



Unmanned Aerial Vehicles and Supply Chain Technology

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Introduction

The use of an Unmanned Aerial Vehicle (UAV) or *drone* to deliver packages and parcels to an urban environment can conjure up images from a science fiction movie. Large supply-chain organizations like Amazon, Walmart and Target are exploring the use of UAVs as a delivery method, so it may only be a matter of time before they will be adopted as an accepted form of transportation. This paper explores the industrial use of UAVs in the Supply Chain and the challenges to widespread adoption.

Unmanned Aerial Vehicles' History

The use of Unmanned Aerial Vehicles dates back at least as far as World War I when the Navy asked the inventor of the gyroscope, Elmer Ambrose Sperry, to develop a fleet of *air torpedoes*¹. The idea of using UAVs for military purposes continued in World War II with the Navy's *Operation Anvil*, but stagnated for decades after the war ended. Nonetheless, UAVs were still used successfully for reconnaissance in Vietnam. In 2006, drones were used for rescue and surveillance in the aftermath of Hurricane Katrina. Recreational use of UAVs became popular as recently as 2015 due to the reduced cost and widespread availability.

Matternet, a Menlo Park, California-based startup founded in 2011, has been delivering medical supplies and specimens in Switzerland, Haiti and the Dominican Republic, since it was founded in 2011. "The technology is here," according to Matternet's Head of Global Business Development, Oliver Evans. He compares the skepticism over drone delivery to the quizzical responses to the first motor cars. Drones don't need drivers, and they don't get caught in traffic.

"It's much more cost-, energy- and time-efficient to send via drone, rather than send it in a two-ton car down the highway with a person inside to bring it to a different lab for testing," said Matternet CEO and founder Andreas Raptopoulos.²

UAVs in the Consumer Products Supply Chain

Amazon is “excited” about rapid home delivery using UAVs. “PrimeAir — a future delivery system from Amazon designed to safely get packages to customers in 30 minutes or less using small unmanned aerial vehicles” is what they are calling the proposed service. According to Amazon, “PrimeAir has great



Figure 1- Prototype of PrimeAir UAV for Delivery
Video at: <http://www.amazon.com/b?node=8037720011>

potential to enhance the services we already provide to millions of customers by providing rapid parcel delivery that will also increase the overall safety and efficiency of the transportation system.” The company released a video demonstrating how UAV use can respond to an immediate consumer need and save the day. While actual home deliveries as pictured in the video may still be far into the future, commercial and industrial drone use is becoming widespread.³

In the fall of 2015 Walmart applied to the Federal Aviation Administration (FAA) to do outside testing of drones. Walmart spokesman Dan Toporek stated that they want to “...test for a reason, because you learn during tests and you tend to evolve and figure out which approaches are most compelling to customers and most efficient for the business.”⁴ Walmart plans to use drones not only for checking inventories and warehouse operations but to take inventory of trailers, buildings and security.

There is a great potential for UAV deliveries in rural locations with little infrastructure or challenging geographic conditions. This would be cost-effective because low-volume remote locations represent a costly part of standard network, and could be beneficial in emergency applications as well. UAVs are not subject to differing configurations due to regional specifics (e.g., mountainous settings or island delivery) and could conceivably replace existing (and complex) processes involving cars, boats, and delivery workers. The availability of using UAVs to deliver packages allows for more than just rapid fulfillment; it also opens the possibility of removing the tether for a consumer to a fixed address. Imagine that you are at a remote location and you need an item due to loss, breakage or forgetfulness. A few clicks on your smartphone and the item is on its way to you at your current location.⁵

UAVs - More Than Just Home Delivery

There are many other supply chain functions that will adapt well to drone use. Asset monitoring is a current use for UAVs. Conducting equipment and supply survey and inventory, providing *eye in the sky* assistance to on-ground operations and remote security camera operations are just some of the uses for UAVs.

Companies in the agri-business supply chain are using UAVs for crop monitoring and chemical application. Drones provide unbiased statistical data to monitor crop growth and damage. Pilotless aircraft application of fertilizers and pesticides provides optimal product dispensing and lessens the opportunity for human error. Elsewhere in the food supply chain, UAVs are used as a way of monitoring livestock. The advantage of using UAVs is that they can cover large areas, provide both GPS location as well as visual information, and produce a low noise footprint which does not frighten the animals. Equipped with multiple camera types and sensors, including thermal, to provide accurate and

complete information, they lower control time and costs, including collecting data from active transponders embedded in livestock.

The power generation, transmission and distribution supply chain is a current user of UAVs. Using unmanned aircraft to inspect power transmission lines improves accuracy and reduces human risk. UAVs provide a safe, cheap and easily deployable alternative to traditional methods. Drones carry cameras that produce high resolution images and thermal images and equipped with transmitters that enable sharing of live footage. They are easy to deploy and can fly to within a few feet of the power transmission lines. Drone inspections can improve the quality, efficiency and safety of inspection while increasing the frequency and reducing the costs of inspection.

Large industrial projects like power plants spend sizable amounts of capital in conducting studies of project sites to identify creatures that qualify for protection and relocation. UAVs can be used to monitor the success of wildlife relocation and health of the animals following project completion.⁶

According to Jamie Exon, San Diego Gas and Electric (SDG&E) Major Projects-Electric Distribution Operations Manager, SDG&E obtained permission from the Federal Aviation Administration (FAA) to operate UAVs for training and research. He also relates that the company currently uses drones for terrain exploration and equipment inspection.⁷ The success of SDG&E in the use of UAVs has not gone unnoticed. Following the lead of SDG&E, Commonwealth Edison, the largest electricity utility in Illinois, has also obtained FAA approval to begin testing the use of UAVs for power line and substation inspection.



Figure 2- SDG&E Experimental UAV

Another industrial application for UAV use is in the drinking water supply chain. UAVs can use traditional cameras, 3D cameras and infrared cameras for intense inspection of canals, waterways and distribution systems to assist management teams with maintenance and repair. They can also be used to keep our water supply and distribution systems secure.

Technological Challenges

Despite the many benefits, there are technological limitations to using drones in the supply chain. Current consumer quality UAVs have a range of about 12 miles, can fly for approximately 45 minutes with a payload of up to 70 pounds and have a top speed of about 35 mph. This puts the delivery range for a UAV at about 5 miles when time for takeoff, delivery and return to base are factored in.

Once range limitations are solved, there remains the vulnerability of drones to hacking. Hackers could gain control of a delivery UAV in flight and reroute the flight plan to hijack the merchandise. Another challenge to UAV use is vandalism. Criminals could, in theory, compromise the flight plan using advanced technology or simply manually interfering with the UAV flight path.⁸

Government Challenges

Proposed FAA regulations mandate that drone operators must be in 'unaided' visual contact with aircraft at all times. This will severely limit the ability of Amazon, Walmart and others to use UAVs in the home delivery model demonstrated in the Amazon video referenced above. But some concerned pilots and aircraft operators herald the proposed FAA ruling, citing the difficulty in UAV operation and successful collision avoidance. Even a skilled UAV operator can accidentally pilot a drone into a fixed object.

Proposed FAA regulations that were due in late April 2016 may divide UAVs into multiple categories to allow for use in various commercial and recreational applications. In theory, FAA regulations offer maximum safety for the public while minimizing cost and restrictions for industrial applications.

Other Challenges

The general public is not thrilled with UAVs' potential for invasion of privacy. High resolution cameras are capable of taking remarkable photo and video from a distance of over 300 feet.

If regulations are enacted that require licensure of the UAV operator, operational costs and availability of trained personnel will become a challenge.

Human error is always a factor in flight operations and can account for more than 30% of UAV accidents, according to one study (Williams, 2004). Maintenance is another area of concern for UAVs. In the same study, mechanical failure was a factor in 45% of accidents.⁹

In a report on *Human Challenges in the Maintenance of Unmanned Aircraft Systems*, Drs. Hobbs and Herwitz present some possible threats to widespread UAV use. They reported that operators could be held responsible for UAV operational failures and consequently liable for damages and loss. Even if there is no operator that same liability could be logically extended to the flight plan programmer and/or the maintenance personnel.

Converting the Challenge into an Opportunity

This presents both an opportunity and challenge for the community college system. The opportunity exists to train members of the future workforce; the challenge is how to be successful in providing the training that industry will need. Possible opportunities for meeting that challenge include:

- UAV Operator – Visual Flight Reference (Unaided Line of Sight)
- UAV Operator – Instrument Flight Reference (Computer-Controlled Flight Plan)
- UAV Flight Plan Programmer
- UAV Accessory Maintenance Mechanic (Thermal, Still, Motion Picture and 3D Camera(s))
- UAV Accessory Maintenance Mechanic (Other Accessories)
- UAV Maintenance Mechanic (Rotary Wing Propeller Systems)
- UAV Maintenance Mechanic (Battery, Combustion Engine and Hybrid Propulsion Systems)

The need to investigate these training opportunities exist today and can best be met through combining

the resources of government organizations, educational institutions and industry to form partnerships to prepare and develop the workforce of tomorrow.

Innovators in UAV Education

Many institutions are striving to deliver the opportunity to educate individuals to fill the over 100,000 job opportunities believed to be coming in the months ahead. Some of the organizations that are already developing or instituting programs in Unmanned Aerial Vehicles and Systems include the following:

California Community Colleges currently developing UAV-related programs include Cypress College, City College of San Francisco, San Diego Miramar College, West Hills College (Lemoore), Victor Valley College (Victorville), Mt. San Antonio College (Walnut) and Ohlone College (Fremont). In addition, West Valley College in Saratoga is awaiting Program Endorsement for their Unmanned Aircraft System Technology Certificate of Achievement. The proposed program at West Valley College includes eight classes (26 units) in Unmanned Aerial System- specific curriculum.

Central Oregon Community College in Bend, Oregon offers an Associate of Applied Science Unmanned Aerial Systems (UAS) Degree Program (100-104 credits). Their UAS Operations program includes 12 classes (45 credits) in General Aviation and UAS Specific Curriculum and an additional five classes (24 credits) in Geographic Information Systems.

Community College of Beaver County in Beaver Falls, Pennsylvania offers an Unmanned Aerial Vehicle Associate Degree in Applied Science (65 credits). Their four-semester program includes 14 classes (43 credits) in General Aviation and UAV Specific Curriculum.

Northland Community & Technical College of Minnesota offers an Unmanned Aerial Systems Maintenance Technician Certificate program (30 credits) at their Thief River Falls Aerospace Campus. Their program concentrates on the maintenance and repair of the components of Unmanned Aerial Systems.

Sinclair Community College of Dayton, Ohio offers an Unmanned Aerial Systems Associate of Applied Science Degree (62 credits). Their program includes 11 classes (23 Credits) of General Aviation and three classes (7 credits) of UAS Specific Curriculum.

Cochise College of Douglas, Arizona offers two Associate Degree in Applied Science degrees (Unmanned Aerial Vehicle Flight Operator and Unmanned Aircraft Systems Technician) through the Military Occupational Specialty (MOS) Credentialing program at Fort Huachuca, Arizona, which are intended for current Unmanned Aerial Vehicle (UAV) flight operators seeking to improve their education. They also offer a transfer program to Embry-Riddle Aeronautical University for both UAV flight operator and unmanned aircraft systems.

Monroe Community College (Rochester, New York) offers an Introduction to Small Unmanned Aerial Systems (SUAS) program through their Corporate College. This 18-hour program includes training on drone operation and each participant receives a Quadcopter.

Through California State Polytechnic University Pomona's College of the Extended University, a Small Systems UAV Operator Certificate is offered. This program is a six-week, single course program that trains participants to operate small UAVs (under 55 pounds). The Extended University also offers an Advanced Unmanned Aerial Systems Certificate that can be a stand-alone program or augment an engineering degree. The Advanced Unmanned Aerial Systems Certificate is a multiple-course certificate program can be completed in approximately one year.

¹ Sifton, John (February 07, 2012). A Brief History of Drones. Retrieved from

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² French, Sally (November 30, 2015). Drone delivery is already here - and it works. Retrieved from

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³ Amazon Prime Air. (n.d.). Retrieved from <http://www.amazon.com/b?node=8037720011>

⁴ Daily Business Report (October 28, 2015) - San Diego Metro Magazine. (n.d.). Retrieved from

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⁵ Courtin for Constellation Research, Guy (February 24, 2015). Drones still useful in supply chains despite FAA regulations | ZDNet. Retrieved from

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⁶ Davis, Chris (July 8, 2014). How Drones Will Change the Utility Industry | Border States. Retrieved from

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⁷ Bewley, Tamara (June 9, 2015). Drones Are the Latest Technology to Catch Utilities' Interest. Retrieved from

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⁸ Sunol, Hector (August 24, 2015). How Drones Will Affect the Logistics Industry in the Next 10 Years - Cyzerg. Retrieved April 12, 2016, from

<http://www.cyzerg.com/how-drones-will-affect-the-logistics-industry-in-the-next-10-years/>

⁹ Hobbs, Alan & Herwitz, Stanley R. (May 2006). Human Factors in the Maintenance of Unmanned Aircraft. Retrieved from

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