Unmanned Aerial Vehicles Usage on South African Construction Projects: Perceived Benefits

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ABSTRACT

In recent years, unmanned aerial vehicles (UAVs) are being employed in various parts of the engineering industries for project development, project management, surveying, among others. UAVs can also be adopted in construction for pre-planning, proper surveying of the given area, checking or inspecting site safety and quality monitoring. Based on these envisaged uses, this study is set to assess the benefits of UAVs usage in the construction industry. This was achieved through a detailed literature review combined with empirical data analysis. Data was retrieved through questionnaire survey distributed to professionals randomly in the South African construction industry. The retrieved data was analysed using descriptive and inferential data analysis methods. Findings revealed that UAVs adoption in the construction industry will lead to reduction in worker's injury as it will be implemented for monitoring of workers activities on site. It was also revealed that UAVs are useful in on-site asset tracking which allows stakeholders to have real-time information on the construction project from anywhere. The study concluded that the efficiency in the performance of the construction industry can be achieved through the adoption of UAVs in the different stages of construction projects.

KEYWORDS

Construction Technology; Drones; Unmanned Aerial Vehicles

INTRODUCTION

Unmanned Aerial Vehicles, also known as drones, were initially aircraft in the early twentieth century created for military operations. However, in the twenty-first century, they had grown into vital assets (Everaerts, 2014). Drones have different sizes and can be furnished with various accessories according to the desired design. Parts of drones are made up of supporting components such as frames, the engine, which consists of a system that gives the drone the ability to take off, the battery that acts as a source of power, the system of electronics and communication used for controlling the drone (Klippstein et al., 2018). The unmanned aerial vehicles have sensors attached (including high-definition camera, wireless network used for Wi-Fi communication, laser scanner,

navigation or GPS unit, RADAR system, ultrasound, etc) (Jalal & Shoar, 2019). They are used for aligning and positioning, and with these sensors, the pilot does not need to interfere manually.
Unmanned aerial vehicles (UAVs) have different applications in the various phases of construction projects by capturing images and videos of varying project sections as required (Ham et al., 2016). Developed countries such as the United States of America have been using unmanned aerial vehicles to ensure safety in construction sites and to inspect the required or desired areas (Carr, 2016). Unmanned aerial vehicles can cover so much ground in a short period (Jalal & Shoar, 2019). They are also able to collect large amounts of data. They intend to increase workers' safety in the construction industry by safely inspecting the site even in areas challenging for humans to access (Jalal & Shoar, 2019). The Federal Aviation Administration (FAA) stated that 1.5 million drones, including 160,000 pilots, acquired registration with the agency, which means a fast growing trend of drones in construction and other sectors (Neubauer et al., 2021). The FAA aerospace forecast shows the increasing growth of drone use between 2020-2040 (Gonczy, 2015). The construction industry has found drone technology in different ways, including data collection, site mapping, surveying, inspection, economically reliable, maintenance because it is reliable and superior productivity. The importance of UAVs in the construction industry cannot be overemphasised. Therefore, this study is set to assess the benefits of UAVs in the construction industry using South Africa as the focus. This is because studies have not been carried out in the study area focusing on the adoption of UAVs for construction projects. Hence, there is a dearth in the body of knowledge to be filled by this research study.

ADOPTION OF UAVS IN THE CONSTRUCTION INDUSTRY

A sizeable number of firm and industrial-level studies confirm positive connections between capital spending in digital technologies and the efficient performance of organisations (Aleksandrova et al., 2019; McNamara & Sepasgozar, 2021; Turk, 2021). Since the 21st century, the necessity for project enhancements and efficacy through the usage of information technology to meet the ever-increasing barriers of knowledge allocation has remained vital to the architecture, engineering, and construction (AEC) division. This necessitates launching a disparate set of technological kits and assets to manage information allocation in the division labelled as information communication technologies (ICTs). Launching these digital technologies (such as UAVs) permitted firms to modernise, advance construction processes, and computerise specific routine duties, diminishing the costs of networking with suppliers and labourers (Jalal & Shoar, 2019).
UAVs technology saves time on building projects by generating precise data input and procedural analytics for on-the-ground project management (Mohamed et al., 2020). This provides instant development of survey-grade patterns and maps, development reporting, and comparisons to design or prior as-built, as well as data analytics, observations, and forecast distribution among partners (Mallela et al., 2018). These reports are provided in less than 24 hours rather than weeks, enabling more data-driven choices and increased project communication. Unmanned aerial vehicle software allows parties to effectively manage building sites from strategy to implementation and maintenance by offering a single source of up-to-date data throughout the asset life cycle (Templin & Popielarczyk, 2020). This promotes digitised and automated monitoring, data processing, and documenting procedures, reduces immediate expert expenses by 20%, saves up to 5% of entire project implementation costs, and more than doubled project viability (Tkáč & Mésároš, 2019).

Furthermore, UAVs can automate data gathering in the field and produce computerised engineering data and ongoing digital project documentation (Sima et al., 2021). This exact, up-to-date data synchronises with the cloud, providing the management team with more accurate readings of finished work. Radio-frequency identification (RFID) technology combined with UAVs can improve traceability and supply chain management of construction projects. The RFID readers installed on drones can recognise tagged goods or materials (Jalal & Shoar, 2019). For example, in Dubai (UAE), a steel yard autonomous monitoring system based on these integrated technologies has been successfully installed to track steel goods such as pipes, plates, and coils (Dowling et al., 2020). Software for creating drone flight paths is installed into the operating system, and several passive RFID tags and scanners are evaluated to determine which is the most successful. These are part of the benefits accrued from the adoption of UAVs. From the reviewed literature, there are numerous benefits to be accrued from the adoption of UAVs in the construction industry. These benefits need to be harnessed in the South African construction industry to improve the efficiency and effectiveness of the industry.

RESEARCH METHODOLOGY

The rationale of the current study is to contribute to the body of knowledge on the benefits of adopting UAVs in the construction industry. This study adopted the quantitative research approach to achieve the set objective. A quantitative research survey is a simple self-reporting system of getting information from a sample of people and reporting on the questions posed by the researcher (Pallant, 2011). The study retrieved data through a well-structured questionnaire distributed to the respondents. These respondents are construction professionals such as architects, quantity surveyors, engineers, construction managers and project managers in the Gauteng province, South Africa. The questionnaire was sectioned into sections A and B where the former addressed the demographic information of respondents and the later addressed the main objective of the study. A 5-point Likert scale questionnaire was developed utilising knowledge obtained from literature reviewed earlier in previous section to gather data relevant to the intent of the research. These include a total of 13 variables that are related to benefits of UAVs adoption. The choice of Gauteng province was because it houses most of the professionals within the country. Two hundred questionnaires were distributed to professionals within the study area using a random sampling approach, and 177 questionnaires were recovered. All the recovered questionnaires were deemed suitable after being reviewed for completion. The data obtained from the questionnaire were evaluated using the Mean Item Score (MIS), Standard Deviation (SD) and Exploratory Factor Analysis (EFA). To determine the normality of the retrieved data, Shapiro-Wilk's test was engaged while Cronbach's alpha was adopted to determine the reliability coefficient of the data collection instrument. The adopted cut-off alpha for this study was 0.70, and all measures were above 0.70, making all data retrieved reliable. This was in accordance to the stipulated acceptable alpha value of 0.7 – 1.0 (Tavakol & Dennick, 2011).

FINDINGS AND DISCUSSION

Background Information of Respondents

The study shows that 48.6% of the respondents are quantity surveyors, 5.1% are architects, 29.9% are construction managers, 4.0% are electrical engineers, 2.3% are project managers, and 5.1% are construction managers and construction project managers, respectively. 31.1% of the respondents shows Diploma has the highest educational qualification, while other respondents show 34.5% Bachelor's Degree qualification, 25.4% Honours Degree qualification, 6.8% Master's Degree qualification and 2.3% Doctoral qualification. 23.2% of the respondents have construction-related work experience that ranges from 1 to 5 years, 41.7% have work experience ranging between 6 to 10 years, 31.1% have a work experience ranging between 11 to 15 years, while 4.0% have work experience between 16 to 20 years.15.8% of the respondents currently works in a consultancy firm, while 48.0% work for a contracting firm. 20.9% of the respondents work for the government, while 15.3% work for private organisations. 4.5% haven't participated in any construction project, while 2.3% have limited working experience of only working in the region of 1-2 projects. 13.0% have been opportune to participate in 3-4 projects, 29.4% have participated in 5 to 6 projects, while 50.8% have participated in any number of construction projects that range between 7 and 8. This is an indication that the group of respondents used for this study possess the necessary background knowledge and academic qualification on construction industry activities and adequate professional qualification needed for the study.

Benefits of UAVs in the Construction Industry

In evaluating the benefits of adopting UAVs, Table 1 reveals the most significant benefit to the adoption is 'Reduced risk of workers' injury' with a mean score (M) of 4.73 and Standard Deviation (SD) of 0.845. Other significant benefits include 'Completion of inspection in reduced time' with M = 4.38; SD = 0.767, 'On-site asset tracking (equipment and materials)' with M = 4.35; SD = 0.699; 'Efficient planning of complex projects' with M = 4.33; SD = 0.701; 'Access to high-value site analytics' with M = 4.33; SD = 0.756; and 'Security and maintenance of construction sites' with M = 4.33; SD = 0.765. As revealed from the table, three variables ranked fourth as they all have the same mean item scores with their SD values also within range. The table also reveals the Shapiro-Wilk test for normality in which the significant value of all the 13 assessed benefits are below 0.05 required criteria for normality (Pallant, 2011). This infers that the information accumulated is non-parametric. The outcome in the table additionally revealed that every one of the assessed factors gave a mean value higher than the average value of 3.0, which suggests that respondents accept that all the 13 variables are substantial benefits of UAVs adoption in the construction industry.

Table 1. Benefits of the adoption of UAVs on construction projects.

Descriptive Statistics				Shapiro-Wilk	
	Mean	Std. Deviation	Rank	Statistic	Sig.
Reduced risk of workers' injury	4.73	0.845	1	0.82	0.000
Completion of inspection in reduced time	4.38	0.767	2	0.776	0.000
On-site asset tracking (equipment and materials)	4.35	0.699	3	0.785	0.000
Efficient planning of complex projects	4.33	0.701	4	0.784	0.000
Access to high-value site analytics	4.33	0.756	4	0.777	0.000
Security and maintenance of construction sites	4.33	0.765	4	0.772	0.000
Digitisation of project lifecycle	4.30	0.665	7	0.778	0.000
3D Mapping	4.20	0.658	8	0.771	0.000
Surveying and Topographic Mapping	4.18	0.67	9	0.77	0.000
Improved business planning and profitability	4.08	0.743	10	0.745	0.000
Project management through augmented reality	4.03	0.716	11	0.745	0.000
Enhanced data sets retrieved from UAVs	3.95	0.654	12	0.742	0.000
Delivery of accurate measurements	3.85	0.699	13	0.714	0.000

From Table 2 showing the pattern matrix result of the EFA carried out, the thirteen (13) variables identified from the literature were factored into three (3) clusters that are thus interpreted based on the observed inherent relationship among the variables in the cluster.

i. A total of five (5) variables were loaded onto cluster 1, as shown in Table 6.0. These variables include 'Improved business planning and profitability' (75.4%), 'Delivery of accurate measurements' (37.8%), 'Digitisation of project lifecycle' (21.2%), 'Access to high-value site analytics' (17.9%), and 'Efficient planning of complex projects' (17.6%). All these can be observed to relate to service delivery. Therefore, this factor cluster can be termed '**Enhanced Services**' with a variance of 47.541%, making it a significant factor that benefits the adoption of unmanned aerial vehicles.
ii. In cluster 2, there are three (3) variables loaded onto it. These variables include 'Surveying and topographic mapping' (83.8%), 'On-site asset tracking (equipment and materials)' (57.5%), and 'Project management through augmented reality' (15.6%). The common factor to the variables in this cluster is that the construction is managed efficiently. Therefore, the cluster is labelled '**Efficient Management**' with a total variance of 10.174%. This cluster is ranked as a factor that benefits the adoption of unmanned aerial vehicles behind the variables in cluster 1.
iii. In cluster 3, five (5) variables are loaded onto it. These variables include 'Reduced risk of workers' injury' (53.7%), 'Completion of inspection in reduced time' (44.8%), 'Security and maintenance of construction site' (42.9%), 'Enhanced data sets retrieved from UAVs' (41.0) and '3D mapping' (35.2%). The common factor to the variables in this cluster is employees' effectiveness. Therefore, the cluster is labelled '**Employee's effectiveness**' with a total variance of 9.010%. This cluster is ranked as the last factor serving as a benefit to adopting unmanned aerial vehicles.

Table 2. Factor loading of the benefit to the adoption of UAVs.

Cluster Factor Groupings	Eigenvalues	% of Variance	Pattern Matrix Factor		
			1	2	3
FACTOR 1 – Enhanced Services	6.180	47.541			
Improved business planning and profitability			0.754		
Delivery of accurate measurements			0.378		
Digitisation of project lifecycle			0.212		
Access to high-value site analytics			0.179		
Efficient planning of complex projects			0.176		
FACTOR 2 – Efficient Management	1.323	10.174			
Surveying and topographic mapping				0.838	
On-site asset tracking (equipment and materials)				0.575	
Project management through augmented reality				0.156	
FACTOR 3 – Employee's Effectiveness	1.171	9.010			
Reduced risk of workers' injury					0.537
Completion of inspection in reduced time					0.448
Security and maintenance of construction site					0.429
Enhanced data sets retrieved from UAVs					0.410
3D mapping					0.352
Total Variance Explained		66.726			

The benefits of the adoption of UAVs were identified and evaluated by professionals in the South African construction industry. Three cluster factors were generated from the respondents' opinions: 'enhanced services', 'efficient management', and 'employee's effectiveness'. The empirical data from this study showed that if used effectively and strategically, UAVs become significant in the construction company. It can address the exposure of workers to the risk of having injuries (Mehta et al., 2020), possess completion of inspection in reduced time (Mohamed et al., 2020), aid on-site asset tracking (Howard et al., 2018), and improve security plus maintenance of construction sites (Andrade et al., 2019). Various factors have been identified through literature as benefits to the adoption of UAVs in the construction industry. One of them, site surveys, are essential for keeping track of construction projects' performance and quality (Mathar et al., 2020). While visiting the worksite to take laser measurements to deliver accurate results, it takes time and can be impossible to reach some locations during particular project periods (Zhao et al., 2019). The adoption of UAVs is observed to enhance the efficiency of site surveillance (Akpan et al., 2021).

UAVs are an excellent element for project marketing teams (Jalal & Shoar, 2019). They possess the ability to record videos from a unique perspective; nothing compares to the wide vistas viewed from the air and the amount of detail captured by unmanned aerial vehicle footage. It is easy to rapidly notice safety hazards and take corrective action (Howard et al., 2018). In addition, it can be used to monitor and document security or vandalism in real-time. Furthermore, unlike stationary cameras, they may be used to manoeuvre and examine a location from all aspects and travel within a structure to collect extra data (Gu et al., 2019). Thanks to enhanced artificial intelligence, information can then be collected and used to provide alerts that trigger fast responses. UAVs can be used to do remote maintenance assessments (Barbedo, 2019). They can cover enormous regions in a short amount of time, collecting photographs in multiple locations and recording data automatically. This is especially important in areas where human employees can be at risk, such as areas where a health and safety problem occurred or areas that are difficult to access, including roof spaces. Users can also view and capture high-quality photographs in real-time for recordkeeping (Gaffey & Bhardwaj, 2020). The repair can then be assigned to a maintenance engineer.

Drones play an important part in construction management interaction. Stakeholders can now watch a site in real-time from thousands of kilometres away (Gorkin et al., 2020). When making critical multi-stakeholder choices, visual access via drones allows for improved collaboration without requiring team members to visit the building site. Architects, designers, facility managers, financiers, and building owners all need to know how the construction project progresses in real time, which UAVs have made possible. In congested construction regions, regular site visits might not be possible for busy specialists, but virtual walkthroughs are available through UAVs. UAVs can be used by construction companies to do remote safety checks (Jalal & Shoar, 2019). When observed from overhead, professionals can rapidly notice safety hazards and take corrective action. In addition, professionals can monitor and document security or vandalism in real-time.

Furthermore, unlike stationary cameras, UAVs can be used to do remote maintenance assessments. They possess the capacity to manoeuvre and examine a location from all aspects and travel within a structure to collect extra data (Cabreira et al., 2019). This is especially important in regions where the environmental terrain, including the access road, is terrible, causing a shortage of labour and the absence of essential machinery.

CONCLUSION AND RECOMMENDATION

The study has evaluated the benefits of the adoption of UAVs for construction monitoring activities in the construction industry. The study shows that digitisation is on the rise with different factors influencing its adoption and usage. Top-rated benefits of adopting UAVs in the construction industry include reducing the workers' exposure to risk, timesaving during an inspection and on-site tracking of equipment and materials. Based on these findings, UAVs adoption plays a significant role in the effectiveness and efficiency of project service delivery in the construction industry. Therefore, it is recommended that construction stakeholders encourage the use of UAVs for project monitoring in the construction industry. The project monitoring activities include physical progress monitoring, technical monitoring, impact monitoring, etc. These will provide the needed balance for unforeseen circumstances that may come up during the project's construction phase. A significant limitation of the study is that the scope only covered the use of UAVs for construction projects in the Gauteng province of South Africa due to accessibility, time, and cost constraints. To have a general overview of how UAVs can be adopted in the construction industry, further studies can focus on retrieving data from construction professionals in other provinces of South Africa or a Southern African study can be conducted.

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