XZ-4 Vertical Takeoff and Landing Multi-Rotor Aircraft

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ABSTRACT

The rapid development of unmanned multi-rotor helicopters has made small electric helicopters ubiquitous and wide spread in our everyday life. From photographic platforms to scientific test beds these machines have invaded our work and activities to a significant extend engaging into areas of service and utilisation that no other technical tool after the personal computer and the smart phone has ever achieved. But with its fast development the limits of the new technology soon are revealed. Multi-rotor helicopters cannot fly to a long distance nor can they sustain prolonged periods of flying without charging the batteries. On the other hand, the good old fixed wing aircraft now equipped with electric motors copes well with such tasks.

A solution to this requirement is the already well studied and tested vertical takeoff and landing technology. But all present developments implement cumbersome and extremely complex systems to achieve the so defined goal.

The current article presents a novel construction of the vertical takeoff and landing electric multi-rotor aircraft, which solves all present problems of complex and expensive structures and systems and offers a simple yet high quality vertical takeoff and landing aircraft design.

Keywords: Vertical takeoff and landing aircraft, Multi-rotor VTOL aerial vehicle.

INTRODUCTION

In recent years multi-rotor helicopters have gained popularity due to the advent of highly efficient electric motors and batteries with large energy densities. Nevertheless, the ubiquitous multi-rotor helicopters are lacking long flying times and long range due to the inefficiency of flying without a fixed wing. Using electric aircraft with fixed wings solves this problem, but another problem occurs – the need for a runway. The solution is an old technology called vertical takeoff and landing (VTOL) aircraft. Current designs are too complex to be feasible for small helicopters and a better and simpler design is needed. The current article presents such a design of the VTOL airplane sub-series XZ-4.

History Of VTOL Fixed Wing Multi-Rotor Airplanes

There is a large number of VTOL aircraft already developed. One of the most famous aircraft of this kind is the Bell Boeing V-22 Osprey (see Fig. 1). It represents a piloted VTOL two-rotor helicopter with a fixed wing aimed at transport of troops and cargos.

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Figure 1. Bell Boeing V-22 Osprey.

The control of flight is achieved through tilting rotors and collective and cyclic pitch control of the propeller blades. This is a very sophisticated technology and has proven hard to adjust and implement. Another example of a convertible VTOL airplane is the unmanned Bell Eagle Eye. Both designs use tilt-rotors and collective and cyclic pitch control (CCPC). They take off and land vertically and perform vertical to horizontal and vice versa flight transitions in the air. More examples of VTOL propeller driven airplanes using CCPC having similar qualities may be found in the literature.

Another type of VTOL propeller driven airplanes achieve vertical to horizontal flight transition using tilt-wing technology (see Fig. 2).

Figure 2. Hiller X-18 uses tilt-wing to perform VTOL manoeuvring.

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A third group of propeller driven airplanes with fixed wing exhibit VTOL features but have neither tilt-rotors nor tilt-wings. These aircraft are the so called tail-sitters. All tail-sitter designs rely on collective and cyclic pitch control of their propellers and/or control surfaces in order to guide their flight. These airplanes carryout the transitions between vertical and horizontal flight by changing the orientation of their whole airframe (see Fig. 3).

Figure 3. Convair XFY-1 Pogo tail-sitter design.

All three groups of VTOL propeller driven fixed wing aircraft mentioned so far use in conjunction or separately control surfaces, tilt-rotors, tilt-wing or collective and cyclic pitch control to maintain their flight attitude. This leads to lower efficiency of flight, extreme complexity of the aircraft, higher initial and maintenance costs and lower reliability.

In order to overcome the drawbacks just noted authors propose novel designs of VTOL fixed wing propeller driver aircraft that do not use control surfaces, tilt-rotors, tilt-wing or collective and cyclic pitch control to maintain their flight attitude. Instead, a multi-rotor system is utilized where by changing rotor speeds the aircraft is controlled successfully in all modes of operation: vertical flight, horizontal flight and intermediate transitional flight modes.

The Zabunov XZ-4 sub-series of VTOL aircraft

The Zabunov XZ-4 sub-series consist of several aircraft models based on multi-rotor fixed wing airplane with static blades (no pitch adjustment), no control surfaces, no tilt-rotors or tilt-wing. Thus the construction of these aircraft is very simple, inexpensive, reliable and lightweight. The XZ-4 sub-series are based on patent issued to the authors for originality and novelty of their work.

Currently there are three models developed: XZ-4, XZ-4A and XZ-4B. Model XZ-4 is a hex-rotor aircraft with fuselage and a fixed wing. No tail control surfaces or stabilizers are present. There are no ailerons either. Thus the airplane has low aerodynamic drag. Four of the

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rotors are positioned on the main wing with propellers in tractor configuration. Another two of the rotors are mounted in nacelles under the wing again in tractor setup so that the upper wing surface is not shadowed. The latter feature was designed into XZ-4 model aiming at installing solar panels on the upper surface of the fixed wing. The other two models XZ-4A and XZ-4B do not offer solar panel capabilities.

XZ-4 is shown on Fig. 4 and Fig. 5.

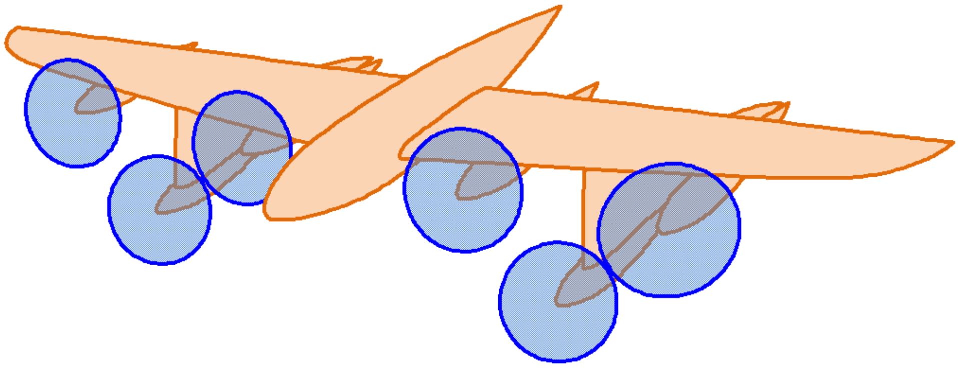

Figure 4. General view of Zabunov XZ-4 VTOL aircraft

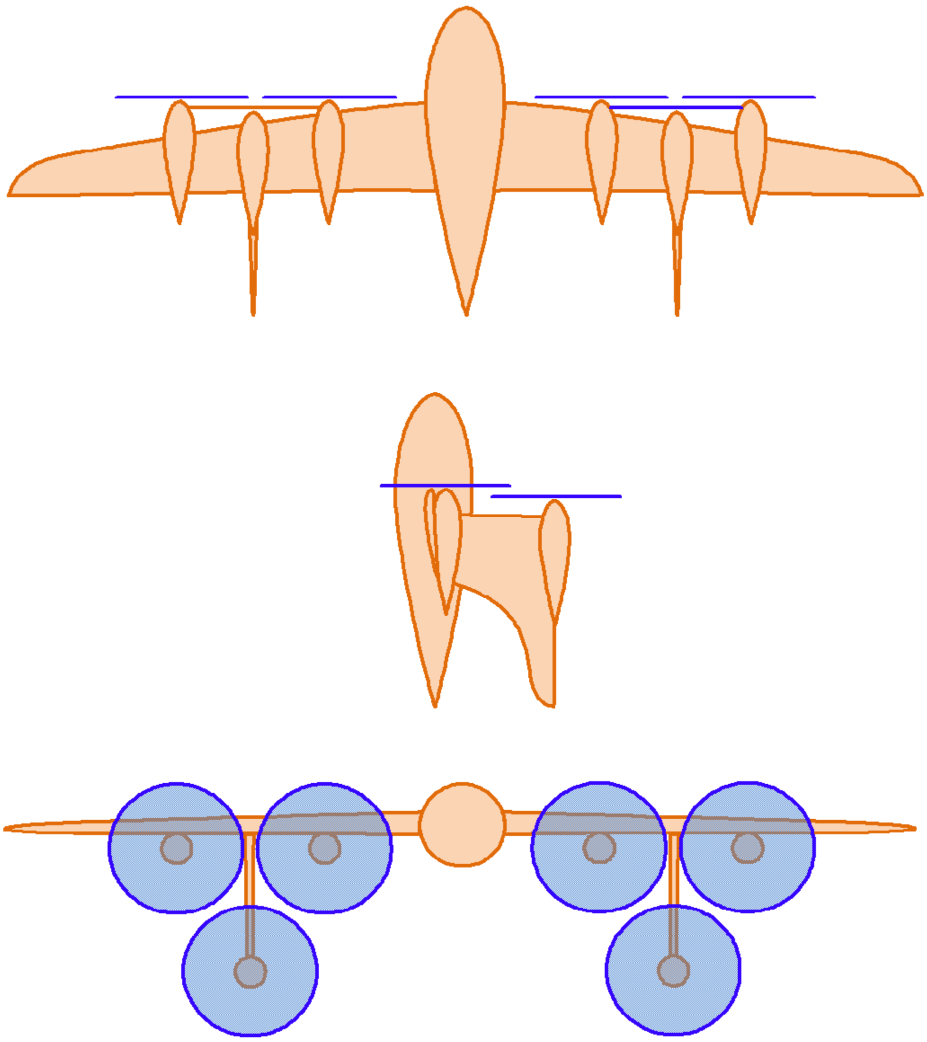

Figure 5. Zabunov XZ-4 bottom, side and front view.

XZ-4 is a tail-sitter aircraft and takes off and lands vertically as a helicopter (see Fig. 5). As it is aimed at horizontal flight in most of the time, propellers are optimized for horizontal flight and its hovering capabilities are not as efficient as those of a conventional multi-rotor helicopter such as XZ-2 or XZ-3 helicopters. Once in the air, XZ-4 is able to make transition from vertical to horizontal flight tilting its whole airframe. In horizontal flying mode XZ-4 is capable of flying to several times longer and to several times longer distances than multi-rotor helicopters due to high efficiency of the main wing. The propellers positions are such chosen that when mounting cameras to the bottom of the fuselage their view is clear and unhindered.

A simpler construction is offered by XZ-4A where the console attached propellers are protruding from the fuselage instead of from the wing. This construction is more rigid hence lighter, but obstructs the sunlight from passing to the upper surface of the wing thus eliminating the possibility of installing solar cells over the wing top surface (see Fig. 6).

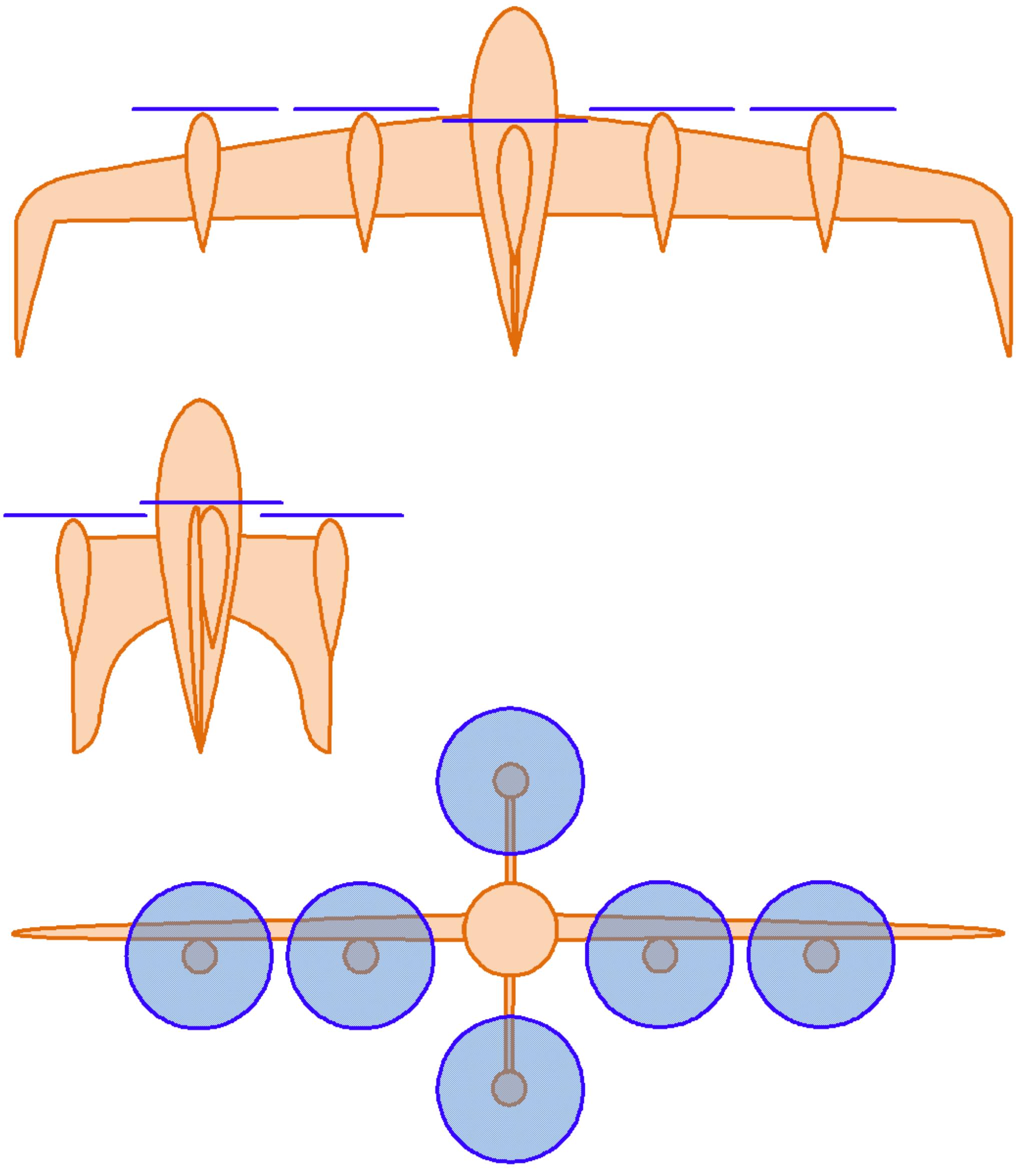

Figure 6. Zabunov XZ-4A bottom, side and front view.

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The third design designated XZ-4B is even simpler in design possessing only four instead of six propellers. This non-complex construction is also less reliable, but cheaper and easier to maintain. XZ-4B is extremely valuable for testing purposes. It is shown on Fig. 7. Again, it is not suitable for solar cells installation on the main fixed wing.

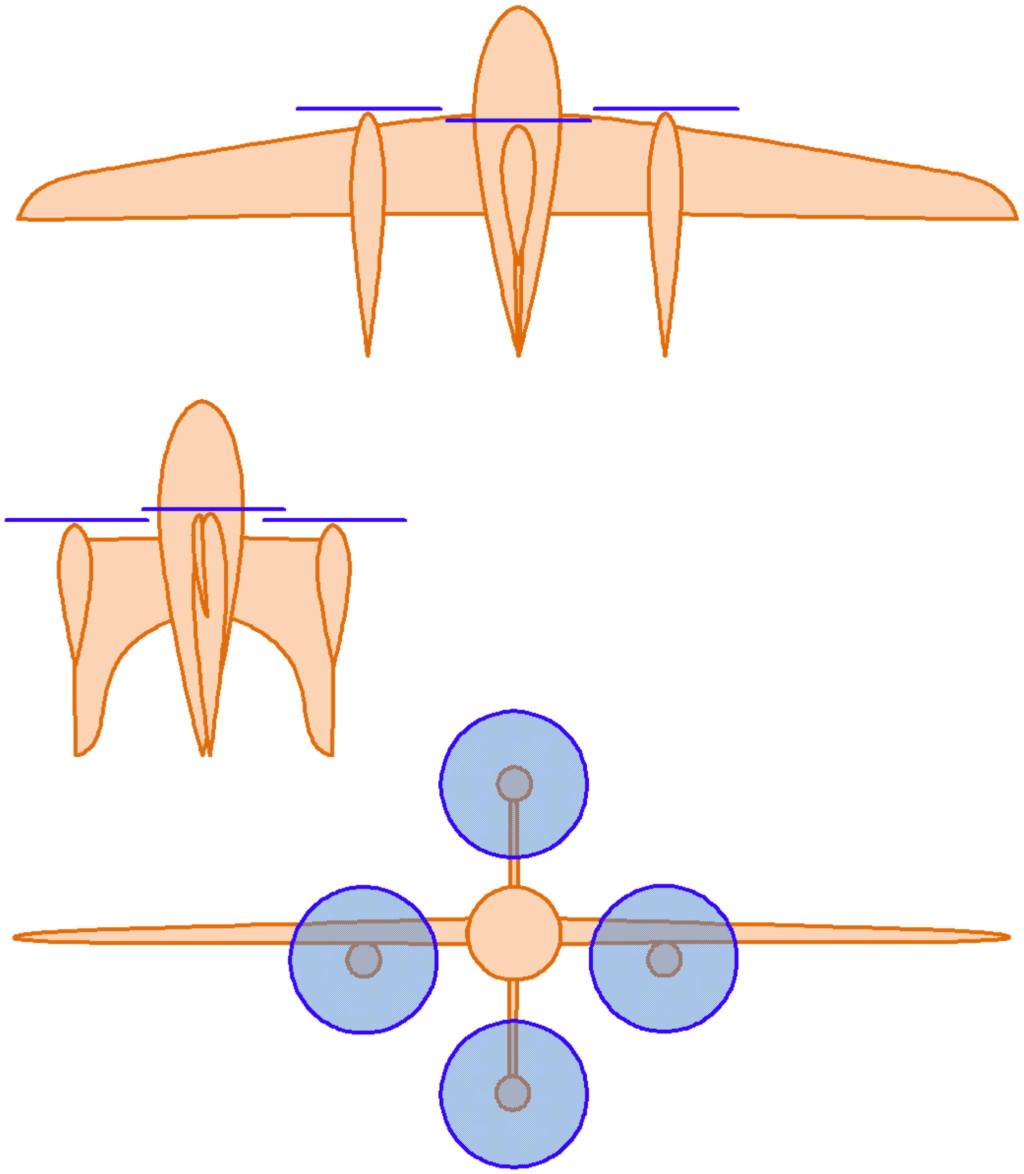

Figure 7. Zabunov XZ-4B bottom, side and front view.

CONCLUSION

Inventing novel VTOL airplane designs in the field of unmanned aircraft is essential due to the current lack of high quality and efficient VTOL propeller driven unmanned airplanes. The Zabunov XZ-4 sub-series of VTOL multi-rotor aircraft fills the gap of efficient, simple, cost-effective and capable aircraft by offering a new approach to VTOL aircraft design.

Authors are continuing their work on new models of unmanned multi-rotor propeller driven VTOL fixed wing airplanes and also of conventional and compound multi-rotor helicopter designs.

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REFERENCES

[1]. Norton, B. (2004). *Bell Boeing V-22 Osprey, Tiltrotor Tactical Transport*. Midland Publishing, 2004. ISBN 1-85780-165-2.

[2]. Wynbrandt, J. (2012). AW609 Finally Ready for its Close-up, *Aviation International News*, 11 February 2012.

[3]. Paur, J. (2013). Meet Project Zero, the World's First Electric Tilt-Rotor Aircraft, *Wired,* 6 March 2013.

[4]. Warwick, G. (1992). Tilting at targets, *Flight International*, page 44, February 1992

[5]. Stephen T. (2009). Boeing looks ahead to a 'V-23′ Osprey, *Flight Global Aviation Connected*, 22 June 2009

[6]. Darling, J. (2011-06-13). "*Ryan X-13 Vertijet". Diseno*. Retrieved 2014-02-09.

[7]. Choi, C. Q. (2010-01-19). *"Electric Icarus: NASA Designs a One-Man Stealth Plane*". Scientific American. Retrieved 2010-02-27.

[8]. Spencer, J. (1998). "*Vertical Challenge: The Hiller Aircraft Story*", University of Washington Press, 1998

[9]. Tony, L., & Dennis, J.(2000). "*Lockheed AH-56A Cheyenne*", Specialty Press Publishers and Wholesalers, 2000

[10]. US Patent US5054716

[11]. US Patent US3201071

[12]. US Patent US8602348B2

[13]. US Patent US2936968

[14]. US Patent US3107882

[15]. US Patent US3393882

[16]. US Patent US3567157

[17]. US Patent US3666209

[18]. US Patent US5141176

[19]. US Patent US1442110

[20]. US Patent US1655114

[21]. US Patent US2837300

[22]. US Patent US5765783

[23]. US Patent US8434710B2

[24]. US Patent USRe.36487

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