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Some Considerations on the Smart City concept. From Necessity to Implementation Challenges

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Abstract – Today, urbanization phenomenon is a reality. Cities are urged to find new solutions for managing their assets in order to prosper, otherwise face decline. This state of facts and necessities require new technologies, new legislation, new managerial approaches and a good understanding of mass psychology. Simultaneously, in the actual era of globalization and scarce resources management, cities must collaborate through efficient information and communication platforms in order to specialize themselves, on the basis of a common strategy. All these challenges have to be studied and addressed for each city, separately and contextually, in order to create the smart cities of 21st century. The aim of the article is to make an overview of the smart city concept development and to underline important aspects, statistics and points of view for its implementation.
Keywords: urbanization, globalization, scarce resources, collaboration, smart specialization, smart cities.

I. INTRODUCTION

A clear and general accepted definition of smart city still lacks, not only in the academic studies, but also in empirical applications of smart concepts and projects [33]. Furthermore, the actual and relevant references research shows what follows [5, 7]:

- "The smart city concept is used to identify a large spectrum of heterogeneous solutions and city programs, involving different types of technologies and aiming to reach a very large set of different and not well-defined goals;
- In the meantime, several different words are used to define similar projects and solutions, even if each of them could easily be attributed to the idea of smart city. For example: wired city, intelligent city, digital city, technocity, and so on. The similarities and the differences between all these "cities" are generally not explained".

According to [7], the main reason of this confusion is that *smart city is not a top-down phenomenon, but a bottom-up one*. The top-down process arises from a well-defined strategic vision of the smart city and it is developed applying the government rules and policies, to reach shared goals stated from the beginning. In the same time, the smart city idea arises from the application of technology to urban problems.

Smart city defines an urban development vision which integrates multiple last-generation technologies in a secure manner, by having the information and communication technology (ICT) industries as basis, in order to manage the city assets and improve the quality of life and the its residents activities, regardless whether they are citizens, private companies, public institutions or non-government organizations [24].

The worldwide trend is to concentrate more and more population in the urban centers, as a consequence of the opportunities, resources and comfort that could be found in these areas. It is expected that the urban population will reach 65% of the total world population by 2050 [26]. Furthermore, there are countries where metropolitan administrations and governance have become more important than regional administrations, managing to directly and indirectly govern the destinies of the communities in the area under their influence.

In previous studies, the adjective "smart" also referred to the government of a city and its capacity to generate innovation in the way services and communication are delivered to the local population. Therefore, a growing concern naturally exists with respect to urban and smart cities development, given the increasing managing challenges and the pressures they are subject to, including the related risks and the rising impact of human or automated decisions.

Table 1 [26] provides an overview of the multitude of domains addressed in the smart city literature, which indicate the many facets of the urban development. The domains can be classified as *hard* or *soft*, in relation to

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the importance that the ICT systems have as key enabling technologies.

"Specifically, hard domains refer to office and residential buildings, energy grids, natural resources, energy and water management, waste management, environment, transport, mobility and logistics. In these settings, an improvement in sustainability relies on the deployment of ICT systems, along with the introduction of appropriate policy interventions and urban planning. In other words, hard domains are the city settings in which the vision of a city that senses and acts can be the most applicable, thanks to the use of sensors, wireless technologies and software solutions to handle *big data"* [26].

Table 1. Literature review on the domain of smart city concept and approach (extended from [26])

Prevalence of investments related to the *hard* domains:		
Domain	***Main objectives***	***References***
Energy grids	Automated grids that employ ICT to deliver energy and enable information exchange about consumption between providers and users, with the aim of reducing costs and increasing reliability and transparency of energy supply systems.	[6, 8, 21, 29]
Public lighting, natural resources, and water management	Managing public lighting and natural resources. Exploiting renewable resources such as heat, solar, cooling, water, and wind power.	[1, 8, 10, 24, 30, 32]
Waste management	Applying innovations in order to effectively manage the waste generated by people, businesses, and city services. It includes waste collection, disposal, recycling, and recovery	[1]
Environment	Using technology to protect and better manage environmental resources and related infrastructure, with the ultimate goal of increasing sustainability. It includes pollution control.	[2, 6, 19, 24, 31]
Transport, mobility, and logistics	Optimizing logistics and transportation in urban areas by taking into account traffic conditions and energy consumption. Providing users with dynamic and multi-modal information for traffic and transport efficiency. Assuring sustainable public transportation by means of environmental-friendly fuels and innovative propulsion systems.	[2, 5, 8, 10, 20, 23, 24, 29, 30, 32, 34]
Office and residential buildings	Adopting sustainable building technologies to create living and working environments with reduced resources. Adapting or retrofitting existing structures to gain energy and water efficiency	[1, 29, 30, 34]
Healthcare	Using ICT and remote assistance to prevent and diagnose diseases, and deliver the healthcare service. Providing all citizens with access to an efficient healthcare system characterized by adequate facilities and services.	[1, 2, 8, 10, 24, 34]
Public security	Helping public organizations to protect citizens" integrity and their goods. It includes the use of ICTs to feed real time information to fire and police departments.	[1, 10, 24, 34]
Prevalence of investments related to the *soft* domains:		
Education and culture	Capitalizing system education policy, creating more opportunities for students and teachers using ICT tools. Promoting cultural events and motivating people participation. Managing entertainment, tourism, and hospitality.	[1, 10, 21, 24, 34]
Social inclusion and welfare	Making tools available to reduce barriers in social learning and participation, improving the quality of life, especially for the elder and disabled. Implementing social policies to attract and retain talented people.	[2, 3, 5, 6, 8, 14, 21, 32]
Public administration and (e-) government	Promoting digitized public administration, e-ballots and ICT-based transparency of government activities in order to enhance citizens' empowerment and involvement in public management.	[1, 3, 5, 6, 8, 10, 14, 27, 29, 30, 32, 34]
Economy	Facilitating innovation, entrepreneurship and integrating the city in national and global markets.	[3, 5, 6, 8, 14, 21, 32]

"The soft domains include areas such as education, culture, policies that foster entrepreneurship, innovation and social inclusion, as well as communication between the local public administrations and the citizens (mainly supported by e-government solutions). In these areas, ICT has a more limited role and is not necessarily aimed at processing and integrating real-time information. This is the case of education, where processes are not based to any great extent on handling transactions. In other cases, such as the one of innovation and social inclusion policies, smart city initiatives are not characterized by new technology deployment but rather by public interventions aimed at creating the right societal and institutional conditions (e.g. incentives, ad-hoc organizational bodies, etc.). In the case of culture, public involvement could be aimed at improving the exploitation and attractiveness of a city's cultural heritage. In the case of policies that foster human capital and innovation capabilities, the role of the local policies in creating the right institutional condition could mean, for example, the establishment and support of local incubators for hi-tech start-ups and their connection to global-scaled

innovation systems. Fields such as healthcare and public safety can be positioned somewhere in - between hard and soft domains, as smart city interventions in these settings can be characterized by the deployment of sensors and wireless technologies (e.g. the use of such technologies to automate the remote assistance of patients outside hospitals) or by the deployment of practices and campaigns aimed at creating social values" [26].

In the context described by the brief presented literature review, the aim of this article is to make an overview of the smart city concept development and to underline important aspects, statistics and points of view for the implementation. In the followings, identified issues and approaches for implementing the smart city concept will be presented.

II. PROBLEMATICS AND APPROACHES

The challenges of developing a smart city are many and depend on a substantial variety of factors, fields and specializations: (macro) economics, sociology, engineering (ITC segment having a high importance), management, real time adaptability (as a component covered by the general systems theory) and so on. As seen in Figure 1, smart city concept is considered a very complex conglomeration of systems and levers that must be organized and coordinated so that the overall situation at that time, legislation, technology, feasibility and the acceptability of the community to be overlapped to the biggest extent possible, by finding the common denominators for reaching greatest positive effects with small efforts.

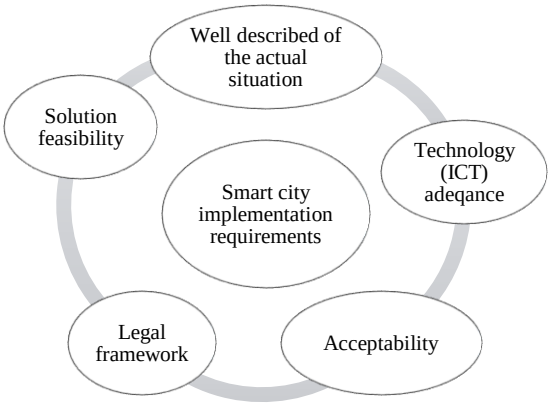

Fig 1. Five parameters to be considered for implementing the Smart Cities solutions

Moreover, the physical and virtual (digital) interconnecting of the cities in this globalization and regionalization era is a priority for their survival and prosperous development. It is well known that some cities have fallen on a descending trend after they had been decoupled from main transportation networks, which had strong negative implications in terms of industrial, commercial and social development.

In the context of the *necessity to interconnect the cities* a new problematic arises, that of smart specialization. This means that each city should capitalize its strong-points in correlation with their potential and resources in the territorial, economic and social existing constellation. A desired principle to be applied in the era of globalization, increasingly scarce resources and ever growing dynamics in all fields is the so-called "*low hanging fruits*", so that the added value to be generated with minimum effort in a short time and with minimum risk.

And, extrapolating this previously given principle, it must be underlined that the attention for the aspects of environmental protection and sustainable development will be crucial for the good management of our planet as a whole and of the communities in which we live, in order not to reach during next dozens of years *the point of no return* on which we are warned by worldwide institutes with forecast expertise.

Developing a smart city will increasingly depend on aligning and integrating the new world of Internet of Things (IoT) in the complex life of the city. This concept defines the network, in exponential expansion worldwide, of smart objects that communicate with each other and which automate, facilitate the activities and improve the living conditions (see Figure 2, 3, 4, 5) [11]. The explosion of smart objects is determined by globalization, fierce competitiveness in the economy, the creation of free software and "open source" applications, which influences more and more the individual and collective mentality, in terms of private and professional life.

The diversity of Internet of Things is practically infinite, as any object of interest can be operated and controlled in the future through the network (Figure 3) [12].

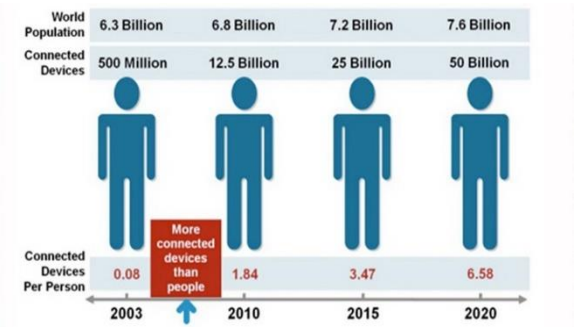

Fig. 2. Estimation of connected devices and population statistics [11]

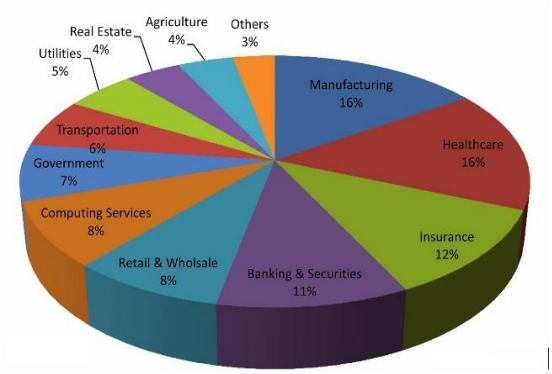

Fig. 3. Estimated IoT added value by 2020 - $ 1.9 Trillion [12]

In all these concerns and approaches for implementing a smart city there is the need to have a good balance and a set of priorities, established through thorough analysis and with the involvement of the civil society and business environment, which are very important components for the long-term success of projects which are initiated and implemented by public administrations. If these two important factors will not be involved, undoubtedly this will lead to the decline of these urban areas, because of the migration of individuals and companies to other more favorable areas, in the context of high mobility which is characteristic to the modern world, namely in the European Union.

Investments needed to be made in order to transform the city into an intelligent one are very high and diverse. Therefore, hiring the business environment in various forms of collaboration, such as, for example, public-private partnerships, is essential. Businesses can faster stimulate and guide the conversion of cities into smart cities, according to their own economic interests, which must be linked in a "win-win" situation with the interests of the local community (Figure 3, 4, 7) [4, 15, 16, 17].

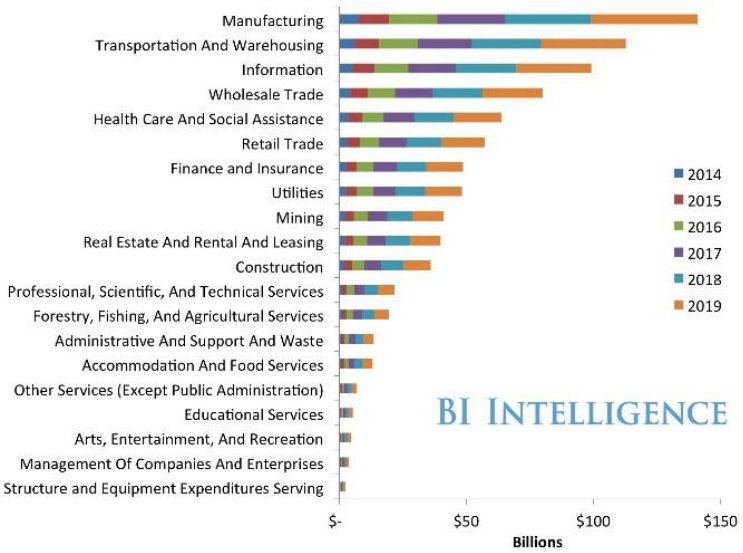

Fig. 4. Estimated investments in IoT solutions by industry [15]

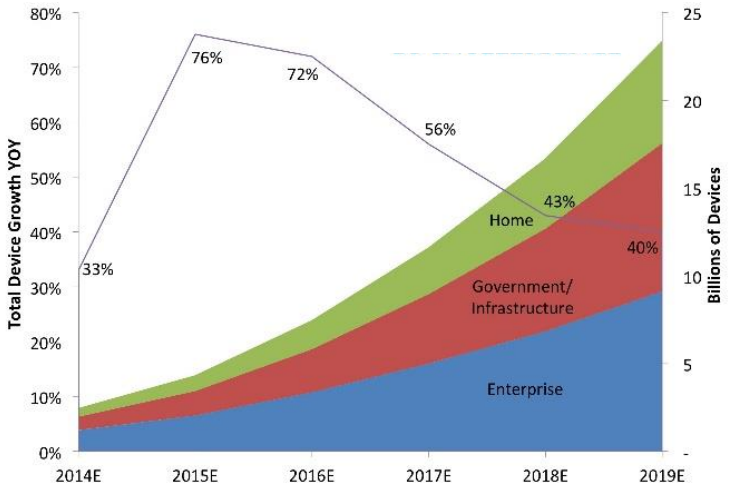

Fig. 5. Estimated number of installed IoT devices by sector [16]

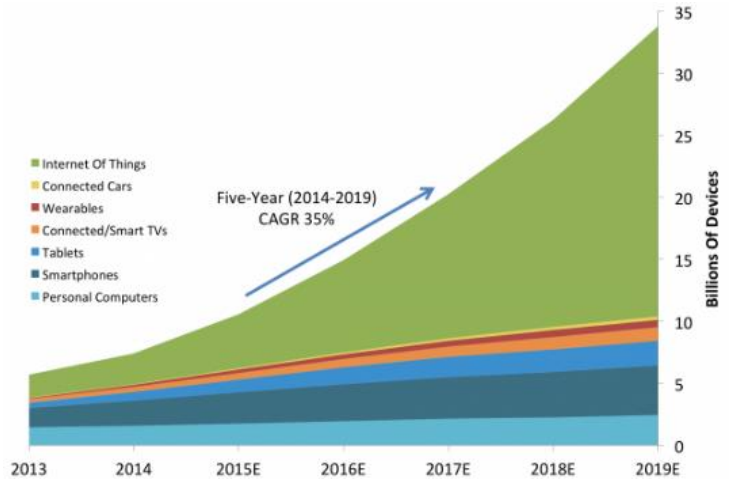

Fig. 6. Estimated number of devices in IoT by type [17]

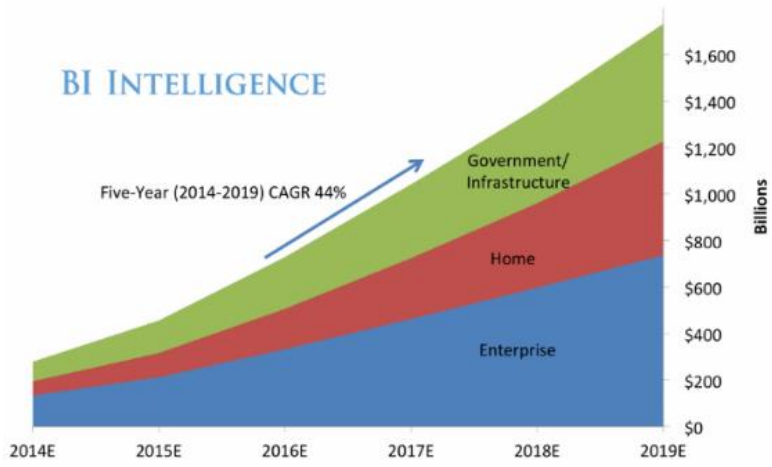

Fig. 7. Estimated IoT added value by sector [4]

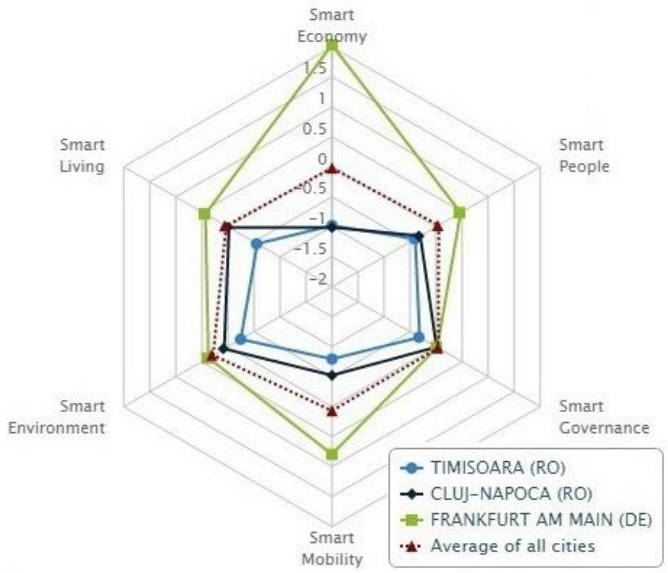

Fig. 8. Benchmarking of Smart Cities[5]

A city can be automated and improved almost indefinitely, within the limits of available resources and community interests, while maintaining respect for the environment, tradition, identity and posterity. In addition, the ability to innovate and to bring together individual solutions into aggregates (e.g. public lamp

[5] Application European Smart Cities 4.0 (2015). Retrieved from www.smart-cities.eu/?cid=5&city=47&ver=4

posts with integrated solutions for telecommunications, video surveillance and monitoring of pollution) will significantly reduce the cost of implementation (Figure 4) [4, 17].

The question is which are the mandatory minimal systems to be implemented and integrated into the functioning of a city for the city to be considered intelligent, so that added value, services, quality of life, security, safety, cost reduction and sustainability to be at the desired levels?

Four pillars are mentioned in the specialty literature, to be managed by the entities that implement smart cities: institutional, infrastructural (physical), economic and social.

- The institutional pillar concerns the improvement of public administration functions and the active and harmonized participation of citizens in local governance.
- The infrastructural pillar serves the traffic management (e.g. safety, fluidization and parking), public adaptable and renewable lighting, quality and gratuity of telecommunications, existence of the monitoring and alerting systems, streamlined collecting of waste, proper irrigation of green spaces, automated reading of utilities consumption, pollution monitoring of all kinds etc.
- The social pillar manages the modernization of education (e.g. digital systems), medicine (e.g. telemedicine), sport, leisure and so on, by using the top technologies.
- The economic pillar aims at increasing the performance in incubating start-up companies, developing financial hubs, creating digital systems for trade and business cooperation, etc. A good analysis of the described pillars is shown in Figure 8.

There are also other perspectives recognized in modeling a smart city. One of the most common is the one that defines the following levels for smart development: economy, citizens, administration, mobility, environment and living conditions.

There is be observed that to these pillars a new *transversal pillar*, namely the capacity to adapt and respond in real time, should be added. The argument for this is that, at present, scientists have not yet identified and mastered all algorithms that function in nature and mankind. This aspect justifies a new pillar, which covers all the other pillars for the achievement at the outset of adaptive and intelligent systems, capable of learning on the fly the patterns in which a community operates, patterns that cannot be defined by simple mathematical models.

However, these adaptive systems will be able, over time, to calculate and determine sophisticated algorithms that function in the outside world, as the "*Eureqa device*" developed by Cornell University, and then they will improve their performance accordingly. Such an adaptive system with its own reaction under continuous improvement will be based on a subsystem of data accumulation in absolute and relative terms, as well as information on trends of observed phenomena, different aspects which are seemingly chaotic, effects of overlapping causes, quantifiable behavior and feedback of users, influence of weather etc. (Figure 9) [18].

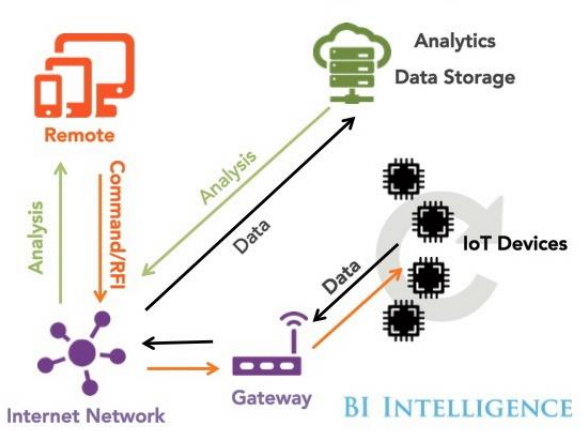

Fig. 9. Internet of Things ecosystem [18]

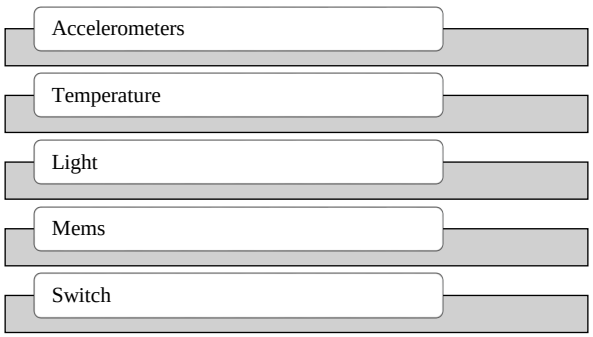

Fig. 10. Sensor types [22]

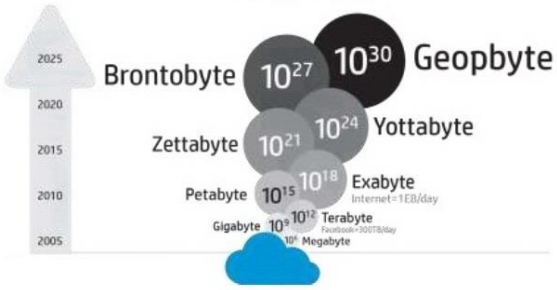

Fig. 11. Estimation of data explosion [28]

This adaptability is based and will rely on a network of sensors that are already part of the systems and smart cities of today (Figure 10). Furthermore, this network of sensors will become more complex, reliable and accurate, so that they can manage all data and information which are necessary to operate at the desired parameters, including the critical situations, such as emergencies and natural or artificial disasters. These sensors will be complemented by other subsystems and the direct feedback of citizens and human operators, feedback that probably will not be

substituted by any other automatic mechanism in the following decades [22].

These data collected by sensors are stored, processed, summarized, correlated and interpreted in certain schemes, so as to support the decision making which is most appropriate by human or automatic operators, which in turn are positioned in a collaborative network of the smart city. These data can be structured (i.e. data that can be recorded in data files) or unstructured (photos, video, social media, emails etc.) [28].

The challenges in this field are multiple, starting from the reliable storage capacity in large amounts and in all circumstances, processing capacity and information security to the information accuracy and models for interpretation and decision making (in meeting the estimation of data explosion shown in Figure 11) [28].

It is this concentration of information and human or automated decisions that increase the risk of cyber-attacks and terrorism, which leads to the need to secure better these control mechanisms operating in smart cities. The systems vulnerability with regard to the physical infrastructure (electrical, medical, for telecommunications, transport, water supply etc.), economic and even social (for automation of specific services) is not a permitted option and can conduct to chaos in few moments, given that citizens will lose to a certain extent their ability to adapt and react rapidly because of the automated systems which they have become accustomed (see Figure 12) [25].

As shown in Table 2, in this new reality of smart cities that are already or are to become metropolises, an issue will be the privacy and the right to privacy of citizens, who will live and work in an environment populated by millions of sensors, cameras, user identification tools etc. [13].

In this context a question arises: what percentage of the population will be willing to give up some of its own privacy to earn additional performance, comfort and safety, as well as what are the citizens willing to give up and what not. Such sociological and psychological matters will have to be weighed very well, before taking any steps to transform the city or interfering in a situation punctual [13].

Table 2. Connected things installed in Smart Cities (Millions) [13]

Smart city subcategory	***2015***	***2016***	***2017***	***2018***
Healthcare	3.4	5.3	8.4	13.4
Public Services	78.6	103.6	133.1	167.4
Smart Commercial Building	377.3	518.1	733.7	1,064.8
Smart Homes	174.3	339.1	621.8	1,073.7
Transport	276.9	347.5	429.2	517.4
Utilities	260.6	314.0	380.6	463.5
Others	8.6	13.3	20.8	32.3
Total	1,179.7	1,1641.0	2,327.7	3,332.5

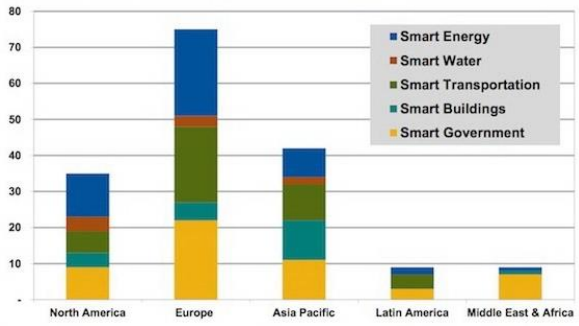

Fig. 12. Smart city projects by region and primary industry sector, world markets: 2013 [25]

Furthermore, in terms of information security and psychology, a critical aspect to be defined with respect to the key management instruments of smart cities is the responsibility of decision and action, no matter human or automatic, because a single command, such as a button press, could trigger actions and chain reactions with large negative effects in case of errors or bad intentions, whether judgment or calculation. This will require the people entrusted with important responsibilities to undergo regular psychological tests, just as the actuation devices will be equipped with dual control mechanisms (e.g. interlocking) and remote intervention mechanisms. And this all the more that the existence of adaptive systems which learn by themselves in time will lead to the development of artificial forms of consciousness, which -at one time- could take different decisions to the decisions acceptable to humans.

The issues outlined above make plausible the idea that each smart city or group of smart cities should own or work with a research-development-innovation center, in order to achieve improved technological solutions and develop new ones. These solutions should take into account all the parameters mentioned before and the balance concerning the human-system dependability, so that people develop harmoniously and healthily, including the psychological and sociological perspective.

In addition, in the context of regional development, rural areas should by no means be ignored, especially those not under the influence of urban poles and which are somewhat isolated. Rural areas present a number of advantages that are complementary to those in urban areas, providing resources and specific facilities. It is therefore necessary that development and smart specialization to be implemented in these areas, in line with the policies and strategies of the cities nearby, so that to produce synergies to enhance their attractiveness for investors and for those who wish to live and work in these areas. Smart development can be done on several levels, one of the essential investment parameters being the added value per area. Thus, intelligent systems can be introduced for irrigation, river flows control, transportation of all kinds, telecommunications, education (ex. digital), medicine (e.g. telemedicine) and so on. The connection between urban and rural

areas is necessary to be produced both physically and virtually.

Creating cities associations, with legal personality or not, which have the vision of transforming into smart cities is desirable. The motivation is simple, proven throughout history that human evolution was always realized by using synergies and based on the ability and the will to learn and progress. These associations could cause more harmonious development, through a synchronous policy of smart specialization, by also assisting the development of rural areas on the connecting routes and thus increasing the performance of the entire region to which they belong.

III. CONCLUSIONS

This work can be considered a preliminary contribution to the development of future research in order to obtain a better understanding of the current phenomena of smart cities. Summarizing, a smart city is made by land, citizens, technology and governance; it could have larger or broader boundaries, from the local urban dimension of a single city, to a region, a network of city, towards the national and global dimension; it should have well defined and measurable goals, regarding these aspects: the environmental sustainability, the creation of smart intellectual capital, the citizens participation and the wellbeing; it is smart because it is intelligent, digital, wired, sustainable, inclusive, democratic etc. (extended from [5, 24]).

The urban systems to be deployed in the smart cities of 21st century are very complex and have to be driven and managed by solid development visions, strategies and competencies. Many aspects have to be considered: technical, economic, social, territorial, environmental, juridical, with respect to efficiency, security, adaptability, sustainability etc. The collaboration with research and development centers is a necessity, as the solutions are ever changing and have to be identified, designed, implemented, adapted and improved.

There are no miraculous fixed solutions for the cities, each one has to take into account the local multivalent specificities and, moreover, they have to adapt themselves over time to the changes of reality. Collaboration platforms and smart specialization among the cities in a region are prerequisites for these cities to survive and prosper in the global and competitive world.

Alike the standalone solutions, synergies among the collaborating cities have to be designed specifically for that area, by covering also the rural spaces in between. Smart cities connection is not in deep study, so there is a lack of knowledge in the field. The solutions for creating smart cities and smart city connections have to be carefully conceived and implemented, adapted to the local and contextual realities and improved over time, by human or automatic interventions.

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