	<p>SMART TERRITORY, INFRASTRUCTURE MAINTENANCE, AND SUSTAINABILITY: THE NECESSARY EVOLUTION OF 'SMART' AFTER COVID-19</p>	<p>3305 BUILDING TECHNOLOGY</p>
<p>COLLABORATION</p>	<p>María-Jesús Rosado-García</p>	<p>3305.06 Civil engineering</p>

SMART TERRITORY, INFRASTRUCTURE MAINTENANCE, AND SUSTAINABILITY: THE NECESSARY EVOLUTION OF 'SMART' AFTER COVID-19

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1. INTRODUCTION

Smart Territories [1], are currently after the COVID-19 pandemic the forced evolution of Smart Cities [2]. Everything that has happened has revealed that the city cannot unequivocally monopolize the interest of the "Smart", but also any element, inside or outside the metropolitan area, be it the public infrastructure or any municipality. The development of humanity has been linked to engineering and its advances with the consequent improvement in the quality of life of people. In particular, civil engineering and infrastructure construction have historically been the tool with which man has adapted to his environment, facilitating coexistence, the residence itself, the transport of goods, people, and communication, or the capture of natural resources. Currently, introducing the current technological level, public works and infrastructures must be the backbone of the territory.

The concept of smart territory emerged not only as a continuation of the smart city concept but also in opposition to it: the "smartization" of cities can produce a digital divide in the territories [3]. The smart territory is understood in this work as Place [4], in the sense that transcending physical meanings, the territory becomes a model of collective innovation, of social and cultural sustainability.

Smart territories are made up of a network of infrastructures, communications, and municipalities whose elements are monitored in such a way that the system is nourished by the amount of data necessary as basic information for the different actions. This requires collaborative environments, citizen interaction, and their involvement in new models of coexistence.

Undoubtedly, the outbreak of the COVID-19 pandemic will lead to pointing out new problems for cities that come to reinforce the EU's idea of modernizing cohesion policy and dynamization through public policies of technological innovation, not only Smart Cities but of the society [5]. It will be worth considering whether the changes experienced in urban dynamics in the context of the pandemic will reverse what was pointed out at the United Nations Conference on Sustainable Development, that half of humanity lives in cities.


On the other hand, it should be noted that currently in the most developed countries there is not so much need to build new infrastructures as there is to maintain existing ones in an optimal state and guarantee the functions for which they were built. Maintenance then becomes the backbone of the required sustainability to which new approaches and development policies are directed, as reflected in the proposal for a new European Bauhaus [6].

The construction sector, both industrial and civil, have not experienced profound changes throughout history concerning the development of a construction project and in what refers to the incorporation of new execution and production techniques. Currently, the greatest presence of smart infrastructures is found in sectors such as aeronautics, military, naval and automotive, where for some years now the sensorization of numerous parameters in its operation has become essential. For all this, it is of interest to carry out a study that encompasses the current state of development in which the different currents of research, methodologies, and approaches in all these fields are found, to offer a global and conceptual vision. It is necessary to search

As the main objectives of the study, it is first to carry out an exhaustive bibliographic review of the state of the art in the field of smart infrastructures about the current of Industry 4.0. The different engineering approaches and the main lines of research on them are analyzed, such as the implementation of Smart cities & territories, the different information and communication technology solutions (ICTs) [7] that make its development possible, as well as the existing technologies and methodologies that allow linking the concept of smart territory to that of sustainability. The approach developed in this work leads to the need to promote maintenance that can be called smart.

2. SMART CITIES AND TERRITORIES.

Currently, existing estimates indicate that by 2030 more than 60% of the world's population will live in cities and urban environments, while by 2050 this figure could exceed two-thirds. In addition, cities account for approximately 70% of the world's energy consumption and greenhouse gas emissions, all this without exceeding 5% of the planet's surface [8].

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This trend brings with it an unprecedented increase in the consumption of resources such as water, construction materials, energy, and waste management by these growing urban environments. Thus, they will be forced to improve the quality of services, increase the efficiency and effectiveness of the management measures of all the necessary resources without losing attention to the reduction of operational costs and infrastructure maintenance, which will be the interconnection and interrelation tools.

Based on the foregoing, it is conceivable that the environments in which human activity takes place should be oriented towards an approach of smart cities and territories, in which new technologies are the main support to increase the quality of life, competitiveness, and services.

Putting the focus on developed countries, the main objective is to maintain existing infrastructure systems so that they are not discarded for reasons related to their maintenance or adaptation cost, useful life, and other reasons.

Therefore, smart infrastructures are the main elements around which smart cities and territories are formed, their main characteristic being the need to be connected and integrated, generating a continuous flow of data, so that proper control and management of said data and through the use of intelligent control tools will allow the optimization of performance and resources. Some of the main components of a smart infrastructure are Smart Buildings, Smart Mobility, Energy Intelligence, Smart Water Management, Smart Waste Management, Smart Healthcare, Smart Digital Layers (Urban, Sensorization, Connectivity, Data Analytics, Automation), Asset Life Cycle [9].

The concept of a smart city or territory is a relatively new and emerging concept whose definitions are very diverse, so it is not completely defined [10]. It should be noted that, in general, the Smart City concept refers to what would be a city or urban nucleus and the Smart Territory concept to a larger territory or region.

From a technological point of view, it is possible to say that a Smart City is a highly complex eco-sustainable system. On the other hand, it can also be defined as a city that monitors and integrates the conditions of all its critical infrastructures[two].

In other cases, the emphasis is placed on the organic integration of the city systems, considering the Smart City as a system of systems [11], that is, a set of interconnected systems that function as a single organism. On the other hand, some definitions highlight different aspects [12], where more importance is given to the impact they cause on the inhabitants, on the economy, on the government, on the environment, on mobility, and life in general in the city.

According to the Mapping Smart Cities in the EU report, a city or territory is considered smart if it has at least one initiative that addresses one or more of six attributes listed as Smart Economy, Smart People, Smart Environment, Smart Mobility, Smart Living, Smart Governance.

One of the main problems in the field of mobility and directly related to sustainability is traffic congestion, which produces high energy consumption and produces a negative impact on the quality of life, to which answers are beginning to be given, such as in the city of Santander (see Figure 1).


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Figure 1 Smart Mobility Santander action plan. Source: Santander City Council

3. INDUSTRIAL REVOLUTIONS AND CURRENT CONTEXT IN UE

It seems necessary to frame the current moment through the approach of the industrial revolutions, each one with a marked change within the social and scientific paradigms.


During the first industrial revolution, the mechanization of production processes meant the socioeconomic transformation from the artisanal to the industrial. The second industrial revolution led to the use of steel, oil, electricity, and, therefore, mass production, however, this was affected to some extent by the standardization of processes. During the third industrial revolution, the use of electronics and information and communication technologies (ICTs) allowed automation.

Today, the fourth industrial revolution is based mainly on the use and implementation of cyber-physical systems, with the spread of the use of the Internet, digitization, sensorization, and the Internet of Things (IoT); that are providing new opportunities, mainly in the field of process optimization, by combining them with Artificial Intelligence (AI) and deep and continuous learning to improve the management of the data generated.

Currently, the fifth industrial revolution is being announced which, compared to industry 4.0, mainly focused on technological economic aspects, also takes into account environmental and social sustainability. Climate change, networking, increasing digitization, and a globalized world bring new challenges for residential centers, houses, neighborhoods, cities, and territories in general. The current COVID-19 pandemic also requires a different approach, making it necessary to redefine the configurations of open, socially oriented, and private spaces, as well as the relationship with the natural environment. Housing has become extremely important [8].

For this reason, the orientation of social consumption practices towards a panorama in which sustainability and the promotion of clean energy production systems (wind energy, photovoltaic energy, etc.) take on a priority value and have sufficient guarantees for its development.

It is worth highlighting the need to also focus on the surrounding civil engineering and communications for infrastructure, transport, in a way that transcends the concept that Smart and sustainability is not only at a local level but also global, that is to say, which reaches all territories (see Figure 2) [13].

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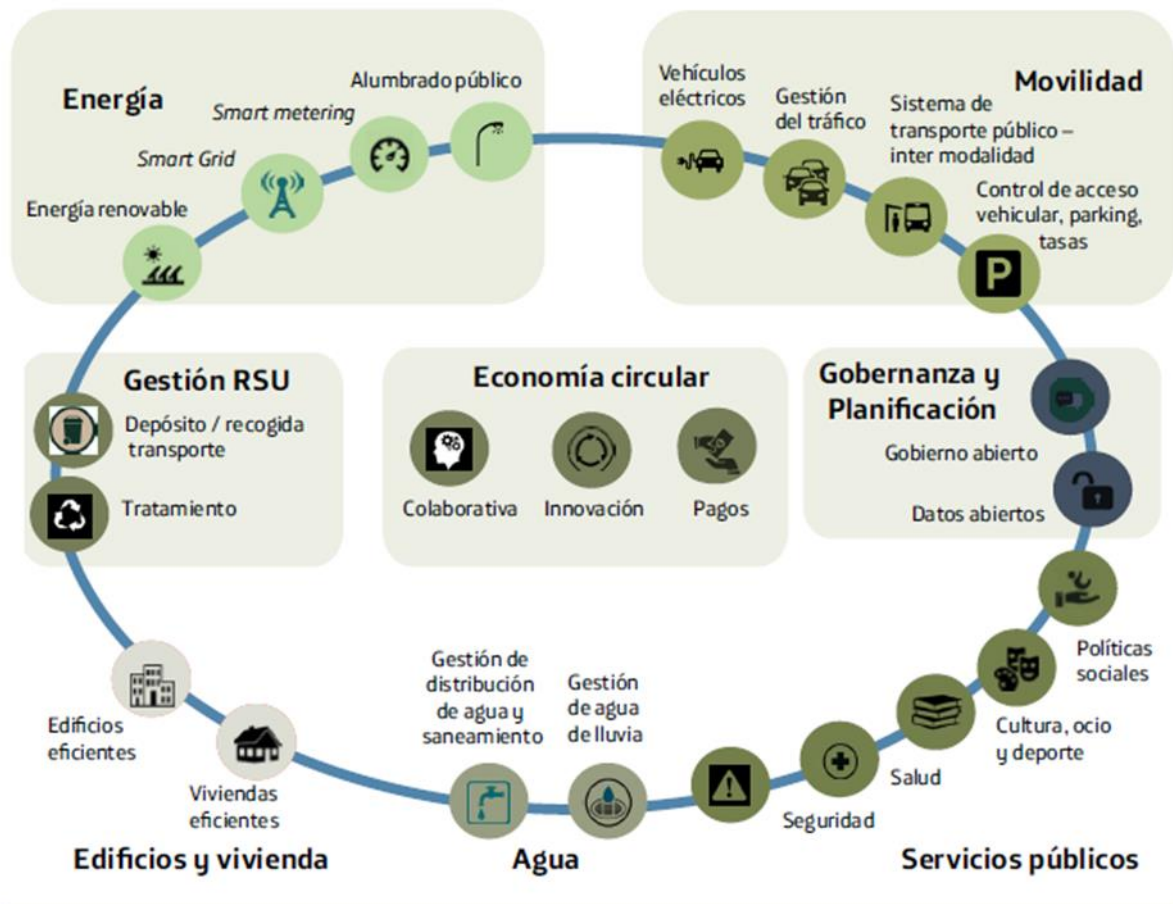


Figure Smart Areas in a smart territory. Source: Ontiveros

The document “Renovation Wave” [8] focuses mainly on the renovation of the European building stock from the perspective of environmental and social sustainability and the plan for the post-COVID-19 recovery. NextGenerationEU appears to be the foundation for development with the inclusion of a list of various avenues of research regarding construction and its related aspects. It is focused on people to ensure that the design, construction, maintenance, operation, rehabilitation, and recyclability of buildings and the built environment drive the much-needed sustainable transition in society and the economy.


The aging process of buildings must be considered as important as the development of new construction, especially in terms of circularity. Therefore, in this context it is essential to share the available information, accelerating the implementation of collaborative methodologies such as BIM (Building Information Modeling) [14] that are vehicles for the design of smart infrastructures.

It is crucial that from the project phase the necessary automation is foreseen for the model, which is alive throughout its useful life so that it can feed on information, which is key in the maintenance phase.

Circularity in design, but also ecological infrastructure and landscape integration are important from the perspective of the natural environment. In general, the concept of smart territory, not just smart cities, must prevail and acquire the necessary importance to be considered.

4. TECHNOLOGICAL SOLUTIONS TO GENERATE SMART INFRASTRUCTURES

The intelligent use of Information and Communication Technologies (ICTs) in today's hyperconnected world in which we live offers infinite opportunities and the generation of smart infrastructures is supported by various technological solutions such as the Internet of

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Things, which is a fast-moving network sprawl consisting of devices with embedded sensors and software that connect and share data. These, in turn, reduce energy consumption, manage traffic and improve various urban operations and services.

Artificial intelligence (AI), Neural Networks, and intelligent control make it possible for machines to learn from experience, perform human-like tasks, and make maintenance decisions.

The term Big Data refers to data sets or combinations of data sets whose size, variability, and growth rate make it extremely difficult to capture, manage, analyze or process them using conventional technologies and tools. Smart Grids or SmartGrid allow the possibility for consumers with energy self-sufficiency capacity to use their energy in response to existing prices and sell their excess electricity to the grid [13].

While the 3G and 4G networks used by mobile phones today pose many problems in supporting the various services needed for smart and sustainable city applications, the development of 5G technology has the potential to transport data much faster and process large volumes of data with minimal delay.

In the case of maintenance, the Digital Twin application is of interest, which is an exact digital replica of a service, product, or process, which, when combined with Artificial Intelligence, is capable of autonomously performing optimization processes and reasoning that allow identifying new opportunities for growth and development.

SCADA systems, Supervisory Control And Data Acquisition allow the management and control of any local or remote system thanks to a graphical interface capable of communicating the user with the system.

5. MAINTENANCE AND MONITORING IN ENGINEERING


Today, maintenance, like other sectors and branches of engineering, faces a new generation within the framework of Industry 4.0, with the use of highly reliable electronic inspection and control equipment, capable of knowing the real status of the equipment through continuous or periodic measurements of numerous parameters such as noise, vibrations, temperatures, carried out using techniques such as ultrasound, thermography or physical-chemical analysis. In addition, the application to the maintenance of ICTs allows the accumulation of empirical experience and the development of data processing systems, which will allow the implementation of expert systems and artificial intelligence in the process in a very short time.

One of the specific objectives is to extend the useful life of the assets that the sustainability required today entails, for which reason it is necessary to go beyond attention to tasks of correcting faults produced according to corrective maintenance and to act before their appearance, with preventive maintenance. Added to the above is the development of so-called predictive maintenance, which is based on continuous monitoring and diagnosis, through system monitoring.

From a general point of view, four main process blocks can be highlighted in the management (see Figure 3) of any type of smart infrastructure.



Figure 3 Management and control process of a smart structure.

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Structural Health Monitoring [15] It is an extremely widespread process in engineering to assess the condition of structures and their components, check if they suffer any critical damage, and carry out preventive maintenance on them.

Regarding the techniques used in the monitoring of structures and components, a distinction is made between data extraction methods, processing methods, experimental testing, and non-destructive techniques.

Among the former, fiber optic technology stands out, mainly in applications of reduced size and weight. Bragg gratings (FBG) [16], manage to reach the last level of the monitoring process by combining a network of sensors distributed over the structure under study and a system for capturing data from the structure itself in real-time [17].

Among the most used methods for data processing [18], one can distinguish the Hilbert-Huang Transform, Wavelet Transform, and Empirical Mode Decomposition (EMD). It is important to take into account the maintenance strategy based on the real condition of the infrastructure, known as Condition Monitoring [19] since it is one of the most effective techniques currently used in predictive maintenance to guarantee the health of equipment and machines in any production process, allowing the detection of problems and potential failures at an early stage.

The implementation of fault detection systems, Fault Detection Systems (FDS), brings great benefits in improving the operability of the equipment due to its early warning characteristics. Normally, Condition Monitoring is usually referred to as a methodology or strategy although it is often considered that, in turn, it is divided into two main areas: Trend Monitoring monitors the operating trend [20] and Condition Checking which makes it possible to determine if the operation of the equipment in certain conditions adjusts to the behavior of the same previously established in similar conditions [20].

It should be noted that the implementation of these strategies makes it possible to anticipate possible breakages, collapses, and failures in equipment, machinery, and infrastructure. The early detection of the symptoms that precede these failures allows planning and carrying out better management of the resources that the maintenance teams must have and therefore extend the useful life of their elements.

6. CONCLUSIONS

Currently, society is immersed in a clear process of adaptation and change aimed at digitization, the development of new control methodologies, and the management of resources and infrastructures for general use. The execution of new constructions, systems, or infrastructures is no longer so essential, now being one of the main development paths the extension of the useful life and the care of said infrastructures, as well as the optimization of the operation, management, and maintenance processes that result in the required sustainability.


The concept of smart infrastructure encompasses and in turn relates multiple aspects, whether social, technological, or engineering, that lead to the generation of smart territories. These must necessarily be developed after the COVID-19 pandemic with the support of what has been initiated in cities around the Smart.

In particular, civil engineering requires changes regarding the methods used in maintenance, since part of the infrastructure is reaching the end of its useful life, so it is necessary to develop strategies aimed at the implementation of new technological systems that, in line with the rest of the productive sectors allow their correct use and operation to be extended over time.

Smart territories must inextricably count on the participation of society. They are structures in collaborative environments whose data is fed by the community. One example is the possibility that sensors integrated into a bridge allow a passer-by to warn of a fault in real-time.

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