AVIATION TRANSPORT

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THE DEVELOPMENT OF A CONCEPT OF AN UNMANNED GLIDER-TUG - PART 1

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Abstract*—The article presents the development of the unmanned glider tug project, a description of the stages of a new technical solution, submitted to the patent office in December 2017 and developed to date. The proposed towing system consists of a universal drone ground control station and a tugboat rigidly connected to the sailplane. The proposed solution is aimed at reducing operating costs and limiting the number of people necessary to service sailplane flights.*

Index Terms—Unmanned aerial vehicle; tug; sailplane model; lift force distribution.

I. INTRODUCTION

The unmanned aerial vehicle (UAV) market is one of the fastest growing sectors of the economy. Apart from the USA and Israel, Poland is one of the world leaders in designing and producing UAVs. According to independent sources, in terms of the value of turnover in this sector of the economy, we are in third place in the world. There are about 4,000 companies producing entire systems or their components. The European Commission forecasts show that civilian unmanned vehicles will constitute 10% of the global aviation market in ten years [2].

Drones used for cargo transport are intensively developed in the world. Many companies are building this type of drones, including the Ritex company from Lower Silesia. Another potential application of this type of machinery is the transportation of medicines in case of emergency or the provision of important documents [3]. The time of their transport can be shortened several times, depending on the terrain. Drones are already used to coordinate rescue operations in the event of natural disasters. Another company that stands out is UAVS Poland Sp. z. o. o producing BSP Aquaila. Aquila is an unmanned helicopter weighing 32 kg with a lifting capacity of 10 kg. It is a fully autonomous drone that performs its own vertical take-off, flight along a defined route and vertical landing. The proprietary "antenna-tracker" system allows you to maintain communication with the drone at a distance of even several dozen kilometers. The main equipment of the Aquila is an observation head with a thermal imaging camera, a classic day camera and a laser rangefinder. The image is both recorded by the camera and transmitted along with the sound in real time to the ground base at a distance of up to 30 km. The drone is able to stay in the air for about 2 hours and its maximum flight altitude is 1500 m. The main rotor blade span is 2 m. Aquila can be used by land surveying companies for terrain imaging or, for example, companies from the energy sector to inspect transmission infrastructure [4].

The construction of the BIRDIE modular powered-lift, developed by FlyTech UAV, established by graduates of the Rzeszów University of Technology, is also very interesting (Fig. 1).

Fig. 1. BIRDIE drone developed by Flytech UAV [5]

The BIRDIE is an airframe-based drone with a rear push engine equipped with optional modules that allow to change the configuration to a vertical altitude. A novelty in the world is the possibility of switching from fixed-wing to VTOL configuration using the attached module. The flight time in the aircraft configuration is 60 minutes, in the VTOL configuration it is 40 minutes. It was developed primarily with photogrammetry in mind. The basic equipment of the drone is a visible light camera, but other equipment can also be installed on board, e.g. a multispectral or thermal imaging camera. Thanks to such equipment, BIRDIE is perfect for mapping the area, creating its 3D model and topographic maps, after installing a multispectral camera, it can be used, for example, in agriculture to assess the vegetation state of agricultural crops or in forestry - to test the quality of the stand. On the other hand, the use of thermovision will prove useful in technical inspections of infrastructure, e.g. gas pipelines, or in mining - when tracing gas leaks underground. The BIRDIE drone is relatively light (2.5–3.9 kg depending on the configuration) and with a small span (1.4 / 1.8 m), which allows for easy hand-take-off [5].

A new hoverbike concept has also been developed in Poland. In 2016, Skynamo Aerospace presented the Hoverbike Raptor (Fig. 2). As the main drive, our compatriots used not an electric motor, but a combustion engine with a capacity of 380 HP, borrowed from the Suzuki Hayabusa track motorcycle [6].

Many companies also conduct research and implementation works on rescue UAVs used to help people drowning in vast bodies of water, where the time of arrival of rescue services plays an essential role.

ROBOLIFEGUARD is a device developed by the AeroAtena consortium for patrolling open areas on land and water, detecting people and objects with the possibility of two-way communication (Fig. 3). Two completed fixed wing prototypes were presented at the Drones for Good competition in Dubai in February 2015. The first was used to test electronic equipment, including thermal imaging cameras and autopilot, and the second was used to test the high-efficiency power unit. The powered-lift concept is currently under development.

Fig. 2. Hoverbike Raptor [6]

Fig. 3. Robolifeguard prototypes [7]

II. Unmanned Tug – General Description

One of the attempts to use unmanned aerial vehicles in a new way is the glider tug concept developed by employees of the State Higher Vocational School in Chełm. It was submitted to the Patent Office of the Republic of Poland in December 2017 under the number P.423710.

Traditional glider take-off is most often carried out with the use of a towing plane or a winch. On some mountain gliders it is also possible to propel the gliders to take off using rubber ropes or by locating the take-off site in such a way that, under favorable conditions, the glider can reach a speed sufficient for independent flight by rolling down the slope. After reaching the appropriate height, the glider pilot releases the towing rope and the glider begins its independent flight. The use of each of these launch systems requires the participation of at least two additional people. The haul behind the plane is expensive, while the other solutions have significant limitations. In the proposed solution, it is possible to reduce the number of people serving the glider take-off and the weight of the tug-glider complex, which significantly reduces energy (fuel) consumption. The aim of the project is to develop a tugboat integrated with the sailplane, steered by a pilot during the take-off phase and capable of returning to the airport on its own.

The project of an UAV – a tug, mainly gliders, has been developed since 2016 (Fig. 4), initially by Tomasz Muszyński. In 2017, Henryk Jafernik, Barłomiej Kostowski, Łukasz Puzio, Arkadiusz Tofil and Józef Zając joined the work on the project.

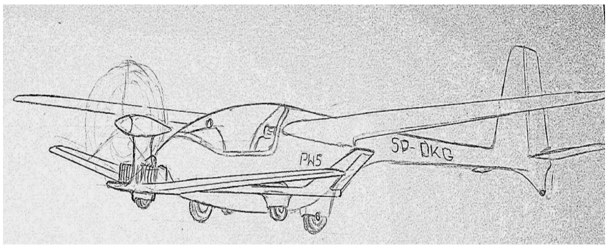

Fig. 4. Sketch of the PW5 glider assembly and the tug with a landing gear with a forward support point, version of the tugboat 1 from 2016 [8]

Four fixed wing versions of the UAV were built and tested, and work is currently underway on the use of a multi-rotor system. The works resulted in a patent application and the implementation of the tug model. The first concept was based on an aircraft in a low wing configuration, with a drag rotor, two tail beams, between which the fuselage of the sailplane is attached [1]. The second version was a modification of the first one, reducing the height of the turret and using a four-wheel chassis with the main wheels at the front. In the third version of the prototype, it was also decided to move the vertical tails away from the cabin, which, with the oblique wing, made it possible to shorten the tail beams and lower the position of the horizontal tail. In the fourth version, the fixed wing system in the form of a flying wing with a pulling propeller was used.

The essence of the solution is to equip the UAV with a glider attachment mechanism and a control system located in the sailplane, which enables the movement of the combined UAV and the sailplane on the ground and their motorized flight (Fig. 5). The solution includes a UAV-tug, a ground flight control station and an additional control system located in the sailplane. The monitoring and control system was initially based on the GPS system. The BSP-tug consists of an airframe with airframe systems, a power unit, and a radio control – RC control system, an autopilot with a stabilization and equipment system – a camera with real-time image and sound transmission from the UAV to the operator, and a flight monitoring system.

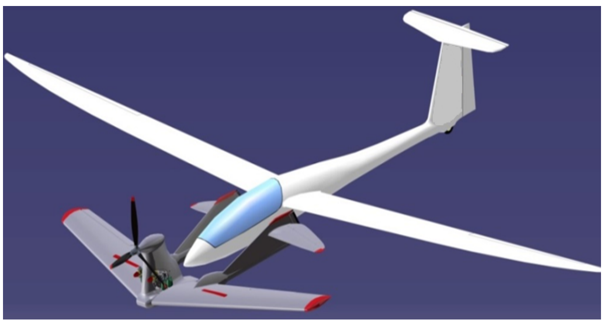

Fig. 5. Combined set of sailplane and UAV-tug boat 2 [9].

The preliminary stage consisted in performing the stability calculations of the UAV with an unusual layout – with a short hull, high-lift towing propeller, two tail beams and the tail under the wings of the sailplane. The calculations were made in the XFLR5 program (Fig. 6).

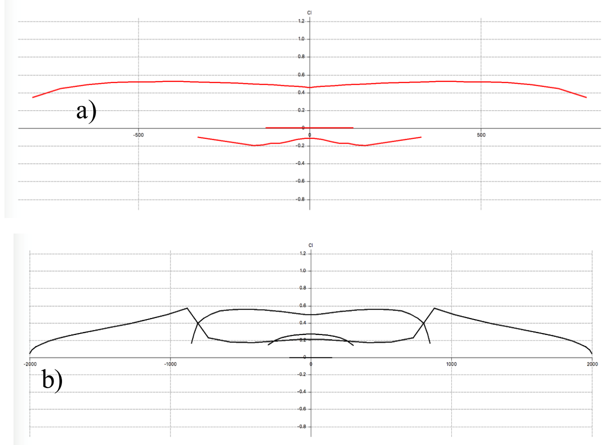

Fig. 6. Comparison of the lift force distribution along the wingspan on the sailplane model without a tugboat (a) and the tugboat model 2 – sailplane model assembly (b)

The performed calculations made it possible to select the tail wedge angles and the angle of the tug's wing relative to the sailplane. Moreover, the centers of gravity were determined and the scope of their change was determined. Based on these calculations, test models were configured and designed, which were tested in a wind tunnel and then tested in flight.

III. Conclusion

The proposed technical solution includes UAV with a glider attachment mechanism and a control system located in the sailplane. Due to performed calculations of the lift force distribution along the wingspan on the sailplane model done in XFLR5 program, the choice of tail wedge angles and the angle of the tug's wing relative to the sailplane were done that will be further tested in wind tunnel and in flight.

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[9] Visualization of concept by Tomasz Muszyński

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Томаш Мушинскій, Лукаш Пуціо, Філіп Донец, Гжегож Руге, Пьотр Скорупа. Розробка концепції бездротового буксира-планера. Частина 1

У статті представлено розробку проекту безпілотного буксира-планера, опис етапів нового технічного рішення, представленого до патентного відомства у грудні 2017 року та розробленого на сьогоднішній день. Пропонована буксирна система складається з універсального наземного поста керування дроном і буксира, жорстко пов'язаного з планером. Запропоноване рішення спрямоване на зниження експлуатаційних витрат та обмеження кількості людей, необхідних обслуговування польотів планерів.
Ключові слова: безпіло́тний літа́льний апара́т; буксир; модель планера; розподіл підйомної сили.

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Томаш Мушинский, Лукаш Пуцио, Филипп Донец, Гжегож Руге, Пьотр Скорупа. Разработка концепции беспроводного буксира-планера. Часть 1

В статье представлена разработка проекта беспилотного буксира-планера, описание этапов нового технического решения, представленного в патентное ведомство в декабре 2017 года и разработанного на

сегодняшний день. Предлагаемая буксирная система состоит из универсального наземного поста управления дроном и буксира, жестко связанного с планером. Предложенное решение направлено на снижение эксплуатационных расходов и ограничение количества людей, необходимых для обслуживания полетов планеров.
Ключевые слова: беспилотный летательный аппарат; буксир; модель планера; распределение подъемной силы.

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