Drone Use in the Construction Industry Leads to Integration into the Current Civil and Construction Engineering Technology Curriculum

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Abstract:

The last few decades Unmanned Aerial Vehicle-systems (UAVs) or Drones have become relevant in the Construction and Engineering Industry. Drones are being used in the Construction and Engineering industry in many aspects, such as project development, project management, construction surveying, construction safety, construction inspection, volume measurements and 3D Modeling. The purpose of this technical paper is to provide an overview of UAVs, a description of the applications on how drones are being utilized in the construction industry, the collaboration of a local contractors current and future drone utilization, and how the Civil and Construction Engineering Technology program at Youngstown State University plans to integrate drone use into the current curriculum.

The implementation of drones into surveying and construction management courses will be necessary for the success of future graduates in the industry.

History of drones:

The use of drones dates back to 1849 when the Austrian Empire utilized unmanned hot air balloons to drop bombs on Venice in the first Italian War of Independence. Drone advancement in the early years of drone use was dependent on the need of the U.S. Military. During the Cold War the U.S. Military developed a classified Unmanned Aerial Systems (UAS) research program, code named 'Red Wagon', and the U.S. also developed the Defense Advancement Research Projects Agency (DARPA) [1].

Dà-Jiāng Innovation Technology Co. (DJI), founded by Frank Wang Tao in 2006, is the leader in residential and commercial Drone production. In 2013 DJI developed the Phantom, the first ready to fly drone, which consisted of software, propellers, frame, gimbal, and a remote control[2]. The introduction of the DJI Phantom started the residential and commercial drone revolution. The uses for drones continue to evolve every day.

Unmanned Aerial Vehicle Systems:

Drones can be categorized into four types depending on their uses: military, recreational, public, and commercial.

A typical drone consists of a quadcopter (four propellers, motor, landing gear, battery and camera) and a remote control. See Figure 1. The camera is attached to a Gimbal (holds the camera stable and steady). The battery contains a power management system and provides up to 25 minutes of flight time (the flight time varies with the type of battery)4. The pilot of the drone

can operate the drone by several methods: by viewing the drone directly (flying by "line of sight"), by viewing a transmitted video that can be viewed on a screen (flying by "first-person view), and the on board computer can receive instructions for a controlled flight path called 'way points' and will return to a home location when the flight is complete (autonomous)3.

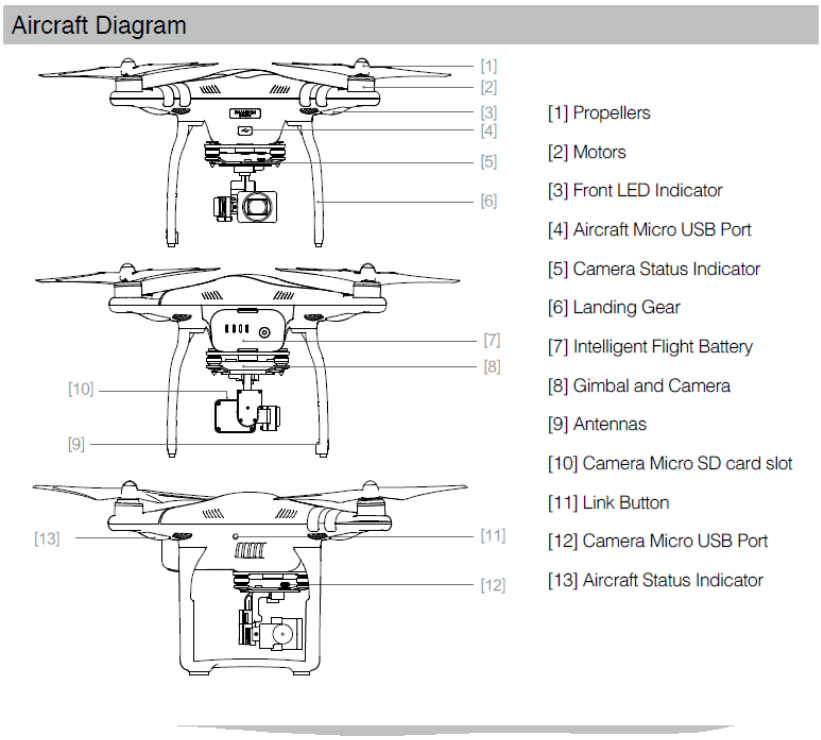

Fig. 1. Phantom 3 DJI Aircraft Diagram[4].

The use of drones in a commercial aspect requires the operator to obtain a Federal Aviation Administration (FAA) certification, known as Part 1073. The general FAA rules for commercial use are: the aircraft must weigh less than 55lbs, the UAV must remain in the visual line of sight of the pilot, operation must be during daylight only, the ground speed cannot exceed 100 mph, the maximum altitude is 400 ft. above ground level, and the maximum weather visibility is 3 miles away from the control station5.

Uses of Drones in Construction and Engineering:

The use of drones are expected to create 100,000 jobs by 2025 according to The Association for Unmanned Vehicle Systems International (AUVSI). The construction industry is expected to account for the largest growth in the commercial industry of drone use3. The uses of drones in the construction and engineering industry are continually growing. Some of the areas of drone use in the construction and engineering industry consist of survey mapping, inspection, and job material tracking.

Survey mapping with drones has changed the industry. The use of drones in surveying has made the job safer, and the speed of producing a survey has decreased from hours to minutes. Drone mapping makes it possible to be able to access areas that may be inaccessible by foot. Drone

mapping is less expensive than traditional methods of surveying. The accuracy of drone mapping is within 0.1 feet6. Lindy Paving, a local company, who supports our students at Youngstown State University's (YSU) Civil and Construction Engineering (CCET) department, utilizes drones to map stored material at their various asphalt production plants. Lindy paving is able to fly their drone over each plant, map the areas that contain the aggregates used in production, and from the mapping determine the amount of each aggregate present at the plant. Lindy Paving uploads the drone images to DroneDeploy, a third party, who then produces the required data needed to create the contour maps needed to calculate the quantity of material at each plant.

The Mahoning County Engineering department has been utilizing drones since 2017. Mahoning County Engineer, Patrick Ginnetti, P.E., P.S provided the following statement regarding drone use at the Mahoning County engineers office,

> "*Mahoning County began investigating the use of Drones a few years ago after attending several continuing education seminars. Several meetings took place with counties that have drones as well as members of the Professional Land Surveyors of Ohio on the uses and policies needed for the operation of the drones. As a result of these discussions and continued educational seminars, Mahoning County moved forward, in a combined effort between the County Engineer's Office and the Sanitary Engineering Department, with the purchase of a drone in late 2017 in an attempt to keep up with the technological advances in both the surveying and engineering professions. In the less than 1 year that we have been operating the drone, the county has taken on several projects. To mention a few, we have fully mapped several paving projects ranging from ½ mile to over 5 miles in length. We have also mapped our facilities, one of the major treatment plants, several pump station projects and we continuously monitor aggregate stockpiles for quantities. Moving forward, our goal is to expand our usage to cover Construction Photo and Video Documentation before, during and after construction, Road Improvement viewings, Ditch Improvement viewings, Traffic Counting and Monitoring, Bridge Inspection, Building Facility Inspection, continued monitoring of Aggregate Stockpiles, Sanitary Sewer Inventory, Treatment Plant Inspections and In-house design work. Mahoning County is determined to continue to grow with the technology and be a leader in the professions of surveying and engineering."*

Another use of drones in the construction industry is inspection. The Oregon Department of Transportation (ODOT) recently completed a study, "Eyes In the Sky: Bridge Inspections Unmanned Aerial Vehicles", the report details their use of drones for inspections of bridges. Inspections of bridges are required every two years, mandated by the Federal Highway Administration (FHWA). The inspections of bridges can be dangerous for the inspector. Inspectors are required to scale the bridges to get to the areas required to be inspected. The use of drones is able to provide the bridge inspector a safe way to observe different areas of a bridge. The drones are able to broadcast live video from a camera to a monitor, enabling the inspector to receive real time data of the inspection. The ODOT report indicates that drones reduce costs and enhance safety in bridge inspection7.

A problem that arises on large construction job sites is the ability to track the location of delivered material on the job site. Drones equipped with radio frequency identification (RFID) readers are currently being used to track and locate material on the jobsite. RFID is a wireless communication technology, consisting of a tag and reader configuration. The tag attached to the material contains pre-written information describing its use and contents. The drone that is equipped with the RFID reader is able to locate the delivered material and convey to the pilot the precise location of the material and identify the information pre-written about the material8.

Classroom Curriculum and Drones:

The Civil and Construction Engineering Technology (CCET) department of Youngstown State University (YSU) will be implementing drones into the curriculum due to the ongoing utilization of drones in the construction and engineering industries as outlined in the paper. Currently the CCET department is implementing drones into the curriculum, faculty are being licensed to operate the drones under the current FAA regulations, and the department has purchased two DJI Phantom 4 drones.

Drones will first be implemented at the freshman and sophomore levels to introduce students to the uses of drones in engineering and construction. The CCET department is currently working closely with the Mahoning County Engineer, Patrick Ginnetti, P.E., P.S. Mr. Ginnetti currently is an adjunct faculty member of YSU instructing the Construction Surveying course. The drone will be used as an alternative to construction mapping and road layout. The drone will be used in the Construction Survey laboratory, where the students will be able obtain hands on operation of the drone. The students will be required to input the mapping coordinates, deploy the drone to a required location, and the drone will then collect the information. The students will upload the information to the required software to obtain the contour mapping of the subject site. The students will be able to use the contour map generated by the software for engineering applications, such as grading plans, underground pipe layout, etc.

Conclusion:

The engineering and construction industry has been advancing through the use of new technology including drones. Engineering technology departments cannot ignore the advancement of the recent technology and continue to educate the students as they have been in the past. The CCET department at YSU has taken steps to implement the use of drones in the curriculum. The areas that were detailed in this paper represent a small area in which drones are being utilized. The use of drones in areas of survey, inspection, and material tracking, help make the work to be more efficient and safe for all involved with the design and construction of all sites. The CCET department at YSU will continue to pursue information on the advancement of drone usage and implement these advancements into the curriculum.

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