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Towards a maintenance 4.0. Chance versus need

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Original
Towards a maintenance 4.0. Chance versus need / Azzalin, M.. - (2020), pp. 119-125.

Availability:
This version is available at: https://hdl.handle.net/20.500.12318/135726 since: 2023-06-03T11:28:51Z

Published
DOI: http://doi.org/

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07 June 2026

Producing Project

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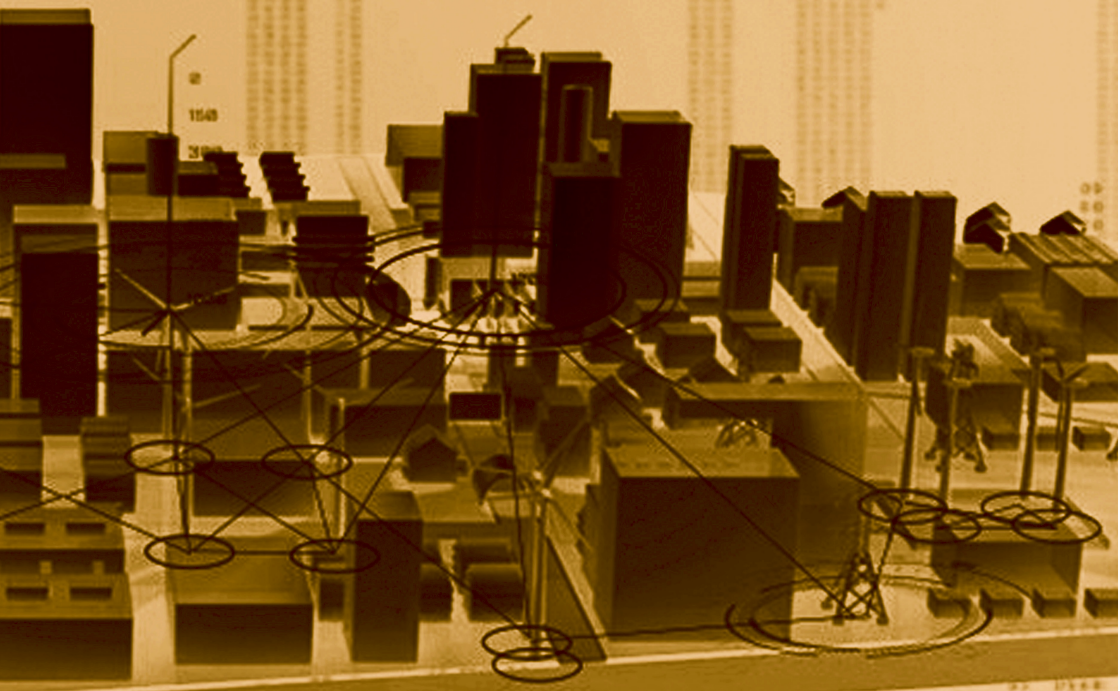

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The transformations created about the design activity by the several challenges started by the economic crisis, climate change and environmental emergencies, together with the impact of the Web and ICT on social and productive systems, highlight many critical issues, but also significant prospects for updating concerning places, forms, contents and operating methods of "making architecture", at all levels and scales.
In this context, the cultural tradition and disciplinary identity of Architectural Technology provide visions and effective operating practices characterized by new ways of managing and controlling the process with the definition of roles, skills and contents related to the production chains of the circular economy/green and to real and virtual performance simulations.
The volume collects the results of the remarks and research and experimentation work of members of SITdA - Italian Society of Architectural Technology, outlining scenarios of change useful for orienting the future of research concerning the raising of the quality of the project and of the construction.

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This e-book has been subjected to blind peer review process.

Cover:
adaption of
Siemens digitalization tour, Siemens, 1996-2019

ISBN 978-88-916-43087

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Released in the month of November 2020.

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47822 Santarcangelo di Romagna (RN) • Via del Carpino, 8
Tel. 0541/628111 • Fax 0541/622595
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PART 1.

DEMAND FOR SERVICES, OFFER OF COMPETENCES
VALUES, CONTENTS AND PROJECT ACTORS
IN THE NEW ORGANIZATIONAL MODELS OF THE BUILDING PROCESS

1.11 TOWARDS A MAINTENANCE 4.0. CHANCE VERSUS NEED

Maria Azzalin[*]

Abstract

Sustainability, resilience, recovering, adjustment, reuse, are expressions of urgency-emergencies. Interoperability, IoT, Big Data, Cloud, Augmented Reality, some terms of a new lexicon. They all introduce assumed discoveries and innovated approaches. They support and reaffirm the necessity of a proactive acting in a new dimension.
Maintenance 4.0. A mix of automation, connection, information and planning, whose operational routine goes transforming itself thanks to the Lean Thinking and the Digital Transformation. However, computer technology is only the motor not the pilot of the new way of working. The revolution involves the tools but it can take place only through coherent processes: the constant maintenance, the taking care of. Opportunity versus necessity.

Keywords: Maintenance 4.0, BIM, Augmented Reality, IoT, Lean Construction

Urban transformations, whatever be their nature, genesis or the mechanisms that rule them, happen according to a sequence that is expressed, on one side, through actions, which connects the subjects that make them to the objects that receive them and vice versa. On the other side, through connections that, inevitably became active in space and in time, and that concern the technical, economic-financial and social sphere, but also ethical and that of behaviour. Actions and connections that have a sphere of activities and reaction time, sometimes synchronous, evident, sometimes asynchronous, hidden inside the «pulsation of a butterfly's wings» (Lorenz, 1972). An image that in its poetic beauty, expresses an important physical-mathematical concept, partly already anticipated from Turing (Turing, 1950) and developed by Lorenz with his studies on Chaos Theory, according to which also light alterations of beginning conditions, are able to cause great variations in the behaviour of a physical system for a long time term. As a result, then, referring to the environmental transformations caused by man, the intervention of what Jonas defines «principle of responsibility» is inevitable (Jonas, 1979) that has to be applied for guarantee-

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ing the survival of the future generations. It is the same axiom that we find again declined in the Protocol of Kyoto (1992), as «principle of precaution».

Also in the Theory of Decrease, of the circle of the eight "R", by Latouche whose exhortation to the saving of the resources, if moved to architectural and urbanistic area of interest, sets up the "R" of the reuse and of the recovery of the existing building and, therefore, of the maintenance. (Latouche, 2007)

If on the one hand then, while pandering the principle of responsibility, sustainability and resiliency become the possible keys to reading of the environmental actions/transformations caused by man, in terms of respect, safeguard and maintenance in time; on the other hand the same terms are set as indicators of no longer negligible urgencies/emergencies of retraining, reuse, safety. Not only that, they feed, if brought back into the disciplinary and operational framework of the Maintenance, an urgent demand for innovation of the intervention processes on the existing heritage, but also of the design processes.

Chance versus necessity. Not with meaning of opposition, instead as expression of an active dualism, propositional. Transformations that demand the Maintenance a rereading of its own traditional strategies and operational practices, conjugating the three aspects of sustainability - social, economic, technical - in a perspective of resiliency, able to involve the different levels of action. Territory, city, building. But they also impose redefining and updating its own role inside the whole building process compared to new competences and professionalisms that the digital revolution has already introduced and to new approaches based on the transfer of the Lean Thinking (Womack et al., 1991) also to the sector of the constructions.

Today, we are truly living a real new revolution: The Fourth one. Every precedent step: Mechanization (XVIII century), Production in series (XIX century), Automation (XX century), has meant a deep transformation of the productive process and a general increase of productivity.

The current step that of Digitization also imposes a radical change of paradigm. A cultural revolution, in which, together with the principles of new disciplines such as the Ecology of the Mind by Bateson (Bateson, 1972) or the Behavioural Economics by Thaler (Thaler, 2016), Nobel prize in Economics in 2017, a new condition is becoming apparent. A condition in which "material and virtual" take on the same value in terms of resources to be put in value.

A vision of "digital oriented" development strongly stimulated by different national governments including Italy that, through the National Plan Industry 4.0 2017-2020, has introduced a series of measures finalized to favour the investments related to integration of "physical goods and digital technologies."

Orientations in comparison to which the construction sector expresses proper and peculiar critical issues: If, from the one hand, in fact, the necessity of a strong acceleration in terms of innovation is shared, from the other one it is clear the limit to be the sector that has always been slow and unwilling to accept changes. Critical issues that have been underlined also by the World Eco-

nomic Forum of Davos in 2016 on the Fourth Industrial Revolution, during which a specific focus has been dedicated precisely to the construction sector.

A missed opportunity, whose consequences, to date, are a general backwardness of the sector and a low productivity. Characteristics analysed and confirmed by a study, in 2017, of the CYFE (Centre for Integrated Facility Engineering) of the Stanford University (Fischer, 2017).

A background, this till now introduced, particularly articulated, useful in understanding dynamics and opportunities of digital transformation/innovation offered by Industry 4.0, characterized, according to the analyses conducted by some groups of experts from different Centres, among which the Boston Consulting, essentially from three levels of development: Smart Production, Smart Services, Smart Energy.

Three interacting levels that outline development guidelines towards which, the various sectors including the Constructions one and the Maintenance itself, must necessarily aim at.

Therefore, close to the terms sustainability and resiliency are placed Internet of Things, Big Data Analytics, Cloud, Interoperability, Virtual Reality and Augmented Reality, terms, that as the first ones, are no longer negligible, voices of a new lexicon which introduces to innovated approaches and to as many innovative operating practices of the design project and of Maintenance one in particular. According to a study conducted by the Italian Maintenance Association (AIMAN, 2017), Maintenance represents one of the most important areas involved in the strategies related to Industry 4.0. Both for the type of services provided, which affect all production sectors indifferently; and for the final objectives of such services, functional to keep in efficiency and to guarantee the correct functioning of the object maintained in the life cycle.

The National reference standard (UNI EN 13306:2018 Maintenance - Maintenance Terminology) defines it as «the combination of all the technical, administrative and managerial actions, during the cycle of life of an entity, directed to maintain it or to bring it in a state in which can perform the required function». Thus, if the objective of Maintenance has always been «to adapt and where possible constantly improve the systems to the changing needs expressed by users, redesigning or replacing them when necessary» (Cattaneo, 2012), clear expression of the requests for resilience, what is now becoming an element of innovation is a proactive maintenance approach.

An approach that, abandoning the principles of passive prevention, the FMECA, Failure Mode and Effects Criticality Analysis (Blanchard, 1978) and assuming as its own those of TPM, Total Productive Maintenance (Nakajima, 1998), bases its assumptions on active prevention, on the Lean Thinking (Womack et al., 1991) Lean Construction (VV.AA., 2014). Strategies, these latter that, already established in other industrial sectors, are spreading also in the construction sector in association with the IPD Integrated Project Delivery (AIA, 2007) and at BIM, Building Information Modeling (Borrmann et al.,

2015), developing new production, organizational and management opportunities and, therefore, also a “Maintenance 4.0”.

It is always the AIMAN, to this regard, to state the necessary elements so that Maintenance actually enters the era 4.0: the key enabling Technologies, Information Communication Technologies (ICT) and technical-organizational processes to be implemented and a progressive digitization plan. Among the key enabling Technologies: Big Data Analytics, Augmented Reality, and Robotics. But also, Horizontal and vertical integration and Cloud.

Nevertheless, computer technologies, the opportunity through BIM models, to manage, check and implement over time all the available technical or/and administrative and management information, which are part of the maintenance strategies are «only the engine not the pilot of a new way of working» (VV.AA., 2016). The new tools and opportunities offered are, in fact, brought back within a holistic vision of the entire building process and, in particular, the life cycle of a building, considering together: quality, durability, environmental, social and economic costs. This scenario includes some of the experiences carried out in the last years by the writer and still in progress. Experiences that have allowed to deal with the aspects mentioned above, both in terms of awareness of the opportunities given by the digital revolution, and with respect to some critical issues that undoubtedly affect the design and management processes and, therefore, the maintenance issues.

Among the most significant experiences are: the establishment of BimCo, an innovative start up that deals with digitization in BIM; the development of a project for an academic Spin-off that has passed the first phase of the selection of the Public Notice POR Calabria FESR 2014/2020; the participation in the drafting of the ITACA Calabria Protocol. Three the main issues addressed: digitization; smart management of information and their transfer from a maintenance standpoint to operational tools.

With reference to the digitization, the experience carried out with BimCo, confirms the potentialities underlined for some time by the world of R&D (Sjostrom et al., 2004) and Standardization (EU Project STAND-IN), (Liebich, 2007). Potentialities which are related to the extended and shared use of interoperability systems, IFC Industry Foundation Classes (ISO 16739:2013 Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries), for the exchange of information among the different operators in the construction sector. Such use was encouraged at national legislative level with the Legislative Decree 50/2016 that incorporates the relative European Directives.

The experience gained with BimCo, also allows to underline some of the factors of slowdown in the adoption of BIM, among all, the still low level of interoperability of architectural, structural, plant engineering, calculation, etc, software, each of which uses a proprietary data representation system.

The goal is the dissemination and use of open data. In addition, the definition of a set of technical standards able to regulate and codify BIM processes. Joint commitment of ISO, CEN and the various national regulatory bodies, including UNI (Italian National Unification Body), which is working on the Italian UNI 11337 series (UNI 11337:2016 Building and infrastructure Digital management of information processes of construction).

Commitment to which is added with reference to the maintenance field, the contribution made by the USACE (US Army Corps of Engineers) who developed the COBie (Construction Operations Building Information Exchange) a non-standardized norm. Digitization and smart data management are therefore two of the central characteristics of Maintenance 4.0, aspects conveyed to the guidelines that have directed the second experience, the participation in the project of the proposal for an academic Spin off. An experience that has done properly both the characteristics of innovation and the critical issues inherent in the general thematic of the tools and procedures for systematization, management, transfer, processing and feedback of information. It could be said, paraphrasing a reflection by Molinari (Molinari, 1989) “Information for Maintenance. Information from Maintenance”.

It is the experimentation of a circular vision of information that ensures the dialogue between the different operators in all phases of the life cycle of the product and allows the passage from the actual maintenance based on breakdown to a proactive approach: Prognostic and Predictive Maintenance. The experience till now conducted in the first phase of elaborating the Spin-off proposal, has shown how the association of BIM and IoT, the one as intelligent and interrogable digital repository, the other as a set of methods and data transmission protocols, despite the critical issues underlined above, introduces countless technical, managerial, economic opportunities. Aspects, also underlined by the planning document of the British government, Construction 2025, according to which in the coming years, the BIM technology combined with the IoT will allow an overall reduction of 33% of the costs related to the whole life cycle of buildings. At the same time, they will reduce of 50% the time between the planning phase and that of commissioning.

The future in this case as well as the vision of the Spin off, consists in defining cloud-based IoT solutions, on intelligent system services, that allow effective forecasting and prevention of the failure through the monitoring of performances.

Objectives confirmed by experiences such as Autodesk Project Dasher, a BIM-based application integrated with sensor systems for reading performance (electrical and occupancy) of buildings over time. Opportunities that, for operational practices of maintenance bring to the progressive affirmation of the association BIM – Lean that directs towards more efficient scenarios of predictive maintenance and Facility Management thanks to the tools of Lean Construction Management (Sacks, et al., 2010).

At the same time, as already highlighted several years ago by Molinari, it emerges the need to reconfirm research addresses on the role of «retroactive informative support of maintenance» (Molinari, 2002), of «privileged observatory» of the phenomena that characterize the transformations over the time of the building systems, their operation and their ways of use.

The possibility of collecting and managing a large amount of data, in fact, reissues the still open question of structuring and re-reading the feedback data, because they can be usefully transferred in life cycle assessments, in estimating the useful life of materials and components (ISO 15686:2000 Buildings and Constructed Assets - Service Life Planning) and then towards production, on the one hand, and design, on the other.

However, digital innovation, as we said, is only the engine not the pilot. The revolution involves the tools but it can take place only through coherent processes: the constant maintenance, the taking care of. It concerns assumed discoveries, reread in a new dimension that combines two modern terms BIM and Lean. A maintenance-oriented design approach that applies the principles of Lean Thinking and recognizes that maintainability is an indispensable design requirement; allowing to guarantee over time the status of the building and its parts, the functioning, the full use of technological systems and the permanence of safety and reliability requirements Issues that the experience of participating in the drafting of the ITACA Calabria Region Protocol (2017) has tried to transfer, in current practices. This by introducing them among the contents of the assessment Area E – Service Quality, which represents one of the five Areas with respect to which the Protocol is articulated in its national version (UNI/PdR 13/1:2016 Environmental sustainability in buildings - Operational tools for assessing sustainability). Aspects that, with reference to the aforementioned Area E, characterize the version of the ITACA Calabria Region Protocol as peculiar and distinguishing factor compared with National and other regional versions. Expression of the will to reaffirm, through the adoption of a series of categories and criterions already present in the SBTool, from which the ITACA Protocol has originated, the centrality of the maintenance aspects for building life cycle.

In this context, the support tools are “rediscovered” too. The Maintenance Plan, as well as the Booklet of the Building, or the Use and Maintenance Book become dynamic tools, capable of receiving and implementing from time to time the feedback coming from the Building Automation and monitoring systems and from the same maintenance activities. So that in order to guarantee in time the best possible operational solution, but also the environmentally correct one and, finally yet importantly ensure a social value, in terms of customer care, to the end users of the asset.

Disregarded opportunities, Cattaneo affirmed «In the last forty years, since when Donella Meadows and her MIT group wrote the Report on The Limits to

Growth for the Club of Rome, nothing new has happened related to maintenance» (Cattaneo, 2012).

Today, perhaps, a renewed opportunity seems arising for Maintenance: Maintenance 4.0. Necessity versus chance.

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