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Application of Drones in Construction: A 2023 Study

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Abstract
This study questioned construction professionals seeking their opinions on the use of drones in the industry. Primary data was collected in the form of a survey that was distributed to general contractors and subcontractors in the United States. Responses provide comparative results indicating overall opinions on the use of drones, the way drones are being used, including the best and worst applications, and most popular software being used to fly and process collected data. Using this information and comparing to previous surveys from past years, the direction of the industry can be determined and future research planned to support and enhance the most important applications.

Keywords
Drones, UAS, Application, Construction, Study

1. Introduction

Compared to other non-farm industries, the construction industry has not seen a significant improvement in productivity over the past fifty years [1]. To increase productivity, the construction industry has begun to look to technology over the past decade with different degrees of success. Drones have become an increasingly popular tool. This study looks at how the construction industry is using this new technology and identifies the most widely used applications in order to focus future research in these areas.

2. Background

A drone is a flying robot with an array of onboard sensors including cameras, position and proximity sensors as well as global positioning satellite (GPS) location capability. They can be flown either manually or autonomously using software with pre-programmed flight planning capabilities. Drones used in construction applications typically weigh less than 55 lbs. and use anywhere from one to eight helicopter style rotors. A four rotor "quad copter" is the most common configuration providing easily controlled stable flight, the ability to hover in a fixed position, and a flight time of 15-30 minutes using a rechargeable battery for power [2]. Airplane style fixed wing drones are also available which are better suited for surveying large areas. The cost of a drone can vary significantly depending on the features they are equipped with. It is common to find drones from under $1,500 to easily over $15,000, but most drones used in a commercial setting will cost from $4,000 to $10,000 [3].

The objectives of this research are:

- To reveal the various applications drones are being used for in commercial construction.
- To discover the software that is commonly used for drones within the construction industry.
- To reveal the barriers associated with using drones in commercial construction.
- To determine the opinion of drones in the construction industry.
- To provide information that may benefit contractors who are considering implementing drones in their company.

This research scope is limited to general contractors and subcontractors located in the United States. It looks at the state of the industry but does not intend to examine effectiveness of the various applications outside the reported use by the contractors participating in the research.

3. Literature Review

The literature review investigates current drone regulations, how drones are currently being used in the construction industry and the known barriers in operating a drone in a commercial setting.

3. 1 Drone Regulations

When drones became prevalent around 2006, safety and privacy became a concern. Drone use and operation at that time was mostly unrestricted as no rules or regulations had been formulated for this new industry. On June 28th, 2016, the US Federal Aviation Administration (FAA) published regulations under 14 C.F.R Part 107 – Small Unmanned Aircraft Systems, commonly referred to today as Part 107.

To operate a drone under the FAA's Small UAS Rule (Part 107), a pilot must obtain a Remote Pilot Certificate from the FAA. This certificate demonstrates that the pilot understands the regulations, operating requirements, and procedures for flying drones in federal. To obtain the certificate one must meet eligibility requirements required for all pilots and pass a written knowledge test like that required for a Private Pilot Certificate. With this certification, one may operate a drone in a commercial setting if they are following the Part 107 regulations. As of October 2023, over 330,000 people have obtained their Part 107 license [4].

A Pilot in Command (PIC) with a current Remote Pilot Certificate is required for any company looking to operate a drone on their construction site. The written test requires learning a lot about weather, airspace, and aviation procedures and the cost is $175 – this may be a barrier for some companies to add drones, and pilots, to their operations. The FAA has increased its resources to enforce regulations [5]. It's not uncommon now for flights in metropolitan areas to receive a visit from either law enforcement or an FAA official to verify proper licensing and compliance with the regulations.

3.2 Aerial Photography & Videography

Apart from documents and reports in textual form, photographs are essential items for documenting the state of construction activities or related processes [6]. "Advancements in UASs enable the efficient collection of photographic and video image information of construction sites. However, using UASs for construction monitoring can be challenging due to the large number of photos taken and possibly low-quality images due to vibrations caused by the rotating propellers" [7]. Nevertheless, photos and videos taken by drones are being used to monitor progress, observe site changes, track material, perform visual inspections, and more with significant success [8].

3.3 Inspections

There are various ways to use drones for inspections, ranging from simple photos that are analyzed by a professional or by use of software specifically designed for inspections. Inspection-specific drone technology is maturing, and several drone models now exist to serve the inspection and asset-management industry [9]. Traditional inspection methods are often costly and sometimes dangerous. The reason drones are popular is that a drone typically only requires a single operator on the ground for controlling its flight and camera. The technology and adaptation are still emerging, but drone inspection techniques today have already been explored for visual inspections, curtain walls, and concrete degradation [10].

3.4 Safety

Safety is the primary concern on any construction site, and there are plenty of potential and proven ways drones can be implemented in safety-related applications. Drones are currently being used to check dangerous areas such as scaffolding, roofs, and other areas that require a tie-off point or expose a worker to a hazardous situation [11].

3.5 Surveying

Possibly a drone's greatest feature is the ability for it to cover a large amount of area in a short amount of time by a single individual. A drone equipped with a camera can be used to survey an area with acceptable accuracy in a fraction of the time it takes with traditional equipment. With the proper software, the drone can take off, fly along the computer-generated flight path, take hundreds of overlapping photos, and then return to land entirely by itself [12]. The traditional surveying methods using GPS, laser scanning, and Robotic Total Stations are effective, but they are usually costly, labor-intensive, and have the potential to have high errors [13].

3.6 Material Tracking

Material tracking is a drone application that is being investigated and shows potential in a construction environment in the near future. The ability to remotely manage and track stored materials would be a big time-saver for projects with large amounts of material on site. A proof-of-concept study was conducted in 2015 on the feasibility of UASs being used for RFID material tracking on construction sites. In a controlled indoor environment, it was determined that RFID tags were able to be accurately scanned at up to 1.65 meters [14]. A properly engineered drone with an RFID scanner programmed to fly a specific route could easily be a quick and accurate way to track incoming materials and locate them in a lay-down yard.

3.7 Barriers

Drones have the potential to be helpful on the job site, but there are reasons why companies are not willing to adopt them. The first barrier to operating a drone could likely be the FAA regulation requirements. FAA regulations may represent a barrier to entry for companies looking to utilize UASs for commercial use [15]. Drones and their respective software are still expensive, and they require hours to become proficient. Through a 2015 survey, 53% percent of industry professionals indicated that "budget" was the main barrier to adopting new technology, followed by "lack of staff support" at 37% and "is it a toy" at 36% [16]. Drones are an emerging technology, and some people prefer to wait until the technology is proven effective before using it. The conservative nature of construction companies can prevent drones and respective new technologies from becoming common in the short term.

4. Methodology

The research method used to collect data was an anonymous online survey. The survey was sent to one-hundred ten (110) construction companies. The survey consisted of twenty-two (22) multiple-choice and open-ended questions. The purpose of the survey was to gather data from several different companies that showed how each company used drones and what their opinion was on drones being used as a tool in construction. The survey was distributed from May1st to May 26th, 2023. The survey was distributed via email to a list of companies that have previously expressed interest in participating in research efforts at Auburn University. The findings of the study are presented in this paper but due to the limited length of the conference paper, in depth analysis is reserved for a future report.

5. Results and Discussion

5. 1 Respondent Profile

Eighty-seven companies responded to the survey before the closing date, giving a response rate of 79%. The survey suggested the most knowledgeable person on drones participate. The most frequent respondent was either a Project Manager/Senior Project Manager (36%) or an Executive Officer (30%). Companies that chose to participate ranged in size from 5 million dollars in annual revenue to more than 5 billion.

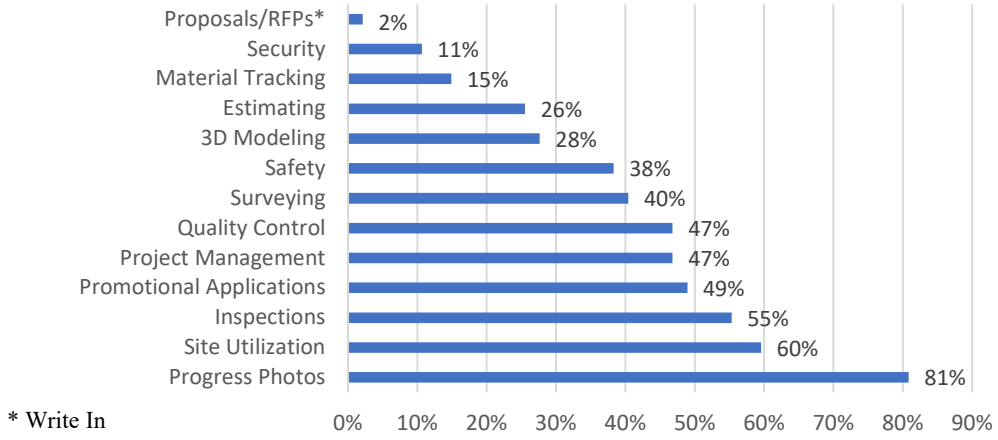

Fig. 1. Drone Applications

Figure 1 indicates applications where companies use drones. Progress Photos, Site Utilization, and Inspections were used by over 50% of the companies. Unsurprisingly, a large majority of respondents (81%) indicated they use drones for Progress Photos. Following Progress Photos, 60% indicated they use drones for Site Utilization, and 55% use drones for Inspections. These three applications are all photo-driven applications, which require little to no third-party software to analyze the data gathered.

Promotional Applications, Project Management, Quality Control, Surveying, Safety, 3D Modeling and Estimating were used by less than 50% of the companies. Most of these applications require third party software to either fly the drone or analyze the data gathered by the drone, which could be a reason less companies are using drones for these applications. Material Tracking, Workforce Monitoring, and Security were all indicated to be drone applications by less than 20% of respondents. This could indicate a lack of drone technology available for these applications. Longer flight times, RFID technology improvements, and pre-flight software improvements could cause these applications to be more useful in the future.

The survey asked how many drones each company owns and found over 50% of respondents indicated they have less than ten (10) to use on the companies' job sites. The lack of drones owned by these companies leads one to believe that drones are not used frequently on jobs, only specific sites have access to drones, drones are not considered essential equipment, or drones are too expensive to implement across all sites. To answer this, a question in the survey asked what percentage of job sites have access to a drone. Almost 43% of respondents said 100% of job sites have access to drones. A few individuals mentioned that while all their job sites have access to drones, only about 10-30% of those job sites use them. This could be due to multiple reasons such as lack of training, cost, time, or application.

Drones are an emerging tool in the construction industry, and while 77% of the companies surveyed are using drones, only 28% indicated they offer drone classes or training. The lack of courses and training provided by these companies results in fewer industry professionals knowing what the capabilities of drones are. If more companies offered drone training, it is logical to assume that more drones would be used and used more often. This data point is consistent with one of the barriers mentioned previously, where 37% of construction professionals indicated a lack of staff support when asked what prevents technologies from being implemented [16].

Drones are only as good as the pilots flying them, but also the software that is used with them. Third party software is available for autonomous flight and data analysis. When asked if third party software such as DroneDeploy is used to fly their drones, 40% said yes which indicates those companies likely use their equipment for more than capturing pictures and video, but also for specific applications that require pre-planning flight software and post processing of the information gathered. The software that individuals cited for flying and analyzing drone data were DroneDeploy, Pix4D, Photoshop, Windows Movie Maker, Final Cut Pro, Hanger 360, Multivista, Skyward, UAV Forecast, Airmap, Propeller, Skycatch, ReCap, and SiteScan.

5. 2 Drone Opinions

The final portion of the survey was used to determine what individuals in construction thought about drones. The respondents were asked if they thought drones have been a beneficial tool in construction to date. The results were overwhelmingly Yes at 89%. When asked to select which answer best describes their opinion on drones, more than 60% said they believe "drones have been and will continue to be an important tool in the construction industry," as shown in Figure 2. This appears to indicate the current construction industry is not opposed to new technology and that they do acknowledge the benefits drones have to offer.

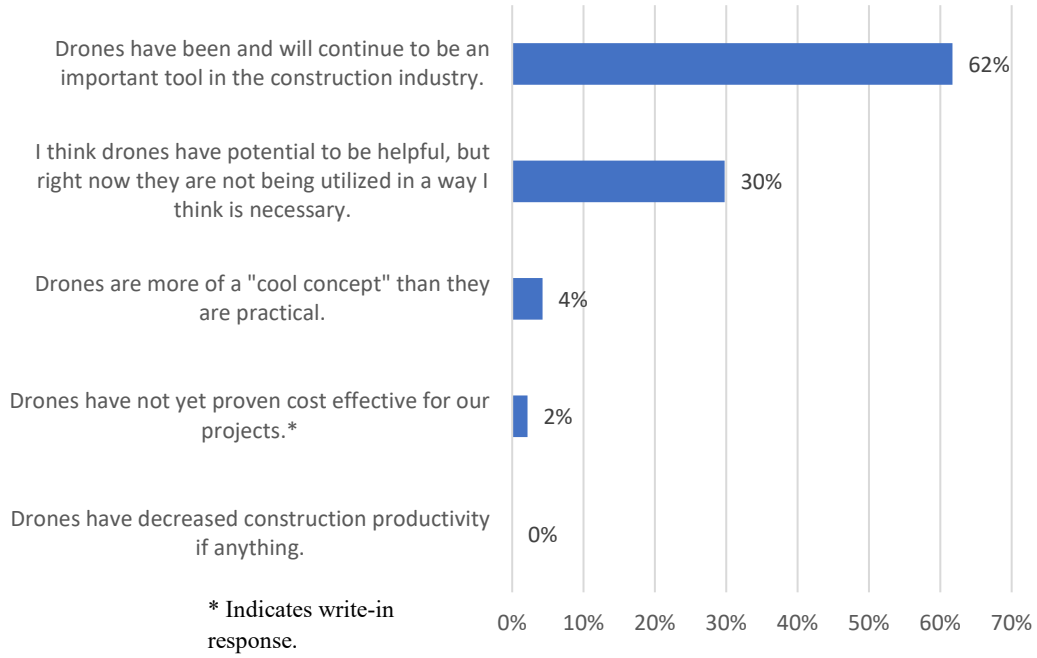

Figure 2. Drone Opinions

The survey then asked the individuals to select what drone application they thought was the best. As suspected, Progress Photos is the application of choice for a large portion of the respondents, approximately 43%. It was determined that Progress Photos, Site Utilization, and Inspections are the three main applications drones are being used for by the companies surveyed. Interestingly, these were not the top three best drone applications indicated. In fact, Site Utilization and Inspections were only considered the best drone application by less than 10% of respondents. The results seem to indicate that the best drone application is the one that only requires a basic drone and takes the least amount of post processing, that being Progress Photos and Promotional Applications. Figure 3 shows the responses.

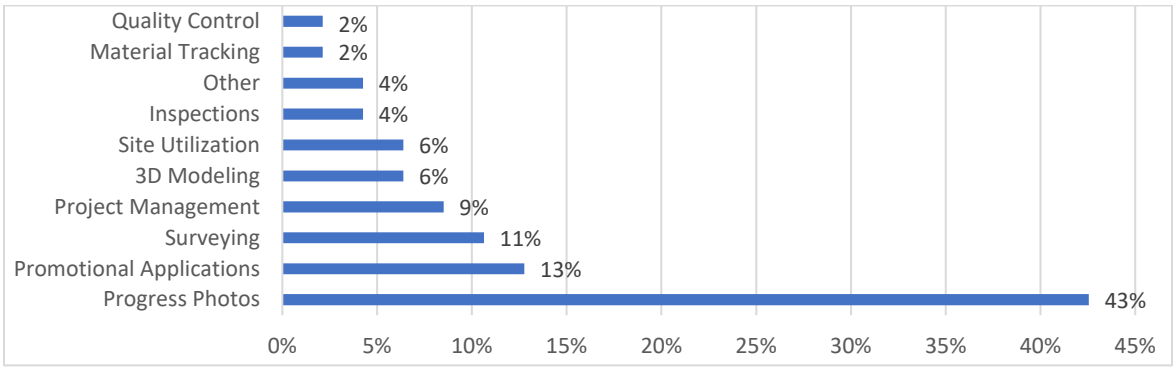

Figure 3. Best Drone Applications

Following this question, the individuals were then asked to select what they thought was the worst application for drones from the same list. The results are shown in Figure 4. Security is the worst application for drones according to 23% of respondents. Estimating is considered the second-worst application with just under 15%. Following Estimating, Material Tracking, Project Management, and Workforce Monitoring were selected by 13%. This is probably due to the lack of software options and technological advancements available today. Material tracking has been shown as proof of concept, but not much more has resulted since the testing of that application. Workforce monitoring is a task that would require long flight times and would not be as effective in gathering information on workers inside a building, as flying a drone inside can be dangerous and is impractical in most scenarios. Project Management is a drone application that would rely heavily on software, but currently, there are not many software options that integrate drones with project management, and the available ones might not do everything a company is looking for. While it appears most respondents are familiar with drones, it is unlikely each respondent has had experience with each drone application. These opinions are just that, opinions. These results are not necessarily conclusive evidence that one application is better than the other.

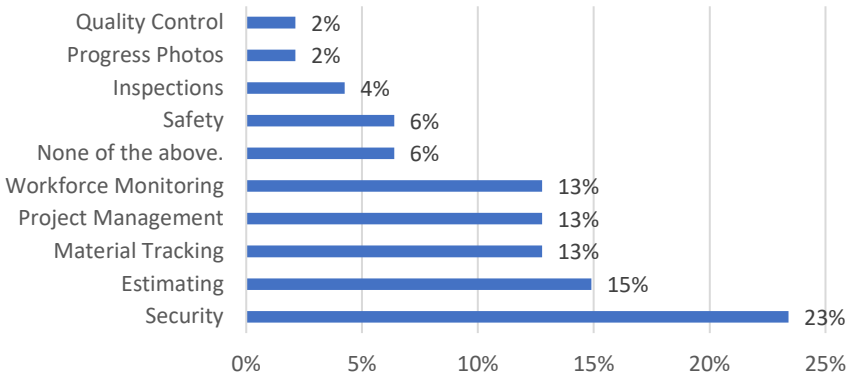

Figure 4 Worst Drone Applications

At least one respondent thought progress photos was the worst application for drones.

5. 3 Summary

The survey proved sufficient in determining trends with drones in construction. The most noteworthy information gathered was the applications most companies are using drones for, the general opinion of drones being used in the construction industry, and the best and worst applications drones are or can be used for. This data proves beneficial, as it shows how companies are already using drones, how they perceive them, and how they think they can perform. All these factors directly influence how, when, and if construction companies use drones. In all, the data provided insightful results and were effective at showing how drones are managed at the companies surveyed.

6. Conclusions

The construction industry is one of the largest industries in the world. For it to keep up with other industries, it will need to continue adopting new technologies to increase productivity, cut costs, and increase safety. This research aimed to determine the current applications for drones in construction, how the industry is reacting to drones, what software is used for the operation of drones, and what barriers make operating drones in a construction setting more difficult.

This research concluded that drones are currently being used in construction by about 77% of construction companies. The most likely application that drones are utilized for today in commercial construction was indicated to

be either Progress Photos, Site Utilization, or Inspections. These three categories were all indicated as activities drones participate in by more than 50% of respondents. These three categories rely almost solely on photos and videos gathered by the drone, with no third-party software required to operate or fly the drone for these applications. Other applications that companies are beginning to transition drone use to are Promotional Applications, Project Management, Quality Control, and Surveying. While these four applications were indicated to be used by only 40-50% of companies surveyed, they are clear indicators that the industry is adopting drones for more than mere photos of a construction site. In comparison with previous study results, the trend appears that these applications will see a rise in adoption in the coming years as drones and relevant technology get better and easier to use. Applications that require third party software to fly or analyze the data gathered with a drone were used as much as the simpler applications. The applications the fewest percentage of companies are using drones for are 3D Modeling, Estimating, Material Tracking, Workforce Monitoring, and Security. These applications are amongst the harder applications to use as they require either precise flying, powerful post-processing software, or both.

While it was concluded that 77% of construction companies are currently using drones, less than 50% of those companies indicated that all their job sites have access to a drone. This could have been due to regulations, cost, application, or other unknown variables that represent barriers to operating a drone. On top of this, most companies indicated that they have less than ten drones to distribute among their job sites, so naturally, not all of the sites will have access or always have access to a drone when they need it.

The research concluded that the software DroneDeploy, Pix4D, Photoshop, Windows Movie Maker, Final Cut Pro, Hanger 360, Multivista, Skyward, UAV Forecast, Airmap, Propeller, Skycatch, ReCap, and SiteScan were the popular choices when it came to either flying a drone, analyzing the data collected by a drone, or both. This is also another clear indicator that companies are finding ways to use drones for complex activities as opposed to photo acquisition only. Compared to other research done within the last few years, the number of companies using in-house pilots compared to subcontracted drone services remained mostly the same at 70% and 30%, respectively [17].

In total, over 90% of the survey respondents indicated that they thought drones were helpful or potentially helpful in construction. This research also concluded that Progress Photos was considered to be the best application for drones. This does not come as a surprise as this application is the easiest and requires the least amount of time to complete. When asked what they thought was the worst application for drones, it was clear that the respondents had a more difficult time pinpointing one application. Workforce Monitoring, Project Management, Material Tracking, Estimating, and Security were all selected to be the worst application by anywhere from 10-15% of respondents. Security ultimately prevailed as the perceived worst application for drones in construction by 23% of the respondents.

7. Further Research

After reviewing the survey and results, it is evident that there are still some questions that could be asked. Follow-up questions regarding respondents' answers could be beneficial in determining more trends and information on the particular question and results. Little to no information was gathered on the cost of and operation of drones, and therefore, no conclusive data was collected on how cost influences a companies' drone operations. Another valuable data point would have been learning perceived risks that come with operating a drone in a construction setting. Whether that risk is safety, legal, regulatory, or some other variable was not determined in this research. These questions were not included and are therefore not discussed significantly in this paper. Regulations are rapidly changing. A more detailed investigation of regulatory, airspace and operational barriers could be useful. Other areas of possible study might include details of training requirements, cost and time, not only for the drone operation itself, but for the software used to process and present the data.

References

[1] Frinault Y. Why the Construction Industry is Stuck in the Past. Online: https://www.fieldwire.com/blog/is-construction-stuck-in-the-1960s/, Accessed: 6/1/2023.

[2] Bharat R. et. al. The societal impact of commercial drones. *Technology in Society*, V45: 83-90, 2016.

[3] DJI, The World leader in Camera Drones/Quadcopters for Aerial Photography. Online: https://www.dji.com. Accessed 6/1/2023.

[4] FAA. Drones By the Numbers. Online: https://www.faa.gov/uas. Accessed 10/11/2023.

[5] FAA. Recent UAS Initiatives. Online: https://www.faa.gov/uas . Accessed 12/2/2023.
[6] Freimuth H. and Konig M. Planning and executing construction inspections with unmanned aerial vehicles. *Automation in Construction*. 96: 540-553, 2018.
[7] Bang S. et. al. UAV-based Automatic Generation of High-resolution panorama…. *Automation in Construction*. 84, 70-80, 2017.
[8] Mosly I. Applications and Issues of Unmanned Aerial Systems in the Construction Industry. *International Journal of Construction Engineering and Management*, 6(6): 235–239, 2017.
[9] Lovelace B. and Wells J. Full coverage: Minnesota DOT expanding drone use for bridge inspections. *Roads & Bridges*, 56(7): 34–38, 2018.
[10] Li Y. and Liu C. Applications of multirotor drone `technologies in construction management. *International Journal of Construction Management*. 0(0): 1–12, 2018.
[11] DroneDeploy. The Connected Job Site - 5 Construction Technologies Reshaping the Future. Online: https://www.dronedeploy.com/resources/ebooks/Accessed 1/6/2022.
[12] DroneDeploy. Surveying & Construction Aerial Site Intelligence. Online: https://www.dronedeploy.com/solutions/construction/. Accessed: 22, 5/2022.
[13] Siebert S. and Teizer J. Mobile 3D mapping for surveying earthwork projects using an Unmanned Aerial Vehicle (UAV) system. *Automation in Construction*. 41: 1–14, 2014.
[14] Hubbard B. et. al. Feasibility Study of UAV use for RFID Material Tracking on Construction Sites. *51st ASC Annual international conference proceedings*. 2015.
[15] Bist A. et. al. Aerial Survey Mapping Drones a Non-Market Strategy Report for Identified Technologies. Online: https://www.identifiedtech.com/. Accessed 14/11/2021.
[16] Holt E. et. al. Emerging Technology in the Construction Industry: Perceptions from Construction Industry Professionals. *ASEE Annual Conference and Exposition Proceedings*. 26.595.1-26.595.10. 2015.
[17] Tatum M. C. and Liu J. Unmanned Aerial Vehicles in the Construction Industry. *53rd ASC Annual International Conference Proceedings*. 2017.