

## **Digital Technologies in Built Environment – An Overview**

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### **Abstract**

Digital technologies are influencing the way we live. It is also shaping the way we design, construct, and manage the built environment around us. From collaborating design and construction ideas to creating the actual design to communicating on-site to training construction workers on health and safety issues there are different levels of involvement of the information and telecommunication technologies in the construction industry. Use of these diverse digital technologies is also spread through to the manufacturing building materials, public planning, and inspection process. The aim of the study is to offer a structured overview, which encapsulates these digital technologies that are being used and can be used in the AEC and property professionals. This study will also explore how these technologies can be introduced to the future professionals who will be the part of this digital practice. The study considers the need for a seamless approach to integrate digital technologies in built environment education and industry where blend of theoretical understanding of the subject matter and technical competence is required.

### **Keywords**

Digital technologies, Built environment, Construction, Education, Integration

### **1. Introduction**

Nowadays there is wide range of technologies making their ways into our daily lives. Using some form of mechanical or digital aid to process numbers, letter – any data, from first mass-produced calculators in early 19<sup>th</sup> century to digital calculators in early 20<sup>th</sup> century to first computers during mid 20<sup>th</sup> century to today's computers to mobile phones to digital cameras to vast number of software and hardware etc., is very accessible. The steady stream of technology input changing the way we process and practice things. As a result, traditional way of conducting business in any sense adjusting itself to these new developments. Although research shows that 'the construction industry has been criticized for its slow adaption of emerging technologies' (Yang *et al.*, 2007) in the past, it can be said that recently, it is embracing new technological developments more efficiently. Currently from design process to realisation of buildings to occupancy to re-use or demolition of a building, digital technologies are widely used. According to a recent search by Lessing *et al.* (2005), both industry representatives and R&D actors agree that Information and Communication Technology (ICT) has an important role to make the sector more efficient and customer friendly. Therefore establishing an inventory of digital technologies as a guide will be beneficial.

### **2. Definitions**

Involvement of the digital technologies in built environment has different levels. 60s and 70s was the decades that digital technologies tiptoeing into the built environment arena by means of data

managements, structural analysis and using computers as drawing aids. From those initial applications today we can talk about “adaptive house” that response to its owner. In order to understand the relationship between the built environment and the ITC, we first need to understand what these terms means to us.

## **2.1. What is Built Environment?**

Most human acts take place in built environments which are shaped by the needs of these acts. Shaping the “environment” one way or another and/or giving new shapes to the “environment” is one of the continuing occupations since the beginning of the man’s history. The Built environment term “describes in one holistic and integrated concept the creative (and not so creative) results of human activities throughout history. The term emerged in the 1980s and came into widespread use in the 1990s” (Bartuska, 2007). There are several components of the built environment and Bartuska (2007) classifies these in to 7 different categories: products, interiors, structures, landscapes, cities, regions, earth.

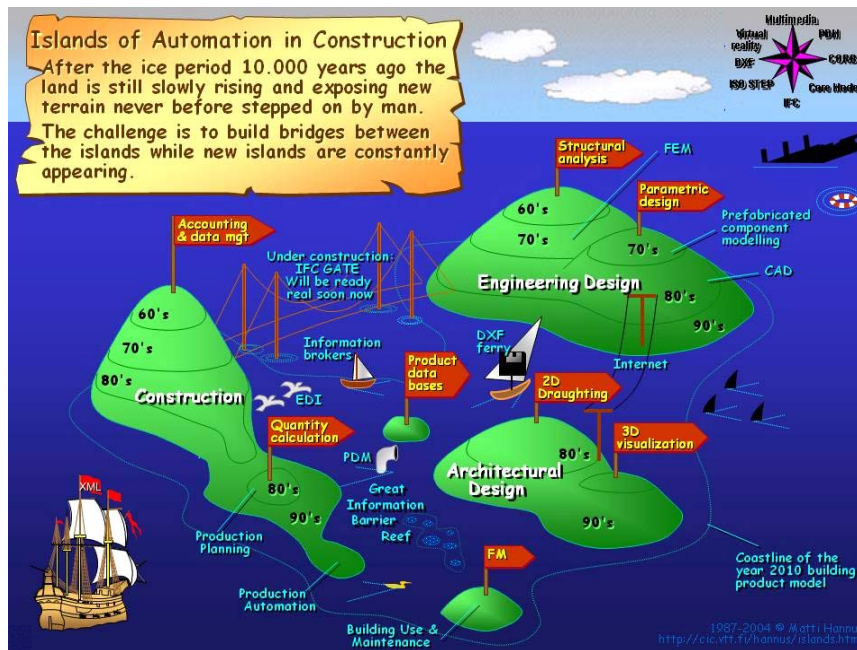
## **2.2. What is Information and Communication Technologies?**

According to ITAA (Information Technology Association of America) information technology (IT), is "the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware." IT deals with the use of computers and computer software to convert, store, protect, process, transmit, and securely retrieve information. Information Technology group at Harvard University suggest that “ICTs include telecommunications technologies, such as telephony, cable, satellite and radio, as well as digital technologies, such as computers, information networks and software”.

## **3. Digital Technologies in Built Environment**

In order to understand the digital technologies in Built Environment, it will be beneficial to overview related literature. According to Turk, (2006) “first uses of computers in construction are reported in 1960s”. Over the years, integration of ITC in the construction industry became an almost an independent subject area. Several attempts made to encapsulate the definition and use of ITC in construction industry. For example Hannus (1996) attempted to explain the current and future trends by using a map of islands (Figure 1). Some researchers such as Fenves (1996) studied the historical development in this area where as Brandon and Betts (1997) classified the subject area into four different clusters namely, integration, communication, intelligence and visualisation. Several other researchers investigated the areas where IT closely attached to the construction or the Built Environment industry such as, Turk (1997, 2002, 2006), Lakmazaheri and Rasdorf (1998), Ekholm (2002), Amor *et al.* (2002) etc. to define and categorize this vast area.

Furthermore, several terms such as construction IT, construction informatics was used to define this area. Turk (2002) suggests the use of “construction informatics” is to capture the whole information handling in construction industry rather than focusing on only communication technologies where as construction information technology is equipment, applications and services that used by organisations to assist human communications, commitment negotiations, problem solving and decision making (Turk, 2000). In this paper, author is trying to achieve a more holistic definition to encapsulate all the digital technologies that assist to design, build and manage the built environment.



**Figure 1: Islands of Automation in Construction (Hannus, 1996)**

Advancing the applicability and capability of digital technologies in built environment area is a major international research and innovation challenge that interests many scientific institutions and the industry partners. Significant amount of literature on this area has been generated over the last fifty years. Comprehensive review on existing research activities as published work both in journals and in conference proceedings provides great assistance to see the progress over the years. Following list attempts to gather some of the most well-known journals and conferences related to ITC in the built environment. ‘Some of the examples of these focused research gatherings are the International Conference on Construction Information Technology (INCITE) and the International Conference on Construction Applications of VR (CONVR), conferences held by the Council for Research and Innovation in Building and Construction, workshop W078 Information Technology for Construction, and the International Conference on Visualisation in Built and Rural Environments (BuiltViz)’ (Greenwood *et al*, 2008), and conferences organised by American Society of Civil Engineers (ASCE) and Arap Society of Computer Aided Architectural Design (ASCAAD), CAAD Futures, Construction in the 21st Century (CITC), Digital Architecture and Construction, Education in Computer Aided Architectural Design in Europe (eCAADe), European Conferences On Product And Process Modelling In The Building Industry (ECPMM), International Conference on Critical Digital, International Symposium on Automation and Robotics in Construction (ISARC) etc. Apart from these focused research gatherings there are also several peer reviewed journals publish research such as: Advanced Engineering Informatics, Architectural Engineering and Design Management, Automation in Construction, Building and Environment, Computer–Aided Civil and Infrastructure Engineering, Computer Aided Design, Computers in Industry, Construction Innovation, Journal of Computing in Civil Engineering, Electronic Journal of Information Technology in Construction, International Journal of Architectural Computing, International Journal of Design Computing, IT in Architecture, Engineering and Construction, Journal of Computing in Civil Engineering, Journal of Urban Technology, etc.

#### **4. Collection of Digital Technologies**

According to research various usage of ITC can be seen in the built environment. These usages can be divided into three main categories:

1. Data Creation: Design, (sketches, 2D drawings, 3D, 4D, nD and virtual reality models, building information models) scheduling, budgeting, construction etc.
2. Data sharing, storing and updating
3. Complex data management and coordination systems such as IBS (integrated building systems, geographic information systems etc.)

It can be said that digital technologies have a critical role in helping to achieve high level of well-being by enhancing living spaces that support the creative, intellectual and spiritual capacities of people and the creation of responsive, adaptable, supportive, and efficient surroundings. There are vast amount of digital technologies, following table attempts to organise the technologies. It should be recognised that the boundaries for the categories are fuzzy and the following table is just an initial framework for further investigation.

**Table 1: Digital Technologies from Design to Occupancy (Based on Thompson E.M., 2008)**

<b>Digital Technologies</b>	<b>Examples</b>
<i>Design</i>	Sketching, 2D CAD, 3D, 4D, nD modelling, building information modelling, virtual reality, augmented reality, geographic information systems, 3D printers etc.
<i>Collaboration and communication</i>	Virtual organisation, video conferencing, email, FTP technology, project collaboration websites/extranets, project collaboration solutions, satellite technology etc.
<i>Data acquisition</i>	3D laser scanning, aerial photography, digital maps, digitizers, laser distance measurer, digital plan measure, etc.
<i>Structure</i>	Responsive construction, responsive façade, active control of traditionally passive elements such as glazing or wall thermal transmission, intelligent components, moveable walls, canals for power/data/voice cabling, flexibility and adaptability of components etc.
<i>Services, energy efficiency</i>	Automatic on/off sensor in the lighting system, electricity, water supply, high-tech, energy-efficient HVAC system, heating, cooling, smart metering technologies etc.
<i>Systems</i>	Building Automation System (BAS), Energy Management System (EMS), Central Control and Monitoring System (CCMS), integrated building management systems, vertical transportation systems, building façade systems, audio-visual and entertainment systems
<i>Management</i>	Maintenance, cleaning, leasing, computerized/interactive building directory, event time and attendance control and reporting etc.
<i>Security, safety, access control</i>	Reduced manpower dependence, CCTV, card access control, smoke detection, intrusion alarms, emergency control of elevators, doors, earthquake sensors, flood detection etc.
<i>Telecommunications (working from home etc)</i>	Fiber-optics capability, built-in wiring for internet access, wiring for high-speed networks, LAN and WAN connectivity, Satellite accessibility, ISDN, etc.
<i>Entertainment</i>	TV, theatre systems, video projectors/screens, video wall etc.

While the above digital technologies originally are not necessarily generated for built environment usage- some of which comes from aerospace and game industry etc. background, they give wider opportunities

to our industry to enhance the quality of the final product, and enable all the parties to visualize, understand, and communicate efficiently. In order to achieve this ultimate “living-space” the relationship between different parties (designer, local authorities, architect, the client, contractor, site engineer, etc) and the skills those parties require needs to be redefined, the traditional design-build-operate framework needs to be challenged and, since designing and building is becoming a data-based activity, the information needs to be shared, updated and collaborated effectively.

## 5. Concluding Remarks

Overall this paper attempts to summarize the digital technologies in built environment. Author believes that there is a need for a comprehensive understanding of these technologies. Digital technologies mentioned in this paper are part of a big tool set that built environment professionals use. When imagination, knowledge and deep understanding of the tools in hand come together, it will generate liveable environments. This becomes more apparent when we consider that ‘none of the great architects of history, neither Sinan, chief architect Sulemaniye Mosque in Istanbul, nor Michelangelo, architect of St Peter's Basilica in Rome, nor even Le Corbusier had such technologies available. However we can only marvel at what they might have achieved today, when digital technologies are able to help built environment professionals to design complex structures more efficiently and effectively’ (Thompson, 2008).

Although there is countless research on different aspects of this extensive subject, a more holistic understanding and definition is required. This vast area is also needs to be introduced to the future professionals. It should be acknowledged that ‘students are entering higher education increasingly computer-literate, with high expectations that they will be introduced to appropriate technologies for their subject disciplines’ (Horne and Thompson, 2008). Higher and further education institutions are facing this fast developing technologies and with the challenges of adapting their curriculums accordingly. ‘The issues of successful implementation of new technologies are not simply financial or technical, but include the location of facilities, needs and types of users, and institutional business strategy which all play a part’ (Horne and Hamza, 2006). According to previous research (Horne and Hamza, 2006; Horne and Thompson, 2008; Ausburn and Ausburn, 2004, etc.), raising awareness, exemplar projects, systematic but informal approach of connecting with staff and with their ideas, encouraging and supporting staff to use these technologies, include these subjects in the curriculum etc. will help the integration process.

## 6. Future Work

Future work will focus on establishing more detailed inventory of digital technologies and strategies of implementing and integrating these technologies into practice.

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