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Abstract

Analysis the description of the technological areas, challenges, and opportunities for designing, developing and managing smart city innovative solutions.

Keyword list

smart cities, technologies, training, mapping areas of applications, ecosystem, competencies, opportunities, innovative solutions.

TABLET OF CONTENTS

O.1 Smart City Technological Innovations

O.1 / A3 Summary

The aim of the project is to develop the competences of the SME managers and owners to drive smart disruptive technology business. More specifically we combine management and digital skills and provide: a map of digital disruptive technologies; training program with modules and materials for smart innovation; toolkit with business models, tools for UX and DT process, social innovation aspects, platform for learning with materials and tools.

The EU is determined to keep pace with its main international competitors. A key element to achieve this is to develop a world-class competitive industry with Key Enabling Technologies (KETs) as basis.

KETs are knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly skilled employment. They enable process, goods and service innovation throughout the economy and are of systemic relevance. They are multidisciplinary, cutting across many technology areas with a trend towards convergence and integration. KETs can assist technology leaders in other fields to capitalise on their research efforts.

This deliverable presents the trends and changes that will affect society and the economy in the next 10 years with respect to Smart Cities.

For the first time in history, half of the world's population was living in urban areas, and predictions raise the percentage to 70% in 2050. Cities account for the bulk of economic wealth and integrate some strategic sectors completely, such as the financial sector. That is why the challenge and work facing cities should focus on creating a new social and economic fabric based on creativity, innovation and new technologies.

To make a city more competitive should address a comprehensive set of areas of development:

- **Knowledge**: Only societies with high skill levels can compete on a global stage. This includes initial knowledge (vocational and university education) and lifelong learning (postgraduate, doctoral, life-long education). In this sense, Universities are key elements. One of the challenges we face is to retain the talent that comes out of these universities, to recover it, and even attract it.
- **Technology**: Technological development, supported by Innovation, is essential to offer competitive products and services. In addition to Research & Development, we must also promote innovation, which includes areas such as new means of marketing and more efficient organisational and managerial systems.
- **Leadership**: The leadership of public institutions in new technologies and innovation must be visible. A city must have a development strategy, but it is not enough if the agents do not believe in it and do not develop it in a coordinated and organised manner.
- **Cooperation and partnerships**: In a global world we must base our work on the Network concept, thus acquiring the resources (financial, knowledge, talent) we need.

In short, we must work to achieve creative and talented cities that are innovative and highly technological.

Cities must generate a virtual space of interaction between citizens, the private sector and government that promotes an inclusive Information Society, which uses Internet and Information and Communication Technologies (ICT) to create an advanced model of community that fosters the sustainable economic and social development of cities based on ICT. In this context, the Digital Local Agenda represents a strategic tool to achieve digital cities in a planned and structured manner. It is important that cities seek to integrate their communities' intellectual capital, knowledge, in their economy and to develop knowledge-based services, with access to that knowledge and to universal, systematic, effective and efficient ICTs that are capable of attracting and retaining talent.

The relationship between knowledge, innovation and competitiveness is very clear. Therefore, that is our goal: to build competitive cities based on knowledge management and innovation. Achieving this involves having well-prepared and educated people, the political will of a committed government with a strategic vision, with supporting infrastructure, with a culture that encourages change in that direction.

All this with a planned strategy and a long-term vision. It involves an integrated concept of development based on participation in community dynamics to achieve common interests, in knowledge management to act effectively in the various fields of local activity, the provision of resources and motivation to innovate and create, and participation in a network of networks and interconnections within and beyond the community. Because you cannot innovate in isolation, you need a context of interaction. We are talking about a creative process that involves all actors in society and in which cooperation and networking are key elements.

The Smart Design project will contribute to the development of this situation and part of it we want to collect through this deliverable.

1. Trends in Society and Economy / Vision for the Future

1.1 Trends in Society and Economy

Description

These are the major findings with respect to the trends:

- Enabling technologies are key to many innovative products and solutions. Some research shows:
- Embedded Systems will be everywhere
- Embedding ICT in all types of artefacts is expected to have a massive impact.
- Our digital and physical world will be integrated.
- Mobile sensor, regulation and control services will be the basis for innovative applications in all areas of our lives.

With a focus on Smart Cities, the project finds it necessary to address key social challenges related to:

- Increase in the proportion of the elderly population. Average life expectancy worldwide will increase to 72 years by 2025 from 46 years in the 1950s.
- The growth of people living in cities: from 3.5 billion in 2011 to 4.9 billion in 2030
- The number of megacities (+10 million inhabitants) that will increase from 21 (2009) to 29 (2025). In 2025, in China alone, there will be 221 cities with more than 1 million inhabitants. Europe currently has 35.
- High density of city populations, increasing pressures on energy, transportation, water, buildings and public spaces.
- Scarcity of resources: if we continue with a regular commercial approach, we will need 2.3 planet earths by 2050.
- The virtualization of communities that has changed our society and the way in which information and knowledge are exchanged.

Integrated systems are defined as KET and will be the basis for many applications. The success of those applications, that is, smart city applications, will have an immediate impact on the success of the activities of the integrated system. But for smart city activities to flourish, specific challenges must be considered:

- In order to create a competitive sector that can compete globally, the development, attraction and retention of highly qualified people is key.
- New smart city solutions require rethinking revenue models, for example. Governments are collecting massive taxes on fossil fuel; By implementing smart mobility solutions, fossil fuel revenues will likely be reduced.
- Specific government support and government objectives will impact the adoption of innovative solutions.
- Public authorities must have a clear policy / leadership related to innovation and new technologies.
- A local digital agenda as a strategic tool is key to achieving digital cities in a planned and structured way.

- Cities should focus on or create a new social and economic fabric based on creativity, innovation and new technologies.
- Solutions will be more focused on the individual. Excellent interaction of the human system is required.
- The large amount of data generated by the billions of interconnected devices must be analysed.

The Smart Desing approach is in line with the major trends in Society and Economy as could be concluded from analyzing several trend roadmaps and position papers, in this sense:

Trends in Society and Economy/ Vision for the Future

The growth of people living in cities, the rising proportion of the elderly population, resources scarcity and the virtualisation of communities are key societal challenges relevant to smart cities. Embedded systems are key technological building blocks for numerous innovative products and solutions in the area of smart cities. Mobile sensors, regulation and control services will be the basis for innovative applications in all areas of our lives.

Unresolved technological challenges

A technological cornerstone for smart city solutions is the “Internet of things”. As building blocks of the “Internet of things” embedded systems are no longer considered only in isolated application contexts. Connectivity and closer interaction with the world put additional demands on embedded systems. Energy efficiency, interoperability, communication, standards, system complexity and dependability are challenges that are currently discussed.

Business opportunities

Social challenges give raise to new needs which provide new market opportunities for developing new businesses. We have analysed and summarized the data concerning business opportunities, in general, there are good market opportunities in the area of Smart Cities, where the biggest potential is in medical devices and the automotive industry. Other areas that we are going to work on in this project are commerce, government, education, transportation, housing, utilities.

1.2 Visionary Scenarios

The Key areas of smart technology innovation to create the map it will offers an overview of the clustered technologies within the domains which we identify to narrow the scope and make them relevant according to our countries and business target.

A city can be defined as smart when it displays a positive performance in these six areas, and when it has been built based on a "smart" combination of elements (communication, infrastructure, economic development) and on purposeful and independent citizen activities (participation, education) that make sound management of natural resources through participatory governance.

As Smart Design wants to boost international cooperation between actors in the field of technologies for smart cities, examples of visionary smart city scenarios may help to align stakeholders, to define common R&D&I projects, develop business partnerships and align cluster strategies. Smart Desing partners decided to work on 6 specific Smart City domains, ic. Commerce, Government, Education, Transportation, Housing, Utilities…. These are the major findings in the analyzed studies with respect to the visionary secenarios in these areas:

Commerce

Digital commerce is becoming increasingly important as a catalyst for economic growth. Although this will require considering the following aspects, among others:

- Promote the growth of digital commerce while strengthening consumer data protection.
- Strengthen data protection in commercial transactions
- Ensure the free flow of data
- Consider aspects such as tariffs, customs duties and other charges on digital products
- Cybersecurity

Government

Smart Governance includes political and active participation, citizen services and the smart use of e-Government. In addition, it often relates to the use of new communication channels, such as e-government or "democracy".

New Technologies enable the introduction of a new relationship between Local Governments and citizens; in particular regarding the introduction of public on-line services and the use of New Technologies to improve the participation of citizens in public decision-making. In general, e-Government can be considered as a concept that consists in improving public governance and the provision of public services through the use of ICT (e-Government), improving the consultation and decision-making processes using ICT (e-democracy) and improving public policy making, with the use of ICT, incorporating more critical agents throughout the process (e-Government) .

In all these aspects, the role played by citizens has a special impact. The new relationship emerging from e-Government has led to the emergence of a new kind of citizen, the e-citizen.

Education

One of the greatest opportunities innovation in education offers is that students can relate to the real world thanks to new technologies. A few years ago, what students could see, hear and feel was delimited by the walls of the classroom. But now, students have transferred the class thanks to mobile devices and the services offered by the internet. And best of all, students can communicate, exchange information, and progress collaboratively with fellow students around the world.

Smart Cities offer some clear advantages that could improve the educational system, for example, from a mobile app that tells us in which classroom we have the first class, guides us to it, and then helps us find the library book that the teacher has requested for the next class. Apart from these practical services, a Smart City would help to boost the university classes.

This new smart city model would therefore serve to employ new methodologies and improve learning. Using new technologies also implies personalized monitoring of the student and the adaptation of the subject to their needs.

Transportation (Mobility)

Smart mobility is a new and revolutionary way of thinking about how we get around — one that is cleaner, safer, and more efficient. Smart Mobility has to do with providing the public with access to new technologies, and the use of these in everyday urban life.

The infrastructure must provide the ability for all users to share and process any information instantly from anywhere. Today, the transmission of vast amounts of information at high speed requires a large bandwidth. Broadband has become the cornerstone of the future development of the Internet and the Information Society. Only with good broadband infrastructure can communications services be developed. These services are being put into operation at a very limited rate, but they will be widespread in the near future.

In recent years, interesting municipal initiatives have been introduced that, taking advantage of wireless technologies, Wi-fi, have established a public telecommunications network that even allows Internet access at a certain speed. The possibility of a free service could be considered "unfair competition"; which is one of the current topics being discussed. Smart mobility refers to using modes of transportation alongside or even instead of owning a gas-powered vehicle. This can take on many different forms, including ride-sharing, car-sharing, public transportation, walking, biking, and more. The need for Smart mobility arose out of increasing traffic congestion and its related side effects, including pollution, fatalities, and wasted time.

Key Principles of Smart Mobility

- Flexibility: Multiple modes of transportation allow travellers to choose which ones work best for a given situation.
- Efficiency: The trip gets the traveller to their destination with minimal disruption and in as little time as possible.
- Integration: The full route is planned door-to-door, regardless of which modes of transport.

Housing

In this this aspect we consider the implementation of smart neighbourhood infrastructures. They are ICT compliant, carbon neutral and sustainable, and are designed to improve residents' quality of life. Some examples:

- Bicycles equipped with sensors to measure pollution and take measurements accordingly.
- Shared platforms: to share cars, equipment, etc. among the citizens of a neighbourhood.
- Smartphones and tablets that increase connectivity on the go and give access to relevant data.
- Augmented reality solutions that provide support, assistance, and information about the place of consumption, use, etc.
- Neighbourhood Guided Virtual Tours - A virtual guide that routes a tourist through a neighbourhood, considering personal preferences, weather forecasts, museum opening hours, etc.

Utilities

In the field the field of public services, we refer to ICT-enabled lifestyles, behaviour and consumption. Everything that facilitates a healthy and safe life in a culturally vibrant city with various cultural facilities and incorporates good quality homes and accommodation. Smart life is also linked to high levels of social cohesion and social capital. In short, it is to collect various aspects that substantially improve the quality of life of citizens, such as culture, health, security, housing, tourism, etc. The development of each of these aspects leads to a more satisfying, fulfilling, and harmonious life.

2. Technological Challenges

2. Smart City Areas & Technologies

The Smart by Design project has contemplated a series of categories with its technologies as we collect in the following list where the challenges are broken down into sub-challenges, detailing which challenging new technologies need to be mastered to overcome the Smart City demands.

No of Categories	Name of categories	II	Technology
I.	Focus Areas (Areas for Innovations)	II.01	Devices
I.01	Communities	II.01.01	Beacon
I.01.1	Arts/culture	II.01.02	Camera
I.01.2	Civic	II.01.03	Component
I.01.3	Employment/labour	II.01.04	GPS
I.01.4	Libraries	II.01.05	IP-Enabled Infrastructure
I.01.5	Parks	II.01.06	Meter/Reader
I.01.6	Tourism	II.01.07	Mobile Device
I.02	Education	II.01.08	Network/Connectivity Component
I.02.1	k-12	II.01.09	RFID
I.02.2	University	II.01.10	Sensor
I.02.3	Workforce development	II.01.11	Smart Card
I.03	Emergency services	II.01.12	Wearable Tech
I.03.1	Coastal defense	II.02	Platform
I.03.2	Fire	II.02.01	Analysis
I.03.3	Medical	II.02.02	Application
I.03.4	Natural disaster	II.02.03	Cloud
I.03.5	Terrorism	II.02.04	Communication
I.04	Energy and Infrastructure	II.02.05	Dashboard
I.04.1	Asset management	II.02.06	Data Analytics
I.04.2	Buildings	II.02.07	Data Collection

I.04.3	Grid	II.02.08	Games
I.04.4	Lightning	II.02.09	Mapping/Location Aware
I.04.5	Public works	II.02.10	Simulation
I.04.6	Transportation	II.02.11	Social Media/Social Analytics
I.04.7	Water	II.02.12	Storage
I.05	Environment	II.02.13	Visualization
I.05.1	Air Quality	II.03	System / Service
I.05.2	Climate	II.03.01	Application
I.05.3	Parks and Natural Resources	II.03.02	Cloud
I.05.4	Waste	II.03.03	Communication
I.05.5	Water	II.03.04	Game
I.05.6	Wind	II.03.05	Information management
I.06	Health/Wellness	II.03.06	Monitoring
I.06.1	Air Quality	II.03.07	Payment System
I.06.2	Food Safety	II.03.08	Predictive
I.06.3	Healthcare	II.03.09	Simulation
I.06.4	Sanitation		
I.06.5	Sports/Recreation		
I.06.6	Water		
I.07	Public safety		
I.07.1	Crime prevention		
I.07.2	Natural disaster		
I.07.3	Terrorism		
I.07.4	Traffic injury/Fatality		
I.08	Quality of Life		
I.08.1	Accessibility		
I.08.2	Animal control/Welfare		
I.08.3	Noise		
I.08.4	Sanitation		
I.09	Social services		
I.09.1	Benefits		
I.09.2	Disabilities		
I.09.3	Families		
I.09.4	Homeless		
I.09.5	Seniors		
I.09.6	Veterans		
I.10	Transportation and Mobility		
I.10.1	Parking		
I.10.2	Personal Transit (Car, Bike)		
I.10.3	Public Transit (Bus, Subway, Bikeshare)		
I.10.4	Toll		
I.10.5	Traffic Management		
I.10.6	Wayfinding		

1.- List of technologies classified by categories

Classifying some of the technologies we present this classification:

Hardware and Communication

Sensor and Actuator Technology

[SmartHomeInterreg[1]], [agendaCPS[2]], [ArcadiaAligningAgendas[3]], [Ingutech[4]], [TelefonicaSmartCities[5]]

A cornerstone of Smart Cities, since data on the life in the city has to be collected (via sensors), and actions have to be accomplished via the actuators.

Challenges:

- Need to increase sensors' accuracy and speed, since these are currently often not sufficient to enable detailed real-time physical awareness.
- Sensors and actuators will be deployed in different and often extremely demanding environments, placing higher demands on their robustness and durability as well as on their size and energy consumption. In the most extreme cases, they may even have to be energy self-sufficient.
- The sensor systems by themselves will need certain intelligence and be able to act autonomously to provide certain services or parts of service without the need to connect to a central server. This requires increased processing power and memory (for example to capture the energy use of individual appliances).

[TelefonicaSmartCities] lists sensors that will be needed for Smart Cities: Security (e.g. smoke detectors), Lighting, Presence of persons, Weather, Transport, Movement (e.g. accelerometer, gyrometer) and Position (e.g. GPS).

Stable Distributed Controllers

[acatechSmartCities[6]], [agendaCPS]

Especially in the domain of Smart Grids, there is a need for concepts for stable, distributed controllers.

Distributed controllers are control systems or networks whose signal-processing components are geographically dispersed and may even be hierarchically structured, rather than being organised centrally.

Problems can arise because of connection failures, signal fluctuations caused by variations in communication latencies and packet loss, which typically has a major influence on controller behavior and can easily result in controller instability. There is therefore a need for control concepts and the associated development and analysis processes and tools to enable the development of control algorithms (recognition, active grid control) that can counteract these effects in a robust, scalable and hierarchical manner and that are adaptive or capable of reconfiguring themselves.

Communication

[agendaCPS[7]], [SmartHomeInterreg[8]], [ArcadiaAligningAgendas[9]], [TelefonicaSmartCities[10]], [MappingSmartCities[11]], [OutSmartActionPlan[12]]

The different parts of a Smart City must communicate and exchange data to be able to provide meaningful services.

A system will consist of Personal Area Networks based e.g. on the Bluetooth and ZigBee short-range radio standards; Local Area Networks use e.g. wireless standards to enable nodes and systems to

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[1] Roadmap Smart Home, 2012
2 Integrierte Forschungsagenda Cyber-Physical Systems, 2012
3 Aligning Research Agendas in Embedded Systems (Arcadia)
4 Ingutech Project Memory, 2012
5 Smart Cities: un primer paso hacia la internet de las cosas (Telefonica), 2011
6 Smart Cities – German Technology for the Cities of the Future
7 Integrierte Forschungsagenda Cyber-Physical Systems
8 Roadmap Smart Home, 2012
9 Aligning Research Agendas in Embedded Systems (Arcadia),2012
10 Smart Cities: un primer paso hacia la internet de las cosas (Telefonica)
11 Mapping Smart Cities in the EU, 2014
12 Smart Cities: An Action Plan, 2011

communicate with much higher data rates and over longer distances; and Wide Area Networks employing 3G, 4G and even 5G mobile communication technology cover much larger areas. Thus, both short range systems, in M2M language referred to as Capillary M2M, and long range system, in M2M referred to as Cellular M2M, will likely co-exist; some predict a full migration to cellular 4G/5G systems.

Challenges:

- The communication infrastructure will need to guarantee the most consistent and uniform service quality possible for all of the system's components.
- As the Smart City system is characterised by a high level of openness, it is necessary to constantly monitor and test the service quality of the connections in the system and make automatic adjustments in the event of any changes to the system.
- The smart city networks will be very heterogeneous; hence, interoperability and transparency will be essential.
- The data communication infrastructure is susceptible to blocking, interruption and eavesdropping, hence optimal data security must be guaranteed.
    - Lightweight cryptographic procedures and protocols that are tailored to the resource limitations.
    - The long service life of the components will require procedures, protocols and cryptographic keys that can either be replaced or that will remain secure throughout the duration of a prolonged service life.
- Sensor data needs to be submitted wirelessly in real time.

Non-Functional Requirements

Energy Efficiency

[CPSWorkshop[13]], [ArcadiaAligningAgendas], [HipeacComputing[14]], [OutSmartActionPlan], [ArtemisiaAgenda[15]]

In Smart Cities, the systems, sensors and actuators will be distributed all over town. Due to the sheer number of systems, and the often-limited access possibilities, the systems need to run as long as possible on their own energy supply. Energy harvesting typically only yields low energy volumes.

Challenges:

- Energy-aware algorithm design, for example using stochastic and approximate systems and algorithms.
- Dynamic adaptation/selection of heterogeneous multi/many core computing resources to application needs. Since the limits of power dissipation/consumption on a chip are already pushed, it will no longer be possible to power on all transistors on future chips simultaneously. Doing so will either dissipate too much heat or consume too much energy. This inability to turn on all of the transistors on a chip is known as “Dark Silicon”.
- Optimizing data movement, both for legacy applications and new computing modalities.
- Global system view for energy management.
- Reducing power consumption.

13 CPS: Uplifting Europe’s Innovation Capacity, 2013
14 The HIPEAC vision for advanced computing in Horizon 2020, 2013
15 2014 MultiAnnual Strategic Research and Innovation Agenda for the ECSEL Joint,2014

Interoperability

agendaCPS[16]], [SmartHomeInterreg[17]], [ArcadiaAligningAgendas[18]], [AutomotiveEmbedded[19]], [USSmartCities2[20]], [Net!Works[21]], [MappingSmartCities[22]], [IntelligenteSystemer[23]], [DanishPosition[24]], [CPSWorkshop[25]]

The sheer number of studies pointing to interoperability and standards makes it a central challenge.

History shows that solutions to specific problems often are siloed, that is they are developed towards a specific problem or domain. On the contrary, solutions for Smart Cities have to be interoperable across the domains mentioned above. [USSmartCities] The most significant research challenge currently is thus the development of a European cross-domain approach to the design and implementation of embedded systems and the solid international standardization of the resulting architecture and tools. [ArcadiaAligningAgendas].

Overall challenges:

- Standardisation (esp. open standards)
- Ensuring interoperability
- Common APIs

A drill-down on standardisation challenges:

- Domain models, ontologies and domain-specific languages (knowledge in a given application domain must be described in a domain model).
- Creating open Middleware, allowing simple integration of components (Plug and Play) and supporting new services.
- Interface specification technologies and interface management.
- Meta-level System-of-Systems coordination and cooperation, interconnectivity of subsystems

An example opportunity in Smart Buildings: Reconcile the standards for control and monitoring “inside the house” (KNX, LONWORKS EEBUS) with emerging standards for “outside building” energy data exchange (extensions of IEC61850, standard for the design of electrical substation automation) to support the integration of buildings in the smart grid.

Dependability

[HipeacComputing[26]], [agendaCPS[27]], [ArcadiaAligningAgendas[28]], [ArtemisiaAgenda[29]], [DanishPosition[30]], [CPSWorkshop[31]]

The Smart City systems need to be dependable and offer uninterrupted services – also during maintenance.

Challenges:

16 Integrierte Forschungsagenda Cyber-Physical Systems, 2012
17 Roadmap Smart Home, 2012
18 Aligning Research Agendas in Embedded Systems (Arcadia)
19 Is Europe in the Driver's Seat? The Competitiveness of the European Automotive, 2010
20 Smart Cities Readiness Guide, 2013
21 Smart Cities Applications and Requirements., 2011
22 Mapping Smart Cities in the EU, 2014
23 Forslag til dansk program om: Teknologier til intelligente systemer, 2009
24 ICT for Embedded Systems, 2011
25 CPS: Uplifting Europe’s Innovation Capacity, 2013
26 The HIPEAC vision for advanced computing in Horizon 2020, 2013
27 Integrierte Forschungsagenda Cyber-Physical Systems, 2012
28 Aligning Research Agendas in Embedded Systems (Arcadia), 2012
29 2014 MultiAnnual Strategic Research and Innovation Agenda for the ECSEL Joint,2014
30 ICT for Embedded Systems, 2011
31 CPS: Uplifting Europe’s Innovation Capacity, 2013

- Achieving higher levels of dependability.
- Secure run-time maintenance, care and development mechanisms.
- Processes for testing the impact of changes on the safety and security goals.
- Certified frameworks for safety relevant systems.
- Design for robustness.
- Platform for fault-tolerance.
- Design for Diagnosis.
- Self-reconfiguring systems, self-diagnosis.

Safety

[DanishPosition], [ITEAVision2030[32]], [agendaCPS].

Safety is related to dependability, but mentioned separately in studies.

Special challenges:

- Component description and testing at run-time; Technologies for describing component safety make it possible to test key guaranteed characteristics such as maturity, permitted application contexts or operating status when components are integrated at run-time.
- Platforms with high-order integrated safety mechanisms; Most current platforms provide very few of the safety mechanisms required to implement safety functions. They are largely confined to hardware-oriented mechanisms such as memory integrity and fault containment or hardware-related mechanisms such as virtualisation.

Security

[Net!Works[33]], [ArcadiaAligningAgendas[34]], [DanishPosition], [agendaCPS]

The distributed nature of the Smart City systems makes it difficult to ensure the security of the services.

Challenges:

- Authentication of sensor data
- Intrusion detection in embedded systems infrastructures
- Trust management
- Development of lightweight cryptographic procedures and protocols
- Dedicated security hardware that can provide secure memory and secure execution environments. Currently, the majority of security hardware is deployed in conventional systems such as desktop PCs (e.g. under the name of Trusted Platform Modules).

Certification

[ArcadiaAligningAgendas], [Net!Works], [ArtemisiaAgenda[35]], [CPSWorkshop[36]]

Embedded Systems must not only be constructed to work in a dependable way, but in most jurisdictions their traits must be officially certified before they may be implemented in Smart Cities. The studies stress that certification must already be supported in the design phase.

Challenges:

- Creating certified frameworks
- Auditing
- Affordable certification
- Modular and scalable approaches

32 High Level Vision 2030 Opportunities for Europe, 2013
33 Smart Cities Applications and Requirements, 2011
34 Aligning Research Agendas in Embedded Systems (Arcadia), 2012
35 MultiAnnual Strategic Research and Innovation Agenda for the ECSEL Joint Undertaking, 2014
36 CPS: Uplifting Europe's Innovation Capacity2013

Engineering Concepts

[Net!Works[37]], [AutomotiveEmbedded[38]], [ArcadiaAligningAgendas[39]], [ArtemisiaAgenda[40]], [DanishPosition[41]], [CPSWorkshop[42]]

From an engineering viewpoint, the exponential growth of complexity in increasingly networked embedded systems is the main challenge.

Challenges on the way to address this complexity:

- Platform thinking
- Tools for complex systems and environments
- Life cycle management
- Design methods and tools

Below, challenges in the engineering tools to address the complexity are more closely looked at.

Architectures

[IntelligenteSystemer[43]], [ArcadiaAligningAgendas], [AutomotiveEmbedded], [HipeacComputing[44]], [ArtemisiaAgenda], [DanishPosition]

A key tool to master Smart City complexity will be architectures.

Challenges:

- System design methods and tools to speed up the design process.
- Architecture-design, - exploration and -evaluation.
- Reference architectures and designs.
- Layered architectures.
- Model-based architectures.
- Components based on standard architecture.
- New architectures to support specific techniques like declarative programming and neural networks.

The [ArtemisiaAgenda] presents a timeline for solving Smart City architecture challenges:

- Short term: Defining global architectures principles, programming paradigms and frameworks taking into account safe and secure operation in non-deterministic environment.
- Medium term: Translating these principles into modular and composable reference architectures and protocols including monitoring and diagnosis as well as application independent software.
- Longer term (see also chapter Higher Abstraction Layers): Adding cognitive users' model to the global Smart City architectural models (extension to novel application contexts).

Requirements Engineering

[ArcadiaAligningAgendas[45]], [ArtemisiaAgenda[46]], [agendaCPS[47]]

Challenges:

- The adequate understanding, analysis and accurate specification of the open application context, problem space, user goals, human-computer interaction, and targeted specification of the functional and non-functional requirements in the shape of formal requirements models.
- The specification of non-functional requirements and quality models as well as the conversion of these requirements into architecture designs and models at the system integration (interoperability and semantic integration) and architecture design levels.

37 Smart Cities Applications and Requirements, 2011
38 Is Europe in the Driver's Seat? The Competitiveness of the European Automotive,2010
39 Aligning Research Agendas in Embedded Systems (Arcadia), 2012
40 MultiAnnual Strategic Research and Innovation Agenda for the ECSEL Joint Undertaking
41 ICT for Embedded Systems,2011
42 CPS: Uplifting Europe's Innovation Capacity, 2013
43 Forslag til dansk program om: Teknologier til intelligente systemer,2009
44 The HIPEAC vision for advanced computing in Horizon 2020, 2013
45 Aligning Research Agendas in Embedded Systems (Arcadia), 2012
46 MultiAnnual Strategic Research and Innovation Agenda for the ECSEL Joint Undertaking, 2014
47 Integrierte Forschungsagenda Cyber-Physical Systems, 2012

- Verification and validation methodology.
- Cooperative and distributed system debugging and validation.
- Environment modelling in the loop.

Requirements-oriented, Integrated Architectures

To integrate the various ontologies and modelling concepts, engineering needs standard requirements models and architecture concepts. The most important challenges are to combine basic system modelling concepts from the relevant domains, to develop an open Smart Cities platform with standard interoperability and Quality of Service services and come up with a way of managing autonomous and evolutionary systems.

Requirements Traceability

It is necessary to formalise the different user and stakeholder requirements and domain and context models, as well as possible ways of mapping these requirements onto the services that deliver them.

Domain Engineering of Open Applications and Platforms

[SmartHomeInterreg[48]], [agendaCPS]

Challenges:

- Specification and development of appropriate domain models including different user and stakeholder viewpoints and requirements.
- Design of interoperable architectural and composition patterns for guaranteeing non-functional requirements.
- Flexible tailoring of the development processes and life cycle and integration management of different components and subsystems across different domains and companies, for example for remote maintenance or updating.

Quality Models and Integrated Validation and Verification Methods

[agendaCPS[49]], [ArtemisiaAgenda[50]], [ArcadiaAligningAgendas[51]]

Challenges:

- Comprehensive quality models, methods and end-to-end processes for the analysis, specification and guaranteeing of non-functional requirements.
- Formal quality models that precisely specify the quality in use requirements in open and networked contexts of use.
- Novel formal verification and validation techniques, including stochastic approaches.

Higher Abstraction Layers

From a technological viewpoint, the most mature stage of Smart Cities is that of tightly networked systems of systems consisting of embedded systems, that use a software-intensive backend to provide seamless real-world services to the citizens (such as modality-agnostic travel).

This level of integration and service provision poses several challenges on abstraction layers high above the hardware level.

Human-computer Interaction

[ArtemisiaAgenda], [ArcadiaAligningAgendas[52]], [CPSWorkshop], [agendaCPS]

If the Smart City services are to be easily used, the embedded systems must take into account the intentions and thinking models of the users – and they must provide a means for the users to understand the systems and their actions.

Challenges:

48 Roadmap Smart Home, 2012
49 Integrierte Forschungsagenda Cyber-Physical Systems, 2012
50 MultiAnnual Strategic Research and Innovation Agenda for the ECSEL Joint, 2014
51 Aligning Research Agendas in Embedded Systems (Arcadia), 2012
52 Aligning Research Agendas in Embedded Systems (Arcadia), 2012

- Cross-sectorial usability
- Intuitive and enhanced accessibility for users
- Human centred design
- Availability of various human-computer interfaces and interaction modalities, such as touch screens, voice commands or body language. Should be modally independent.
- Intention and plan recognition, behaviour, and routine capturing
- User and human modelling, to enable the diagnosis, simulation, prediction, and support of human behaviour in interactions. Includes modelling complex interactions. Current research is focused on two applications: the "virtual test driver" and the "empathic virtual passenger".

Learning

[agendaCPS], [ArcadiaAligningAgendas]

Systems should adapt their behaviour and the way they cooperate to the requirements of their current context; One key challenge for this capability is the ability to build up knowledge, for example with regard to particular situations and the behaviour of human beings or based on experience from previous applications and interactions with different contexts.

Challenges for the machine learning and (big) data mining algorithms:

- Not stable enough to be used in safety critical environments.
- Not designed to handle the huge volumes of data involved.
- Relevant data are scattered across several distributed database systems.

Self-organisation

[ArcadiaAligningAgendas[53]], [agendaCPS[54]], [SmartHomeInterreg[55]], [DanishPosition[56]], [CPSWorkshop74], [ITEAVision2030[57]]

The Smart City technical systems becoming so complex, it will be required that they organise themselves, to integrate new resources, carry out new tasks, route around defective components, or adapt to changing environmental conditions. Especially in communication, self-organisation is required to ensure reliable communication.

Challenges:

- Self-adaptation.
- Emergence in self-organizing systems.
- Dynamic resource discovery and integration.
- Autonomous, Adaptive and Predictive Control

Connection to Business Software Backend / Cloud

[TelefonicaSmartCities[58]], [ITEAVision2030], [agendaCPS], [acatechSmartCities[59]], [Net!Works[60]]

Overall, system integration ultimately aims at an ICT-based integration of all urban infrastructures.

It is still open if the storage and analysis of data will be handled in a central facility (perhaps in the Cloud) or - more privacy friendly - in distributed nodes of the network.

For an ecosystem of providers of Smart City services, a service provisioning platform is required. Needed is a platform that facilitates the delivery of services in the scope of the Smart City. It consists of modules that allow for example to manage prices, agent negotiations, trust management, and service discovery.

[53] Integrierte Forschungsagenda Cyber-Physical Systems, 2012
[54] Roadmap Smart Home, 2012
[55] ICT for Embedded Systems, 2011
[56] CPS: Uplifting Europe's Innovation Capacity, 2013
[57] High Level Vision 2030 Opportunities for Europe, 2013
58 Smart Cities: un primer paso hacia la internet de las cosas (Telefonica), 2011
59 Smart Cities – German Technology for the Cities of the Future, 2011
60 Smart Cities Applications and Requirements, 2011

The availability of Open Data is another key ingredient for useful Smart City services that will make sense economically.

3 Public Programs and Policies

This chapter identifies for each region, which public programs and policies are already in place to support the embedded systems and smart cities sector, and how relevant those policy frameworks are for Smart Design.

3.1 Basque Country, Spain

RIS 3 Strategy

The Research and Innovation Smart Specialization Strategy (RIS 3) of the Basque Government (SPRI) are part of the different overall strategies developed by the EU: Europe Strategy 2020, Horizon 2020, Innovation Union, European Strategy related to Key Enabling Technologies (KETs) and Common Strategic Framework developed for the application of the Structural Funds.

RIS 3 are an indispensable condition for access to the European Cohesion Funds and could have impact in the funds related to Research, Innovation and Economic Development.

RIS 3 intend to define regional R+D+i strategies which “smart”, in the sense of contracting their resources and investments in the areas where synergies existed with existing and potential productive capacities of the region. Smart specialization means, to identify the characteristics and actives of each region, to highlight their competitive advantages and meet the participants into a shared future vision. The main objective of the whole process of RIS 3 is to support the productive transformation to create employment and social welfare in the medium-long term. For this reason, a set of starting criteria is defined to be considered in the election of the priority areas.

The Basque Government has defined 3 smart specialization criteria related to advanced manufacturing, energy and biosciences (where human health is in the main core of the activity). Besides, a series of niches have been identified with different level of maturity related to territory.

- http://ris3euskadi.eus/

Plan for Science, Technology and Innovation 2020

The Plan for Science, Technology and Innovation 2020 of the Basque Government gives a shared vision of the future, combining the necessary establishment of objectives and the budgetary allocation commitment from Public Institutions (top & down politics) with the contribution of the System Agents to define the specialization priorities (bottom up politics).

The push and promotion of Science, Technology and Innovation is a transversal process that concerns many aspects of social life, and in this connection, requires a full system of governance which includes all the capacities and responsibilities.

The coordinated Plan for Science, Technology and Innovation activities in the Basque Country begins by an overall vision of the developed activities by the Basque Institutions to encourage inter-institutional cooperation and collaboration and the complementarily of measures and the push of coordinated projects.

- http://www.spri.es/actualidad/noticias/euskadi-aprueba-su-estrategia-de-especializacion-inteligente-y-las-lineas-estrategicas-del-pcti-2020#

Digital Agenda of Euskadi 2020

The new interdepartmental plan, led by the Department of Innovation and Information Society Department of Economic Development and Competitiveness of the Basque (Euskadi) Government, is aimed at promoting and enhancing the Information Society in Euskadi with a time horizon of 2020.

- http://www.euskadi.eus/contenidos/plan_departamental/14_plandep_xileg/es_def/adjuntos/Agenda%20Digital%20de%20Euskadi%202020%20-%20Anexo%202017.pdf

3.2 Romania

RIS 3 Strategy

The vision created through the Research and Innovation Smart Specialization Strategy of the North-West Region in Romania is that by 2034 we will be among the most innovative regions in Central and Eastern Europe, capitalizing on the research-development-innovation activities in order to increase incomes, the number of jobs and the standard of living.

The Smart Specialization Strategy of the North-West Development Region was developed in accordance with the RIS3 Guide developed by DG Regio and Urban Policy. An extremely important step in the process of elaborating the Strategy was the inclusion of the Region in the project "RIS3 for less developed regions", implemented by the Joint Research Center (JRC) of the European Commission, under the coordination of DG Regio and Urban Policy and with the financial support of the European Parliament.

One of the most important aspects of the support received was the operationalization of the entrepreneurial discovery process (EDP), a key element not only of the elaboration process but also of the implementation of the smart specialization strategies. With the help of European Commission experts, this process was organized according to a methodology that ensured optimal results, from the perspective of selecting areas of specialization, supporting and developing the interaction of key actors in the quadruple helix system, generating and developing quality project ideas. that can contribute to the achievement of regional specialization objectives.

Six such entrepreneurial discovery workshops have been organized throughout 2016 and 2017, covering the following fields and domains: cosmetics and food supplements, furniture, paper, plastic, packaging, agri-food, health, metal processing, production technologies: machines, equipment, machinery, ICT.

Upon the EDP, the SWOT analysis of the socio-economic context and innovation potential of the region, and an in-depth analysis of the R-D-I activity, the following main strategic directions have been established:

- Alignment with European and global trends by adopting / creating and disseminating new technologies in order to transform economic activities and structural change of the regional economy.
- Supporting development through innovation in traditional economic fields in the region
- Reducing the development gap compared to more developed regions by adapting it rapidly to the 4th industrial revolution (social and economic digitalization)
- Rational and efficient use of resources according to the principles of circular economy
- Innovative management of societal challenges

The following 3 pillars are going to support the operationalization of these strategic directions:

1. Health and welfare innovation covering
2. The development of emerging sectors
3. Digital transformation through the regional digital agenda

The first 2 pillars can be considered to be verticals that include the domains: health, agri-food, cosmetics and food supplements, new materials and advanced production technologies. These will be enabled and supported by digital innovation.

The entire strategy can be found here, available in Romanian only:

- https://www.inno.ro/en/knowledge-hub/resources/details/news/strategia-de-specializare-inteligenta-a-regiunii-de-dezvoltare-nord-vest-ris3-nv/

3.3 Bulgaria

RIS 3 Strategy

Bulgaria has a National Innovation Strategy for Smart Specialisation 2014–2020 as well as some regional / local S3s (Severen – Tsentralen Region, Sofia, Plovdiv, Varna and Ruse). The national strategy identifies four thematic priority areas for the whole country:

Informatics and ICT - New and hybrid applications (including 3D digitization) for industrial design, assembling, visualization, prototyping and other areas (cultural heritage). Big Data, Grid and Cloud Technologies. Development of wireless sensors and language technologies.

Healthy life and biotechnology industries - Improved high productive technologies for traditional food sector; new approaches to diagnostics and medical instruments and equipment; advanced solutions, nano and biotechnologies to be applied in medicine, health care services, other than in blue economy; green/ bio-based economy

Mechatronics and clean technologies sectors - Clean technologies and new solutions for sustainable energy systems with focus on the transport sector; "smart homes" and "smart cities" solutions; advanced automation processes, including 3-D modelling, and assisted management software solutions with application in manufacturing.

New technologies in creative and re-creative industries - Computer and mobile applications and games with educational marketing and/or entertainment character.

Innovation infrastructure in ICT is offered by the established ICT clusters that act as platforms for the development of innovative companies and innovative ideas and catalyse the process of commercialization of research.

There is also a National Roadmap for Research infrastructure 2017-2023. National Roadmaps for development of research infrastructure are the key instruments for implementing the national research strategies and they also reflect upon the priorities of European Union. Large research infrastructures are subject to special attention at EU level because their construction and maintenance require significant financial and human resources.

- **https://s3platform.jrc.ec.europa.eu/regions/BG/tags/BG**

3.4 Netherlands (NORTHERN NETHERLANDS – AMSTERDAM)

RIS 3 Strategy

In 2011, the Northern Netherlands drafted a position paper that stressed the pro-active, even pioneering, role the region endeavours to assume within Europe. In their RIS3, the Northern Netherlands go beyond the formal requirements set forth by the EC. The RIS3 describes how the Northern Netherlands can contribute to tackling societal challenges on a European level.

The RIS3 strategy for the Northern Netherlands follows an approach based on three main steps. The first one focuses on identifying specific societal challenges; the second step aims at finding innovative solutions to those challenges; and the last step is to apply those solutions to the Northern Netherlands which can be applied on a regional, national and global level.

- https://www.snn.nl/en/smart-specialisation

RIS3 Strategies for other regions in the Netherlands:

- https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/region/nederland

NL Smart City Strategy

The Dutch National Smart City Strategy is a nation-wide plan that aims to address how the Netherlands can ensure that cities are liveable in the future. Presented in 2017, this strategy takes a unifying approach that extends beyond any single sector, to improve quality of life and maximise economic opportunities for people living in cities. Five preconditions for success have been established: 1) safe, standardized digital infrastructure; 2) public-private partnership with room to experiment; 3) new models of governance, integral and in collaboration with citizens; 4) education and employability; and 5) regional collaboration in which cities operate as a network.

To put the Strategy to practice, the five largest cities in the Netherlands have been tasked to translate the National Smart City Strategy to their own cities. Additionally, each city has their own area of focus:

- Amsterdam: Circularity
- Rotterdam: Sustainability (resilience & energy transition)
- The Hague: Safety & Security
- Utrecht: Healthy Urban Living
- Eindhoven: Smart Mobility
    - https://instituteforfutureofliving.org/wp-content/uploads/NL_Smart_City_Strategie_EN_LR.pdf (EN)

Amsterdam: Circular City

This program establishes the steps towards a transition to circular economy in Amsterdam. With the goal of conserving natural resources and reducing waste, a circular city is based on new ways of thinking, that include the use of smart data, innovative design and interdisciplinary collaboration.

The full program (in Dutch) is available here:

- https://www.amsterdam.nl/en/policy/policy-innovation/policy-circular-city/.

4. Special Capabilities

4.1 Basque Country, Spain

In the case of the Basque Country, we are going to reflect two public-private initiatives that reflect very well the capacities of the sector:

Basque Digital Innovation Hub

The Basque Digital Innovation Hub (BDIH) it is an initiative that responds to the Basque smart specialization strategy RIS3 in advanced manufacturing, Basque Industry 4.0, to support the business fabric in the experimentation of digital innovations.

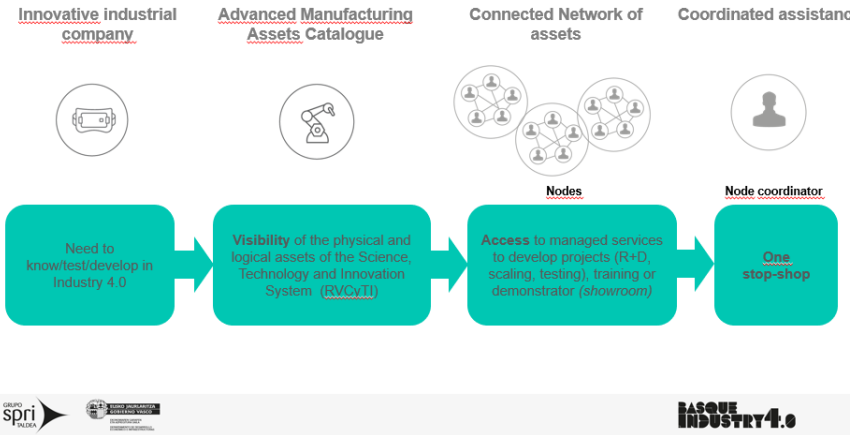
The aim of this initiative is to provide industrial enterprises, especially SMEs, with the technological capabilities needed to meet the challenges of industry 4.0.

The aim of the network is to provide easy and efficient cost access to the Basque industrial fabric, especially to SMEs, to innovative and excellent scientific-technological capabilities in the advanced manufacturing environment, enabling it to evolve and be more competitive.

It consists of a digitally-linked network of R+D infrastructures, pilot plants and specialized know-how in different areas of advanced manufacturing.

The network is owned by R+D Centers, vocational training centers and universities and is supported by regional public institutions.

The network will be used for the development of R+D projects, scaling of industrial projects, exhibition of cutting-edge technologies and also as a resource for training and acceleration of start-ups.



Spri.es

Basque Industry 4.0

The Basque Country has a long history in defining economic development strategies in the last 35 years. Priority areas are a combination of technologies, products, processes and services from different sectors and areas of expertise to respond to areas of opportunity.

The advanced manufacturing strategy is a priority area of the Smart Specialization Strategy RIS3 Euskadi. Its implementation is carried out through public-private cooperation led by the Steering Group.

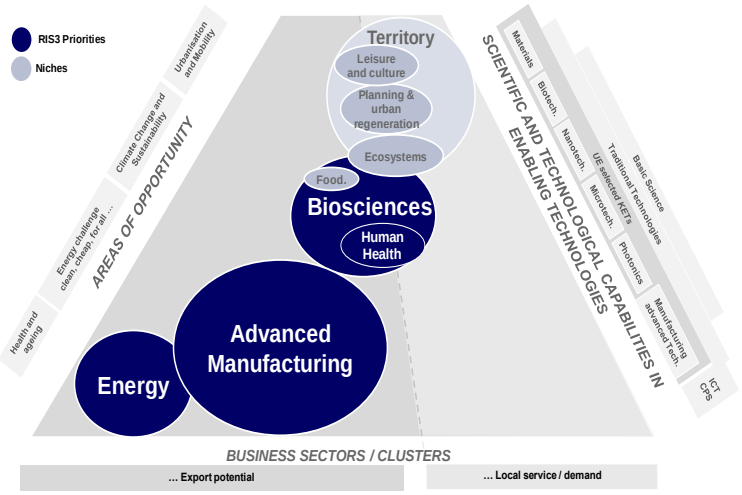
Mission

To strengthen the position of the Basque Country as an economy with an industrial base through the promotion of knowledge intensive manufacturing

Strategic Objectives

1. Added Value: To help and guide Basque companies towards more knowledge intensive manufacturing activities which have greater added value

2. Integration of KETs: To promote multi-disciplinary and technological convergence in a structured fashion so as to develop best-in-class manufacturing capacities and solutions while optimizing existing resources



3. Global value chains - Cluster 2.0: To integrate local and international value chains to meet the challenges of Advanced Manufacturing using the sum of the particular capacities of each sector and its companies

4. Scaling Up: To foster collaboration and support as a catalyst for the industrialization of the results of R+D+i in Advanced Manufacturing

5. Talent: To support education and job training in technologies and management systems related to Advanced Manufacturing

Technological priorities

The commitment to technological development in advanced manufacturing is crucial to maintain the competitiveness of the industry and to ensure positioning in market niches with greater added value.

1. Advanced materials & processes

2. Intelligent, Flexible & efficient production systems

3. Energy efficiency

4. Digital & Connected Factory

4.2 Romania

The local software development ecosystem, around the city of Cluj-Napoca has been on a constant growth since the late 1990's. According to a national study on the IT sector from 2017, there are more than 1200 active IT companies in Cluj-Napoca, employing a workforce of more than 14.000 professionals. The start-up ecosystem has been on a rise, alongside local SMEs, large companies and multinationals, covering a wide range of services and fields for providing digital transformation solutions.

There are quite a number of local/regional companies providing smart city solutions, together with research and development efforts, among the ones that are more experienced being: AROBS

Transylvania Software, Evozon, Fortech, Control Data Systems, Indeco Soft, Global E Business Solutions and many more.

- https://www.evozon.com/software-development-services
- https://www.arobs.com/home-automation-system/
- https://www.fortech.ro/technical-expertise/iot-software-development/

We've selected only a handful of solutions relevant for the key areas of the Smart by Design project: government, transportation and mobility, lifestyle / housing and utilities. The examples can be found below:

Governance

The SIGMA MaP system integrates the existing data in the IT systems of the City Hall and subordinated institutions regarding the activities of collecting local taxes and duties, investments, projects, green spaces, urbanism and urban planning, with real-time data from sensors water or air quality measurement, car meters, etc. SIGMA MaP natively integrates information on social assistance and protection, allowing the creation of social risk maps and the identification of problems specific to micro-communities. The corroboration of these data with the information provided by the Non-Governmental Organizations providing social services paints a clear picture of the social status of the community. External data sources (information and satellite imagery, open source data or real-time information from sensors or connected devices - Internet of Things) are retrieved and displayed in an easily intelligible format, organized in thematic maps and processed to build a real image of the community:

- https://indecosoft.ro/site/sigma-en/

ePetitions - The use of the online petition system facilitates the interaction between the citizen and the authority and allows the institution to receive complaints from citizens, register them automatically, process them on specific flows and respond to taxpayers, also by electronic means (SMS, email), thus reducing correspondence costs. The petition system is natively integrated with the document management module provided by Indeco Soft (CID), and the georeferenced data regarding the petitions are transmitted to the SIGMA MaP management system.

Transportation / Mobility

City Pulse is a complete hardware and software solution that improves urban traffic management and transportation operations by: (1) Management of complex public transport networks, (2) Real-time tracking of the transport fleet and the number of passengers, (3) Accurate information about the arrival time of the means of transport. The platform provides public transport companies with an administration platform that allows the configuration of routes, stations and transport schedules, real-time tracking of the fleet by GPS, generation of reports and real-time statistics on the number of passengers, time deviations and bus speed. The platform provides citizens with a web and mobile application that allows trip planning, real-time bus tracking, information on timetables, routes and arrival time.

- https://www.gebs.ro/case-studies/city-pulse/

ZONIZ is a proximity platform that uses beacon technology to connect the digital world with public institutions and locations in a city. Beacons are discrete sensors that help transmit information directly to your mobile phone, depending on your location. Using beacon technology, Zoniz connects the real world with the digital one, the users of the application being always up to date with what is happening in their city. Through the ZONIZ mobile application, citizens and tourists receive interactive content on their mobile phones, in a personalized context for their location. In this way, they enjoy exciting experiences every time they interact with the city - whether they are kept up to date with city hall projects, participate in contests or opinion polls related to public services and future projects, or receive promotional discounts offered by their favourite brands.

- https://www.zoniz.com/about.html

Housing / Lifestyle

CityCardIndeco - system of personalized cards for access to cultural events and institutions, respectively granting of rewards (bonuses) for culture consumers. The system provides local authorities with

statistical data on the cultural appetite of citizens and their preferences, by age, social, etc. The system integrated with the electronic payment services provided by Indeco Soft allows the online purchase of tickets for events, museums, the purchase of season tickets or parking tickets, obtaining discounts from partner economic agents. At the same time, by using the system, information is obtained on the consumption of public services (especially cultural) at urban level.

- https://www.indecosoft.ro/

Utilities

Smart Metering by Control Data Systems. Hazardous Emission Monitoring System and Power Meter:

- The hazardous emissions monitoring system was implemented in 5 cities in Romania
- Power meter was implemented in 2 cities in Romania
- Communication products: radio modules and gateways (routers)
- Communication infrastructure based on ISA100 wireless technology - from Modbus sensors
- Web interface / data reading application (UX)
  - http://www.cds.ro/projects/

CityCon by Indeco Soft is an information system for the unitary management of resource / utility consumption, at the level of an administrative-territorial unit and represents the starting point towards making their use more efficient and providing the necessary support to develop a strategy for sustainable development of the administrative-territorial unit. in the field of resource consumption and energy efficiency. The system allows the recording of monthly consumptions, by types of utilities, for each unit / point of consumption and offers the possibility to make comparisons between units and points of consumption in the same categories. The recording of simple monthly invoices and common invoices for several entities and the recording of consumption based on meter reading can be done manually or automatically by processing the data (files) received from the supplier. The system structures the consumption and billing details for each institution / subordinated unit and provides statistics on average and total consumption for time intervals, by types of resources, suppliers and consumption points, statistics consolidated at the level of consumption points or units and benchmarking reports.

- https://www.indecosoft.ro/

3.-i-SCOPE by Indeco Soft Within an ICT-PSP financing, Indeco Soft has developed software modules that facilitate the calculation of the energy-solar potential of the surfaces available in the urban environment (roofs, unused relief, etc.). Measurements of existing slopes or made by local public authorities can be used for the construction of the map of energy potential - solar of the locality. These modules can work independently or can be integrated with SIGMA MaP services

4.3 Bulgaria

Digital transformation of the economy

Bulgarian startups are developing solutions according to the latest global technological trends and almost half of them (47%) offer world-class innovation. Key challenges for innovative digital enterprises include: timely access to funding (36%), qualified experts (33%), lack of institutional support (31%), and easy access to administrative services (25%). In terms of capabilities and capacity for innovation, a research by MOVE.BG. The Innovation Ship 2019 survey presents the most comprehensive and detailed mapping of the Bulgarian digital ecosystem. It is found that the first trends of a possible emergence of a new wave of deep tech startups in the Bulgarian digital ecosystem. There also seems to be a growing specialization among the small digitals. Of them, 34% focus on offering their solutions to the tech industry, and 24% focus on the financial sector. The third most popular industry to focus on is somewhat surprisingly education with 22% of companies reporting it as a primary target. 47% of companies offer a global innovation, innovation is intimately connected with product-based offering. According to it software engineers and developers are the hardest to find and 49% of companies declare that finding employees in this field is the biggest challenge. When talent is scarce, companies have found innovative

ways to recruit capable people. One of the key recommendations of the people who participated in the survey is to foster a stronger educational system and research sector that can meaningfully contribute to the development and commercialization of innovative business ideas.

Companies are mostly involved in platform building (42%), big data analytics (28%), machine learning and AI (32%), cloud computing (25%) and since 2019 – automation systems (25%). This is followed by blockchain/API and Connectivity/IoT – one in five companies offer any of the latter. Less attention is received by offerings in virtual reality, and information security. The least number of companies is interested in offerings in the field of biometry, which is highly specialized and requires expert knowledge in numerous areas. Nevertheless, biometry has seen a slight decrease since last year, which shows that seemingly the Bulgarian market in the field follows the global trends with certain lags.

- http://edit.bg/wp-content/uploads/2019/12/innovationship-2019-en-pdf-web.pdf

Digital Transformation Strategy for SOFIA

Sofia (1.3M inhabitants), capital city of Bulgaria, is a social and economic metropolitan centre contributing about 30% to the national GDP. Its ambitions towards a smart city are laid down in the Sustainable Energy Action Plan 2012-2020 with integrated actions for the implementation of energy management, holistic energy planning and renovation of the building stock, integrated measures in the transport and waste management. Sofia is home to one of the most developed start-up ecosystems in Central and Eastern Europe and is the start-up hub of the Balkans. Sofia ranks 1st in the Smart City Development category and 7th in the overall ranking of Emerging Europe for the best cities for doing business in Central and Eastern Europe – Business-Friendly Cities Perception Ranking 2020. Sofia is also in the Top 10 in the Quality of Life category, sharing the 5th place with Gdynia, Poland, Bratislava, and Slovakia. For the ranking, Emerging Europe investigated 75 cities in the region of developing Europe – capitals and cities with over 200,000 inhabitants. The Business-Friendly Cities Perception Ranking 2020 is part of the Emerging Europe Awards 2020 – the third edition of a program that presents the best of Europe's developing region and honours the achievements of individuals, public and private organizations, projects, and initiatives.

The mission of the Digital Transformation Strategy for Sofia (DTSS) is to define and elaborate an action plan and a series of actions that strengthen the ICT business ecosystem located in Sofia, enabling (a) to develop innovative solutions for the digital transformation of the city; (b) to create new markets for digital products and services at local, national or global level, and facilitate the access to these markets; and (c) to support the system of innovation (local or national) for the development and absorption of new digital services and solutions.

In order to reach this goal, the DTSS will pursue the **following ambitions**:

- To enable most companies in the ICT business ecosystem of Sofia to engage in the digital transformation of the city by developing and offering innovative products and e-services. This may be achieved by enhancing the capability of ICT companies for making products and services suitable for the digital transformation of the city; moving ICT companies upstream from outsourcing to higher added-value services; using hackathons and competitions as a way for developing new products and e-services; and developing e-services based on open data.
- To create markets for ICT products and e-services at local and national levels, by selecting and facilitating the access of ICT companies (small and large) to other industries, the public administration, and utility organisations. This may be achieved by opening the public market for digital services; promoting the standardisation of e-government services across administration departments and cities of Bulgaria; increasing the awareness and inform ICT companies about digital services and solutions to be deployed by local and central governments; creating markets for digital services by utility providers (water, waste, energy); creating markets for digital services in transportation service providers; and increasing the awareness about the benefits of the digital transformation in utility, transportation, and government services.
- To enhance the local innovation ecosystem by funding mechanisms, information services, and brokerage agents, facilitating the digital transformation of the local economy, and enhance the skills of the local ICT labour market and the start-up ecosystem to support the digital transformation. This

may be achieved by providing training and skills in data science and analytics, mathematics, AI and deep learning, algorithms for optimisation, software programming and software engineering; and limiting the separation between digital and non-digital skills, advancing interdisciplinary training between ICT, business, and engineering.

Smart City Cases from Bulgaria

Virtual transportation map, navigation and virtual parking tables

It is an integrated information system for search and live monitoring of the transport vehicles lines and roads with their time schedules and for live monitoring for free places in the city parking.

WiFI4EU in the Sofia Municipality

In 2020, the Sofia Municipality received a voucher under the WiFi4EU initiative. The city has installed 22 wireless access points. They provide free Wi-Fi of 100 Mbit / s in the area from Vitoshka Street (St. Nedelya Church) to the National Palace of Culture and the Bridge of Lovers. The devices are managed and monitored by a specialized portal in the Sofia Municipality and can provide simultaneous continuous service to a large number of users. When the user enters the WiFi4EU network for the first time, he/she must agree to the general conditions set by the European Commission (applies to all participating municipalities). Then the user will be remembered by the system and will be automatically connected to WiFi4EU zones available in Bulgaria and throughout Europe.

Virtual complaints section at the Urban Mobility Center!

This is a virtual space where citizens can express their dissatisfaction with the services provided by UMC and the transport operators. Complaints are accepted with exact details that can identify the employee.

Cases under development

Cases (projects), based on smart city technologies that have been identified by the local working group as pilot activities for immediate implementation, in order to launch the implementation phase of the digital transformation strategy and start generating immediate results - Smart City Roadmap. (Source: The digital transformation strategy for Sofia: A platform for smart growth; Digital Cities Challenge Initiative).

Distributed platform of urban data

Creating a Data Lake – a storage repository that holds a vast amount of raw data in its native format, including structured, semi-structured and unstructured data. The data lake will not only be used to store data from and for the municipality but also business, citizens, academia. After creating the data lake, we would expand with different modules used for analytics, visualisation, and modelling, thus creating a data hub. General goal – help stakeholders be more informed and facilitate evidence-based policy making.

Sofia's Digital twin (cyber-physical platform for decision-making optimisation)

Digital twin – a digital profile of the physical city that helps to optimise its performance and can be used as a platform for planning and decision- making but also experimentation, and research and development. General goal – help decision makers and experts to better plan and make decisions about development of the city.

Online platform for services in schools

For a few years now there has been an operating system for acceptance and attendance in kindergartens. Expanding it to the public schools and build new functionalities that allow new e-services. General goal – improve the communication between student parents and schools.

Dashboard for real-time utilities consumption

Creation of e-utility services in help for building owners to save energy, gas and water using smart sensors. Creation of a mobile app/website for following utility consumption in real time. Testing in 3-5 properties (manufacturing, administrative, residential, retail). General goal – optimisation of utility costs.

Development of utilities efficiency model

Development of a single model for efficiency based on meteorological conditions – create an online platform for data collection and analysis that helps utility companies to increase the efficiency of resource utilisation. General goal: increased efficiency and service quality.

Transport modelling

Creation of a dynamic transport model of the city. To be used to test scenarios. General goals: better planning and mobility management in the city.

Integrated Mobility Platform

Creation of an integrated mobility platform that provides real time information about all types of transport and routes in the city. General goal: optimise mobility as a service

Neighbourhood car sharing

Building a platform for shared electric cars for a certain number of neighbouring residential buildings. General goals: improve the urban environment.

Digital and physical space for start-ups located in Sofia

Development of new or customisation of an existing e-platform for start-ups and scale-ups. Creation of an office for consultations for founders. The team there would also be responsible for synchronising, supporting and developing existing initiatives engaged with inspiring entrepreneurial qualities and innovative thinking. General goals: promote entrepreneurial qualities and innovative thinking among young people, improve founders' entrepreneurial skills, make it easier for start-ups and investors to connect.

4.4 Netherlands

City Data

The municipality of Amsterdam offers free access to anyone who is looking for reliable and up-to-date information about the city. All the Data in the online portal can be searched and used by all citizens. Various formats are available, from interactive graphics to dashboards and others.

- https://data.amsterdam.nl/ (in Dutch)

Global Innovation Index

The country scores 4th among 129 in the Global Innovation Index 2019.

The Netherlands produces more innovation outputs relative to the levels of innovation investments.

- https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2019/nl.pdf

5. Main initiatives already in place

5.1 Basque Country, Spain

In Basque country, there already exist initiatives fostering Smart Cities. A brief explanation of their focus is provided here.

I-Sare

The objective is to deploy a smart micro grid that is efficient, sustainable and safe to serve as a testing ground to develop and evaluate the status of different generation and storage technologies (renewable energy, electric car, etc.).

To do so, an experimental infrastructure has been developed in Gipuzkoa (Basque Country) for the development of the smartisation of various components that make up the intelligent power networks and their integrated management.

- http://www.i-sare.net/pages/quees.html (only in Spanish)

Mobility Lab

This project allows optimising infrastructure management and efficiency of vehicles traffic mobility.

The Vehicles Flow Management system allows easing the condition of roads, reducing accidents and travelling times, the economic costs involved for drivers, increase the performance vehicles use and minimize environmental impact.

Smart Cities Catalogue

Development of a catalogue that contains the definition and concept of Smart City as well as in individual tabs, the products - services / scope of action of GAIA companies that have solutions for the Smart environment.

- https://www.gaia.es/smartcities/es/home/

As Fabrik

The objective is to Increase the competitiveness of Bilbao companies in the technological services 4.0 sector to provide an adequate response to the challenges associated with the digital transformation of the industrial sector.

It is a collaborative Ecosystem where people attached to the technological services sector or the Basque industrial fabric and those who could become (university students, entrepreneurs and professionals), acquire the necessary skills to provide services to companies in the environment Industry 4.0.

- https://uia-initiative.eu/en/uia-cities/bilbao

5.2 Romania

According to a 2018 study by VegaComp (https://vegacomp.ro/wpr/wp-content/uploads/2018/10/radiografia-smart-city-romania_2018.03.20-en.pdf) regarding the number of planned or already implemented smart city initiatives in Romania by local authorities, the North-Western region has 2 cities in the top 3: Oradea and Cluj-Napoca with 20 and 18 smart city initiatives. The following solutions and apps are already functional, improving the quality of life for citizens:

e-Governance

e-Governance has a number of public services that can be accessed or performed online. The Participatory budgeting process is one of the flagship projects of Cluj-Napoca City Hall, happening on a yearly basis since 2017. It's a process that offers citizens the possibility to propose community-based initiatives covering all aspects of the city's life: infrastructure, education, health, mobility, environment and then vote for them online. The local budget provides the funding for the implementation of the winning projects. Details can be found here: https://bugetareparticipativa.ro/ Furthermore, in regards to e-governance, the issue of construction permits, certificates and other types of documents cand be done via online queries. Also paying local taxes or fines, filing in complaints or demanding various documents; more than 3000 complaints were filed in through the My Cluj app alone in its first 6 months since launch in early 2017.

Transportation and Mobility

For better transportation and mobility there is a wide range of already available solutions like: interconnected traffic lights, e-ticketing systems, self-service bike rentals, mobile payments via apps for parking or public transportation. The Cluj Parking app has over 6.000 user accounts on both Android and iOS. The public transport company in Cluj-Napoca has a fleet of 41 fully electrical buses, over 250 modern buses, 112 trolley-buses and 26 trams covering 60 transportation routes and a distance of 421 km Details can be found here (Romanian only): http://ctpcj.ro/index.php/en/despre-noi/evenimente/plan-administrare-ctp/1333

Lifestyle

In terms of Lifestyle, there's an online reservations platform to access sport from public sports facilities. There are dozens of free of charge public wi-fi networks available in most of the central locations of Cluj-Napoca and Oradea and more than 300 CCTV cameras.

Smart Grid

Smart grid system for public lighting covering 1500 luminaires, smart lighting in public parks are used in order to raise the efficiency of spending on public utilities.

5.3 Bulgaria

There are several initiatives and projects in Bulgaria that foster the smart city concept implementation. There are brief explanations of some of them:

Digital Transformation Strategy of Sofia

The city of Sofia participated in the initiative Digital Cities Challenge of the European Commission. The result was the elaboration of the Digital transformation strategy for Sofia (DTSS): A platform for smart growth. https://innovativesofia.bg/wp-content/uploads/2020/06/Digital-Transformation-Strategy-for-Sofia-Final-accepted-ENG.pdf. DTSS defined an action plan and a series of actions that strengthen the ICT business ecosystem located in Sofia, enabling (a) to develop innovative solutions for the digital transformation of the city. As for further implementation of the action plan the city signed an Agreement with the European Investment Bank for technical support for its realisation with concrete investment projects.

AirThings - The initiative includes the installation in the city of Sofia of air sensors to monitor temperature, humidity, CO2 and other toxicity.

CircE - The project is aimed at updating, developing and implementing an integrated waste system.

Smarter together

It is a joint project that was aimed to improve citizen's quality of life in nowadays transforming cities. The project focuses on finding the right balance between ICT technologies, citizen engagement and institutional governance to deliver smart and inclusive solutions. Therefore, six neighbourhoods in different European countries experimented with innovative smart city components, including co-creation processes and high-quality refurbishment measures to explore new ways of adding value in urban societies: Munich, Lyon and Vienna – the three lighthouse cities implement the main demonstration activities in specific districts, monitor the results and upscale solutions at city level; Santiago de Compostela, Sofia and Venice – the three follower cities had to replicate the key findings from lighthouse cities in targeted areas, implementing them in different urban and institutional environments. In this initiative the city of Sofia has a plan for the development of 5 innovation clusters (innovation labs, heating district and renewable energy sources, holistic refurbishment for low energy districts, smart data management platform & services, e-mobility solution).

Sofia Smart City Marketplace

An initiative of the Cluster Sofia Knowledge City to develop a platform for publishing, storing and open access to a database of validated or ready-to-validate product and technological innovations that can be used in the process of transforming the city into a smart city. It is designed primarily for those local government officials responsible for the development of the smart city by providing them with a simplified process for finding information on the latest products, applications, technologies and technological solutions with which the municipal structures can cope. more successfully with the challenges in the management of the processes and infrastructure of the city. The principle of operation of the platform is as follows: the data on product and technological solutions are entered by their owners (suppliers) in the database, and employees receive access for general and more detailed search, discovery and acquaintance with them. An intelligent filter and keyword search method is applied. General information is also available to any ordinary visitor to the platform without the need for registration.

- The platform is beta version https://smartcitymarketplace.eu/.

Planning a Black Sea smart city of Bourgas

Burgas's smart city agenda supports smart city planning and development. The city is now keen to lend structure to its ambitions and is developing a Smart City Roadmap that refines its strategic intent and prioritise future investment intentions accordingly. Smart city of Bourgas integrates technology with infrastructure to enable urban development that is more intelligent, interconnected, and efficient. The intention is to facilitate the creation of new business models and the advancement of local innovation ecosystems in pursuit of more environmentally and economically sustainable opportunities for growth and development. Burgas appears to be delivering on this promise. Because of its manageable size and

other endowments, Burgas is the perfect "urban laboratory" in which to test smart applications in a relatively controlled environment. The municipality's commitment to a considered programme of further interventions that will form the mosaic of its proposed Smart City Roadmap will only make it smarter.

These are some selected examples from a smart **city planning agenda**:

- **Interactive smart mobility terminals** - the city has developed an interactive terminal system and mobile application to make travelling easier and more convenient. Transport users can access the interactive terminals at various transport hubs and intermodal terminals around the city. These can be used to access bus timetables and real time information about all of the city's various transport modes, details of events in the city, and even the weather. The development of these terminals is intended to facilitate more sustainable urban mobility in the city and is part of Bourgas' Sustainable Urban Mobility Plan.
- **Smart lampposts** - the city is installing solar-powered lampposts fitted with LED bulbs and a reactive dimming system that will save over half of Burgas's energy used for street lighting. In addition to offering solutions for energy savings, sensors installed on smart lampposts can gather data on noise and pollution levels and traffic, sharing this information with the city to inform future urban developments based on Burgas's needs. In a novel development, some lampposts in the tourist area are fitted with sprinklers that release a modest and mist-like water-spray to cool pedestrians in high summer.
- **Intelligent public transport** - the city has created an intelligent system to make its public transport safer, more efficient and convenient. Financed by the municipality, the European Regional Development Fund and the European Bank for Reconstruction and Development, the project increases the attractiveness and comfort of the current system, provides real-time information for passengers, introduces integrated ticketing, and includes video surveillance to increase passenger safety and reduce ticket fraud.
- **Bicycle sharing service** - the city started the implementation of a bike-sharing service as long ago as 2012 and was the first Bulgarian city to include the practice as part of an integrated urban mobility policy. The initial project, "Cycling City – a Model of Modern Urban Mobility", was financed by the Global Environmental Fund and aimed to increase infrastructure for and access to non-motorised transport. Since its introduction, the system has been extended and constantly upgraded, with e-bikes envisaged for the near future.
- **Business incubator** - a listed building in a prime location has been refurbished and re-modelled as a business incubator for innovative, high-tech and digitally enabled projects that, once sufficiently developed and ready for up-scaling and/or production, can be transferred to a more appropriate location in an innovation cluster in one of the new industrial zones.
- **Urban dashboard** - the city's initiative draws on two European Regional Development Fund projects23 that focus on building knowledge and capabilities in the field of information and communications technology, as prioritised in Bulgaria's Innovation Strategy for Smart Specialisation. In pursuit of the project's objectives, Burgas has been identified as an ideal test-bed. To this end, the city is creating a so-called urban dashboard. The latter builds on new and existing digital infrastructure and seeks to integrate disparate data sets from the municipality and other city partners to monitor, evaluate and optimise public investment plans and service delivery. By affording opportunity for significant improvement in communication and information flows between dispersed organisations and activities, the dashboard should also facilitate the introduction of new ways of organising shared work and co-operative enterprise, strengthening Burgas's competitive advantage as part of its wider smart city endeavour.

Sustainable Technologies And Combined Community Approaches Take Off (STACCATO)

With the STACCATO project three European capital districts - Amsterdam-Noord (Amsterdam, the Netherlands), Óbuda (Budapest, Hungary) and Oborishte (Sofia, Bulgaria) - demonstrated sustainable energy concepts in existing representative residential areas. The urban areas all faced technical arrears and a lack of social cohesion. These large-scale demonstration sites, in combination with research and

development aimed at innovative and reproducible renovation concepts and approaches, served the purpose to accelerate the transition to a sustainable energy supply in existing housing areas in Western and Eastern Europe.

Sofia Tech Park

The Sofia Tech Park was an Initiative financed by the Operational Programme 2007-2014. Now it is a state-owned company, which aims to boost the development of research, innovation and technological capabilities of Bulgaria through implementing different projects. This is the first science and technology park in Bulgaria. The park is expected to become a prestigious location for national, regional and global researchers and innovative companies, showing examples of a knowledge – based economy in Bulgaria and the Balkans region. The park was officially opened in December 2015.

The Smart Cities Information System (SCIS) of City of Varna

SCIS is a knowledge platform to exchange data, experience and know-how and to collaborate on the creation of smart cities, providing a high quality of life for its citizens in a clean, energy efficient and climate friendly urban environment. SCIS brings together project developers, cities, research institutions, industry, experts and citizens from across Europe. SCIS focuses on people and their stories – bringing to life best practices and lessons learned from smart projects. Through storytelling, SCIS portrays the “human element” of changing cities. It restores qualitative depth to inspire replication and, of course, to spread the knowledge of smart ideas and technologies - not only to a scientific community, but also to the broad public!

Launched with support from the European Commission, SCIS encompasses data, experience and stories collected from completed, ongoing and future projects. Focusing on energy, mobility & transport and ICT, SCIS thus showcases solutions in the fields of energy-efficiency in buildings, energy system integration, sustainable energy solutions on district level, smart cities and communities and strategic sustainable urban planning. Projects in the scope of SCIS are mostly co-funded by the European Commission, for example, the 12 Horizon 2020 Smart Cities and Communities (SCC1) projects (such as Triangulum, Sharing Cities or Stardust), the 7th Framework Programme projects CELSIUS and City-zen, and many more!

SCIS therefore analyses project results and experiences to:

- Establish best practices which will enable project developers and cities to learn and replicate.
- Identify barriers and point out lessons learned, with the purpose of finding better solutions for technology implementations and policy development.
- Provide recommendations to policy makers and policy actions needed to address market gaps.

5.4 Netherlands

Higt Tech NL:

The Dutch microelectronic sector is mainly clustered in the Southern and the Eastern parts of the Netherlands. The cluster High Tech NL, together with the associated partner Business Cluster Semiconductors Netherlands (BCSNL), covers all aspects of microelectronics; from process/technology research and production tools/equipment to electronic components and end-user products. Additional major concentrations of microelectronic activity are found in the western part of the Netherlands, around Delft and in the northern part around Assen. All these ecosystems are very well connected to each other. Most of the East and South of the Netherlands micro- and nanoelectronics clusters are concentrated around a few cities; Eindhoven, Nijmegen and Enschede, always close to innovation campuses, such as the High-Tech Campus in Eindhoven, the High-tech Factory in Enschede and the NovioTech Campus in Nijmegen and the universities. This concentration in relatively close kernels is a clear advantage for Dutch researchers and engineers who successfully follow efficient multi-disciplinary open innovation principles in the technology and product development process over the complete region.

- http://www.hightechnl.nl/

AMS – ix (Amsterdam internet exchange)

Ams-IX is one of the world's largest data transport hubs. The platform allows for Internet Exchange in various points and operates multiple interconnection platforms around the world.

It was created at the beginning of the nineties, in Amsterdam, and has now expanded to other locations, in the U.S, India, and others. AMS-IX is a member of the European Internet Exchange Association, a network that allows the interconnection of more than two systems, facilitating Internet traffic.

- https://www.ams-ix.net/ams.

Region of smart factories (rosf) | Northern Netherlands

ROSF is a network of companies who conduct research into new technologies to improve factories in the northern region of the Netherlands. The project has a regional focus on the production and manufacturing industry of Northern Netherlands.

About 40 companies are part of ROSF, including bigger companies such as Phillips, but also a number of SMEs. One of the goals of the project is to stimulate knowledge transfer between small and big companies. The ROSF platform has joined forces with the Dutch Smart Industry Agenda. Together, these two entities work to establish a flexible and digitally connected manufacturing industry in Europe.

- https://rosf.nl/

5.5 Europe: Smart City Initiatives

European Innovation Partnership for Smart Cities and Communities

The European Innovation Partnership on Smart Cities and Communities (EIP-SCC) brings together cities, industry and citizens to improve urban life through more sustainable integrated solutions. This includes applied innovation, better planning, a more participatory approach, higher energy efficiency, better transport solutions, intelligent use of Information and Communication Technologies (ICT).

- (http://ec.europa.eu/eip/smartcities/)

Smart Cities Stakeholder Platform

The Smart Cities Stakeholder Platform initiated by the European Commission (http://eu-smartcities.eu/) with the dual aim of i) identifying and spreading relevant information on technology solutions and needs required by practitioners and ii) providing information for policy support to the High Level Group and the European Commission. It is both a web-based and physical Platform open to anyone who registers on it. Backbone is the contributions by stakeholders in a bottom-up way, owned by the stakeholders. The Platform is one of the two governance bodies of the Smart Cities and Communities European Innovation Partnership (EIP).

- http://eu-smartcities.eu/

Energy Cities

European Association of local authorities (http://www.energy-cities.eu/) in energy transition has as objective:

- To strengthen your role and skills in the field of sustainable energy.
- To represent your interests and influence the policies and proposals made by European Union institutions in the fields of energy, environmental protection and urban policy.
- To develop and promote your initiatives through exchange of experiences, the transfer of know-how and the implementation of joint projects.

JRC Institute for Energy and Transport

The JRC's Institute for Energy and Transport mission is to provide support to European Union policies and technology innovation to ensure sustainable, safe, secure and efficient energy production, distribution and use and to foster sustainable and efficient transport in Europe.

- http://iet.jrc.ec.europa.eu/

6 Training Needs

This section includes an analysis of the sections related to training and commercial opportunities that arise in the implementation of the analysed scenarios and the capacities that companies need to take advantage of these opportunities.

Through the project consortium and the clusters that participate in this project, it is evident that companies that have relationships with the Smart Cities area may have different roles and, therefore, different Business Models depending on where and how they are located. in the value chain.

The different roles are usually connected to the production and supply of components, platform operations, service and support in different aspects. This shows how companies can be located according to the entire value chain or to different parts of the value chain. Some companies may be fully integrated system providers or operate as specialized service providers for individual components, operating platforms or process the collected data for different service purposes.

For these different focus areas, different trainings will emerge. E.g. Some companies focus on end users (both companies and consumers), while other companies have other companies in the Smart Cities field as their customers. The review of the possible aspects of the Business Models from the sources will be treated as one, which means that we will not differentiate between the different parts of the value chain and, therefore, it is up to the companies themselves to find their place in the value chain. and from the inspiration of his own Business Model analysis. Finally, many companies will likely think of their businesses differently than a value chain, but rather on a business website, where many different companies and customers collaborate, rather than suppliers and customers.

As for the channels, they are related to the way the company reaches its customers. It stands out strongly in the sources and it is evident that in the Business Models they depend to a great extent on collaboration, both between private and public companies in the Smart Cities business and with end users.

6.1 Customer

On the part of the company, it will be important to analyse well the profile of clients to which it is directed and describe which clients there are in relation to the business and, therefore, to focus on possible business opportunities in the Smart Cities area. Some of the sources focus on specific areas, while others have an overview of Smart Cities. In general, there are good market opportunities in the Smart Cities area. E.g. an estimate of over 40 billion integrated applications by 2020 or 1.1 million jobs in integrated software in Europe in 2015. Opportunities for market growth can be seen in many different areas. Artemisia61 stresses that there is almost no area of application in which integrated systems do not have a direct or indirect impact. Arcadia62 highlights the market potential in different markets, where the greatest potentials are in medical devices and the automotive industry. Other areas are Rail, Manufacturing, Security, Health and Mobility. But they can also be other new sectors, such as food, energy and agriculture.

Customer segments will also depend on where a company is located in the value chain / commercial website. Some customer segments will be other parties to the Smart Cities business, both private and public companies (B2B and B2P). Other customer segments will be the end user of the product, platforms or services. These clients can again be private and public companies, or consumers (B2C). Therefore, the customer segment is highly dependent on the location in the value chain / commercial website.

6.2 Customer Relation

The customer relationship describes the relationship between the customer and the company. Some of the sources highlight the importance of collaboration. This is both when customers are the end user and

61 Artemisia – Aligning Research Agendas in Embedded Systems (Arcadia) (ArcadiaAligningAgendas).
62 Arcadia Annex 2 (Part C) about embedded/cyberPhysical Systems of the 2014 MultiAnnual Strategic Research and Innovation Agenda for the ECSEL Joint Undertaking (ArtemisiaAgenda)

when they are other companies in the Smart Cities business. Collaboration is innovation and R&D of products and services, so that companies can learn and influence the technological developments of others and also to obtain knowledge of the end customer.

6.3 Value Proposition

The value proposition describes both the products and what value the products create for the customer. In the sources analysed the focus is mainly on the different products. By products, we mean physical products and single components, the platform and the services and information offered to the customers. This highlights again where the companies place themselves in the value chain. Some companies will focus on single component development, others focus on creating and administrating a platform and some again focus of the services that can be provided from the data. This also shows the tight relationship between the nine building blocks, where choices in one building block affect those of the other building blocks. The value the products create for the customer is not as much highlighted in the sources, but some of the presented value is in advertising, which can be done more efficiently, where you only reach out to the interesting customer based on the data, or in trafficking, where the data can be used to guide the traffic.

6.4 Courses

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

The training is intended to describe key aspects related to smart cities. It is our opinion that the focus on training and skills and companies' understanding of their resources and skills will be analysed throughout the project. This appears to be a natural first step in helping companies better understand how they can thrive on the smart cities’ agenda.

Annex 1

Mapping the smart city technologies areas of application

KISMC

By smart city technologies in this annex are meant those technologies that refer to the concept of a smart city, most often these are digital and/or data-based technologies that are applicable in the real conditions of the city and contribute to the city's coping with public problems or challenges. In smart cities, these technologies are used to develop "critical infrastructure" in the following areas: transport (mobility), water and waste management, construction, energy, security, education, health, and urban management.

Mapping the smart city technologies means identifying as many as possible implementation projects (good practices) of such technologies in the main areas of applications in the smart cities.

There were identified during this project **60 implementations of smart city technologies in 8 (eight) main areas of application**s of these technologies in the smart city. The cases are at different stages of implementation and were found within the reports of many smart cities around the world.

1. Smart city transport (mobility) area

1. **Autonomous vehicles** - vehicles equipped with sensors and software to work alone; full self-management capability (level 4) is achieved when human intervention is not expected to take control at any time.
2. **Bicycle sharing** - bicycles for public use, either in docking centers or as freely used, to provide an alternative to riding, public transport, and private bicycle ownership. This option can cover the first mile / last mile segment when public transport does not take a door-to-door journey.
3. **Car sharing** - access to short-term use of cars without full ownership; can be bidirectional (station-based), unidirectional (free-floating), spot-to-spot, or partial.
4. **Congestion pricing** - fees for using a personal car in certain areas, during peak demand, or both.
5. **Demand-based micro-transit** - sharing services with fixed routes, fixed stops, or both, often complementing existing public transit routes. The algorithms use a historical search to determine routes, vehicle size, and travel frequency. May include seat reservation options.
6. **Payment by digital public transport** - digital and contactless payment systems in public transport, which allow prepayment and faster upload. Includes smart cards and mobile payments.
7. **Electronic call (private and combined)** - the real-time ordering of point-to-point transportation via a mobile device. Unified e-ringing involves the dynamic connection of individual journeys with compatible routes to increase vehicle utilization (ie local real-time search optimization).
8. **Integrated multimodal information** - real-time information on price, time, and availability of transport options in many modes.
9. **Intelligent road signals** - improving overall traffic by dynamically optimizing traffic lights and speed limits, leading to higher average road speeds and less frequent stopping and returning. Includes preferential light technology that prioritizes emergency vehicles, public buses, or both.
10. **Consolidation of the parcel load** - online matching of the demand for supplies with the available supply of freight capacity. By making maximum use of vehicles, fewer trucks make more deliveries.
11. **Predictable maintenance of transport infrastructure** - sensory monitoring of the condition of public transport and related infrastructure (such as rails, roads, and bridges) so that predictive maintenance can be performed before accidents and disruptions occur.

12. Real-time public transport information - real-time arrival and departure information for modes of public transport, including informal bus systems.
13. Real-time road navigation - real-time navigation tools for selecting driving routes, with signals for construction, detours, traffic jams, and accidents. This is especially true for those who drive alone or in a car.
14. Smart mailboxes - boxes in a place where people can pick up packages using individual access codes sent to their mobile devices.
15. Smart parking - systems that direct drivers directly to the available spaces; may affect demand through variable charges.

2. Smart city water & waste management

16. **Leak detection and control** - remote monitoring of the condition of the pipes with the help of sensors and control of the pump pressure to reduce or prevent water leakage. Early identification of leaks can lead to follow-up by relevant city departments and utilities.
17. **Smart irrigation** - optimizing irrigation by analysing information such as local weather, soil conditions, plant species, etc. to eliminate unnecessary watering.
18. **Monitoring of water consumption** - feedback (via a mobile application, e-mail, text, etc.) on the water consumption of the occupant in order to raise awareness and reduce consumption. Smart water meters allow utilities to measure consumption remotely, reducing labour costs for a manual meter reading. It also allows for dynamic pricing.
19. **Water quality monitoring** - real-time water quality monitoring (in networks, rivers, oceans, etc.) through signals delivered to the public through channels such as a mobile application, e-mail, text, or website. This warns the public to avoid consumption or contact with polluted water and to make cities and utilities follow the problem immediately.
20. **Digital tracking and payment for waste disposal** - digital payment systems according to the volume of generated waste; includes feedback (via mobile app, email, text, etc.) provided to users to raise awareness and reduce waste.
21. **Optimization of the waste collection route** - use of sensors in the waste containers to measure the volume of waste and direct the routes of waste trucks. This application restricts the travel of garbage trucks to bins with a small amount of waste.

3. Smart city construction

22. **Building automation systems** - systems that optimize the use of energy and water in commercial and public buildings by using sensors and analysis to manually or automatically eliminate inefficiencies. Includes optimized lighting and HVAC, as well as features such as access/security control and parking information.
23. **Home energy automation** systems - optimization of energy consumption from the home by using intelligent thermostats, programmable and remotely controlled electronic devices (smart home), and control of backup electricity.
24. **Tracking energy consumption in the home** - tracking the consumption of electricity in homes with feedback provided to the consumer through a mobile application, e-mail, or text to raise consumer awareness and promote their protection. It also allows utilities to remotely measure electricity use.

4. Smart city energy

25. **Supply automation systems** - various types of smart grid technologies, including FDIR, M&D, Volt /Var, and substation automation, to optimize energy efficiency and grid stability.

26. **Dynamic electricity pricing** - dynamic adjustment of electricity prices to reduce electricity consumption and reduce electricity generation costs. By reducing peak consumption, cities can reduce the number of power plants that operate during peak hours.
27. **Intelligent street lamps** - connected and equipped with sensors energy-saving street lights (including LED), which optimize brightness and reduce maintenance needs. Smart street lights can be equipped with speakers, shot sensors, and other features to improve functionality.

5. Smart city security

28. **Body cameras** - audio, video, or photographic recording systems commonly used by police officers to record incidents and police operations.
29. **Crowd management** - technology for monitoring and, where necessary, guiding crowds to ensure safety.
30. **Data-based building inspections** - use of data and analysis to focus inspections on the buildings with the highest potential risks (e.g., prioritization of commercial buildings for fire code inspections and homes for lead inspections).
31. **Disaster Early Warning Systems** - technology designed to anticipate and mitigate the effects of natural disasters such as hurricanes, earthquakes, floods and forest fires.
32. **Emergency response optimization** - the use of analyses and technologies to optimize the processing of emergency calls and field operations, such as the strategic deployment of emergency vehicles.
33. **Shot Detection** - Acoustic surveillance technology that includes audio sensors to detect, locate and alert police agencies to real-time shooting incidents.
34. **Home security systems** - security systems that monitor homes and alert users, emergency services, or both, to unusual activity.
35. **Personal alarm applications** - applications that alert you to an emergency by alerting the Emergency Center, loved ones, or both. Devices (such as personal protective equipment, crash detectors, and fall warning systems) can transmit location and voice data.
36. **Predictable control** - the use of big data and analysis (including social media monitoring) to predict more accurately where and when crimes are likely to occur. These systems are used to deploy police patrols and prevent prevention.
37. **Real-time crime mapping** - a technology used by law enforcement to map, visualize and analyse crime incident models. Information gathering and intelligence services as a management tool for the efficient allocation of resources and accountability among employees.
38. **Intelligent surveillance** - intelligent monitoring to detect anomalies based on visual emissions, including face recognition, intelligent closed-circuit television systems, and registration number recognition.

6. Smart city education

39. **Personalized learning** - the use of data from students to identify people who need extra attention or resources; the potential for adapting the learning environment for individual students.
40. **Online retraining programs** - lifelong learning opportunities provided in digital format, especially to help people who are unemployed or at risk of becoming unemployed to acquire new skills.
41. **Local e-career centers** - online platforms for publishing open positions and profiles of candidates; can use algorithms to match compatible candidates with available jobs.
42. **Reduce job search time and increase net new employment**.

7. Smart city healthcare

43. **Public health interventions based on maternal and child health data** - use of analyses to target highly targeted health interventions for at-risk groups (in this case, identification of pregnant and new mothers to conduct educational campaigns for and postnatal care).
44. **Public-based health interventions to improve sanitation and hygiene** - use of analyses to target highly targeted interventions, such as understanding where to increase rainfall absorption capacity or collecting data on sewage leaks systems.
45. **Urgent aid alerts** - technologies that alert passers-by trained in CPR so that victims of cardiac arrest receive prompt and urgent care.
46. **Monitoring of infectious diseases** - collection, analysis and response to prevent the spread of infectious and epidemic diseases. Includes awareness and vaccination campaigns (eg for HIV / AIDS).
47. **Integrated patient flow management systems** - real-time hardware and software solutions that provide visibility to where patients are in the system to improve hospital operations and coordinate use at the city or multi-site level.
48. **Lifestyle clothing** - portable devices that collect data on lifestyle and activity indicators and inform the user; they can promote exercise or other aspects of a healthy lifestyle.
49. **Online care search and planning** - tools that support the selection of providers and providers with financial and clinical transparency.
50. **Real-time air quality information** - real-time sensors to detect and monitor the presence of air pollution (outdoor, indoor, or both). Individuals can view the information online or on a personal device and decide to change their behaviour accordingly.
51. **Remote patient monitoring** - collection and transmission of patient data for analysis and intervention by the healthcare provider elsewhere (eg monitoring of vital signs or blood sugar). Includes drug adherence technologies that help patients take medications as recommended by their healthcare provider.
52. **Telemedicine** - virtual interaction of the patient and the doctor through audio-visual technology.

8. Smart city governance

53. **Obtaining licenses and permits for business digitally** - a digitalized process (as an online portal) for companies to obtain licenses and permits for operation.
54. **Digital Tax Submission** - a business channel to perform online tax filing.
55. **Obtaining permits for the use of land and buildings by digital means** - digitalization and automation of the application process for permitting the use of land and construction, reducing the time for approval, and increasing transparency.
56. **Open database for the cadastre** - a complete database for the plots in the city, open to the public; allows for a more efficient land market by creating transparency of available land and reducing the cost of registering plots.
57. **Peer-to-peer accommodation platforms** - digital markets where individual owners can list and rent properties for short-term accommodation.
58. **Digital civil services** - digitalization of state administrative services aimed at citizens, such as filing income tax, registering cars or applying for unemployment benefits.

59. **Local applications of civic engagement** - public engagement in urban issues through digital applications. It may include reporting problems and maintenance needs (for example, reporting broken street lamps through an application), providing information on policy decisions, participating in digital urban initiatives (such as open data hackathons), and interacting with city authorities and social services departments. networks,
60. **Local communication platforms** - websites or mobile applications that help people connect and potentially meet other people in their community. It can be used to find people with similar interests and hobbies, to connect with neighbours, etc