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Analysis of Amazon Prime Air UAV Delivery Service

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ABSTRACT

The UAV, or also called drone, is extensively being spread out to various applications and last-mile delivery service is one of the applications which attracts logistics companies including Amazon.com, Inc. Although Amazon Prime Air delivery service using UAVs is widely advertised, slight amount of Amazon delivery UAV information is revealed to public and undermining it became the main purpose of this paper. Throughout the paper, Amazon delivery UAV itself is analyzed in the aspect of UAV classification(DoD) and ideal HW specifications: motor, battery pack, controller, and frame. Particularly, the ideal HW specifications of Amazon delivery UAV are deduced by comparing three resources including information from Amazon disclosure, theoretic calculation, and xcopterCalc calculation. Then, post and parcel delivery market is analyzed by predicting the future based on the present volume and revenue growth between 2012 and 2020 and it shows that there would be a continuous shift from B2B to B2C industries. The delivery cost is further analyzed by considering two opposing cases, that is, cost benefits with or without Amazon Prime Air service between 2013 and 2021. It is indeed revealing that net shipping cost with Amazon Prime Air service will become only 8.6% compared to the one without Amazon Prime Air service in 2021. Last but not least, rules and regulations related to Amazon delivery service are deeply analyzed by studying FAA FAR Part 107 and listing 14 CFRs.

KEYWORDS: Amazon, Delivery, Drone, Last-Mile, Prime Air, UAS, UAV

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1. Introduction

Flying objects, such as an unmanned aerial vehicle(UAV) are getting to be a necessary item which a nation, a company, and a person should possess in order to utilize in a variety of fields. Having a precise controllability of a UAV will certainly revolutionize the life of modern human in the aspect of tremendous applications of UAV. The UAV, or also called drone, delivery service is one of the promising value-added industries and related technologies are particularly led by Amazon.com, Inc. although there are many competitors around the globe, including DHL Express, UPS, Inc., FedEx Corporation, SF Express Co., Ltd., and so forth[1].

Until now, e-commerce leading companies including Amazon, Alibaba Group, and etc. contracted with multinational courier delivery services companies including DHL Express, UPS, Inc., FedEx Corporation, and etc. to deliver goods from suppliers to customers. However, to meet the ever-increasing customers' desire for cheaper, faster, and more accurate delivery services, e-commerce companies replaced simple labor resources with robots. For instance, Amazon now uses about 45,000 autonomous robots across 20 fulfillment centers, including Kiva robots carrying shelves to human workers who pick up packages and Amazon even plans to replace package picking human workers with picking and palletizing robots soon[2,3].

Using autonomous robots, either flying or driving, are for the lower shipping cost and now e-commerce companies started to turn their eyes to even outside of mere fulfillment centers which were a territory of multinational courier delivery services companies until recently. This is one of the main reasons why existing logistics delivery companies started to participate in the delivery UAV development race. At the same time, using autonomous robots would let deliveries be performed 24/7 which shortens delivery time and, of course, with less work errors during a series of delivery procedures compared to human workers.

In fact, the last-mile logistics delivery service of the e-commerce market using UAV, unmanned ground vehicle(UGV), semi-autonomous UGV, robots, crowdsourcing, bike couriers, and even advanced algorithms and analytics, has been spotlighted for the last several years due to the predicted mega-impact on the logistics industry in the near future in the aspect of shipping cost, time, area, and so on[4-6].

Not only the company sales related aspects, but also the autonomous delivery robots which mostly use eco-friendly Li-Ion batteries as power sources would reduce environmental contamination as well with less exhaust gas emission including CO2, NOx, PM, and etc. based on new logistics platforms. Low or zero CO2 alternatives to conventional petroleum-based fuel is indispensable for decarbonization of delivery vehicles by reaching the ambitious objective of reducing the emissions of CO2 from transport by 60% by 2050 and achieving CO2-free logistics in major urban centers until 2030[7].

Among various shipping methods mentioned above, the Amazon Prime Air UAV, in particular

operated by Amazon is deeply analyzed in this paper since the UAV will probably be the most revolutionary last-mile shipping tool within the next five to ten years and Amazon is currently considered as a pioneer in those fields[8].

Amazon Prime Air service is the complete autonomous shipping service needing no any human operator involvement. Overall procedures of the Amazon Prime Air delivery service are shown in[9], although there could be numerous different methods for the last-mile delivery.

Beside the above automation processes, many additional automation features including battery charging/swapping[10-12], group health management[13-15], UAV swapping, HW/SW inspections, and etc. might be requested as the number of UAVs rapidly increases after the Prime Air service kickoff.

Through this paper, we tried to cover every aspect of Amazon Prime Air delivery service if possible based on the publicly accessible information and our prediction.

We inspect Amazon Prime Air UAV in Section 2 and analyze current delivery market in Section 3. Then, we start to analyze delivery cost in Section 4. Rules and related regulations are covered through Section 5. Finally, we conclude in Section 6 with possible future works that might be required to improve the Amazon Prime Air delivery service.

2. Analysis of Amazon Delivery UAV

Most logistics delivery UAVs, including Amazon Prime Air UAV are vertical take-off and landing(VTOL) type UAVs and are categorized as small size UAV according to <Table 1>(AGL: above ground level; MSL: mean sea level) and <Table 2>. A small size UAV seemed to be the optimum size for delivering an about 2.3 *kg* weighing package within half an hour.

표 1. 미국 국방부에 따른 무인항공기 분류[16]

Table 1. UAVs classification by the U.S. Department of Defense(DoD)[16]

Size	Max. Gross Takeoff Weight(*kg*)	Normal Operating Altitude(*km*)	Airspeed (*kph*)
Small	< 9.4	< 544.3 AGL	< 185.2
Medium	9.4 – 24.9	< 1587.6	< 463
Large	24.9 – 598.7	< 8164.7 MSL	< 463
Larger	> 598.7	< 8164.7 MSL	Any Airspeed
Largest	> 598.7	> 8164.7	Any Airspeed

Overall specifications of Amazon delivery UAV are listed in <Table 3>[18]. Here, the missing UAV weight is calculated later in <Figure 1>.

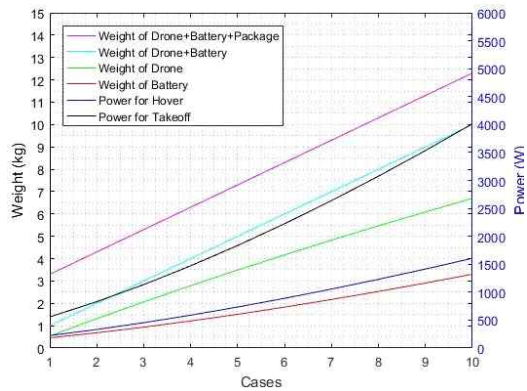

그림 1. 아마존 무인항공기의 무게 추세선 분석

Figure 1. Weight trend line analysis of Amazon UAV

표 2. 상업용 배송 무인항공기 사양 (모두 수직이착륙 형태)

Table 2. Specifications of commercial delivery UAVs (all VTOL type)

	Model	Launch (Year)	Package Weight (*kg*)	Flight Range (*km*)	Air Delivery Package Type
Amazon.com, Inc.	Prime Air	2018	< 2.3	< 16	Package
DHL Express	PaketKopter	2017	< 3	< 12	Emergency medicine
UPS, Inc.	-	2019	-	-	Package
FedEx Corporation	-	2020	-	-	Package
Domino's Pizza Inc.	DomiCopter	-	-	-	Pizza
S.F. Express[17]	-	-	< 10	< 20	Package

표 3. 아마존 배송 무인항공기 사양

Table 3. Specifications of Amazon delivery UAV

Frame Size(*cm*)	91.4
Rotor Size(*cm*)	25.4
UAV Weight(*kg*)	-
Number of Motor	8
Flight Time(*min*)	30
Top Speed(*kph*)	80.5
Range(*km*)	16
BLDC Motor RPM(*rpm*)	10,000
Package Weight(*kg*)	2.3
Max. Payload(*kg*)	14
Flight Altitude(*m*)	< 150(Class G Airspace)
Battery Pack	LiPo 6S or 10S, 22.2 *V* or 37 *V*, 10,000 *mAh*
Built-in Function	Sense and Avoidance

From the lift equation,

$$L = \frac{1}{2}\rho v^2 S C_L \tag{1}$$

where L is the lift force(*N*), ρ is the air density(*kg/m3*), v is the local flow velocity(m/s), S is the rotor spinning area(*m2*), and C_L is the lift coefficient, we can get

$$v = \sqrt{\frac{2W}{\rho C_L S}} \tag{2}$$

where W is the UAV system weight(*N*) since the lift force and the weight of the UAV are equal while the UAV is hovering or moving with a constant velocity.

Then, required power for hovering can be derived as

$$P_{hover} = \frac{1}{4}\rho S v^3 = \frac{1}{4}\frac{1}{\sqrt{\rho S}}\left(\frac{2\left(W_{drone} + W_{battery} + W_{package}\right)}{C_L}\right)^{\frac{3}{2}}. \tag{3}$$

In particular, required energy to hover for 30 *min* can be calculated as,

$$E = P_{hover} t = 1800 P_{hover} \tag{4}$$

where E is the amount of energy(*W*) and t is the flight time(*s*). Since the energy density of the typical LiPo battery is 0.875 *MJ/kg*(same with approximately 243 *Wh/kg*)[19], weight of the battery pack can be calculated as

$$m_{battery} = \frac{E_{battery}}{875000} = \frac{1800}{875000} P_{hover}. \tag{5}$$

표 4. 3가지 리소스로부터의 아마존 무인항공기 사양

Table 4. Specifications of Amazon delivery UAV from three resources

	Amazon Disclosure	Theoretic Calculation	xcopterCalc Calculaton
Frame Size(*cm*)	91.4	91.4	115
Rotor Size(*cm*)	25.4	25.4	43
UAV Weight(*kg*)	-	3.8	2.13
Number of Motors	8		
Flight Time(*min*)	30		
Top Speed(*kph*)	80.5	80.5	11
Range(*km*)	16	16	2.2
BLDC Motor RPM(*rpm*)	10,000	10,000	9537
Package Weight(*kg*)	2.3		
Max. Payload(*kg*)	14	14	24.8
Flight Altitude(*m*)	< 150(Clas G Airspace)		
Battery Pack	LiPo 6S or 10S, 22.2 *V* or 37 *V*, 10,000 *mAh*	LiPo 6S or 10S, 22.2 *V* or 37 *V*, 10,000 *mAh*, 1.7 *kg*	LiPo 10S, 37 *V*, 10,000 *mAh*, 1.7 *kg*
Built-in Function	Sense and Avoidance		

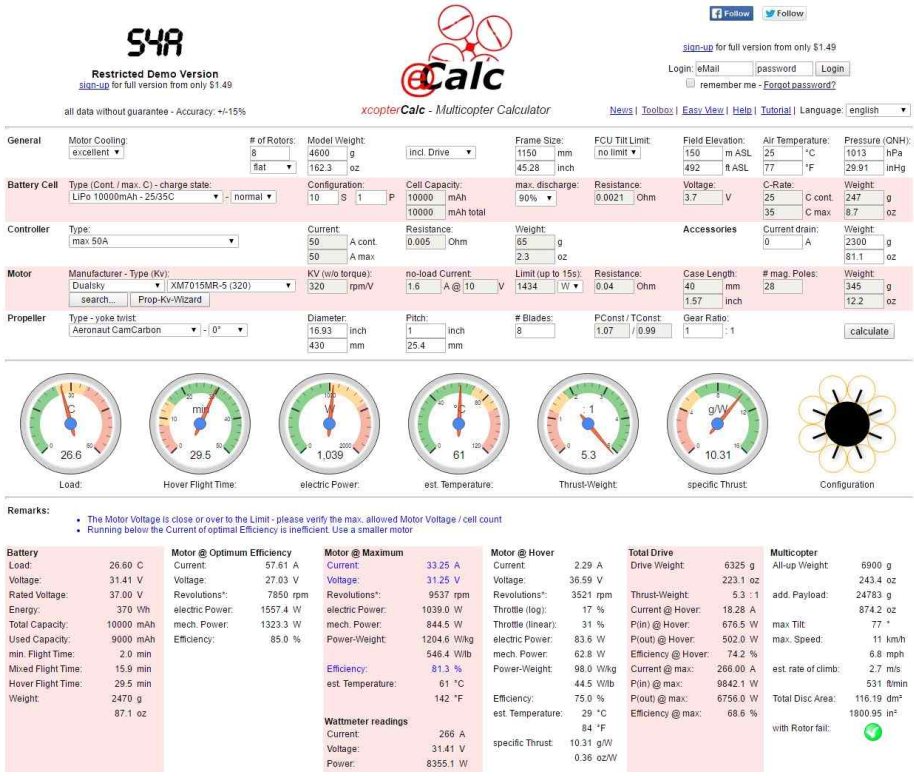

그림 2. 6S 배터리팩 구성의 아마존 무인항공기에 대한 eCalc 결과

Figure 2. The eCalc results for Amazon UAV with 6S battery pack configuration

We also assume that the maximum required power for the takeoff operation is 2.5 times of the required power for hovering operation, so we set $P_{takeoff} = 2.5 P_{hover}$. Then, using $\rho = 1.225\, kg/m^3$, $S = 0.405\, m^2$(using $S = 8\pi r^2$), and $C_L = 1.2$(at 45° angle of attack[20]) with various candidates of W_{total}(sum of W_{drone}, $W_{battery}$, and $W_{package}$), we can achieve a plot shown in <Figure 1>.

Since Amazon UAV uses 10,000 *mAh* battery pack according to <Table 3>, we could calculate the battery pack weight as,

$$m_{battery} = \frac{10\, Ah}{243\ Wh/kg \cdot \frac{1}{37\ V}} = 1.52\, kg. \quad (6)$$

In addition, with additional battery management system(BMS) PCB, cover packages, and etc., the weight of the battery pack is assumed as about 1.7 *kg*. With this information, we could determine following data based on <Figure 1>; $m_{drone} = 3.8\, kg$, $m_{battery} = 1.7\, kg$, $m_{package} = 2.3\, kg$, $P_{hover} = 760\ W$, and $P_{takeoff} = 2000\ W$. These data meet well with the data(<Figure 2>) achieved by using the web-based RC aircrafts inspection tool, called xcopterCalc[21], except several parts. As summarized in <Table 4>, these results imply that specifications disclosed by Amazon are not quite realistic data. Based on the summarized data in <Table 4>, ideal specifications of Amazon UAV are chosen as shown in <Table 5>.

표 5. 아마존 배송 무인항공기의 이상적 사양

Table 5. Ideal specifications of Amazon delivery UAV

Frame Size(*cm*)	115
Rotor Size(*cm*)	43
UAV Weight(*kg*)	3.8
BLDC Motors	8
Flight Time(*min*)	30
Top Speed(*kph*)	80.5
Range(*km*)	16
Motor RPM(*rpm*)	10,000
Package Weight(*kg*)	2.3
Max. Payload(*kg*)	14
Flight Altitude(*m*)	< 150(Class G Airspace)
Battery Pack	LiPo 10S, 37 *V*, 10,000 *mAh*, 1.7 *kg*

2.1 Motor

According to <Figure 2>, Dualsky XM7015 MR-5 320 motor shown in <Figure 3> is chosen and specifications are listed in <Table 6>[22]. However, since total weight of the eight motors occupies too much portions out of the total Amazon UAV weight, it is recommended to devise motors with less weight and we assume the motor would weigh about 0.16 *kg*.

표 6. 아마존 무인항공기 모터 사양

Table 6. Specifications of Amazon UAV motor

Manufacturer	Dualsky	Amazon
Type	XM7015MR-5	-
KV(*rpm/V*)	320	400
Idle Current(*A*)	1.6	1.6
Burst Current(*A*)	65	65
Peak Power(*W*)	1434	500
Resistance(Ω)	0.04	0.04
Case Diameter(*mm*)	70	50
Case Length(*mm*)	40	20
Weight(*kg*)	0.35	0.16

그림 3. 아마존 배송 무인항공기용 모터[22]

Figure 3. A motor chosen for the Amazon delivery UAV[22]

2.2 Battery Pack

Though there are various fuel systems for the UAV just like EV(<Table 7>), recent researches on the UAV fuel system has been focused on improving existing nickel cobalt manganese(NCM) LiPo technologies by adding new additive materials or on developing new chemical composition for high density, high power, and light weight battery pack and these research trends will last until the next five to ten years. Also, boost charging, low-temperature endurance, high safety assurance, and increase cycle life are additional differentiated functionalities of the UAV LiPo battery pack.

Though most micro, mini, and small size UAVs use 3S 11.1 *V* battery pack and medium size UAVs use 6S 22.2 *V* battery pack, a battery pack of the Amazon UAV is configured to be 10S 36 *V* for the system efficiency(<Table 5>).

Regarding the battery pack weight, though xcopterCalc calculated the battery pack weight as 2.47 *kg*, it is recommended to devise a battery pack with less weight and we assume the battery pack would weigh 1.7 *kg*(<Table 5>).

표 7. 상업용 무인항공기 배터리팩 목록

Table 7. List of commercial UAV battery pack

UAV Type	Power Source
Micro, Mini, Small, and Medium	NCM LiPo Battery or Petroleum-based Fuel
Large	Petroleum-based Fuel
Solar Powered	Hybrid(Fuel Cell + NCM LiPo)

2.3 Controller

Microprocessor, sensors, interfaces, power system, weights, dimensions, and etc. of the Amazon UAV are assumed to be similar with 3DR PX4 Pixhawk autopilot system[23]. The weight of the controller is assumed to be 0.25 *kg*.

2.4 Frame

Since the total weight of eight motors is 0.96 *kg*(<Table 6>) and total weight of the Amazon UAV is 3.8 *kg*(<Table 5>), the weights of the frame and the remaining parts(eight propellers, eight ESCs, controller, and etc.) should weigh less than 2.84 *kg*. By assuming each propeller weight as 0.02 *kg*, ESC weight as 0.065 *kg* (<Figure 2>), controller weight as 0.25 *kg*, frame including a package gripper should weigh less than 1.91 *kg* which is a quite reasonable system design requirements compared to the DJI S1000+ UAV frame[24].

3. Analysis of Delivery Market

According to the analysis of the post and parcel industry performed by Accenture PLC[25], top five high performers include Singapore Post, bpost, Posten Norge, UPS, and Poste Italiane are focusing on three main strategies:

1. Defend the core business by driving strong mail profitability and by investing in mail innovation.
2. Invest in the parcels opportunity by exploiting eCommerce trends and by driving better B2C margins while stimulating B2B growth.
3. Diversify selectively by expanding their logistics business and by adopting a commercial mindset and business-oriented culture.

Summary of the analysis is shown in <Table 8> where CAGR represents a compound annual growth rate. Here, we could notice that parcel volume and revenue are abruptly increasing while mail volume and revenue decreases. Also, high performers are focusing more on B2C than B2B industry.

4. Analysis of Delivery Cost

According to Amazon, UAV delivery will cover 86% of products sold on Amazon and it would reduce 80% of last-mile shipping cost and would result only $1 shipping fee for the 30 *min* UAV delivery service.

If we assume that one UAV could deliver at maximum eight shipments per day, it would take one and half hours of delivery time and maintenance time with twelve hours of work time during a day. Also, additional assumption is made that the price of the UAV will decrease at a CAGR of 5% over the period. Analysis of Amazon UAV delivery cost based on previous assumptions is shown in <Table 9>.

5. Analysis of Rules and Regulations

UAVs used in the Amazon Prime Air service are categorized as the small UAV by aviation law and standard terms have not been internationally established yet. Therefore, terms such as unmanned aircraft, unmanned aerial vehicle, remotely piloted vehicle, model aircraft, and etc. are interchangeably used at the moment. Especially the unmanned aircraft system(UAS) is defined as a concept that includes not only the UAV but also on-board equipments and communication equipments. The small UAV follows regulations defined in the Federal Aviation Administration's(FAA) Federal Aviation Regulations(FAR) Part 107 Small Unmanned Aircraft Regulations[28].

5.1 Background

The existing FAR does not provide sufficient standards for integrating the existing airspace with UAVs. The FAR also does not substantially allow the commercial use of UAVs by applying FAR PART 91 which

표 8. 우편 및 소포 산업 분석(상위 5위)

Table 8. Analysis of the post and parcel industry(top 5 high performers)

			2012	2013	2014	...	2020
Post	Volume Growth(%)		-5.0			-	-
	Revenue Growth(%)		-0.5			-	-
Parcel	Volume Growth(%)		20.7			-	-
	Revenue Growth(%)		21.2			-	-
	Volume & Revenue Shift from B2B to B2C(%, CAGR)	North America	-	6.5(B2C), 2.5(B2B)			
		Western Europe	-	5.5(B2C), 1.5(B2B)			
		Asia Pacific	-	14.0(B2C), 4.0(B2B)			

표 9. 아마존 프라임 에어 서비스 운영으로 인한 비용 혜택[26-27]

Table 9. Cost benefits occurred by operating Amazon Prime Air service[26-27]

		2013	2014	2015	2016	2017	2018	2019	2020	2021
Without Amazon Prime Air	Net Shipping Cost as of Cost of Goods Sold(%)	6.5	6.7	7.0	7.8	8.8	10.1	11.7	13.7	15.9
	Net Shipping Cost($M)	3,500	4,200	5,000	6,400	8,025	10,025	12,375	15,075	18,125
With Amazon Prime Air ($500 valued UAV)	Amazon Prime Air Operating Cost($M)	-	-	-	44.3	51.2	65.6	79.5	100.4	110.4
	UAV Shipment as of Total Shipment(%)	-	-	-	17	34	52	69	86	92
	Number of UAV Shipment(M Unit)	-	-	-	248	504	768	1,040	1,312	1,574
	Total Amazon Shipment(M Unit)	-	-	-	1,459	1,482	1,477	1,507	1,526	1,538
	Net Shipping Cost as of Cost of Goods Sold(%)	6.5	6.7	7.0	6.5	5.9	4.9	3.7	2.0	1.4
	Net Shipping Cost($M)	3,500	4,200	5,000	5,356	5,348	4,878	3,916	2,211	1,560
	Net Shipping Cost Per Unit($/Shipment)	-	-	-	3.7	3.6	3.3	2.6	1.4	1.0
	Saving Cost($M)	-	-	-	1,044	2,677	5,147	8,459	12,864	16,565

commonly applied to the operation of all aircraft within the United States[29].

Through the FAA Modernization and Act of 2012 Section 331-336 established in February 2012, UAVs weighing less than 24.9 *kg*(55 *lbs*) used for hobby, leisure, and commercial purposes were classified and secured possibilities for commercial use.

However, the commercial use of UAVs was selectively granted through individual evaluations without detailed criteria and it limits the expansion of the use of commercial UAVs. So, it was required to provide a standard for the integrated operation of UAVs in the airspace and the FAA FAR Part 107 Small Unmanned Aircraft Regulations was enacted in June 2016 through the

establishment of a notice of proposed rulemaking(NPRM). It is currently being applied within the airspace since August 2016.

5.2 Summary of FAR Part 107

FAR Part 107 is divided into four categories as operating limit, license and responsibility, UAV requirements, and model aircraft as shown in <Table 10>. In case of operational limitation, it limits the weight of UAV under the law to be less than 24.9 *kg*(55 *lbs*). Regarding the commercial use of UAVs, it includes limitations and specifications for the operating time, location, condition, and etc.

In case of Remote Pilot in Command Certification and Responsibilities, FAR Part 107 specifies conditions for becoming a pilot, methods to acquire licenses, and responsibilities and obligations of a pilot. In addition, there are no standards for safety and airworthiness requirements, but pre-flight inspections are required. It also specified the model aircraft operation criteria for classifying commercial and leisure use.

To summarize FAR Part 107, recreational UAV operations can be operated by anyone without age limits, but UAVs over 2.5 *kg*(5.5 *lbs*) must be registered with the government and flight operations are prohibited within 8 *km*(5 *mi*) of the airport without prior authorization. For the commercial use, an operator must be over 16 years old, UAVs must weigh less than 25 *kg*(55 *lbs*), fly less than 122 *m*(400 *ft*), and fly less than 160 *kph*(100 *mph*)[30].

Although the FAA's FAR Part 107 regarding the UAS operating system and regulations launched on August 29th, 2016 falls short of the requirements of the logistics industry, including the Amazon, the FAR Part 107 leaves some regulations open for specific waivers. It is expected that commercial use of UAVs will be spread out once the UAV operating system is complemented. As of January 1st, 2017, more than 300,000 UAVs are already registered for the commercial use, more than 55,000 have applied for the UAV pilot certification, and more than 10,000 have been qualified for the UAV pilot.

6. Conclusions

In this paper, we have proposed thorough analysis of Amazon Prime Air delivery service using UAVs in terms of HW specifications, delivery market, delivery cost, and related rules and regulations. Although most information is rough estimation but it clearly shows how post and parcel industries would change by starting to use UAVs and how related companies prepare for their competitors.

In the future, we will further analyze various additional aspects of Amazon Prime Air delivery service, including delivery time, delivery area, environmental impact, public acceptance, flight safety, and privacy dispute.

표 10. FAR 파트 107 제한의 CFR 14개 조항 분석

Table 10. The 14 Code of Federal Regulations(CFRs) breakdown of FAR Part 107 limitation

Weight	Weight less than 55 *lbs* in total.(aircraft, including attached systems, payload, and cargo)
Line of Sight	Visual line-of-sight(VLOS) only; 1. At all times the small unmanned aircraft must remain close enough to the remote pilot in command and the person manipulating the flight controls of the small UAS. 2. A pilot should be capable of seeing the aircraft with vision unaided by any device other than corrective lenses. 3. At all times the visual observer(VO) is not required.
Registration	Foreign-registered small unmanned aircraft is allowed to operate under FAR Part 107 if it satisfies requirements of FAR Part 375.
Right of Way	Yield to other aircraft.
See and Avoid	See and avoid requirements can be used as long as requirements are satisfied in other ways.
Weather Minimum	Visibility of 3 *mi* from the control station.
Airspeed	Maximum ground speed of 100 *mph*(87 knots).
Altitude	Maximum altitude of 400 *ft* AGL or remain within 400 *ft* of a structure if higher than 400 *ft* AGL.
Operation Time	Daylight only; 1. Civil twilight with appropriate anti-collision lighting(30 *min* before official sunrise to 30 *min* after official sunset in local time).
Operation Space	Available in all airspace(except Class A); 1. Operations in Class B, C, D, and E airspace with the required air traffic control(ATC) permission. 2. Operations in Class G airspace without ATC permission.
Operation Limitation	No operations from a moving aircraft. No operations from a moving vehicle unless the operation is over a sparsely populated area. No careless or reckless operations. Requires preflight inspection by remote pilot in command(RPIC). Small unmanned aircraft may not operate over any person, not directly participate in the operation, not operate under a covered structure, and not operate inside a covered stationary vehicle.
Operator	RPIC or VO operate requires only one unmanned aircraft operation at one time; 1. A person may not operate a small unmanned aircraft if he or she knows or has reason to know of any physical or mental condition that would interfere with the safe operation of a small UAS.
Payload Limitation	No carriage of hazardous materials. Operations with external loads are allowed if the object being carried by the unmanned aircraft is securely attached and does not adversely affect the flight characteristics or controllability of the aircraft.
Purpose	Transportation of property for compensation or hire.

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아마존 프라임 에어 무인항공기 배송 서비스 분석

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요 약

무인항공기(혹은 드론이라고도 불리는)는 다양한 어플리케이션에 널리 보급되고 있으며, 그 중 한가지인 최종 1마일 배송 서비스용 무인항공기는 아마존사를 비롯한 물류 회사들의 이목을 끌고 있다. 무인항공기를 이용하는 아마존사의 프라임 에어 서비스는 널리 광고가 되어 잘 알려졌지만, 정작 아마존 배송 무인항공기에 대한 정보는 많이 알려지지 않았고 이것을 밝히는 것이 본 논문의 주목적이다. 논문을 통해 아마존 배송 무인항공기 자체의 무인항공기 분류(DoD) 및 이상적 하드웨어 사양(모터, 배터리팩, 컨트롤러, 그리고 프레임)을 분석하였다. 특히 아마존 배송 무인항공기의 하드웨어 사양들은 아마존이 공개한 정보, 이론적 계산, 그리고 xcopterCalc 계산 정보 등 세 가지 리소스들을 비교하여 추론하였다. 그 후, 2012년과 2020년 사이의 우편 및 택배 시장의 물량 및 매출 성장 정보가 예측하였으며, 이는 B2B에서 B2C 산업으로의 지속적인 변화가 있을 것임을 보여준다. 추가로 2013년과 2021년 사이의 배송 비용이 아마존 프라임 에어 서비스를 적용했을 경우와 그렇지 않았을 경우를 비교함으로서 분석하였다. 이는 2021년이 되었을 때, 아마존 프라임 에어 서비스의 순 배송비가 이를 적용하지 않았을 때에 비하여 8.6%에 불과함을 보여준다. 마지막으로, 아마존 배송 서비스와 관련된 규칙 및 규정들을 FAA FAR 파트 107를 분석하고 14가지 CFR을 나열함으로서 심도 있게 분석하였다.

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