

Challenges of introducing flying drones and creating automated systems for goods and food delivery

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Abstract: Most people still believe that pilotless vehicles flying over our heads and carrying goods is just a fantasy straight out of a science fiction movie. But the world's largest e-commerce companies are in strong competition to control the drone delivery market. As the need for commercial deliveries in the big cities grows, businesses are confronted with a fundamental constraint in surface road capacity. Drone delivery tries to circumvent this limitation by taking advantage of the vertical dimension above city streets. This research investigates the vehicle design components of the delivery drone problem, such as flying efficiency, energy consumption, loudness, safety issues, which are critical to delivery drone feasibility. The qualitative research conducted found that companies are facing challenges like finding size and cargo balance, they are confronting with the problem of writing complex software, the need to optimize for battery consumption or even project costs rise high.

Keywords: drone, drone delivery, parcel delivery, last-mile delivery, autonomous delivery system, law regulation, innovations, COVID-19.

1 Introduction

Today drones are used by many people in different sectors. The number of industries using drones is increasing. One of the main usage areas of drones is food and goods delivery sector [1]. During the COVID-19 pandemic, the demand for food and goods delivery has increased significantly. Customers of delivery companies are wary of using courier services, as this can lead to infection with the coronavirus. At the same time, the food delivery segment is actively developing as well, which is facilitated by both the development of technology and the coronavirus pandemic. However, despite the growth, the market faces a number of problems. Basically, they are all related to the pandemic, which has not only a positive (for this business segment) effect, expressed in an increase in the number of food orders, but also a negative one [2, 3], namely the lack of couriers, people are afraid to work in a pandemic, the couriers themselves become carriers of

infection. Companies trying to cover the increased demand were faced with the fact that traditional delivery methods were not effective, which, combined with increased security costs, made the companies unprofitable [4, 5].

The aim of the present research is to identify the main problems that delivery companies face when trying to implement effective automated courier systems using drones for the delivery of food and other commodities. It is necessary to classify the existing problems that stand in the way of companies and try to find a solution to these problems.

The very direction of delivery of goods via drones is new for business, companies are just beginning to develop automated systems that allow the delivery process to be carried out with minimal involvement of human personnel in this process. [6, 7, 8] In this regard, this research work is of high relevance and may be of particular interest both to companies involved in the area under study and to other researchers interested in the field of delivery. Furthermore, this research aims to figure out the main problems that delivery companies face when they implement automated delivery systems using drones for the delivery of food and other goods. It is important to find out the existing problems that stand in the way of companies and try to issue a solution to these problems. Today main business operators, traders are introducing automated systems for drones to deliver goods and food. The research question is why drone-based automated delivery systems are still not widely used. The research objectives are firstly, to conduct an analysis of existing projects of automated delivery systems. Secondly, to identify, based on the analysis, the stages of their (systems) implementation, strengths and weaknesses. Furthermore, it is necessary to identify the problems faced by companies in the process of implementing their initiatives. And finally, to identify the main factors hindering the implementation of projects.

Today many engineers try to develop a system where drones are controlled automatically [9]. There are some companies in different countries which operate automated visual drone shows. Hundreds of drones are controlled from one system and can result with eye-catching visuals [10].

Of course, controlling drones with one automated system makes it easy and enjoyable, but it may have some difficulties too. If the drone signal is lost it can fall down onto the people, roads or cars; for long-distance deliveries, drones may do not have enough battery to be able to come back or to reach the client. Problems can occur.

By doing this research, some important key points of problems can be identified. Companies that use automated system for drones now, and those who want to start to do business in this sector can benefit from this research paper. Based on these, the results can be used not only by organizations which apply automated system in industries, but also by newcomers, who can implement these methods.

As mentioned before, the number of drone deliveries, especially with automated system raises day by day. So, this sector continuously is challenged by minor and giant problems. By doing this research the problem, challenges will be covered and some potential solutions and recommendations will be given by the interviewees and the researchers.

The following chapters will give an introduction to the world of drones through literature review, the research methods and the interview results will be summarized. Finally, the challenges and problems will be discussed and some recommendations will be given.

2 Literature review

The potential of delivery drones to be an important part of our future trading activities is very high. This issue has become a topic that has been constantly discussed by both the business and academic communities. It's worth noticing that, there are not many works devoted to this area of business, and most of them touch upon solving problems that are no longer relevant or consider mainly the technical aspect of such projects. On the one hand, some authors [5] mainly deal with the aspect of the development of an automated system, the ecosystem of unmanned aerial vehicles, energy consumption issues, etc. However, the aspect of legislative regulation is only slightly affected. On the other hand, authors in their work are devoted to the legislative regulation of the use of drones in the commercial sphere, as well as the creation of a classification that divides countries by levels of legislative regulation [4].

This type of information resources is the primary source, as they give a possibility to track the status of certain projects implemented by companies at the current stage, assess their commercial effectiveness and interest in working with similar projects by various companies which discussed by groups of authors in their works [4, 5, 3]. These sources consider the prospect of introducing automated delivery systems, its role in the logistics system and its impact on the daily life of the urban population. Aspects of the design and technological development of drones are touched upon, as well as the problems faced by companies. An example of such a problem can be the situation with Amazon, when the incompetence of managers ruined a project associated with an automated delivery system using drones [11, 12].

The first studies in this area were conducted by Murray and Chu [13], addressing some difficulties connected to decrease the journey time for drones when they return to the depot. Subsequently, Gonçalves et al. [14] addressed the issue of safety by presenting a safety model which is based on place/transition (PT) nets to demonstrate evidence of drone safety, which is essential in the airworthiness certification procedure.

Given the novelty of this area, the scientific community has not yet managed to form a fairly wide range of fundamental research in this area. Basically, most of

the serious academic work is concentrated in the field of engineering and deals with the design and development of drones, as well as software for them. There are not enough works that affect the development of business in this direction and related problems, and of those works that can be found in the public domain, they mainly affect the legislative side of the issue. The situation is slightly different in information sources, such as the media, private publications and analytical reviews. Such sources are represented by a large volume of articles that are devoted to companies developing automated delivery systems based on drones. However, as a rule, such sources consider the commercial side of the issue and practically do not pay attention to the problems that companies face in the implementation process.

3 Research Method

The research project is planned to include a quantitative and a qualitative phase. For the first phase of the research that is the present research, qualitative method is used. Four in-depth interviews with the organizations using automated system for drone deliveries will be conducted, their responses will be analyzed to evaluate their experience, experiment in order to test their system before and after some corrections. The key research approach is interview with users, system generators, designers and (IT) engineers to find what the real problems they face at present and have already faced lately. Based on the interviews, difficulties and real experiments of using automated system will be explored. Interviews are planned with the designers, IT engineers and system managers in order to learn exactly their experience, obstacles and how they overcome the problems.

The interviewees gave their consent to the interviews, anonymity was ensured, and the interviewers strived to create a pleasant and comfortable atmosphere during the interviewee process. The interviews lasted around 31 minutes and the interviewees previously received the open questions so that they could prepare for the interview.

4 Results

4.1 Demographic profile

Interviews were conducted with 4 representatives of companies which operate in drone delivery sector. Except 1 of them (45 years old), all are 23 and 25 years old young people. All have degrees from higher education which makes us think about the importance of higher education in this field. Three of the interviewees are married. All respondents are at different positions, departments of the companies such as software developer, electrical engineer, engineering designer and CEO. The companies they work are of different ages – aa young company with three years, two relatively young enterprises with 7 and 9 years of age and one mature company were represented.

4.2 Experience with drones for deliveries

The different companies face different problems, that results from their experience in the field and the company's age. The CEO and founder of the investment fund of the company defines problems as they do not carry out engineering tasks themselves, but first of all it is the development of new technologies, as well as application and flight frameworks, flight permission. The company works with high technologies and is specialized in UVL (drones) technologies. As a result of these problems, projects become more expensive and take longer time to complete. The second company which is one of the market leaders in its home country, does IT business, and is also known with food delivery services and taxi services. The representative of the company, who is programmer, says he cannot speak about the design features of the project as these are sensitive data. He finds that there are many difficulties in writing software, problems occur when drones must avoid obstacles, they cannot not get lost on the ground but need to interact with traffic on the road, etc. *"The implementation of all these tasks is a very difficult job even for an experienced team and requires many hours of tests and error correction"* he adds. It is mentioned that, in the final version of the software, it is necessary to cut down on potential working ideas due to very complex technical implementation, sometimes outright churches are used because there are simply not enough resources to implement certain special technologies.

The third interview was hold with a company that makes developments in the field of automated industry. From the interviewee's point of view, who is an electronics engineer, the main problem is to achieve a balance between the size (weight and overall dimensions) of the drone and the cargo that it is able to carry. The size of a drone should not be too large, as its task is to deliver small-sized goods to people. If the drone is large, then it will be impractical to use within the suburban and even more so in urban areas. But it is necessary to design drones so that they can carry enough cargo, which finally, results in an increase in the size of the drone itself. He admits that it is a difficult task. Therefore, the engineers try to make drones from lightweight, but durable material like carbon. As a result, he added, their team managed to design a fairly balanced model. He states that, however, the overall dimensions of the drone are still too large, the model needs to be refined and reduced in size. So far, it is far from working in urban conditions.

The last, the fourth interview was conducted with a specialist of engineering design of a company which develops drones for the needs of the Russian business and government. He finds several problems the company faces in the process of developing new products, technical difficulties arise both at the design stage and in the process of direct implementation. Often there are problems with fuel cells, the weather conditions hinder the developments, since it is cold in winter in Russia and very hot in summer so it is rather difficult to choose a fuel element that can provide the necessary amounts of energy so that it does not refuse in winter and does not overdo it in summer. In order to solve this problem, the company is

implementing a system in drones that cools the batteries in summer and warms them in winter.

Concerning legislation concerns, most of the interviewees mention that there are direct effects of legislations on the companies and projects. Especially in case of personal data protection and personal information case, governments are too strict, which makes situation extremely difficult for the companies. The electronic engineer (third company) mentions several security and legal problems, i.e. the delivery drone is not currently able to work in urban environments because it is too large, it cannot fly at an acceptable height; the modern urban infrastructure is not yet ready for such changes, and, moreover, there is also potential security and safety issues like the threat of hackers hacking their drones. Therefore, their country's legislation to try to protect the citizens, does not allow the implementation of such projects at the moment.

While the CEO of another company operating in Russia, also mentions that in Russia, the situation with legislative regulation is not yet the most difficult, but the clients face a large number of difficulties. For example, in Moscow, it is not possible to just launch a drone without special permission, and in the case of commercial use, one has to go through complex bureaucratic procedures, e.g. each drone must be registered.

The pandemic situation's effect cannot be excluded from questions. Each interviewees accepted that the pandemic situation had a positive impact on the drone related companies. Interest in the projects as a whole increased with the onset of the covid pandemic. People were afraid of contacts with couriers because they did not want to get accidentally infected, many couriers were also afraid of catching an infection from clients, so projects, which were aimed at minimizing human personal contacts and encouraging contactless deliveries became especially relevant during this period. While for programmers, the pandemic brought more work and business, the demand for a variety of remote services, including delivery, has significantly increased. The company's management managed to attract more employees to implement projects in this industry, including drone delivery projects as well.

Regarding the competitors in the sector, the interviewees believe that because of the political environment and the legal regulations these companies don't have serious competitors at the moment. The CEO of the company operating in Russia has mentioned Yandex as their main competitor, even though Yandex is currently developing a ground-based version of the courier drone [15]. Another competitor, Wildberries, was mentioned which is developing large-sized delivery drones. These are large companies, with large resources, and accordingly, they have more opportunities. The CEO of other company states that the competitors are mostly from China, for example DJI.

On responding to questions on mass promotion and related problems the CEO of the company from Russia responded that *"The demand for courier drones is*

growing now, but it still does not make up the bulk of companies' revenue, but it's expected to change in the near future. Now the growth of interest is observed not only among private companies but also among government agencies, for example, the Russian post". The software developer mentions their rule such as corporations are not willing to replace business processes that are understandable to them with new ones. In the other two companies, they have not started to work busily on this mass promotion as they are still in the test period and the company plans to deal with mass promotion after the testing and pilot phase is completed.

Interviewees were asked how they see their partners' and people's reaction to these projects. In general, all four interviewees mention positive feedback and high interest from partners, customers and people in general. *"But still some ordinary people do not really like it when drones fly over their private areas, but our company works on it"* stated by the specialist in engineer design.

The last question was related to safety issues, especially in the urban areas. The interviewees all mention that it is one of the most difficult problems in the implementation of such projects. From an engineering point of view, it is not so difficult to make a safe small-sized drone model, the technology is quite developed, but from programming point of view, it is difficult, especially considering the fact that the drone will have to work autonomously. Therefore, protection systems are integrated into the drones in case they run out of charge or go off course, these drones must find a place to land where it is safe and must wait for a specialist technician there. While the CEO frankly admits that no one has an absolutely safe solution right now, drones may break down right in the air, they may bump into obstacles, there may be a malfunction in the system, or they might be hacked. The company can only make the drones as safe as possible; the company strives to implement the maximum safety and security possible at present. It is exactly like with cars, they can get into an accident for a variety of reasons, they can crash or simply break down, these problems make them a dangerous invention for humans. However, they are used in our everyday life.

5 Conclusion

Based on the interview results the following challenges can be summarized related to the mass introduction of drones in delivery services, especially in rural and urban areas (Figure 1).

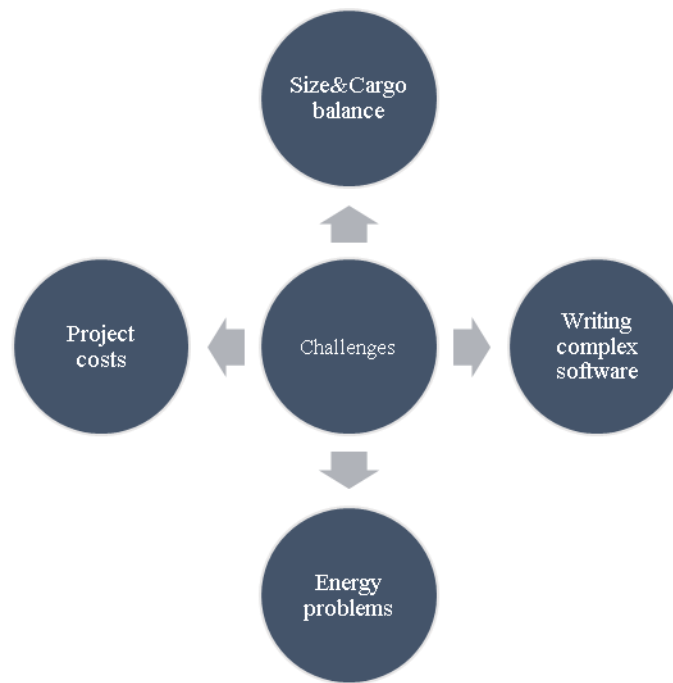


Figure 1 Problems of developing a delivery drone

A number of problems that were identified as a result of the interviews has already been touched upon in scientific papers. For example, the issues of managing groups of drones and creating a group AI for them were studied by Mustaev [16]. If the opposite approach is considered, then it is worth paying attention to the work of Krasovsky et al. [17]. However, a number of issues currently faced by engineers developing automated delivery systems have not yet been addressed by the scientific community. This can include such problems as balancing the size of the drone and the load it can carry, in general, this is a rather complex area that includes both problems with energy consumption and the development and implementation of new materials.

However, if we talk about the issue of energy consumption, then in related areas (the use of drones in agriculture) research is already underway on this issue, and here it is worth paying attention to the work of a group of authors, Simdyankin et al. [18] or Wang et al. [19] or even [20]. But at the moment it can be stated that the available scientific work on the above problems is further to improve.

In this paper we analyzed the drawbacks and the benefits of using drones in the delivery process in urban areas. We conducted interviews with four companies. Companies mentioned several problems which they face. They are about difficulties of writing software, fuel cells, balance between the size of the drone and the cargo, costs of projects.

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