A1, K.B1, S.B1,	Week 1	1
1.2. Essential concepts to understand Cloud Computing definitions	E&T	K.A1, S.A1, K.B1, S.B1,	Week 1	1
1.3 Evolution: from individual servers to cloud-connected servers to Edge servers.	E&T	K.A1, S.A1, K.B1, S.B1,	Week 1	1
1.4. Business models in Cloud Computing. Private Cloud Computing (on-premise, managed and hosted), public and hybrid. IaaS, PaaS and SaaS. Examples of companies that offer Cloud Computing services in each of these modalities.	E&T	K.A1, S.A1, K.B1, S.B1,	Week 1	1
2 Cloud Computing Infrastructure				
2.1. Cloud Computing Infrastructure: Standards and norms, Certification bodies, Independent data centers, Other risks, Physical spaces.	E&T	K.A1, S.A1, K.A2, S.A2, K.B1, S.B1, K.B2, S.B2,	Week 1	1
2.2. Cabinets, Racks, Chassis and Pods	E&T	K.A1, S.A1, K.A2, S.A2, K.B1, S.B1, K.B2, S.B2,	Week 1	1
2.3. Servers (processors, memories and storage systems), racks and PoDs (Points of Delivery).	E&T	K.A1, S.A1, K.A2, S.A2,	Week 1	1

		K.B1, S.B1, K.B2, S.B2,		
2.4. Network equipment: Network Interfaces (NIC), switch, connection aggregation (bonding) and Internet connection.	E&T	K.A1, S.A1 K.A2, S.A2, K.B1, S.B1 K.B2, S.B2,	Week 2	1
2.5. Storage equipment.	E&T	K.A1, S.A1 K.A2, S.A2, K.B1, S.B1 K.B2, S.B2,	Week 2	1
3. Deployment of Cloud Computing solutions				
3.1. Deployment of Cloud Computing solutions: Elastic Infrastructure, Virtual machines and containers.	E&T	K.A2, S.A2, K.A3, K.B2, S.B2, K.B3,	Week 2	3
3.2 Virtual machines and hypervisors. IaC (Infrastructure as Code) (practical application with Promox and Ansible)	E&T	K.A2, S.A2, K.A3, K.B2, S.B2, K.B3,	Week 2	3
3.3. Linux Basics	E&T	K.A2, S.A2, K.A3, K.B2, S.B2, K.B3,	Week 2	1
3.4. Application Containers: Docker	E&T	K.A2, S.A2, K.A3, K.B2, S.B2, K.B3,	Week 3	1
3.5. Container orchestration (practical application with Kubernetes)	E	K.A2, S.A2, K.A3	Week 3	2
3.6. Container and cluster management (practical application with Portainer), Monitoring and alerts (practical application with Prometheus and Grafana).	E&T	K.A2, S.A2, K.A3, K.B2, S.B2, K.B3,	Week 4	3

3.7. Virtual Machine to use.	E&T	K.A2, S.A2, K.A3, K.B2, S.B2, K.B3,	Week 4	1
4. Hyperscalers: Amazon Web Services, Microsoft Azure and Google Cloud Platform				
4.1. Introduction.	E&T	K.A4, S.A1, S.A3, K.B4, S.B1, S.B3,	Week 4-5	0.5
4.2. Cloud Service Providers (servers, storage, colocation, others).	E&T	K.A4, S.A1, S.A3, K.B4, S.B1, S.B3,	Week 4-5	0.5
4.3. Hyperscalers (reference architectures, services and subsystems, Amazon Web Services, Communication between subsystems.	E&T	K.A4, S.A1, S.A3, K.B4, S.B1, S.B3,	Week 5	2
4.4. Cloud Management Platforms (Openstack).	E&T	K.A4, S.A1, S.A3, K.B4, S.B1, S.B3,	Week 5	2
4.5. Practical application.	E&T	K.A4, S.A1, S.A3, K.B4, S.B1, S.B3,	Week 5	1
5. Introduction to software development and deployment for Cloud Computing				
5.1. Introduction.	E	K.A5, S.A4	Week 6	0.5
5.2. Lift-and-shift or native cloud development.	E	K.A5, S.A4	Week 6	0.5

5.3. Traditional Server-based development versus Serverless.	E	K.A5, S.A4	Week 6	0.5
5.4. Migrating On-Premises Software to Serverless.	E	K.A5, S.A4	Week 6	0.5
5.5. The micro service versus the monolith.	E	K.A5, S.A4	Week 6	0.5
5.6. Distributed processing and Map-Reduce.	E	K.A5, S.A4	Week 6	0.5
5.7. Devops and configuration management.	E	K.A5, S.A4	Week 6	0.5
5.8. Devops and container technology.	E	K.A5, S.A4	Week 6	0.5
5.9. Continuous Integration versus Continuous Deployment.	E	K.A5, S.A4	Week 6	0.5
5.10. Deployment and green blue deployments.	E	K.A5, S.A4	Week 6	0.5
5.11. Security in Cloud Computing.	E	K.A5, S.A4	Week 6	1
6. New technologies applied to Cloud Computing				
6.1. Introduction to AI.	E	K.A6, S.A4	Week 7	0.5
6.2. AnythingOps AIOps. Application of AI techniques in the automation of Cloud Computing systems.	E	K.A6, S.A4	Week 7	0.5
6.3. AI techniques in automation of Cloud Computing systems.	E	K.A6, S.A4	Week 7	1
6.4. Edge Computing.	E	K.A6, S.A4	Week 7	1
5 Revision				
5.1 Course revision			Week 7	2

3.2.5 Data analytics and visualizations

COURSE CATEGORY	Enabling Technologies
COURSE NAME	Data Analytics and Visualizations
COURSE CODE	DAV
DURATION	40 hours during 7 weeks

COURSE DESCRIPTION
This course provides an overview of Data Analytics and Visualizations concepts, methodologies, techniques and use cases oriented in Smart Cities (SCs). The course will help students gain the necessary knowledge to integrate advanced data analytics techniques and well-established data visualization principles into SCs applications along with complementary technological paradigms such as Cloud Computing, Internet of Things (IoT) and Augmented/Mixed Reality.

OBJECTIVES	
This course aims to:	
O1	Make the students familiar with the fundamental principles and techniques of data analytics and data visualization in the SCs perspective
O2	Discuss Data Analytics for interpreting massive amounts of data in SCs applications
O3	Describe Data Visualization concepts in SCs applications
O4	Present Data Analytics and Data Visualization SCs use cases
O5	Explain how Data Analytics and Data Visualization can be integrated with state-of-the-art technological trends such as Cloud Computing and IoT

LEARNING OUTCOMES		
Smart Cities Engineer		Link to aims
By the end of the course, the students will (knowledge):		
K.A1	know the key concepts of Data Analytics and Data Visualization	O1
K.A2	be familiar with applications of Data Analytics in SCs	O2
K.A3	have an overall knowledge of the fundamental principles of visual information / information graphics / statistical graphics in the field of SC	O3
K.A4	be aware of typical Data Analytics and Data Visualization Smart Cities use cases	O4
K.A5	understand the integration of Data Analytics and Data visualization with contemporary computing trends (i.e., Cloud	O5

	Computing, IoT/AIoT, Big Data, Augmented/Mixed Reality, Artificial Intelligence etc)	
Moreover, by the end of the course, the students will be able to (skills):		
S.A1	Explain the methodologies and key components of Data Analytics and Data Visualization	O1
S.A2	Identify how Data analytics can be applied in SC applications	O2
S.A3	Describe common Data Analytics and Data Visualization use cases	O4
Smart Cities Technician		
By the end of the course, the students will (knowledge):		
K.B1	know the key concepts of Data Analytics and Data Visualization	O1
K.B2	be familiar with applications of Data Analytics in Smart Cities	O2
K.B3	have an overall knowledge of the fundamental principles of visual information / information graphics / statistical graphics in the field of SC	O3
K.B4	be aware of typical Data Analytics and Data Visualization Smart Cities use cases	O4
K.B5	understand the integration of Data Analytics and Data visualization with contemporary computing trends (i.e., Cloud Computing, IoT, Big Data, Augmented/Mixed Reality, Artificial Intelligence etc)	O5
Moreover, by the end of the course, the students will be able to (skills):		
S.B1	Apply common Data Analytics techniques and methods to real SCs datasets	O2
S.B2	Apply common Data Visualization techniques and methods to real SCs datasets	O3
S.B3	Assist in the integration of Data Analytics and Data Visualization frameworks with cutting-edge technologies (i.e., cloud computing, AR/MR)	O5

TEACHING & LEARNING METHODS	Total Hours: 40
The course is delivered through online asynchronous courses (40 hours).	

ASSESSMENT METHODS		
Type	Submission Week	% Contribution
Evaluation quiz #1	Week 1	20%

Evaluation quiz #2	Week 3	20%
Evaluation quiz #3	Week 5	20%
Evaluation quiz #4	Week 7	20%
Project	2 weeks after the revision	20%

RECOMMENDED TEXTBOOK(S)

1. Embarak, O. 2018, *Data Analysis and Visualization using Python: Analyse Data to Create Visualizations for BI Systems*, Apress, ISBN 978-1484241080.
2. Khan, M., A., Algarni, F., Quasim, M., T., *Smart Cities: A Data Analytics Perspective*, Springer Cham, December 2020, ISBN 978-3-030-60921-4.
3. Alavi, A., Buttlar, W., G., *Data Analytics for Smart Cities (Data Analytics Applications)*, Auerbach Publications, 1st edition, 2018, ISBN 978-1138308770.
4. Halegua, G., R., *Smart Cities*, MIT Press Essential Knowledge Series, February 2020, ISBN 9780262538053
5. Rajendran, S., Sabharwal, M., Ghinea, G., Dhanaraj, R., K., Balusamy, B., *IoT and Big Data Analytics for Smart Cities: A Global Perspective*, A Chapman & Hall book, 2022 (1st edition), ISBN 9781032108551.

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1 Introduction to Data Analytics and Data Visualization				
1.1 What is Data Analytics	E & T	K.A1, K.B1	Week 1	1
1.2 What is Data Visualization	E & T	K.A1, K.A2, K.B1, K.B2	Week 1	1
1.3 Advantages of Data Analytics and Visualization	E & T	K.A1, K.A2, K.B1, K.B2	Week 1	1,5
1.4 Data Analytics and Data Visualization for Smart Cities	E	S.A1, S.A2	Week 1	1,5
2 Data Analytics for Smart Cities				
2.1 Computing and Cloud Storage infrastructure	E & T	K.A2, K.A5/K.B2, K.B5	Week 2	1,5
2.2 Data manage	E & T	S.A2/S.B1	Week 2	1,5
2.3 Data variety and quality criteria	E & T	K.A1, K.A2, K.B1, K.B2	Week 3	1
2.4 Advanced analytics algorithms	E & T	K.A1, K.A2, K.B1, K.B2	Week 3	4,5
2.5 Real-time analytics	E	K.A2, K.A5/S.A2	Week 3	3,5
3 Data Visualization for Smart Cities				
3.1 Visualization principles and techniques	E & T	K.A1,K.A3,K.B1,K.B3 / S.A1, S.B2	Week 4	2,5
3.2 Software tools for Data Visualization	E & T	S.A1,S.B2	Week 5	6,5
3.3 Realtime visualizations and user interactivity	E	S.A1, S.A3	Week 5	4
4 Smart Cities Use Cases				

4.1 A Data Analytics and Visualization architecture for Smart Cities	E & T	K.A4 ,K.A5, K.B4, K.B5/ S.A3, S.B3	Week 6	4
4.2 Decision-making processes for Smart Cities	E & T	K.A4, K.A5,K.B4,K.B5/S.A3,S .B3	Week 7	6

3.2.6 Machine Learning with Big Data

COURSE CATEGORY	Enabling Technologies
COURSE NAME	Machine Learning with Big Data
COURSE CODE	MLBD
DURATION	40 hours during 7 weeks

COURSE DESCRIPTION
This course provides an overview of Machine learning concepts and related scientific domains, methodologies, techniques and use cases concerning the Smart Cities (SCs) domain. The course will help students gain the necessary knowledge to apply ML techniques in SCs scenarios by hands-on practice using simplified examples in Python. Moreover, they will see certain integration settings that combine ML with big data infrastructures (cloud) and IoT data streams.

COURSE DESCRIPTION	
This course aims to:	
O1	Introduce students to the basic Machine Learning (ML) concepts, types of techniques, how ML relates to data mining, and provide examples of typical applications in the SCs domain
O2	Explain Machine Learning techniques suitable for the data gathered from typical SCs application domains and how they can support effective decision making
O3	Describe representative case studies of using Machine Learning and data mining from the SCs domain and give examples of implementation in relative programming environments
O4	Explain how Machine Learning can be integrated with state-of-the-art technological trends such as Cloud Computing and IoT

LEARNING OUTCOMES		
Smart Cities Engineer		Link to aims
By the end of the course, the students will (**knowledge**):		
K.A1	describe the basic logic of ML techniques suitable for the data gathered from typical SCs application domains and make effective decisions concerning which techniques are suitable	O1

K.A2	be familiar with examples of typical ML applications in the SCs domain, the types and sources of smart cities data and available programming tools	O1
K.A3	explain the basic logic of ML techniques suitable for the data gathered from typical SCs application domains and how they can support effective decision making	O2
K.A4	describe representative case studies of using Machine Learning and data mining from the SCs domain and their implementation in relative programming environments	O3
K.A5	understand the integration of ML with state-of-the-art technological trends such as Cloud Computing and IoT	O4
Moreover, by the end of the course, the students will be able to (**skills**):		
S.A1	Select appropriate ML techniques and effective decision making	O2
S.A2	apply common ML techniques on datasets gathered from representative smart cities application domains	O3
S.A3	integrate ML with cutting-edge technologies (i.e., cloud computing, IoT generated data streams)	O4
Smart Cities Technician		Link to aims
By the end of the course, the students will (**knowledge**):		
K.A1	understand the basic Machine Learning (ML) concepts, types of techniques and how ML relates to data mining, information retrieval and statistics	O1
K.A3	explain the basic logic of ML techniques suitable for the data gathered from typical SCs application domains and how they can support effective decision making	O2
K.A4	describe representative case studies of using Machine Learning and data mining from the SCs domain and their implementation in relative programming environments	O3

K.A5	understand the integration of ML with state-of-the-art technological trends such as Cloud Computing and IoT	O4
Moreover, by the end of the course, the students will be able to (**skills**):		
S.B1	apply common ML techniques to explore large datasets to reveal patterns	O3
S.B2	assist in the integration of ML with cutting-edge technologies (i.e., cloud computing, IoT generated data streams)	O4

TEACHING & LEARNING METHODS	**Total Hours: 40**
The course is delivered through online asynchronous courses (38 hours) and a revision online synchronous session (2 hours) at the end of the course.	

ASSESSMENT METHODS		
Type	Submission Week	% contribution
Evaluation quiz #1	Week 1	20%
Evaluation quiz #2	Week 3	20%
Evaluation quiz #3	Week 5	20%
Evaluation quiz #4	Week 7	20%
Project	2 weeks after the revision	20%

RECOMMENDED TEXTBOOK(S)

1. Machine Learning Techniques for Smart City Applications: Trends and Solutions, Dr. Jude Hemanth, Springer Cham, 2022, https://doi.org/10.1007/978-3-031-08859-9
2. Ullah, Z., Al-Turjman, F., Mostarda, L., & Gagliardi, R. (2020). Applications of Artificial Intelligence and Machine learning in smart cities. *Computer Communications*, *154*, 313-323. https://doi.org/10.1016/j.comcom.2020.02.069
3. Machine Learning Approaches for Smart City Applications: Emergence, Challenges and Opportunities, by Sonam Mehta, Bharat Bhushan, and Raghvendra Kumar. In Recent Advances in Internet of Things and Machine Learning, 2022, Volume 215, ISBN : 978-3-030-90118-9
4. França, R.P., Monteiro, A.C.B., Arthur, R., Iano, Y. (2021). An Overview of the Machine Learning Applied in Smart Cities. In: Khan, M.A., Algarni, F., Quasim, M.T. (eds) Smart Cities: A Data Analytics Perspective. Lecture Notes in Intelligent Transportation and Infrastructure. Springer, Cham. https://doi.org/10.1007/978-3-030-60922-1_5
5. Machine Learning for Smart Cities 1.0, Video presentation by J. Kastelan and N. Jones available at https://olc.worldbank.org/content/machine-learning-smart-cities-10
6. Band, S. S., Ardabili, S., Sookhak, M., Theodore, A., Elnaffar, S., Moslehpour, M., ... & Mosavi, A. (2022). When Smart Cities Get Smarter via Machine Learning: An In-depth Literature Review. *IEEE Access*.

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1 Introduction to Machine Learning with Big Data				
1.1 What is Machine Learning (ML) and types of techniques	E &T	K.A1	Week 1	3.5
1.2 ML, Information Retrieval, Data Mining and Statistics	E &T	K.A1	Week 1	2.5
1.4 ML applications in Smart Cities	E &T	K.A2	Week 1	1.5
2 ML for Smart Cities				
2.1 Types and sources of Smart Cities data and Big Data	E &T	K.A2	Week 2	2.5
2.2 Programming tools for implementing ML	E &T	K.A2, K.A4	Week 2	4
2.3 Python libraries for ML	E &T	K.A2, K.A4	Week 2/3	4
2.4 Techniques applied per Smart Cities application domain	E	K.A3/S.A1	Week 3	2
2.5 Selection of appropriate ML techniques and effective decision making	E	K3/S.A1	Week 3	2
3 ML case studies for Smart Cities				
3.1 Case study: Clustering for SC features with k-means	E &T	K.A4/S.A2, S.B1	Week 4	3.5

3.2 Case study: Regression for taxi surge pricing with XGBoost	E &T	K.A4/S.A2, S.B1	Week 4/5	3.5
4 ML combined with IoT and Cloud Computing				
4.1 IoT data streams	E	K.A5/S.A3, S.B2	Week 5	2
4.2 ML for IoT data streams	E	K.A5/S.A3, S.B2	Week 5	2
4.3 Study case of ML application on a cloud infrastructure	E	K.A5/S.A3, S.B2	Week 6	5
5 Revision				
5.1 Course revision	E &T	N/A	Week 7	2

3.2.7 3D printing

COURSE CATEGORY	Enabling Technologies
COURSE NAME	3D Printing
COURSE CODE	3DP
DURATION	28 hours during 7 weeks

COURSE DESCRIPTION
The purpose of the course is to provide the overview of 3d modeling, design, and printing, as well as its uses in the context of smart cities. In smart cities, sound technological solutions are required to minimize resources, maximize ergonomic functions, reduce costs, and rethink strategies and processes; hence 3D printing is a perfect match.

OBJECTIVES	
This unit aims to:	
O1	Make the attendants familiar with the concept of 3d modeling
O2	Make the attendants familiar with the concept of 3d design
O3	Make the attendants familiar with the concept of 3d printing
O4	Describe the use of the 3d modeling, design and printing technology in the context of smart cities

LEARNING OUTCOMES		
		Link to aims
By the end of the course, the students will be able to (knowledge):		
K1	name and describe the basic elements of the 3d technologies	O1, O2, O3
K2	justify the need for 3d design and printing technologies	O1, O2, O3, O4
K3	describe the capabilities of a 3d modeling system	O1
K4	name and describe the common functions of a 3d design software	O4
K5	describe, state and explain the parts of a 3d design and modeling software	O1, O2
K6	name and describe the basic parts of a 3d printer	O3
K7	name and describe the basic printing materials and 3d printing techniques	O3

K8	describe the basic services of a 3d printing software	O3
K9	describe applications of 3d printing in smart cities	O4
Moreover, by the end of the course, the students will be able to (skills):		
S1	design three-dimensional models using 3d software	O1
S2	set the properties to the printing software, to have a reliable print out	O3
S3	recognize and use productively the basic tools of a 3d design application	O2
S4	prepare 3d models for 3d printing	O1
S5	model and print their own creations	O3, O4

TEACHING & LEARNING METHODS	Total Hours: 28
The course is delivered through online asynchronous means.	

ASSESSMENT METHODS		
Type	Submission Week	% contribution
Evaluation quiz #1	Week 2	15%
Evaluation quiz #2	Week 4	20%
Evaluation quiz #3	Week 5	20%
Evaluation quiz #4	Week 6	20%
Project	2 weeks after the revision	25%

RECOMMENDED TEXTBOOK(S)

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W. Rosen, Brent Stucker, Springer, 2nd Ed, 2015.
2. The 3D Printing Handbook: Technologies, design and applications, Ben Redwood, Filemon Schöffer and Brian Garret, 3D Hubs B.V., 2017

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1. Introduction to 3d Technologies				
1.1 Introduction	E & T	K1	Week 1	2
1.2 3d Design, 3d Modeling and Rendering	E & T	K3/S1	Week 1	2
1.3 3d Design methods	E & T	K8/S3	Week 2	2
2. 3d Design				
2.1 Introduction to Fusion 360	E	K5/S1	Week 2	2
2.2 Simulation and Analysis	E	K4/S3	Week 3	2
2.3 Documentation and Technical drawings	E	K3/S2	Week 3	2
3. 3d printing				
3.1 History	E & T	K2	Week 4	2
3.2 3D printing methods	E & T	K7/S4	Week 4	2
3.3 Parts of a 3d printer	E & T	K6/S4	Week 5	2
3.4 Printing materials- Advantages & disadvantages	E & T	K7/S4	Week 5	2
4. Applications of 3D printing in Smart cities				
4.1 Slicers	E & T	K8/S5	Week 6	4
4.2 Object Libraries	E & T	K8/S5	Week 7	2
4.3 Applications of 3d printing in Smart Cities	E & T	K9	Week 7	2

3.2.8 Blockchain

COURSE CATEGORY	Enabling Technologies
COURSE NAME	Blockchain
COURSE CODE	Blockchain
DURATION	28 hours during 7 weeks

COURSE DESCRIPTION
This course provides an overview of the blockchain technology. Blockchain can play a key role in solving societal issues and achieving efficient urban management in modern cities. Blockchain enables network participants to exchange data with a high degree of reliability and transparency without the need for a centralized administrator. Cities have a variety of stakeholders and the exchange of data among stakeholders is essential for highly convenient urban services. Blockchain is expected to be used for this data exchange. Cities based on blockchain are considered to be more competitive, sustainable, and inclusive than their counterparties. Embracing the blockchain, cities under a new form of governance will better integrate citizen needs, boost the collaborative economy, and make both corruption and fraud, more difficult.

OBJECTIVES	
This unit aims to:	
O1	Make the students familiar with the fundamentals of blockchain technology
O2	Discuss blockchain applications in smart Energy and smart Mobility
O3	Discuss blockchain applications in Public Administration and Services
O4	Describe the applications of blockchain in smart Real Estate
O6	Discuss the applications of blockchain and cybersecurity in smart cities

LEARNING OUTCOMES		
		Link to aims
By the end of the course, the students will be able to (knowledge):		
K1	describe the key concepts of blockchain technology	O1
K2	describe applications of blockchain in Smart Cities	O2, O3, O4, O5
K3	explain the architecture of blockchain and its components	O1
Moreover, by the end of the course, the students will be able to (skills):		

S1	analyze the block chain applications in a structured manner	O2, O3, O4, O5
S2	research, analyze and design blockchain networks, consensus protocols and decentralized applications	O1
S3	plan security and compliance across the blockchain network and apply cryptographic mechanisms such as hash functions and digital signatures	O1
S4	research and evaluate new tools and technologies and integrate them into a blockchain network or its applications	O1
S5	develop, test, monitor and maintain a blockchain network, with a focus on performance, distributed computing, consensus protocols, cryptography and other security measures	O1
S6	develop, test, monitor and maintain decentralized applications, smart contracts, back-end systems, client-side applications and other components that make up the application stack	O1
S7	document development processes, artifacts and best practices as well as blockchain applications or systems	O1
S8	use Blockchain within a specific environment	O2, O3, O4, O5
S9	perform transactions in cryptocurrency	O1, O5
S10	develop smart contracts	O1
S11	apply blockchain technology in the context of smart cities	O2, O3, O4, O5

TEACHING & LEARNING METHODS	Total Hours: 28
The course is delivered through online asynchronous means (28 hours).	

ASSESSMENT METHODS		
Type	Submission Week	% contribution
Evaluation quiz #1	Week 2	15%
Evaluation quiz #2	Week 4	20%
Evaluation quiz #3	Week 5	20%
Evaluation quiz #4	Week 6	20%
Project	2 weeks after the revision	25%

RECOMMENDED TEXTBOOK(S)

1. Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction, Narayanan A., Bonneau J., Felten E., Miller A., Goldfeder S., 2016, ISBN: 9780691171692.
2. Blockchain By Example: A developer's guide to creating decentralized applications using Bitcoin, Ethereum, and Hyperledger, Bellaj Badr, Richard Horrocks, Xun (Brian) Wu, Packt Publishing Limited, 2018.
3. Cryptography and Network security Principles and Practices, William Stallings, Pearson/PHI, 2017.
4. Mastering Bitcoin, Antonopoulos A., Wood G., O'Reilly Publishing, 2017, ISBN:978-1-491-95438-6.
5. Mastering Blockchain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained, Imran Bashir, Packt Publishing, 2nd Ed, 2018.
6. The Business Blockchain: Promise, Practice, and Application of the Next Internet Technology, Mougayar, W., Hoboken, New Jersey: Wiley, 2016.

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1. Blockchain architecture	E & T	K1/S1	Week 1	2
2. Types of Blockchain technology	E & T	K1/S2	Week 1	2
3. Cryptography	E & T	K1/S3	Week 2	2
4. Data structures	E & T	K3/S4, S5	Week 2	2
5. Smart contracts	E & T	K3/S10	Week 3	2
6. Web development	T	K3/S8	Week 3	2
7. Blockchain Programming	E	K3/S5, S6, S7	Week 4	4
8. Blockchain applications for Smart Cities	E	K2/S11	Week 5 and 6	12

3.2.9 Drones

COURSE CATEGORY	Enabling Technologies
COURSE NAME	Drones
COURSE CODE	Drones
DURATION	24 hours during 6 weeks

COURSE DESCRIPTION
The course presents the main principles and underlying technologies for Aerial Unmanned Vehicles (UAVs, aka drones). Furthermore, applications of the subject technologies in smart cities are provided, along with specific case studies.

OBJECTIVES	
This unit aims to:	
O1	Present the main technologies related to unmanned aerial vehicles
O2	Present commonly used hardware used for unmanned vehicles
O3	Present autonomous vehicle modeling and control
O4	Analyze the safety frameworks and current industry practices for vehicle development
O5	Present applications of unmanned and autonomous vehicles related to smart cities

LEARNING OUTCOMES		
		Link to aims
By the end of the course, the students will be able to (knowledge):		
K1	describe the main aspects of the technology underlying aerial unmanned vehicles	O1, O4
K2	describe the architecture of a drone and the basic principles	O2, O3
K3	describe a typical mission planner programming environment	O3
K4	enumerate applications of drones in the context of smart cities	O5
Moreover, by the end of the course, the students will be able to (skills):		
S1	design, manufacture and program an unmanned aerial vehicle	O1, O2
S2	utilize drones related to the context of IoT in the smart city environment	O5

TEACHING & LEARNING METHODS	Total Hours: 24
The course is delivered through online asynchronous means.	

ASSESSMENT METHODS		
Type	Submission Week	% contribution
Evaluation quiz #1	Week 2	15%
Evaluation quiz #2	Week 4	20%
Evaluation quiz #3	Week 5	20%
Evaluation quiz #4	Week 6	20%
Project	2 weeks after the revision	25%

RECOMMENDED TEXTBOOK(S)

1. Introduction to Unmanned Aircraft SystemsMarshall, Douglas, et al., CRC Press, 2nd Ed., 2016.
2. Introduction to UAV SystemsFahlstrom, Paul, and Thomas Gleason, Wiley, 4th Ed., 2012.
3. Make: Drones: Teach an Arduino to Fly, McGriffy, David, Maker Media Inc., 1st Ed., 2017.
4. Make: Getting Started with Drones, Terry Kilby and Belinda Kilby, Maker Media Inc., 2016.
5. Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs, Baichtal, Que Pub, 2015.
6. Building a Quadcopter with Arduino, Vasilis Tzivaras, Packt Publishing, 2016.

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1. Introduction, historical review and types of UAVs	E & T	K1	Week 1	4
2. Drone technology				
4.1 Drone Anatomy	E & T	K2/S1	Week 2	2
4.2 Hardware and software stack	E	K2/S1	Week 2	1
4.3 Drone programming	E	K2/S1	Week 2	1
4.3.1 Mission planner	E & T	K3/S1	Week 3	2
4.3.2 Swarms and swarm programming	E	K3/S1	Week 3	2
3. Drone applications				
5.1 Search and rescue	E & T	K4/S1	Week 4	2
5.2 Load distribution	E	K4/S1	Week 4	2
4. Drone applications in Smart cities				
6.1 Traffic Management	E & T	K4/S2	Week 5	0,5
6.2 Crowd Management	E & T	K4/S2	Week 5	0,5
6.3 Disaster Control and Monitoring	E & T	K4/S2	Week 5	0,5
6.4 Smart Transportation	E & T	K4/S2	Week 5	0,5
6.5 City Planning	E & T	K4/S2	Week 5	0,5

6.6 Illegal Construction Supervision	E & T	K4/S2	Week 5	0,5
6.7 Engineering Monitoring	E & T	K4/S2	Week 5	0,5
6.8 Municipal Waste Management	E & T	K4/S2	Week 5	0,5
6.9 Urban Security	E & T	K4/S2	Week 6	0,5
6.0 Case study: Drone Monitoring System Smart City	E & T	K4/S2	Week 6	3,5

3.2.10 Autonomous Cars

COURSE CATEGORY	Enabling Technologies
COURSE NAME	Autonomous Vehicles
COURSE CODE	Autonomous cars
DURATION	24 hours during 6 weeks

COURSE DESCRIPTION
The course presents autonomous cars, the main principles and the underlying technologies. Furthermore, applications of the technologies in smart cities are provided, along with specific case studies.

OBJECTIVES	
This unit aims to:	
O1	Present the main technologies related to autonomous cars
O2	Present commonly used software and hardware for autonomous cars
O3	Present autonomous cars modeling and control
O4	Analyze the safety frameworks and current industry practices for autonomous cars development
O5	Present applications of autonomous cars vehicles related to smart cities

LEARNING OUTCOMES		
		Link to aims
By the end of the course, the students will be able to (knowledge):		
K1	describe the main aspects of the technology underlying autonomous cars	O1, O2, O3, O4
K2	describe a typical mission planner programming environment	O3
K3	enumerate applications of autonomous cars in the context of smart cities	O5
Moreover, by the end of the course, the students will be able to (skills):		
S1	design and prototype an autonomous car using relevant technologies	O2, O3, O4
S2	program an autonomous car	O3
S3	develop autonomous cars related to the context of IoT in the smart city environment	O5

TEACHING & LEARNING METHODS	Total Hours: 24
The course is delivered online asynchronously.	

ASSESSMENT METHODS		
Type	Submission Week	% contribution
Evaluation quiz #1	Week 2	15%
Evaluation quiz #2	Week 4	20%
Evaluation quiz #3	Week 5	20%
Evaluation quiz #4	Week 6	20%
Project	2 weeks after the revision	25%

RECOMMENDED TEXTBOOK(S)

1. Creating Autonomous Vehicle Systems, S. Liu, L. Li, J. Tang, S. Wu, J-L Gaudiot, Morgan & Claypool, 2nd Ed., 2020, ISBN: 978-1681739359.
2. Engineering Autonomous Vehicles and Robots: The DragonFly Modular-based Approach, Shaoshan Liu, Wiley-IEEE Press, 2020, ISBN: 978-1119570561.
3. Autonomous Vehicles: Opportunities, Strategies and Disruptions: Updated and Expanded Second Edition, Michael E. McGrath, 2nd Ed., 2019, ISBN: 978-1706683599.
4. Robot, Take the Wheel: The Road to Autonomous Cars and the Lost Art of Driving, J. Torchinsky, Apollo Publishers, 2019, ISBN: 978-1948062268.
5. Connected Vehicles: Intelligent Transportation Systems, Radovan Miucic, Springer International Publishing, 2019, ISBN: 978-3-319-94785-3.
6. 2030 The Driverless World: Business Transformation from Autonomous Vehicles, Sudha Jamthe, ISBN: 978-1973753674.

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1. Introduction and historical overview to autonomous cars				
1.1 Introduction to autonomous cars	E & T	K1	Week 1	1
1.2 Historical overview	E & T	K1	Week 1	1
2. Technology of Autonomous cars				
2.1 Levels of Autonomous Driving	E & T	K1/S1	Week 1	1
2.2 Communication Technologies	E & T	K1/S1	Week 1	1
2.3 Components	E & T	K1/S1	Week 2	1
2.4 Objectives	E & T	K1/S1	Week 2	1
2.5 Required Capabilities	E & T	K1/S1	Week 2	1
2.6 Artificial Intelligence	E	K1/S1	Week 2	1
2.7 Emerging Technologies	E	K1/S1	Week 3	1
3. Requirements				
3.1 Fault Tolerance	E	K2/S2	Week 3	1
3.2 Latency	E	K2/S2	Week 3	1
3.3 Architecture	E	K2/S2	Week 3	1
3.4 Resource Management	E	K2/S2	Week 4	1
3.5 Localization	E	K2/S2	Week 4	1

3.6 Security and Privacy	E	K2/S2	Week 4	2
4. Open Challenges				
4.1 Security	E	K3/S3	Week 5	2
4.2 Radar Interference Management	E	K3/S3	Week 5	1
4.3 Heterogeneous Vehicular Networks	E	K3/S3	Week 5	1
4.4 Artificial Intelligence for Autonomous Driving Cars	E	K3/S3	Week 6	2
4.5 Edge-assisted Autonomous Driving Cars	E	K3/S3	Week 6	2

3.3 Non-technical courses

3.3.1 Soft skills

COURSE CATEGORY	Horizontal Skills
COURSE NAME	Soft Skills
COURSE CODE	SS
DURATION	40 hours during 8 weeks

COURSE DESCRIPTION
The objective of this module is to define and explain the importance of soft skills for professionals and equip learners with skills that will enable them to navigate their environments, be flexible, communicate and work well with others, perform well and achieve their goals complementing hard skills and create additional value for their professional role.

OBJECTIVES	
This unit aims to:	
O1	Make the students familiar with the importance of cultivating their soft skills as key factors that contribute to their professional and personal development
O2	Present the Interpersonal communication skills and how to develop them
O3	Describe the importance of teamwork and collaboration for achieving better results / reaching the goals set within their work environment
O4	Describe the processes they need to undertake for developing their critical thinking and problem-solving skills
O5	Discuss about leadership and management and related topics (motivation, EQ) and their significance in their working life
O6	Discuss about changes, their effectiveness in people's behaviour and actions and the skills that need to be developed so as to overcome them successfully

LEARNING OUTCOMES		
		Link to aims
By the end of the course, the students will (knowledge):		
K1	Be familiar with the importance of soft skills for their professional and personal development	O1
K2	Identify the various forms of communication and principles of effective communication and negotiation	O2
K3	Be aware of the basic principles and advantages of collaboration and team working	O3
K4	Recognize principles, phases and tools of creative problem-solving procedures and decision making	O4
K5	Be aware of the difference between management and leadership and the importance of EQ and motivation	O5

K6	Be familiar with the factors that lead to changes and the skills that need to be developed to successfully tackle them	O6
Moreover, by the end of the course, the students will be able to (skills):		
S1	Discern hard from soft skills and identify pathways for their development	O1
S2	Communicate with clarity and conviction and tailor their communication strategy according to the specificities of each context	O2
S3	Create effective, flexible and resilient teams by motivating the team members and handling common conflicts that arise within teams	O3
S4	Gather information about a problem, identify and analyze problems and use techniques in order to come up with a decision	O4
S5	Use the design thinking process for problem analysis	O4
S6	Build and sustain trustful relationships with colleagues and supervisors through responsible leadership	O5
S7	Provide an example of changes occurring in their professional life and prepare a list with actions undertaken that will help them to adapt to the aforementioned changes	O6

TEACHING & LEARNING METHODS	Total Hours: 40
The course is delivered through online asynchronous courses (38 hours) and a revision online synchronous session (2 hours) at the end of the course.	

ASSESSMENT METHODS		
Type	Submission Week	% contribution
Evaluation quiz #1	Week 1	25%
Evaluation quiz #2	Week 3	25%
Evaluation quiz #3	Week 4	25%
Evaluation quiz #4	Week 7	25%
Project	2 weeks after the revision	0% (optional)

RECOMMENDED TEXTBOOK(S)

1. Tang, A. (2008). Leader's Guide to Mindfulness, The: How to Use Soft Skills to Get Hard Results (The Leader's Guide) 1st Edition. F.T Publishing International
2. Higgins, J. (2018).10 Skills for Effective Business Communication: Practical Strategies from the World's Greatest Leaders Paperback. Tycho Press
3. Almonte, R. (2022). A Practical Guide to Soft Skills: Communication, Psychology, and Ethics for your professional life. Routledge

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1 Introduction to Soft Skills				
1.1 The role of Soft Skills for Professional Development / Hard vs Soft skills	E + T	K1/S1	Week 1	1
2 Interpersonal Communication				
2.1 Introduction to interpersonal communication: Definition and key elements	E + T	K2/S2	Week 1	1
2.2 Basic principles of effective communication and key barriers	E + T	K2/S2	Week 1	1
2.3 Effective negotiations: key characteristics of a successful negotiator, negotiation styles and strategies	E + T	K2/S2	Week 1	1
2.4 Description of the negotiation process	E + T	K2/S2	Week 1	1
3 Teamwork and Collaboration				
3.1 Definition of Teamwork and collaboration and key benefits	E + T	K3/S3	Week 2	1
3.2 Building effective teams	E + T	K3/S3	Week 2	1
3.3 Setting common goals	E + T	K3/S3	Week 2	2
3.4 Conflict Resolution	E + T	K3/S3	Week 3	2
4 Critical Thinking and Problem Solving				
4.1 Critical thinking: definition and key components	E + T	K4/S4	Week 3	1
4.2 Introduction to problem solving	E + T	K4/S4	Week 3	1
4.3 The problem-solving process and its importance	E + T	K4/S4	Week 3	3

4.4 Creative Problem solving	E + T		Week 4	2
4.4.1 Introduction to the creative problem-solving process	T	K4/S4	Week 4	1
4.4.2 Creative problem solving through design thinking	E	K4/S4, S5	Week 4	2
4.5 Barriers to encounter during decision making	E + T	K4/S4	Week 4	1
5 Leadership and Management				
5.1 Leadership: definition and importance	E + T	K5/S6	Week 5	1
5.2 Manager vs Leader	E + T	K5/S6	Week 5	1
5.3 Leadership styles	E + T	K5/S6	Week 5	1
5.4 The importance of motivation	E + T		Week 5	1
5.4.1 Key factors that affect motivation	T	K5/S6	Week 5	1
5.4.2 How to motivate your Employees	E	K5/S6	Week 5	1
5.5 The role of Emotional Intelligence in leadership	E + T		Week 6	2
5.5.1 Definition and Key Characteristics	T	K5/S6	Week 6	1
5.5.2 What it takes to be an effective leader	E	K5/S6	Week 6	2
6 Managing Through Change				
6.1 Introduction to change management: definition, factors of occurrence and importance	E + T	K6/S7	Week 6	2
6.2 The change management process	E + T	K6/S7	Week 7	2
6.3 Adaptability, Resilience, and Openness to change	E + T	K6/S7	Week 7	1
7 Revision				
7.1 Course revision	E + T		Week 8	2

3.3.2 Entrepreneurship skills

COURSE CATEGORY	Horizontal Skills
COURSE NAME	Entrepreneurship skills
COURSE CODE	ES
DURATION	40 hours during 8 weeks

COURSE DESCRIPTION
The objective of this module is to familiarize students with the conceptual framework, content, and operating environment of entrepreneurship as well as introduce them to the fundamentals of business development.

OBJECTIVES	
This unit aims to:	
O1	Knowledge of the concept and significance of entrepreneurship, as well as the environment in which the business develops and operates
O2	A breakdown of the stages of the business process (developing a business idea; evaluating business models; developing a business plan; locating resources and forming agreements; selecting a sustainable development model)
O3	Recognition of the significance of the "eco-smart system" in the development of entrepreneurial action
O4	Management principles and techniques applicable to projects or one's own enterprise, with an emphasis on the discovery of novel approaches while adhering to established quality standards and legal requirements.

LEARNING OUTCOMES		
Smart Cities Engineer		Link to aims
Students are expected, upon successful completion of the course, to have the following knowledge to enable them to:		
KA1	Understand the significance and complexity of contemporary entrepreneurship	O1
KA2	Identify and describe areas for business process improvement.	O2
KA3	Have the capacity to comprehend management principles and methods applicable to projects	O2
KA4	Select sustainable business models through critical and analytical reasoning	O3
KA5	Recognize the necessary connection between entrepreneurship and innovation	O4
KA6	Develop a plan of action for the business and a strategy for the business's future	O2
In addition, by the time the students have completed the course, they will be able to:		

SA1	Promote or develop entrepreneurship	O1&2
SA2	Recognize investment and development incentives and take advantage of professional opportunities	O1&3
SA3	Create detailed business plans	O2
SA4	Collaborate, coordinate, and manage the parties involved in business venture planning and implementation	O2&4
SA5	Evaluate the impact of a variety of external and internal factors on entrepreneurship	All
Smart Cities Technician		Link to aims
Students are expected, upon successful completion of the course, to have the following knowledge to enable them to:		
KB1	Recognize the relevance and complexities of modern entrepreneurship	O1
KB2	Report on opportunities for business process improvement	O2
KB3	Understanding of management ideas and practices applicable to projects	O2
KB4	Manage long-term business models	O3
KB5	Recognize the critical link between entrepreneurship and innovation	O4
KB6	Understand the business's plan of action as well as its future strategy	O2
In addition, by the time the students have completed the course, they will be able to:		
SB1	Recognise entrepreneurship	O1&2
SB2	Take advantage of investment and development incentives, as well as professional prospects	O1&3
SB3	Manage the parties engaged in the planning and implementation of a commercial initiative	O2&4
SB4	Evaluate the effect of internal and external variables	All

TEACHING & LEARNING METHODS	Total Hours: 40
The course is delivered through 38 hours of asynchronous online instruction and a 2-hour synchronous online review session.	

ASSESSMENT METHODS		
Type	Submission Week	% contribution
Evaluation quiz #1	Week 3	20%
Evaluation quiz #2	Week 5	20%
Evaluation quiz #3	Week 7	20%
Evaluation quiz #4	Week 8	40%
Project	2 weeks after the revision	0% (optional)

RECOMMENDED TEXTBOOK(S)
Recommended Bibliography: 1. Bessant J. and Tidd J., Innovation and Entrepreneurship, 3rd Edition, Wiley. 2. Deakins D. and Freel M.Entrepreneurship and Small Firms, 5th Revised edition, McGraw-Hill. **Related scientific journals:** 1. The International Journal of Entrepreneurship and Innovation 2. Strategic Entrepreneurship Journal 3. Journal of Innovation and Entrepreneurship

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1 Introduction to Smart Cities and Entrepreneurship for Engineers				
1.1 Introduction to the concept of Smart Cities	E&T	KA1/SA1/ KB1/SB1	Week 1	3
1.2 Role of Entrepreneurship in Smart Cities	E&T	KA1/SA1/ KB1/SB1	Week 1	2
1.3 Types of Entrepreneurship	E&T	KA1/SA1/ KB1/SB1	Week 1	1
2 Identifying Opportunities in Smart Cities				
2.1 Creativity and Innovation	E&T	KA2/SA2/ KB2/SB2	Week 2	2
2.2 Business Model Development	E&T	KA2/SA2/ KB2/SB2	Week 2	2
3 Developing Entrepreneurial Mindset and Skills				
3.1 Emerging Technologies in Smart Cities	E&T	KA3/KB3/ SB4/ SA5	Week 2	3
3.2 Digital Skills for Entrepreneurs	E&T	KA3/KB3/ SB4/ SA5	Week 3	3
3.3 Urban Infrastructure in Smart Cities	T	KB3/SB3/ SB4/ SA5	Week 3	3
4 Technology Integration and Innovation				
4.1 Sustainable Development Goals (SDGs) and Smart Cities	E&T	KA5/KB5/ SB4/ SA5	Week 4	3
4.2 Circular Economy Principles	E&T	KA5/KB5/ SB4/ SA5	Week 4	3
5 Funding, Growth, and Implementation				

5.1 Funding Landscape for Smart City Startups	E&T	KA4/KB4/SA3/ SA4	Week 5	2
5.2 Growth Strategies and Scaling	E	KA4/KB4/SA3/ SA4	Week 5	2
5.3 Regulatory and Legal Considerations	E	KA4/KB4/SA3/ SA4	Week 5	2
6 Practical Implementation and Action Planning - Business plan				
6.1 Developing a Smart City Entrepreneurship Action Plan	E&T	KA6/KB6/SA3/ SB3	Week 6	2
6.2 Pitching and Presenting Business Ideas	E&T	KA6/KB6/SA3/ SB3	Week 6	2
6.3 Structure	E	KA6/SA3/ SB3	Week 7	1
6.4 Marketing–Pricing–Communication–Sales	E	KA6/SA3	Week 7	1
6.5 Costs - Financial Ratios - Cash Flows - Taxes	E	KA6/SA3	Week 7	1
7 Interdisciplinary Collaboration	E&T	KA3/KB3/ SB4/ SA5	Week 8	2

3.3.3 Green skills

COURSE CATEGORY	Horizontal skills
COURSE NAME	Green skills
COURSE CODE	GS
DURATION	26 hours during 7 weeks

COURSE DESCRIPTION
This course provides a complete overview, with various levels of detail, of the basic concepts related to sustainability and the use of technology and the Internet of Things (IoT) inside Smart Cities. The educational path will help students to acquire the necessary knowledge to promote and develop one's own green skills, the application of technologies for the acquisition, processing and archiving of collected data. The goal is to create professionals capable of finding and developing increasingly innovative and sustainable solutions for the management of human activities typical of cities. The course will focus on the concepts of circular economy, energy conservation and waste management.

OBJECTIVES	
This unit aims to:	
O1	Make the students familiar with the concepts related to sustainability and sustainable management of human activities typical of cities.
O2	Develop critical judgement skills on current ways of managing human activities in the city context
O3	Identify strengths and weaknesses in smart city management
O4	Develop alternative strategies to improve the sustainability of the systems analysed.
O5	Evaluate and predict performance improvement in planning new strategies
O6	Improve the sustainability of the society

LEARNING OUTCOMES		
Smart Cities Engineer		Link to aims
By the end of the course, the students will (knowledge):		
K.A1	Understand the concepts of sustainability (environmental, economic and social)	O1
K.A2	Know the main stages of history of sustainable development and main international and European agreements related to sustainability (sdg's and Green New Deal)	O1
K.A3	Learn the difference between the concepts of circular economy and green economy	O1 O2 O3

K.A4	Be familiar with LCA (life cycle assessment) and circular economy assessment concepts and what are their main principles	O3 O4
K.A5	Have an overall knowledge of the main methods of sustainable management of the city	O5 O6
K.A6	Learn the main descriptive parameters of sustainability and the main environmental certifications	O3
Moreover, by the end of the course, the students will be able to (skills):		
S.A1	Identify strengths and weaknesses in smart city management	O1 O2
S.A2	Process the collected data and design sustainable solutions	O3 O4
S.A3	Develop alternative management strategies	O3 O4 O5
S.A4	Use green skills to promote changes in social habits towards more sustainable ways	O4 O6
S.A5	Identify possible future applications of technology and ICT to increase the sustainability of smart cities	O4 O5 O6

Smart Cities Technician		
By the end of the course, the students will (knowledge):		
K.B1	Understand the concepts of sustainability (environmental, economic and social)	O1
K.B2	Know the main stages of history of sustainable development and main international and European agreements related to sustainability (sdg's and Green New Deal)	O1
K.B3	Learn the difference between the concepts of circular economy and green economy	O1 O2 O3
K.B4	Be familiar with LCA (life cycle assessment) and circular economy assessment concepts and what are their main principles	O3 O4
K.B5	Have an overall knowledge of the main methods of sustainable management of the city	O5 O6
K.B6	Learn the main descriptive parameters of sustainability and the main environmental certifications	O3
Moreover, by the end of the course, the students will be able to (skills):		
S.B1	Identify strengths and weaknesses in smart city management	O1 O2
S.B2	Identify collected data and verify proper functioning of data collection tools	O3 O4
S.B3	Support the development of procedures to manage and maintain infrastructures and data collecting tools	O3 O4 05
S.B4	Use green skills to promote changes in social habits towards more sustainable ways	O4 O6

S.B5	Collaborate in the implementation of future applications of technology and ICT to increase the sustainability of smart cities	O4 O5 O6

TEACHING & LEARNING METHODS	Total Hours: 25
The course is delivered through online asynchronous courses (23 hours) and a revision online synchronous session (2 hours) at the end of the course.	

ASSESSMENT METHODS		
Type	Submission Week	% contribution
Evaluation quiz #1	Week 2	33%
Evaluation quiz #2	Week 4	33%
Evaluation quiz #3	Week 6	34%
Final test (project work)	Week 7	0% (optional)

RECOMMENDED TEXTBOOK(S)

1. European Commission. A European Green Deal. Available Online: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (accessed on 13 January 2025)
2. European Commission. Sustainable Development Goals. Available Online: https://commission.europa.eu/strategy-and-policy/international-strategies/sustainable-development-goals_en
3. Food and Agriculture Organization of the United Nations. Sustainable Food and Agriculture. Available online http://www.fao.org/sustainability/en/ (accessed on 13 January 2025)
4. Ecological Footprint Calculator. Available online https://www.footprintcalculator.org/home/en (accessed on 13 January 2025)
5. Ellen MacArthur Foundation. Available online https://ellenmacarthurfoundation.org/ (accessed on 13 January 2025)
6. WWF World Wide Fund For Nature. https://wwf.panda.org/?referer=wwforg (accessed on 10 January 2023)
1. ISO International Organization for Standardization. https://www.iso.org/standards.html (accessed on 13 January 2025)

OUTLINE	Smart Cities Profile	LOs	Week	Estimated effort in hours
1 Apply the circular economy concept				
1.1 Sustainability**,** Circular Economy and Green economy: definitions and principles	T+E	K1,K2, K3/S1	Week 1	2
1.1.1 Circular Economy standards and assessment method	E	K4,K6/S1,S3	Week 1	1
1.1.2 ESG - Environmental, social, and corporate governance	E	K3,K6/S1,S3	Week 1	1
1.2 Sustainable Development Goals (SDGs) and Green New Deal	T+E	K1, K2/S1,S4	Week 2	1
1.3 LCA (Life Cycle Assessment) applied to Smart Cities	T+E	K4,K5/S2,S3	Week 2	2
2 Energy conservation				
2.1 Introduction to energy management and conservation	T+E	K5/S1	Week 3	1
2.2 EMS Energy Management Systems: data and impact	T+E	K5,S2,S3	Week 3	2
2.2.2 The role of Energy Manager	E	K6/S2,S4,S5	Week 3	1
2.2.3 Energy Management related certifications	E	K6/S2,S4,S5	Week 3	1
2.3 Energy management planning in smart cities	T+E	K4,K5/S2,S3,S4,S5	Week 4	1
2.4 Case studies on energy efficiency, consumption reduction and conservation	T+E	K5/S2,S3,S5	Week 4	2
3 Waste management				
3.1 Waste classification and ~~environmental~~ impact ~~of waste~~	T+E	K5/S1	Week 5	2
3.1.1 Waste sampling and analysis	E	K6/S2	Week 5	1
3.1.2 The Rule of the 4Rs	T+E	K4,K5/S3,S4, S5	Week 6	1

3.2 Sustainable waste management	T+E	K4,K5/S3,S4, S5	Week 6	3
3.3 Supply chain management and the 5Rs (Reduce, Reuse, Refurbish, Repair and Recycle): the value of waste	T+E	K3,K5,K6/S3,S4,S5	Week 6	2
4 Revision				
4.1 Course revision + final test	T+E		Week 7	2

4 References

[1] ESCO, ESCOpedia, learning outcomes . Retrieved on 10th October 2022
[2] ESCO, ESCOpedia, competence. Retrieved on 10th October 2022.
[3] ESCO, ESCOpedia, knowledge. Retrieved on 10th October 2022.
[4] ESCO, ESCOpedia, skill. Retrieved on 10th October 2022.
[5] Christine Peterson, "*Bringing ADDIE to Life: Instructional Design at Its Best*", Journal of Educational Multimedia and Hypermedia, 12(3), 227-241. Norfolk, VA: Association for the Advancement of Computing in Education (AACE).

4. ANNEX: Mapping between the learning outcomes defined at macro-level and the learning outcomes of each course of the SMACITE curriculum

Note: As at the macro-level design of the learning outcomes, the knowledge and skills in the domains of Drones, Blockchain, 3D printing and Autonomous vehicles has been characterized optional, the mapping does not cover those courses.

SMART CITIES TECHNICIAN

Item	SMACITE description	Course	Learning Outcomes of the course
IoT knowledge	Categories, requirements, limitations and vulnerabilities of smart connected devices and automatic control systems for digital control, distribution, saving and use of energy and information management.	Internet Of Things	K.A1: Know the main principles of IoT technology K.A2: Learn the typical architecture of IoT K.A3: Be familiar with IoT application in Smart Cities K.A4: Learn the architecture of an IoT device, its distinct components and how they interact K.A5: Know the common limitations and vulnerabilities of IoT devices K.A6: Be familiar with the different communication protocols applied in IoT and their main characteristics K.A7: Learn how they can use the IoT technology to build automation and control systems in Smart Cities
IoT skills	Install connected devices, (sensors, light switches, plugs, energy meters, cameras, etc.) and interconnect these devices to system and to relevant sensors.	Internet Of Things	S.B1: Install and configure IoT devices S.B2: Interconnect IoT devices with sensors and the IoT system
Security knowledge	Methods or pathways deployed by hackers to penetrate or target systems illegally and techniques and tools to detect and avert	Cybersecurity	K.B1: Learn the main cybersecurity threats in a Smart City K.B2: Know the main measures that improve cybersecurity

Item	SMACITE description	Course	Learning Outcomes of the course
	malicious attacks and protect ICT systems, resources and users		K.B3: Know which are the most important cybersecurity techniques
Security skills	Analyze functioning and performance of systems to identify and categorize weaknesses and vulnerability to intrusions or attacks. Deploy diagnostic tools and resources to solve them including firewall configuration.	Cybersecurity	S.B1: Identify the main cybersecurity threats in Smart Cities S.B2: Configure and use cybersecurity equipment and tools S.B3: Use cybersecurity monitoring tools S.B4: Define a basic cybersecurity policy
Cloud Computing knowledge	Technical concepts of cloud technologies and organization schemes for digital data storage locally (hard-drives and RAM memories) and remotely, via network, internet or cloud.	Cloud Computing	K.B1: Identify the most appropriate Cloud Computing solution for each use case. K.B2: Become familiar with deploying cloud infrastructures, platforms, and applications. K.B3: Learn key maintenance and monitoring procedures in Cloud Computing solutions. K.B4: Appreciate capabilities of major commercial Cloud Computing services.
Cloud Computing skills	Identify and execute steps to provision cloud resources, creating code that interacts with cloud services to implement functional requirements in application design and code and automate manual or repeatable processes.	Cloud Computing	S.B1: Choose the most appropriate Cloud Computing solution for each use case. S.B2: Use deployment tools for different Cloud Computing solutions. S.B3: Point out key tasks to maintain and monitor Cloud Computing solutions.
			K.B1: know the key concepts of Data Analytics and Data Visualization

Item	SMACITE description	Course	Learning Outcomes of the course
Data analytics knowledge	Understanding statistical methods, practices and data techniques for collection, organization, structuring data elements, analysis, interpretation and presentation of data (local and cloud) to reinforce the human understanding of information.	Data analytics and visualizations	K.B2: be familiar with applications of Data Analytics in Smart Cities K.B3: have an overall knowledge of the fundamental principles of visual information / information graphics / statistical graphics in the field of SC K.B4: be aware of typical Data Analytics and Data Visualization Smart Cities use cases K.B5: understand the integration of Data Analytics and Data visualization with contemporary computing trends (i.e., Cloud Computing, IoT, Big Data, Augmented/Mixed Reality, Artificial Intelligence etc)
Data analytics skills	Collect data from connected devices, detect and correct corrupt records from data sets (according to defined quality criteria) and normalize data to minimize dependency, eliminate redundancy and increase consistency	Data analytics and visualizations	S.B1: Apply common Data Analytics techniques and methods to real Smart Cities datasets S.B2: Apply common Data Visualization techniques and methods to real Smart Cities datasets S.B3: Assist in the integration of Data Analytics and Data Visualization frameworks with cutting-edge technologies (i.e., cloud computing, AR/MR)
Machine Learning and Big Data knowledge	Principles, methods and algorithms of machine learning, statistics and data mining.	Machine Learning with Big Data	K.A1: understand the basic Machine Learning (ML) concepts, types of techniques and how ML relates to data mining, information retrieval and statistics K.A3: explain the basic logic of ML techniques suitable for the data gathered from typical SCs application domains and how they can support effective decision making

Item	SMACITE description	Course	Learning Outcomes of the course
			K.A4: describe representative case studies of using Machine Learning and data mining from the SCs domain and their implementation in relative programming environments K.A5: understand the integration of ML with state-of-the-art technological trends such as Cloud Computing and IoT
Machine Learning and Big Data skills	Explore large datasets identifying patterns according to predefined methods with statistics, databases or AI and generate reports of information in a comprehensible way.	Machine Learning with Big Data	S.B1: apply common ML techniques to explore large datasets to reveal patterns S.B2: assist in the integration of ML with cutting-edge technologies (i.e., cloud computing, IoT generated data streams)
Business and Management knowledge	Understanding methodologies behind management of projects or of own business venture, identifying applicable quality standards and legal dispositions.	Entrepreneurship knowledge	K.B1: Recognize the relevance and complexities of modern entrepreneurship K.B2: Report on opportunities for business process improvement K.B3: Understanding of management ideas and practices applicable to projects K.B4: Manage long-term business models K.B5: Recognize the critical link between entrepreneurship and innovation K.B6: Understand the business's plan of action as well as its future strategy
Business and Management skills	Manage resources (budget, deadline, results, and quality) according to plans and control and report progress and changes according to customer requirements in a feasible way according to legal dispositions.	Entrepreneurship skills	S.B1: Recognise entrepreneurship S.B2: Take advantage of investment and development incentives, as well as professional prospects

Item	SMACITE description	Course	Learning Outcomes of the course
			S.B3: Manage the parties engaged in the planning and implementation of a commercial initiative S.B4: Evaluate the effect of internal and external variables
Green knowledge	Understand processes behind urban environment design considering aspects such as infrastructure, water, green and social spaces, circular economy, energy conservation and waste management.	Green skills	K.B1: Understand the concepts of sustainability (environmental, economic and social) K.B2: Know the main stages of history of sustainable development and main international and European agreements related to sustainability (sdg's and Green New Deal) K.B3: Learn the difference between the concepts of circular economy and green economy K.B4: Be familiar with LCA (life cycle assessment) and circular economy assessment concepts and what are their main principles K.B5: Have an overall knowledge of the main methods of sustainable management of the city K.B6: Learn the main descriptive parameters of sustainability and the main environmental certifications
Green skills	Follow policies and regulations aimed at environmental sustainability (e.g., reduction of waste, energy and water consumption, reuse and recycling, and sharing economy) and adopt sustainability-oriented mindset on ecological attitude and on environmental	Green skills	S.B1: Identify strengths and weaknesses in smart city management S.B2: Identify collected data and verify proper functioning of data collection tools

Item	SMACITE description	Course	Learning Outcomes of the course
	impact of behavior, implementing designed measures to reduce pollution (air, noise, light, water or environmental).		S.B3: Support the development of procedures to manage and maintain infrastructures and data collecting tools S.B4: Use green skills to promote changes in social habits towards more sustainable ways S.B5: Collaborate in the implementation of future applications of technology and ICT to increase the sustainability of smart cities
Smart Cities Knowledge	General concepts of Smart Cities and the basic tools to manage and analyze them.	Smart Cities	K.A1: Understand that Smart City-type solutions require the integration of very diverse technologies and highlight how each one of them intervenes in the general architecture as a system of systems. K.A2: Become familiar with the capabilities, limitations, and use of Smart City technologies. K.A3: Know basic tools for data management, analysis and presentation to support decision-making processes in Smart City solutions. K.A4: Acknowledge the importance of responsible funding, finance, sustainability and citizen participation in the success of Smart City solutions. K.A5: Be aware of the impact of Smart City solutions in our way of life and our footprint management.
Smart Cities Skills	Know different use cases in various sectors, become familiar with the essential technological tools that allow isolated solutions to work in complex Smart City	Smart Cities	S.A1: Explain Smart City-type solutions and technologies. S.A2: Recognize the different systems within the Smart City system itself.

Item	SMACITE description	Course	Learning Outcomes of the course
	applications improving citizen's quality of life, make an efficient use of non-renewable natural resources and therefore optimize available resources.		S.A3: Identify and use appropriate tools to process and manage in real time large amounts of data. S.A4: Commit to address major ethical and environmental challenges of Smart city solutions from a holistic perspective

SMART CITIES ENGINEER

Item	SMACITE description	Course	Learning Outcomes of the course
IoT knowledge	Principles, requirements, limitations and vulnerabilities of smart connected devices and automatic control systems for digital control, distribution saving and use of energy and information management.	IoT	K.A1: Know the main principles of IoT technology K.A2: Learn the typical architecture of IoT K.A3: Be familiar with IoT application in Smart Cities K.A4: Learn the architecture of an IoT device, its distinct components and how they interact K.A5: Know the common limitations and vulnerabilities of IoT devices K.A6: Be familiar with the different communication protocols applied in IoT and their main characteristics K.A7: Learn how they can use the IoT technology to build automation and control systems in Smart Cities K.A8: Be familiar with the role of cloud computing in IoT
IoT skills	Design and calculate smart systems, based on grid load, duration curves, energy simulations, etc.	IoT	S.A1: Identify different applications of IoT technology in Smart Cities by utilizing smart connected devices and/or automatic control systems S.A2: Design the architecture of smart systems for Smart Cities by exploiting the IoT technology
		Cybersecurity	K.A1: Know the implications of cybersecurity in Smart Cities

Item	SMACITE description	Course	Learning Outcomes of the course
Security knowledge	Methods and standards to protect ICT systems, resources and users against illegal or unauthorized use, identifying, assessing and dealing with all types of risks including from cloud computing		K.A2: Understand the digital architecture of a Smart City K.A3: Learn the main cybersecurity threats in a Smart City K.A4: Know the main measures that improve cybersecurity K.A5: Know which are the most important cybersecurity techniques K.A6 Know which are the most important cybersecurity techniques Know what is the risk management plan
Security skills	Create strategy for safety and security, with set of rules and policies. Analyze systems to identify risks and implement procedures for identifying, assessing, mitigating them and prepare recovery plans	Cybersecurity	S.A1: Explain the implications of cybersecurity in a Smart City S.A2Identify the main cybersecurity threats in Smart Cities S.A3: Configure and use cybersecurity equipment and tools S.A4: Use cybersecurity monitoring tools S.A5: Define a basic cybersecurity policy S.A6: Propose a secure architecture for Smart Cities

Item	SMACITE description	Course	Learning Outcomes of the course
Cloud Computing knowledge	Technologies to access resources (hardware, software, services, etc.) through remote servers and software networks irrespective of location and architecture and metrics and alarms for monitoring services.	Cloud Computing	K.A1: Identify the most appropriate Cloud Computing solution for each use case. K.A2: Become familiar with deploying cloud infrastructures, platforms, and applications. K.A3: Learn key maintenance and monitoring procedures in Cloud Computing solutions. K.A4: Appreciate capabilities of major commercial Cloud Computing services. K.A5: Understand native programming paradigms for Cloud Computing K.A6: Know the possibilities of edge computing.
Cloud Computing skills	Design infrastructure (networks and architecture) to implement optimized cloud solutions for customer requirements, fault toleration, workload and business needs. Identify elastic and scalable and cost-effective solutions and remediate deployment issues	Cloud Computing	S.A1: Choose the most appropriate Cloud Computing solution for each use case. S.A2: Use deployment tools for different Cloud Computing solutions. S.A3: Point out key tasks to maintain and monitor Cloud Computing solutions. S.A4: Be inquisitive regarding new developments/technologies applied to Cloud Computing.
Data analytics knowledge	Statistical methods, practices and data techniques for collection, organization, structure of data elements, analysis, interpretation and presentation of data	Data analytics and visualizations	K.A1: know the key concepts of Data Analytics and Data Visualization K.A2: be familiar with applications of Data Analytics in Smart Cities

Item	SMACITE description	Course	Learning Outcomes of the course
	(local and cloud) to reinforce the human understanding.		K.A3: have an overall knowledge of the fundamental principles of visual information / information graphics / statistical graphics in the field of SC K.A4: be aware of typical Data Analytics and Data Visualization Smart Cities use cases K.A5: understand the integration of Data Analytics and Data visualization with contemporary computing trends (i.e., Cloud Computing, IoT/AIoT, Big Data, Augmented/Mixed Reality, Artificial Intelligence etc)
Data analytics skills	Define data quality criteria; perform data analysis with statistical techniques to interpret data to assess development and innovation.	Data analytics and visualizations	S.A1: Explain the methodologies and key components of Data Analytics and Data Visualization S.A2: Identify how Data analytics can be applied in SC applications S.A3: Describe common Data Analytics and Data Visualization use cases
Machine Learning and Big Data knowledge	Big data technologies (machine learning, datamining, etc.) for smart cities to develop novel software ecosystems upon which advanced mobility functionalities emerge.	Machine Learning with Big Data	K.A1: describe the basic logic of ML techniques suitable for the data gathered from typical SCs application domains and make effective decisions concerning which techniques are suitable K.A2: be familiar with examples of typical ML applications in the SCs domain, the types and sources of smart cities data and available programming tools

Item	SMACITE description	Course	Learning Outcomes of the course
			K.A3: explain the basic logic of ML techniques suitable for the data gathered from typical SCs application domains and how they can support effective decision making K.A4: describe representative case studies of using Machine Learning and data mining from the SCs domain and their implementation in relative programming environments K.A5: understand the integration of ML with state-of-the-art technological trends such as Cloud Computing and IoT
Machine Learning and Big Data skills	Explore large datasets to reveal patterns using statistics, database or AI and present information in a comprehensible way.	Machine Learning with Big Data	S.A1: Select appropriate ML techniques and effective decision making S.A2: apply common ML techniques on datasets gathered from representative smart cities application domains S.A3: integrate ML with cutting-edge technologies (i.e., cloud computing, IoT generated data streams)

Item	SMACITE description	Course	Learning Outcomes of the course
Business and Management knowledge	Management principles and methodologies for projects or for own business venture, identifying creative solutions and according to quality standards and legal dispositions.	Entrepreneurship skills	KA1: Understand the significance and complexity of contemporary entrepreneurship KA2: Identify and describe areas for business process improvement. KA3: Have the capacity to comprehend management principles and methods applicable to projects KA4: Select sustainable business models through critical and analytical reasoning KA5: Recognize the necessary connection between entrepreneurship and innovation KA6: Develop a plan of action for the business and a strategy for the business's future
Business and Management skills	Manage and plan resources (budget, deadline, results, quality), according to codes of conduct, and monitor progress and changes according to customer requirements and advice in a creative and feasible way according to legal dispositions.	Entrepreneurship skills	SA1: Promote or develop entrepreneurship SA2: Recognize investment and development incentives and take advantage of professional opportunities SA3: Create detailed business plans SA4: Collaborate, coordinate, and manage the parties involved in business venture planning and implementation SA5: Evaluate the impact of a variety of external and internal factors on entrepreneurship

Item	SMACITE description	Course	Learning Outcomes of the course
Green knowledge	Political and technical processes to design urban environment and optimize land use considering aspects such as infrastructure, water, green and social spaces, circular economy, energy conservation and waste management.	Green skills	K.A1: Understand the concepts of sustainability (environmental, economic and social) K.A2: Know the main stages of history of sustainable development and main international and European agreements related to sustainability (sdg's and Green New Deal) K.A3: Learn the difference between the concepts of circular economy and green economy

Item	SMACITE description	Course	Learning Outcomes of the course
			K.A4: Be familiar with LCA (life cycle assessment) and circular economy assessment concepts and what are their main principles K.A5: Have an overall knowledge of the main methods of sustainable management of the city K.A6: Learn the main descriptive parameters of sustainability and the main environmental certifications
Green skills	Apply principles, policies and regulations aimed at environmental sustainability (e.g., reduction of waste, energy and water consumption, reuse and recycling, and sharing economy) and promote a sustainability-oriented mindset on urban ecological attitude and on environmental impact of behavior, applying measures to reduce pollution (air, noise, light, water or environmental).	Green skills	S.A1: Identify strengths and weaknesses in smart city management S.A2: Process the collected data and design sustainable solutions S.A3: Develop alternative management strategies S.A4: Use green skills to promote changes in social habits towards more sustainable ways S.A5: Identify possible future applications of technology and ICT to increase the sustainability of smart cities

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