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# Smart and Sustainable cities, a new definition for a Resilience-driven city

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**Abstract.** Start The idea of Smart and Sustainable are trending topics in the current literature. The idea of Resilience is for sure a component to be considered in the design of modern cities. This paper, after having considered the state of the art, analyses the relationships and the evolution of the idea of smart, sustainable and the possible evolution of the topics connected with Resilience in the smart sustainable city. The paper considers the strong link between the sectors of Science that are considering Resilience as a part of their current research, reading the components of it according to the Architectonic paradigms. The definition of the role of the modern Architect and of the modern Architecture in connection with the other disciplines is a core part of the publication. The framework of the document is the definition of the potential of interaction of the figure of the Architect with the other scientists in a pervasive set of theories that affect the modern city. The paper defines also the idea that is not fully considered the impact on the Urbanism, traditionally led by Architects, of the IT technologies on the built environment. Opportunities and treats deriving from a not-governed set of processes linked to the Urban areas.

## 1. Introduction

The contents of the definition of smart and sustainable have enjoyed a crescendo in popularity, leaving the areas of the traditional sectors, hybridizing and sometimes losing the originality and relevance to the original disciplinary sectors [4] [5] [6]. A different topic concerns the juncture between several terms that have undergone the hybridization and use in other scientific areas, different from each other, as in the case of the term "smart sustainable city" which originated in order to respond to the challenges of globalization and related problems environment and sustainable development, urbanization and urban growth, sustainable urban development and sustainable cities. This paper respond to the need of a definition of the boundaries for the idea of "smart" and "sustainable" connecting "resilience" as category to be taken into account in the definition of the modern city. The method is aimed to understand best practices in other sectors in which the idea of "resilience" is developed in a systematic way in order to understand how the idea of "resilience" in other scientific sectors can be adapted and applied to built environment-related sciences, in particular the documentation of ITU (International Telecommunication Union) [3] comparing it with the observation of reality from the Italian trends in the Management of Built Environment.



## 2. Scope of the work

Scope of the work is the Built Environment application of the IT-based technologies and methods for preventing the risks for the smart sustainable city, considering the aspect of resilience as an element to be integrated in the definition of “smart sustainable city”.

The evolution of the "smart sustainable city" terminology must consider the component of resilience in a term of evolution, both in terms of definition and real use with a functional purpose for all areas of society. Also in terms of popularity there are aspects that are considered strongly linked by the mainstream discussion on the smart city and technology, adding the idea of “smart grid” as system of technologies that operate into the city, becoming a true “hype” [4] in recent years without understanding the true connection with built environment sectors of research. The concept is linked to technological systems, critical infrastructures, power grids, energy network systems [11], information and telecommunication networks, transport networks, water supply systems, banking and financial systems. It can be considered in this area also the definition of “critical infrastructure” [4] as a part of the built environment carrying risky effect on other systems in case of failure. Once the critical infrastructure has been defined as a category in its aspect of risk for the built environment systems, it is necessary to adapt the definition to a different level, that of Architecture. Understanding how the concept of Smart Sustainable City can be integrated with a different plan, is linked to the idea of risk for the system, considering the increasing dependence from smart systems for the built environment and the everyday life of Cities. Underscoring critical infrastructures not only those that are physical and linked to the idea of a built environment but also non-physical ones but linked to the concept of the network, which in turn presupposes a concept of interdependence and relationship between several actors, it is interesting to understand how it should be considered the definition of resilience also in terms of risk associated with the destructive event, with a view to effects on the interactions between actors and between different systems.

## 3. Method

This paper is the result of the observation of the state of the art and the possible evolution of the disciplines of the Management of Built Environment in the sense of Information and Communication Technology (ICT). The evolution, actually in Italy, is monitored by Gesti.Tec lab at Politecnico di Milano and by BRaVe Management and Technology spin-off of Politecnico di Milano since 2000. The research group became a reference for the Real Estate in the Italian Academia and market with the scientific partnership with Assolombarda-Confindustria Milano Lodi Monza e Brianza, the union of Companies and Industries of Lombardia Region [24], collecting the needs of companies in the territorial area and developing research themes in order to fulfill the need for innovation in Real Estate for Companies in Lombardia since 2008 [25]. The evolution trends collected as Voice of the Customer VoC [27] in the last period, during the activities of the research group are presented into the paper, integrated (with some reference research work outside the research group in order to widen the focus in terms of approach and to double-check the consistence of the trends observed [23] [26]) and compared with the Technologies growing in popularity in ICT and in manufacturing management, considering the effects on the Management of Built Environment and the opportunities for the sector to innovate its procedures and strategies. It has been considered in particular the effect on Sustainability and Resilience of the state of the art in the ICT practice [1-9], reading and evaluating strategic and operational reports in their compliance with Management of Build Environment. It has been chosen to study as reference for the Resilience in Smart cities (from the ICT point of view) the documentation by ITU (International Telecommunication Union), the Agency of the United Nations, the delegated institution for issues concerning ICT [3], reading the trends and the needs of the management of built environment observed by Gesti.Tec Lab with the possibilities and threats of the ICT issues connected potentially to the management of built environment, according to the ITU statement: “The use of ICT can accelerate innovation, improve access to basic services and create a new model of (sustainable development)” [3] . The trends collected in this paper have never been analyzed before both as individually as connected to ICT and high tech related.

#### 4. Discussion

It is observed a number of trends according to the study of the current situation in management of built environment [27], some of them are defined as needs expressed by companies that are aimed to compete in the global environment. These trends are collected for the first time in an organic way and it has been considered each of them for its connection with the ICT. The trends are to be considered also as the possibility to innovate the sector of Architecture, Built Environment and Construction.

##### *4.1. Dependence on Information Systems, risk and opportunities from Built Environment Management. The idea of Resilience.*

The greatest risk lies in the characteristic of systemic and integrated thinking: the modern management theories have been based on the concept of eliminating paper first in companies and then in the management of the State, sharing information in shared virtual spaces and this has generated territorial governance procedures fundamentally linked to idea of interaction and therefore to the state of vulnerability, in the next lines are analyzed trends linked to this general idea.

##### *4.1.1. Sharing Economy risks and opportunities for Management of built environment companies: Prop-Tech, Fin-Tech companies and Governance.*

The aspect of sharing economy has influenced the way of conceiving the space of the sustainable city [12] [13], increasingly based on: shared transport systems [14], such as bike or car sharing, taxi applications, based also on Real Estate management systems as IT applications that allow agile renting of apartments through a sharing platform, or on systems of control of services to the citizen at the level of the urban facility management. Prop-Tech and RE-Tech entities such as start-ups (and not only [15]) found a place in the globalized city, basing their business model on technologies, providing services to antique needs and known users in the city but in a modern and smart way [17]. This is a clear link of the interaction of Architecture as science of management of the built environment with application of Information Technology. Information technology for Architecture [16] has played an important role allowing for strong innovations, not only at the level of the building (think of energy saving systems) but also at the level of the city and the vast area. A similar idea of resilience and interaction between systems and its relationship with the management of the city is represented by networks: water supply, energy, telecommunications, information and data. Every modern network presupposes a wide use of information technologies that need people for the management, updating, maintain and programming innovation. The control of obsolescence, of the value of the assets necessary for the systems to work correctly, presupposes an effort of strategy and constant management by Policy makers and by the actors involved in the definition aspects.

All this aspect are related for sure with the smartness of the city in its openness to sharing economy but also, as we just stated, are related to Resilience for the connection with interdependent systems.

It can be mentioned the set of instruments put in place by the Nations Joined in the ORMS (Organizational Resilience Management System), a document implemented to define the key indicators to establish and control the resilience of organizations at a global level. The idea of resilience associated with the smart sustainable city (SSC) is not only linked to the interaction of systems that must resist the shock but must contain a strong idea of governance of the possibility of considering any event that may occur in its effect on the systems. Understanding interactions, mapping them, constructing representations that can provide analysts with the tools to support decision makers in the phases of defining territorial government policies is the first component of truly intelligent planning.

##### *4.2. Needs for a deeper level of analysis in the built environment sectors: interactions between IT and Architecture management, smart tools for smart city management.*

We cannot avoid to consider that the figures of analysts are real systems experts, rather than specific technicians, reporting to the vision of a multidisciplinary competence system able to solve technical problems, design solutions and design scenarios with complete information.

The solution to the need to predict, to calculate the impacts of a shock-like event, to suggest changes to the current system of laws certainly belongs to a team of experts, coordinated by those who do not have only a thorough view of the technique but are able to understand the true heart of complexity, the interaction of non-independent micro-systems. Like the rest of the companies, the city (as an entity managed by professionals with a strategic, tactical and operational plan that has some basics in common with a company in terms of interaction and management models [18]) is experiencing the evolution of information technology that the companies have already experienced in the eighties and nineties, when the information systems of MRP Material Resource Planning monopolized the need for support for forecasting, procurement, planning time and resources. The theme of the risk embedded in the systemic approach of various modules that interact and the understanding of the coordination role assigned to the human component and the definition of a System Informatics is a good parallel to define a trend in the cities: the understanding of a dependence on ICT systems to support the management of the built environment that must be governed and made less risky in case of events with a shock characteristic. The resilient system must therefore consider the central role of the project and the project manager, completing with a systemic vision the power of technical tools and specific skills [2] The assignment of responsibilities and roles defines a further level of increase in system security. A system is resilient when among the actors there is a complete awareness of the roles and tasks and consequently an effective division of the aspects to be considered in case of shock and to be taken into account in the design phase of the systems. Coordination is nothing more than the way to maximize the efficiency of technical solutions, to resolve conflicts and delimit the areas of influence of technical areas, checking that each component of the system acts in the strategic direction marked. Objective control, therefore, assumes a fundamental role also in relation to the definition of interaction and risk making it necessary to elaborate a system of analysis and control of univocal performance indicators in order to be effective in the design and control of parameters of interest for achieving the objectives. The indicator-based approach is very similar as a concept to a dashboard that is able to provide a set of critical parameters for the coordinator and therefore for the decision maker so that it can be supported in the decision. The role of Architecture must also be considered key in terms of managing the project and managing the effects of the project on the built environment, making the Architect's role close to a new dimension between the design of buildings and the study of the effects of technologies support integrated with urban and building systems.

#### *4.3. Needs for measuring the connection between Smart Sustainable City (SSC) and Resilience, the step up to the Smart Sustainable City-Resilient (SSC-r)*

The new approach presupposes a cultural evolution of the world of information technology that must recognize the lack of an organized and functional vision for the well-being of the individual in the city, as well as a sustainable, smart and resilient vision of the city [19]). The SSC-r is the Smart Sustainable City-Resilient, in which Resilience is an attribute to be inserted in any definition of Smart and Sustainable City, considering the needs of the end users (the Public Interest) and the attention to the interactions of systems linked to the smartness of the city and its possible application, like sharing Economy.

The level of resilience management in the city and in the systems of the built environment can be defined through a system of indicators, as implemented in the documents elaborated by the United Nations in the "Key Performance Indicators: Organizational Resilience Management System" [10], 28 indicators based on 5 different critical success factors: Policy, Governance, Maintenance, Exercise and Review, Risk Management, Planning, in turn grouped together in System Design (Policy, Governance, Maintenance, Exercise and Review) and Application (Risk Management, Planning). The second category highlights the importance of the component of the Plans that organize the operational level, defining the tactical plan linked to the strategic plan of the first category, that of System Design. The dimensioning of a dashboard that evaluates the resilience on two levels, the strategic one (of the project, of the governance) and the tactical one (that of the operational plans of the strategies at the operative level) presupposes an integrated management of the resilience theme, also at the urban level,

releasing the strategic plan from the operational one and establishing key indicators for the two categories. The efficiency of the measures thus can be maximum and can be methodologically correct as an approach, also to establish standard procedures to be taken into account to prevent an event, evaluate the impacts in case of occurrence, preventing the a priori risks and allowing an effective resolution in case of an event that can affect the system status. This type of document from a higher institution, supranational and with a huge and high vision of the societal interactions between Countries and People demonstrates the need for a coordination between the different aspects of management of the city in its strategic aspects (plans and policies) and operational (decision support tools, like indicators systems to evaluate the performances of the city and the effectiveness of the measures) [19]). The idea of merging the aspects of Smart and Sustainable with the Resilience and its management is a natural evolution of the condition of the modern city. It is needed at this point a study of the full interactions of IT systems with: the sustainable city, the smart city (in his social aspects) and the area of work of Architects and Civil Engineers as managers of Built Environment. It is needed a Benchmark analysis of the state of the art of the Information Technology idea of Resilience in the Smart Sustainable City.

## 5. Conclusion

### *5.1. Benchmark analysis with the ICT sector in order to understand the common points of innovation potential in the Management of Built Environment*

At this point it is needed a benchmark analysis of the ICT components of the Smart Sustainable City for two reasons: ICT have considered Resilience as category since the very beginning of its history, developing systems to avoid disruptions and failure in systems affecting other components of business, the second reason is linked to the need to understand the connection of the studies about Resilience for SSC in ICT sectors for defining the SSC-r in a stronger way. It is to be considered that the needs expressed, selected and analyzed in this paper are to be considered also in their strong connection with resilience and dependence on ICT, in terms of risk of failure of the artificial intelligence. Considering Architecture as a permeate aspect of the Society, in each of its components linked to the management of everyday life and business, one can consider the level of detail of the Smart Sustainable City according to the definition of ITU [7] [8] [9]. The idea of seeking innovation in the sector in which the greatest progress has been made in the last few years can be a valid beginning to build an organized scheme with all the components.

Starting from the scheme generated by the UN authority for security and computer integration, we can build an analysis with the dual objective of building an idea of SSC-r a Smart, Sustainable and Resilient city, as presented in Figure 1, defining the areas in which critical issues can be defined within a smart system structure with the notion of resilient already integrated in itself, presenting a fundamental element: resilience as a marginal feature of the smart city.

The aspect of resilience must certainly be considered as a necessary feature of a modern city, of a territorial area, coming out from the concept of residuality for the concept of resilience in cities.

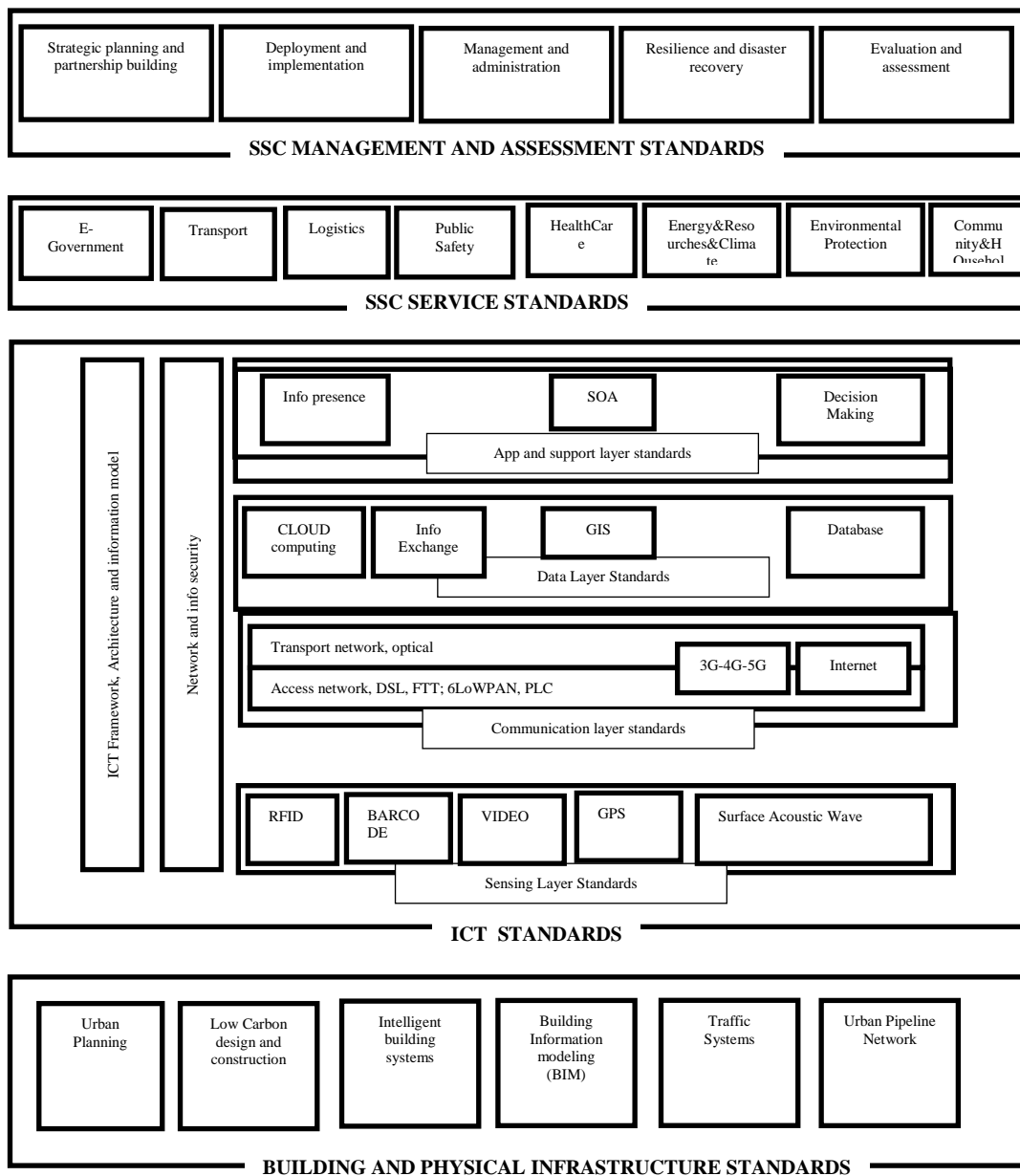
Considering Architecture as a permeate aspect of the Company, in each of its components linked to the management of everyday life and business, one can consider the level of detail of the Smart Sustainable City (SSC) according to the definition of ITU International Telecommunication Union) [7] [8] [9]. The idea of seeking innovation in the sector in which the greatest progress has been made in the last few years can be a valid beginning to build an organized scheme with all the components.

Starting from a scheme generated by the UN authority for security and computer integration in Figure 1, we can build an analysis with the double objective of building an idea of SSC-r a Smart, Sustainable and Resilient city. It is clear how all the components of the resilience in the information technology have a fallout on the categories of Architecture and a relapse on the work of the modern architect, a figure that will be called to design systems more than one-dimensional objects from the point of view of interconnection IT and with the doors that the world of Information leaves open to the connection between the virtual world and the real world. The power of calculation and storage of data, the

permeability of design support tools (BIM, CAD) to the sharing of ideas and projects, the sharing and participation of stakeholders determine a necessary presence of the Architect to the processes they intend to consider the resilience as a necessity to make the interaction with the virtual world safe and efficient, without creating unnecessary superstructures that replicate traditional systems with redundancy, rather than implementing the degree of safety of the built environment.

### *5.2 Frameworks Terms and definition*

The scheme presented in Figure1 represent the interaction of IT systems with the different aspects of the Smart City, seen as built environment entity to be managed and with a strong dependence from sharing systems based on Computers and artificial intelligence. The top of the table represents the strategic aspect of the management of the city “SSC MANAGEMENT AND ASSESSMENT STANDARDS), including aspects of strategic planning, management and administration, resilience and disaster recovery, evaluation and assessment. It can be seen in this part what already discusses in the previous section of this work about governance. Resilience is a marginal box in the SSC framework, even if it is taken into consideration at the top of strategic plans for disaster recovery. In the section “SSC SERVICE STANDARDS” it is represented all the set of aspect of the services to people provided by the City: E-Government, Transport, Logistics, Public Safety, HealthCare, Energy Resources and Climate Control, Environmental Protection, Community. This level is the one linked to the main idea of City Facility Management and to service provided by private entities to citizens (i.e. Logistics and Transports) but with a strong impact on Resilience and with a strong dependence on Computer-based applications in the smart city. The bottom box: “BUILDING AND PHYSICAL INFRASTRUCTURE STANDARDS” is related strongly to the activity of the city, governed by city managers but planned by Architects and Construction Engineers. Urban Planning, Low Carbon Design and Construction, Intelligent building systems, Building Information Modeling (BIM), Traffic Systems, Urban Pipeline Network are the components of the box and it is strongly present the connection with the area of interest for built environment management, given the ICT (Information and Communication Technologies) standards. “ICT STANDARDS” is the area of the core section of the model, considering the ICT Framework, Architecture and Information model and Network and Info Security. In this section are included all the first-level technologies connecting the strategic plan with the building scale: GIS, Cloud systems, 3-4-5G networks are presented with Standard Operation Procedures and RFID, GPS or Video supports as the true sentinels on the territory of the operational level of the smart city. The figure is a clear example of the interaction at different levels of the different possibilities for managers of built environment to manage ICT tools with a strategic system of plans, according to a SSC-r -linked policies. The inner part of the figure is a continuous evolution as it is linked to the evolution of the technology in its core definition, not necessarily linked to the evolution of the Smart City but whose change must be monitored by Architects, a new shape of Architects, able to manage processes, understand interactions, measure indicators and manage IT effects on the built environment.



**Figure 1.** Framework of SSC standards (ITU-T FG-SSC) Elaborated by the Authors



In [9] is presented an analysis of the terminology of the key worlds for Smart Sustainable Cities performed by International Telecommunication Unit ITU, showing the connection with the trends analyzed from the observation of the needs expressed by Real Estate sector.

ICT
Adaptable
Reliable
Scalable
Accessible
Security
Safe
Resilient

**Figure 2.** Terms in (ITU-T FG-SSC) for Smart Sustainable City Elaborated by the Authors

Standard of living
Employment
Citizens well being
Medical Welfare
Physical Safety
Education
Environmental safety
Physical and Service Infrastructure
Transportation and Mobility

**Figure 3.** Terms in (ITU-T FG-SSC) for Smart Sustainable City Elaborated by the Authors

Water
Utilities and Energy
Telecommunications
Manufacturing
Natural and man-made disasters
Regulatory and compliance
Governance
Policies and processes standardization

**Figure 4.** Terms in (ITU-T FG-SSC) for Smart Sustainable City Elaborated by the Authors

## 6. Results

The work [9] represents the need to define from a ICT side the idea of Smart Sustainable City, defining and studying in literature (from Academia and Industry level) the idea of the SSC. It is evident that the key terms are to be linked with Key Performance Indicators, as part of the definition of Figure 1 in the upper level of the model prosed, the “SSC MANAGEMENT AND ASSESSMENTS STANDARDS”. Without a control of the parameters it is impossible to define the performance of the City as a system made up by different components, in which ICT and Architecture are to be considered the main bricks that builds the interactions between built environment and the ICT tools. It is needed a new form of Architect or Civil Engineer, from one side able to read the changes of the society, along the opportunities and threats from sharing economy (for example) in its interaction with the City management and a key figure able to be proactive and able to design processes and projects, considering the huge opportunities coming from the innovation in ICT systems, at any level. Sustainability as defined in the last three tables and in [9] regarding the SSC is also being able to link all the innovation measures to an idea of Resilience, being able to link and considering Resilience and

the main constituent of the “SSC MANAGEMENT AND ASSESSMENTS STANDARDS”, using “ICT STANDARDS” as tools to be deeply known by the manager of built environment and to be understood in their potential for the evolution of the Architecture of the city. The governance of the processes in the Urban Environment is directly linked to the evolution of technology “ICT STANDARDS” that by definition are really hard to be defined because they are linked to innovation and innovation linked to ICT has had a fast growth in the last decade. A manager of built environment is living not only the metamorphosis of the manager in manufacturing companies after the introduction of ICT in processes but it is needed to understand the complexity of interactions between different aspects of the society connected to the built environment. “BUILDING AND PHYSICAL INFRASTRUCTURE STANDARDS” are set into Urban Planning (in its evolution as Urban Planning methods supported by technology and not only relying on static sources such as Census and static database) and Building Information Modeling (BIM), two amongst the innovations that are considered at Urban level and at the building scale the innovation in Architecture nowadays.

Smart Sustainable City-Resilient, in this article defined for the first time in the observed literature as SSC-r is the true evolution of the management of the Smart Sustainable City. Resilience, analyzed in the benchmark of this paper puts under the light the need of integration of the categories of Sustainability, Resilience and Smartness of a city. The strong link with ICT for Architecture is twofold in the definition of the SSC-r: for the dependence on the ICT systems, the computer based management of the city and the building and for the level of consciousness of the ICT sectors of the importance of resilience. It should be also considered that ICT changed some aspects of designing, selling and controlling services linked to the Construction sector, thinking on the evolution of Prop-Tech and Re-Tech companies it is clear that the possibilities of a governed development of ICT are huge.

Moreover the ICT sector considers Resilience in a narrow and restricted to technology level, a different scale step up is required from managers of built environment in their modern evolution. This paper has set the basis for the implementation of the SSC-r and for developing the figure of its manager and designer, considering all the possible interactions and evolutions linked to computer-based technology.

Another point to be considered is the possibility to connect the procedures used commonly in the management of contracts, for example, in Facility Management (in all its extensions, from the City to the building scale, the possibilities given by “smart contracts” are huge [20]) and rich in risk if not governed by proper procedures and properly trained professionals, able to coordinate Information Technology teams and adapting the vision of the Architect with the infinite possibilities given by ICT applications. In the case of smart contracts the conceptual line of this paper helps to see the potential of the source of risk in terms of safety of the code [21] but also opportunities in terms of transparency and efficiency for the management of the procedures in a decentralized society, not only for Facility Management-related contracts but also for a wider use inside the Regional Area, considering all the interactions of systems with Architecture and Management of Built Environment [22].

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