Transport and logistics hub for unmanned aircraft

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Abstract. The problems of a transport and logistics hub and its technical equipment for cargo receiving and sending by remoted-piloted vehicle unmanned aircraft are explored. The advantages of remoted-piloted vehicles using for multimodal transportation are shown. The general information of the necessary equipment for landing fields and cargo terminals are provided. The principles of an intelligent dispatch system with a dedicated module as part of the transport and logistics hub are outlined. Recommendations of the introduction of multimodal transportation in commercial exploitation are presented.

1. Introduction
In order to ensure rapid goods delivery to remote regions, air transport is used. In foreign multimodal air transport systems, specially designed cargo containers are used [1]. That makes it possible to maximize the using of the aircraft dimensions. The production of special aircraft containers is due to the fact that the cargo capacity of the aircraft is not always fully utilized. The transportation of goods that have a mass significantly, less than the mass of the container is widely used. Pallets are used to combine cargo and to simplify handling operations.

In order to receive and process cargo following the Russian part of international transport corridors, multifunctional transport and logistics centers are created in large transport hubs and seaports that ensures the integration of goods, information, service and financial flows [2]. Creating routes for multimodal transportation requires a comprehensive solution at the level vehicle-infrastructure and various approaches to the many related issues. Multimodal transport hubs will make it possible to solve both tactical tasks for coordinating the work of all participants in the transport process and strategic tasks related to the modernization of the existing transport system. However, for the mass round-the-clock and year-round air transportation, especially to hard-to-reach areas, it is necessary to increase the number of runways, equip them with specialized equipment and prepare the corresponding number of flight crews.

Currently, there is scientific knowledge and tools for the development of fully autonomous vehicles worked without pilots in any situation. When massively used, these vehicles can create tremendous economic and social benefits. Solving the problems of transporting goods to hard-to-reach areas will allow to solve economic and social problems.

One of the advanced technical solutions is hybrid unmanned aerial vehicle of vertical take-off and landing [3, 4]. Vertical take-off and landing are provided by four propeller groups with electric motors and propellers made of composite materials, which work in quadcopter mode. Propeller groups are attached to the wing, which is attached to the fuselage in the center of mass. The mid-flight engine with a propeller is located in the front of the aircraft and provides flight in cruise rating. The wing provides high
aerodynamic quality and the necessary lifting force in horizontal cruise flight. The control devices provide control of the aircraft in an airplane flight mode. In quadcopter mode, control is carried out by adjusting the speed of the lifting propellers.

Thus, for the widespread introduction of multimodal transport by unmanned aircraft, it is necessary to study the structural and functional solutions for creating a ground-based complex, including an equipped landing field, a cargo terminal and an operational control unit connected to an intelligent transport system.

2. Structural elements of the transport and logistics hub

2.1 Landing fields and cargo terminal

Under these conditions of the legislation of the Russian Federation, unmanned aircraft can only be operated from helicopter aerodromes.

The dimensions, surface evenness and ways to the landing field have the dimensions shown in table 1.

| Field elements | Size of landing field elements, m |
|----------------|----------------------------------|
|                | Over 15 tons                     |
|                | 5 to 15 tons                     |
|                | Less than 5 tons                 |
| Total area     | 80 x 80                          |
|                | 50 x 50                          |
|                | 35 x 35                          |
| Working area   | 20 x 20                          |
|                | 20 x 20                          |
|                | 15 x 15                          |
| Safety zone    | 30                               |
|                | 15                               |
|                | 10                               |

Landing fields are intended for take-off and landing by helicopter can be located both separately and on the territory of existing airfields. The organization of joint flights of aircraft and helicopters is governed by the instructions for the production of flights at this aerodrome.

Maintenance of landing fields in the operational state is carried out either by the aerodrome service, or by the operator’s aviation personnel at separately located landing sites. In this case, the person responsible for the maintenance of the landing field is instructed in a certified aerodrome service and is allowed to perform duties by order of the head of the airline.

The immediate advantage of using helicopter airports is wide distribution throughout the Russian Federation. In addition, according to the law, it is possible to organize temporary landing fields, which is convenient in difficult-to-reach areas [5].

The Air Code of the Russian Federation obliges the appointment of an unmanned aircraft commander who manages the crew of an unmanned aircraft and is responsible for the safe execution of the flight. Thus, the commander must be present indirectly at all landing sites, which are points of recept and transfer of cargo.

The number of technical crew at the landing field is calculated according to the standards, based on the necessity of control of the take-off and landing of the unmanned aircraft, maintain the technical support of the landing field in good condition and load and unload the goods [6].

To optimize labor costs, it is proposed to perform a cargo terminal robotic with the following functions:

- automated reception and storage and delivery of goods;
- automatic formation and stacking of transported goods in a container;
- providing landing and take-off;
- collection and transmission of air navigation data;
- collection and transmission of weather data;
- placement of equipment for an accurate positioning system;
- communication and data transfer to the ground control point of flights;
- providing refueling / charging unmanned aircraft.
To perform its functions, a robotic cargo terminal needs hardware and software compatibility with remoted-piloted vehicle.

2.2 The intelligent dispatching system

The intelligent dispatching system produced by KNITU-KAI, provides for the collection of information from individual elements of the infrastructure, including cargo terminals. Other functions are ensuring stable communication; comprehensive data protection; formation of flight tasks; optimization of solving logistic problems; route calculation; solving external navigation problems; data transfer between unmanned aircraft [7, 8].

An intelligent dispatch system has two modules: administrative and flight control. In the field of controlling of the unmanned aircraft flight, the following tasks are solved:

- automated formation and delivering of the flight mission;
- control of the flight mission;
- automated monitoring of the cargo terminals;
- automated monitoring of the landing fields;
- cargo logistics;
- predicting the time of arrival of an unmanned aircraft at its destination;
- planning of maintenance of unmanned aircraft.

Communication and digital data exchange is provided in the radio segment, providing communication in the line of sight to 100 km; ground segment, using existing 2G \ 3G \ 4G and promising 5G digital data channels; space segment using satellite transponders, providing continuous transmission of telemetric information. Telemetry information is transmitted from the board to the ground, including an assessment of the state of the onboard systems, its spatial position, motion parameters, and visualization of the environment surrounding the unmanned aircraft.

Data security is ensured by the identification, authorization and authentication of participants in the data transfer process, automatic data encryption, secure management of encryption keys. This keys that are used to protect information when transmitting data, data in an unmanned aircraft control system, and protecting access to the payload.

The intelligent dispatching system manages the life cycle through the collection, systematization and analysis of information on the condition of unmanned aircraft, landing fields for predicting the technical condition and predictive maintenance.

The efficiency of the intelligent system can be estimated through the cost of transportation

\[ F(C) = \min F(t_{\text{flight}}, L, t_{\text{operation}}), \]

where \( t_{\text{flight}} \) is the flight time of the unmanned aircraft; \( L \) is the length of the route; \( t_{\text{operation}} \) is the operation time for loading and unloading operations, transportation, refueling / charging of an unmanned aircraft, etc. It should be noted that the time of pre-flight, after-flight preparation, maintenance work on an unmanned aircraft, are not optimized.

Thus, an intelligent dispatching system is the main element of the cargo transportation process, as it provides informational support for all stages of cargo transportation from the client to the destination, including information about contracts and includes templates of waybills available to users, and has a simple mechanism for evaluating its effectiveness. In each separate transport and logistics hub, a dedicated module of the intelligent dispatching system operates. The settings of module takes into account the geographical location of the landing field, the capacity of the cargo terminal, statistics and the specifics of the goods carried.

3. Results and discussion

As a result of the research, generalizations were made from the already known experience in the practical implementation of multimodal transportation of goods and after analysis the following recommendations were made:
Currently, a market for unmanned vehicles of various transport categories has been formed with the possibility of transporting goods from 1 to 50 kg. This greatly facilitates the organization of the cargo process. According to forecasts, the unmanned aircraft market will increase along with an increase in the volume and weight of cargo carried. Therefore, the next task is to find potential customers for the organization of profitable cargo transportation routes, taking into account the current and potential capabilities of unmanned aircraft;

- The possibility of commercial operation of unmanned aircraft directly depends on the availability and quality of dedicated communication channels for coordinating and controlling the movement of unmanned aircraft;

- The required dimensions of the landing fields for the developed unmanned aircraft are much smaller than the approved helicopter fields. This is primarily due to the lack of an appropriate regulatory framework. Therefore, it is necessary in the near future to begin work on codes of laws, similar to that which regulates the work of air transport;

- For the successful operation of unmanned aircraft, it is necessary to quickly re-equip the landing sites with the means and modules of intelligent dispatch systems, similar to the intelligent ground cargo transport system.

4. Conclusions

Unmanned aircraft has a great commercial potential, not fully realized at present. The area of multimodal cargo transportation is a market where unmanned aircraft can occupy significant positions, and owners of transport companies with a fleet of unmanned cargo aircraft have high profits. At the same time, organizational issues regarding the introduction of unmanned aircraft in multimodal transportation have not yet been resolved. However, the creation of the transport and logistics hub described in this work will make it possible to overcome some of the existing barriers.

Reference

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