

Chapter 3

Innovation for the Digitization Process of the AECO Sector



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Abstract The conference's Innovation session gathered more than 20 papers ranging from the digitization of the construction world to the digital twin of complex infrastructure such as port areas. The common denominator of the presentations was the methodological search for the best combination of physical reality and digital replication, always putting the functionality and operability of the built environment at the center of the study. In fact, the contributions, although coming from very different research realities, clearly highlighted the inescapable path toward the integration of the digital world in the AECO sector.

Keyword Digital Twin · AECO · IOT · Digital platform

The cultural and socioeconomic shocks of the last years, deeply marked by the pandemic crisis, are proposing with the greatest urgency new thoughtful and evolutionary visions building on all positive and negative recent experiences, bearing in mind the fundamental contribution of technological innovation to cope with the present global changes scenario.

The dawn of the digital revolution heralded and described before it had even been triggered is a key issue on the agenda of the built environment, considered at any scale of analysis. It seems that a new paradigm is presently needed, in order to replace the actual documentation-based approach with a practical method of quality control, able to recognize both in structural evidence and building processes, those pivotal factors of development that can be used to measure and monitor the performance of single and multiple buildings and the parties involved.

The initial transition to the digital world, which focused essentially on three-dimensional models, led to a significant transformation in planning, design, construction processes, and management, in terms of both contents and participants, with a

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focus on the organization of collaborative information flows and production procedures, optimizing instruments crucial to determining when top-quality results have been achieved.

It is precisely this surprising stock of untapped but available potential that makes digitalization appear to be less a phase of evolutionary adaptation, strictly speaking, than both a significant moment of growth and, in the meantime, a tremendous opportunity.

As a matter of fact, the digital revolution is becoming more and more an essential asset at the core of architectural design and construction activities, and this is calling for the mentioned paradigm shift from a document-based approach to a concrete application of a quality control method, to be reflected in the use of structured data within all construction process (Agostinelli et al. 2020).

This is the reason why, the ‘Innovation’ session within the ‘Technological imagination’ conference—held in Roma La Sapienza in June 2022—has been designed as an occasion for discussing those features and tools to be considered as driving factors of the mentioned digital revolution, with careful attention to innovative methodologies and instruments for controlling the quality of construction projects and processes, as well as their integration with best available technologies.

The session focus centered on the following topics proposed for the discussion to the participants:

- ICT Innovations in Architecture and Civil Engineering;
- Digital Transformation and AEC and The Role of Enterprise Architecture;
- Advances in Digital Engineering, Computing, and Simulation for the AEC Industry;
- Innovative Digital Technologies and Engineering Systems (e.g. Digital Twins);
- Project Management in design and construction processes;
- Advances in digital engineering, computing, and simulation.

The introductory statements were entrusted to highly qualified technology and communication experts. The initial contribution to the debate was an interview by the editor in chief of *La Repubblica*, Mr. Maurizio Molinari, who was asked to elaborate on his vision of the new professional profiles emerging as a result of the impending digital transition. Afterward, it was Professor Michael Grieves, the developer of the digital twin approach in 2002, who was asked to make a projection of prospects after the digital twin.

Data analysts are usually focusing on the process of combing data to find new relevant patterns for the business sector or other stakeholders. BI analysts are more suitable at making sense of what has happened and doing so at scale. Data analysts are better at looking for patterns that state what might happen, and vice versa. BI analysts are sounder at translating business requirements into the appropriate graphs, charts, spreadsheets, and dashboards. They tend to work close to the front line with business users and subject matter experts. They also need a solid understanding of business workflows, finance, and accounting to translate the raw data into a form that final users would find easier to use. BI analysts need a deep understanding of the technical side of working with structured databases and data warehouses. They

must be fluent in writing complex SQL queries and creating complex joins across tables. Familiarity with various query optimization techniques helps ensure they create reports that cut database processing overhead.

BI analysts may get formed with very different SQL data transformation skills.

For example, they may work with extract, transform, and load tools, to transfer subsets of data from an operational database into a data warehouse to support a new query. Some basic user experience design skills can also help them identify the best way of presenting data to users that is simple and can explain the appropriate story (Cristani et al. 2015).

The next keynote speaker, Prof. Grieves, provided an overview of the state of digital innovation and pointed out that digital transition is already going further, converging into experiments in the metaverse. According to Prof. Greves, the driving force behind this transition is the Digital Transformation of business, with extensive use of advanced technologies related to artificial intelligence, digital twins, augmented and virtual reality, AR/VR goggles, and wide connectivity.

Digital transformation is already transferring part of the activities to cyberspace where even portions of the company's assets are relocating, changing their economic value; this process can be both an issue or a huge opportunity. To leverage the opportunity, most companies will need to transform their business models and their market offer. The potential issue is whether their market could also shift to the cyberspace with similar rapidity and whether it would make sense to create rapidly metaverse as a platform to meet their customers and provide them with a satisfying experience.

How and when people will actually access the metaverse is the current unknown of the matter: there will be probably a hybrid situation where part of the company (processes, activities, resources, services, software products) will be in the cyberspace and part of the customers will be accessing those by moving to the cyberspace, thus effectively transacting in the metaverse. However, still part of the company will remain in the physical space and consequently part of the transactions will be occurring in the physical space. A mixed space will keep existing where the cyber is in connection with the physical dimension for a long time.

Afterward, Prof. Maurizio Talamo, full professor of cyber security at University of Rome 'Tor Vergata', opened as key discussant the thematic session on innovation, with an introductory speech. Prof. Talamo emphasized how the concept of cyber security is of paramount importance in the development of digital innovation and clearly highlighted the most relevant fields of application for this matter in the field of innovation, namely:

- Risk Assessment and Management;
- Business Continuity and Resilience;
- Cyber Defense;
- Digital Identity management and Privileges;
- Application Security (API, ERP, secure code review);
- Data Protection.

For assisting construction industries, manufacturing, and business opportunities, digital security can employ the technology to stress-test and otherwise evaluate the vulnerabilities and capabilities of controls on computing environments. The ability to attack a live twin of a production environment—complete with ongoing updates reflected from the original system or environment—without putting data or productivity at risk potentially allows security teams to be as aggressive as they need to be without compromising operations (Cristani et al. 2016).

Concerning the contributions to the session, 18 papers were accepted for publication, coming from several Italian universities as well as from academic institutions from Iran, Pakistan, and Belgium; five contributions were selected for oral presentation at the conference, namely:

- *Short-Term Wind Speed Forecasting Model using Hybrid Neural Networks and Wavelet Packet Decomposition;*
- *Digital Twin for an innovative waterfront management strategy. Pilot project DSH2030;*
- *Digital Twin Models Supporting Cognitive Buildings for Ambient Assisted Living;*
- *COGNIBUILD: Cognitive Digital Twin Framework for Advanced Building Management and Predictive Maintenance;*
- *Untapping the potential of the digital towards the green imperative: the interdisciplinary beXLab experience.*

The most selected topic by the authors has been ‘Innovative Digital Technologies and Engineering Systems (e.g. Digital Twins)’.

The ‘digital twin’ concept is returning frequently among the keywords as well as ‘Maintenance’. Also, the ‘Energy’-related topic received a consistent attention, intended in some cases as ‘simulation’ as well as ‘culture’.

The field of technological innovation seems a very productive ground for methodologies, tools, and experimentation, and the digital twin emerges as the most promising methodology.

The analysis of the selected interventions also shows that the main use cases of the presented methodologies concerned the fields of energy management, maintenance, and safety applied to the whole built environment (both single building and more complex infrastructures). Innovation in technologies leads to the following major innovations:

- *For energy: integrated management of local micro-grids capable of simultaneously managing energy consumption and production;*
- *For maintenance: moving from ‘scheduled maintenance’ to ‘predictive maintenance’;*
- *For safety: use of imaging and computer vision technologies to automatically monitor abnormal behavior, processes, and management of human and instrumental resources.*

Research in technological innovation is confirmed as the field of applied experimentation on which to continue implementing the industry/university relationship.

Most of the papers in fact concerned experimental applications of applied technologies with direct connection with the built environment such as, for example, the utilization of digital workflow for social housing deep renovation design process.

In conclusion, it is important to underline how innovation is one of the fundamental drivers for the green and digital transition of built environment, where technology has a key role for many different aspects.

Innovation is crucial for all industrial sectors to keep their competitive edge, as it fosters a shared culture of constantly looking to do things better. It can help organizations become more efficient and sustainable, adapting to continuous and multifaceted changes of the conditions in which they operate.

Adopted at scale, it can create more consistent supply chains, with each member driven to meet a shared goal of progressive change and improvements, guided by the latest standards of construction methods, construction products, or facilities management.

The increasing diffusion of innovations on the organizational-managerial level with the use of information Communication Technology (ICT), both thanks to the introduction of these technologies together with those of electronic systems for plant automation, security systems, and communications in the building product to realize the new forms of building control and management that are variously defined as Computer integrated Building (CIB), when applied to tertiary buildings, 'domotics' or Home Automation, when implemented in residential construction sites (Scannapieco et al. 2017).

In this direction (technological and organizational innovation), new technologies based on electronics play a very crucial role. They allow the efficient realization of administrative, material purchasing, design, and work scheduling operations, with a small number of technical employees, favoring, through the concentration of information and the possibility of decentralizing production functions.

Information technologies formalize and standardize procedures and lead to the development within the companies of precise and defined responsibilities for specific problems, favoring the processes of specialization and technical-managerial management. Innovation, research and development, and invention are closely linked.

Research and development thrive on the application of new information that will aid in the development of new technologies, products, services, or systems. Inventing new products or services is a sign of a progressive organization and can be a significant revenue earner.

Innovations drive efficiencies through standardization, while many technical innovations have created joined-up workflows beyond the physical space, from offsite construction to virtual reality, the Internet of Things, and flying factories.

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