Evaluation Methods of Investments to Mobile Applications and Smart Technology in Construction Projects

Tomáš Mandičák, Peter Mésároš, Annamária Behúnová(✉), Marcel Behún, and Matúš Tkáč

Faculty of Civil Engineering, Technical University of Košice, Vysokoškolská4, 042 00 Košice, Slovakia
{tomas.mandicak,annamaria.behunova}@tuke.sk

Abstract. Smart technologies and solutions have represented an increasing growth in every industry over the last decade . Many of the smart solutions are focused on improvement with a view to sustainability. The basis of smart solutions is advanced technologies and interactive systems that respond to changed conditions. These technologies are increasingly being implemented in the field of construction and intelligent buildings or urban areas. The construction industry shows great possibilities for the implementation of smart and progressive technologies. However, construction projects represent a volume-intensive investment. The same applies to the implementation of smart solutions, which, however, can also provide savings. This needs to be evaluated very much. It is necessary to use evaluation methods of investments in these solutions. This paper is largely devoted to the evaluation methods of investments in mobile applications and smart technology in the construction industry. The research aims to conduct an overview of evaluation methods of investments to smart technology in construction projects. Research also describes examples of the use of specific smart solutions in the construction industry and urban planning. The output of the research is an overview of Evaluation methods of investments, which can be applied and used in assessing investments in advanced technologies in construction.

Keywords: Smart technology · Mobile applications · Evaluation methods of investments · Construction projects

1 Introduction

Sustainability is a new not only phenomenon, but above all, a real need of the 21st century [1]. The emphasis on sustainability is felt every day. Extensive discussions within Europe or world leaders address the issue of environmental burdens and their impact on countries' economies [2]. There is a great deal of pressure on environmentally friendly materials in every sector [3]. Construction is in the same situation. There is also pressured to reduce emissions, carbon footprints or other negative impacts of the industry

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in the construction segment [4]. Construction is a segment that is largely considered a major producer of waste [5]. As part of the green policy, several initiatives have been taken to reduce the volume of negative effects in this sector as well [6]. It is necessary to say that the construction sector is closely linked to other sectors. Consumption of materials largely requires addressing the issue of their production [7]. This segment is also demanding on logistics processes [8]. The implementation of a construction project requires great knowledge in the field of logistics. The challenge in this digital age is to reduce these negative impacts in construction with smart solutions and smart technologies [9]. It is the use of smart technologies that can significantly contribute to the sustainability of this segment [10]. Information and communication technologies are one of the tools that can have a positive impact on sustainability and the environment, but also on economic sustainability [11]. For this reason, it is essential to discuss the cost of the whole life cycle of a construction project [12, 13]. Progressive technologies represent new possibilities in construction, which on the other hand improve the digital skills of managers [14]. At the same time, the use of smart technologies in construction brings an increase in the quality of outputs in this segment [15].

Smart solutions in building and construction and design should lead to a reduction in environmental burdens and a sustainable economy [16]. In other words, smart technologies are also supposed to have a positive impact on the economics of building project management [17]. These technologies can effectively reduce costs and, on the other hand, contribute to better project management [18]. Therefore, the implementation of smart technologies in construction should lead to the question of how and when it will be profitable. It is the performance parameters concerning new progressive technologies that need to be monitored [19]. Investment in construction is the second-largest amount of investment in the national economy. Investments in IT solutions represent the largest volume of investments. It follows from these facts that the scale of investments in these areas is so large that it is necessary to assess these investments. Therefore, there is a basic research question on how to evaluate investments in smart technologies in construction projects. The issue of key performance indicators focuses on efficiency and performance as such. This can be measured in several ways. In the context of the perception of smart and mobile technologies in construction as an investment, it is necessary to assess and evaluate these investments from an economic point of view. The aim of this survey is to map the possibilities of methods for evaluating investments in smart technologies in the field of construction.

2 Smart Technology and Mobile Applications in Construction Projects

According to several studies, smart technologies implemented in construction are beneficial [20]. These studies highlight the benefits of implementing digital and knowledge technologies from multiple perspectives. In the context of smart technologies and the use of urban planning, several technologies are useful for solving smart cities [21]. One large group, therefore, consists of the so-called GIS technology and digital technology use for urban planning purposes. Intelligent solutions in construction and also for the

city have the ability to capture real-time data that is communicated between stakeholders to optimize decision-making by using digital technology [19].

Geographic information systems (GIS) and digital technologies are based on spatial and temporal analysis of data collected into groups according to their purpose. Their goal is to model future trends and predict impacts on project implementation and the environment. These technologies are also largely based on the use of mobile devices and applications that interact. The growth of smartphones is significant, as according to the study, the use of smartphones has increased by 2% in the last year. In absolute terms, this currently represents just over 5 billion users [22].

The technology of terrestrial laser scanning and aerial photogrammetry using drones currently represents another opportunity to implement digital technologies and smart solutions in urban planning and construction. It can serve as an effective and progressive tool in the field of 3D spatial digitization of buildings and their geometric dimensions. These technologies try to display 3D buiPodklldings in detail in a digital environment, which is to be made for project documentation. These technologies automate this otherwise demanding process. The advantage is the simulation of changes itself and simple changes in planning, as it is a digital output. Laser scanners are a beneficial tool to measure buildings and urban areas, including all buildings (Fig. 1).

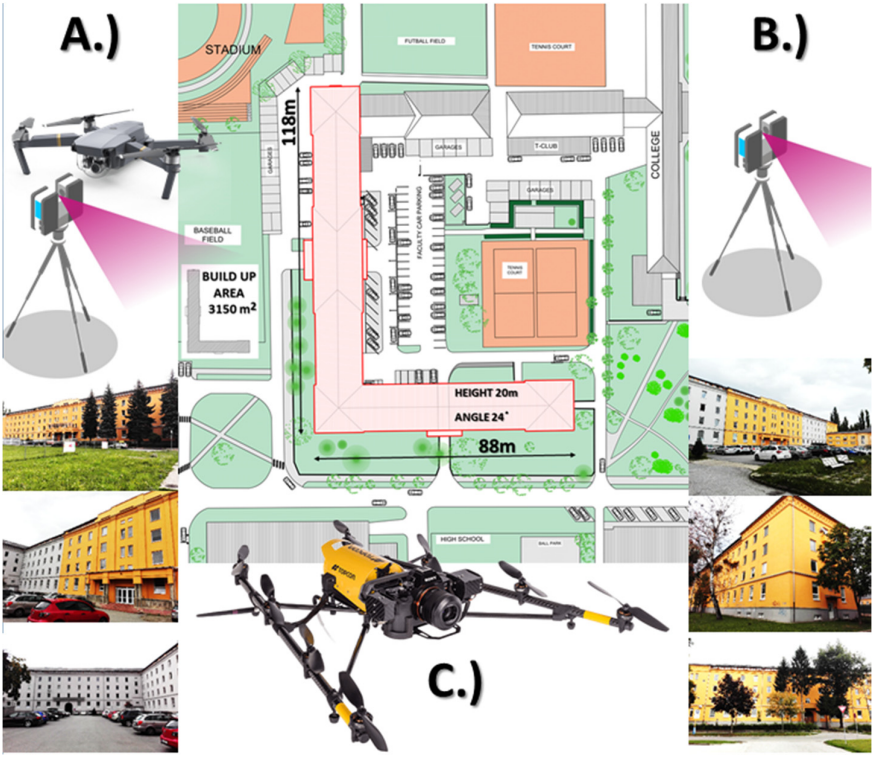

Fig. 1. Progressive methods of data collection for digital model of buildings (building – faculty of civil Engineering in Kosice)

The fact that it works and that such a smart solution can be applied in practice is confirmed by another study carried out in the city of Kosice. The picture shows the building of the Faculty of Civil Engineering, which was the reference for the given research. This building was monitored and had to be turned into project documentation and a digital model. For these purposes, three variants of data acquisition and creation of a digital point model were used. As the picture describes, one of the solutions was to obtain data via a 3D scanner. Another variation was photogrammetry and a third combination were the use of drones.

The next picture describes in more detail the capture of the roof and problematic buildings. For these purposes, AV appears to be the best solution for data collection. This study compared the suitability of the various methods (Fig. 2).

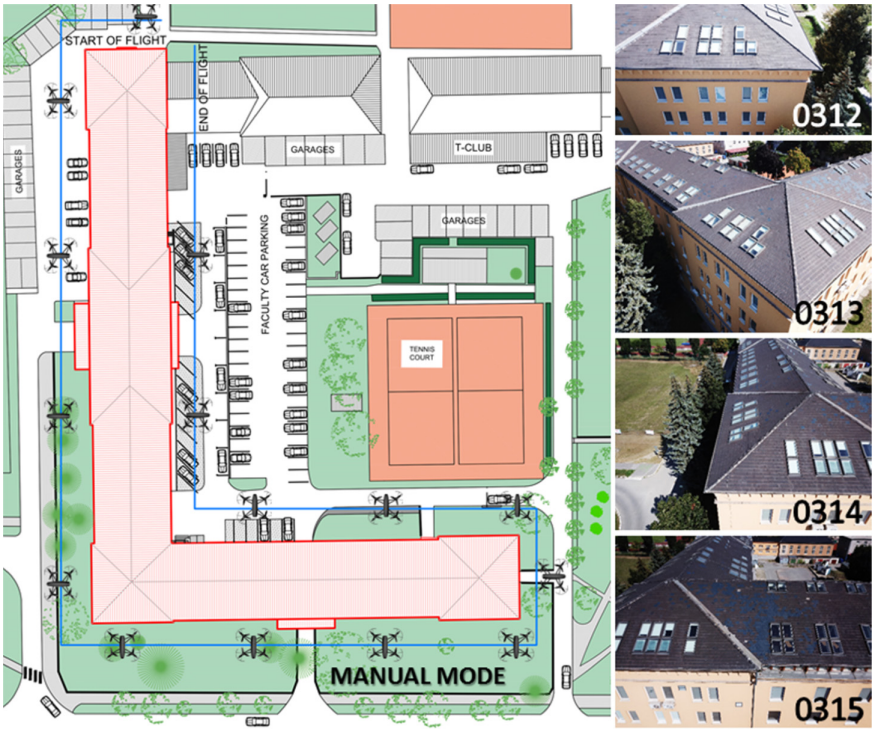

Fig. 2. 2D model and 3D model of building (roof detail)

The output of this is a fully digital model, which can be worked with in several programs (Fig. 3). Importantly, this model is an input for other technologies, especially BIM technologies, which in interaction with GIS and other mobile applications it can be an effective tool for smart solutions.

The basis is the creation of a point cloud, which can then be processed later and used in a BIM environment. This easily obtained 3D model can be considered as an initial step towards a smart solution even in the construction industry. It should be noted that

Fig. 3. Data processing from point cloud to 3D model

it is good to use an aerial 3D scanner to capture a part of the city and several buildings. It captures several objects at once, and its range is much larger.

In this study it was used similarly focused technologies in Australia. The study pointed to the suitability of addressing these smart technologies and connectivity and mobile applications [23]. The authors of the study (described in Fig. 4) showed these smart technologies connected to mobile devices and applications in practice. There is comparison of digital–physical twin at the city scale, management and integration of Building Information Modelling (BIM) and Geographic Information Systems (GIS) for a digital model of a proposed building.

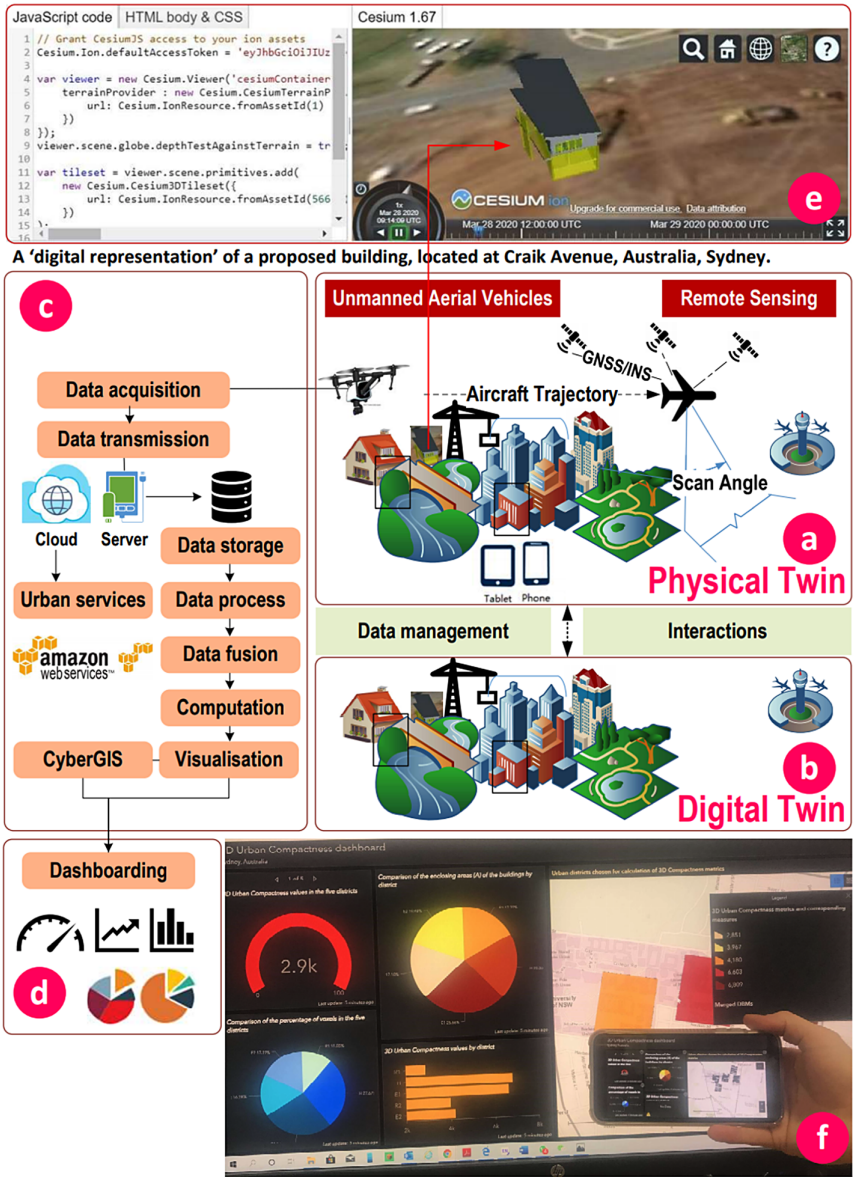

Fig. 4. Connection of digital situation, real or physical situation and mobile devices [23]

3 Evaluation Methods of Investments in Construction Projects

Evaluation of investment projects is a basic decision-making tool for project managers, who are responsible for the success of projects. This also applies to the construction industry, where the volume and scope of investments are among the largest in the country's economies. The implementation of smart and progressive technologies requires the

same amount of attention focused on investment evaluation. The assessment of different projects and the selection of the optimal one can be done based on several perspectives.

On the one hand, it can be a factor of liquidity, time and risk, on the other hand, a factor of the effect that the investment brings. In the first case, they are static and dynamic investment evaluation methods [24]. In the second case, there are cost efficiency evaluation criteria, profit efficiency evaluation criteria, net cash income criteria [25]. Static methods are gaining favor due to their simplicity. This includes the Average rate of return and Payback. However, due to the nature of IT and construction projects, these methods largely only point to the current efficiency trend. They do not take into account and predict the time factor and its value. Also, the construction industry often incurs expenses in other years, which change over time (amendments to contracts, changes in project documentation as a result of which the ground is also requirements for SMART solutions and tools, etc.). These are all reasons that can determine the quick selection of a narrower number of projects, but not the main decision-making tool for investment selection. These methods are not sufficient for the purposes of investment evaluation and comparison, or other authors have worked on progress on how best to implement these evaluation methods in the assessment of projects [26].

Dynamic methods of evaluating investment projects seem much more used and more appropriate. These include the best-known net profit value (NPV). As it is only rarely in the case of investment decisions that the expenditure incurred at the beginning of the investment is used once. If there are gradual capital expenditures (which is a fact for the vast majority of investment projects), it is necessary to update capital expenditures throughout the life cycle or construction project, or intelligent so-called smart solution.

$$\mathrm{NPV} = \sum_{n=1}^{N} \mathrm{P_n} \frac{1}{(1+\mathrm{i})^{n+T}} - \sum_{t=1}^{T} \mathrm{K_t} \frac{1}{(1+\mathrm{i})^{t}}$$

NPV - net present value.
P - cash income from investments in individual years of life.
n - individual years of life.
N - service life.
i - required return (interest rate).
K - capital expenditure.
t - individual years of construction (or SMART solution).
T - construction time (IT user time).

The profitability index is related to the net present value of the investment project. It is a relative indicator that expresses the ratio of expected discounted cash receipts from the project to initial capital expenditures [25]:

$$\mathrm{I_R} = \frac{\sum_{n=1}^{N} \mathrm{P_n} \frac{1}{(1+\mathrm{i})^{n}}}{\mathrm{K}}$$

$\mathrm{I_R}$ - profitability index.
P - cash income from investments in *n* years of life.

n - individual years of life.
N - service life.
i - required return (interest rate).
K - capital expenditure.

Other authors have a different view on the calculation and comparison of investments. Previous methods took into account a pre-selected interest rate. The internal rate of return method looks for a percentage equal to the interest rate at which the project is profitable. An enterprise should accept a project if its internal rate of return is higher than the discount rate [26, 27].

$$\sum_{n=1}^{N} P_n \frac{1}{(1+i)^n} = K$$

P - cash income from investments in individual years of life.
n - individual years of life.
N - lifetime.
i - sought interest rate.
K - capital expenditure.

Another suitable method is economic value added (EVA). This represents the net return on the company's operating activities less the cost of capital. To quantify the economic added value during the entire life of the investment project, it is necessary to convert all individual EVA values and discount and add them. In the case of a positive outcome, the investment brings the benefits of implementing a smart solution [28].

$$EVA_{PV} = \sum_{n=1}^{N} \frac{NOPAT_n - WACC * C_n}{(1+i)^n}$$

EVA_{pv} – present value of economic value added.
NOPAT – main activity profit after tax.
WACC - weighted average cost of capital.
C - capital tied up in assets, necessary for the main operation of the company.
n - individual years of service life.
N - service life.
I - required return (interest rate).

Costs are a basic evaluation criterion for many projects. Therefore, this view for the implementation of smart solutions is in the first place when assessing some projects. The implementation of smart solutions in construction takes place to reduce costs in some part, or during the entire life cycle of the solution or construction project. The cost criteria for the effectiveness of investment projects can therefore include the Average Annual Cost Method and the Discounted Cost Method. The comparison of average annual costs is typical of the average annual cost method.

$$R = 0 + I * J + V$$

R – annual average costs.
O – annual depreciation.
i – required return (interest).
J – investment cost (capital expenditure).
V – other annual operating expenses.

The Discounted Cost Method is based on the same principle as the average annual cost method, but the average annual costs are replaced by the sum of the investment discounted operating costs of the individual variants over the life of the project.

$$D = J + \sum_{n=1}^{N} V_n$$

D - discounted costs.
J - investment costs.
V_n - discounted other annual operating expenses.
n - individual years of life.
N - service life.

These basic investment methods have their advantages and disadvantages. It's not possible to determine at a flat rate which is the best method. It depends on several factors and the main criteria for evaluating the investment project. Dynamic methods take into account the time factor, which in many cases will be a better alternative than static ones. When considering solutions where the main criterion will be cost, it is appropriate to use cost methods. An overview of the methods and main evaluation criteria is given in Table 1.

Table 1. An overview of the methods and main evaluation criteria [24–28]

Methods	Static method	Dynamic method	Cost method
The average rate of return	x		
Payback	x		
NPV - net present value method		x	
The profitability index		x	
The internal rate of return method		x	
EVA – economic value added		x	
R – annual average costs			x
The discounted cost method			x

4 Conclusion

Construction is a sector where there is a large volume of investment. Investment projects in the field of IT implementation (smart solutions, progressive and digital technologies) require an axial evaluation based on selected criteria. Smart solutions should bring several benefits that users (the investor) can define. Based on this, the main criteria are chosen to assess the benefits of the solution. Methods of evaluating investment projects take into account several factors. Most often, it is about time, cost and cost, which are the key performance indicators of all projects. Based on this, it is necessary to choose the right method of comparing investment plans. This survey pointed out possible methods in the selection of the investment plan and summarized their advantages, respectively, the possibilities when it is appropriate to use these methods. At the same time, the paper also provides an overview of smart solutions and mobile solutions, when it is appropriate to use one of the mentioned methods. These traditional economic methods of evaluation are, in many cases, general, but their use must be based on specific factors. Therefore, it is necessary to consider a specific investment project in new technology, analyze the benefits and define the main factor based on which they will be evaluated. This research needs to be taken further. This means trying to look for dependencies and creating a methodological model when it is appropriate to use which method.

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