

Last Mile Delivery with Autonomous Vehicles: Fiction or Reality?

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Abstract—Autonomous vehicles (AVs) are a disruptive technology of the 21-st century that are beginning the next revolution of the transportation of people and goods. Their presence has a particular impact on the future directions of development of E-commerce. The number of online orders is in a steep incline, and so is the necessity to deliver goods to the customer in an efficient and environmental friendly way. Using autonomous drones, pods and vans for delivery of goods has already become reality [1]. But, what is the state of the art of the companies offering these services and how do people feel about it? The aim of this paper is to make an overview of the business models of the companies developing AVs for Last Mile Delivery (LMD) of goods and to find out what is the attitudes of the online customers towards using AVs for delivery of their goods.

Index Terms—Autonomous vehicles, Last mile delivery, Business Model, Survey, Public opinion

I. INTRODUCTION

With the growth of the E-commerce as a common global practice for shopping, the number of on-line orders has considerably increased, as have the expectations of the customers for faster last mile delivery. In the pursue of solution for satisfaction of these expectation and in the struggle for greater market share, the leading companies have dedicated a considerable effort and money to find more innovative and efficient ways of last mile delivery of packages [2]. One such solution is delivery of packets to customers using Autonomous Vehicles (AVs) [3]. These vehicles have become a reality due to the advances of electric vehicles technology, computer vision and machine learning.

We can already witness drones in the skies delivering packets above the crowded cities [4] or autonomous pods wandering around the pavements of the cities carrying worm meals from the restaurants. Although many such vehicles are in a pilot phase for becoming approved and secure delivery solution, there are already companies that launched AVs that offer commercial delivery services. Since the LMD with AVs is in pilot phase only in few developed countries, one of the

goals of this papers is to identify these companies and give a general picture of their business model.

Although these ambitious ideas for LMD are not far from becoming common practice, there is still public skepticism for their full incorporation regarding the safety concerns imposed by letting driver-less drones, pods or vans make decision on their own in busy roads and crossroads or crowded pedestrian areas. Other concerns that affect customers are the security of the goods delivered, the privacy of the customers. In order to sense the public opinion for acceptance of AV in LMD, we conducted a survey that compares the e-commerce customers preference for delivery of their orders via AVs as opposed to traditional delivery.

The rest of the paper is organized as follows. In section two we present an overview of the business models which companies use for AVs in LWD. The survey to gauge the public opinion on AVs in LWD is presented in section three, along with the results. A discussion about the result is laid out in section four. Finally, we present the concluding results in section five.

II. LAST MILE DELIVERY BUSINESS MODELS EVALUATION

In order to evaluate the current state of AVs for LMD, we searched for companies that have autonomous delivery of goods as their primary revenue model. As a source, we used the publicly available data on the Internet, such as the official web sites of the companies, news articles and blogs. The companies included in the analysis were classified based on whether they use drones (Figure 1) or ground based vehicles such as pods and vans (Figure 2). We considered Amazon Prime Air Delivery [5], Wing [6], Tactical Robotics [7] and Drone Delivery Canada [8] in the first group, and Starship Technologies [9], Marble [10], Robby Technologies [11], Nuro-R1 [12], Dispatch Carry [13] and EZ-Pro [14] in the second group. The aggregated results for the properties of the business model canvas are shown in Table I.



Fig. 1. Drone-based delivery: Amazon Prime Air



Fig. 2. Ground-based delivery: Robby Technologies

TABLE I
OVERVIEW OF BUSINESS MODEL PROPERTIES OF LMD COMPANIES

	Ground-based delivery	Drone-based delivery
Year founded	2014-2018	2012-2018
Type of company	Start up	Existing company
Country	USA, England, Germany, France	USA, Canada, Israel
Radius	up to 10 km	up to 150 km
Freight weight max.	/	1.5 - 500kg
Type of packages	Groceries, food, packets	Packets, cargo
Security	Yes	Yes
Fully implemented	Yes	Yes
Assistance	Mostly no	No
Model	B2B	B2B and B2C
Revenue model	Retailer paid	Consumer and retailer paid
Funding	\$55M-\$1B	/
Cost	/	/

According to the table results, the ground-based delivery business has been founded in the past few years by start-up companies with considerable investments. Their business model is B2B, i.e., they offer services to retailers that need delivery of goods to their customers, mostly groceries or meals from local restaurants. Their vehicles cover ranges of up to 10km and, with a few exceptions, deliver the goods with no assistance. The recipient is usually notified for the arrival of the vehicle, and upon insertion of a security pin, the packet can be withdrawn from the vehicle. In the case of an assisted

vehicle, the human operator only delivers the package from the vehicle to the door of the customers. The companies charge the retailers for the delivery service. On the other hand, the drone-based delivery business is a few years "older" and has been generally founded by wealthy and well known companies (hence the lack of funding data) with the aim to cover larger regions of urban areas and to deliver heavier packets, which, in some cases, can be classified as cargo. In their business model, besides offering service to the retailers, they also offer delivery service directly to the customers. Therefore, the companies can also directly charge the customer for delivery of the goods. Both groups provide mobile applications, so the customers can get notified and track where their delivery are in real-time. The vehicles are completely autonomous, but constantly monitored by ground operators who can take the control in critical situations. All the companies are founded in developed countries and they all have full implementation in the current year or expect to go commercially next year.

III. SURVEY

In order to evaluate the preference of people to use AV delivery as opposed to the traditional delivery, we conducted a short online survey [15], [16]. The survey consisted of different groups of questions which aim to profile the customers according to their socio-demographic characteristics and their attitudes toward AV last mile delivery. The structure of the survey is depicted on Figure 3.

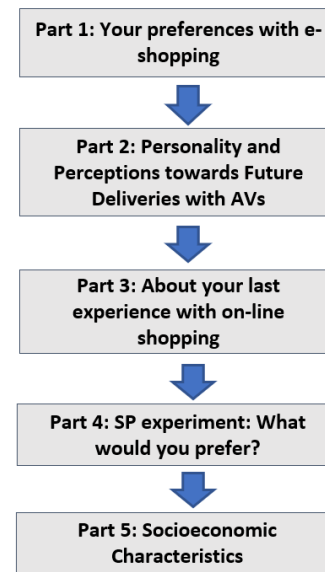


Fig. 3. Survey structure

The survey was conducted in March 2019 within a period of 2 days. The majority of the participants were attendants of a Training school related to the autonomous connected transport. The questionnaire was completed by 33 participants from 12 countries with average age of 38.1 year. Most of the participants had first or second degree of education. The participants were gender-balanced.

The first group of questions profiles the participants as online-shoppers. Figure 4 shows the frequency of using delivery services when shopping on-line different types of products. From the figure we can see that when purchasing big size products or food from the supermarket the participants seldom use delivery, or use it only a few times a year. The frequency is slightly higher for delivery of small sized products (books, electronics, toys, etc), clothes and shoes, which ranges between never and once a week. What is most frequently delivered to the users is food from a restaurant. The results show that the customers still do not receive their everyday shopping items directly in their homes or offices.

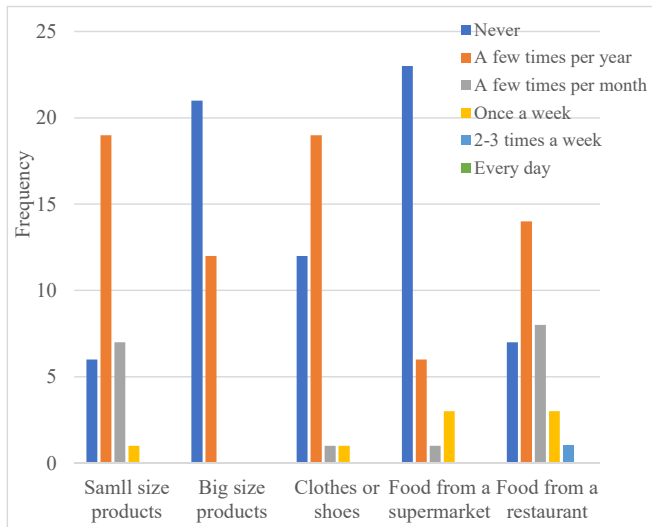


Fig. 4. Frequency of using delivery services for online buying of different types of products

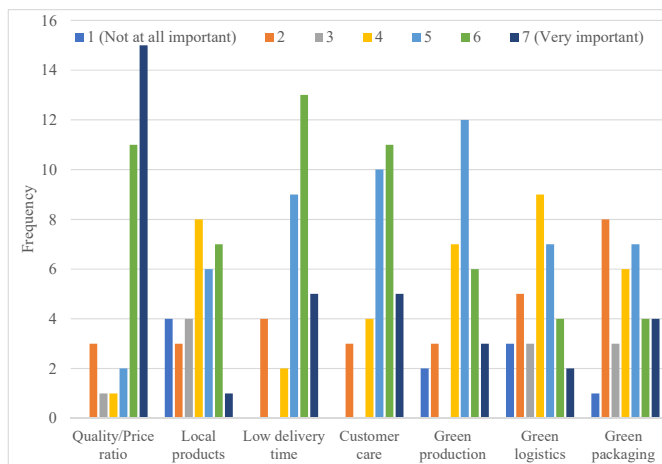


Fig. 5. Perception of importance when buying a product online

Figure 5 shows the perception of importance when buying a product on-line. The most important aspect of on-line shopping for the participants is the quality/price ratio of the product, the delivery time and the customer care, which means that they

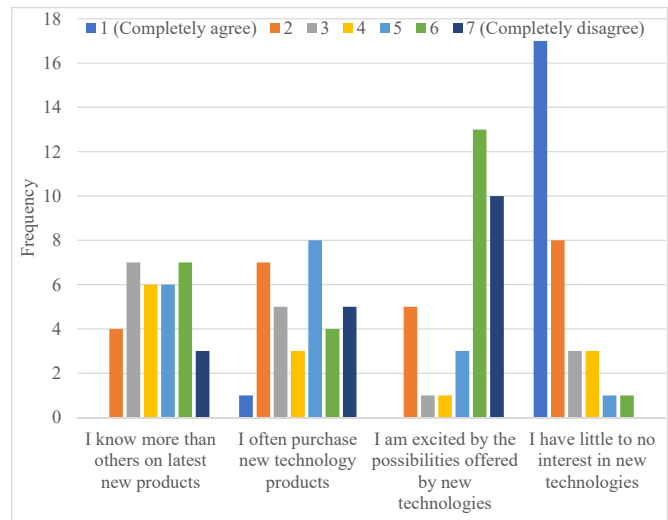


Fig. 6. Customers' attitude towards new technologies and products

want to get cheap products with good quality in a very short time, and at the same time, to be sure that they can get the best of what they paid for. The participants have shared opinion regarding the locality of the products: some of them prefer that the products are local so that they can be delivered faster, while some give no importance to the origin of the product, since what matters *most* is its price. Most of the participants also give *some* importance to the environmental impact of e-commerce, from the perspective of production, packaging and logistics.

Since delivery with AVs by itself is a new technology, the participants were asked questions that reveal their attitudes towards new products and technologies. From the results presented in Figure 6, we can conclude that the most of the participants have big interest in new technology and are excited by the possibilities they offer. However, they have different levels of knowledge related to the new technologies.

When asked about their perceptions towards future deliveries with AV, as Figure 7 shows, the majority of participants would greatly value fast delivery with AVs, although there are some that do not give much credit to the whole idea. Nevertheless, they mostly disagree that the delivery with AVs will cause them to lose control over their personal security. The fact that the AVs are unattended when moving in the open space leaves many doubts about the safety of the packets on their way to the customers, which can be seen by the responses of half of the participants. On the other hand, as shown in the analysis of the business models of the LMD companies, the packets are secured with a unique code shared with each customer separately, so that only the customer, can open the case upon arrival. Therefore, another half of the participants do not fear that the packet may be stolen. Similar distribution of responses can be observed on their opinion about the data privacy with AVs deliveries. Despite of these concerns, a vast majority of the online customers would use AVs to receive their orders in the future.

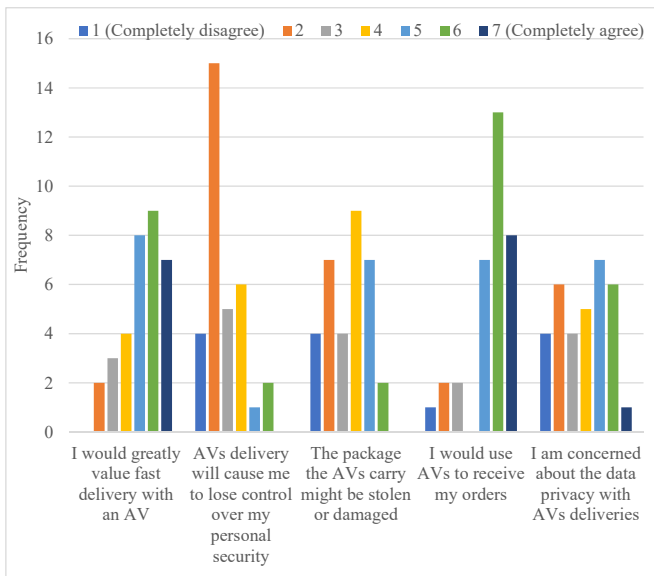


Fig. 7. Perceptions towards Future Deliveries with AV

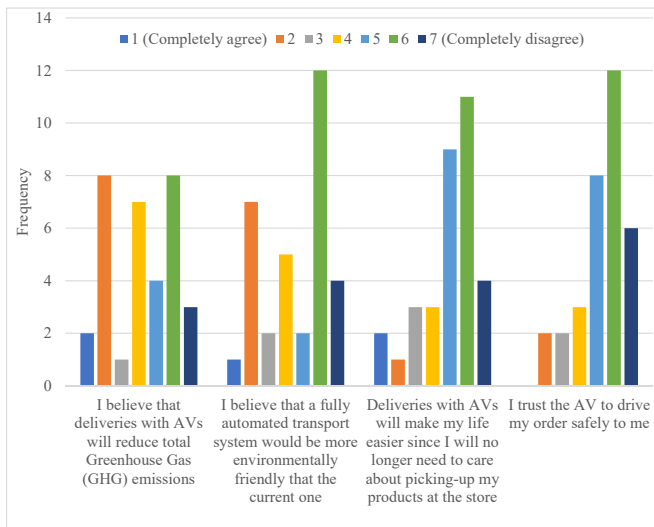


Fig. 8. Perceptions towards Future Deliveries with AV and the environment

The positive attitude of the participants towards the AVs is also confirmed in the results shown in Figure 8. The AVs are highly trusted to safely deliver the orders to the customers. Moreover, they believe that this mode of delivery will considerably make their life easier when shopping is concerned, since they do not have to leave the commodity of their homes in order to pick-up their products.

In the survey, the participants were also asked about the impact of the AV delivery on the environment. In Figure 8, we can see that they mostly believe that the automated transport system would be more environmentally friendly than the traditional delivery system. However, not all the participants believe in such a scenario. The situation is also quite similar in the responses regarding their beliefs that the AVs will reduce

the greenhouse gas emissions. One reason for the skepticism, despite the fact that the AVs are electrically powered, is that they do not see that the growth of the autonomous vehicles will come to a scale that will dominate over the traditional transport, so that AV-based delivery can have any global effect.

IV. DISCUSSION

The results show that the participants generally keep up with the new technologies and are eager to use the latest tech-products. However, for certain products, they still do not use delivery services for on-line purchase as often as it would be expected for a future where most of the purchases will be made on-line. As the participants have never had experience with AV delivery, a certain part of them are unsure about using AVs in their future deliveries, fearing that their packet will be stolen, or that they would have issues with their privacy. The lack of AVs delivery may be a good reason for such attitude, since the customers are not acquainted with the efforts that the companies make to provide the best of the delivery service. One should also note that the average age of the participants is rather high, and hence, different results may be expected from younger generations which have grown with high technologies from their earliest ages. It should also be mentioned that the survey was conducted for only a short period of time and distributed only to a small group of people and their friends with same level of education, which resulted in a relatively small number of participants which is not high enough to represent the global opinion of the general public.

V. CONCLUSION

The AVs are already at our doorways. The companies are intensively introducing them in the delivery services, complying with the increasing demands of innovative and efficient delivery for the E-commerce. From our on-line company search, we can conclude that the companies are keeping up with these demands by offering drone-based and ground-based delivery with AVs. They offer many features such as security, safety, speed, environment awareness and, most importantly convenience, which make them a promising substitution to the tradition transportation for delivery. The same conclusion can be obtained from the survey that we conducted on a small group of e-commerce customers. Most of the participants of our survey accept and strongly believe in the future of the AVs. They think that AVs will make their life easier without fearing their own safety or the safety of the goods they order. They also find the AV delivery more environmental friendly than the tradition one. However, there is still a minority that feels doubtful about the AVs and their benefit. Since the most important aspects for all the participants are good quality/price products, fast delivery and customer care, and at the same time, there are participants that are not convinced about the safety of the products and their privacy, the current and the future companies dealing with the AV delivery services will have to consider offering acceptable prices for a fast service, guaranteeing the safety of the goods, the costumers' data and all the participants in the traffic. At this day, the AVs are

still under doubts by many people, just like the traditional vehicles were less than a century ago. With this in mind, if we go forward to the future, we may be quite sure that AVs will conquer the market of global transportation, leading the modern civilization to next level of progress. .

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