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To cite this article: I V Kovalev *et al* 2019 *J. Phys.: Conf. Ser.* **1399** 055095

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Analysis of the current situation and development trend of the international cargo UAVs market

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Abstract. The article presents analysis of the current situation and development trends of the international UAVs cargo market. It is shown that the UAVs market has made a transition from a stage of studying technologies to commercial operation and implementation of finished products. Nowadays it is at the stage of rapid growth. However, a global market for cargo UAVs and commercial services on their basis for transporting bulky goods is still at the early stage of commercial development. At the same time, the trend for the development of cargo UAVs with the large carrying capacity corresponds to the analysis results of the global air cargo market.

1. Introduction

First of all, it should be noted that the civil sector of the world unmanned aerial vehicles (UAVs market), as well as markets of separate countries, is still being formed [1]. It is at the development stage, so-called “primary concentration”, characterized as *immature*. The next stage of the development is 2022–2025. Their main features will be large-scale application of drones for commercial purposes, and the expansion of their functionality. In this regard, the participants in this market will find solutions for new problems. In particular, market regulators should be “adapted” to the new reality, and manufacturers should develop technologies that maximize the efficiency of drones.

Also it should be noted that such problems as insufficient primary data due to the limited free access to reports of specialized organizations, as well as significantly different sources of assessments of the state and development of this market makes conducting study of the global civil drone market difficult.

For example, BI Intelligence analysts [2] presented a report on the growth of the commercial drones industry. The authors note that drone technology (Drone/UAVs technologies) continues to improve rapidly. It is obvious that gradually unmanned aerial vehicles may become the mainstream in various branches of industries. The developed UAVs regularities helped the United States, Europe and China to become the three largest potential markets for the commercial application of drones in the world. For example, the US Federal Aviation Administration (FAA) regulates flights of all commercial and consumer unmanned aerial vehicles. Some states have their own regularities in accordance with companies deploying unmanned aerial systems must operate. In Europe and in the USA, a lot of national regularities have been developing due to the absence of all-European regularities regarding the unmanned aerial vehicles. In China, the military controls more than half of the airspace, limiting the



application of unmanned aerial systems in the small part of the country. It is significantly less compared to the United States and other European countries.

It is characteristic that the legislation on the application of commercial unmanned aircraft systems in most leading countries is changing, providing wider opportunities for such systems application in the coming years. It allows operators to operate their unmanned aircrafts in new areas of airspace and in new technological conditions.

2. Trends in the international UAVs market

It is instructive to consider the trends in the international UAVs market that were formed in 2016 with a view to 2020 [3].

1. The key factor concerning the growth of the UAVs market is civil consumers. It is expected that the annual growth of the commercial drone market will be 19%, and the military drone market will be 5% by 2020.

2. The military sector will continue to dominate on the purchasing drones. Among the reasons are the high prices for military UAVs and the growing number of countries that would like to purchase these devices.

3. The well-known developers with the experience in the production of military drones will not have special advantages in the civil UAVs market. Nevertheless, these companies will try to implement their technological achievements obtained in the development of military UAVs market with the large-scale demand. For example, there exist plans to enter the civilian market for Aerovironment, known for its developments for the US military.

4. Multicopters are gaining an increasing market's share. At the same time, the interest in tailsitters, as systems combining the advantages of the "aircraft" and "multicopter" schemes, is gradually growing. A tailsitter is a vertical take-off drone that, once in the air, turns horizontally and flies like an aircraft-type drone. For landing, such a drone returns to a vertical position again and lands on special "edges" extending from the wings and tail, which serve as its support. This device is distinguished from convertiplanes by the absence of rotary elements. According to DroneDeploy, drones with a fixed wing are used only in 6% of cases, losing to multicopter.

5. The boundaries between professional and consumer UAVs started to narrow. The average price for all types of devices shows a decline that will continue in the coming years.

6. The approaches to the implementation of such systems that would allow monitoring UAVs in the airspace are planned. In the USA, DARPA commissioned the development of the Aerial Dragnet System which should allow monitoring small drones in the airspace over cities. Initially, the system will help to protect the US military, conducting military operations out of the state in urban environments. In future, the system is planned to be used in the interests of power structures in the United States. The topic is being actively studied in other countries. The problem is that the use of the existing air traffic control systems is difficult, both because of the small size of most UAVs and because of the expected rapid increase in the number of UAVs due to the insufficient automation degree of traditional systems.

7. A trend is determining for the use of "connected drones". Such devices constantly communicate with the "cloud" via the LTE/5G cellular network. This creates the basis for processing the collected data, including video streams in near real-time mode, as well as for transmitting the information about the world around it to the UAVs. Mass plugging in of UAVs to LTE/5G networks will require some modernization of cellular communication networks, from the development taking into account the prospects for mass service of UAVs. A lot of mobile operators are already working in this direction.

8. The necessity of such a restriction on the UAVs application as "direct visibility" between an operator and an object is questioned. The cancellation of this requirement or the simplification of its obtaining for commercial application of UAVs outside the "direct visibility" cannot be ruled out. The FAA is considering eliminating restrictions associated with flying over people and the need to keep the drone out of sight.

9. A trend for the increase in the market share of compact drones, including pocket and folding models is forming.

10. The automation is growing in the field of launch and maintenance of UAVs. In particular, fully automated systems for their launch and maintenance are appearing. Such systems are effective for automating repetitive processes, for example, patrolling drones, using UAVs for regular monitoring of crops, etc. The concepts of automatic UAVs recharging during flight missions are being developed.

11. A trend is forming for the application of additive manufacturing technologies (3D printing). The use of 3D printing is noted not only for the development of drones and for their production.

12. A number of UAVs application areas are distinguished by the largest demand for services using UAVs. The global market for commercial UAVs is formed around the following areas: agriculture, energy, oil and gas, utilities, construction, real estate, news services. We can also note the promising sector of UAVs application by emergency services.

13. It can be stated that e-commerce and the delivery sector are not becoming the central driver of UAV a market growth. Earlier, this segment was associated with high expectations due to the interest in it from a number of global companies, such as Google and Amazon [4, 5].

14. In the coming years, the advanced countries should complete the formation of the main packages of laws regarding the UAVs application. However, due to the rapid development of technologies (for example, producing UAVs for transporting people, cargo UAVs, etc.), the legislation will continue to be amended.

15. The technological barriers today simultaneously limit the market and create new business opportunities. For example, developments in the field of artificial intelligence and specialized sensors support and expand the UAVs industry. The technologies such as geofencing and automatic collision avoidance make flying drones safer and allow regulators to reduce their fears about the appearance of a multitude (swarm) of drones in the sky.

16. The investment growth into the UAVs industry is observed. Although this industry is still new, it is starts to attract serious investments from major players, including chip producers and defense departments.

17. UAVs create the competition for the existing market segments, for example, they introduce themselves into the segments that currently serve satellites and manned aircraft. The demand for high-quality aerial survey data is growing, and the market for geographic information services is being formed.

18. It is also peculiar that a large-volume market is being formed for the UAVs detection and counteraction systems, of the military and civil purposes. According to Reportbuyer, a global anti-drone market will grow to \$ 4.5 billion by 2026. The average annual growth will be 29.9% from 2019 to 2026. The trend is facilitated by an increase in cases of heterogeneous violations associated with increased availability and improved capabilities of consumer devices.

19. The borders between military and civil UAVs disappeared. The application of military UAVs in the interests of civil services (emergency rescue services, environmental services) is noted. There have been a lot of cases of civil UAVs application for military purposes. Civil UAVs are produced with parameters similar to military ones. They are UAVs with the possibility of a long stay in the air, the ability to move to a great distances from an operator.

20. Currently, modular UAVs are produced. They can be assembled in different configurations "for a certain purpose" from standard modules.

So, it can be stated that the commercial market for drones of various applications has formed only in the previous 3-4 years, while military drones have been used for much longer. Drones have been actively applied for photo-video filming, cartography (geodesy), monitoring (video surveillance), agribusiness, media and media, etc. In general, the UAVs market has made a transition from the stage of studying technologies to commercial operation and implementation of finished products and it is currently at the stage of rapid growth.

3. World Cargo Drones Market (CUAVs)

The world market of cargo UAVs (CUAVs) and commercial services based on their basis for goods transportation is also at the early stage of commercial development [6]. However, according to J'son&

Partners Consulting, a total number of CUAVs will be about 9.5% of the total global market for commercial UAVs (a number of the sold drones) by 2020. In value terms, this is about \$ 1.4 billion by 2020. The global market for CUAVs -based services will exceed the drone sales market in several times by 2020.

According to J'son& Partners Consulting, more than half of the foreign offers of cargo drones in the world are ready for commercial sale (56% on sale, 44% in development). According to the forecast of the Russian AERONET Association for the period until 2035, delivery by drones in cities will bring up to 55 % of all revenues of companies/operators operating CUAVs (45% is delivery in rural areas).

Multicopter dominates in the structure of CUAVs portfolios of foreign manufacturers; it accounts more than half of all offers (55%). Glider drones takes the second place (31%). Small multicopters are currently the main offer on the market due to their lower cost and acceptable flight range and carrying capacity for transporting small cargo.

The general market trend is the modified application as CUAVs, combining flight performance and airframe efficiency, as well as maneuverability and ability to take off and land, inherited from multicopters.

The technical characteristics of CUAVs offered on the market can vary greatly even within similar types of UAVs. The values spread of the flight range, carrying capacity and cost of devices can reach multiple values.

A turn hovercraft (a propeller plane) is an aircraft with rotary engines (usually propellers). It operates as lifting, and in horizontal flight as pulling in taking off and landing; while the lifting force is provided by the wing of an airplane type. Typically, motors rotate with the screws, but it is possible that only screws can rotate.

Functionally, this design is close to a vertical take-off and landing aircraft (VTOL), but usually modified aircrafts are classified as rotary-wing aircraft due to the design features of the propellers. Convertible aircrafts use light-loaded, low-speed propellers close to helicopter propellers and allowing the device to fly in helicopter mode, i.e., with a small angle of the propellers rotation. Large propellers of convertible aircrafts, comparable to the wing span, help it in vertical take-off, but they become less effective compared to the smaller-diameter propellers of a traditional airplane in horizontal flight.

Nowadays, the USA operates commercial V-22 Osprey convertible aircrafts with a flight weight of 27.4 tons and a maximum flight speed of 509 km/h in aircraft mode and 185 km/h in helicopter mode.

The development and application of convertible aircrafts characterize a very important aspect of the operation of cargo CUAVs. This is an opportunity to take off and land in not equipped areas with special runways, or on runways of very short length and without special hard cover.

It should be noted that aircrafts of AN-2 type and its modifications have this capability. This makes it possible to create CUAVs based on them, which are practically not inferior to convertible aircrafts in terms of characteristics, but which are significantly more reliable, since they have no nodes for turning engines (screws) and transients from one flight mode to another (vertical/horizontal flight).

In the USA, a startup Natilus set an ambitious task of developing jet drones capable of flying across the Pacific Ocean. They are assigned the role of cargo carriers, the delivery with their help will be cheaper than the transportation by manned aircrafts, but more expensive than by aircrafts, especially by unmanned aircrafts.

In [7], it is noted that the interest in the application of CUAVs is due to economic efficiency. According to experts, the cost of one hour of aerial operations with the equipped AN-2 aircraft in the interests of agricultural consumers exceeds the cost of an hour of a half-pilot version of this aircraft almost twice. In addition to financial benefits, the application of unmanned aerial vehicles is advisable where there is a threat of harm and a threat to life for personnel, and also, if it is necessary, as quickly as possible to send help to those in need.

Table 1 presents the types of CUAVs, their advantages and disadvantages. The following versions are presented:

- with a fixed wing (airplane type);
- with a rotary wing (convertiplane);

- unmanned helicopters;
- multicopter.

Table 1 shows that at present there is no unequivocally better version of CUAVs for use in order to deliver goods. Each of the presented types should be considered to solve a specific logistic problem.

Table 1. Advantages and disadvantages of various types of CUAVs

Type of the UAV	Advantages	Disadvantages
With a fixed wing	Long range Durability Low cost Efficiency	Significant take-off and landing space Low maneuverability
Unmanned helicopters	Vertical take-off Maneuverability High payload	High cost High Service Requirements
Multicopter	Vertical takeoff Simple start-up Low weight	Low payload Short flight time Wind susceptibility
With a rotary wing	Combination of advantages of UAVs of the first and second type	Technological complexity High cost

In addition to the CUAVs type, as a rule, various versions for the engines used there are considered. Nowadays, in the civil sphere of CUAVs, mainly electric motors and internal combustion engines are used. Electric motors are environmentally friendly and they have no loud noise. Their peculiar feature is low cost of recharging the battery. However, among the disadvantages one can point out weight of the battery and a short flight range without recharging. Accordingly, internal combustion engines are distinguished by the possibility of a long flight range, simplicity of refueling. At present hybrid engines for CUAVs are also being developed.

It should be noted a gradual shift towards the use of unmanned aerial systems (UAS) if we talk about the development trends of intra-regional air cargo. Experiments in this area, among others, focus on the delivery of goods to hard-to-reach areas. For example, such a task is actual in Russian conditions [7], taking into account the relatively low population density in certain areas. In this regard, the analysis of the most effective ways of solving this problem is currently required.

So, today a lot of companies are engaged in research in the field of mail and small cargo delivery using drones. It is considered that such devices will quickly deliver their packages to customers. However, all drones are tested currently and they are not capable of handling bulk cargoes.

Speaking about the development of weight-lifting ability of CUAVs, it is worth noting the project of the German Aerospace Center (DLR), which began to develop a new large cargo unmanned aerial vehicle [8] that will be used for cargo delivery to areas affected by natural disasters, as well as for urgent transportation of spare parts. According to AviationWeek, the aircraft will fly at low altitude in a single airspace.

A new transport UAV, developed by DLR, will be able to deliver various cargoes weighing up to one ton. It is planned to develop a new aircraft in the coming years. In addition to participating in humanitarian and rescue operations, the drone is planned to be used in regular cargo carriage. Technical details about this new aircraft are not known yet. Probably, it will be a hybrid drone capable of vertical taking-off, landing and horizontal flight as an aircraft. The device will apply several noise reduction technologies, including additional landing gear fearing and flow swirls. These devices will be tested on a passenger aircraft A320.

It is important that in simultaneously with the development of the drone, DLR will study the technical capabilities of embedding the device in a single European airspace.

Russian companies RTI “Aerospace Systems” and “Tiber” have agreed to develop a heavy class unmanned aerial vehicles (UAVs) for monitoring the Arctic shelf. This was reported by the press service of "Tiber" at the exhibition RussiaArmsExpo (RAE). We are talking about the joint work on a complex with heavy CUAVs of the aircraft-type weighing one and a half tons. The drone will have a large range and flight duration for 4 thousand kilometers and 35 hours, respectively. The development will be equipped with an automatic control system SAU-9.1 that includes a pilot system, an on-board computer and the equipment of the latest generation.

4. Analysis of the state and development trends of the air cargo carriage market

The development of heavy CUAVs conforms to the analysis results of the global air cargo carriage market [7]. Precisely air cargo remains one of the drivers of global trade growth in recent years. In many respects, the dynamics of these rates depends on the level and growth rates of the economy of the corresponding regions.

The intensification of world trade and the ongoing processes of globalization lead to the increase in demand for carrier services at the global and regional levels (see figure 1, compiled by the authors of [7] based on IATA [9-11]).

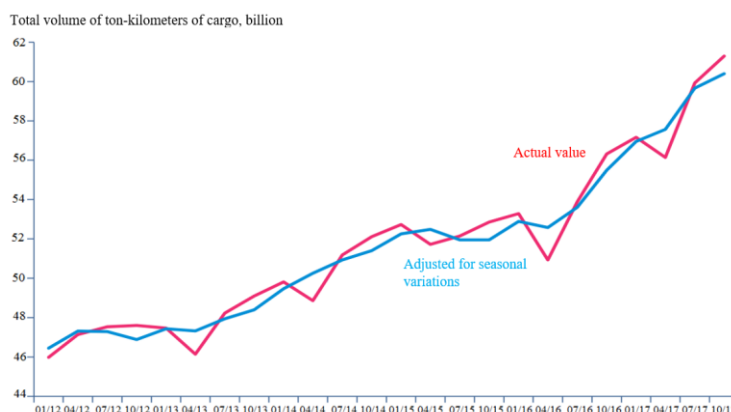


Figure 1. Dynamics of ton-kilometers of the world cargo carriage (based on IATA data).

According to the International Air Transport Association (IATA), over the past five years, the volume of cargo has increased from 48 to 62 billion ton-kilometers, i.e. by 29%. At the same time, the growth rate in recent years has increased markedly, only from April 2016 to October 2017 the studied indicator increased by 21%.

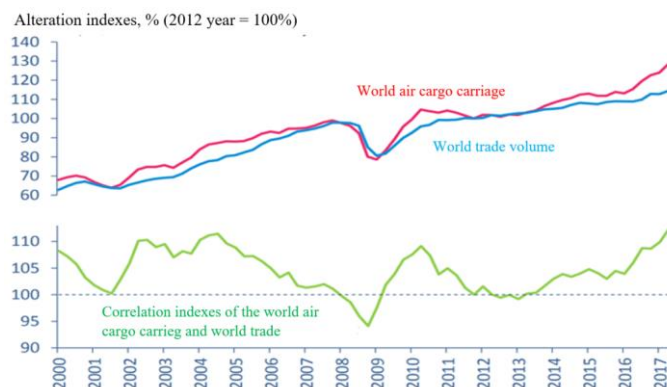


Figure 2. Comparison of indicators in the world trade changes of air cargo carriage (based on IATA).

According to experts, by the beginning of the 2020s, the volume of cargo carriage could double. It is predictably that cargo carriage growth indicators are closely related to world trade growth indicators, as it is shown in figure 2.

However, in figure on the basis of IATA data [9–11], graphs 2 demonstrate the growth indicator of air cargo and cargo carriage tends to exceed the growth indicator of world trade [7]. Due to higher growth rates, global air cargo carriage increased by about 30% compared to 2012, while world trade grew only by 15%.

The processes mentioned above are not equally significant for all regions of the world, and their intensity largely depends on the level of development and growth rates of the respective economies. The highest growth rates of air carriage are forecasted in the regions of Europe and the Asia-Pacific region.

According to airport sites in November 2017, the largest increase in air cargo carriage was observed in Shanghai (+10.9%), Miami (+8.3%), and Seoul (7.1%) annually. Cargo turnover was declined in Los Angeles (-1.3%) and Abu Dhabi (-2.6%).

Along with trends in increasing demand for air carriage services, a gradual consolidation of participants in this market is observed. The increased competition and the decreased rate of return lead to the need for cooperation between various transport companies, freight forwarders, courier services, etc.

In these conditions, companies from various countries, both European and Asian, and Russian companies (airports, air carriers, etc.) need to find opportunities for deeper integration into the global air cargo carriage system.

5. Conclusion

The analysis of the international air cargo carriage market shows that they are one of the drivers of world trade growth and in recent years have been growing at a faster growth rate. This explains the emerging trend today, aimed at creating high-capacity CUAVs. It is shown that some aircraft-type CUAVs do not concede in characteristics to convertible aircrafts, i.e., they have the ability to take off and land in areas not equipped with special runways, or on runways of very short length and without special hard cover. Moreover, they are more reliable, since they do not have nodes for turning engines and transients from one flight mode to another. In many respects, the interest in using CUAVs caused only to economic efficiency, but also to the possibility of using unmanned aerial vehicles where there is a threat to life for people, as well as providing operational aid to people in emergency situations.

Acknowledgments

The authors are grateful to the China Aviation Industry General Aircraft Zhejiang Institute Co., Ltd for supporting this study and creating favorable conditions for research.

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