

Flying an Unmanned Aerial System (UAS) Responsibly and Effectively

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In only a few short years, unmanned aerial systems (UAS), also known as drones, have gone from an expensive hobby to the next wave in autonomous vehicles. An explosion of commercially available, high performance multi-rotors at relatively low price points, has propelled many different industries, including construction, to adopt them as test beds and tools. With ever-expanding usefulness and dropping costs, adoption rates will only increase. It is only a matter of time before they are as commonplace on jobsites as hammers and tape measures.

The Demand for UAS's: Affordability & Simplicity

In recent years, advances in battery storage capacity, data transmission, electronic sensors, GPS accuracy, and control systems have led to an increase in the popularity and sophistication of small UAS's flown by hobbyists while also driving down prices. One of the most notable products of this movement has been the propagation of UAS's known as quadcopters. Quadcopters have become popular because they offer many of the benefits of traditional helicopters while eliminating most of their drawbacks. Quadcopters have two sets of counter spinning rotors, two clockwise and two counterclockwise. They have a fixed pitch and control is maintained by adjusting the RPM of individual motors; whereas helicopters require complicated and often fragile linkages to control rotor pitch for flight control. This makes quadcopters mechanically simpler and easier to build and maintain. The tradeoff for quadcopters is the difficulty in coordinating the rotors for controlled flight. With advances in electronic sensors and microcontroller based autopilots, this coordination can be easily handled by the aircraft's systems instead of the pilot. The level of semi-automation present in quadcopters makes them simple to fly for the most inexperienced user while delivering unparalleled stability. This means that quadcopters, and multirotor UAS's in general, are and will continue to be inexpensive and reliable tools for low altitude air operations for the foreseeable future.

Federal Aviation Administration Regulation

Several years ago, Congress recognized the rapidly growing demand for UAS's across a wide spectrum of users and the benefits that these tools offer. In 2012, Congress directed the FAA to incorporate UAS's into the National Airspace System (NAS) by September 30, 2015 under the FAA Modernization and Reform Act of 2012. In the meantime, the FAA tried to balance public safety with public interest and the burden of regulation by giving exemptions for commercial use under Section 333 of the Act. This was a laborious process both for exemption seekers and the FAA. In February of 2015, the FAA released a Notice of Proposed Rulemaking regarding small UAS's (sUAS), and after nearly a year of delays, the FAA finally integrated sUAS's into the NAS under 14 CFR Part 107 in August of 2016. Part 107 created a framework for commercial use of UAS's up to 55 pounds and eliminated the need for one-off exemptions of federal regulations. It has streamlined the use of these tools and made them easily accessible to many industries. Though there are still many restrictions on their use, the Part 107 regulations in place allow far more use with less regulatory compliance costs than the previous Section 333 exemption process.

General Contractor's Use of UAS's

In September 2016, our firm purchased a DJI Phantom quadcopter for use as an aerial photography and jobsite monitoring tool. This particular model featured an out-of-the box first person view (FPV) setup with an integrated 12 megapixel camera on a three axis gimbal. The gimbal steadied the camera and provided for stable video even when the quadcopter was traveling or in windy conditions. Accessories that were purchased along with the Phantom were spare rotors, rotor guards, an extra battery, and a hard case capable of storing the Phantom with the rotor guards attached.

In late September, the Phantom was delivered to a remote, large scale jobsite. Since then, it has been flown by a superintendent more than 20 times to capture jobsite progress videos and monitor the lifting of large joists. The footage captured has been shown at owner meetings and is seen by the client as a valuable tool for informing their constituents of the project's progress. After operating on a jobsite for nearly five months, the only maintenance the Phantom needed was firmware updates released by the manufacturer. Aside from progress videos, the Phantom was also used to document safety violations and standing water and mud on the site. As some months while the UAS was on site saw heavy rainfall, this documentation proved invaluable for claiming rain days. Without the Phantom, photographic documentation of the 200-acre site would have required time consuming trips around the site to take photographs that would not have shown a comprehensive view, or expensive manned aerial photography. Instead, the project team was able to easily record site conditions immediately after rain events in a matter of minutes. A breakdown of the costs and benefits of the Phantom while on the project site can be seen below.

Cost	Month 1	Month 2	Month 3	Month 4	Month 5	Total
Aerial Photography	\$200	\$200	\$200	\$200	\$200	\$1,000
UAS Aerial/Video/Photos	\$1,500					\$1,500

Benefits	Month 1	Month 2	Month 3	Month 4	Month 5	Total
Time Saved in Documentation	1	2	4	4.25	3	15.75
Total Hours of Video	.25	.25	1	1.5	1	5
Jobsite Issues Identified	2	3	11	12	5	35
Safety Issues Identified	0	1	0	1	1	3

While the use of the Phantom on the jobsite did not see a savings over this period in comparison to traditional aerial photography, it will realize such a savings by the end of the project. Issues identified on the project site included inefficient organization of the laydown yards, standing water and mud after rain events, and differences in progress between the mechanical subcontractor and roofing subcontractor that could have resulted in schedule impacts. The flyovers also documented adjacent property before and

after work to make sure that no damage was caused by site work. The potential safety issues identified included the installation of an electric fence on the adjacent property.

Privacy Concerns

UAS's, and quadcopters in particular, have given rise to privacy concerns. There have even been several incidents of homeowners shooting down UAS's they believed to be over their property or being used to surveil them. While such action is usually deemed illegal, the concern for personal privacy is legitimate. While the aerial surveillance capabilities of UAS's make them incredibly useful within many industries, they are also disconcerting to many private citizens.

While the vast majority of UAS operators have nothing but good intentions, the concerns of individuals who fear for their personal privacy need to be addressed. For the construction industry, this can be done through community engagement and education programs near jobsites using UAS's. If these individuals are made aware of the usage parameters, benefits that UAS's bring to the project and that they are being used by professionals in a professional context, it is less likely they will be apprehensive at the thought of a quadcopter hovering near their property line.

Many states have already passed or are considering legislation restricting the use of UAS's for governmental and private use, and it is only a matter of time until there is legislation in every state along with precedent setting court cases addressing such laws. Until that time, businesses in every industry should work with the public to assuage any concerns.

Advances in UAS Technology

The future for UAS's will involve increased automation and customization. The presence of stabilizing automatic pilots and the ease of customization amongst many UAS's has driven their popularity among hobbyists and spurred their adoption commercially. As newer technologies are developed for UAS's, they will most likely follow the same path. Currently, manufacturers are looking for the next thing that will set their products apart from others and make them more capable or cost effective than their competitors. As UAS's have become more sophisticated and more companies have entered the market, it is no longer a differentiator in the industry to have built in FPV functionality, programmable waypoints, gimbals, or control via a mobile application. There are currently several companies that offer products with these features and more, at price points at or below the original purchase price of the Phantom our firm is currently using.

One of the next great differentiators in capability will be collision avoidance. Currently, there are several products that utilize this technology, with more on the way. These systems use sensors such as stereoscopic cameras and ultrasonic sonar to

detect objects and their distance from the UAS and prevent the user from flying into them. These systems will become more commonplace in the next 3-5 years and eventually a standard feature. In 10-15 years, we should expect to see more advanced object recognition and automation incorporated into these systems so that UAS's can identify obstacles and figure out the best way to navigate around them.

Other differentiators will include portability and durability. These attributes have proven important in other more established technologies like cameras and mobile phones, and it is only logical that UAS's will follow the same trends. Early cameras were bulky and required tripods, but they have evolved into the tiny devices found on almost every cell phone in the world. Recent years have also seen the rise of action cameras, many of which are easily mounted on UAS's, that are nearly indestructible. Mobile phones have gone from the suitcase phones of the 1980's to small, water and dustproof computers. DJI and GoPro have already released collapsible, action oriented UAS's designed to be taken anywhere, and it is only a matter of time before all-weather models are released by a manufacturer. These features would give even more flexibility and usefulness to already useful tools.

Another future differentiator could be an upgrade over current FPV functionality using videospheres. Videospheres are immersive 360° by 360° videos in which the watcher can view any angle filmed simply by moving their display device, and they are captured using camera arrays and software that stitches together images from each camera into spherical video frames. Using this technology on drones would enable pilots to have an immersive cockpit view similar to that on traditional manned aircraft, but with the possible added benefit of having clear sight lines in every direction. Similar technology has already been implemented on manned military aircraft like the F-35. It would also have the capability of producing immersive user experiences within buildings, enabling faster, better inspections and better interior documentation. As fiber optic connections become more ubiquitous and data transfer rates improve over the coming decades, owner representatives, inspectors, or quality control personnel could perform inspections at any time using small UAV's or ground based rovers from their offices by streaming videospheres to VR headsets. The greatest hurdle for this capability is transmitting the large volumes of data that videospheres require and eliminating latency between what the cameras see and what is projected in front of the operator.

The Need For Responsive Regulation

Congress and the FAA were forced to address the rising commercialization of UAS technology by rapid adoption in recreational and commercial use. This rise in use was something that the FAA had never envisioned, and something that required an entirely new thought process. The process of developing rules and regulations for the use of UAS's has taken years. However, the rules and regulations being put into place may soon be outdated and obsolete.

In the FAA's Small UAS Notice of Proposed Rule Making, issued on February 15, 2015, the FAA stated that they "considered proposing that a UAS operator be permitted to exercise his or her see-and-avoid responsibilities through technological means, such as onboard cameras. We recognize the technology is developing that could provide an acceptable substitute for direct human vision in UAS operations. FAA does not, however, believe this technology has matured to the extent that it would allow it to be used safely in small UAS operations in lieu of visual line of sight." One can only speculate as to when the FAA will revisit this position, but it will probably need to do so very soon. Once again, the next great differentiator in UAS's, and soon to be the norm, is automated collision avoidance.

Safe, Courteous, and Responsible UAS Operation

UAS's have the capability of making countless human jobs safer, more productive, and more profitable, but industry and private individuals must lead the way. The only way that unmanned aerial systems can reach their full potential and usefulness is for the public and regulatory authorities to keep open minds about UAS applications and avoid overly burdensome regulations that stifle further innovation and adoption. Like manned flights, there are thousands of UAS flights per day. The majority of these flights happen with no notice, but when something goes wrong, it can easily become the focus of negative attention in the press and social media. As a budding technology under scrutiny from a regulatory body like the FAA, UAS's can ill afford such attention. To avoid such negative publicity and maintain a positive public perception, all UAS operators need to do is fly responsibly and respectfully by avoiding unnecessary risks during flight and being considerate of those around them.