Pantas and Ting

# Sutardja Center

for Entrepreneurship & Technology

Berkeley Engineering

# **Drones for Deliveries**

## Abstract

With advancing drone technologies and increasing commercial usage, we believe the last mile shipping industry is ripe for disruption by delivery drones. Drones can significantly accelerate delivery times and reduce the human cost associated with the delivery. This report examines the value chain and opportunities in the delivery drones market. It also discusses the barriers for adoption. It concludes with our case for drones to handle the last mile of delivery of most lightweight packages.

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#### **Project I - Industry Strategy Example Outline**

Section I – Introduction/Observation of a change and a hypothesis of what effect it will have in the industry

Section II - Existing Market: Map relevant firms in the industry/space (today's players with data and strategies on each)

Section III - Technology: The technical factors or technology changes i.e. market limits, network effects, new technological capabilities, key components, limitations

Section IV - Broad Contextual Factors: Any political environment, regulatory or societal factors to consider

Section V - Today vs. Future: Of the existing firms in the area, who will win and lose and why. Indicate new opportunities, what are the likely strategies and responses (potential acquisitions

Section VI- Summarize and Predict Opportunity: Where is the optimal white space, align abstract, hypothesis and summary

# Section I: Introduction: Main Hypothesis and Topic

The internet evolution continues. Whether it is online shopping, ordering food, buying gifts, grocery runs, shipping official or personal packages the consumer space is increasingly relying on fast and reliable door step delivery. The market for delivering goods is massive. Shipping, Logistics, Online shopping businesses are investing heavily in the entire supply chain upto the last mile delivery to make it fast and efficient. On the other hand, there are significant technological advances in building drones in the delivery area. Drones could allow accelerated delivery times, improved accuracy and reduce human cost associated with delivery. Which leads us to believe --

## Drones will handle last mile delivery of most lightweight packages.

## Section II: Existing Market

## 2.1 Introduction to Unmanned Aerial Vehicle (UAV)

Drone is an aircraft without a human pilot onboard. Its flight is either controlled autonomously or by the remote control of a pilot/operator on the ground. Currently there are two kinds of UAVs aka Drones:

- 1. Autonomous aircraft
- 2. Remotely Piloted aircraft

Drones have been traditionally used by military and special military operations but are being explored for increasing number of civil applications such as policing, firefighting, nonmilitary security work, inspection of power pipelines and other applications.

According to a research report from Radiant Insight, "Unmanned aerial systems (UAS) markets at \$609 million in 2014 are forecast to reach \$4.8 billion dollars, worldwide by 2021. This is a sizable market growth with oil and gas mapping, utility line inspection, package delivery, and agricultural applications accounting for virtually all the unit sales. Drones can provide more information at less cost than a human inspection team can" (Radiant Insight 2015).

# 2.2 Current players



## **Retailers**

### Amazon

Amazon is the largest online retailer with revenue of 88.9B in 2014. It has been the most public and advanced in experimenting with drones for package delivery. It has already proposed "Amazon Prime Air" and is working with FAA for regulatory and safety standards. Amazon Prime Air is designed to deliver packages via a drone in just 30 minutes. On the heels of getting FAA permission for experimental test flights in the United States in March, the U.S. Patent and Trademark office has published Amazon's patent application for its drone delivery system (US Patent 20150120094). Amazon is thinking beyond just home delivery and already has design for features like "Bring it to Me", which would captures a customer's location by GPS data received through mobile devices (Marsh 2015). Amazon has been granted experimental rights by FAA in March 2015: Drones can only be flown at

400 feet or below during the day in clear weather conditions, and must remain in the line-of-sight of their operators, who must hold at least a private pilot's certificate and medical certification.

Current drone technology can handle packages of up to 5 lbs. The chart below shows that 21.5% of total packages delivered by Amazon are eligible to be delivered by drones (Keeney 2015).



Source: Keeney, Tasha. "How can Amazon Charge \$1 for Drone Delivery?" Ark Invest, May 5, 2015.

### Google

In Aug 2014 Google revealed that it has been working on drone delivery for the last 2 yrs. The project is called Project Wing and is run by Google X, the company's research lab. It has been running experiments in Australia as their regulations around UAVs is much more permissive than the U.S. During this initial phase of development, Google landed on an unusual design called a tail sitter, a hybrid of a plane and a helicopter that takes off vertically, then rotates to a horizontal position for flying around. For delivery, it hovers and winches packages down to the ground. At the end of the tether, there's a little bundle of electronics they call the "egg," which detects that the package has hit the ground, detaches from the delivery, and is pulled back up into the body of the vehicle.

#### **Other Retailers:**

There are many other online retailers who may not be experimenting with drones directly, they could partner with a logistics company that provides drone deliveries.

## **Delivery and Logistics companies**

FedEx

FedEx's 2014 revenue is 45.57B. FedEx has acknowledged that it has had conversations with drone manufacturers for drone delivery but does not expect the international courier market to adopt it.

### UPS

UPS's 2014 revenue is 58.26B. In 2013, sources familiar with the company's plans said it has been testing and evaluating different approaches to drone delivery. It is more skeptical and does not think that it will catch on soon as mainstream delivery mechanism.

### DHL

DHL's 2014 revenue is 60.18B. In September, DHL Express launched its "parcelcopter", a helicopter-style drone which will deliver "medications and other urgently needed goods" to the remote North Sea island of Juist (Russon 2014). DHL will operate the parcelcopter on a regular basis, initially on a research basis.

#### **AMP Holdings**

In June 2014, AMP Holdings announced that it had successfully designed and developed a prototype of HorseFly, a battery operated UAV (AMP Holdings Inc. 2014). These can be combined with the workhorse trucks to deliver packages.

## **Drone Manufacturers**

#### Matternet

Matternet is a start-up in the bay area that is focusing on perfecting drone-based delivery systems. They are focused on the whole solution (drones, landing pads, batteries, charging software, cloud software for management and navigation/transportation centric operations). They have successfully partnered with organization like Swiss Post to conduct pilots to deliver post by drones. They have raised \$2.2 million in seed capital from investors including Flextronics, Scott Banister, and Nas (Biggs 2015).

The following manufacturers are not focused on last-mile deliveries but on other applications like photography and amatuer applications. The number of players in this segment just depicts how familiar and aware people are getting with drones. See Table A-1 for their annual sales. Technology is also being perfected along the way to support this adoption rate.

### DJI

DJI is a Chinese technology company founded in 2006 by Frank Wang and headquartered in Shenzhen, Guangdong province, China. It manufactures commercial and recreational unmanned aerial vehicles for aerial photography and videography. This company has a

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range of products such as flying cameras, flying platforms, flying controllers and other accessories. It is the leader in civil-drone industry. It is a privately held company with revenue of up to 0.5 billion USD in 2014 and projected to hit 1.0 billion USD in 2015.

#### 3DR

3DR is a privately held drone manufacturing company, headquartered in Berkeley, CA. It is a direct competitor for DJI and focuses on civil-drone industry. 3DR contributed significantly in making Dronecode, an Open Source UAV platform. It is Linux based software to provide open source and reliable software for drones. Multiple sponsors like Intel, QualComm and Parrot have become members of this open-source project. Since 2012, 3DR has received investments from various different venture firms and received its most recent funding in April 2015.

#### Parrot

Parrot made \$53.35 million from drones in 2013 which, at \$300 a drone (average price of AR Drone ~\$200 and AR 2.0 ~\$400 in 2013), is about 180,000 units (Booton 2014). Revenues from drone sales for Parrot tripled in 2014 which, accordingly raises the units moved to 530,000. Parrot expects to triple revenues again in 2015 with a full fleet of drone options on the market with an average price of about \$400. This would translate to around 1.1 million units sold in 2015 if all of Parrots drone models sell equally.

## **Drones for Online Delivery - Factors and motivation:**

For online retailers, various shipping methods are available today:

- Partner with a logistics company to deliver merchandise to the customer's door. This includes standard (5-7 day) shipping, Two day shipping and One-Day shipping. Cost of shipping increases as the shipping time decreases. Lot of retailers offer free shipping after a fixed cost of shopping (for e.g. minimum \$50 purchase). Most of these shipping methods are limited to domestic markets. Retailers also take a flat-fee for year around 2-day delivery (for e.g. Amazon prime).
- 2. In-Store pickup: Most of the retailers with brick and mortar presence/stores also offer free in-store pickup. This is a good way for customers to get access to online inventory instead of being limited to what is available at the local store. If the product is in a local store's inventory, customers can pick it up within a few hours. If it is not in a local store's inventory then it is shipped to the store within standard or 2-day shipping mode. In this case, retailer makes use of the regular fulfillment and supply-chain logistics to get these products to the local store. Once available, a customer can pick it from the store.

- 3. Retailer truck delivery: Retailers selling bigger packages like appliances and furniture ship their merchandise to a customer's house in trucks. These trucks are either a fleet of trucks managed and operated by the retailer or is through a partnership with a logistics company. These shippings are usually costly and customers' pay extra for shipping and delivery.
- 4. Futuristic delivery by Drone: Amazon has this as an option but is has not been approved by the FAA yet.

### Motivation to adopt Drones:

Main factors that could motivate online retailers to adopt drones are:

- Cost
- Value of fast delivery
- Convenience

#### There are three possible models in which drones can be used for delivery:

**Global courier and delivery service companies using drones for last-mile delivery**: Logistics companies have been experimenting with drones for delivery. The US courier and parcel delivery services industry consists of about 7,500 companies both large and small, which have combined annual revenue of about \$90 billion. The industry has seen steady growth in the last few years. A major chunk of the industry is held by its two key players, FedEx (FDX) and United Parcel Services (UPS). The industry is both capital-intensive and labor-intensive. Labor expenses include the wages and salaries paid to drivers, pilots, operators of call centers and drop-off locations, ground and administrative staff, and loading crews.



Source: Schmidt, Ally. "A Look at the Courier Service Industry in the United States", Market Realist, July 17, 2015.

#### Drone delivery by drones operated and managed by online retailers:

According to Business Insider (Smith 2015):

"Drone deliveries will translate to instant cost savings, part of which will be passed on to consumers. It costs far less to operate a fleet of unmanned aerial vehicles than it does a fleet of ground vehicles. It costs 10 cents to deliver a 4.4-pound (2 kilo) package over six miles (9.7 kilometers) using a drone, according to Raffaello D'Andrea, who co-founded Kiva Systems (the warehouse robots used by Amazon). That's far cheaper than the \$2 to \$8 per package that it costs Amazon today using ground transportation for deliveries over this "last mile." Offering 30-minute delivery at such a low cost to consumers could boost Amazon's e-commerce and retail market share. That's because "high-than-expected shipping costs" are the top reason why consumers abandon a shopping cart online, so the retailer achieving the most significant reductions in shipping fees will likely win consumer loyalty and market share. Competing retailers and shippers other than Amazon are also working on delivery drones, but Amazon seems to be the furthest along in its testing."

In July 2014 it was revealed Amazon was working on its 8th and 9th drone prototypes, some that could fly 50 miles per hour and carry 5-pound packages, and had applied to the FAA to test them.

It is projected that Amazon will have savings of \$500M per year.





**Companies providing drone operations and management:** There could be companies that offer service drones for flight and also management console and software. Matternet is a company that is exploring subscription based leasing of drones.

# Section III: Technology

# 3.1 Current state

In today's drone technologies, there are three leading grades of drone categories: consumer, enterprise and military (see Table A-2 for more details).

Today, military drones are the more advanced and sophisticated drones in the industry. They can do pretty much everything but they are very expensive and require an extensive infrastructure to operate. For example, Northrop Grumman Global Hawk costs \$223 million and it has a flight range of 14,154 miles. Military drones are used for weapon payload deliveries, reconnaissance, and target training.

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Consumer drones are the most accessible and cheapest drones to fly, but at the same time, they lack long-range capabilities and are susceptible to weather conditions. Consumer drones can carry cameras for video recording and taking pictures. An example, 3D Robotics, which includes a camera, costs \$500 and it can fly for 22 minutes. Most consumer drones include gyroscope and accelerometers for easy flying.

The enterprise drone space is in an evolution state. Companies and solutions in this space are evolving to solve many problems and provide a variety of services. Enterprise drones are servicing farms, checking electric towers, record terrain topology and package delivery which is the focus of this report. Enterprise drones can cost up to \$10K and can have 12 miles range.

## 3.2 Advances in Drone maintenance and support

#### Battery

A current disadvantage for transportation drone is battery life. Current commercial drone batteries offer about 10 to 20 minutes of flight time. Flight time can be reduced even further based on the shipment weight. One solution to this problem is to offer remote charging stations, allowing drone vehicles to continue assigned tasks. For example, Skysense, a German based startup has developed a charging pad, which offers a 10A charge rate using a 100-240V power input (Lavars 2014). Other technologies include wireless charging. Solace Power, a start up in partnership with Boeing, has developed 'resonant capacitive coupling', a wireless charging technology, which allows direct power transmission from point A to B (Etherington 2015). Although advances in battery life has struggled for the most part, its limitations have not prevented drone companies from innovating solution to extend transport range.

#### Management and Monitoring

Drone management and monitoring development is well under way with multiple companies providing comprehensive autonomous transport solutions. These solutions extend from simple OEM components to complete centralized management suites, which can include the following categories:

- · Integrated flight planning
- Air traffic management
- Automated regulatory compliance
- Flight operation logging and reporting
- · Asset management

### **Complete Solutions**

One company that is aiming at one stop solution is Matternet located in Menlo Park, California. Aside from supplying an autonomous drone for light transportation, Matternet also provides a centralized cloud based flight planner. Using existing information about restricted airspaces, ground topology, population density, weather and building location, Matternet flight planner creates drone flight paths on demand. A pilot indicates the delivery destination using a mobile app, and Matternet automates the rest: creates a delivery plan and manages the drone flight. Once the delivery package is on its way, Matternet will notify the package receiver of the flight status and when the package has been delivered.

Other companies focus on just drone regulatory compliance, which are mainly centralized software solutions. Professional drone operators generally use these solutions to plan, manage, track and record drone flights. Skyward, a Portland based company, not only provides these types of software solutions, but it also offers professional services around management needs, including insurance services.

### OEM's

There are plenty of Drone OEM suppliers. Some are very well established, providing hardware components that are used on every variety of drones. UAV Navigation is an example of a company that supplies navigation components to drone manufacturers. Other OEM suppliers are looking into the future for integrated drone solutions. Airware is a company looking to solve the drone air traffic problem (in conjunction with NASA). Airware believes cellular capable drones can use cellphone networks to communicate with a centralized drone air traffic control system. This system would then be able to establish a direct link with the drones and communicate new flight instructions if required to avoid collisions or reroute with a new flight plan.

## 3.3 Technology Outlook

Next year in 2016, the drone industry will have a milestone in which the FAA will approve condition for pilotless drones and package delivery. Beyond 2016, the next milestone will be air traffic controlled delivery. For this to happen, these technologies will be needed:

- · Heavy rain resilient and withstand damage from bad weather and animals
- · Automated regulatory compliance
- Autonomous accident avoidance while flying at high speeds
- · Direct Drone Communications using cellular networks (as mentioned above)



# Section IV: Broad Contextual Factors

## 4.1 Regulations

In the US, regulation for commercial drone deliveries is still evolving. The Federal Aviation Administration (FAA) oversees the airspace in the US. Currently, flying a drone commercially without special clearance from FAA is illegal. Companies can apply to the FAA for a Section 333 exemption to operate drones commercially. So far, the FAA has issued about 1407 of these exemptions (Dillow 2015). For example, FAA granted Amazon.com's request to test delivery drones outdoors in Apr 2015. However, Amazon is restricted to flights below 400 feet and less than 100 miles per hour. In July 2015, the FAA has approved the first drone delivery which is part of a joint venture between NASA, Virginia Tech University and an Australian startup, Flirtey, etc (Vanian 2015). The Flirtey operated drone successfully delivered medical supplies to a rural health clinic in Virginia.

The FAA has also proposed a set of new rules for commercial drones. It is expected that in 2016, the new regulation will replace the current exemption approval process under Section 333. The table below lists some of the proposed rules. While the regulations are evolving, some of these limitations will be problematic for large scale adoption of drones for deliveries. For example, the requirement of one operator per drone and the requirement of having the drone visible from the operator will limit the degree of automation and cost savings using drones for delivery can provide. It is expected that the industry will work closely with the FAA to refine the regulations so that delivery by drones can become a reality.

Table 4-1: FAA proposal for small UAS conducting non-recreational operations

Height limit of 500 feet

| Speed limit of 100 miles per hour            |  |  |  |
|--|--|--|--|
| Daylight and visual-line-of-sight operations |  |  |  |
| One operator per drone                       |  |  |  |
| Certified operator required                  |  |  |  |

In addition to federal regulations, each state may also have additional laws (NCSL 2015). For example, Florida SB 766 prohibits using drones to capture images of private property without consent if there is reasonable expectation of privacy. Arkansas HB 1349 prohibits use of drones for voyeurism.

## 4.2 Societal Factors

Beyond regulations, there are also additional societal factors that affects wide adoption of drones for commercial deliveries. While drones are becoming more commonplace, acceptance of this new technology depends on overcoming a number of issues when drones become part of everyday life.

- Privacy: Many drones today carry an on-board camera. While delivery drones do not necessarily depend on cameras for navigation, it could be included for additional features. Privacy safeguards will need to be put in place for people to be comfortable with many of these hovering around in close proximity to their residences.
- Safety: Since drones are still relatively rare in everyday usage, there is no established safety record. Once a large number of drones are in operation in dense urban areas, the possibility of getting into accidents increases. For example, drones might fly into other objects and damage them, drones might collide with each other and drones might crash and hit someone, etc.
- Environmental: There are also environmental factors to consider. Currently, even flying a single drone can create loud noise along its flight path. If there are a lot of them flying around, it can create a noise pollution problem that needs to be dealt with. Since drones are typically flown at low altitude, it might also collide with birds in its flight path and create additional environmental concerns.

# Section V: Today vs Future

## 5.1 Drones Ecosystem

As the market traction picks up and as the FAA rules shape up to be more conducive to conducting tests for deliveries, there will be more companies that will flourish to build out the complete ecosystem for last mile delivery. This ecosystem will be composed of drone manufacturers, battery, charging stations, landing pads, devices and software for air traffic coordination, drone recovery and safety, drone insurance to policing and license plates.

# 5.2 Drone, battery and landing pads manufacturers

Drone manufacturers will focus more on building out drones specifically designed for deliveries. As we mentioned earlier, most of the current drones are built for carrying cameras to take pictures and videos rather than as a transportation utility. Companies like Parrot, Matternet, DJI and 3DR will burgeon and start building out more robust, faster, longer lasting drones that will be able to carry the majority of packages (less than 8 pounds) for 10 miles. These manufacturers will accompany the drones manufacturing with longer lasting batteries, to carry the drones back and forth from hub to final destination. Charging pads will be manufactured and built out in highly trafficked areas enabling drones to stop and charge along their flight routes.

## 5.3 Regulations and Support Ecosystem

As the drones become more commercial and business oriented and the FAA issues the rules, the software and device to enforce these rules will need to built into the drones in order to respect, speed, altitude, allowed routing for the drones and land to drone communication to direct them or divert them in allowed directions. Big companies like Google or Amazon will be able to enter and set the standards for communication between the various drones and the software and device manufactures will be able to build on top of these standards.

## 5.4 Drones Safety, Repairs, Insurance

Companies working on drone safety will be able to add ways to prevent strong crashes of drones in case of mechanical failures. Companies and technicians repairing drones will have a vibrant business and the insurance will need to adapt to insure the drones as they will run in the \$5000 range. Insuring against failures will help fix the drones, their batteries or the landing pads, with the cost of replacement needing to go low in order to have a replacement be a viable solution for the businesses.

# Section VI: Conclusion

Drones will eventually be successful in the last mile delivery space for three main reasons:

- 1. Cost
- 2. Value of fast delivery
- 3. Convenience

With reasonable cost of less than \$5,000 and fast speed of delivery of less than 20 minutes, the drones are bound to succeed in delivering the last mile for both the brick-and-mortar companies and large internet retailers. For brick-and-mortar companies with a nearby local presence (eg. Walmart, Target, ...), deliveries will become faster and more convenient. For the large internet retailers like Amazon, it will need to build out warehouses close to where people live in order to compete on speed that the traditional brick and mortar will have. It will make the deliveries happen faster and at more economical prices therefore helping fuel the adoption of the drones for lightweight deliveries.

This will create a supporting ecosystem and a surrounding industry which will be able to create value for everyone and make the end consumer's life better. The first adopters will likely win as they will be able to learn faster, iterate and establish their brand names as the cheaper and faster companies to deliver packages. Examples of some companies that are ahead in this space are Amazon and Walmart, which are already testing the drones and are ahead of the game. This will be a great boost for them in the long run and enable them to stay competitive and earn new customers given the cost, convenience and speed of delivery.

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# Appendix

# Table A-1: Drones annual sales



Source: Amato, Andrew. "Drone Sales Numbers: Nobody Knows, So We Venture A Guess", DroneLife.com, April 16, 2015.

# Table A-2: Technology Analysis of Drones

| Grade<br>Aspect | Consumer                                 | Enterprise                           | Military                                    |
|-----------------|--|--------------------------------------|---|
| Function        | Carries cameras for pics and videos      | Package delivery, farming, topology  | Delivers weapons                            |
| Cost            | \$500                                    | \$5,000-\$10,000                     | \$5,000,000                                 |
| Package weight  | 1-2 pounds                               | 5-7 pounds                           | 200 pounds                                  |
| Charging time   | ~120 min                                 | ~60 minutes                          | hydrogen fuel cell<br>10 minutes            |
| Solar charging  | n/a                                      | Acquila 3 months                     | In development                              |
| Flight distance | ~3 miles                                 | 2 lbs package for 12 miles           | 48 hours                                    |
| Example         | 3D Robotics \$500;<br>22 min flight time | MatternetOne \$5K;<br>range 12 miles | NG Global Hawk<br>\$223M, range<br>14,154mi |



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