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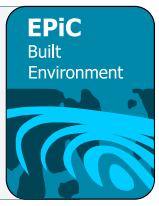

An Industry Focused Course to Address Barriers and Benefits of Drones in Construction

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Since the release of CFR Title 14, Part 107 in 2016, the use of Unmanned Aircraft Systems or drones, has significantly increased in the construction industry. This paper discusses the results of a survey of over 50 construction professionals with the goal of better understanding how drones are used, the perceived benefits and barriers, and how an Applied Drone Technology course offered through Clemson University address those barriers. The survey found that over 80% of the respondents used drones for progress photos and marketing. However, less than 10% use drones for thermal imaging, quantity take-offs, safety, and quality control overlays. The respondents indicated that the most significant benefits of drone use were to provide improved documentation, the perception by their clients and communication. The lowest perceived value was related to increasing efficiency, safety, cost control, and BIM modeling. The most significant barriers to using drones included earning an FAA remote pilot certificate, uncertainty about regulations, the liability of drone operation, and the lack of flight skills. Each of those barriers is addressed in the drone course and evaluated favorably by the contractor group.

Key Words: Drones, UAS, Curriculum,

Introduction

Before the release of Title 14 Part 107 of the Code of Federal Regulations in 2016, the use of Unmanned Aircraft Systems (UAS), commonly referred to as drones, for commercial purposes was limited. Since then, however, the use of drones for commercial purposes has significantly increased. In October of 2020, the FAA reported that since 2016, nearly 500 thousand commercial drones have been registered, and 200 thousand people have received their remote pilot certificate (FAA, 2020a). To put these numbers in perspective, there are only 220,000 civil manned aircraft registered with the FAA and 665 thousand manned aircraft pilots in the U.S. (AOPA, 2019; FAA, 2020b). The use of drones has not been unnoticed by the construction industry. They have been used for construction progress monitoring (Lin, Han and Golparvar-Fard, 2015), thermal inspections (Rakha, Liberty, Gorodetsky, Kakillioglu and Velipasalar, 2018), bridge inspection (Dorafshan and Maguire, 2018; Ham, Han, Lin, and Golparvar-Fard, 2017), landslide monitoring (Lucieer, de Jong, and Turner,

2014), stockpile calculations (Hugenholtz, Walker, Brown, and Myshak, 2014), orthophoto maps (Bang, Kim, and Kim), (land surveying (Aguera-Vega, Carvajal-Ramirez, and Martinez-Carricondo, 2017), disaster management (Adams, Levitan and Friedland, 2014), site-to-BIM (Hamledari, Davari, Azar, McCabe, Flager, and Fisher, 2017), and construction safety monitoring (Gheisari, Irizarry and Walker, 2014). Government agencies, such as the Federal Highway Administration (FHWA), are also taking advantage of the technology. Last year, in a FHWA publication, they said that "construction inspectors that use UAS are reducing inspection time, improving effectiveness, increasing safety, and lowering costs" (FHWA, 2019).

As just described, the literature is well-populated with use cases for drone technology. This paper will present the findings from a survey of construction professionals located throughout the southeast. The study has three specific objectives.

1. Identify which specific tasks contractors are using drones for.
2. Understand the perceived benefits and barriers of contractors using drones.
3. Determine how useful a new "Applied Drone Technology" course would be to builders.

The survey presented here is a pilot survey of a more extensive study. Based on the responses, the research team will update the survey to target areas not fully explained. The researchers hope to publish the updated survey results in a peer-reviewed academic journal.

Background

Drones are most commonly categorized as single-rotor, multirotor, fixed-wing, or hybrid (Li and Liu, 2019). A single-rotor drone has the appearance of a model helicopter and frequently enjoyed by the hobbyist. A multirotor will have two or more fixed-angle propellers and adjust pitch, roll, yaw, and thrust by varying the propeller's speed. The quadcopter is a variant of the multi-rotor classification and has some significant advantages. Quadcopters are commonly used in the construction industry due to their stability, maneuverability, low cost, minimal maintenance, ability to hover, and ease of operation (Li and Liu, 2019; Irizarry and Costa 2016). A fixed-wing drone has an appearance of a traditional airplane and, as its name suggests, maintains its lift by passing air over a fixed airfoil. Fixed-wing aircraft typically are faster and have longer flight time. They are not used in the construction industry nearly as often as multi-rotor drones primarily due to their inability to hover. Hybrid UAS are a blend of the multi-rotor and fixed-wing and can take off vertically and mid-flight switch to a fix-wing type of propulsion.

Li and Liu "comprehensively investigate[d] the current applications of multirotor drones" in the construction industry with an in-depth literature review (2019). They divided the applications identified in the literature by construction phase. Specifically, they grouped the applications by land surveying, logistics, on-site construction, maintenance, and demolition. A summary of the applications they found are shown in table 1.

Methodology

The author's institution has an active industry advisory board with a long history of supporting the program. A online survey was developed by the author and tested among several colleagues for clarity and logistical performance. They survey questions were a range of likert scale, multiple

selection and write in responses. The questions developed were based on drone activities, barriers and benefits identified in the literature and the experience of the author. The survey invitation was sent by email to over 200 individuals and 51 responded to the online survey.

Table 1
Multi-rotor Drone Use In Construction Industry (Li and Liu, 2019)

Construction Phase	Primary Task	Subtask
Land Surveying	GPS photogrammetric surveys	
	Site geometry change and evaluation	
	Documentation	
Logistics	Transporting goods from supplier to jobsite (not allowed in under Part 107)	
	Assess management with GPS, ultra-wide band radio and radio frequency identification	
On-Site Construction	Safety	Real-time video surveillance
	Quality management	Defect detection
		Comparison of BIM design model with drone captured as-built point clouds
	Time management	Collect as-built information
		Update estimates from drone data
		Support schedule updates
	Progress monitoring	Real-time project monitoring and inspection
		As-Built point cloud overlay contract documents
	Documentation	
	Site management	Augmented reality
Construction Facilities Management	Inspection	Post natural disaster structural inspection
		Roof inspection
	Water leakage issues	Curtain wall inspection
		Concrete degradation inspection
Demolition	Waste management	
	Documentation	

The survey respondents were primarily made up of large general contractors or construction managers (88%) and worked in the commercial sector (73%). Only 22% had fewer than 100 employees. Markets other than general contracting and construction management included residential (2%), industrial (10%), heavy civil (10%), and other (6%). A breakdown of the major sample characteristics is provided in table 2.

Table 2

Sample Characteristics

Builder Type	%
General contractor or construction manager	88%
Subcontractor	6%
Developer	4%
Other	2%
Market Sector	
Commercial	73%
Residential	2%
Industrial	10%
Heavy civil or site development	10%
Other	6%
No. of Employees	
<10 people	8%
Between 10 and 25 people	0%
Between 25 and 50 people	2%
Between 50 and 100 people	12%
>100 people	78%

The survey also addressed drone ownership. A large majority (76%) of those who responded indicated that their company owned at least one drone and have used it to support their business in some way. Another 20% indicated that their company has used a drone professionally but subcontracted the services through a third party vendor. Only three respondents (6%) indicated that their company has not ever used a drone. Each of those three indicated they were "subcontractors." Every general contractor and construction manager firm included in the study has used drones at some level. See table 3.

Table 3

Drone Ownership

Respondents' Drone Ownership	%
Own at least one drone and have used it to support their business.	74.5%
Do not own a drone but have subcontracted drone services from a vendor in the past.	19.6%
Have not used drones for their business in the past.	5.9%

Findings

Drone Use

A key objective of the study was to identify how drones are being used in the field. Li and Liu, whose work is summarized in table 1, captured how drones could be potentially used. However, many of those applications are advanced and may not be in widespread use. The survey asked which of a list of drone activities provided had they participated in the past three months. The intent was to burrow into how drones were commonly used and not just a novelty or in an experimental capacity. Table 4 provides a summary of the 51 responses. The vast majority of users indicated that they used drones for job site progress photos (90%) and marketing purposes (80%). The next tranche of uses was less common. Approximately 55% indicated they used it for video production, and another 49% indicated they used it for inspections and creating 3D models. Roughly a third (31%) indicated they used it to support their BIM models. Thermal photography, quantity take-offs, safety, and quality control overlays were each used by 10% of the respondents or less.

Table 4

Drone Use

Which activities do you use drones for at least every 3 months?	%	Count
Job site progress photos	90.2%	46
Marketing	80.4%	41
Video production	54.9%	28
Inspection	49.0%	25
Creating 3D models (photogrammetry)	49.0%	25
Supporting BIM models	31.4%	16
Thermal photography	9.8%	5
Other	5.9%	3
Quantity take-offs	5.9%	3
Safety	3.9%	2
Quality Control Overlays	3.9%	2

Perceived Value of Drones

Another survey question addressed what value the respondents believed that drones brought to their company. Similar to table 4, there seemed to be three tranches of responses. A significant majority thought that drones improved job site documentation (90%), and drone use was positively perceived by their clients (80%). Approximately 55% thought drones improved communication, 49% job site coordination and logistics, and 31% quality controlled. Less than 10% thought that drones improve job efficiency, safety, costs, or BIM modeling. See table 5 for a summary of the 51 responses.

Barriers to Drone Use

A key objective was to identify the leading barriers to why more contractors are not using drone technology in their business. A list of potential barriers was identified from the experience of the author. The survey asked the respondents to rate from 1 – 100 how significant the barrier was to drone use. The most significant barrier was obtaining the Part 107 license (54 points) followed closely by uncertainty about what the regulations are (46 points). Liability (44 points), lack of flight skills (41 points), and insufficient training (40 points) are also significant barriers. See table 6 for the complete scoring of the barriers.

Table 5

Value of Drone Use

What value do you think drones bring to your company?	%	Count
Improved job site documentation	90.2%	46
Positive perception by clients	80.4%	41
Improved communication	54.9%	28
Improved jobsite coordination	49.0%	25
Improved logistics	49.0%	25
Improved quality control	31.4%	16
Reduced risk	9.8%	5
Increased job efficiency	5.9%	3
Improved safety	5.9%	3
Reduced cost	3.9%	2
Improved BIM modeling	3.9%	2

Table 6

Why contractors are not using drones

Why are more contractors not using drones in their business? Rate 1 (least) to 100 (greatest) significance.	Average Rating
Employee with a FAA Part 107 certificate	53.8
Uncertain about what the regulations are	46.2
Liability of operating a drone	43.6
Lack of skills to fly a drone	40.8
Insufficient training	40.3
Insufficient value from drone use	39.1
Insurance cost	31.2
Equipment cost	25.5
Clients are not interested	24.6
Privacy concerns	18.6

Applied Drone Technology Course

Through XXXXXXXXXXXX University's professional studies program, the author has developed an Applied Drone Technology course tailored explicitly to drone use in construction. A 3-minute overview video of the course was provided, and the respondents were asked how useful the topics (learning objectives) were for a company looking to start or expand their drone program. Similar to the question related to barriers, the list of attributes was asked to be scored from 1 – 100. Table 7 shows how the participants responded. Preparation for the Part 107 exam was rated highest with 93 points. Learning how to receive airspace authorization, file waivers, create 3D models, and creating topographic maps all received 80 or more points. See table 7 for a complete listing of the course topics and how the respondents weighted their usefulness. All were above 70 points, which indicated to the author that the topics were well received by the contracting community.

Table 7

Course Topic Usefulness

How useful are these course topics to a company looking to start or expand their drone program? Rate 1 (least) to 100 (greatest).	Average Rating
Part 107 remote pilot exam preparation	93.3
Airspace authorization (LAANC)	84.8
File waivers to FAA Part 107 rules	82.5
Create 3D models from drone imagery	81.1
Create topo maps from 3D models	80.8
Including surveyed ground control points in 3D models	79.6
Create orthophotos from 3D models	78.4
Flight training with computer simulator	77.7
Pre/post flight checklists	77.1
Remove unwanted artifacts from 3D models	75.2
File accident report with FAA	73.4
Drone specific environment forecast (ex wind/satelites at 400ft)	71.9
Program autonomous (autopilot) flights	70.3

Conclusions

The study had three main objectives. The first was to identify which specific tasks contractors are using drones for. The findings show that builders are primarily using drones for their most simplistic functions. Over 80% use them for job site progress photos and marketing purposes, with another 55% using them for video production. Image and video capturing is the most basic functionality of UAS technology. Less than half of those surveyed are using drones for a higher-level functionality. Only 49% are using drone imagery for 3D models and photogrammetry. Less than 10% use drones for thermal photography, quantity take-offs, safety, inspections, or quality control overlays. Considering

the sample was almost entirely made of large commercial contractors, the authors can only assume that the percentages would be lower for smaller contractors or contractors in the residential market. Quantifying drone use in different size companies and other markets is recommended for a future study.

While the survey suggests that drones' full functionality has not yet been widely embraced, there does appear to be significant potential for drone use, and the most significant barriers can be easily removed. First, over 80% of the respondents indicated that owners positively perceive drone use. From the literature and the study results, half or more feel that drones can be used to improve documentation, communication, coordination, and logistics. There is a direct link between those improvements and the profitability of the company. Additionally, the highest-ranked barriers to drone use can be easily removed. The five highest-ranked barriers were earning their Part 107 certificate, knowing the regulations, liability, lack of flight skill, and insufficient training. Each of those can be addressed in a comprehensive drone course. That was the intent behind the Applied Drone Technology course offered through XXXXXXX University. The 5-week course prepares contractors to pass the Part 107 exam and then execute the requirements on a job site. For example, the Part 107 requires air traffic control authorization to fly in Class C airspace. The course shows contractors resources to identify airspace classification and how to request instant authorization. The course also reduces the barriers of the liability of operating a drone and lack of flight skills by using a cutting edge flight simulator. The simulator approximates the physics of 14 of the most common drones. Students' progress is recorded and sent to the instructor to help them improve. The feedback received on the survey related to the topics covered in the course was very positive. No topic received a score of less than 70, and as previously stated, many directly address removing the leading barriers to drone use. The course is currently on-going, and as contractors complete it, they are asked to complete a satisfaction survey. The results will be released when enough participants have completed the class, and meaningful results can be shared.

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